Plastic Surgery Case Review

Oral Board Study Guide

Albert S. Woo
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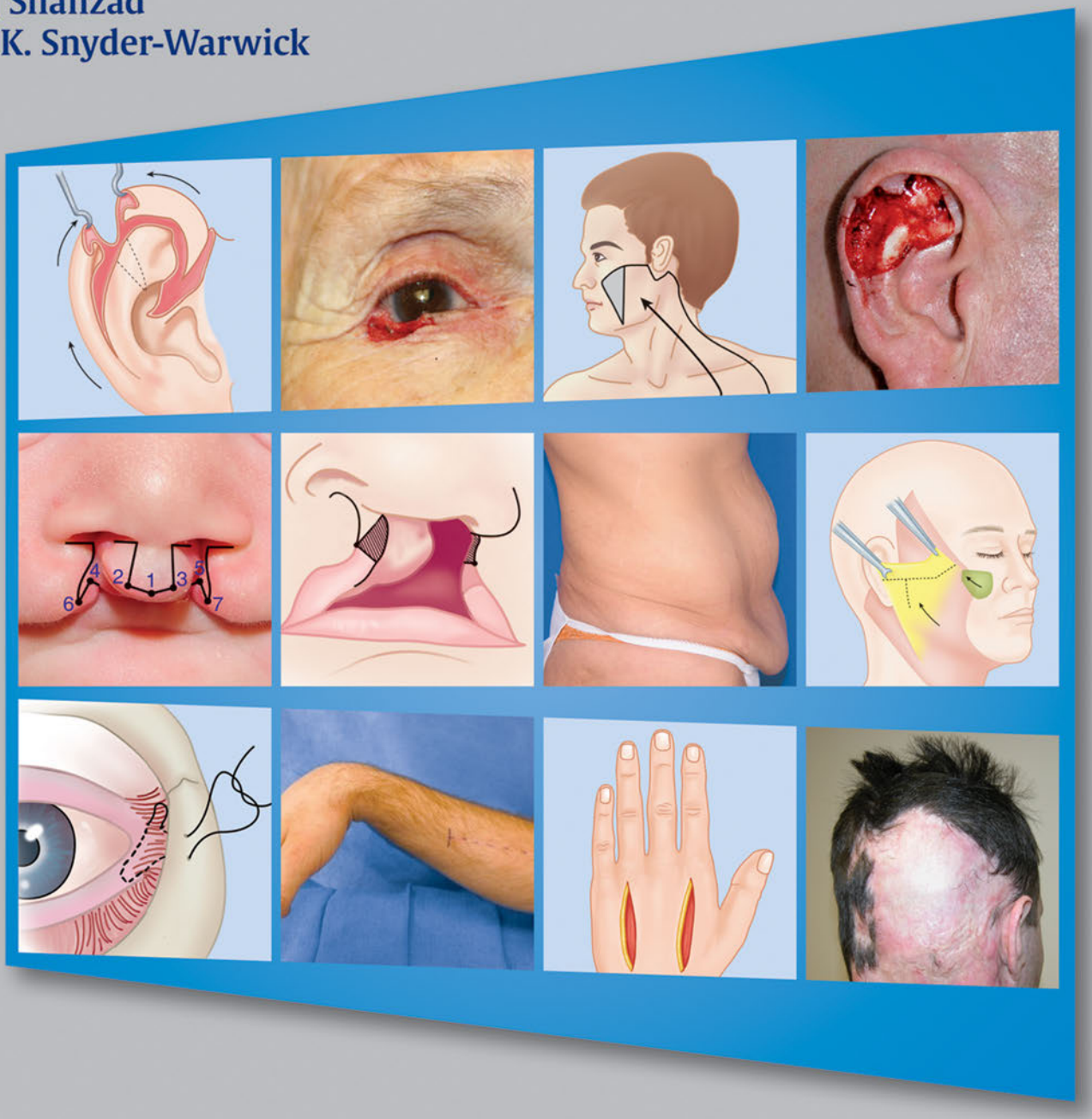

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Oral Board Study Guide

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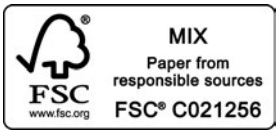

This book is dedicated to my wife, Judy, the mother of my two children, without whom no accomplishment is ever worthwhile.

Preface

The field of plastic surgery is as wide as it is deep. It is a specialty unique in its ability to defy definition. Contrary to the paradigm of other surgical disciplines, plastic surgery has no organ system to call its own. Therefore, those in our field will regularly operate on patients from head to toe, venturing from skin to bone, sometimes delving even deeper into the vital organs of the body. Possibly the best means of description comes from the original Greek term *plastikos*, derived in turn from *plassein*, meaning "to mold, shape, or form." Indeed, plastic surgeons use specialized techniques and principles to remodel the body, replacing what has been lost and potentially creating that which is missing. This may have been expressed best by a founding father, Gaspare Tagliacozzi, who in 1597 stated, "We restore, repair, and make whole those parts … which fortune has taken away, not so much that they may delight the eye, but that they may buoy up the spirit and help the mind of the afflicted."

Given the vastness of the field and the unusual difficulty in defining its boundaries, the task that academic plastic surgeons face in teaching the specialty to ensuing generations becomes especially daunting. Despite this enormous undertaking, training programs have done an excellent job in working to define a curriculum and provide a vast array of surgical experiences for residents and fellows. Because it is nearly impossible to have every trainee learn every single operative procedure, the specialty has been distilled into numerous critical areas of learning—with a number of standard procedures and foundational principles that all plastic surgeons are expected to have mastered.

The purpose of this book is to serve as an additional resource for education among those pursuing a career in plastic surgery. In particular, it is especially geared toward individuals preparing for their oral board examinations. The cases are therefore designed to be relatively short and straightforward, focusing upon the critical elements of knowledge and decision making. They are not necessarily intended to present the latest "cutting edge" procedures or to be exhaustive, but rather to discuss safe and proven methods of patient care.

The book comprises 50 cases, each of which explores a fundamental topic of study. The first page of each case includes a photograph of a representative patient and a short description, such as one might find in a board examination setting. Readers are encouraged to examine each scenario and thoroughly explore how the patient might be approached clinically. What critical elements of the patient's history and physical examination are necessary? Is any further work-up needed before a surgical plan of action is determined? What key components of treatment should be identified and discussed in a test environment? Should complications occur, how will they be managed? What critical mistakes should the practitioner be conscious to avoid? Each of these questions should be asked and answered before the subsequent body of the text is read.

The text was inspired by the "mock oral examination" that is regularly conducted by the Division of Plastic Surgery at Washington University in St. Louis. Although the examination is invariably a difficult undertaking for the residents, trainees and faculty alike have always uniformly agreed that the testing is a tremendously worthwhile learning endeavor. It is the hope of the editors that this work may prove in some way useful to other plastic surgeons, at all levels of experience. Students and residents might use this work as a quick study resource, which may highlight areas of further study or point out details in decision making that are possibly not readily obvious in didactic texts. Older surgeons may find the book useful as a review, reminding each of us of small details that we may have forgotten.

Acknowledgment

The authors would like to acknowledge the contribution of Dr. Susan E. Mackinnon, who initially developed the concept for this book and inspired its development.

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Part 1

Section I. Facial Fractures

1 Zygoma Fractures

Farooq Shahzad & Albert S. Woo

Fig. 1.1 (a-b) A 20-year-old man presents to the emergency department with left cheek pain and swelling after an assault to the face.

1.1 Description

- Left midfacial and periorbital edema with malar depression and left enophthalmos.
- Computed tomography (CT) demonstrates depressed left zygomaticomaxillary (ZM) complex fracture with comminution at the ZM buttress.
- By definition, the left orbital floor is fractured in a displaced ZM complex fracture.

1.2 Work-up

1.2.1 History

- Mechanism of injury: Helpful in determining angle of force and severity of injury.
- Previous facial injuries or fractures.
- Change in vision, loss of vision, or double vision.
  - Must rule out orbital injuries before considering operative intervention.
- Numbness of the cheek or upper lip signifying infraorbital nerve V_2 injury.
- Change in occlusion.

1.2.2 Physical examination

- ATLS protocol: Identify any potentially life-threatening conditions.
- Perform a detailed examination of the face, including inspection for swelling and depression; palpation for tenderness, crepitus, or step-off; sensory and motor examinations; eye, nasal, and intraoral examinations; and examination of ears and tympanic membrane.
- Signs of ZM complex fractures are malar depression (masked by soft-tissue swelling early on), subconjunctival and periorbital ecchymoses, enophthalmos and/or hypoglobus (usually masked by orbital swelling resulting in ptosis), inferior slant of the palpebral fissure, numbness in the infraorbital nerve distribution, and upper buccal sulcus ecchymoses.

1.2.3 Pertinent imaging or diagnostic studies

- High-resolution maxillofacial CT scan
  - Evaluate the five articulations of the zygoma for degree of displacement and comminution: (1) *lateral orbital rim* (zygomaticofrontal [ZF]); (2) *inferior orbital rim*; (3) *ZM buttress*; (4) *zygomatic arch* and temporal articulation; and (5) *lateral orbital wall* (zygomaticosphenoid [ZS]).
  - Evaluate orbital floor defect. *Coronal images are critical to this evaluation.*

1.2.4 Consultations

- Trauma evaluation based on mechanism of injury and if other injuries suspected.
- Ophthalmology consultation in all orbital fractures to rule out ophthalmologic injury. Must be performed *before operative intervention* because intraoperative manipulation may exacerbate eye injury.

1.3 Treatment

- Always start with the ABCs (airway, breathing, circulation) of trauma. All emergent injuries must be managed first.
  - Definitive treatment of facial fractures may be delayed for up to 2 weeks without compromising results. Longer delay in treatment increases risk for infection and the need for osteotomies as bone healing takes place.
- Simple, nondisplaced fractures do not need surgery and may be managed conservatively.
- Fractures that are significantly displaced or comminuted at multiple articulations require open reduction/internal fixation (ORIF). Plates should be positioned at facial buttresses (▶ Fig. 1.2).
  - Critical points of fixation include the following: (1) ZF region or lateral orbital rim, (2) infraorbital rim, and (3) ZM buttress. At least three points of fixation are necessary to

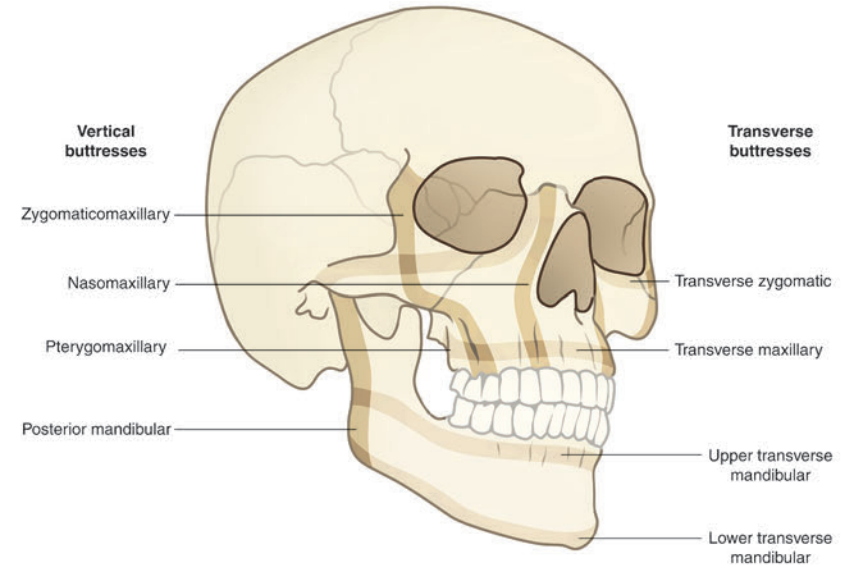

Fig. 1.2 Buttresses of the face. Vertical buttresses include the zygomaticomaxillary and nasomaxillary buttresses. The infraorbital rim, maxillary alveolus, and mandible contribute to transverse buttresses of the face.

guarantee three-dimensional stability. When necessary, the zygomatic arch may be stabilized at a fourth point of fixation.

- The operative approach is determined by the status of the zygomatic arch. If the arch is comminuted or otherwise irreducible, a coronal incision will be needed for reduction and fixation of the arch. Otherwise, the zygoma can be reduced and fixed with an anterior approach.
- The **standard anterior approach** consists of three incisions:
  - Lateral part of upper blepharoplasty incision (or lateral brow incision) for access to the lateral orbital rim and wall. Note that *the best means of confirming three-dimensional reduction of a ZM complex fracture is at the lateral orbital wall, which is accessed through this approach.*
  - Lower-eyelid incision (transconjunctival, subciliary, or subtarsal) for inferior orbital rim and orbital floor.
  - Upper buccal sulcus incision for access to maxillary buttresses.
- **Isolated zygomatic arch fractures:** May be reduced via temporal (Gillies) or intraoral (Keen) approach.
- **Orbital floor evaluation:** As a component of the ZM complex, the orbital floor is (by definition) fractured when the zygoma is displaced and must be evaluated at the time of operation.
  - If the patient has enophthalmos or hypoglobus, or if a sizable defect is present, the floor should be reconstructed with an implant (e.g., porous polyethylene or titanium) or bone graft after the ZM complex fracture has been reduced.

1.4 Complications

- **Retrobulbar hematoma:** Can occur at time of injury or postoperatively. Signs are severe eye pain, proptosis, afferent pupillary defect, change in visual acuity, and ultimately blindness. This is a *surgical emergency* and requires an immediate lateral canthotomy with inferior cantholysis for drainage of the hematoma. Mannitol, acetazolamide, and ophthalmology consult are supplementary measures. Immediate return to the operating room is usually indicated.
- Inadequate reduction resulting in malposition.
- Orbital floor undercorrection or overcorrection resulting in enophthalmos, proptosis, or vertical dystopia. Requires implant repositioning.
- Anesthesia or paresthesia in infraorbital nerve distribution. This is most commonly due to nerve contusion and generally resolves within 6 months.
- Lower-lid ectropion (subciliary incision) or entropion (transconjunctival incision). This usually responds to eyelid massage but may require surgical correction. The subciliary incision has the highest risk for ectropion in comparison with the transconjunctival and subtarsal approaches.
- Infection requires antibiotics and possible hardware removal.

1.5 Critical Errors

- Failure to assess ABCs in acute trauma.
- Failure to evaluate for other facial injuries on examination or CT scan. Watch out for naso-orbito-ethmoid (NOE) fractures, which may occur concomitantly.
- Not knowing the various approaches for zygomatic fracture exposure and fixation.
- Not knowing the indications for orbital floor reconstruction.
- Inability to recognize and treat a retrobulbar hematoma.

2 Mandible Fractures

Leahthan Domeshek & Albert S. Woo

Fig. 2.1 (a-c) A 50-year-old man presents to the emergency department following an assault to the face.

2.1 Description

- Malocclusion with left-sided anterior open bite.
- Displaced oblique right subcondylar fracture extending through sigmoid notch.
- Displaced, comminuted fracture of left posterior body of mandible, with possible involvement of mandibular third molar (tooth No. 17).

2.2 Work-up

2.2.1 History and physical examination

- **ABCs** (airway, breathing, circulation): Attention to stability of the airway, given multiple mandible fractures. Rarely, intubation may be necessary if the patient cannot protect the airway.
- Concomitant injuries: Manage any potentially life-threatening injuries first. The repair of mandibular fractures is not emergent and can be performed on an elective basis (generally within 14 days of injury).
- Palpate/manipulate the mandible for step-offs and instability.
- Assess *mobility* (ability to open and close mouth, deviation of mandible on movement) and *occlusion* (may evaluate based on wear facets of teeth).
- State of dentition: Patients with edentulous mandibles will require more aggressive procedures to rigidly fix bone segments because of decreased bone stock.
- Neurologic examination: The *mental/inferior alveolar nerve* provides sensation to the lower lip and frequently sustains neurapraxic injury with blunt trauma. The *marginal mandibular branch* of the facial nerve innervates the depressors of the lower lip and is rarely injured.
- Assess for concomitant midfacial fractures (may alter occlusion).

2.2.2 Pertinent imaging or diagnostic studies

- High-resolution maxillofacial computed tomography (CT): This is the gold standard for imaging. Three-dimensional reconstructions may assist in further evaluating injury.
- When CT is unavailable, other studies may be useful.
  - Panorex: Allows visualization of the entire mandible and dentition. Limited evaluation at symphysis and condyles. Additional Towne view improves visualization of subcondylar regions.
  - Mandible series (anteroposterior, lateral, oblique, open-mouth reverse Towne view).

2.3 Treatment

2.3.1 Initial management (in the emergency department)

- Oral chlorhexidine rinse: Decreases oral flora/bacterial count.
- Bridle wire (optional): Stainless steel wire typically placed two teeth away on either side of a fracture line to help with temporary stability. May be useful to increase patient comfort in the setting of unstable fractures.

2.3.2 Definitive treatment

- Can be delayed for up to 2 weeks without compromising results. Longer delay in treatment increases risk for infection and need for osteotomies as bone healing takes place.

2.3.3 Nondisplaced fractures

- *If stable:* Conservative management with a soft, non-chew diet for roughly 4 weeks. Subsequent instability or displacement necessitates operative treatment.
- *Mild instability:* Treat with maxillomandibular fixation (MMF).
  - Two types of MMF are reasonable: Arch bars and intermaxillary fixation (IMF) screws.
  - MMF is effective in patients only when appropriate dentition is present.
  - Rule of thumb
    - *Subcondylar:* 2 weeks with early return of motion using guiding elastics.
    - *Body/angle:* 4 weeks.
    - *(Para)symphyseal:* 6 weeks.

2.3.4 Displaced fractures

- Open reduction/internal fixation (ORIF)
  - Wide exposure of fractures.
  - Establish occlusion (MMF may help with this).
  - Plate fractures.
  - Release MMF and confirm normal occlusion when condyles are seated in the temporomandibular joint (TMJ).
  - Reestablish MMF if indicated.
- Generally, transfacial approaches are preferred for the ORIF of *comminuted* fractures: Increased visualization, access to all mandibular surfaces. Also use in edentulous patients for improved reduction.
- Plating technique
  - Stronger plates (i.e., fracture or reconstruction) necessary to establish rigid fixation of the inferior border of the mandible.
  - A *tension band* may be placed superiorly to avoid splaying of the fracture line. This may be accomplished with either a miniplate just below the tooth roots or an arch bar anchored to the dentition.
- Subcondylar/ramus fractures (▶ Fig. 2.2)
  - Mildly displaced: Preferentially treat with closed methods (MMF with early release and elastic guidance). Muscular forces and proprioception compensate for architectural deformities in these regions, permitting normal functional occlusion in the setting of mild displacement that would be intolerable elsewhere.
  - ORIF necessary if deformity precludes proper mandibular movement or occlusion (i.e., condylar head displacement into middle cranial fossa; foreign body lodged in TMJ; bilateral subcondylar fractures that will result in an anterior open bite).
  - Preferred approaches: Extraoral via *retromandibular* incision (good exposure of fracture, ease of plating) or submandibular (*Risdon*).

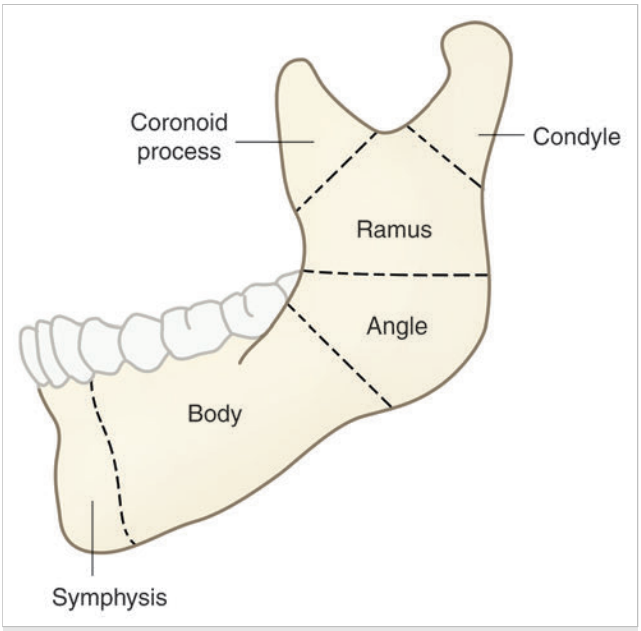

Fig. 2.2 Zones of the mandible.

- **Angle fractures:** Require ORIF. If the third molar is involved, it must be removed if it interferes with reduction.
  - Intraoral approach with percutaneous access for plating along the inferior border appropriate for easily reduced noncomminuted fractures.
  - *Champy technique* is also acceptable in straightforward, noncomminuted fractures of the angle. This entails placement of a tension band plate at the external oblique ridge without use of an inferior border plate.
  - Risdon approach for comminuted fractures.
- **Body fractures:** Require ORIF.
  - Intraoral (vestibular) approach preferred for most fractures: Excellent visualization of and access to mandibular body, no external scars, little risk to vital structures (i.e., marginal mandibular nerve).
  - Risdon approach for comminuted fractures and those requiring exposure/manipulation of inferior border of mandible. Useful for wide access to posterior body fractures.
- **(Para)symphyseal fractures:** Inherently unstable and require ORIF.
  - Intraoral approach for most fractures: Excellent exposure, permits continuous visual assessment of occlusion, no external scars.
  - Extraoral (submental) approach may be useful for comminuted fractures.
  - Before completion of the case, the patient must be examined with MMF released.
  - The condyles must be firmly seated in the TMJ fossa, and normal occlusion must be confirmed. If this does not result in normal occlusion, the plates must be released and the fracture re-reduced.
  - Once occlusion has been confirmed, MMF may be reestablished as necessary.
- **Edentulous mandibles:** Prone to malunion due to limited bone stock.
  - Require more aggressive treatment, generally with an external approach and fixation with large reconstruction plates that provide long-term stability.
  - In limited circumstances, one may consider use of a Gunning splint or wiring in the patient's current dentures. This provides less stability than an open approach.

2.4 Complications

- Malocclusion: Adequate occlusion must be confirmed before completion of the procedure.
- Malunion/nonunion: May require débridement and bone grafting.
- Infection: Avoid the urge to remove plates until fracture healing has been achieved. Early removal of hardware will otherwise result in malocclusion.
- Damage to inferior alveolar nerve: Avoid injury by keeping hardware away from the midportion of the mandible where nerve courses.

2.5 Critical Errors

- Failure to obtain accurate occlusion and reduction before plating fractures.
- Failure to confirm normal occlusion upon completion of surgery.
- Failure to remove plates and re-reduce the mandible if the patient does not have normal occlusion after MMF is released.

3 Frontal Sinus Fractures

Neil S. Sachanandani & Albert S. Woo

Fig. 3.1 (a-c) A 37-year-old man presents following an assault to the forehead with a baseball bat.

3.1 Description

- Large, oblique forehead laceration extending down to bone.
- Displaced left frontal sinus fracture with involvement of the anterior and posterior tables.

3.2 Work-up

3.2.1 History

- Mechanism of injury: Helpful in determining severity and type of injury.
- Change in vision, loss of vision, or double vision.
  - Must rule out orbital injuries before considering operative intervention.
- Numbness of forehead signifying injury to cranial nerve V_1 distribution.
- Rhinorrhea: Concerning for dural injury and cerebrospinal fluid (CSF) leak.

3.2.2 Physical examination

- Identify any potentially life-threatening conditions.
- Identify lacerations over the forehead, glabella, or supraorbital ridge; may be used for direct access for repair in selected cases.
- Evaluate for palpable step-offs and/or depressions in the frontal area.
- Evaluate for sensibility changes in supraorbital/supratrochlear nerve distribution.
- Examine for CSF rhinorrhea.
  - *Ring test* at the bedside.
  - May test for *β-transferrin* in nasal discharge, signifying CSF.
- Test function of frontalis and corrugator muscles.

3.2.3 Pertinent imaging or diagnostic studies

- High-resolution maxillofacial computed tomographic scan: Assessed in both axial and coronal planes.
  - Evaluate for involvement of anterior/posterior tables and determine degree of comminution/displacement.
  - Evaluate *nasofrontal outflow tract* for ability to drain the frontal sinus.
  - Identify intracranial injuries (pneumocephalus, etc.) and other facial fractures.

3.2.4 Consultations

- Neurosurgical consultation is necessary if intracranial injury is suspected (significant displacement of posterior table, pneumocephalus, CSF rhinorrhea).

3.3 Treatment

- Management is guided by the injury pattern (▶ Fig. 3.2).
- Nondisplaced fractures of the frontal sinus may not need operative repair.

3.3.1 Isolated, displaced anterior table fracture

- Open reduction/internal fixation (ORIF) is performed through a preexisting laceration or coronal incision. The sinus is preserved.
- Anterior table fracture *with associated nasofrontal duct injury*
  - Mandates **frontal sinus obliteration** and permanent blockage of the nasofrontal ducts.
  - The frontal sinus mucosa is completely removed with a high speed drill and diamond burr. The frontal sinus is obliterated with a pericranial flap, fat, fascia, bone chips, or spontaneous osteogenesis (no material used). There is no significant advantage to any one of these particular techniques over the other.
    - Required for isolation of the frontal sinus from the sinonasal tract to prevent contamination and mucosal regrowth from the ethmoids into the frontal sinus.
  - The anterior table is replaced, reduced, and plated as needed.
  - Performed only if there is minimal or no posterior table displacement and no CSF leak.

3.3.2 Combined anterior/posterior table fractures

- Involvement of the posterior table is concerning for *dural injury* and must be addressed by a neurosurgeon before repair of the fracture.
  - Injuries with displacement of the posterior table of less than one table width are frequently observed when there is no clear evidence of dural tear.
- When the posterior table is minimally involved but the nasofrontal ducts are injured, **frontal sinus obliteration** is indicated.
- When the posterior table is significantly displaced or comminuted, **cranialization** of the frontal sinus with obliteration of the frontonasal outflow tract (duct) should be performed.
  - Cranialization steps are identical to those of frontal sinus obliteration, with the addition of complete removal of the posterior table.
  - A *pericranial flap* is placed along the floor of the anterior cranial fossa to separate the nasal and intracranial cavities.

3.4 Complications

- Frontal sinusitis, meningitis/encephalitis, brain/epidural abscess: Must obliterate the nasofrontal outflow tract to prevent bacterial contamination of intracranial contents.
- Mucocele/mucopyocele: May present many years after trauma as a consequence of inadequate removal of sinus mucosa.
- Cavernous sinus thrombosis.
- Posttraumatic deformity from inadequate anterior table reconstruction.

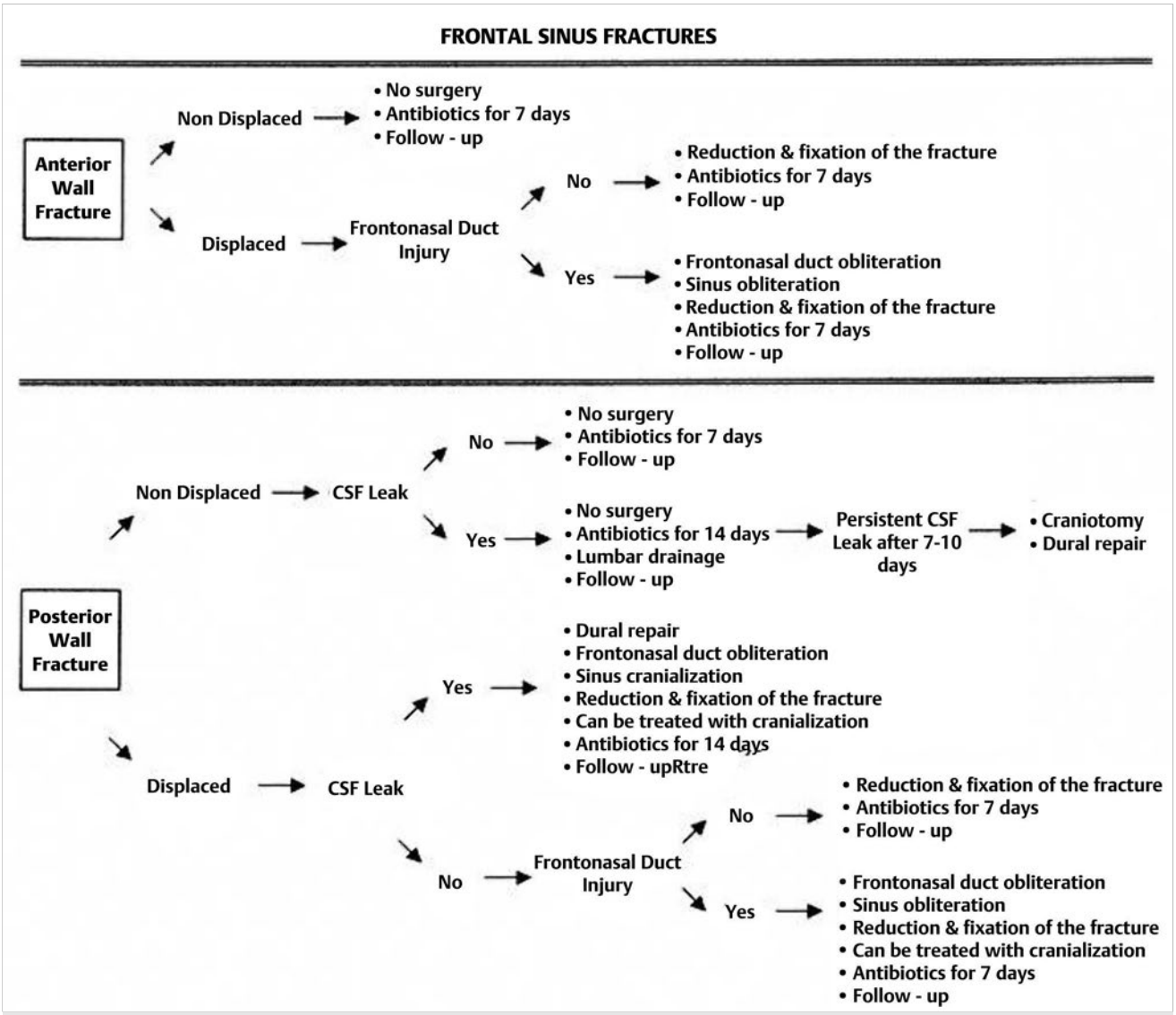

Fig. 3.2 Algorithm for the management of frontal sinus fractures. (Reproduced with permission from Yavuzer R, Sari A, Kelly C, et al. Management of frontal sinus fractures. Plast Reconstr Surg 2005;115:79e–93e.)

3.5 Critical Errors

- Failure to evaluate for cerebrospinal fluid leak.
- Failure of thorough irrigation and débridement on initial encounter.
- Failure to remove all of the mucosa during sinus obliteration.
- Failure to separate the nasal cavity from the anterior cranial fossa during cranialization.
- Failure to obtain neurosurgical consultation when there is involvement of the posterior table or evidence of brain injury.

4 Le Fort Fractures

Michael J. Franco & Albert S. Woo

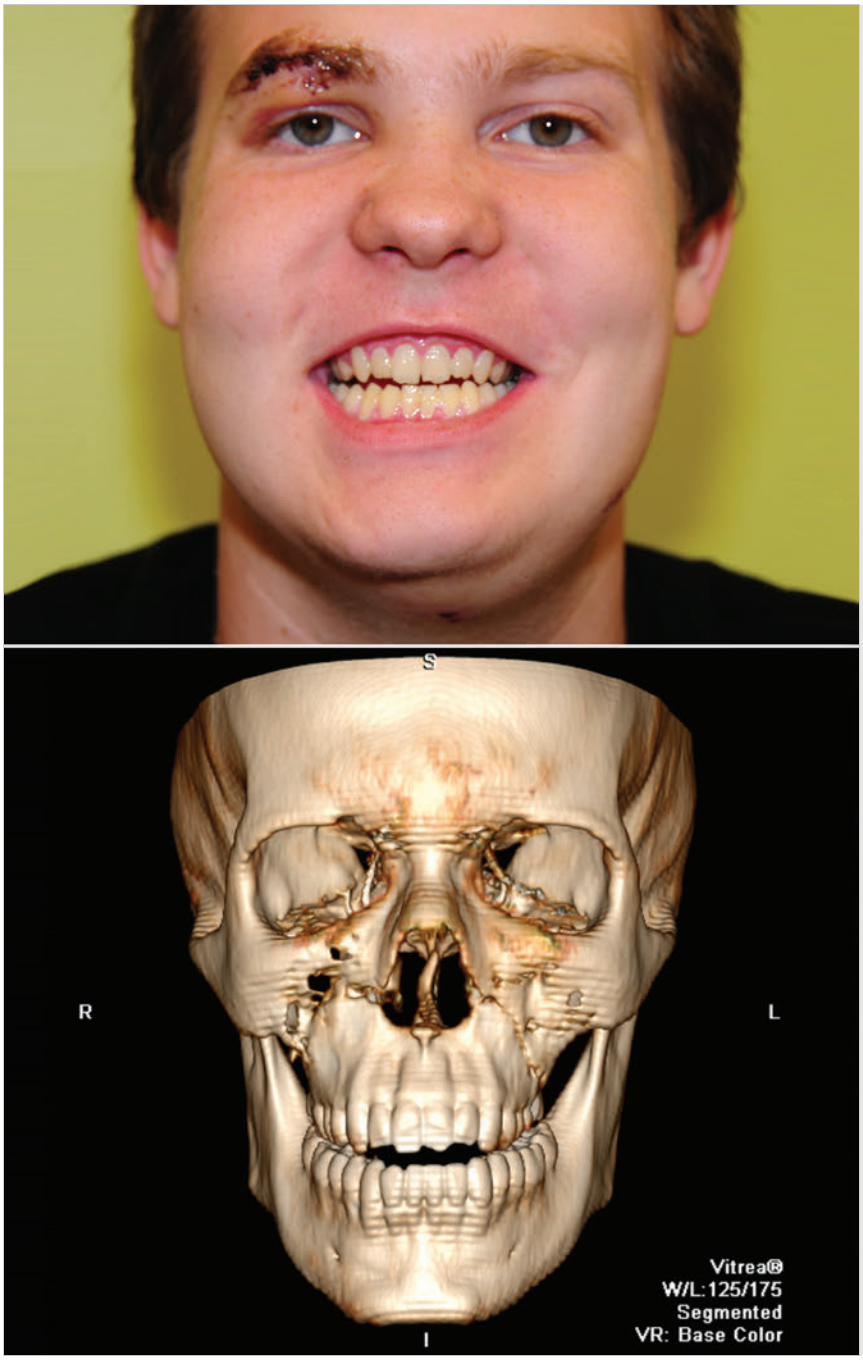

Fig. 4.1 An 18-year-old man presents with malocclusion and upper jaw pain following a motor vehicle collision.

4.1 Description

- Anterior open bite. Evidence of repaired right brow laceration.
- Transverse fracture across the maxilla involving the zygomaticomaxillary (ZM) and nasomaxillary (NM) buttresses on both sides, consistent with a Le Fort I fracture. (Coronal images are needed to evaluate the pterygoid plates to confirm the diagnosis.)
- Fracture extending from the right NM buttress to the infraorbital rim without displacement at the nasofrontal (NF) junction, consistent with a type IA naso-orbito-ethmoid (NOE) fracture.

4.2 Work-up

4.2.1 History

- Mechanism of injury: Helpful for determining severity of impact and trajectory of force.
- Changes in vision, occlusion, breathing, or hearing.
- Previous facial trauma.

4.2.2 Physical examination

- Identify any potentially life-threatening conditions. Always take spinal precautions and rule out cervical injury.
- Perform a detailed examination of the face, including inspection for swelling and depression; palpation for tenderness, crepitus, or step-off; sensory and motor examinations; eye, nasal, and intraoral examinations; and examination of ears and tympanic membrane.
- State of dentition: Fractured, missing, or rotten (carious) teeth and occlusal pattern.
- Assessment for midface instability: Stabilize the face at the nasal root (left hand) and grasp the upper anterior alveolar arch (right hand) and pull forward/down. If the midface is mobile with stability at the nasal root, it is indicative of a Le Fort I fracture. If there is also mobility at the NF suture, it is a Le Fort II fracture. If there is also mobility at the zygomaticofrontal suture, it is a Le Fort III fracture (▶ Fig. 4.2).

4.2.3 Pertinent imaging or diagnostic studies

- High-resolution maxillofacial computed tomographic scan
  - Fracture of the pterygoid plates is the sine qua non of Le Fort fractures.
  - *Le Fort I* is a transverse fracture of the maxilla involving the ZM and NM buttresses.
  - *Le Fort II* is a pyramidal fracture involving the ZM buttress, inferior orbital rim, inferior and medial orbital wall, and NF region.
  - *Le Fort III* causes craniofacial dysjunction and involves the zygomatic arch, lateral orbital rim, lateral orbital wall, orbital floor, medial orbital wall, and NF region.

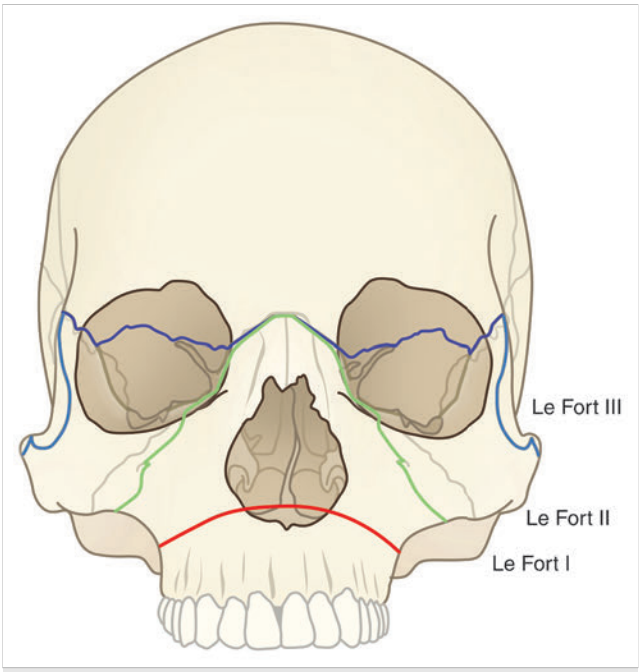

Fig. 4.2 Le Fort fractures patterns. Le Fort I: transverse fracture through the zygomaticomaxillary (ZM) and nasomaxillary buttresses. Le Fort II: pyramidal fracture through the ZM buttresses, infraorbital rims, medial orbit, and nasofrontal (NF) junction. Le Fort III: complete craniofacial dysjunction with separation of the cranium from the face at the zygomaticofrontal sutures and the orbital and NF junction.

4.2.4 Consultations

- Ophthalmology consultation in all orbital fractures to rule out ophthalmologic injury. Must be performed before operative intervention because intraoperative manipulation may exacerbate eye injury.

4.3 Treatment

- ATLS (*a*dvanced *t*rauma *l*ife support) protocol: Airway, breathing, circulation, disability, exposure. All emergent injuries must be managed first.
  - Definitive treatment of facial fractures may be delayed for up to 2 weeks without compromising results. Longer delay in treatment increases risk for infection and need for osteotomies as bone healing takes place.

4.3.1 Nondisplaced, stable fractures

- Nonoperative management is an option with a soft, non-chew diet for 4 to 6 weeks.
- Close follow-up to ensure that the patient maintains good occlusion.

4.3.2 Displaced, unstable fractures

- Require open reduction/internal fixation (ORIF).
- The establishment of *normal occlusion* is critical because this is most noticeable to the patient.

- Maxillomandibular fixation (MMF) can be performed by using dental wear facets as guides. This may be accomplished with Erich arch bars or intermaxillary fixation (IMF) screws.
- Bone gaps at buttresses: Especially those > 5 mm will not heal and require bone grafting.
- In easily reducible, minimally displaced fractures of the maxilla and/or mandible, patients may be treated with 4 to 6 weeks of MMF.

4.3.3 Surgical technique

- Nasal intubation.
- A bilateral gingivolabial incision is made 5 to 10 mm from the apex of the sulcus, and the anterior wall of the maxilla is exposed subperiosteally.
- Occlusion is established with MMF.
- Reduction of the fracture: Impacted fractures or difficult reductions due to early fibrous union may require the use of Rowe disimpaction forceps.
- Fracture stabilization
  - *Le Fort I:* Plating is performed at the ZM buttress and the NM buttresses.
  - *Le Fort II:* ZM buttresses and infraorbital rims. Uncommonly, plating of the NF junction is necessary if this region is significantly displaced.
  - *Le Fort III:* ZF (lateral orbital rim) regions and NF junction.
- MMF is then released and occlusion is checked with mandibular condyles seated in the glenoid fossa.

4.4 Complications

- Malocclusion: May be secondary to incomplete initial reduction of the fractures or lack of stabilization with MMF.
- Nonunion, malunion, or fibrous union: Requires débridement of the fracture site, possible bone grafting, and refixation.
- Infection: Be very cautious about removing hardware when the bones have not healed completely because this can result in loss of reduction. If possible, try to keep hardware in place.

4.5 Critical Errors

- Missed injuries and failure to perform a trauma work-up.
- Failure to diagnose and treat concomitant facial fractures. Watch out for NOE fractures (as in this case), which require additional reduction and stabilization.
- Failure to ensure centric occlusion at the time of fracture repair.

5 Pediatric Mandible Fractures

Noopur Gangopadhyay & Albert S. Woo

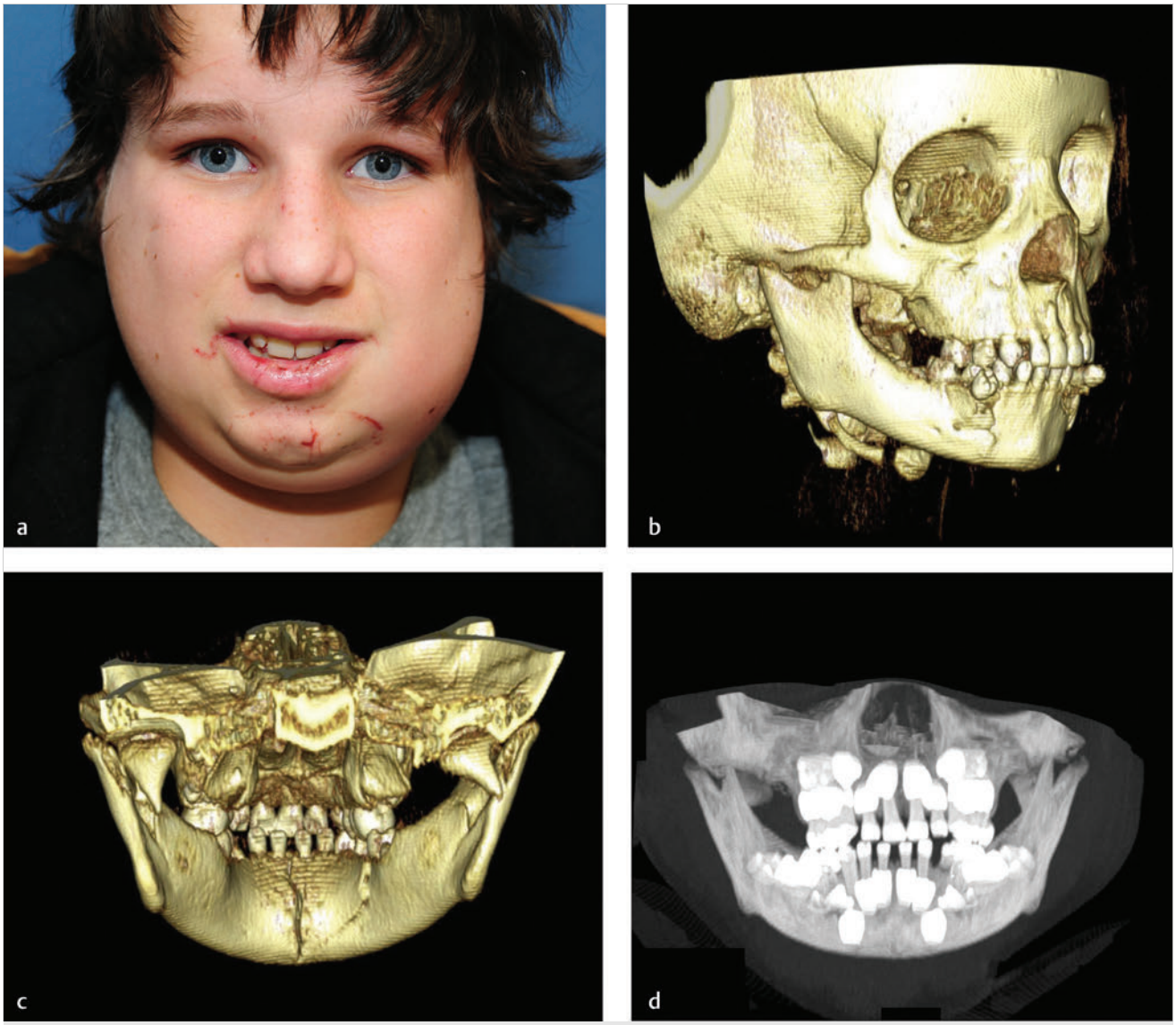

Fig. 5.1 (a-d) A 7-year-old boy presents to the emergency department after an ATV (all-terrain vehicle) crash with pain in his jaw and occlusal abnormalities.

5.1 Description

- Comminuted and significantly medially displaced bilateral subcondylar fractures.
- Comminuted right mandibular body fracture.
- Greenstick fracture of the inner (lingual) table of the mandibular symphysis.
- Multiple injured teeth.

5.2 Work-up

5.2.1 History and physical examination

- Complete trauma evaluation, including ABCs (airway, breathing, circulation).
  - Must evaluate risk for airway compromise. Rarely, intubation may be necessary to protect the airway.
  - Evaluate for associated injuries, including cervical spine injuries.
- Difficult to assess history in children. They may describe jaw pain with movement and noticeable changes in occlusion.
- Inspect face for asymmetry and areas of tenderness, swelling, or ecchymosis.
  - Ecchymosis of preauricular areas can indicate underlying fractures.
  - Chin laceration may indicate superiorly directed force consistent with condylar fractures.
  - Deviation of jaw opening or limited mobility.
  - Intraoral examination may reveal lacerations or hematomas; evaluate for dental injuries, including presence of permanent dentition.
  - Body/angle fractures may affect the inferior alveolar nerve, causing numbness of the lower lip and teeth.
- State of dentition
  - Children ages 6 to 12 will present in various states of mixed dentition. Younger children will have permanent tooth roots deep to their primary dentition. *These factors will critically influence a surgeon's options for reconstruction of injuries.*
  - Assess for dental fracture, stability, tooth root exposure, and caries.

5.2.2 Pertinent imaging or diagnostic studies

- High-resolution maxillofacial computed tomography: Gold standard for evaluation of facial trauma. Three-dimensional reconstructions may assist in evaluating injury. Maximum-intensity projection view (when available) can reveal dentition for evaluation of tooth roots.
- Panorex: Requires patient cooperation, and patient must be upright for the study. Allows visualization of the entire mandible and dentition. Towne view adds improved evaluation of condyles.
- Plain radiography (mandible series with anteroposterior, lateral, oblique, and open-mouth Towne view): These studies are of limited benefit in younger patients, whose skeletons are less calcified than those of adults.

5.3 Treatment

- Goals of treatment: Restoration of occlusion, function, and facial balance.
- Facial growth: Vertical growth of the mandible occurs primarily in the subcondylar region and may be disrupted in severe injuries to this area. Counseling regarding this risk is important.
- Pediatric bone has the ability to remodel. Thus minimally displaced fractures with near normal occlusion can be treated conservatively.

5.3.1 Acrylic dental splints (Gunning splints)

- If the patient is younger than age 2, the deciduous teeth have not completely erupted and cannot tolerate arch bars. Open reduction/internal fixation (ORIF) with plates also risks injury to tooth roots.
- An acrylic splint may be fixed in place to both occlusive surfaces with circum-mandibular, circum-piriform, and other types of fixation wires (▶ Fig. 5.2).

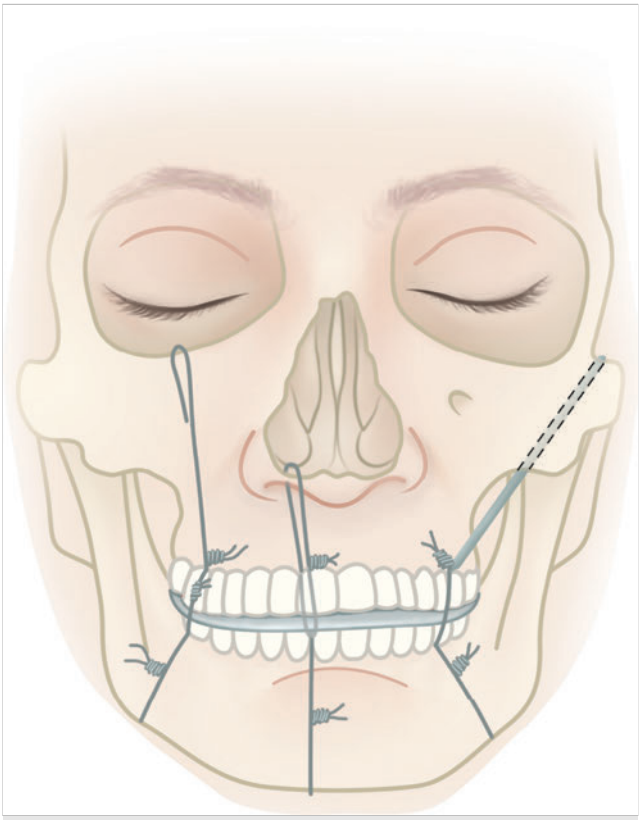

Fig. 5.2 Options for wiring techniques, including circum-mandibular, circum-piriform, circum-orbital, and circum-zygomatic wires. At least three points of fixation should be used to optimize stability of the fixation.

5.3.2 Erich arch bars for maxillary fixation

- If adult molars are present or the deciduous molars are reasonably solid, they may be used to stabilize arch bars. (Children ages 2 to 5 years have reasonably solid deciduous molars, whereas children ages 6 to 12 years have mixed dentition.)
  - Circum-mandibular wires may be used to additionally stabilize a lower arch bar.
  - A maxillary arch bar may be fixed anteriorly to the piriform aperture or anterior nasal spine.
- In older children with adult dentition, intermaxillary fixation (IMF) may be established with arch bars or IMF screws in standard fashion.
  - Crowns of deciduous teeth and partially erupted permanent teeth make interdental wiring difficult and potentially traumatic to future dentition.

5.3.3 Timing of immobilization

- Fractures in children heal more quickly than those in adults, and the ability of the condyle to remodel following injury to this area is also excellent.
- **Condylar fractures:** Treated conservatively with soft diet and physical therapy.
- **(Sub)condylar fractures:** When fractures to the condyle are present, immobilization should be minimized (roughly 2 weeks) to decrease the risk for ankylosis of the temporomandibular joint (TMJ).
- **Body and angle fractures:** 3 to 4 weeks.
- **Parasymphyseal fractures:** 4 weeks.

5.3.4 Open reduction and internal fixation

- ORIF is performed if normal occlusion can not e obtained with closed reduction or if more than one fracture is present.
- The presence of developing tooth roots is critical in operative planning.
- In **bilateral subcondylar fractures**, the vertical height of the mandible is lost.
  - Miniplates with monocortical screws are placed at inferior mandibular border to minimize injury to developing tooth roots.
  - At least one of the fractures must be repaired to reestablish the height of the mandible and prevent eventual collapse resulting in a permanent open bite.
- Surgical access (see Case 2)
  - Intraoral approach through a gingivolabial sulcus incision for symphyseal and body fractures.
  - Intraoral approach with percutaneous screw placement versus Risdon (external) approach for angle fractures.

5.4 Complications

- Abnormalities of occlusion or dentition: Suggestive of inadequate initial reduction or stabilization.
- Ankylosis of the TMJ: Especially notable when the condyle is fractured and the patient is treated with long-term immobilization.
- Growth disturbance: May be unavoidable because of severity of injury, especially in the subcondylar region.

5.5 Critical Errors

- Failure to address subcondylar fractures and mandibular height, resulting in permanent open bite and malocclusion.
- Plating the mandible fractures without regard to permanent tooth roots.
- Failure to discuss with family growth disturbance related to subcondylar fractures.
- Failure to release maxillomandibular fixation and confirm the presence of normal occlusion with condyles seated appropriately in the glenoid fossa upon completion of the case.

Part 2

Section II. Face Cancer (Squamous Cell Carcinoma, Basal Cell Carcinoma, Melanoma, and Reconstruction (including Mohs Defects))

6 Lip (Cancer and Reconstruction)

Tracy S. Kadkhodayan & Terence M. Myckatyn

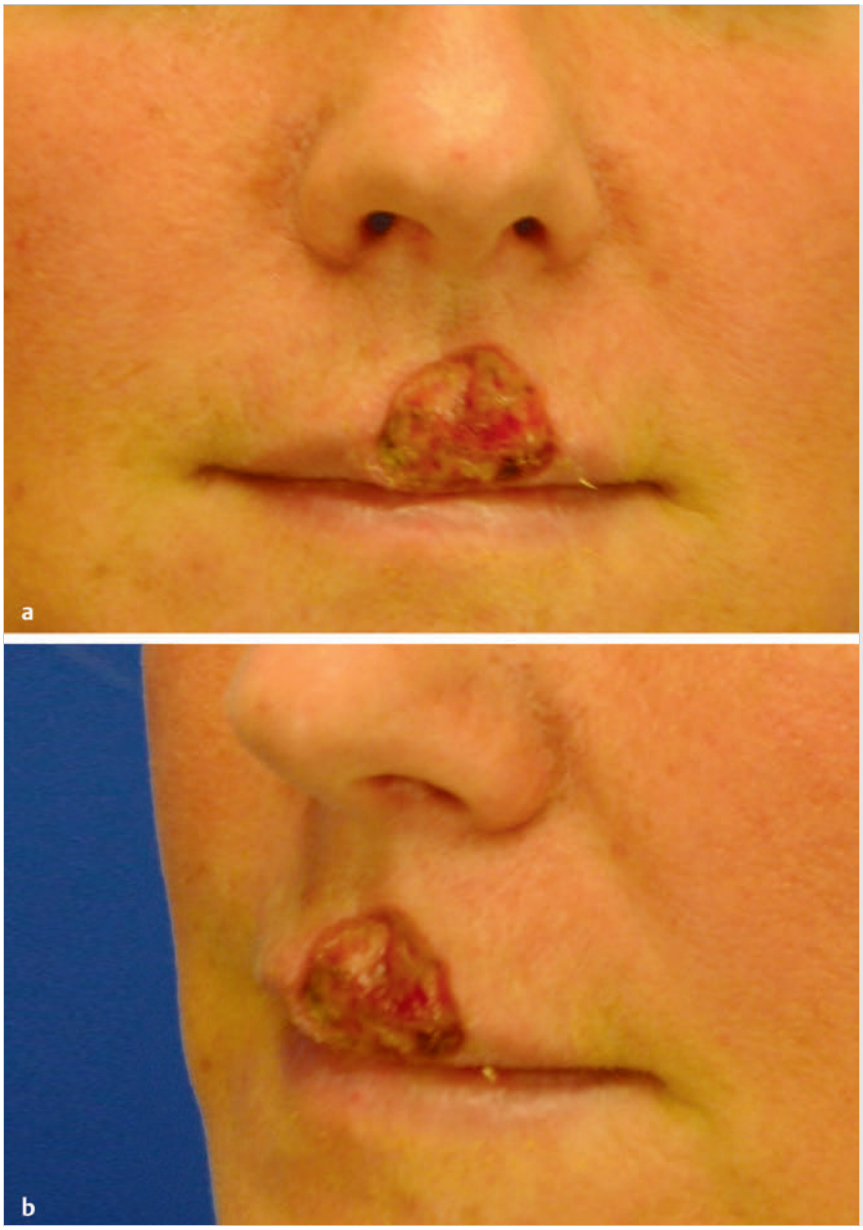

Fig. 6.1 A 42-year-old woman presents with a defect on her upper lip after Mohs surgery for basal cell carcinoma resection.

6.1 Description

- A 2.3 × 2.5-cm partial-thickness defect of central upper lip involving mucosa, vermilion, and cutaneous lip.
  - Involves multiple critical structures: Cupid's bow, philtral dimple, and philtral columns bilaterally.
- Orbicularis oris muscle intact.

6.2 Work-up

6.2.1 History

- History of sun exposure.
- Personal and family history of skin cancer.
- Genetic conditions: Xeroderma pigmentosum, Gorlin (nevoid basal cell) syndrome, albinism.
- History of radiation therapy
- Organ transplantation: Squamous cell carcinoma is the most common cancer in solid organ transplant recipients

6.2.2 Physical examination

- Full-body examination of integument.
- Lymph node examination to rule out metastatic disease.

6.2.3 Diagnostic studies

- If patient presents initially without resection, a biopsy should be performed at the time of evaluation to *establish a diagnosis.*
  - Full-thickness *incisional* versus *excisional* biopsies may be performed. Avoid shave biopsies.

6.3 Treatment

- Consider Mohs surgery, if available.
  - Allows examination of ~ 100% of surgical margins; highest cure rates.
  - Board examiner may require that you excise this yourself.

6.3.1 Excision (▶ Table 6.1)

- **Basal cell carcinoma:**
  - Standard margin is 2-5 mm
  - Larger margin for high risk types (poorly defined borders, recurrent, perineural invasion, aggressive growth pattern)
  - Radiation therapy can be used for non-surgical candidates

Table 6.1 Standard margin recommendations for different types of skin cancer

Basal Cell Cancer	Squamous Cell Cancer	Melanoma (Breslow thickness)
Standard margin: 2–5 mm	< 2 cm, well differentiated: 4 mm	In situ: 5 mm
Margin for aggressive subtypes: 7 mm	> 2 cm, invasive to fat, high-risk location: 6 mm	< 1 mm: 1 cm
		1 to 2 cm
		> 2 mm: 2 cm

- **Squamous cell carcinoma:** Most common type in lip, > 90% occur on lower lip.
  - 4 mm margins for low risk lesions: Well/moderately differentiated, well defined borders, trunk/extremity lesions > 2 cm.
  - 6 mm margins for high risk lesions: Poorly differentiated, poorly defined borders, perineural/vascular involvement, Clark level IV or V, recurrent, high risk locations (mask area of face, hands/feet, genitalia)
  - Enlarged lymph nodes should be evaluated for metastases with FNA or core needle biopsy.
  - Radiation therapy can be used for non-surgical candidates
- **Melanoma:** Margins determined by **Breslow thickness**.
  - In situ: 5 mm.
  - < 1 mm: 1-2 cm
  - 1 to 2 cm.
  - 2.1 to 4 mm: 2 cm.
  - > 2 cm: 2 cm.
  - Stage Ib (0.76-1 mm thick with ulceration or mitotic rate > = 1 per mm2) or stage II melanoma (> 1 mm thick) may require sentinel lymph node biopsy (ENT or surgical oncology consultation). If lymph nodes are positive, neck dissection is performed.
  - Stage III melanoma (positive lymph nodes) may require interferon (medical oncology consultation).

6.3.2 Reconstruction

- Goals: Restoration of function (oral competence, speech) and cosmesis.
- Reconstruction should be delayed until *negative margins are confirmed* on final pathology.
  - Local wound care or temporizing skin graft in interim.
  - Fresh frozen pathologic evaluation cannot ensure negative margins.
- Surgical pearls
  - Mark or tattoo landmarks (e.g. white roll, red line) before infiltrating local anesthetic.
  - Primary closure: Upper lip ≤ 1/4 defect, lower lip ≤ 1/3 defect.
- **Mucosal/vermilion defects:** Replace "like with like."
  - *Mucosal advancement:* When defect is partial thickness.
  - *Vermilion advancement:* Musculovermilion flaps for small, full-thickness defects.
  - *Vermilion lip switch*
    - For larger defects, primarily of the upper lip.
    - Requires second stage (2 weeks) for division of flaps.
  - Tongue flap
    - Anteriorly based, from the ventral surface.
    - Requires second stage for division (~10 days).
- **Upper lip full-thickness defects:** Focus on restoration of landmarks.
  - Primary closure if defect ≤ 1/4 of lip.
  - *Full-thickness skin graft:* When muscle layer is not involved.
    - Consider replacement of full aesthetic subunit.
  - *Abbe flap* (▶ Fig. 6.2)
    - *Lip switch* from lower to upper lip, designed as half the defect width.
    - Can correct defects involving 1/3 to 1/2 of the lip.
    - Second stage for division at 2 to 3 weeks.

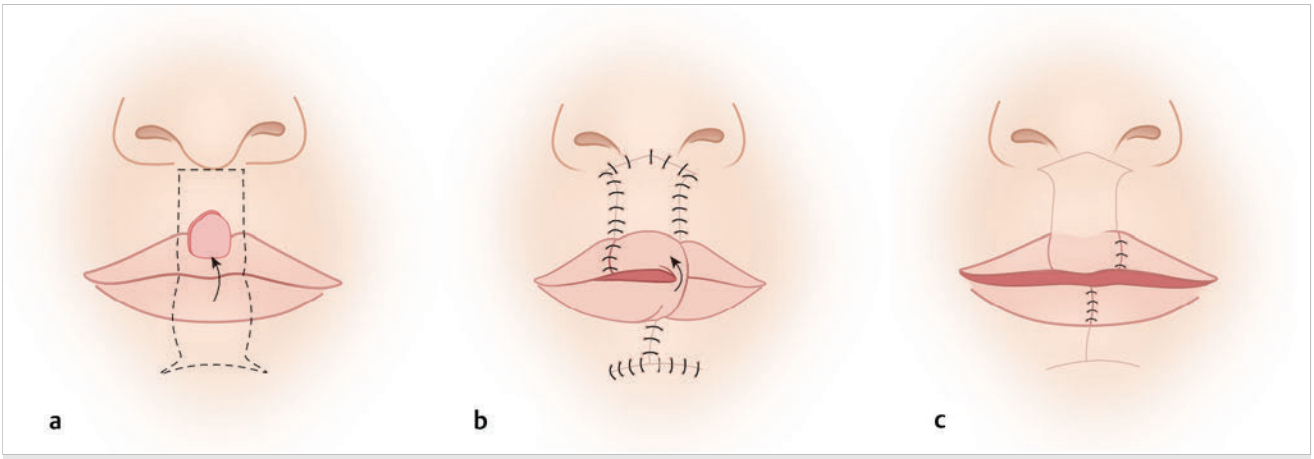

Fig. 6.2 Abbe flap. (**a**) The Abbe flap is elevated from the central lower lip. For central upper defects, it is elevated to the labiomental fold. For lateral defects, it continues through the central chin pad. (**b**) It is inset onto the columella, above the columellar base, with the extensions to the nasal sill. (**c**) The flap is divided and inset at 2 weeks.

- Karapandzic flap (▶ Fig. 6.3)
  - Myocutaneous rotational flap primarily for lower lip defect involving 1/3 to 2/3 of lip; may be used for upper lip as well.
  - Restores oral competence (*preserves neurovascular pedicle*) but may result in microstomia.
- Lower lip full-thickness defects
  - Primary closure if defect ≤ 1/3 of lip.
  - *Reverse Abbe flap:* Upper to lower lip switch.
  - *Schuchardt* For defects 1/3 to 2/3 of the lip.
    - Performed with lip advancement with incisions in labiomental crease.
    - Typically combined with lip switch to prevent microstomia.
  - *Karapandzic*: As noted above.
- Bernard-Burrow-Webster procedure: For defects > = 2/3 of lip.
  - Bilateral cheek advancement flaps with Burrows triangles excised at the nasolabial and labiomental crease.
- Commissure defects
  - Estlander flap (▶ Fig. 6.4): Lip switch involving the commissure.
    - Useful for full-thickness defects, 1/2 to 2/3 of the lip.
- Total lip reconstruction
  - *Free radial forearm flap* with palmaris longus sling for support.
  - Bernard-Burrow-Webster procedure: As noted above.

6.4 Complications

- Recurrent cancer: Re-excision is necessary.
- Wound dehiscence, partial flap necrosis: Treat with local wound care.
- Microstomia: May be preventable with postoperative splinting.
  - Abbe flap (single or bilateral) may be useful adjunct to primary flap procedure.
- Oral incompetence: Orbicularis reconstruction is important for prevention.

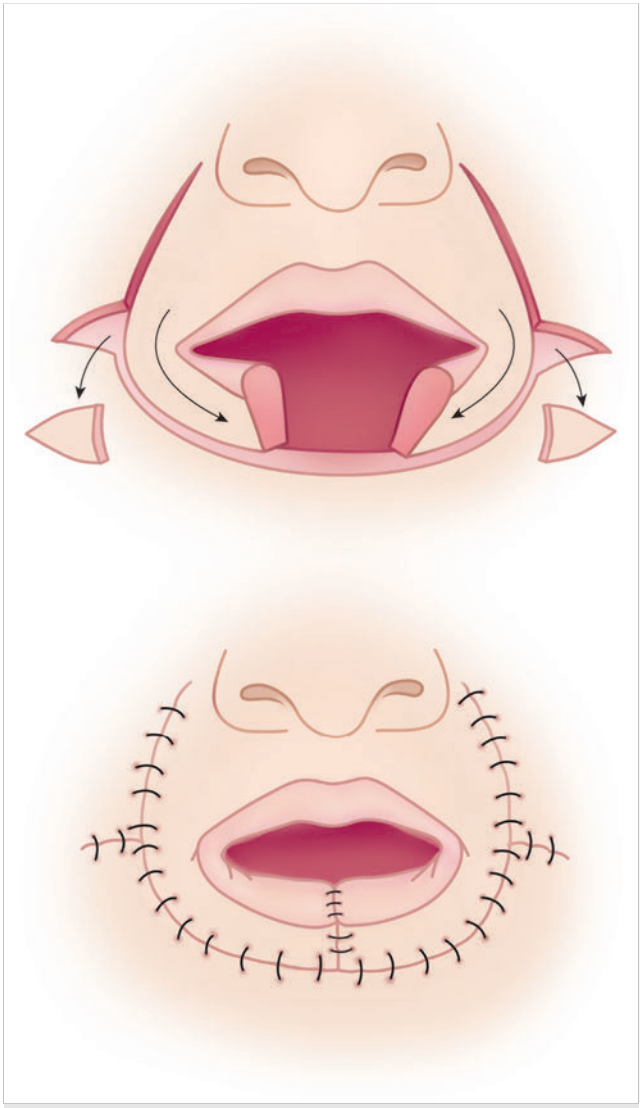

Fig. 6.3 Karapandzic flap.

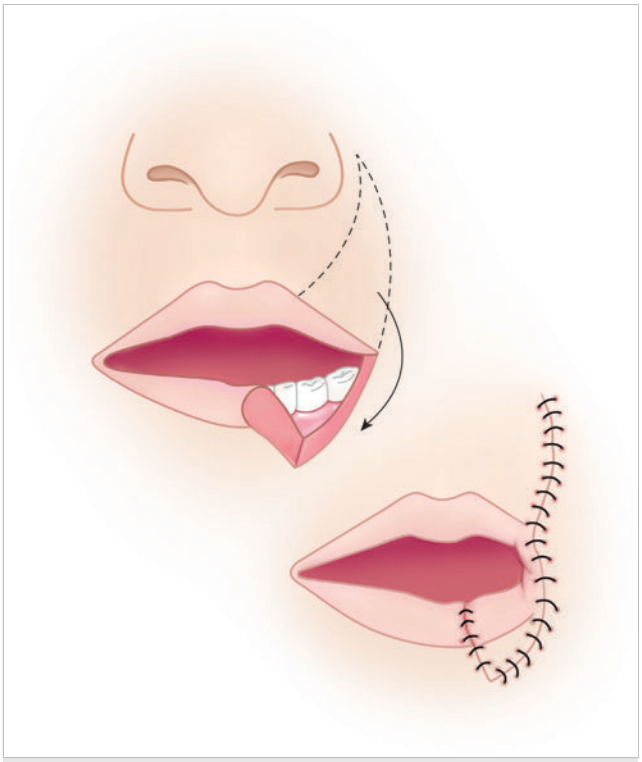

Fig. 6.4 Estlander flap.

6.5 Critical Errors

- Failure to perform appropriate biopsy when concern for melanoma.
- Inadequate resection.
- Reconstruction before ensuring negative margins.
- Failure to repair orbicularis oris musculature.
- Failure to address all three layers of missing tissue (mucosa, muscle, skin) or ignoring critical structures (philtrum, Cupid's bow, white roll).

7 Nose (Cancer and Reconstruction)

Alison K. Snyder-Warwick & Marissa Tenenbaum

Fig. 7.1 A 59-year-old woman presents to the clinic with a lesion on her nasal tip that she noticed 3 months ago.

7.1 Description

- Full-thickness defect of the sebaceous skin covering the nasal tip.
- The structural framework and nasal lining are not violated.
- The defect measures < 1.5 cm in size, which is appropriate for local tissue transposition.
- Involves one nasal subunit, the tip, but does not violate the remaining aesthetic subunits.

7.2 Work-up

7.2.1 History

- History of sun exposure.
- Personal or family history of skin cancer.
- Inherited predisposing conditions
  - Xeroderma pigmentosum, Muir-Torre syndrome, Gorlin syndrome, albinism, basal cell nevus syndrome, others.

7.2.2 Diagnostic studies

- Full-body integument examination.
- If patient presents initially without previous treatment, a biopsy should be performed at the time of evaluation to *establish a diagnosis.*
  - Full-thickness *incisional* versus *excisional* biopsies may be performed. Avoid shave biopsies.

7.3 Treatment

- Consider Mohs surgery consultation, if available.
  - Allows examination of ~ 100% of surgical margins; highest cure rates.
  - Board examiner may require that you excise this yourself.

7.3.1 Excision (see ▶ Table 6.1)

- Basal cell carcinoma: 2- to 5-mm margin. Larger margin for aggressive subtypes.
- Squamous cell carcinoma
  - 4 mm if lesion < 2 cm, well-differentiated, not invasive.
  - 6 mm if lesion > 2 cm, poorly differentiated, invasive into fat, or in high-risk location (central face, ears, scalp, hands, feet, genitalia).
- **Melanoma:** Excision margins determined by Breslow thickness.
  - In situ: 5-mm margin.
  - < 1 mm: 1-cm margin.
  - 1 to 2 mm: 1- to 2-cm margin.
  - > 2 mm: 2 cm margin.
  - *Stage II melanoma* (depth > 2 mm or > 1 mm with ulceration) may require sentinel lymph node biopsy (*surgical oncology consultation*).
  - *Stage III melanoma* (positive lymph nodes) may require interferon (*medical oncology consultation*).

7.3.2 Reconstruction

- Do not reconstruct until tumor-free margins are confirmed.
  - Fresh frozen pathologic evaluation cannot ensure negative margins.
  - Excision and dressing versus temporary skin graft are reasonable first steps.

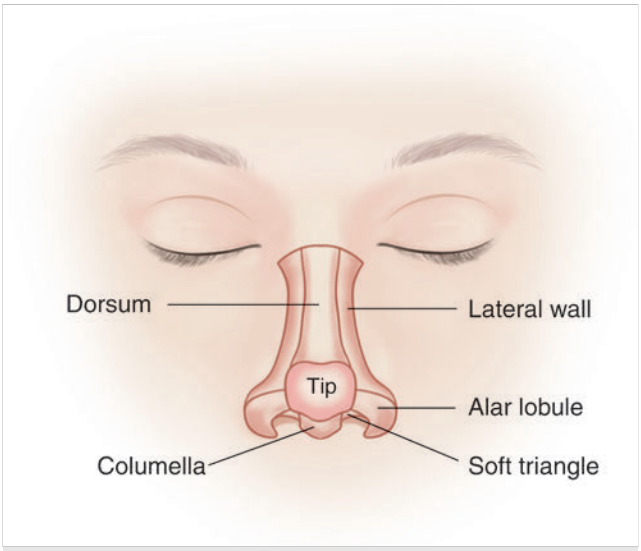

Fig. 7.2 Aesthetic subunits of the nose.

- Nasal subunits (▶ Fig. 7.2)
  - Nine nasal subunits
    - Three midline subunits (dorsum, tip, columella).
    - Three paired lateral subunits (sidewalls, alae, soft triangles).
  - Scars best placed at borders of subunits for optimal aesthetics.
  - **Subunit principle:** If a defect comprises > 50% of the tip or alar subunit, the residual normal skin should be discarded and the entire subunit resurfaced. This principle is somewhat debated.

7.3.3 Reconstructive options

- Healing via secondary intention
  - Small, superficial defects on *concave* or *planar* surfaces away from mobile landmarks (e.g., medial canthal area, sidewalls, alar groove).
  - Cover with moist dressing (e.g., petroleum jelly).
- Primary closure
  - Defects < 0.5 cm in upper 2/3 of the nose.
- Full-thickness skin graft
  - Small (< 1.5 cm) and superficial defects in upper 2/3 of nose.
  - Skin from above the clavicles provides best color match (e.g., forehead, preauricular, postauricular, supraclavicular).
- Composite chondrocutaneous graft
  - Small (< 1 cm), full-thickness alar rim and columella defects.
  - From auricular helix, rim, or ear lobe.
- Local flaps: Small (< 1.5 cm) superficial defects.
  - *Transposition (banner) flap:* Upper 2/3 of nose.
  - *Bilobed flap* (▶ Fig. 7.3): Lower 1/3 of nose.
  - *Dorsal nasal (miter) flap* (▶ Fig. 7.4): Dorsum and tip defects (< 2 cm).

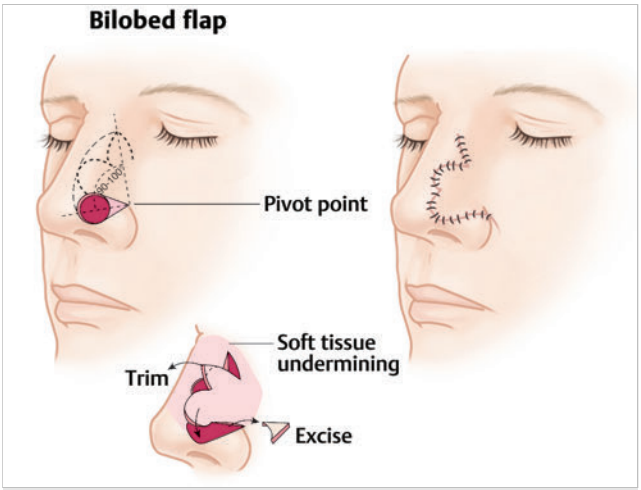

Fig. 7.3 Bilobed flap.

- Regional flaps
  - *Nasolabial flap*
    - Based on perforators from facial and angular arteries.
    - Single-stage, superiorly based flap: Superficial sidewall and alar defects.
    - Two-stage flap: Deep alar defect requiring placement of cartilage graft.
  - Forehead flap
    - Based on supratrochlear artery.
    - Two or three stages, depending on severity of defect.
    - Workhorse for large (> 1.5 cm) or deep defects (involving framework replacement).
- Full-thickness defects: Require replacement of *outer skin, framework, and lining.*
  - Framework donor sites: Nasal septal, conchal, and costal cartilage; cranial bone graft.
  - Nasal lining reconstructive options: Turnover hinge flap of adjacent skin, skin graft, rotation–advancement flaps from residual nasal lining, septal mucoperichondrial flaps, folded forehead flap, facial artery musculomucosal (FAMM) flap, free flap (radial forearm, anterolateral thigh [ALT], dorsalis pedis).

7.4 Complications

- Recurrent cancer: Re-excise.
- Wound dehiscence, partial flap necrosis: Local wound care.

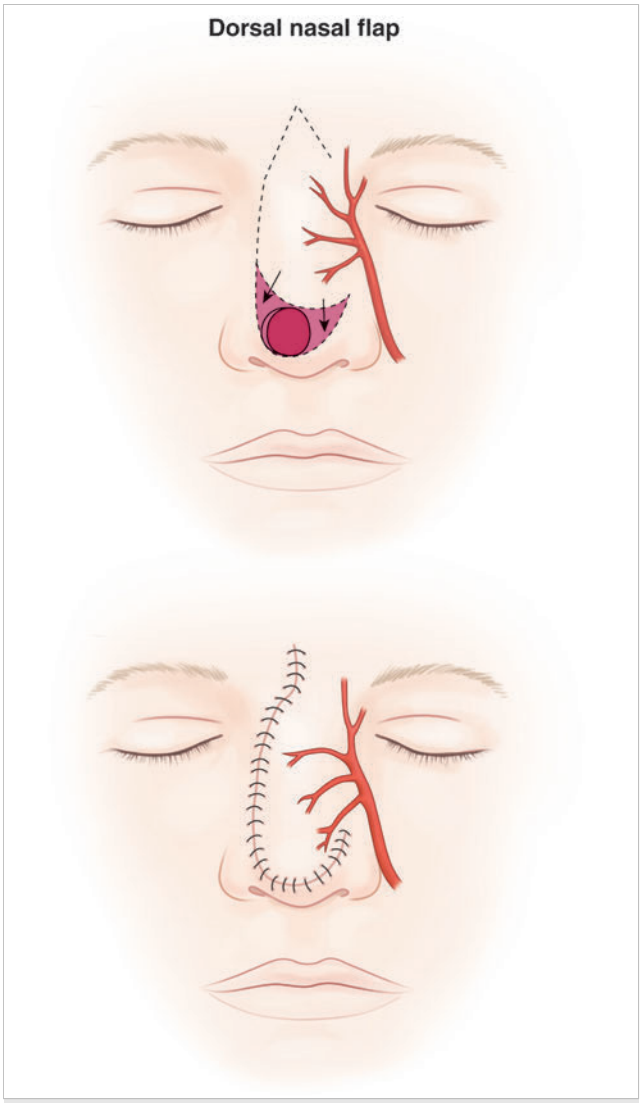

Fig. 7.4 Dorsal nasal flap.

7.5 Critical Errors

- Failure to biopsy suspicious skin lesion.
- Inadequate resection.
- Reconstruction before ensuring negative margins.
- Failure to describe the defect (nasal subunits).
- Failure to reconstruct all necessary layers of the nose (mucosa, cartilage framework, skin).

8 Eyelid (Cancer and Reconstruction)

Jason R. Dudas and Eva A. Hurst

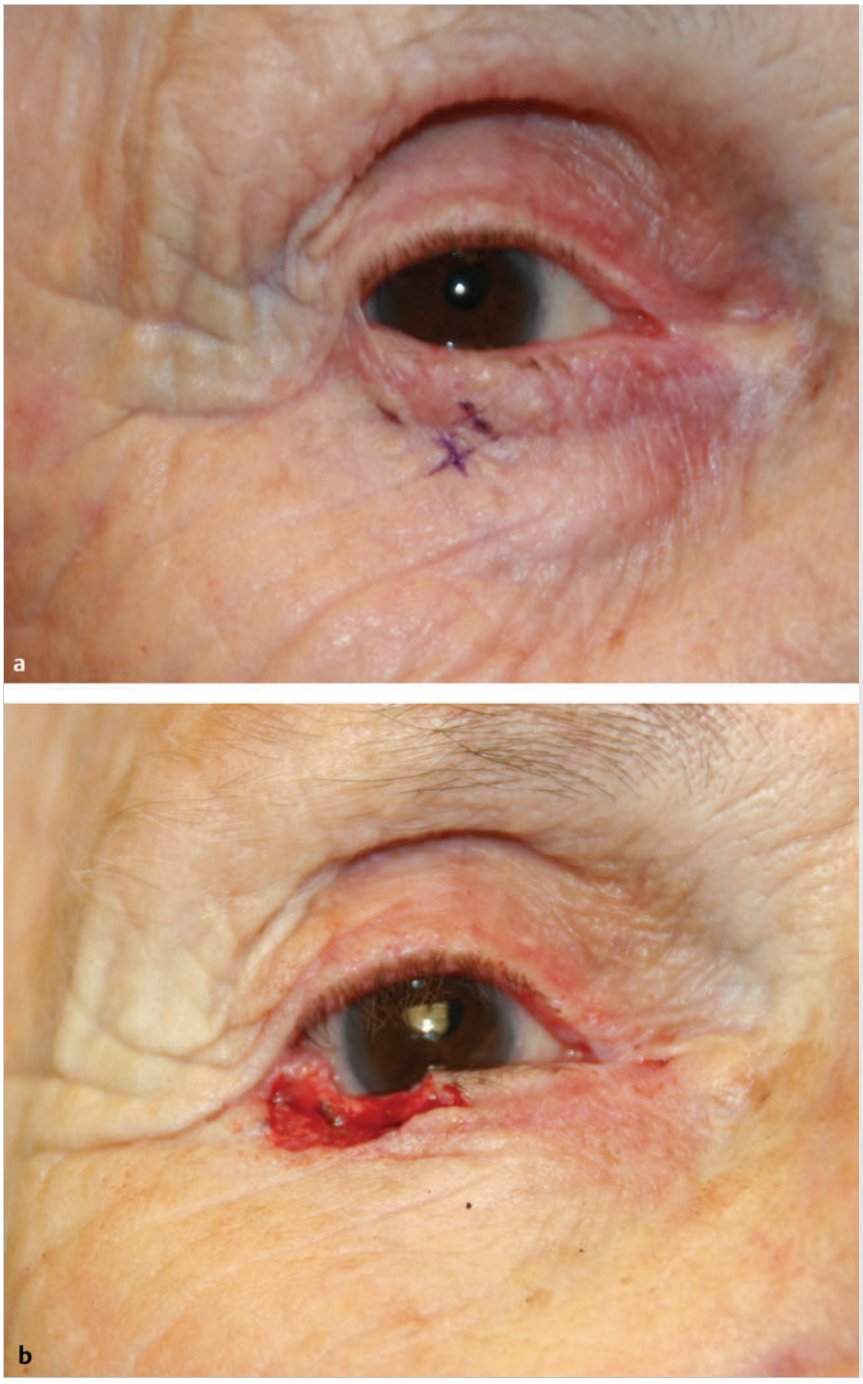

Fig. 8.1 An 87-year-old woman presents with basal cell carcinoma of the lower eyelid and resultant defect following excision.

8.1 Description

- Basal cell carcinoma of lower eyelid with *poorly defined margins* (e.g., good candidate for Mohs micrographic surgery).
- Full-thickness defect of lower eyelid
  - ~ 50%, including lid margin and entire height of tarsus.
- Contiguous skin and muscle defect extending to cheek–lid junction.
- Medial and lateral canthal tendons intact with no evidence of lacrimal system involvement.

8.2 Work-up

8.2.1 History

- History of ophthalmologic conditions, including dry eye and excessive tearing.
- Personal or family history of skin malignancy or significant sun exposure.
- History of previous periorbital surgery or trauma.

8.2.2 Physical examination

- Divide the periocular region into "zones" (▶ Fig. 8.2).
- Determine layers that have been lost.
  - Full or partial thickness.
  - Skin, muscle, tarsus, conjunctiva.
- Evaluate canthal support and suspected involvement of lacrimal system.
- Identify viable elements available for reconstruction (i.e., skin, muscle, tarsus, conjunctiva).
- Evaluate eyelid function.

8.2.3 Diagnostic studies

- *Establish the diagnosis:* If it was not done earlier, an incisional biopsy should be performed at initial visit to confirm the pathology.

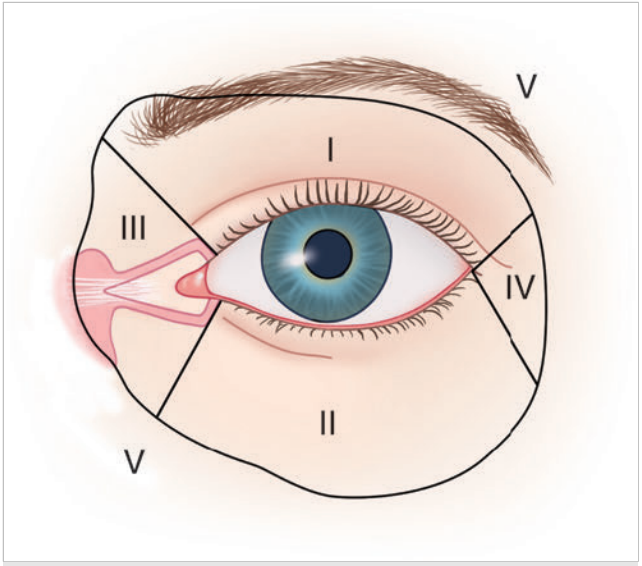

Fig. 8.2 Zones of the eyelid.

- Confirm negative pathologic margins following initial resection before attempting significant reconstruction.
- Magnetic resonance imaging: Useful adjunct in determining extent of tumor and lymph node status in cases of aggressive tumor histology (e.g., perineural invasion or deeply invasive tumors).

8.2.4 Consultations

- *Ophthalmology:* For visual acuity and field testing, Schirmer test.

8.3 Treatment (▶ Fig. 8.3)

8.3.1 Key points

- Need to reconstruct all missing layers.
  - *Anterior lamella:* Skin and orbicularis muscle (outer covering).
  - *Middle lamella:* Tarsus and septum (structural support).
  - *Posterior lamella:* Conjunctiva (inner lining).
- If full thickness (i.e., all three lamellae), must reconstruct at least one of these layers with a flap.
  - Cannot reconstruct full-thickness defects with grafts simultaneously. A flap is necessary to provide vascularity to the graft.

8.3.2 Zone I (upper lid)

- Partial thickness
  - < 50% of eyelid width: Primary closure with local tissue advancement.
  - > 50% of eyelid width: Full-thickness skin graft (FTSG) from contralateral upper eyelid.
- Full thickness
  - < 25%: Primary closure with possible canthotomy and/or cantholysis.
  - 25 to 50%: Tenzel semicircular rotational flap
  - 50 to 75%: Reconstructive options
    - Cutler Beard flap (with cartilage graft): Full thickness lower lid pedicled flap. Division performed at 6 to 8 weeks.
    - Composite graft (i.e., tarsoconjunctival graft from contralateral upper lid or nasal septal cartilage–mucosa) and local myocutaneous flap
  - > 75%
    - Lower lid transposition (Mustardé lid switch) flap.
    - May need cheek advancement to reconstruct donor site.
    - Forehead flap with mucosal graft

8.3.3 Zone II (lower lid)

- Partial thickness
  - < 50%: Primary closure with local tissue advancement.
  - > 50%: Reconstructive options
    - FTSG from contralateral upper eyelid.
    - Upper lid transposition (Fricke, Tripier) flap.

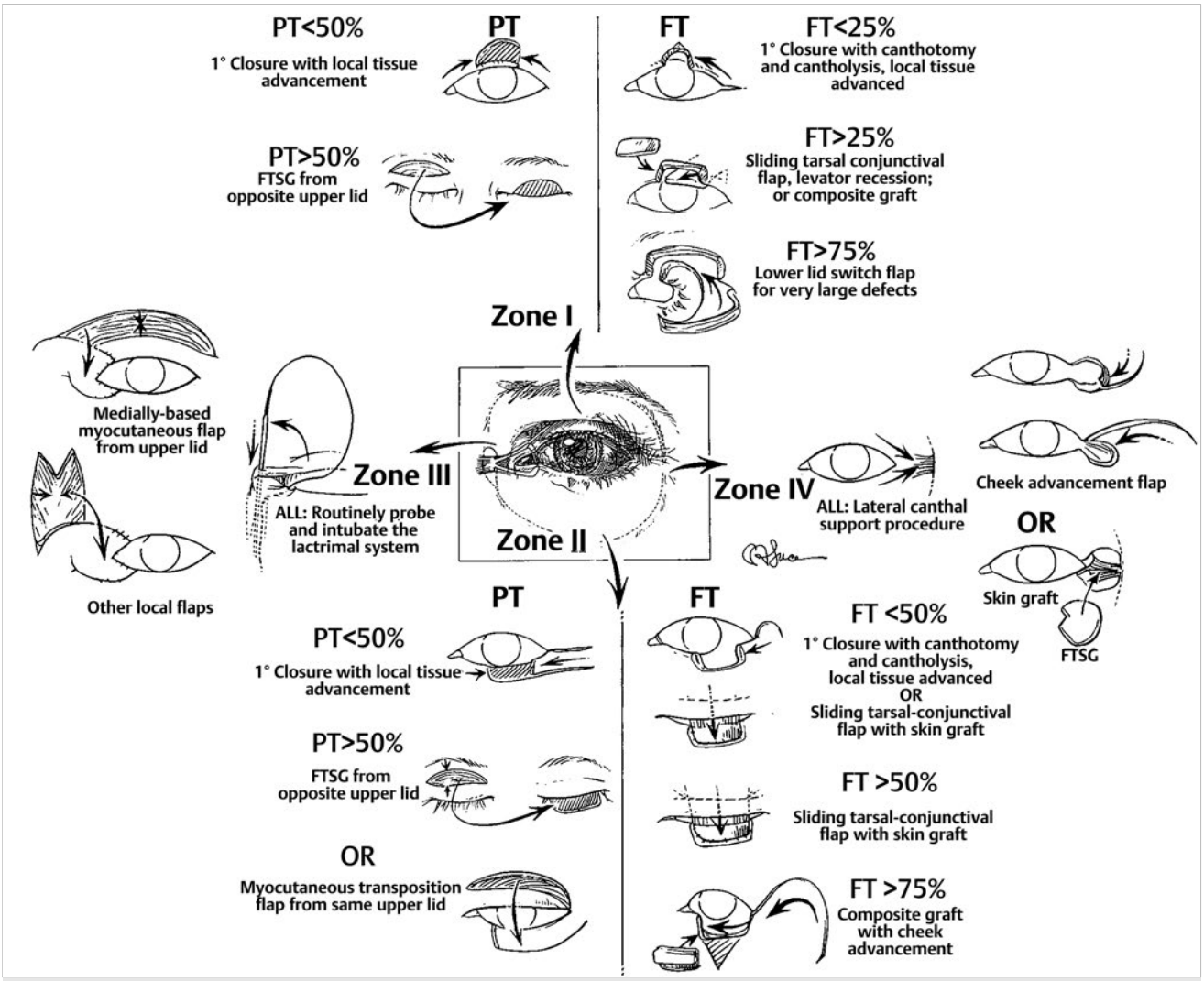

Fig. 8.3 A summary of guidelines for reconstruction of the periocular region. FT, full thickness; FTSG, full-thickness skin graft; PT, partial thickness. (Reproduced with permission from Spinelli H, Jelks GW. Periocular reconstruction: a systematic approach. Plast Reconstr Surg 1993;91(6):1017–1024.)

- Full thickness
  - < 25%: Primary closure with canthotomy and/or cantholysis.
  - 25 to 50%: Tenzel semicircular rotational flap
  - 50 to 75%: Tarsoconjunctival (Hughes) flap with FTSG.
  - > 75%: Cheek advancement flap with a graft (palatal mucosa, septal cartilage-mucosa).

8.3.4 Zone III (medial canthus)

- Intubate the lacrimal system.
- Local flaps from upper eyelid or glabella.
- Healing by secondary intention is acceptable (in areas of concavity).
- If detached, medial canthus should be reconstructed posterior and superior to its original location.

8.3.5 Zone IV (lateral canthus)

- Cheek advancement flap or FTSG.
- Lateral canthal supporting procedure: **Canthopexy** or **canthoplasty**.

8.3.6 Zone V (periorbital) or multiple-zone defect

- Corneal protection is priority.
- Immediate coverage with *myocutaneous flap* or FTSG.
- Definitive reconstruction may need to be staged.

8.4 Complications

- Ectropion
  - Avoid tension on closure.

- All flaps should be designed with tension oriented horizontally. Vertical tension will pull the eyelid down, increasing the risk for ectropion.
- Perform *lateral canthal support* procedure.

- Corneal abrasion
  - Avoid contact of suture material with cornea: Resorbable sutures only with buried knots.
  - Avoid contact of *keratinized epithelium* with cornea.
- Suboptimal aesthetic outcome
  - Avoid vertical incisions: Can lead to notching.
  - Accurate reapproximation of eyelid layers.
  - Preserve medial continuity of lash line if possible.

8.5 Critical Errors

- Failure to identify extent of defect (i.e., anterior and/or posterior lamella).
- Failure to confirm negative margins before reconstruction.
- Failure to reconstruct all lamellae appropriately
  - Example: Using graft on graft (FTSG + chondromucosal composite graft).
- Failure to recognize concomitant injury, such as lacrimal system or canthal involvement.

9 Ear (Cancer and Reconstruction)

Tracy S. Kadkhodayan & Terence M. Myckatyn

Fig. 9.1 A 50-year-old man presents with a right ear defect following Mohs resection of basal cell carcinoma.

9.1 Description

- Full-thickness skin defect extending down to cartilage over antihelix.
- Exposed cartilage with partial loss of perichondrium.

9.2 Work-up

9.2.1 History

- History of sun exposure.
- Personal or family history of skin cancer.
- Genetic conditions: Xeroderma pigmentosum, Gorlin (nevoid basal cell) syndrome, albinism.

9.2.2 Physical examination

- Full-body integument examination.
- Lymph node examination.

9.2.3 Diagnostic studies

- If patient presents initially without resection, a biopsy should be performed at the time of evaluation to **establish a diagnosis**.
  - Full-thickness *incisional* versus *excisional* biopsies may be performed. Avoid shave biopsies.

9.3 Treatment

- If resection has not yet been done, consider Mohs surgery, if available
  - Allows examination of ~ 100% of surgical margins. Highest cure rates.
  - Board examiner may require that you excise this yourself.

9.3.1 Excision (see ▶ Table 6.1)

9.3.2 Reconstruction

- Should be delayed until negative margins are confirmed on final pathology.
- Local wound care or temporizing skin graft in interim.
  - Fresh frozen pathologic evaluation cannot ensure negative margins.

9.3.3 Treatment by size

- Small defects (< 1/4 of ear)
  - Primary closure ± Tanzer excision patterns.
  - Wedge resection (defect < 1.5 cm).
  - Healing by *secondary intention* or *skin graft* (if intact cartilage and perichondrium).
- Medium defects (1/4 to 1/2 of ear)
  - Local flaps and grafts.
  - Contralateral chondrocutaneous composite graft.
- Large defects (> 1/2 of ear)
  - Total ear reconstruction (see Case 14: Microtia).
  - *Complete avulsion:* Replantation if superficial temporal artery or posterior auricular artery available.

9.3.4 Treatment by location

- Upper 1/3
  - Skin graft: Preferably contralateral postauricular full-thickness skin graft; poor results for helical rim defects.
  - For helical rim defects < 2 cm
    - **Antia-Buch** (▶ Fig. 9.2): Chondrocutaneous helical rim advancement flaps based on posterior blood supply.
  - For large helical rim defects (> 2 cm)
    - Two-stage procedure: (1) initial coverage of ear with postauricular skin; (2) subsequent release and skin grafting of residual defect.
    - Tubed pedicle flap from postauricular skin: Two stages.
    - Converse tunnel technique or tubed pedicle flaps.
  - **Banner flap:** Skin flap based on anterosuperior auriculocephalic sulcus
    - Combine with contralateral auricular cartilage graft for larger defects (> 2 cm).
  - Chondrocutaneous transposition flaps: Often require grafting of donor site
    - Orticochea procedure: Based laterally on helix.
    - Davis flap: Based anteriorly on crus helicis, from conchal bowl.
  - Costal cartilaginous framework and temporoparietal fascial flap for large defects.
- Middle 1/3
  - Helical rim defect: Chondrocutaneous advancement flaps.
  - Mastoid (postauricular attachment) flap: Skin flap only.
    - Often requires second stage (3 to 4 weeks) for division and/or split-thickness skin graft to donor site.
    - May combine with contralateral auricular cartilage graft (i.e., Dieffenbach flap).

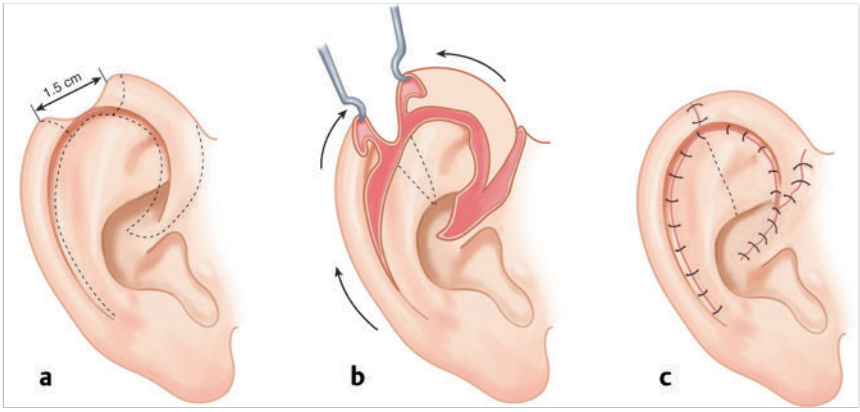

Fig. 9.2 (a-c) Antia-Buch helical rim advancement

  - Converse flap: Contralateral auricular cartilage graft tunneled under skin flap from mastoid, requires second stage (3 weeks) for division and inset.
- Lower 1/3
  - Lobule reconstruction difficult because of lack of structural support.
  - Superiorly based flaps with cartilage graft.
  - Contralateral composite lobule grafts.
  - Postauricular chondrocutaneous flaps.
- External auditory canal
  - Maintenance of patency more important than coverage.
  - Requires use of stent or splint for 6 months.

9.4 Complications

- Recurrent cancer: Re-excise.
- Wound dehiscence, partial flap necrosis: Local wound care.
- Infection/chondritis
  - Antibiotics: Topical mafenide and oral fluorquinolones have excellent cartilage penetration.
  - Débridement if appropriate.
- Hematoma: Prompt incision, drainage, and bolster application.
- Scar contracture leading to blockage of external auditory canal.
- Cartilaginous deformities.

9.5 Critical Errors

- Failure to perform appropriate biopsy when concern for melanoma.
- Inadequate resection.
- Reconstruction before ensuring negative margins.
- Inadequate infection prophylaxis: Topical mafenide (Sulfamylon; Mylan Pharmaceuticals, Canonsburg, PA; topical) and fluoroquinolones (systemic) have excellent cartilaginous penetration.
- Inadequate dressing: Bolster, suction drain to prevent hematoma.
- Failure to stent the external auditory canal.

10 Cheek (Cancer and Reconstruction)

Santosh Kale, Albert S. Woo & Terence M. Myckatyn

Fig. 10.1 (a,b) A 56-year-old man presents after Mohs resection of squamous cell carcinoma of the right cheek.

10.1 Description

- Ulcerated lesion over the right cheek malar eminence abutting the lower eyelid–cheek junction.
- Following resection, full-thickness defect of the inferior lid–cheek junction that involves
  - Lower eyelid: Preseptal orbicularis muscle and orbital septum.
  - Suborbital cheek: Skin, fat, SMAS (superficial musculo-aponeurotic system).
- Moderate skin laxity on examination.

10.2 Work-up

10.2.1 History

- Malignancy: Timeline of presentation.
- History of sun and environmental exposure.
- Personal and family history of skin cancer.
- Genetic conditions: Xeroderma pigmentosum, Gorlin (nevoid basal cell) syndrome, albinism.
- Complicating comorbidities
  - Cardiopulmonary/peripheral vascular disease, diabetes, obesity, tobacco use, prior irradiation, previous surgery, anticoagulation.

10.2.2 Physical examination

- Full-body integument examination.
- Lymph node examination to rule out concern for metastatic disease.
- Wound characteristics (hair-bearing areas, adjacent skin laxity).
- Subunit involvement (▶ Fig. 10.2)
- Reconstruction based on correction of facial subunits.
- Cheek may be considered one large subunit or it may be divided into zones.

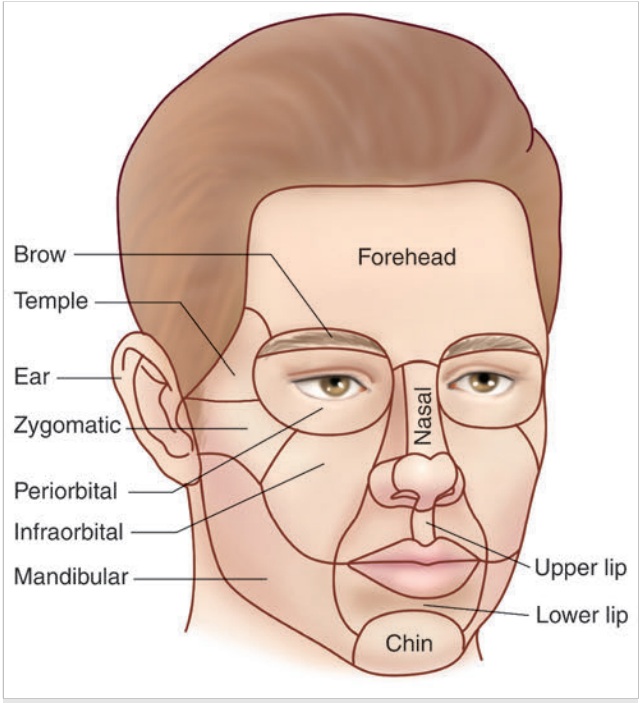

Fig. 10.2 Facial subunits may be utilized to guide reconstruction.

10.2.3 Diagnostic studies

- Full-thickness *incisional* versus *excisional* biopsy may be performed. Avoid shave biopsies.
- Biopsy any other suspicious skin lesions (if previously not performed)

10.3 Treatment

- Reconstruction should be delayed until *negative margins are confirmed* on final pathology.
  - Local wound care or temporizing skin graft in interim.
  - Fresh frozen pathologic evaluation cannot ensure negative margins.

10.3.1 Excision (see ▶ Table 6.1)

10.3.2 Reconstruction

- Must consider eyelid support when operating along the eyelid–cheek junction
  - Consider canthoplasty/canthopexy for additional support of lax eyelid.
- **Primary closure:** When adequate skin laxity is present.
- **Skin grafts:** Less ideal color match
  - When patient is a poor flap candidate because of comorbidities.
  - High risk for recurrence or temporary coverage before definitive reconstruction.
- Transposition flaps (banner, rhomboid): Useful for smaller defects of the face.
- Mustardé cheek rotation flap (▶ Fig. 10.3)

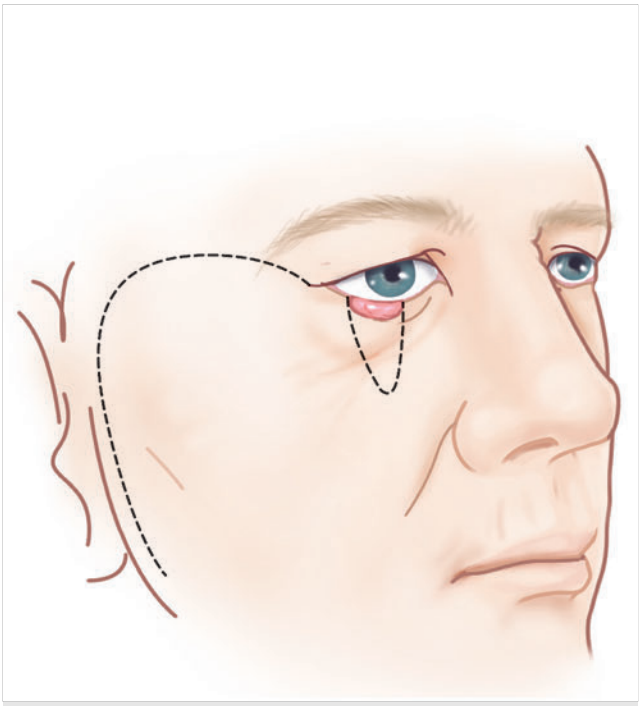

Fig. 10.3 Mustardé cheek rotation flap for reconstruction of defects involving the lower eyelid.

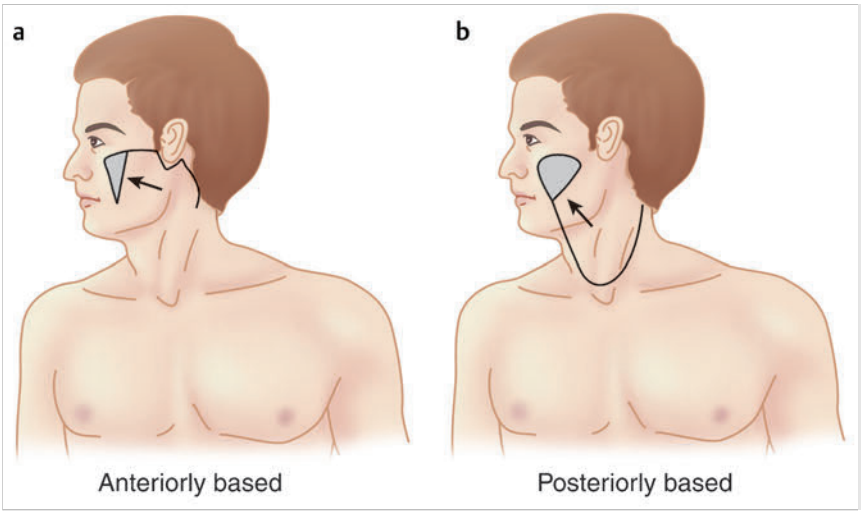

Fig. 10.4 Design for cervicofacial flap. (a) Anteriorly based. (b) Posteriorly based

- Wide-based cheek rotation flap useful for defects of the lower eyelid or infraorbital region.
- Allows tissue to be advanced superiorly to minimize retraction of the lower eyelid.
- Extends along lid margin transversely to the preauricular region.
- Burow triangle removed in the lateral cervical region.
- May be elevated in subcutaneous plane or deep to SMAS (to increase blood supply).

- Flap should be anchored to zygoma or inferolateral orbital rim periosteum to prevent ectropion.
- Cervicofacial advancement flap (▶ Fig. 10.4)
  - Anteriorly or posteriorly based flap that advances/rotates facial skin to fill defect.
  - Similar in concept to Mustardé flap, but without involvement of lower eyelid.
  - Designed below eyelid transversely to ear, extends inferiorly around earlobe
    - Dissected above SMAS, releases zygomatic retaining ligaments.
- Flap should be anchored to zygoma or inferolateral orbital rim periosteum to prevent ectropion.
- Cervicopectoral flap (▶ Fig. 10.5)
  - Design similar to that of cervicofacial flap but dissection extends postauricularly and down in front of hairline across neck to allow additional movement.
  - Cervicofacial flap may be extended to cervicopectoral flap if inadequate release of the tissues is achieved with initial procedure.
  - Dissected deep to platysma, can incorporate pectoral and deltoid fascia.
- Regional flaps
  - Useful for large defects.
  - Deltopectoral, cervicohumeral, pectoralis major, trapezius, latissimus flaps.
  - Less ideal skin and color match than local flaps using like skin.
- Tissue expansion
  - May be performed when few reconstructive options exist and reconstruction can be delayed.

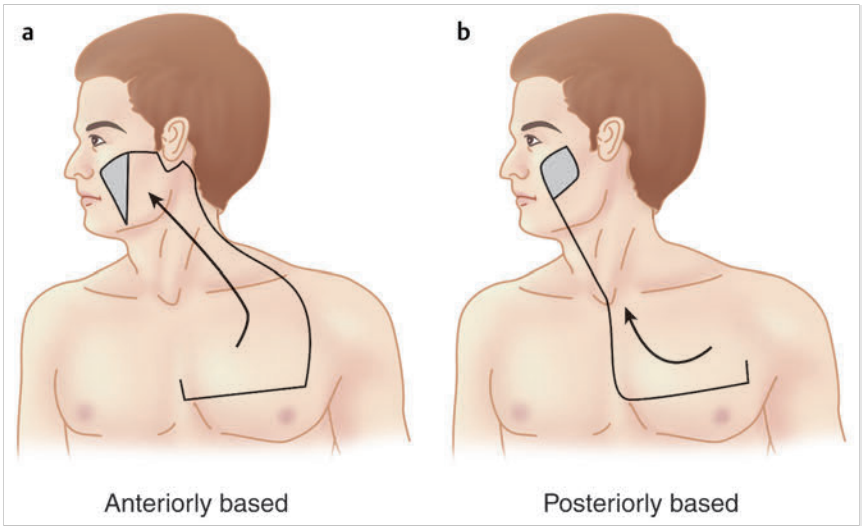

Fig. 10.5 Design for cervicopectoral flap. (a) Anteriorly based. (b) Posteriorly based

- Microvascular reconstruction
  - May be performed when locoregional options are absent or inadequate for reconstruction.
  - Helpful for reconstruction of large oral mucosa defects or when composite tissue reconstruction (mucosa, bone, skin) is necessary.
  - Disadvantage: poor color and texture match.

10.4 Complications

- Ectropion: Frequently results from excessive downward pull of lower eyelid.
- Partial flap loss: Frequently may be managed with local wound care.
- Contour abnormalities and unsightly incisions/color match.
- Alteration of hair-bearing region with advancement of hair-bearing areas into previously hairless areas.
- Hematoma: Large flaps should have drains placed at initial procedure.

10.5 Critical Errors

- Failure to obtain negative margins on pathology before reconstruction.
- Poor flap design that is inadequate to reconstruct a sizable facial defect.
- Failure to consider the importance of the lower eyelid, resulting in ectropion
  - Inadequate support of the eyelid (canthoplasty/canthopexy).
  - Failure to suspend flap to periosteum of zygoma or inferolateral orbital rim periosteum.
  - Poor design of flap with downward vector along lower eyelid, leading to high risk for ectropion.

Part 3

Section III. Face Congenital

11 Unilateral Cleft Lip

Albert S. Woo

Fig. 11.1 Full-term newborn male presents to the clinic with the displayed congenital anomaly.

11.1 Description

- Complete unilateral cleft lip deformity
  - Cleft nasal deformity: Nostril is widened and slumped (alar cartilage is inferiorly, posteriorly, and laterally displaced), but not hypoplastic. The nasal tip is bulbous and shifted toward the cleft.
  - Septal deformity: The septum is shifted *away* from the cleft.
- Alveolar cleft.
- Complete unilateral cleft palate.

11.2 Work-up

11.2.1 History

- Family history of orofacial clefting.
- Feeding difficulties, appropriate weight gain.
- Additional medical problems and associated syndromes.

11.2.2 Physical examination

- Evaluate involved structures (lip, alveolus, palate, unilateral, bilateral).
- Evaluate for associated birth anomalies consistent with a syndromic presentation.

11.2.3 Diagnostic studies

- Only if concern for other systemic illness or syndrome

11.2.4 Consultations

- Best managed by a **multidisciplinary team**: Plastic surgery, pediatric otolaryngology, speech pathology, child psychology, audiology, genetics, pediatric dentistry, orthodontics, maxillofacial surgery, social work, and nursing.
- Genetic evaluation if any concern exists.

11.3 Treatment

- Management via a multidisciplinary team.

11.3.1 Schedule of treatment

- Multiple procedures anticipated (see ▶ Table 11.1 for cleft management timeline).

Table 11.1 Timeline for the management of a child with cleft lip and palate deformity

Age	Treatment
Newborn	Feeding assessment, initial clinical evaluation, possible genetics referral
0–3 mo	Molding therapy, possible cleft lip adhesion
3 mo (or after molding)	Definitive cleft lip repair
1 y	Cleft palate repair
3–4 y	Assessment of velopharyngeal competence
7–10 y	Alveolar bone grafting following presurgical orthodontics (during period of mixed dentition)
Skeletal maturity	Septorhinoplasty, final revisions as necessary; orthognathic surgery if evidence of midfacial growth disturbance

- Feeding: critical aspect of cleft care.
  - Specialized nipples/bottles: Haberman feeder (with a squeezable tip), or Pigeon nipple (with cross-cut opening for faster flow), or Dr. Brown's Level 2 nipple with Pigeon valve.
- Molding: Narrows cleft and aligns alveolar arch to optimize repair.
  - Not employing any molding technique is also a reasonable option.
  - Lip taping: With Steri-Strips or commercially available devices (e.g., DynaCleft; Canica Design, Almonte, Ontario, Canada).
  - **Nasoalveolar molding (NAM)**
    - Passive molding appliance rapidly becoming the gold standard for optimizing nasal shape.
    - Alveolar molding alone takes place until alveolar ridges are 5 mm apart, then nasal prongs are attached to improve the shape of the nose.
  - Latham appliance
    - Active molding appliance expands palate and retracts premaxilla.
    - Less commonly used because of concerns regarding maxillary growth.
- Lip adhesion (not mandatory)
  - Performed surgically, in place of molding techniques.
  - Preliminary repair of skin ± muscle between 6 weeks and 3 months of age.
  - Goal: Minimize tension during the definitive cleft repair performed around 3 to 6 months of age.
- Cleft lip repair: At approximately 3 months of age
  - *Rule of 10s:* 10 lb of weight, 10 g of hemoglobin, 10 weeks of age.
  - May be delayed secondary to molding (NAM) or earlier lip adhesion.
- Cleft palate repair: At approximately 1 year of age
  - Earlier repairs favor speech but potentially compromise maxillary growth and vice versa.
- Alveolar bone grafting
  - Performed during period of mixed dentition (roughly 7 to 10 years of age) after appropriate orthodontics.
- Cleft nasal/septal reconstruction
  - Optimally performed once the patient has reached skeletal maturity. Can be combined with "touch-up" procedures to optimize appearance.
  - Septoplasty is frequently deferred until this time.

11.3.2 Cleft lip repair technique

- Millard rotation–advancement repair
  - Most commonly recognized repair technique (▶ Fig. 11.2).
  - The short medial lip element is *rotated*, and the lateral lip is *advanced* into the defect.
  - Regardless of the technique you are most familiar with, you should plan to discuss the Millard technique unless you are prepared for extensive questioning on a procedure that the examiner may not be familiar with or may be unwilling to accept.
  - Other valid techniques include the Mohler modification, Noordhoff technique. Older procedures, such as the Randall-Tennison Z-plasty, are no longer widely accepted.
- Primary cleft nasal reconstruction: Performed at the time of primary lip repair, now widely accepted but not mandatorily performed.

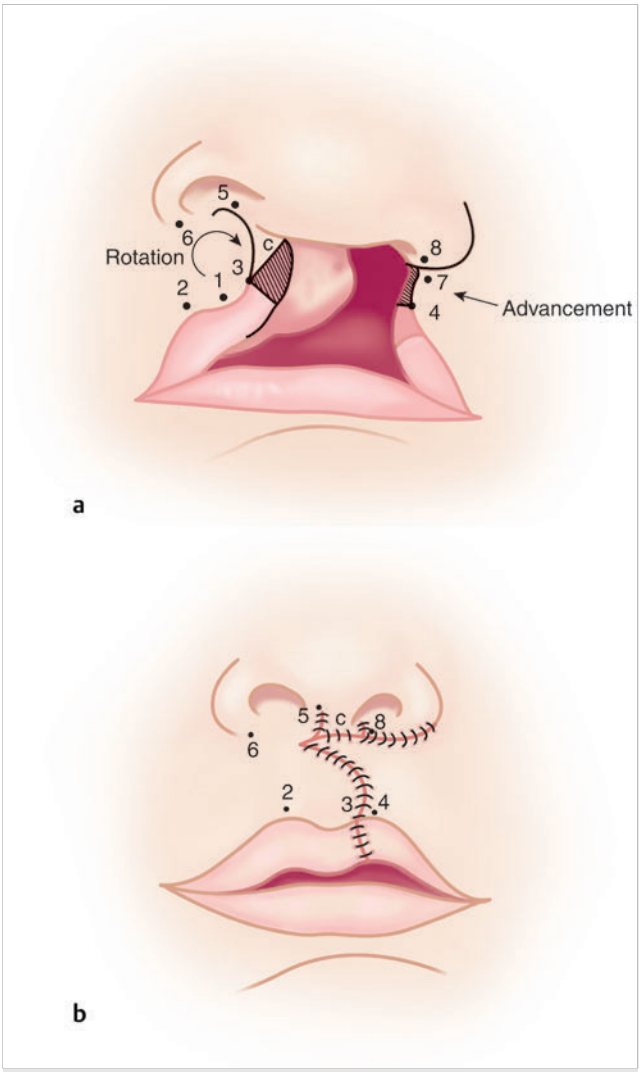

Fig. 11.2 (a,b) Millard rotation–advancement flap for correction of unilateral cleft lip deformity.

- Surgical markings
  - Essential component of examination. You MUST know how to mark a cleft lip.
  - Critical points (▶ Fig. 11.3)
    1. Center of *Cupid's bow.*
    2. *Peak of Cupid's bow* on noncleft side.
    3. Measure from point 1 to point 2 and mark point on opposite side.
    4. Edge of *white roll* on lateral lip element.
  - Critical flaps
    - **Rotation flap:** From point 3 in an arc up to base of columella and potential back-cut past midline to get appropriate rotation.

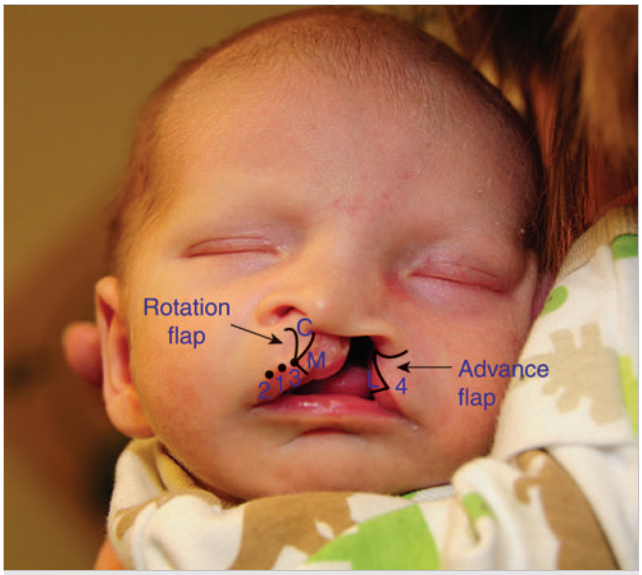

Fig. 11.3 Definitive markings on patient case study. Standard markings for Millard rotation–advancement.

    - **Advancement flap:** From point 4, skirting along lateral cleft margin to nostril, then extending laterally to base of ala.
    - **C flap:** Used to reconstruct base of columella on cleft side.
    - **L flap:** Can be used to reconstruct nostril floor or advance lateral nasal wall.
    - **M flap:** Can add more mucosa for intraoral lining.

11.4 Complications

- Cleft lip dehiscence.
- Infection.

11.5 Critical Errors

- Inability to draw a cleft lip repair and to identify where each point goes with closure.
- Unfamiliarity with timing of repair.
- Discussing techniques other than Millard rotation–advancement repair without appropriate knowledge and familiarity.
- Advocating controversial procedures, such as gingivoperiosteoplasty, primary septal reconstruction, or other nonstandard procedures, may negatively impact examination.
- Discussing optional therapies without appropriate knowledge (i.e., Latham appliance). If you mention it, be prepared to elaborate upon it.

12 Bilateral Cleft Lip

Farooq Shahzad & Albert S. Woo

Fig. 12.1 (a,b) You are asked to see a 7-day-old infant boy born with a cleft lip.

12.1 Description

- Complete bilateral cleft lip deformity
  - Notable projection of the premaxilla with good symmetry.
  - Cleft nasal deformity: Widened nostrils bilaterally with short columella.
- Bilateral alveolar cleft deformity with pronounced gap between segments.
- Likely complete bilateral cleft palate (not completely visualized).

12.2 Work-up

12.2.1 History

- Family history of orofacial clefting.
- Feeding difficulties, appropriate weight gain.
- Additional medical problems and associated syndromes.

12.2.2 Physical examination

- The examination should focus on four features: Nose, lip, alveolus, and palate.
  - Cleft lip and palate classification
    - Unilateral versus bilateral.
    - Complete (involvement of nasal floor) versus incomplete.
    - Isolated cleft lip (primary palate) versus cleft lip and palate (primary and secondary palate).
- Additional facial dysmorphic features.
- Complete physical examination to look for any other anatomical abnormality
  - Consider possibility of syndromic presentation.

12.2.3 Pertinent imaging or diagnostic studies

- Guided by physical findings (e.g., echocardiogram, renal ultrasound, skeletal X-rays).

12.2.4 Consultations

- Children with clefts are ideally cared for by a **multidisciplinary team**: Plastic surgery, otolaryngology, speech pathology, audiology, child/developmental psychology, nursing, pediatric dentistry, orthodontics, and oral and maxillofacial surgery.

12.3 Treatment

- Management via a multidisciplinary team.

12.3.1 Schedule of treatment (see ▶ Table 11.1 for cleft management timeline)

- Feeding: critical aspect of cleft care
  - Specialized nipples/bottles: Haberman feeder (with a squeezable tip) or Pigeon nipple (with cross-cut opening for faster flow)
  - Monitor weight: After the first 2 weeks of life, the child should gain half a pound every week.
- Presurgical molding: Narrows cleft and improves symmetry
  - Lip taping: Started soon after birth.
  - **Nasoalveolar molding (NAM):** Facilitates lip repair by bringing lip elements together and improving position of lower lateral nasal cartilages. It also aligns the alveolar segments. This is rapidly becoming the gold standard for preoperative molding before surgical intervention.
  - **Latham appliance** (active molding appliance): Expands palate, retracts premaxilla. Less commonly used because of concerns regarding maxillary growth.
  - **Surgical lip adhesion**: Can be used in wide clefts by suturing the skin and mucosa ± muscle of the lip elements. Performed at 6 weeks to 3 months of age. Goal: Decrease tension at subsequent definitive lip repair.
- Surgery
  - Timing: Lip repair is typically performed around 3 months of age.
    - May be delayed because of health concerns or additional time needed for molding.

12.3.2 Cleft lip repair technique

- Various techniques have been described: McComb, Trott, Cutting, Millard, Fisher, and Mulliken methods (▶ Fig. 12.2). Because of only minor variations between procedures, any reasonable technique may be used as long as key principles are followed.
  - Orbicularis reconstruction (▶ Fig. 12.3): Current methods bring in muscle from the lateral lip to the midline to reconstruct the orbicularis sling.
  - Philtral preservation: The prolabial skin is preserved to create the philtrum. However, the prolabial vermillion (central red lip) is discarded, and vermilion from the lateral lip is brought to the midline.

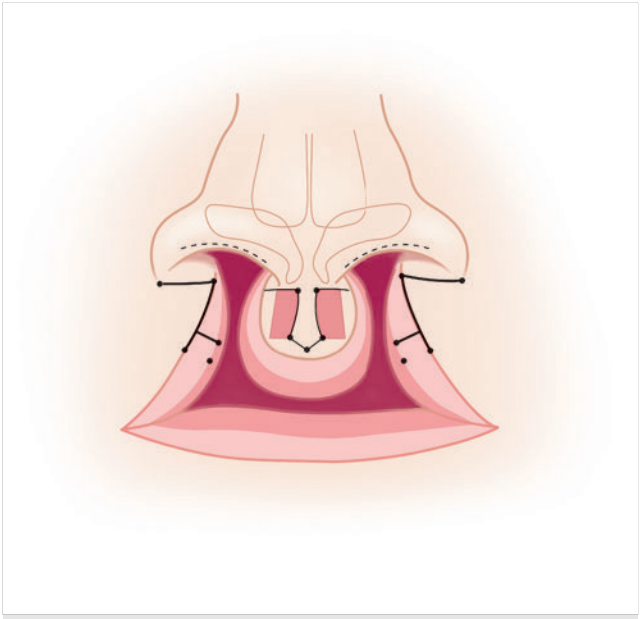

Fig. 12.2 Standard markings for bilateral lip repair

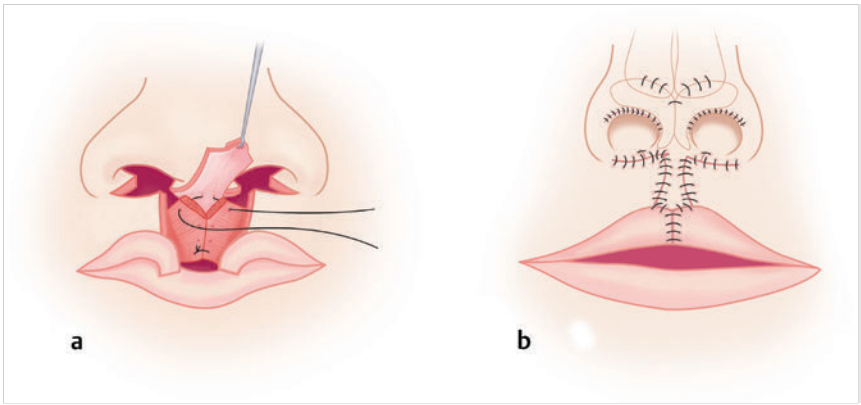

Fig. 12.3 Bilateral cleft lip repair advocated by Mulliken. (**a**) Orbicularis muscle and vermilion from lateral lip elements are brought to the midline. The skin of the prolabium is preserved to create the philtrum. (**b**) Result following repair of the cleft lip. Note that Mulliken advocates external rim incisions for primary cleft nasal repair.

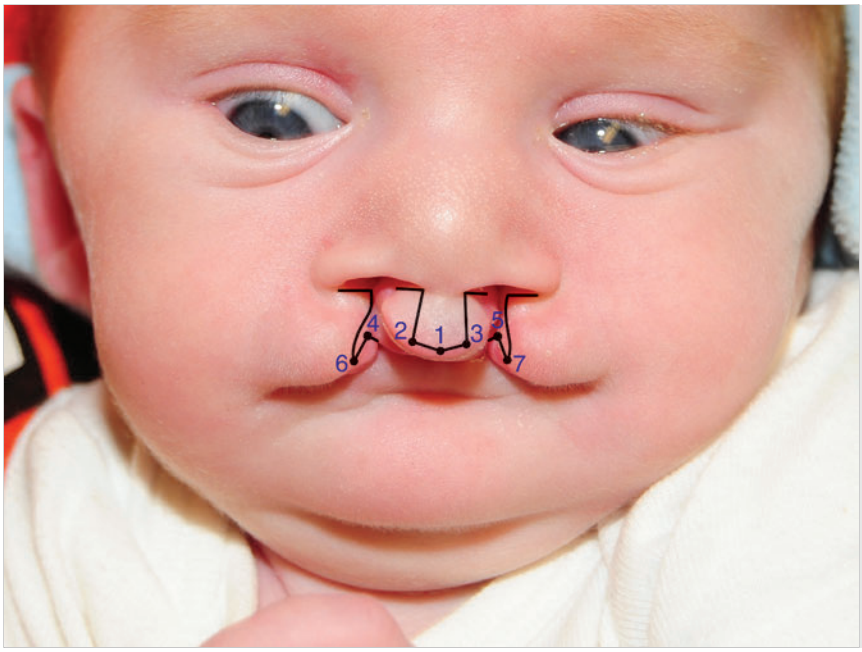

Fig. 12.4 Author's suggested markings (modeled after the Cutting technique).

- Markings (▶ Fig. 12.4)
  - *Philtral flap:* The bottom of the philtral flaps (points 1, 2, and 3) are marked 2 to 2.5 mm apart. The flap narrows slightly as it extends up to the columella, with its length typically 6 to 8 mm.
  - *White roll and vermilion:* The white roll is marked (points 4 and 5) on the lateral lip element where it begins to diminish medially. Another point (6 and 7) is marked lateral to each of these points at a distance equal to the distance from point 1 to point 2 (~ 2 to 2.5 mm wide). Mark the vermilion perpendicular to points 4 and 5. Draw a line from points 6 and 7, above the white roll, up to the nasal sill and then transversely under the ala.
  - Nasal reconstruction: *This is an optional procedure and is NOT performed by all cleft surgeons.* Exposure is obtained via a separate rim incision (Mulliken method), extension of philtral flaps to rim incisions (Trott method), or extension of philtral flaps to incisions in the membranous septum (Cutting method). The lower lateral nasal cartilages are dissected in the supraperichondrial plane, and interdomal sutures are placed to approximate the nasal tip.

12.4 Complications

- Bleeding.
- Infection.
- Dehiscence.
- Prolabial ischemia: Remove nasal stent or any other compressive structures, if placed.

12.5 Critical Errors

- Failure to monitor feeding/weight gain.
- Inability to draw a cleft lip repair and to identify where each point goes with closure.
- Unfamiliarity of timing of repair.
- Failure to evaluate for other congenital anomalies.
- Advocating controversial procedures, such as gingivoperiosteoplasty, primary septal reconstruction, or other nonstandard procedures, may negatively impact examination.
- Discussing optional therapies without appropriate knowledge (i.e., Latham appliance). If you mention it, be prepared to elaborate upon it.

13 Cleft Palate

Farooq Shahzad & Albert S. Woo

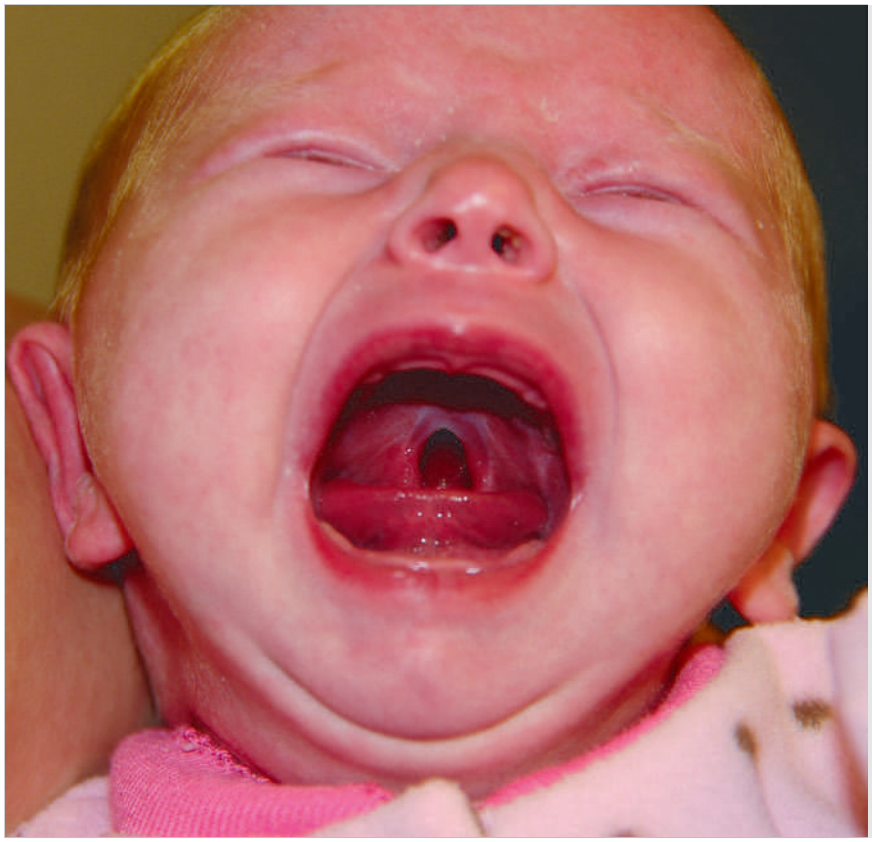

Fig. 13.1 You are asked to evaluate this newborn girl with a cleft of the palate.

13.1 Description

- Incomplete cleft of the *secondary* palate extending to the hard and soft palate junction.
- The *primary* palate is not affected (anterior to the incisive foramen).

13.2 Work-up

13.2.1 History

- Airway concerns (especially with small jaw - Pierre Robin sequence).
- Feeding concerns, appropriate weight gain
  - Infants with cleft palate are not able to breastfeed because of their inability to create appropriate suction.
- Exposures during pregnancy (alcohol, anticonvulsants, corticosteroids).
- Family history of orofacial clefting or craniofacial syndromes.
- Additional medical problems
  - Children with isolated cleft palate have a 40% incidence of *syndromic* presentation.

13.2.2 Physical examination

- Evaluate for facial dysmorphic features.
- Classify the extent of cleft and involved structures.
  - Primary and/or secondary palate (dividing point is incisive foramen).
  - Complete or incomplete.
  - Unilateral or bilateral (vomer visible on one or both sides): May not always be classified if hard palate is not affected.
- Evaluate for **Pierre Robin sequence** (micrognathia or retrognathia, glossoptosis, and airway difficulties).
- Head-to-toe examination for any other anatomical abnormality or evidence of syndromic presentation
  - **Van der Woude** syndrome (autosomal dominant): cleft lip and/or palate with lower lip pits.
  - Isolated cleft palate more likely to have associated anomalies than cleft lip and palate.

13.2.3 Pertinent imaging or diagnostic studies

- Evaluate other organ systems (e.g., echocardiography, renal ultrasound, X-rays of the spine) if suspicion for other congenital anomalies or a syndrome.
- Genetic testing if a syndrome is suspected. Chromosomal microarray analysis is frequently used.

13.2.4 Consultations

- **Multidisciplinary team:** Plastic surgery, pediatric otolaryngology, speech pathology, child psychology, audiology, genetics, pediatric dentistry, orthodontics, oral–maxillofacial surgery, social work, and nursing.
- If Pierre Robin sequence, a pediatric otolaryngologist should be involved for airway management.
  - The infant needs to be closely followed for *sleep apnea* with continuous pulse oximetry and evaluation of *desaturation during feeding.* Laryngoscopy and bronchoscopy may be needed for airway evaluation if obstruction is severe and surgical intervention is considered.
- Genetics evaluation, particularly if associated anomalies are present.

13.3 Treatment

- Management via multidisciplinary team.
- Feeding: Infants with cleft palate are at higher risk of being underweight.
  - Inability to create an effective suction force because of palatal cleft. As a result, the infant tires before feeding until satiated.
  - Elevate head and cradle infant at 45 degrees.
  - Specialized nipples/bottles: Haberman feeder (with a squeezable tip), Pigeon nipple (with cross-cut opening for faster flow), or Dr. Brown's level 2 nipple with Pigeon valve.
  - Monitor weight closely.
- Pierre Robin sequence: Infants require close airway monitoring (neonatal intensive care unit, continuous pulse oximetry). Most babies respond to side or **prone positioning**. Other strategies are nasopharyngeal airway, nasal continuous positive airway pressure, tongue lip adhesion, mandibular distraction, and tracheostomy.
- Surgical repair: Typically at around 1 year of age (see ▶ Table 11.1). Earlier repair puts child at increased risk for maxillary growth abnormalities; later repair delays language development.
  - Hard palate repair
    - **Two-flap palatoplasty (Bardach):** Most commonly used technique, in which mucoperiosteal flaps are elevated based on greater palatine vessels (▶ Fig. 13.2).
    - **Von Langenbeck palatoplasty:** Lateral relaxing incisions, usually when primary (anterior) palate not involved.
    - **V-Y push back palatoplasty (Veau-Wardill-Kilner)**
  - Soft palate repair
    - **Intravelar veloplasty:** Most commonly used technique, in which levator veli palatini muscles are dissected out and reapproximated in a transverse orientation.
    - **Double-opposing Z-plasty (Furlow):** Musculomucosal flaps are elevated with opposing Z-plasties from the oral and nasal mucosa layers (▶ Fig. 13.3).
  - All patients require postoperative airway monitoring with continuous pulse oximetry.
    - Myringotomy tubes: Infants with cleft palate are at higher risk of ear infections/effusions and frequently undergo placement of ear tubes at time of cleft palate repair.

13.4 Complications

- Airway obstruction: This can be due to bleeding, edema, or tongue swelling. Suction oropharynx. May place nasopharyngeal airway. If tongue stitch is in place, use to pull tongue forward to open the posterior airway. If tongue is obstructing, prone positioning may help. If no response to above measures, endotracheal intubation may be needed.

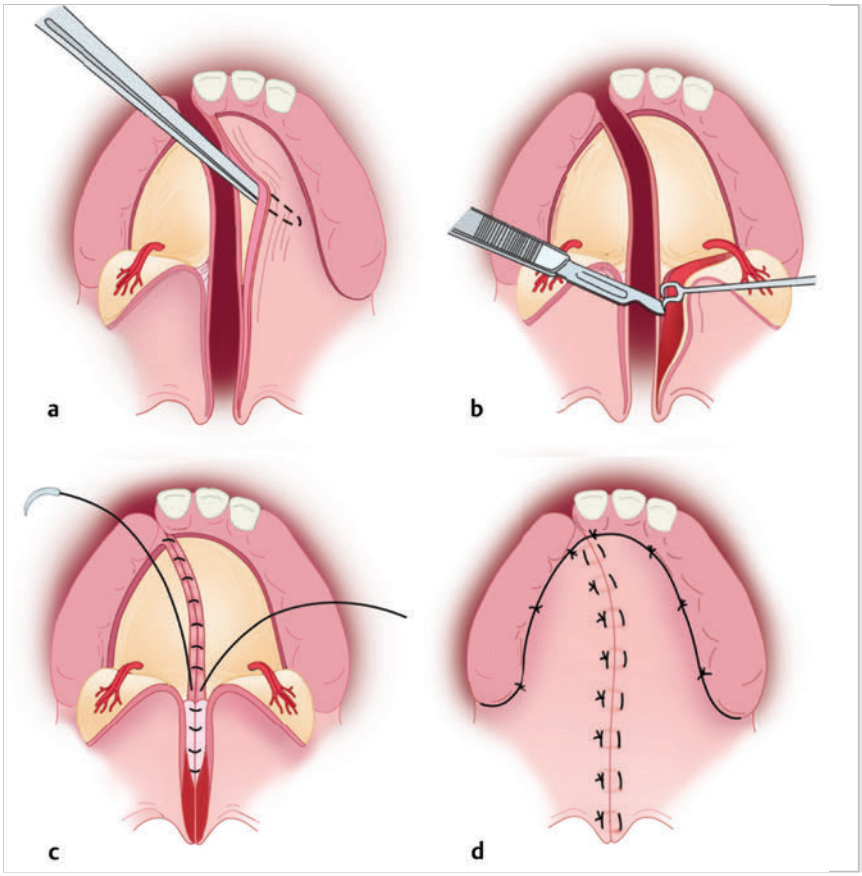

Fig. 13.2 Bardach two-flap palatoplasty. A. Hard palate mucoperiosteal flaps are elevated based on the greater palatine vessels. B. Soft palate is incised and muscle is separated from the nasal and oral mucosa. C. Nasal lining is repaired and the levator musculature is dissected out and approximated at the midline to establish the intravelar veloplasty. D. Appearance of the palate after repair is complete.

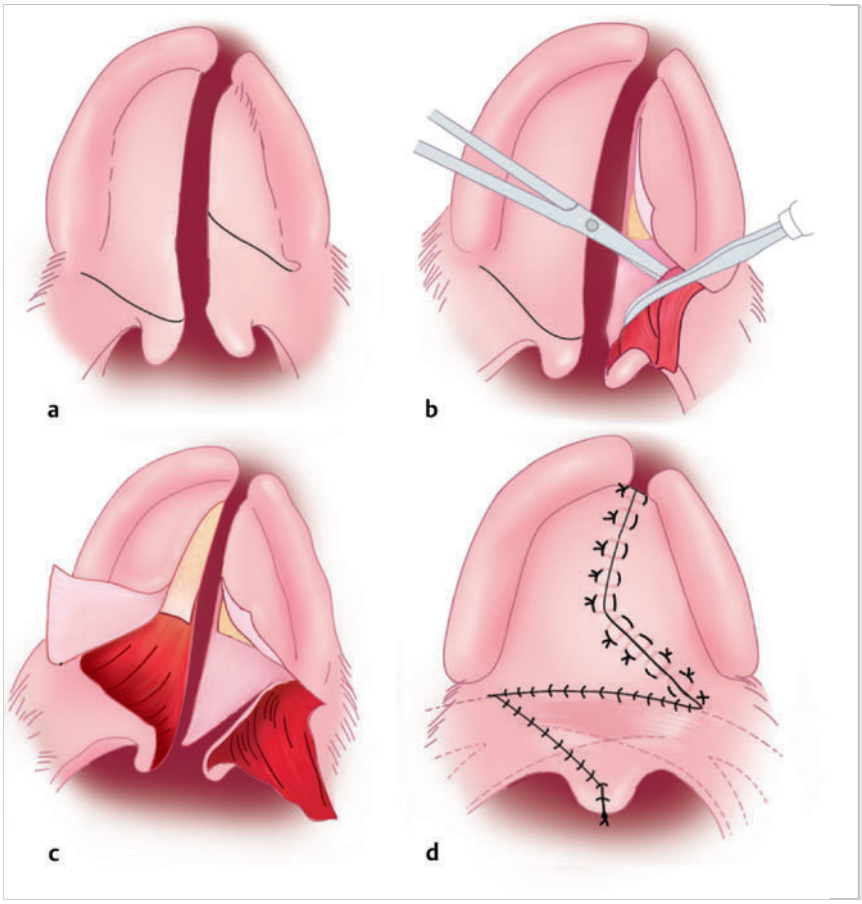

Fig. 13.3 Furlow double opposing Z plasty. A. Z plasties are marked over the soft palate oral mucosa. B. A right-sided (relative to the patient) posteriorly based musculomucosal flap and left-sided anteriorly based mucosal flap is elevated. C. An opposing Z plasty is marked on the nasal side. A right-sided anteriorly based mucosal flap and left-sided posteriorly based musculomucosal flap is elevated. D. Both the Z plasties are transposed and sutured together.

- Bleeding: Usually minor and self-limited; requires airway monitoring. If severe, return to operating room for control.
- Palatal fistula: Usually manifests several weeks after surgery. This is not an emergency and may be managed electively.
  - If asymptomatic, can initially treat nonoperatively and repair in conjunction with any future surgery.
  - If symptomatic (nasal regurgitation/hypernasal speech), should be repaired. Re-repair is typically performed with local palatal tissue ± AlloDerm (LifeCell, Bridgewater, NJ). Other options (e.g., tongue flap, facial artery musculomucosal [FAMM] flap, and free flap) are reserved for more complex, intractable cases.

13.5 Critical Errors

- Failure to assess and monitor adequacy of airway.
- Failure to address feeding and/or failure to monitor weight gain.
- Failure to consider the cleft as a part of a syndrome or failure to assess for other congenital anomalies.
- Inability to draw cleft palate repair; unfamiliarity with timing of repair.
- Failure to monitor the airway in the postoperative period.
- Failure to manage patient in multidisciplinary team setting.

14 Microtia

Farooq Shahzad & Albert S. Woo

Fig. 14.1 The parents of this 5-year-old boy would like to have the child's ear reconstructed.

14.1 Description

- Right ear microtia (lobular type)
  - Absence of anatomical landmarks of the right auricle except for abnormally oriented lobule.
  - Superior auricle consists of residual hypoplastic, disorganized cartilage.
- Absence of external auditory meatus.

14.2 Work-up

14.2.1 History

- Hearing loss and previous hearing aid placement.
- Family history of ear abnormalities, facial clefts, or syndromes.
- Asymmetric facial movements.
- Visual impairment.
- Cardiac or renal dysfunction.

14.2.2 Physical examination

- Classify anomaly: Unilateral or bilateral; severity of auricular hypoplasia (lobular type, conchal type, anotia); presence of external canal.
- Evaluate quality of periauricular skin, position of hairline.
- Complete physical examination: Assess for facial symmetry (**hemifacial microsomia**), epibulbar dermoids (**Goldenhar syndrome**), occlusal abnormalities, mandibular hypoplasia, facial nerve function, orofacial clefts, **Treacher Collins syndrome** (bilateral microtia; hypoplasia of maxilla, zygoma, and mandible; downward-slanting palpebral fissures; colobomas).

14.2.3 Pertinent imaging or diagnostic studies

- Complete audiometric testing
  - Evaluate conductive or sensorineural hearing loss.
  - The cochlea (inner ear) is usually intact. The patient may therefore benefit from a conductive hearing aid or external canal/middle ear reconstruction to restore hearing to the affected ear.
  - Assess patient for use of a bone-anchored hearing aid (BAHA) and discuss the possibility of surgical reconstruction to aid hearing.
- Temporal bone computed tomography to evaluate middle ear and inner ear anatomy.

14.2.4 Consultations

- Audiologist: For hearing evaluation. Most patients with microtia have *middle ear atresia* with resultant *conductive hearing loss*. However, the inner ear is usually intact with a viable sensorineural apparatus.
- Otolaryngologist: Evaluation for BAHA. With bilateral microtia and hearing loss, hearing aids should be placed within weeks of birth to allow speech development. Even in cases of unilateral microtia, conductive hearing aids may be a beneficial option.
  - When hearing is present in only one ear, the unaffected ear must be closely monitored and *aggressively treated* if problems occur to optimize patient's hearing.

14.3 Treatment

- Several options exist for reconstruction of the microtic ear. Care should be taken with surgical decision-making because few options exist for revision or redo if the patient has a poor initial result.

14.3.1 Autogenous

- Reconstruction requires rib harvest, which is used to create a costal cartilaginous framework.
- **Brent technique** (▶ Fig. 14.2): four stages classically described
  - Begun as early as 6 years of age.
  - Stage I: Framework construction and placement
    - Harvest of contralateral sixth through eighth ribs.
    - Inset in pocket posterior to ear vestige.
  - Stage II: Earlobe transposition.
  - Stage III: Ear elevation and split-thickness skin graft.
  - Stage IV: tragus construction, conchal excavation.
- Repair of the atretic middle ear: Higher complication rate, not necessary if hearing aids provide adequate hearing. If pursued, middle ear reconstruction should be done after external ear reconstruction to minimize scar tissue at the time of microtia reconstruction.
- Nagata technique (▶ Fig. 14.3): two stages
  - Not performed before 10 years of age because of need for abundant cartilage.
  - Stage I: framework construction, lobule transposition
    - Harvest of ipsilateral sixth through ninth ribs.
    - Construct has a second, stacked layer of cartilage to improve projection of the antihelix; also contains a tragal component.
  - Stage II: ear elevation with banked cartilage graft, coverage with temporoparietal fascial flap and split-thickness skin graft.

14.3.2 Alloplastic (▶ Fig. 14.4)

- Classically, a single-stage reconstruction with a porous polyethylene (Medpor; Stryker, Kalamazoo, MI) auricular implant.
- A large (~ 12 cm) temporoparietal fascia flap is harvested to completely cover the Medpor construct and minimize the chance of extrusion.
- Obviates chest wall donor site morbidity. Implant infection extrusion and fracture remain risks.

14.3.3 Prosthetic

- A prosthetic ear can be created to mirror the opposite, normal ear.
- The prosthesis may be attached by *adhesive* (time-consuming and sometimes unstable) or held in place by an

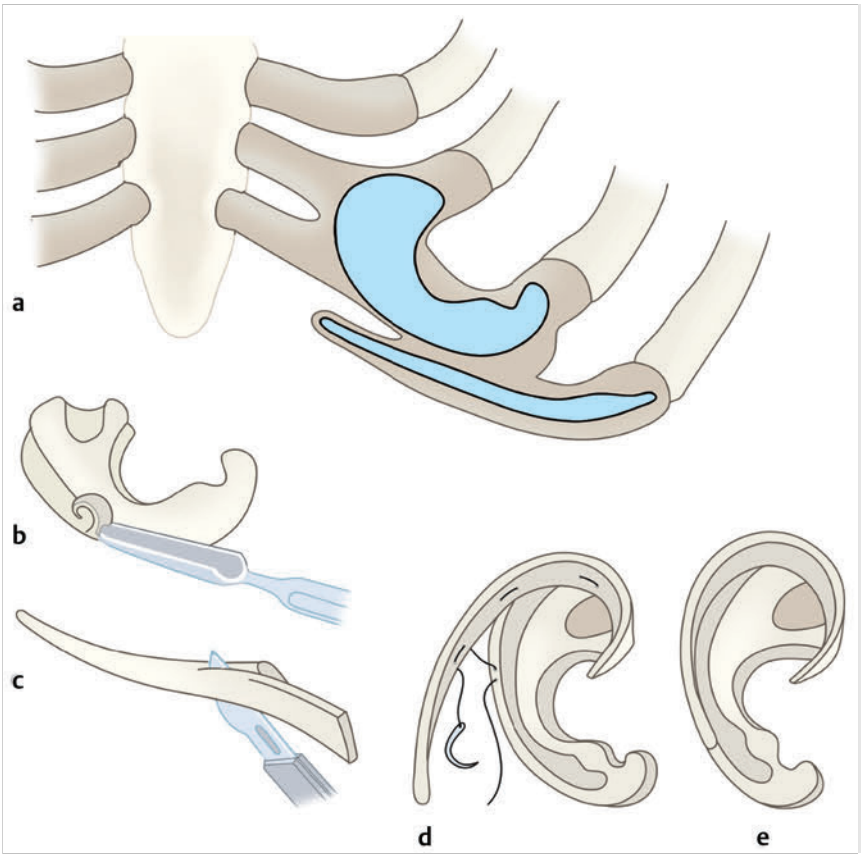

Fig. 14.2 The Brent technique: fabrication of ear framework from rib cartilage. The Brent framework consists of two pieces. The base is obtained from the synchondrosis of two rib cartilages, and the helical rim is obtained from a "floating" rib cartilage. The details are carved into the base with a gouge. The helical rim piece is thinned and attached to the base with nylon sutures.

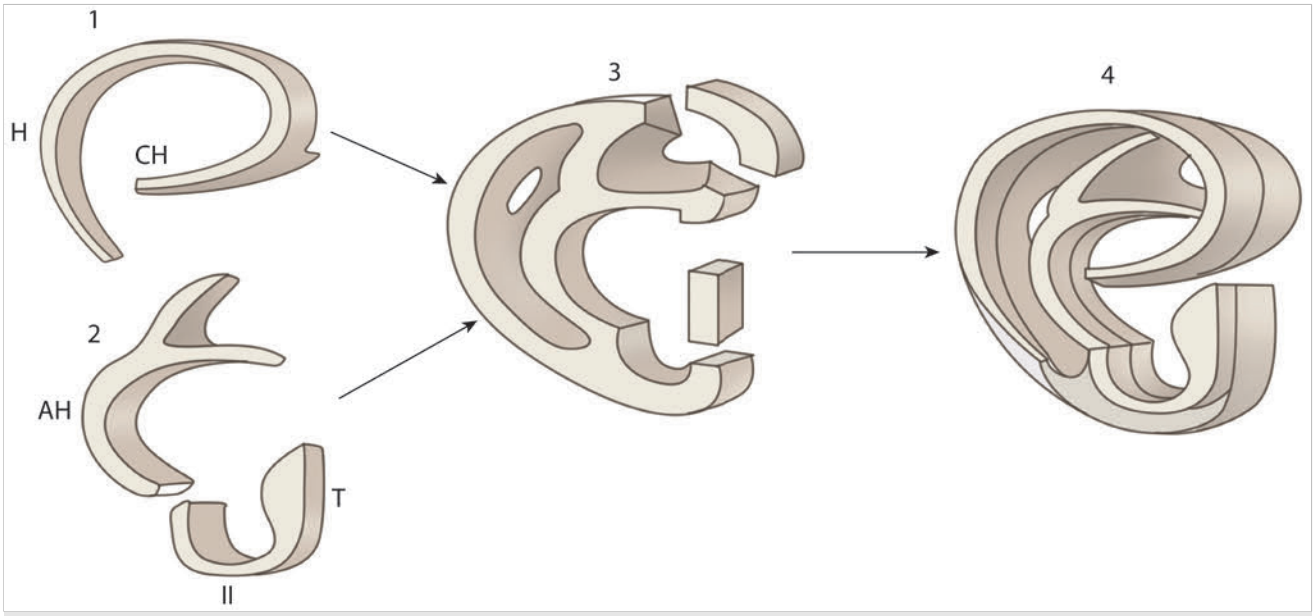

Fig. 14.3 The Nagata technique. Stage 1: fabrication of the costal cartilage framework. (1) The helix and crus helicis unit constructed from the ninth costal cartilage. (2) The antihelix and superior and inferior crus unit constructed from the remaining portions of the seventh and eight costal cartilages. The incisura intertragica and tragus unit constructed from the remaining portions of the seventh and eighth costal cartilages. (3) The base frame constructed from the seventh and eighth costal cartilages. (4) The fabricated frame. *AH*, antihelix; *CH*, crus helicis; *H*, helix; *II*, incisura intertragica; *T*, tragus.

Fig. 14.4 Medpor porous polyethylene implant. The two-piece implant consists of a helical rim and ear base.

osseointegrated frame placed in the mastoid bone. An osseointegrated framework violates the skin of the ear and eliminates the possibility of later autogenous or alloplastic reconstruction.
- Typically indicated for failed primary reconstruction, poor local tissue quality, and patients with poor anesthetic risk.
- Requires meticulous hygiene and lifelong follow-up for maintenance of the prosthesis.
- Repair of the atretic middle ear: Higher complication rate, not necessary if hearing aids provide adequate hearing.

If pursued, middle ear reconstruction should be done after external ear reconstruction to minimize scar tissue at the time of microtia reconstruction.

14.4 Complications

- Skin necrosis resulting in cartilage exposure: early intervention is mandatory to save the cartilage framework.
  - < 1 cm: Local wound care with antibiotic ointment protects cartilage from desiccation and may allow healing.
  - > 1 cm: Local skin and fascial flaps are necessary for coverage.
- Infection: Immediate incision and débridement with antibiotic irrigation in combination with systemic antibiotics. If Medpor implant used, immediate debridement of exposed portions and coverage with flap must occur to prevent seeding of bacteria in graft material.
- Hematoma: Requires immediate evacuation.
- Pneumothorax: If it occurs during rib harvest, evacuate air and repair pleural defect. Tube thoracostomy is rarely necessary.
- Chest wall contour deformities: Prevent by preserving perichondrium and replacing unused cartilage.
- Cartilage resorption.

14.5 Critical Errors

- Failure to assess for other features of craniofacial microsomia.
- Failure to refer to audiologist for hearing evaluation and hearing aids.
- Failure to monitor unaffected ear to protect patient's hearing status.
- Failure to promptly and aggressively manage hematoma, cartilage exposure, or infection.
- Performing middle ear reconstruction before external ear reconstruction.

Part 4

Section IV. Face Cosmetic

15 Aging Face and Neck

Tracy S. Kadkhodayan & Marissa Tenenbaum

Fig. 15.1 A 60-year-old woman requests a consultation for facial rejuvenation because she looks "old and tired."

15.1 Description

- Middle-aged woman.
- Skin: Minimal actinic damage and glabellar rhytids, crow's feet and perioral rhytids.
- Eyelids: Hooding of the upper lids and fat herniation of the lower lids.
- Midface: Prominence of the nasojugal groove, nasolabial folds, and labiomental folds; midface descent and moderate jowling.
- Neck: Moderate skin laxity and platysmal banding.

Table 15.1 Fitzpatrick scale for skin type

Type	Color	Tanning
I	White, very fair; often has freckles	Always burns, never tans
II	White, fair	Usually burns, rarely tans
III	Beige complexion, most common	Usually tans, occasionally burns
IV	Beige, Mediterranean complexion	Rarely burns, tans easily
V	Dark brown complexion	Rarely burns
VI	Black	Never burns, deeply pigmented

15.2 Work-up

15.2.1 History

- What does the patient specifically want improved? What are her primary concerns?
- Previous facial procedures and surgeries.
- History of hypertension, blood thinners/platelet inhibitors, *smoking* (must quit at least 4 weeks before surgery).

15.2.2 Physical examination

- Facial analysis
  - Upper third: Evaluate brow position, upper and lower eyelid laxity, lateral canthal position, presence of nasojugal grooves, forehead and periorbital creases (with and without animation).
  - Middle third: Assess malar descent; presence of nasolabial folds, jowls, marionette lines; upper and lower lip fullness and wrinkling; angle of mouth (e.g., depressed oral commissure); projection of chin; nasal analysis (see Case 19).
  - Lower third (neck): Evaluate skin laxity, degree of subcutaneous and subplatysmal fat, evidence of platysmal banding, measurement of cervicomental angle.
- Fitzpatrick scale for skin type (▶ Table 15.1)
  - Classifies response of skin to ultraviolet light.
  - Useful for determining response of skin to aging and surgical intervention.

15.3 Treatment

15.3.1 Facelift

- Standard incision (▶ Fig. 15.2): Temporal (within or in front of hairline); preauricular (anterior border of helix, pretragal or posttragal, below and around earlobe); postauricular (retroauricular sulcus, extending horizontally to the hairline).
  - *Short scar technique:* Preauricular incision with incision around earlobe but not extending into hairline. Limited to younger patients with minimal skin excess.
- Surgical techniques: Multiple options are reasonable, although SMAS (superficial musculo-aponeurotic system) and SMASectomy procedures are most common.
  - Subcutaneous facelift
    - Undermining only in subcutaneous plane with skin flap redraped in superoposterior direction.
    - Higher recurrence rate because of absence of deeper suspension.
  - SMAS facelift (▶ Fig. 15.3)
    - The SMAS is incised transversely below (traditional SMAS dissection) or above (extended SMAS dissection) the zygomatic arch, and then preauricularly down to the anterior border of the sternocleidomastoid.
    - The SMAS flap is undermined, trimmed, redraped, and plicated in a superoposterior direction.

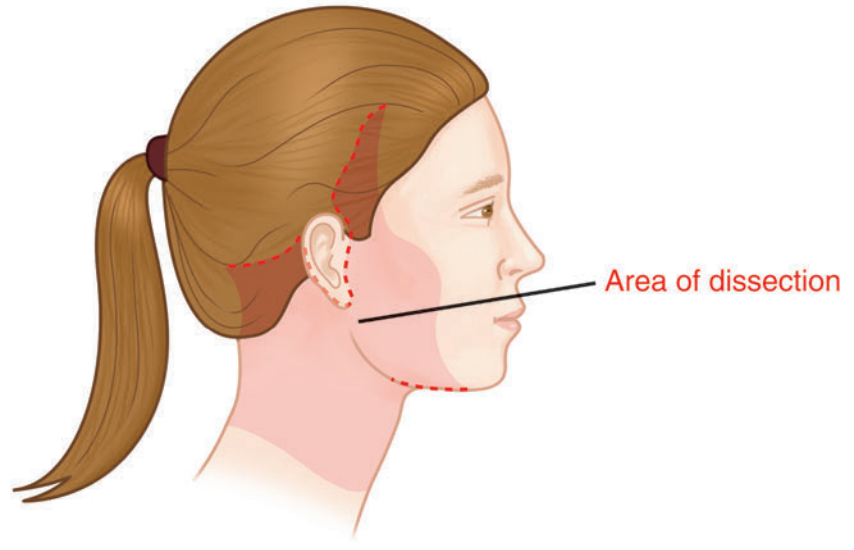

Fig. 15.2 Standard facelift incision. Typically extends from within the temporal hairline, anterior to the ear and behind the tragus, around the lobule and into hairline of the posterior scalp.

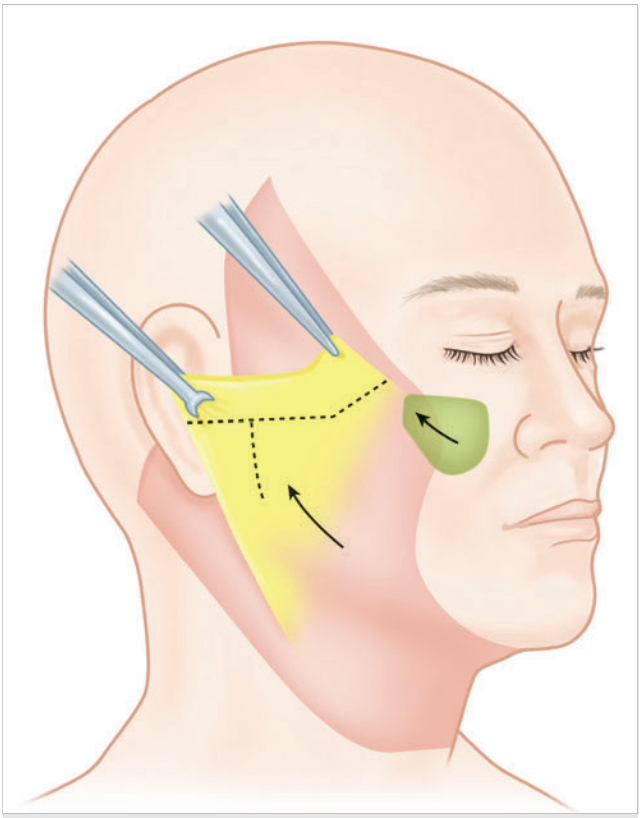

Fig. 15.3 Standard SMAS (superficial musculo-aponeurotic system) dissection with plication.

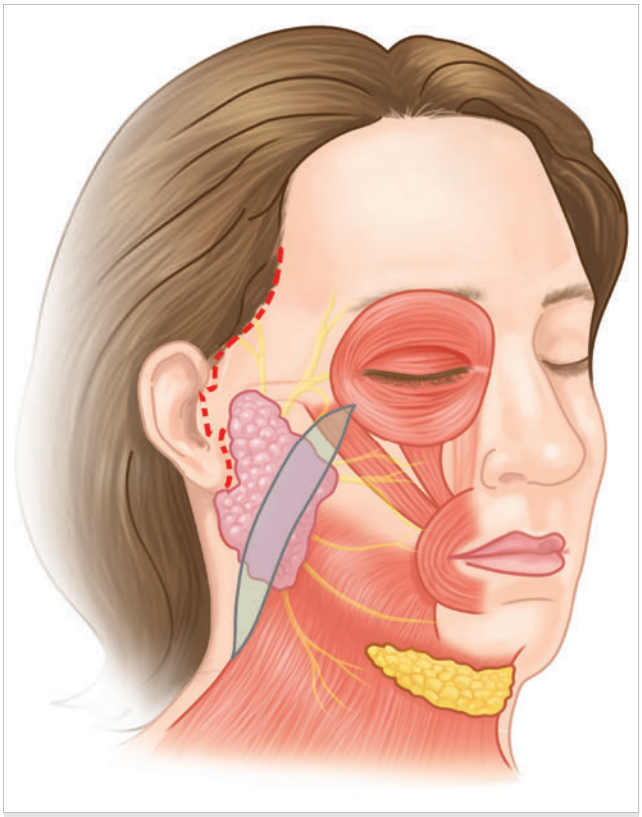

Fig. 15.4 SMASectomy procedure. SMAS (superficial musculo-aponeurotic system) resection takes place along the malar eminence and lateral edge of the orbicularis muscle, over the parotid gland, and inferiorly into the neck to the posterior portion of the platysma muscle.

  - Facial nerve branches run in the sub-SMAS layer and can be injured with overly aggressive dissection.
- SMASectomy procedure (▶ Fig. 15.4)
  - Similar to the SMAS procedure, but rather than extensive dissection under the SMAS layer, an ellipse of SMAS is excised from the malar eminence to the posterior neck. The SMAS edges are then sutured together to tighten this layer.
  - Decreases risk for facial nerve injury because of decreased dissection in this layer.
- Composite facelift: Skin and SMAS dissected as a single flap.
- MACS (minimal access cranial suspension) lift: Purse-string sutures placed in SMAS and suspended to deep temporal fascia.
- Subperiosteal facelift: Midface elevated in subperiosteal plane and redraped.

15.3.2 Neck rejuvenation (▶ Fig. 15.5)

- Platysmaplasty ± platysmal myotomy
  - Submental incision.
  - Platysma dissected, tightened, and reapproximated in midline.
  - Platysma can be divided at least 6 cm inferior/posterior to lower mandibular border to improve neck definition.
- Submental liposuction.

15.3.3 Adjunct treatments

- Fat grafting.
- Fillers
  - Hyaluronic acid, calcium hydroxyapatite, polylactic acid.
- Cutaneous resurfacing
  - Dermabrasion.
  - Laser resurfacing: Carbon dioxide, erbium:YAG (yttrium aluminum garnet).
  - Chemical peels
    - Superficial: Jessner solution, salicylic acid, α-hydroxy acids (glycolic acid).
    - Deep: Trichloroacetic acid, phenol (requires cardiac monitoring).
- Botulinum toxin
  - Glabellar region, transverse and vertical forehead rhytids, crow's feet, perioral rhytids.

15.4 Complications

- Hematoma: Correlated with high blood pressure. Take back to operating room immediately and evacuate.
- Skin necrosis: Local wound care, scar revision when healed. Avoid the compulsion to revise this early because the tissues have already been stretched and are not likely to heal after additional tightening.

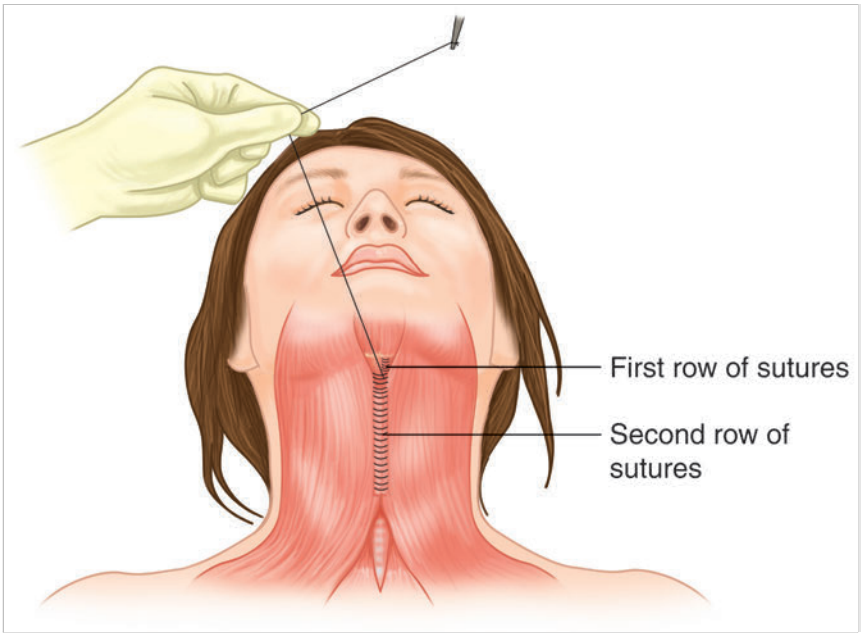

Fig. 15.5 Plastysmaplasty involving submental incision and plication of the platysma at the midline. The platysma may be divided posteriorly to improve neck definition, as necessary.

- Nerve damage: More common with sub-SMAS dissection because of additional dissection. Many are transient neurapraxias due to traction or cautery injury.
  - Great auricular nerve injury: Most commonly noticed nerve injury.
  - Buccal branch of facial nerve: Most commonly injured nerve. Injury not usually noticed because of nerve interconnections with other facial nerve branches.
- Dissatisfied patient
  - A dissatisfied patient does not necessarily mean that the surgeon has made an error.
  - Have a plan for how you will manage patients who are unhappy with their results. ("I want my money back." "You didn't fix the saggy skin on my neck.")

15.5 Critical Errors

- Failure to recognize preoperative risk factors and control postoperative hypertension.
- Failure to take a patient back to the OR immediately for hematoma. Even a small collection can cause flap necrosis.
- Management of skin necrosis: avoid the desire to take a patient to the operating room for flap necrosis because surgery may lead to more problems.
- Failure to institute prophylaxis for herpes in all patients undergoing skin resurfacing.
- Inability to recognize or discuss the risk for embolic complications from periorbital injectable agents (e.g., blindness).

16 Aging Upper Face (Brow and Lids)

Neil S. Sachanandani & Marissa Tenenbaum

Fig. 16.1 A 56-year-old woman comes to your office seeking a more refreshed facial appearance.

16.1 Description

- Glabellar frown lines and periorbital rhytids
- Asymmetric brow position.
- Excess upper lid skin.
- Tear trough deformity
- Midface decent with prominent nasolabial folds

16.2 Work-up

16.2.1 History

- Identify medical conditions that may increase the risk for complications.
  - Blepharochalasis, Graves disease, benign essential blepharospasm.
  - Rosacea, pemphigus, sarcoidosis.
  - Previous periorbital and facial procedures.
- Assess for a history of *dry eyes.*
  - Blepharoplasty may worsen a previous history of dry eyes.
  - Contact lenses: If patient is able to use contact lenses comfortably, there is no history of dry eyes and tear production is normal.
  - Recent LASIK surgery: Should not undergo blepharoplasty for at least 6 months following procedure.
  - Postmenopausal hormone replacement therapy (HRT)
    - 70% higher risk for dry eye.
    - Additional 15% increase in risk for dry eye every 3 years during HRT.

16.2.2 Physical examination

Forehead analysis

- Position of anterior hairline
- Shape and slope of forehead
- Transverse forehead and glabellar rhytids

Brow analysis

- Eyebrow shape: Should be a gentle curve with the medial and central portions wider than the lateral aspects.
- Eyebrow peak: Should be located at or just lateral to the lateral limbus.
- Eyebrow location: Brow peak should be 1 cm above supraorbital rim in women and at supraorbital rim in men.
- Brow ptosis:
  - may be compensated by hyperactivity of frontalis muscle. Immobilize frontalis and ask patient to open eye and assess brow position.
  - Lateral extension of upper lid hooding onto periorbital region is a marker of forehead ptosis (Connell sign).

Eyelid analysis

- Upper lid:
  - Excess skin, fat herniation, lacrimal gland prolapse
  - Lid position: should not be lower than 2 mm from superior limbus.
  - Supratarsal fold position: measure margin-crease distance. Normal 7 to 11 mm. High position indicates levator dehiscence.
  - Levator function: measure eyelid excursion from maximal down gaze to extreme up gaze while stabilizing the brow.
  - Cover test: to unmask sub-clinical ptosis if there is asymmetric lid position.
- Lower lid
  - Excess skin, fat herniation, tear trough
  - Lid position: lower lid should not be below inferior limbus
  - Lid laxity: lid distraction more than 6 mm requires canthal procedures.
  - Snap back test: after distraction lower lid should immediately snap back to its position
  - Position of eye in relation to orbital rim: positive vs negative vector.
- Lateral canthal position:
  - Lateral canthus is positioned slightly superior to medial canthus (positive canthal tilt) by an average of 4 degrees.
  - Negative canthal tilt may require canthopexy.

Assess for dry eyes

- Schirmer test (see Case 18).
- Bell's phenomenon (see Case 18).

Ocular examination

- Visual acuity.
- Visual fields.

16.3 Treatment

16.3.1 Browlift

- Multiple techniques available
  - Open coronal
    - Incision is made within the hairline (usually with small zigzag incisions).
    - Powerful technique for brow elevation.
    - Scar may be more visible with this technique.
  - Endoscopic
    - Commonly used technique for brow elevation.
    - Access incisions are made in scalp, and brow is fixed after endoscopic release of retaining structures (see below for technique).
  - Direct approach
    - Incision immediately above brow with resection of redundant tissue.
    - Obvious scar on forehead.
  - Transpalpebral: Access is obtained through an upper blepharoplasty approach.
  - Temporal browlift: Lateral brow elevated via incisions in temporal scalp.
- Incisions for endoscopic browlift
  - Mark midline.
  - Identify sentinel vein.
    - Usually 1.5 cm above and lateral to the lateral canthus. Seen more easily in the dependent position.

- Frontal branch of the facial nerve
  - Lowest branch, usually 1 cm above the sentinel vein.
- Temporal crest: Curved line marked just in front of the contracting temporalis muscle.
- Vectors: There are several options for vectors of lift and fixation. These directional elements are part of the initial marks that guide the direction of the browlift and are drawn on the forehead.
  - Vector from the alar base to the lateral canthus projected onto the forehead.
  - Vector from the oral commissure to the lateral canthus.
  - An oblique line along the scalp starting at the apex of the brow.
- Incisions: Five incisions are used. All of the incisions are typically 1 to 2 cm in length.
  - One midline: Placed longitudinally 0.5 to 1 cm behind the hairline.
  - Two "vector" incisions: 1.5 to 2 cm behind the hairline. Aligned with the forehead vector markings and will determine the placement of the fixation device. Usually 6.5 to 7 cm lateral to the midline marking.
  - Two lateral incisions: 1.5 to 2 cm behind the hairline, 3 cm lateral to the vector markings in the temporal region.

16.3.2 Upper lid blepharoplasty

- Multiple techniques available
  - Transconjunctival fat removal from the medial pocket.
  - Skin excision only
    - ± Fat removal.
  - Skin and muscle excision
    - ± Fat removal.
    - Ptosis repair may be performed at same time.
- Markings for upper lid blepharoplasty
  - The inferior excision line is drawn first by starting with a mark at the upper eyelid crease
    - 10 mm above the lash margin in women, 7 mm above the lash margin in men.
  - There should be a gradual downward curve toward the medial and lateral canthi.
    - Each corner should be 6 mm above each canthus.
    - The medial mark should not be medial to the caruncle.
    - The lateral mark should not extend lateral to the lateral orbital rim.
  - The superior mark should be at the level of the lateral limbus.
    - At least 1 cm of eyelid skin between this mark and the thicker brow skin.
  - The superior mark should be tapered medially and laterally in a curve paralleling the inferior marks, making sure the height of the excision does not exceed 5 mm medially.

16.3.3 Lower lid management

- Multiple options available
  - Fillers.
  - Pinch blepharoplasty: Excise only redundant skin that can be held with a pinch.
  - Transconjunctival fat removal/redistribution
    - Limited skin excision may be performed through separate subciliary incision.
  - Transcutaneous approaches
    - Skin only.
    - Skin–muscle flap.
- Markings for lower lid blepharoplasty
  - A single point is chosen at the level of the lateral canthus along the lower lid. This point is extended 6 to 10 mm laterally along one of the crow's feet, being sure to have at least a 1-cm bridge between this and an upper blepharoplasty incision.
  - The mark is extended centrally from the initial point in a curve paralleling the lid margin 1 to 2 mm below the lash line and then tapering to a point 4 mm below the punctum medially.
  - While performing a skin–muscle flap technique, at least 4 to 5 mm of the preseptal orbicularis must be preserved to keep spontaneous blinking intact.

16.4 Complications

- Vision loss
  - Usually caused by retrobulbar hemorrhage.
  - Evacuation must be performed in the operating room immediately or a lateral canthotomy must performed at the bedside to prevent permanent vision loss.
- Hematoma.
- Dry eye syndrome: Patients must undergo adequate work-up for dry eyes before surgery.
- A-frame deformity
  - Deep upper lid sulcus with reduced amount of medial orbital fat caused by excessive resection (peaked arch deformity of the supratarsal crease).
- Dehiscence of the levator attachments may create ptosis after blepharoplasty.
  - May require ptosis repair.
- Lagophthalmos and corneal exposure
  - Develop from anterior lamellar shortage or excessive orbicularis removal.
  - Treated acutely by taping the eye closed at night with application of ophthalmic ointment.
- Infection.
- Ectropion
  - Caused by the combination of lower eyelid laxity and scarring of the capsulopalpebral fascia–septum interface.

16.5 Critical Errors

- Failure to take patient to the operating room immediately when signs of retrobulbar hematoma are evident.
  - If unable to go to the operating room, must perform a lateral canthotomy at the bedside.
- Failure to address the brow ptosis at the time of upper lid ptosis blepharoplasty.
- Excessive fat removal.
- Overzealous resection of the upper lid skin and/or muscle during upper lid blepharoplasty.
- Transection of inferior oblique muscle during lower lid transconjunctival approaches.

17 Lower Lid Ectropion (Cicatricial)

Michael C. Nicoson & Terence M. Myckatyn

Fig. 17.1 (a,b) A 50-year-old man presents with lower eyelid exposure and excessive tearing following previous lower eyelid blepharoplasty.

17.1 Description

- Lower lid ectropion: Eversion of the lower eyelid margin, resulting in scleral show and exposure of the conjunctiva.
- Subciliary scar of the lower eyelid from previous operative procedure → cicatricial ectropion.

17.2 Background

- Ectropion is the most frequent lid malposition seen clinically.
  - Characterized by eversion (outward turning) of the lid margin with exposure of the conjunctiva.
  - Classified according to time of onset and pathophysiology (cicatricial, senile, paralytic, congenital).
- Cicatricial ectropion results from shortening of the anterior lamella of the eyelid.
  - Secondary to trauma, burn injuries, complications of blepharoplasty, involutional patterns, and medications.

17.3 Work-up

17.3.1 History

- Symptoms: Epiphora (excessive tearing), ocular irritation, xerophthalmia (dry eyes), poor cosmesis.
- Any prior eyelid-related surgeries or trauma. History of duration and progression of symptoms.
- Ask about patient medications and if any new medications have been started.

17.3.2 Physical examination

- Inspect the eye and lid margin. Evaluate location of the punctum.
  - The normal punctum position is inverted toward the lacrimal lake.
- Evaluate for scleral show and rounding of the lateral canthus.
- Epiphora: Excessive tearing due to punctum eversion.
- Assess condition of the lower lid skin and support of the lower eyelid.
- Evaluate for incomplete eyelid closure and corneal abrasions
- *Snap-back test:* Pull lower lid down and away from the globe for several seconds and wait. The eyelid should snap back immediately. Delay or inability to do so (without blinking) indicates significant ectropion.
- *Pinch test:* Significant lid laxity is present if the lower eyelid can be pulled more than 6 mm away from the globe.
- Facial nerve function: Confirm function of orbicularis oculi to close eyes.
- Bell's phenomenon

17.3.3 Diagnostic studies

- No definitive radiographic studies are needed. However, in the setting of trauma, maxillofacial computed tomography provides further detail about fracture patterns.
- **Schirmer test:** Objective measure of tear production/secretory capacity
  - Always assess patient for *dry eye symptoms* because these can worsen postoperatively if no preventative measures are taken (i.e., canthopexy/plasty).
  - Place a strip of filter paper on the lower lid lateral sclera for a 5-minute period.
  - Measure the amount of wetting: < 10 mm of wetting is abnormal.

17.4 Treatment

17.4.1 General principles

- Release any scar tissue or tethering.
- Reconstruct affected layers appropriately.
  - Anterior lamella: Skin and orbicularis muscle.
  - Middle lamella: Orbital septum.
  - Posterior lamella: Conjunctiva.

17.4.2 Surgical options

- Anterior lamella: Eyelid skin and orbicularis muscle layer
  - *Full-thickness* skin graft (FTSG)
    - Common donor sites of FTSG: Upper lid, retro- and preauricular regions, supraclavicular region.
    - Contralateral (upper) eyelid tissue provides the best aesthetic outcome; closest color and thickness match.
    - Consider bolster dressing to prevent seroma formation.
  - **Tripier flap** (▶ Fig. 17.2)

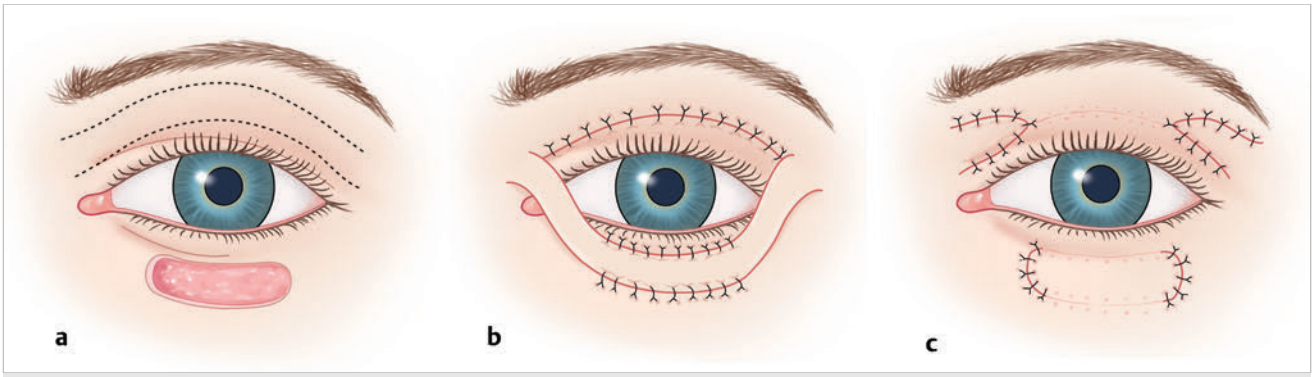

Fig. 17.2 (a-c) Tripier flap (bipedicled).

  - A bipedicled musculocutaneous flap from the superior lid. A single pedicle (usually laterally based), may also be performed.
  - Used for partial-thickness coverage of the lower lid. In contrast to FTSG, provides additional muscle layer for coverage.
- Middle lamella: Support layer of lower eyelid consisting of orbital septum
  - Repair primarily if possible. Grafts need to be reasonably stiff for structural support.
  - Palatal mucosal graft: Replaces both middle and posterior lamellar layers.
  - Cartilage graft: Harvested from septum or ear.
  - Allograft (e.g., acellular dermal matrix)
    - No donor defect and available off the shelf. However, this technique is less accepted as a standard for reconstruction of this layer.
- Posterior lamella
  - **Hughes tarsoconjunctival flap:** Two-stage procedure (▶ Fig. 17.3)
    - Transfers conjunctiva and a small portion of superior tarsus for a subtotal or total lower lid reconstruction. Divided at second stage.
    - Middle and posterior lamellae are reconstructed with this procedure.
    - Skin coverage via FTSG or flap.
- Adjunct measures for lower lid support
  - Canthop*exy*
    - Involves tightening the lateral canthus to the periosteum.
    - Does NOT involve lateral canthus disinsertion.
    - Allows mild lid tightening and mild canthal elevation.
  - Canthop*lasty*
    - Involves detachment of the lateral canthal tendon from the orbit and subsequent repositioning for correction of horizontal lid laxity.

17.5 Complications

- Skin graft loss.
- Localized infection.
- Globe injury/corneal abrasion: Lubricating the cornea and using a corneal protector intraoperatively reduces the risk.
- Bleeding and retrobulbar hematoma
  - Maintain meticulous operative hemostasis and control blood pressure.
  - If there is evidence of proptosis and concern for hematoma, return to the operating room immediately or evacuate at bedside.

17.6 Critical Errors

- Inadequately reconstructing each of the critical layers of the eyelid.
- Failure to consider a horizontal lid-tightening procedure when excessive laxity is present.
- Using a split-thickness rather than a full-thickness skin graft (to prevent contracture).

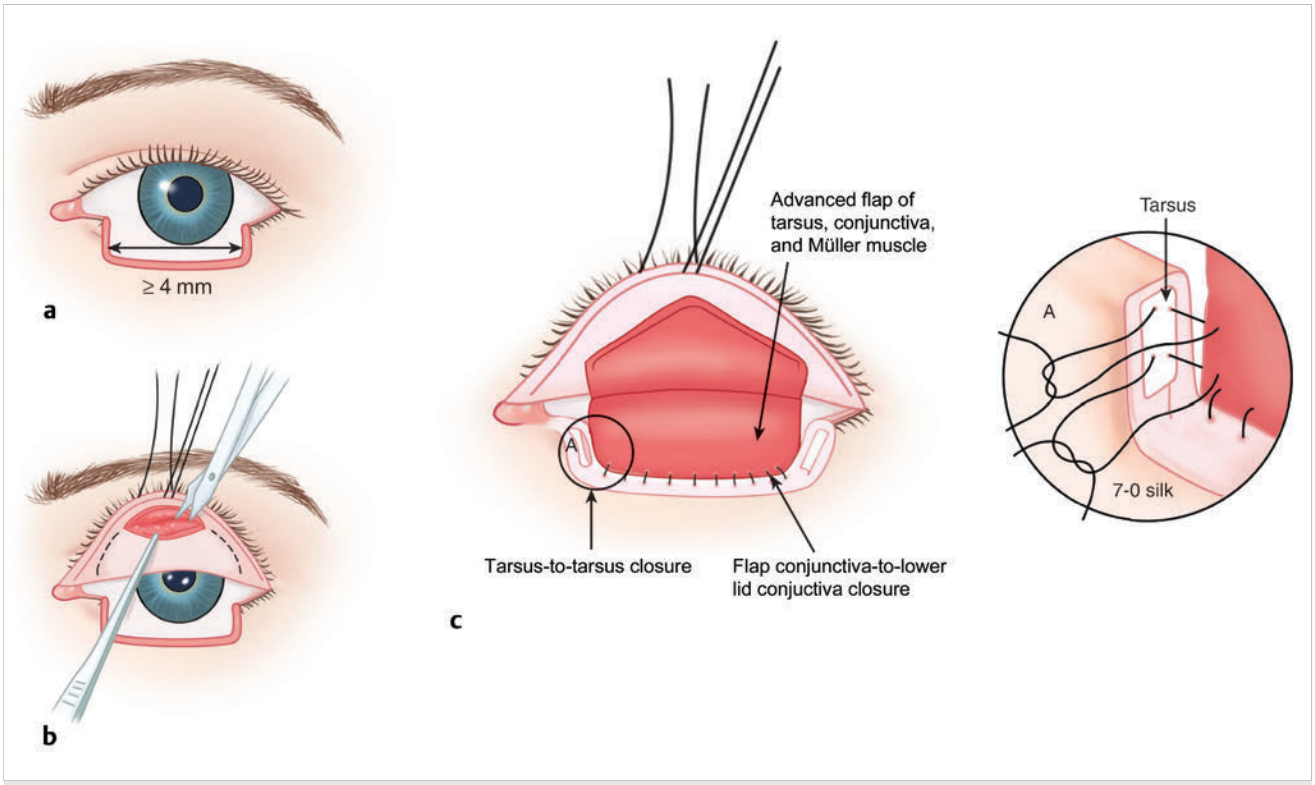

Fig. 17.3 (a-c) Hughes tarsoconjunctival flap.

- Placing a skin graft on a nonviable/nonvascularized wound bed (e.g., other graft material).
- Harvesting a deficiently sized skin graft and failure to bolster the skin graft after placement.
- Failure to replace missing soft tissue after the cicatricial ectropion has been released, resulting in severe scar contracture due to healing by secondary intention.
- Failure to recognize and promptly treat retrobulbar hemotoma.
- Injury to extraocular muscles, especially the inferior oblique muscle, during dissection along the orbital floor.

18 Lower Lid Ectropion (Senile or Paralytic)

Noopur Gangopadhyay & Albert S. Woo

Fig. 18.1 A 65-year-old man presents to the clinic with excessive watering and constant irritation of his left eye.

18.1 Description

- Lower lid ectropion: Outward turning of eyelid margin; involutional or senile caused by horizontal lid laxity and age-related weakness of the canthal ligaments and pretarsal orbicularis oculi.
- Additional findings include upper eyelid laxity, brow ptosis (right more than left), and mild tear trough deformity of the right lower lid.

18.2 Work-up

18.2.1 History

- Symptoms: Epiphora (excessive tearing), ocular irritation, xerophthalmia (dry eyes), poor cosmesis.
- Classification: Punctal ectropion (lacrimal punctum everted only), medial ectropion, generalized ectropion, lagophthalmos (inability to completely close eyes), secondary exposure keratopathy, senile ectropion, paralytic ectropion, or cicatricial ectropion.

18.2.2 Physical examination

- **Snap-back test:** Pull lower lid down and away from the globe for several seconds and wait. The eyelid should snap back immediately. Delay or inability to do so (without blinking) indicates significant ectropion.
- **Pinch test:** Lid laxity is present if the lower eyelid can be pulled more than 6 mm away from the globe.
- Medial canthal laxity test: Pull lower lid laterally away from the medial canthus and measure displacement of medial punctum; the greater the distance measured, the greater the laxity. Normal displacement is 0 to 1 mm.
- Lateral canthal laxity test: Pull the lower lid medially away from lateral canthus and measure displacement of the lateral canthal corner; the greater the distance measured, the greater the laxity. Normal displacement is 0 to 2 mm.
- **Bell's phenomenon:** The patient attempts to close the eyes while the examiner holds the eyelids open. If the eyes rotate superiorly Bell's phenomenon is present and indicates that this protective mechanism is in place.

18.2.3 Diagnostic studies

- **Schirmer's test:** Filter paper is applied to the fornix. The amount of moisture on the strip is measured after 5 minutes. Normal: > 10 mm.
- Corneal examination with flourescein to analyze corneal changes or lacerations.
- Slit lamp examination: Evaluate for corneal abrasion or dryness.

18.3 Treatment

18.3.1 Correction of horizontal lid laxity

- *Tarsal shortening:* pentagonal wedge excision lateral to lateral limbus to avoid notching (rarely used).

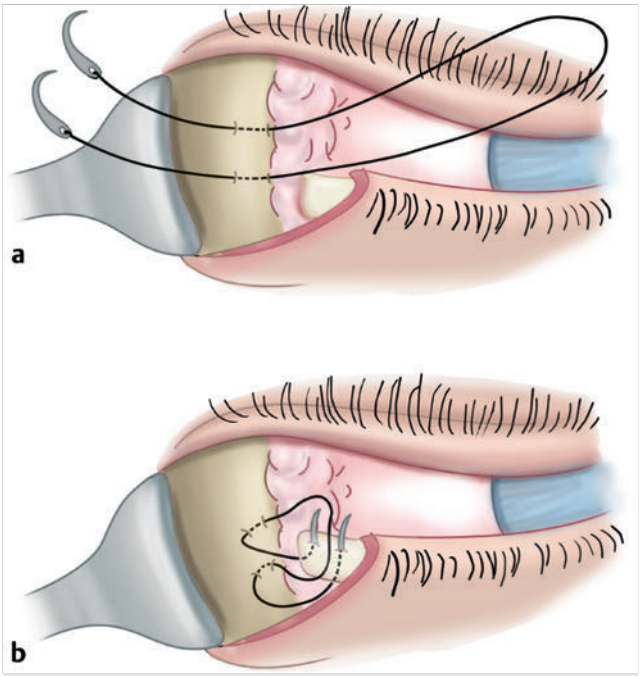

Fig. 18.2 Lateral canthal strip procedure. The lower limb of the lateral canthus is divided as in a lateral canthoplasty. A. The tarsal plate is additionally de-epithelialized before the lateral lid is resuspended along the lateral orbit rim. B. Sutures anchored in the orbit are fixated to the lateral canthal strip.

- *Lateral canthoplasty* (▶ Fig. 18.3): Divide commissure with repositioning/tightening of the lower canthal tendon into the site of origin (Whitnall tubercle).
  - *Lateral canthal strip* (▶ Fig. 18.2): Additional tightening (in more severe cases) may be obtained by de-epithelializing the skin over the lateral canthal tendon to shorten it further before insertion into the lateral orbit.
- *Lateral canthopexy/retinacular suspension* (▶ Fig. 18.4): Tightening of lateral canthus or lateral retinaculum to periosteum with permanent sutures placed into the inner aspect of the orbit. Can be used in less severe cases, and no disinsertion of lateral canthus is performed. Access is achieved through lateral lower lid blepharoplasty approach.

18.4 Complications

- Corneal and conjunctival exposure: Conjunctival keratinization, corneal breakdown, epiphora, and pain. Keep cornea and conjunctiva well lubricated to prevent exposure and drying.
- Surgical complications: Bleeding, hematoma, infection, wound dehiscence, pain, poor positioning of the tarsal strip
  - **Retrobulbar hematoma:** *This is a surgical emergency.* Although adjunctive measures may be used (i.e., administration of carbonic anhydrase inhibitors or osmotic agents), the key treatment is surgical intervention. This may be performed by immediate return to the operating room for exploration and evacuation of hematoma or emergent *lateral canthotomy with cantholysis* at the bedside.

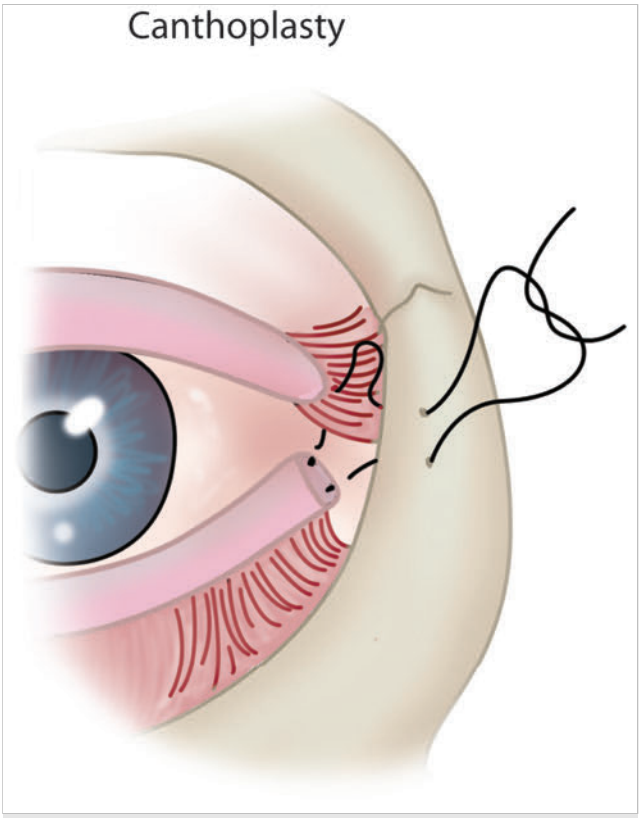

Fig. 18.3 Lateral canthoplasty procedure. The lower limb of the lateral canthal tendon is divided and repositioned along the internal rim of the lateral orbit after additional tightening of the lower eyelid is achieved.

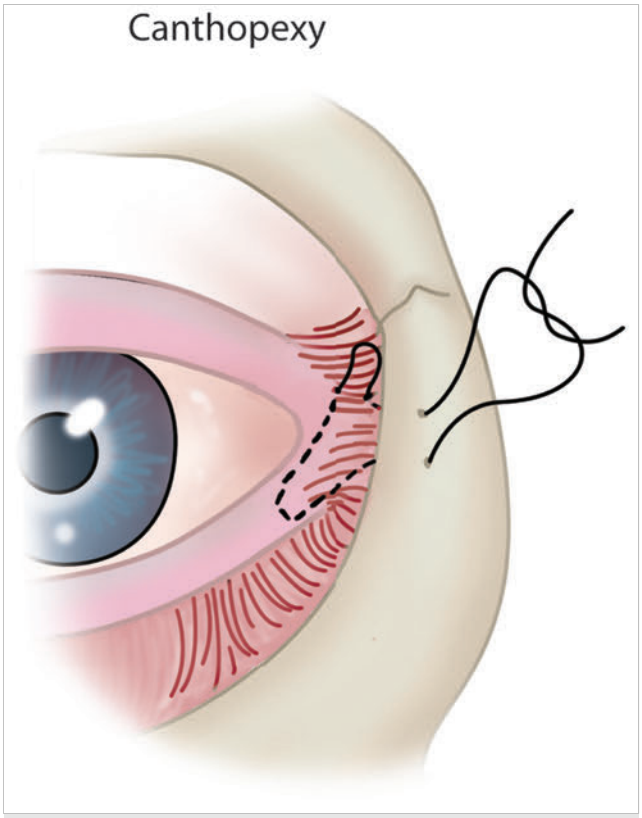

Fig. 18.4 Lateral canthopexy. The lower eyelid is supported without shortening of the lid.

18.5 Critical Errors

- Failure to return immediately to the operating room when signs of retrobulbar hematoma are present. If the operating room is not available, a lateral canthotomy and cantholysis must be performed at bedside.
- Failure to appropriately diagnose etiology of ectropion (senile, paralytic, cicatricial, congenital) and establish an appropriate means of treatment.
- Failure to reinsert the lateral canthus appropriately with permanent suture fixation.

19 Rhinoplasty

Amy M. Moore & Albert S. Woo

Fig. 19.1 (a-c) A 23-year-old woman presents to your office with concerns about the appearance of her nose.

19.1 Description

- Young woman with prominent dorsal hump.
- The nose is long and narrow, without significant deviation.
- The nasal tip is well defined, with some prominence of the cephalic margins of the lower lateral nasal cartilage.
- The nasolabial angle (columella to upper lip) is acute (< 90 degrees).

19.2 Work-up

19.2.1 History

- Identify specific concerns with appearance of nose.
- Difficulty with breathing or history of snoring.
- Prior nasal surgeries or smoking history.
- Motivating factors: Personal (internal) desire or external pressure.

19.2.2 Physical examination

- Evaluate patient in front of a mirror.
- Identify skin type, skin thickness, symmetry, and balance of facial aesthetic units.
- Describe external nose by assessing frontal view, lateral view, and base view.
- Frontal view: Allows assessment of balance, symmetry, shape, and tip contour, including the following: nasal bones and width, dorsal aesthetic lines, nasal deviation, contour irregularities, upper and lower lateral cartilage irregularities, alar width
  - Tip assessment: Evaluate bulbosity, tip-defining points, alar shape, nostril size and shape.
- Lateral view: Allows assessment of nasal length, dorsum, tip, projection, rotation, alar–columellar relationship, radix height, frontonasal angle, chin projection, and anthropomorphic landmarks
  - Critical angles are the nasolabial angle (90 to 100 degrees in women, 90 degrees in men) and frontonasal angle (115 to 130 degrees).
  - Hypoplastic/retruded chin: May affect overall balance of face. Can consider concurrent genioplasty.
- Base view: Allows assessment of nostril shape and size, columellar width, alar base width, length of medial crura, curvature of lateral crura, alar lobule thickness, septal position
  - Ideal base view is an isosceles triangle in which the upper third is tip lobule and lower two-thirds is columella/nare.
- Internal examination: Includes evaluation of the nasal septum, internal and external nasal valves, turbinates, and lining
  - Cottle maneuver and examination with vasoconstriction should be performed to assess for airflow.

19.2.3 Pertinent imaging or diagnostic studies

- Photographic documentation during preoperative consultation is advocated.
- Photograph face and nose in the anteroposterior, lateral, worm's-eye, and bird's-eye views.

19.3 Treatment

- Open approach: Most common technique
  - Access is achieved with a transcolumellar (stair-step or inverted-V incision extending into inferior margins of the lower lateral nasal cartilage.
  - Allows direct access to the septum (for cartilage harvest/septoplasty) by separating the lower lateral nasal cartilages and accessing the septum via the anterior septal angle.
- Closed approach: Less commonly used and criticized for decreased visualization and control during the procedure
  - Access to the cartilages may be established through intercartilaginous, transcartilaginous, or marginal incisions without the transcolumellar component.
  - Septum may be approached with transfixion, hemitransfixion, or Killian incisions.
- Techniques to consider
  - Dorsum/radix
    - Reduction: Dorsal humpectomy with rasping of bone and excision of redundant cartilage.
    - Augmentation: cartilage graft (crushed or diced cartilage, which may be wrapped in temporoparietal fascia or Surgicel [Ethicon 360, Somerville, NJ] for additional control of material), AlloDerm (LifeCell, Bridgewater, NJ) graft and bone graft.
  - Spreader grafts: Beneficial to open internal valve, close open roof deformity, and add support to the nasal dorsum.
  - Septal resection: Must leave an L-strut of at least 1 cm to preserve adequate septal support. Perform only after hump reduction to prevent over-resection of the cartilage.
  - Lower lateral cartilages: Cephalic trim may be performed leaving 8 mm of cartilage.
  - Tip shaping: Columellar strut graft (prevents loss of tip projection), transdomal and interdomal sutures (to narrow the nasal tip), tip graft (for additional nasal tip projection).
  - Osteotomies: Lateral "low-to-high" osteotomies typically performed to narrow a wide nasal base (with infracture). Medial osteotomies as needed. May be performed internally through nasal mucosa with protected-tip osteotomes, or externally with a 2-mm osteotome through the skin.
  - Inferior turbinates: May be outfractured, crushed, or resected to improve nasal airway.
- Cartilage grafting: Donor sites include nasal septum, ear, and rib.
- Postoperative splinting
  - Internal: Petroleum gauze nasal packings, Doyle (silicone) splints.
  - External: Denver (aluminum) splints, Aquaplast (Medco, Tonawanda, NY) mold.

19.4 Complications

- Septal hematoma: Needs immediate drainage to prevent septal necrosis.
- Malpositioned cartilage grafts.
- Open roof deformity from aggressive over-resection/rasping of bony dorsum.
- Saddle nose deformity from overly aggressive septal resection, lack of dorsal support.
- Pollybeak deformity may result from inadequate reduction of the dorsum or decreased nasal tip projection due to loss of support.

- Over-reduction of nasal tip structures can lead to alar pinching, lateral nasal wall collapse, retracted ala and/or retracted columella.
- Inverted-V deformity from disruption of the upper lateral cartilages from the dorsal septum and nasal bones with failure of restabilization.
- Prominent scarring or infection.

19.5 Critical Errors

- Inadequate preoperative assessment and planning.
- Lack of appreciation of patient physical characteristics.
- Lack of coherent operative plan.
- Failure to evaluate structures of the face other than nose (i.e., retruded chin).

20 Facial Paralysis

Alison K. Snyder-Warwick & Thomas H. H. Tung

Fig. 20.1 A 6-year-old boy presents with inability to smile on left side, present since birth

20.1 Description

- Complete left-sided facial paralysis.
- Facial asymmetry: Left palpebral fissure widening, left nasolabial fold effacement, right-sided deviation of Cupid's bow, and inferior malposition of the left oral commissure, which demonstrates no movement with smiling.
- The child has a fairly balanced brow position and minimal external nasal valve asymmetry.

20.2 Work-up

20.2.1 History

- Onset of symptoms
  - Congenital or acquired.
  - Acute, subacute, or chronic.
- Duration and rate of progression.
- Complete or incomplete; unilateral or bilateral.
- Associated syndromes or syndromic features.
- Associated symptoms: Headaches, blurred vision, dry eyes, vertigo, hearing loss, otorrhea, oral incompetence, speech difficulties, snoring, nasal obstruction.
- History of the following: Trauma; infection (Bell palsy, Ramsay Hunt syndrome, Lyme disease, tuberculosis); neuromuscular disease (myasthenia gravis, Charcot-Marie-Tooth disease, Guillain–Barré syndrome); tumors (neurofibromatosis type 2); diabetes; travel history; pregnancy; family history; surgical history (otologic, rhytidectomy, parotidectomy).

20.2.2 Physical examination

- Perform complete head, neck, and cranial nerve examination.
- Examine all branches of the facial nerve.
  - Temporal (frontal): Elevation of forehead.
  - Zygomatic: Closure of orbicularis oculi.
  - Buccal: Elevation of cheek and oral commissure.
  - Marginal mandibular: Depression of oral commissure and lower lip.
  - Cervical: Contraction of platysma.
- Eyes: Evaluate eye closure, vision, corneal defects, ectropion.
  - *Schirmer test* (see Case 18).
  - *Bell's phenomenon* (see Case 18): If absent, greater concern for corneal injury.
- Evaluate facial movements at rest and in multiple different expressions.
  - Assess midline deviation, measure amount of excursion with movement.
  - Assess brow movement, nasal valve function, and *synkinesis* (involuntary contraction of additional facial muscles with voluntary facial movement due to aberrant neuroregeneration).
- Assess overall muscle status (hypertonic, normal, or atrophic), voluntary and involuntary movements (synkinesis, fasciculations).

20.2.3 Pertinent imaging or diagnostic studies

- Vary by case.
- Hematologic work up: Complete blood cell count (evaluate for infection, leukemia), Lyme titer.
- Temporal bone computed tomography.
- Magnetic resonance imaging: To evaluate brain, facial nerve, or parotid glands.
- Biopsy: Facial nerve, lip (for salivary tumors), fine needle aspiration of parotid mass.
- Electrodiagnostic studies: Nerve conduction studies, electromyography (EMG).
- Electroneurography (ENoG): Compares amplitude of summation potentials of paralyzed side of face with that of normal side.

20.2.4 Consultations

- Depends upon situation: Possibilities include ophthalmology, otology, neurology, psychiatry, speech, physical and occupational therapy, and/or psychology.

20.3 Treatment

20.3.1 Nonsurgical management

- *Steroid* treatment for idiopathic, autoimmune, or certain traumatic injuries.
- Corneal protection
  - *Lubrication*, especially at night, with eye ointment to prevent injury and drying.
  - Eye patch when necessary.
- Antibiotics or *antivirals* for specific infections, if identified.
- For *Bell's palsy*, steroid course and valacyclovir (Valtrex; GlaxoSmithKline, Philadelphia, PA) within 10 days of symptom onset.
- Neuromuscular retraining
  - To facilitate symmetric movements and minimize undesired gross motor activity (e.g., synkinesis).
  - Mirror training, negative biofeedback, stretching exercises, massage.
- Chemodenervation: Helps to minimize undesired movements and helps to achieve facial symmetry
  - Useful for management of unilateral marginal mandibular branch paralysis.

20.3.2 Surgical management

Goals: Corneal protection, normal resting tone, oral competence, symmetric smile

Determinants of treatment

- Duration of injury/presence of motor end units.
- Nature and extent of injury/insult.

Acute repair following nerve injury

- Direct nerve repair: Acceptable if tension-free coaptation is possible in the acute period (ensure outside of any zone of injury).
- Interpositional nerve grafting: Should be performed if tension-free coaptation not possible
  - Donor site options: Sural (reversed to prevent branching), split sural, great auricular.
  - Useful in planned oncologic facial nerve resections.
- **Cross-facial nerve grafting** from contralateral facial nerve (cranial nerve VII) to one or more branches of injured nerve to reinnervate acute unilateral palsy
  - Can be performed only if early reconstruction and if opposite side is completely normal.
  - In delayed reconstruction, motor end units are not functional after 12 to 24 months, and a free muscle transfer is required (see below).

Options for delayed surgical reconstruction

- **Static slings:** Provide resting symmetry only
  - Tensor fasciae lata, temporoparietal fascia, palmaris, plantaris, dermal allograft.
- **Regional muscle transfers** (temporalis muscle sling or masseter muscle transfer)
  - Avoids free tissue transfer and allows dynamic movement.
  - Patient must consciously bite down on affected side to smile.
- **Free muscle transfer** for dynamic movement (two main options for innervation source)
  - Cross–facial nerve graft with free muscle transfer (two-stage procedure)
    - Stage 1: Sural nerve graft sutured to redundant branches of cranial nerve VII on unaffected side. Ends are banked in upper lip of affected side.
    - Stage 2: Free muscle transfer driven by cross–facial nerve graft. Performed ~ 9 to 12 months later (follow Tinel sign in nerve graft to determine readiness for free muscle transfer).
    - Most commonly used innervation source for free muscle transfer in facial reanimation.
    - Can provide spontaneous smile without muscle retraining.
  - Single-stage free muscle transfer driven by ipsilateral masseteric branch of cranial nerve V
    - Gaining increasing acceptance.
    - Patient must consciously bite down to obtain smile. Reports exist of spontaneous smile development over time, especially in younger children with greater plasticity of the brain.
  - Donor muscles: *Gracilis*, latissimus, pectoralis minor, serratus.
  - Other possible donor nerves: Partial XII, partial XI.
  - Access achieved with facelift–type preauricular incisions extending past earlobe for a short distance along posterior border of mandible.
- Other symmetry procedures
  - *Platinum weights* placed in upper eyelid to allow eyelid closure.
  - *Canthopexy/canthoplasty* to improve paralytic lower eyelid ectropion.
  - Browlift (endoscopic, open, or direct browlift above eyebrow) to improve brow ptosis due to paralysis.
  - Chemodenervation, rhytidectomy, myomectomy can be performed to aid in facial symmetry.
- **Postoperative care:** Physical therapy, including muscle retraining, may optimize outcomes. Oral commissure splints may be used to prevent descent in the early postoperative period.

20.4 Complications

- Facial nerve reconstruction is challenging and, even with the best techniques, does not result in a complete restoration of facial function and movement.
  - Asymmetry (static/dynamic) and poor muscle function are common findings after reconstruction.
- Hematoma: As in facelift procedures, patients should be returned to the operating room immediately for evacuation.
- Synkinesis and dyskinesis are common findings during nerve regrowth following injury and may not necessarily be avoidable.
- Disinsertion of muscle.
- Nerve graft or flap failure.

20.5 Critical Errors

- Establishing unrealistic expectations.
- Failure to address concerns about eyelid closure and prevention of corneal abrasions and xerophthalmia.
- Inadequately educating patient regarding options and procedures.
- Failure to evaluate etiology of paralysis.
- Failure to promptly return to operating room if hematoma develops or if there is concern for free flap failure.

Part 5

Section V. Foot and Lower Extremity Reconstruction

5

21 Open Wound: Upper Third of Leg

Leahthan Domeshek & Thomas H. H. Tung

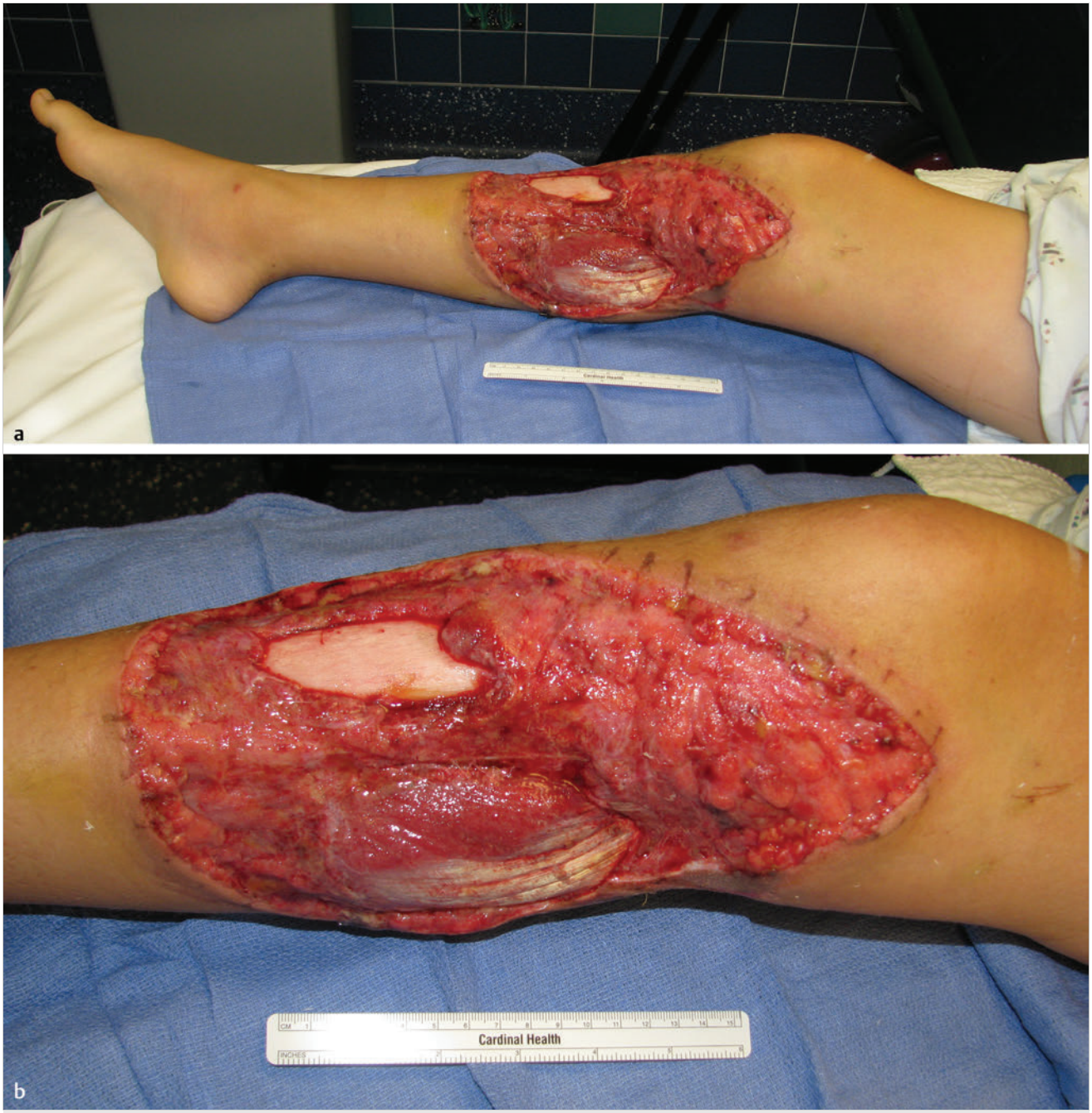

Fig. 21.1 A 15-year-old girl presents following an all-terrain vehicle (ATV) accident with soft-tissue injury to the right leg.

21.1 Description

- Open wound involving the proximal half of the right lower extremity
  - The proximal third of the anterior tibia is exposed with no evidence of periosteum. However, no clear fracture of the bone is visible.
  - The medial gastrocnemius muscle is exposed.
  - Tissue loss is present over the proximal half of the anterior–medial right leg measuring ~ 25 cm in length (based on visible ruler).

21.2 Work-up

21.2.1 History

- Etiology
  - Traumatic: Mechanism of injury. Evaluate for concomitant injuries.
  - Tumor resection: Extent of resection.
  - Chronic: Etiology of wound and history of previous management.
- Age, comorbidities (diabetes, peripheral vascular disease, coronary artery disease, smoking history), nutritional status, steroid use, history of radiation treatment.

21.2.2 Physical examination

- In trauma cases, evaluate ABCs, use ATLS protocol.
- **Gustilo classification** of open tibial fractures (▶ Table 21.1).
- Vascular status: Pulses, temperature, color, turgor, ankle-arm indices.
- Neurologic examination (especially sensation on plantar surface of foot).
- Evaluate for compartment syndrome.

Table 21.1 Gustilo classification of open tibial fractures

Grade	Wound	Bony injury
I	< 1 cm, clean, minimal soft-tissue injury	Simple, with minimal comminution
II	> 1 cm, moderate contamination, moderate soft-tissue injury	Moderately comminuted fracture
III A	< 10 cm, crushed tissue and/or contamination; local coverage usually possible	Significant contamination or segmental bone loss, possible vascular injury, highly contaminated wound, high-velocity injury
III B	> 10 cm, crushed tissue and/or contamination; inadequate soft tissue; *requires regional or free flap*	As above
III C	Major vascular injury requiring repair for limb salvage; amputation necessary in some cases	As above

21.2.3 Pertinent imaging or diagnostic studies

- Plain films: Evaluation of bony injuries.
- Arteriography: Emergent if vascular status threatened or elective if plan for free flap.

21.2.4 Consultations

- Vascular surgery: If vascular repair required and surgeon does not have microvascular expertise.
- Orthopedic surgery: Management of bony injury.

21.3 Treatment

21.3.1 Principles of lower extremity reconstruction

- Débridement
  - Remove all devitalized, contaminated, and infected tissue.
  - Multiple débridements may be necessary before coverage.
- Fixation
  - Internal fixation: Closed fractures and low-energy open fractures
    - Intramedullary rods or plate fixation.
  - External fixation: Severe comminution, extensive soft-tissue damage, poor bone stock, or segmental bone loss
    - External fixator or Ilizarov distractor for stabilization/treatment.
    - May place antibiotic spacer beads if bone gap and contamination are present. These will need to be replaced with a bone graft at a later time.
- Temporizing measures
  - Vacuum-assisted closure (VAC) or temporary dressing: Useful between débridements before definitive coverage procedure.
  - Definitive reconstruction may be performed once achieve adequate debridement, patient is stable, and reconstructive plan complete.

21.3.2 Soft-tissue reconstruction (upper third of leg)

- Skin graft: Healthy vascularized bed necessary for adequate take.
- Pedicled muscle flap
  - Gastrocnemius muscle flap
    - Workhorse for reconstructing upper third of leg.
    - Muscle is split at midline. The medial head (larger) or lateral head or both may be used.
    - Supplied by medial (medial head) and lateral (lateral head) sural arteries, which arise from the popliteal artery and enter distal and deep to muscle origin. Coverage with split-thickness skin graft.
  - Tibialis anterior
    - Important for ankle dorsiflexion and thus not expendable.
    - Split and used as bipedicled flap (preserves function).
    - Supplied by perforators from anterior tibial artery.
  - Proximally based soleus muscle
    - Supplied by popliteal artery, posterior tibial artery, and peroneal artery

- Distally based vastus lateralis muscle
  - Based on the descending branch of the lateral circumflex femoral artery
  - Less reliable
- Free flap
  - If extensive, soft-tissue trauma precludes use of local muscle flaps.
  - Muscle (latissimus, rectus, gracilis) or fasciocutaneous flaps (anterolateral thigh).

21.3.3 Bony reconstruction

- Management of bone gaps
  - Nonvascularized cancellous bone graft: For defects < 6 cm. Important to ensure healthy, vascularized soft-tissue coverage for graft survival.
  - Vascularized bone graft: For defects > 6 cm. Free fibula flap commonly used.
  - Distraction osteogenesis: For defects > 2 cm.

21.3.4 Amputation

- If extremity cannot be salvaged (complete disruption of posterior tibial nerve, crush injuries with warm ischemia times > 6 hours, serious associated life-threatening injuries).
- Loss of sensation to plantar surface of foot signifies poor prognosis for functional recovery.

21.4 Complications

- Chronic osteomyelitis: Requires radical débridement, removal of infected hardware, closure of dead space with well-vascularized tissue (muscle flap), and long-term antibiotics (6 weeks after débridement and closure).
- Flap loss: May require another flap, if possible. Amputation remains an option.
- Fracture nonunion/malunion: Débridement, bone grafting, and fixation.

21.5 Critical Errors

- Failure to adequately débride nonviable or infected tissue.
- Not having a complete plan for both soft-tissue and bone reconstruction.
- Unnecessary delay in treatment. This will increase the chance for osteomyelitis and poor outcome.
- Inadequate management of complications.
- Failure to recognize compartment syndrome.

22 Open Wound: Middle Third of Leg

Louis H. Poppler & Terence M. Myckatyn

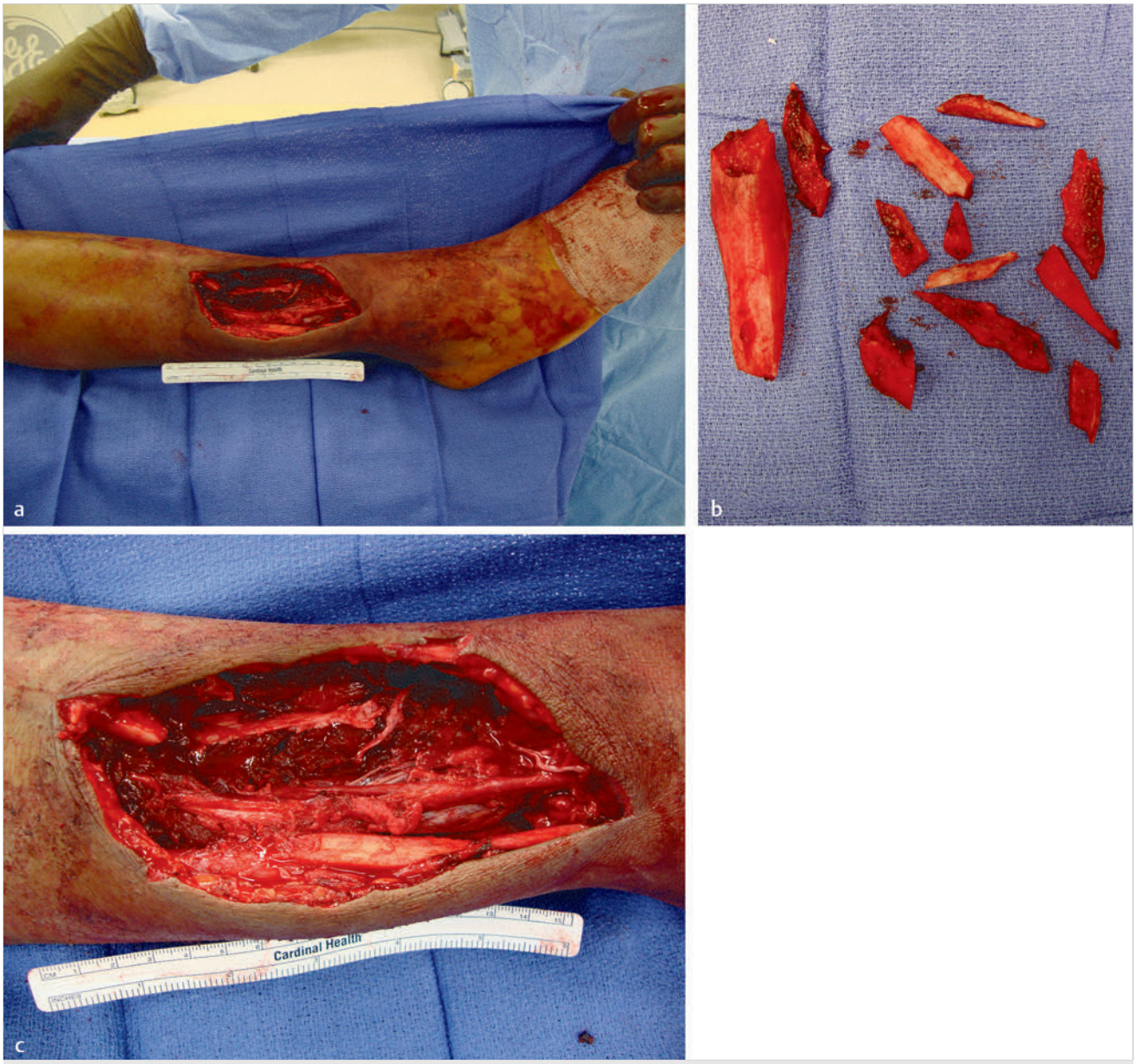

Fig. 22.1 A 20-year-old man presents to the emergency department after being shot in the right leg, with resulting tibial bone loss, fibula fracture, and transection of the anterior tibial and peroneal arteries .

22.1 Description

- Open wound of the middle third of the right leg
  - Gustilo grade III C (see ▶ Table 21.1): Severely comminuted bone and soft-tissue defect with vascular compromise.
  - A 35 × 20-cm soft-tissue defect, and a 16-cm tibial bicortical bony defect.

22.2 Work-up

22.2.1 History

- Etiology
  - Traumatic: Mechanism of injury. Evaluate for concomitant injuries.
  - Tumor resection: Extent of resection.
  - Chronic: Etiology of wound and history of previous management.
- Comorbidities of prognostic significance
  - Peripheral vascular disease, cardiovascular disease, diabetes, smoking history, nutritional status, steroid use, radiation treatment.

22.2.2 Physical examination

- In trauma cases, evaluate ABCs (airway, breathing, circulation).
- Wound assessment
  - Soft-tissue damage: Size of wound, depth, zone of injury.
  - Degree of contamination, exposure of vital structures.
  - Vascular supply to lower extremity, extent of bony defect.
- Vascular examination
  - Examine pulses, temperature, color, turgor.
  - Ankle–arm index (AAI) measurements, Doppler examination.
- Neurologic examination: Check for peroneal or tibial nerve injuries.
- Rule out *compartment syndrome.*
  - Compromised neurovascular status.
  - Pain out of proportion to injury on flexion and extension of extremity.
  - Compartment pressures > 30 mm Hg.

22.2.3 Pertinent imaging or diagnostic studies

- Plain films: Evaluation of bony injuries.
- Arteriography: Emergent if vascular status threatened; elective procedure if plan for free flap reconstruction.

22.2.4 Classification: When the injury involves a fracture

- Gustilo classification system of open tibial fractures (see ▶ Table 21.1).

22.3 Treatment

22.3.1 Initial management

- Stabilize fracture.
- Restore vascular inflow, if necessary.
- Assess compartments and perform fasciotomies when required.
- Débride and wash out wound until ready for reconstruction.
  - Serial débridement usually required.
  - Vascular structures require immediate coverage.

22.3.2 Timing of reconstruction: Three phases of wound progression

- Acute (1 to 5 days): Contaminated but not infected, edematous, hemorrhagic.
- Subacute (1 to 6 weeks): Colonized, infected, bony demarcation still not clear.
- Chronic (> 6 weeks): Granulating, contracting wound; infection limited to scar; bony demarcation clear.
- *Early definitive reconstruction* (< 72 hours, according to Godina) has the lowest flap failure rates, lowest postoperative infection rates, and fastest time to bony union in the pre-negative pressure wound therapy (NPWT) era.

22.3.3 Soft-tissue reconstruction

- Surgical reconstruction of soft-tissue wounds divides leg into three zones.
  - Upper third (see Case 21).
  - **Middle third.**
  - Lower third (see Case 23).
- Direct closure: Remains an option in simple injuries with adequate tissue.
- Skin graft: Healthy vascularized bed necessary for adequate take
  - Should not perform over vital structures, such as nerves, vessels, and bone.
- Local muscle flaps
  - Gold standard for reconstruction of defects of middle third of lower extremity
    - Covered with skin graft.
  - Soleus muscle flap
    - Workhorse flap for middle third defects.
    - Can be split longitudinally (hemisoleus) for smaller defects in which the entire muscle is not needed for reconstruction.
    - Supplied by branches of popliteal artery, posterior tibial artery, and peroneal artery.
  - Gastrocnemius flap
    - May be useful in middle third defects, although most commonly used for reconstruction of proximal third (see Case 21).
    - Muscle can be divided into medial (larger) and lateral heads.
  - Flexor digitorum longus: Will cover only small defects in lower half of middle third.
  - Extensor digitorum longus: Can cover defects < 5 cm in size.

- Extensor hallucis longus/flexor hallucis longus: Can cover only very small wounds.
- Tibialis anterior: Can be taken as a whole or longitudinally split for coverage of smaller defects. Significantly functional donor morbidity.

- Free tissue transfer (see Case 23)
  - Remains an option for coverage of large or complex defects that cannot otherwise be managed with local or regional flaps.
- Integra (bilayered dermal substitute; Integra LifeSciences, Plainsboro, NJ)
  - Has been used successfully for coverage of clean, stabilized, well-vascularized wounds with exposed vital structures.
  - Outer silicone layer is removed, and a thin skin graft is used to cover the newly vascularized material roughly 2-3 weeks following initial application.
  - May serve as a salvage measure when other procedures have failed.

22.3.4 Bony reconstruction

- If there is a bony defect, bone reconstruction must be performed first.
  - Essential elements of osseous healing are good blood supply and stabilization.
  - Broken fragments distal to a fracture rely entirely on periosteal blood supply until entry of the metaphyseal vessels. *Preserve periosteum* wherever possible.
- Options for bone gap reconstructions
  - Nonvascularized bone graft: Not recommended for defects > 6 cm, although successful reports of up to 10 cm have been described. An intact fibula keeps extremity at length.
  - Free osseous or osteocutaneous flap transfer: Indicated for defects > 6 cm
    - Common choices: Fibula, iliac crest, scapula.
  - Distraction osteogenesis (Ilizarov method): Can be used for bone gaps up to 12 cm. During distraction, soft-tissue defect may be grafted, covered with a flap, or managed with local wound care.
    - Requires patience and patient compliance.

22.4 Complications

- Infection (cellulitis, osteomyelitis, hardware infection).
- Flap loss/exposure of bony hardware.
- Nonunion/malunion of fracture.
- Vascular compromise.
- Compartment syndrome.

22.5 Critical Errors

- Inability to recognize and débride all devitalized tissue.
- Failure to obtain adequate stabilization.
- Delay in obtaining stable soft-tissue coverage.
- Failure to recognize compartment syndrome.
- Performing vascular or nerve reconstruction within the zone of injury.

23 Open Wound: Lower Third of Leg

Santosh Kale & Thomas H. H. Tung

Fig. 23.1 A 35-year-old man presents with an open wound to the left leg following a high-speed motorcycle accident. He has undergone open reduction/internal fixation (ORIF) of left tibia and fibula fractures.

23.1 Description

- Gustilo grade III B (see ▶ Table 21.1) open bilateral malleolar fracture with exposed distal tibia and hardware.
- Full-thickness defect of the medial distal third of leg with inadequate soft-tissue coverage.

23.2 Work-up

23.2.1 History

- Mechanism of injury/etiology of wound (traumatic, oncologic, vascular insufficiency, other).
- **Medical comorbidities:** Cardiopulmonary or peripheral vascular disease, diabetes, obesity, hematologic disorders, nutritional status, collagen/vascular disorders, steroid use.
- *Tobacco* use.
- Preoperative *functional status.*
- Support network.

23.2.2 Physical examination

- Primary survey
  - Airway, breathing, circulation.
  - Assess for vascular compromise.
  - Distal pulses.
- Secondary survey
  - Concomitant injuries.
  - Extent of lower extremity injury: Neurologic and musculotendinous examinations.
  - Assess exposed structures: Nerves, vessels, joints, tendons.
- Potential donor sites.
- Fractures: **Gustilo classification system** of open tibial fractures (see ▶ Table 21.1).

23.2.3 Pertinent imaging or diagnostic studies

- Plain films: Including one joint above and one below site of injury.
- Angiography
  - Emergent setting: If concern for vascular compromise.
  - Subacute setting: If no vascular compromise, to evaluate zone of injury and vascular access for reconstruction.

23.2.4 Consultations

- Trauma surgery, orthopedic surgery, vascular surgery (if vascular injury).

23.3 Treatment

- Treatment of emergent and life-threatening issues during primary survey.

23.3.1 Acute management

- Fracture stabilization.
- Restoration of vascular inflow (if indicated).
- **Fasciotomies** (if indicated): Maintain high suspicion for compartment syndrome.
- **Wound irrigation and débridement:** Thorough débridement is paramount to successful reconstruction. May require multiple sessions to achieve clean wound bed.
- Coverage of vital structures (nerves, vessels, bone).
- Infection control
  - Irrigation and débridement.
  - Antibiotic coverage.

23.3.2 Bony reduction and stabilization

- Immobilization with cast, internal or external fixation.
- Management of bony gaps
  - Defects up to 6 cm: May be managed by nonvascularized bone graft under muscle flap.
  - Defects > 6 cm: Require vascularized osseous (or osteocutaneous) flap (e.g., free fibula).
  - Defects 10 to 12 cm: Distraction osteogenesis. Not commonly used in setting of trauma.

23.3.3 Soft-tissue reconstruction

- Goal: Stable soft tissue coverage with minimal donor morbidity.
- Donor tissues and any vascular anastomoses should be outside zone of injury.
  - May require vein grafts.
- Eradicate infection before reconstruction.
- **Reconstructive ladder**
  - Primary closure: Typically not applicable.
  - Healing via secondary intention ± negative-pressure wound therapy (NPWT).
  - Skin grafting: If appropriate recipient bed, potentially applicable after NPWT.
  - Bilaminate neodermis (Integra; Integra LifeSciences, Plainsboro, NJ): If clean wound bed and only very small area of exposed bone/tendon/vasculature.
  - Local/regional flaps
    - Consider reverse sural artery flap, dorsalis pedis flap, FHL (flexor hallucis longus), tibialis anterior.
  - **Free tissue transfer** (gold standard for wounds of lower third of leg)
    - Muscle with split-thickness skin graft (i.e., latissimus, rectus abdominis, serratus anterior, gracilis).
    - Musculocutaneous (i.e., latissimus, parascapular, TRAM [transverse rectus abdominis myocutaneous]).
    - Fasciocutaneous (i.e., anterior lateral thigh [ALT], radial forearm).
    - Osteocutaneous (i.e., fibula).
- Amputation: Remains a final option
  - Severely traumatized extremity
    - Involvement of three or more compartments.
    - Multilevel or severe vascular injury.
    - Severe crush or loss of muscle.
  - Posterior tibial nerve transection.
  - Failed vascular reconstruction.
  - Medical comorbidities.
  - Patient unwilling to undergo necessary rehabilitation with reconstruction.

23.4 Complications

- Infection.
- Flap loss: partial or complete.
- Lower extremity vascular compromise.
- Bony nonunion/malunion.

23.5 Critical Errors

- Microvascular anastomosis within zone of injury
  - Long pedicle or vein grafts may be required to avoid this complication.
- Infection
  - Avoid with adequate débridement of *soft tissues and bone*, removal of infected hardware, and prompt reconstruction.
- Lower extremity vascular compromise
  - Avoid by investigating vascular supply to distal extremity after injury, using end-to-side anastomosis if single vessel perfusion to foot, and establishing appropriate inflow (vascular intervention).

24 Foot and Ankle Reconstruction

Justin B. Cohen

Fig. 24.1 A 36-year-old man presents to the emergency department following a gunshot wound to his right foot.

24.1 Description

- Roughly 11 × 7 × 3-cm open wound to the plantar surface of the right foot.
  - Encompasses .large aspect of weight-bearing surface.
  - Likely tendinous and bony disruption.
  - Exposed metatarsal heads.
  - Wound appears clean and well perfused with viable tissue proximally and distally.

24.2 Work-up

24.2.1 History and physical examination

- Obtain patient's baseline functional and ambulatory status.
- Determine medical comorbidities.
  - Vascular disease, smoking, nutritional status, immunosuppression, renal disease, autoimmune disease, radiation, coagulopathy.
- Assess for evidence of impaired peripheral blood flow.
  - Palpation and Doppler examination of dorsalis pedis and posterior tibial arteries, check of capillary refill, pulse oximeter reading on each toe to assess viability, observation of bleeding wound edges.
- Motor and sensory examination to assess extent of injury.
- Tetanus status.

24.2.2 Pertinent imaging or diagnostic studies

- Redundancy to evaluate bony framework and possible foreign bodies (i.e., bullet fragments).
- Consider angiography for possible vascular injury and preoperative surgical planning.
  - Magnetic resonance angiography and computed tomographic angiography are additional options when the patient is not a candidate for an invasive interventional procedure with contrast dye injection under general anesthesia.
  - Renal status may be pertinent to deciding the appropriate modality.

24.2.3 Consultations

- Trauma evaluation.
- Orthopedic surgery, for management of bony injury.
- Vascular surgery, if vascular inflow is a concern.

24.3 Treatment

24.3.1 Acute management

- Thorough operative irrigation and débridement performed emergently
  - All nonviable tissue needs to be removed and sharply débrided.
  - Copious irrigation and removal of foreign bodies.
  - Careful examination of the extent of the wound (under tourniquet).
  - Consider wound vacuum-assisted closure (VAC) placement between procedures.
  - Repeat wound exploration and débridement after 48 hours.
- Preoperative antibiotics to reduce risk for wound infection.
- Appropriate management of fractures as indicated.
- Definitive closure only after wound is clean and bony stabilization is obtained
  - Stable biomechanical alignment is the first goal of acceptable foot function.

24.3.2 Surgical algorithm

- Simple closure is frequently *not* possible because of wound size.
- Closure by secondary intention or skin grafting is *not* a good option because of the exposed critical structures and the location on the weight-bearing surface.
- The plantar surface needs to be able to tolerate significant repetitive weight bearing and shear forces. Form, function, and aesthetics must be considered.
  - The ability to wear a normal shoe is a significant consideration.
  - Durable skin coverage with solid attachment to deeper structures is essential.
- Local flaps
  - Limited by their size.
  - Length-to-width ratio should not exceed 1:1.5 in the lower extremity.
  - Flaps should be designed outside the zone of injury.
- Pedicled flaps
  - Mathes-Nahai classification of muscle flaps (▶ Table 24.1).
  - Often provide only small amounts of tissue and leave significant donor defects.
  - Few good muscle flaps exist in the lower extremity because most are type IV and have segmental minor pedicles.
  - Small defects (< 6 cm^2) can be reconstructed with type II muscles, such as abductor hallucis brevis, abductor digiti minimi, and flexor or extensor digitorum brevis flaps.
- Fasciocutaneous and cutaneous flaps are more useful on non–weight-bearing portions of the foot.
- Pedicled flaps include medial plantar, lateral calcaneal, dorsalis pedis, and fillet of toe flaps.

Table 24.1 Mathes-Nahai classification of muscle flaps

Type	Vascular pedicle	Example
I	One vascular pedicle	Tensor fasciae latae, gastrocnemius
II	Dominant pedicle(s) and minor pedicle(s)	Gracilis, soleus, trapezius
III	Two dominant pedicles	Gluteus maximus, rectus abdominis, serratus, temporalis
IV	Segmental vascular pedicles	Sartorius, tibialis anterior
V	One dominant pedicle and secondary segmental pedicles	Latissimus dorsi, pectoralis major

- Free microvascular flaps
  - Frequently used option for reconstruction.
  - Success rate is high (> 90%). However, failure usually entails complete loss of the flap.
    - Foot is typically reconstructed with free muscle flaps and split-thickness skin graft (STSG) or fasciocutaneous flaps.
    - End-to-side arterial anastomoses with two venous outflows are preferable to optimize distal blood flow to foot.
  - Free muscle flaps with STSG provide well-vascularized tissue to the wound bed.
    - Microvascular muscle flaps include gracilis, rectus abdominis, serratus anterior, latissimus dorsi (less often used because of increased morbidity with crutch walking).
  - Microvascular fasciocutaneous flaps include radial forearm, anterolateral thigh, scapular, and parascapular flaps.
  - Postoperative care is essential, especially for plantar wounds.
    - Elevation of the extremity in the immediate postoperative period to aid in venous drainage.
    - Followed by dangling of the extremity at 1-2 weeks, light weight bearing at 1 month, and full weight bearing at 2 months.
- Amputation remains a reasonable option, especially in patients who are poor candidates for extensive reconstruction or who may not be able to tolerate a long rehabilitation period.
  - Transmetatarsal amputation (TMA) maintains significant limb functionality by preserving the midfoot, distal to the ankle joint.
    - May provide adequate skin for direct closure.
  - Chopart amputation removes the forefoot and midfoot, preserving the talus and calcaneus.
  - Syme amputation includes ankle disarticulation and removal of malleoli.

24.4 Complications

- Infection.
- Hematoma.
- Flap loss (partial or complete)
  - Local flaps tend to undergo partial necrosis (usually at the critical, most distal edge). Flaps should be designed to be larger than necessary to minimize tension.
  - Free flap loss is most likely complete and will require débridement and closure with VAC, local flap, or another free flap.
- Free flap: Vessel thrombosis or compromised arterial flow
  - Patient must be taken back to the operating room for exploration *immediately.*
  - Vascular complications can be due to underappreciated zone of vascular injury, endothelial disruption, baseline vascular disease, and increased thrombogenicity secondary to trauma.
- Hyperkeratosis at the border of the flap and normal tissue can be managed with secondary Z-plasties or keratinolytic shavings.

24.5 Critical Errors

- Choosing a poor flap, especially a local flap that cannot adequately cover the defect.
- Designing a free flap with microvascular reconstruction within the zone of injury.

Part 6

Section VI. Breast

25 Breast Cancer Reconstruction

Jessica M. Belz, Albert S. Woo, & Thomas H. H. Tung

Fig. 25.1 A 43-year-old woman with a history of mastectomy for left breast cancer desiring breast reconstruction.

25.1 Description

- Absence of the left breast with well-healed transverse mastectomy scar
  - Mastectomy skin flaps are tethered to anterior chest wall without evidence of radiation-associated skin changes.
- The right breast has grade I ptosis, good skin tone, and elasticity.
  - There are no striae, discharge, or dimpling.
  - There is a roughly 2-cm well-healed transverse chest wall scar just superior to the right breast, consistent with previous port placement for chemotherapy.

25.2 Work-up

25.2.1 History

- Type, size, and staging of tumor (tumor, node, metastasis [TNM] classification helpful).
- Oncologic surgical technique (e.g., modified radical mastectomy, lumpectomy)
  - If already treated, length of time in remission and any evidence of recurrence.
- History of chemotherapy/radiation therapy, plans for any further treatment.
- Current breast size, desired breast size.
- Family history of breast cancer, including *BRCA* testing (if performed).
- Date and results of most recent mammogram.
- History of smoking/tobacco use.
- Patient's reconstructive desires and expectations.

25.2.2 Physical examination

- *Body mass index (BMI)*: Weight (kg)/[height (m)]^2
  - BMI > 35: Patient is poor candidate for free TRAM (transverse rectus abdominis myocutaneous) reconstruction.
- Mastectomy site deformity: Quality and quantity of skin, presence of radiation changes, location of scar(s).
- Unaffected breast: Size, shape, projection, skin quality, degree of ptosis, presence of masses and lymphadenopathy.
- Overall body habitus and donor site availability.
- Abdominal wall and back scars.

25.2.3 Pertinent imaging or diagnostic studies

- Mammogram (especially if operating on unaffected breast).

25.2.4 Consultations

- General surgery/surgical oncology.
- Medical oncology.
- Radiation oncology (if needed).

25.3 Treatment

25.3.1 Preoperative considerations: Three important decisions

- Timing: *Immediate* versus *delayed* reconstruction
  - Immediate reconstruction may have better cosmetic outcome by allowing skin-sparing mastectomy patterns.
    - Allows reconstruction in reduced number of surgical procedures.
  - Delayed reconstruction may be preferred in certain situations (e.g., autologous reconstruction if adjuvant radiation planned).
- Type: *Prosthetic* versus *autologous* reconstruction
  - Expander/implant reconstruction
    - Ideal candidates are women with small to moderate-sized breasts undergoing bilateral reconstruction.
    - Radiation is a relative contraindication (higher incidence of wound-healing problems, capsular contractures, infections, implant extrusion).
    - *Advantages:* Shorter operations and no donor-site morbidity.
    - *Disadvantages:* Frequent trips to the medical center for fills, longer overall course until final reconstruction.
  - Autologous tissue reconstruction
    - Abdominal tissue is the most common donor site (i.e., pedicled TRAM, free TRAM, DIEP [deep inferior epigastric perforators], and SIEA [superficial inferior epigastric artery] flaps).
    - Other options are latissimus dorsi flap (usually with an implant), superior or inferior gluteal artery perforator flaps, transverse upper gracilis (TUG) flap, Rubens flap (deep circumflex iliac vessels), anterolateral thigh flap.
    - *Advantages:* Breast with more natural look and feel and better symmetry in unilateral procedures.
    - *Disadvantages:* Longer surgery and donor-site morbidity.
- Contralateral breast symmetry: Reduction/mastopexy, augmentation, or neither
  - Contralateral matching procedure, if needed, can be done at the same time or as a second stage.

25.3.2 Surgical considerations

- Expander/implant reconstruction
  - Expander size chosen based on breast width and height.
  - Midline, inframammary fold, and lateral mammary fold marked preoperatively.
  - Skin-sparing or nipple-sparing mastectomy performed. Skin flaps assessed for viability.
  - Expander placed in total subpectoral position or partial subpectoral position with acellular dermal matrix (sutured to inferolateral border of pectoralis major and inframammary fold) covering the inferior aspect.
  - Expander inflated intraoperatively, with the volume based on appearance of skin flaps.
  - Expander filled every 2 to 3 weeks to desired final volume, then overfilled by ~ 30%.
  - After a period of pocket consolidation, patient taken to operating room and expander exchanged for a permanent

implant. Capsule modification can be done to provide optimum shape.

- Autologous tissue reconstruction
  - Pedicled TRAM flap
    - Flap is marked on abdomen, based on ipsilateral or contralateral rectus abdominis muscle, to include periumbilical perforators.
    - Flap is elevated, and zone 4 and part of zone 3 are discarded.
    - Flap is brought through a subcutaneous tunnel and inset into chest wall.
    - If abdominal fascia cannot be closed primarily, mesh is required.
    - A delay procedure (dividing the deep inferior epigastric pedicle) can increase flap reliability in the presence of risk factors like smoking, obesity, and radiation.
    - *Contraindications:* Insufficient abdominal wall tissue or previous subcostal incision that has transected the superior epigastric vessels.
    - *Advantages:* Safe procedure that can be performed relatively quickly.
    - *Disadvantages:* Requires sacrifice of rectus abdominis muscle, which can result in abdominal wall weakness, hernia, and bulges. Bilateral procedure results in decrease in abdominal wall strength.
  - Free TRAM flap
    - Based on deep inferior epigastric vessels.
    - Recipient vessels are thoracodorsal or internal mammary vessels,
    - Muscle-sparing free TRAM decreases abdominal wall morbidity,
    - *Advantages:* Based on dominant vascular system → better blood supply. This results in ability to use larger volumes of tissue and decreased risk for fat necrosis.
    - *Disadvantages:* Technically demanding. Do not consider in patient with morbid obesity (BMI > 35).
  - Free DIEP flap
    - Based on one or two deep inferior epigastric perforators.
    - *Advantages:* Total muscle sparing results in minimal abdominal wall morbidity.
    - *Disadvantages:* Technically demanding.
  - Pedicled latissimus dorsi myocutaneous flap
    - Typically used with an implant.
    - In the presence of previous radiation, provides nonradiated soft-tissue cover for implant.
    - Good option if abdominal wall tissue not available for reconstruction or abdominal wall morbidity not acceptable to patient.

25.4 Complications

- Mastectomy skin flap loss
  - Partial thickness: Can manage with local wound care.
  - Full thickness or risk for implant exposure: Take to operating room, débride, and close.
- Expander infection
  - If cellulitis: Start oral or intravenous antibiotics.
  - If fails to resolve or suspect purulence: Take to operating room for washout and likely implant removal.
- Fat necrosis: Débridement and flap repositioning. Large areas may require another flap or an implant.
- Total flap loss: If pedicle thrombosis picked up early, take to operating room emergently for attempt at salvage.
- Abdominal wall hernia or bulge: Fascial repair or mesh placement.

25.5 Critical Errors

- Recommending prosthetic reconstruction in the presence of radiation.
- Discussing an autologous breast reconstruction option that you do not know very well.
- Inability to manage complications.
- Failure to screen remaining breast for cancer preoperatively.

26 Tuberous Breast Deformity

Jessica M. Belz & Terence M. Myckatyn

Fig. 26.1 A 44-year-old woman requesting correction of breast asymmetry.

26.1 Description

- Tuberous breast deformity on the left
  - High inframammary fold, deficiency of lower medial and lateral quadrants of the breast, enlarged areola with herniation of breast tissue, and grade II nipple ptosis.
- On the right, she has hypomastia with grade II nipple ptosis.

26.2 Work-up

26.2.1 History

- Personal or family history of breast cancer.
- History of prior breast surgeries.
- History of smoking/tobacco use.
- Plan for future childbirth. Anticipated changes in weight.
- Patient goals and expectations.

26.2.2 Physical examination

- Characteristics of tuberous breast
  - Reduced breast diameter, high inframammary fold, deficient skin envelope inferiorly, breast hypoplasia, and herniation of breast tissue through the areola.
- Grolleau classification of tuberous breast deformity
  - Type I: Deficiency of lower medial quadrant.
  - Type II: Deficiency of entire lower pole of breast.
  - Type III: Deficiency of all quadrants.
- Regnault classification of ptosis (▶ Table 26.1).
- Key measurements
  - Distance from sternal notch to nipple, from nipple to inframammary fold; breast base diameter.

26.2.3 Pertinent imaging or diagnostic studies

- Mammogram (if clinically indicated): For example: patient age > 40 years or 10 years prior to age of family member with previous breast cancer history.

Table 26.1 Regnault classification of breast ptosis

Grade	Findings
I	Nipple at inframammary fold
II	Nipple below inframammary fold
III	Nipple at most inferior aspect of breast
Pseudoptosis	Nipple at or above inframammary fold with lower-pole breast ptosis

26.2.4 Consultations

- Psychiatry/developmental psychology: Some patients, especially adolescents, may require intervention given the psychological morbidity associated with this condition.

26.3 Treatment

26.3.1 Staging of reconstruction

- Single-stage procedure
  - Permanent implant placed to correct breast asymmetry.
- Two-stage procedure: Useful when significant deficiency of skin envelope exists
  - Tissue expander initially placed to allow correction of significant volumetric asymmetry.
  - Permanent implant placed at second stage.

26.3.2 Components of surgery

- Periareolar approach: De-epithelialize and decrease size of areola.
- Undermine the lower pole of the breast subcutaneously to the desired position of the inframammary fold.
- Release subareolar constriction ring via radial scoring or dividing the inferior pole of the breast vertically or horizontally.
- If volume needs to be added, a permanent implant or temporary tissue expander is placed in a subglandular, submuscular location, or dual plane.

26.3.3 Contralateral breast procedures

- Ipsilateral augmentation procedures cannot establish normal breast ptosis that might be present on the normal side.
- Reduction/mastopexy or augmentation may be performed to improve symmetry.

26.4 Complications

- Residual asymmetry.
- Persistent deformity.
- Complications of implant or tissue expander.
- Wound healing difficulties
- Nipple Necrosis

26.5 Critical Errors

- Failure to correctly identify the tuberous breast deformity.
- Augmenting the breast without addressing the tuberous qualities.
- Failure to obtain preoperative screening mammogram in women > 35 years of age.

27 Breast Augmentation

Simone W. Glaus & Marissa Tenenbaum

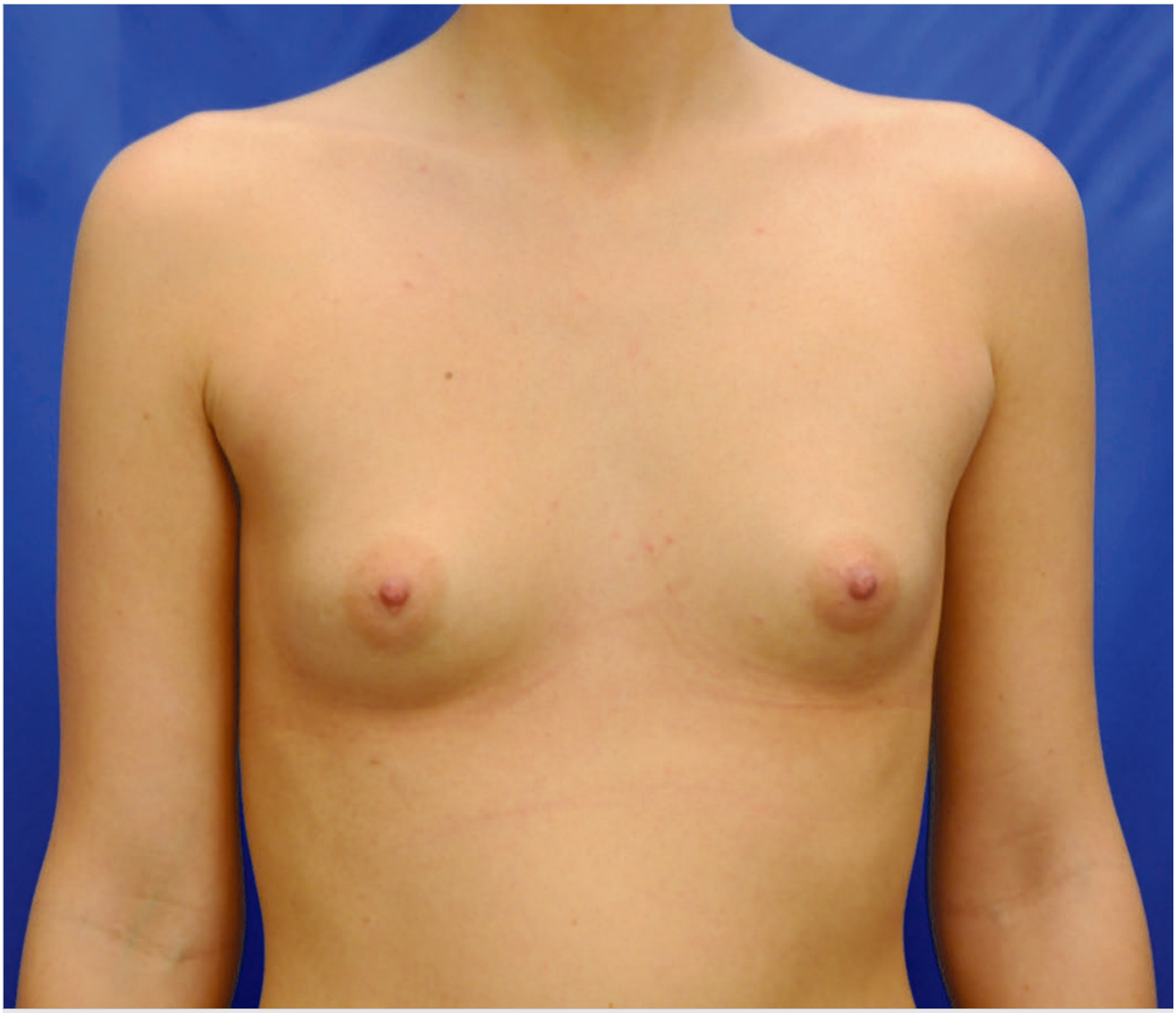

Fig. 27.1 A 21-year-old woman presents to your office to discuss breast augmentation.

27.1 Description

- Hypomastia: Small A to AA cup breasts with mild asymmetry
  - Left inframammary fold is slightly higher than the right inframammary fold.
  - Left nipple is slightly higher than the right nipple.

27.2 Work-up

27.2.1 History

- Age, medical comorbidities, anticoagulant use, smoking history.
- Pregnancy/breastfeeding history, plans for future childbearing.
- Personal history of breast disease and/or procedures, prior mammography or ultrasound.
- Family history of breast cancer.
- Current bra size and desired breast size.
- Motivation for surgery.

27.2.2 Physical examination

- Evaluate breast shape, skin quality, and adequacy of tissue envelope (e.g., upper pole pinch thickness).
- Identify any *asymmetries* (volume, nipple–areola complex, inframammary fold position), thoracic wall abnormalities.
- Palpate for breast masses or axillary lymphadenopathy. Identify skin dimpling or nipple discharge.

27.2.3 Pertinent imaging or diagnostic studies

- **American Cancer Society guidelines** for clinical breast exam (CBE) and mammography should be followed.
  - CBE every 3 years for women ages 20 to 39 years; CBE every year for women ages 40 and older.
  - Yearly mammograms for women ages 40 and older.
- Breast masses or lymphadenopathy discovered on physical examination should be evaluated before augmentation.

27.3 Treatment

- *Informed consent* must include management of patient expectations and thorough discussion of existing asymmetries, potential complications, rupture screening recommendations, rates of revisional surgery (~ 20%), responsibility for cost of revisions, and eventual need for implant exchange or removal.
- Standard perioperative care
  - A single preoperative dose of a cephalosporin is indicated.
  - Sequential compression devices should be used before induction if general anesthesia is administered.

27.3.1 Implant selection

- Implant size
  - Saline implants available up to 1,000 mL.
  - Silicone implants available up to 800 mL.
- Implant type: Saline versus silicone versus form-stable silicone; smooth versus textured; round versus anatomical; low, moderate, or high profile
  - Silicone implants are FDA-approved only for primary augmentation in women at least 22 years of age.
  - The FDA recommends magnetic resonance imaging screening for silicone implant rupture at 3 years after implantation, then every 2 years thereafter.
- Implant placement
  - Subglandular: Can have pleasing aesthetic results, but with higher contracture rates and implant palpability. This plane may complicate future mammography because the implant is present adjacent to glandular tissue.
  - *Submuscular:* Placement is completely under pectoralis major muscle. Decreased capsular contracture rates. Breast may be distorted with muscle contraction.
  - *Dual plane:* Placement under pectoralis major superiorly, but subglandular placement inferiorly. Decreased contracture rates, but allows expansion of the inferior pole.
- Incision/approach: Periareolar, inframammary, axillary, transumbilical.
- Current breast augmentation planning involves a tissue-based approach that acknowledges individual soft-tissue limitations rather than a strictly volumetric approach.

27.3.2 Cancer screening

- Breast augmentation does not increase the risk for breast cancer, but implants may interfere with mammographic screening.
- Submuscular implants interfere significantly less than subglandular implants.
- Silicone gel implants do not affect the incidence of connective tissue diseases.

27.4 Complications

- High revision rate (~ 20%).
- Capsular contracture
  - Baker capsular contracture classification (▶ Table 27.1).
  - Inframammary incision < periareolar incision.
  - Submuscular placement < subglandular placement.
  - For subglandular placement, textured < smooth (no advantage in submuscular placement).
- Infection.
- Rupture
  - Saline: Risk ~ 1% per year.
  - Silicone
    - Risk ~ 0.5% at 3 years (Mentor Core Study: primary augmentation).
    - Risk 5.5% at 6 years (Inamed Core Study: primary augmentation).
- Rippling, palpability.

Table 27.1 Baker capsular contracture classification

Grade	Severity	Findings
I	Normal	Natural feel; normal in size and shape
II	Minimal	Slightly firm; normal appearance
III	Moderate	Firm; appears abnormal and notable to patient
IV	Severe	Hard, painful to the touch; appears abnormal

- "Double-bubble" deformity
  - Type A: Implant sits above breast mound.
  - Type B: Implant sits below breast mound.

27.5 Critical Errors

- Failing to recognize common abnormalities complicating augmentation (e.g., tuberous breast deformity, thoracic wall abnormalities, significant asymmetries).
- Performing a procedure outside the standard of care (e.g., silicone implant in patient younger than 22 years, extra-large volume augmentation, transumbilical approach).
- Inability to handle common postoperative complications.
- Failure to obtain preoperative screening mammogram in women > 35 years of age.

28 Mastopexy/Augmentation

Simone W. Glaus & Marissa Tenenbaum

Fig. 28.1 A 57-year-old woman presents with a chief complaint of "sagging breasts."

28.1 Description

- Grade III ptosis (see ▶ Table 26.1): Nipple below the inframammary fold (IMF) and at the most inferior portion of the breast.
- Deflated breasts with large skin envelope relative to parenchymal volume.
- Poor skin elasticity.
- Asymmetry of breast size and nipple position.

28.2 Work-up

28.2.1 History

- Determine patient's motivation for seeking surgery and primary desired result (lift, increased volume, correction of asymmetry, or combination).
- Prior history of breast procedures (may impact blood flow to nipple–areola complex [NAC]).
- Personal risk or family history of breast cancer, prior mammography.
  - See Case 27 (American Cancer Society guidelines).
- Pregnancy and breastfeeding history, plans for future pregnancy.

28.2.2 Physical examination

- Systematic evaluation of the ptotic breast
  - Relationship of nipple to inframammary fold.
    - *Regnault classification* of breast ptosis (see ▶ Table 26.1).
  - Relationship of breast tissue to inframammary fold (vertical overhang).
  - Overall size and surface area of the breast.
  - Quality of skin (elasticity, thickness, striae) and breast parenchyma.
  - Breast and/or chest wall asymmetries.
- Key measurements
  - Sternal notch to nipple, nipple to IMF during stretch, breast base width, superior and inferior pole pinch thickness, anterior pull skin stretch, estimated parenchymal fill.
- Clinical breast examination for masses.

28.2.3 Critical topics for discussion

- Impact of breast augmentation on surveillance for breast cancer.
- Potential complications (e.g., nipple loss, asymmetry) and relatively high rate (~ 20 to 25%) of revisionary surgery.
  - How revision costs will be handled.
- Rates and detection of rupture for saline versus silicone versus form-stable silicone implants.

28.3 Treatment

- Contraindications to treatment
  - Body dysmorphic disorder, inappropriate motivation (e.g., salvaging marriage, peer pressure), significant breast disease, collagen vascular disease.
- Surgical options
  - Augmentation alone: Breast enlargement
    - A mild lift may be achieved by filling the skin envelope.
  - Mastopexy alone: Lifting the NAC and tightening the skin envelope without volumetric enlargement.
  - Combined augmentation/mastopexy
    - May be performed as a single or staged procedure (if staged, mastopexy usually first).
    - Combined procedure can lead to increased morbidity and has high revision rate.
- Preoperative markings (also note key measurements, above)
  - Midline, breast meridians, IMFs, tangential line between IMFs, mastopexy markings, proposed nipple position, nipple to midline.

28.4 Augmentation (see Case 27)

- Incision placement (consider future mastopexy in your decision process): Periareolar, inframammary, transaxillary, transumbilical.
- Implant placement: Subglandular, subpectoral, totally submuscular, "dual plane."
- Implant type: Saline versus silicone (▶ Table 28.1), smooth versus textured envelope, round versus anatomical shape, size.

28.4.1 Mastopexy

- Techniques
  - Periareolar (simple, Benelli): Allows limited lift around the NAC.
  - Vertical scar (Lassus, Lejour, Hammond, Hall-Findlay).
  - Inverted-T scar (Wise pattern skin excision, other skin incision patterns).

28.4.2 Augmentation/Mastopexy

- General principles
  - Place implants first, then tailor the skin envelope to new breast volume.
  - Tailor/tack skin intraoperatively with patient upright before committing to planned mastopexy pattern.
  - Employ different mastopexy patterns, if needed, for breast asymmetries.
  - Conservative, superficial skin undermining only to decrease risk for NAC necrosis and wound-healing complications. Always maintain a pedicle to the NAC.

Table 28.1 Comparison between saline and silicone implants

	Pros	Cons
Saline	Easily adjustable size	Rippling
	Low contracture rates	Less natural feel
	Ruptures noted clinically, saline absorbed	
Silicone	More natural feel	Higher contracture rates
	Lighter weight than saline	Larger incisions for placement
	Lower chance of notable rippling	Magnetic resonance imaging necessary to evaluate for rupture

- General technique
  - Talc-free gloves.
  - Perioperative antibiotics, antibiotic irrigation of implant pocket.
  - No-touch technique for implant placement.

28.5 Complications

- Complication rate significantly higher for combined augmentation/mastopexy than for either procedure alone.
- Early complications
  - Hematoma/seroma.
  - Compromised nipple viability
    - Release sutures if "dusky nipple" identified.
    - May necessitate implant removal.
  - Wound breakdown.
  - Pneumothorax.
- Late complications
  - Infection.
  - Rippling and wrinkling.
  - Capsular contracture: Baker classification (see ▶ Table 27.1).
  - Implant displacement, extrusion, rupture.
  - Breast asymmetry/nipple malposition.
  - Contour deformities, including double-bubble deformity (types A and B).
- Cost of revisions: Know how you will address revisions (e.g., free, operating room and anesthesia costs only, full cost of a new procedure). This should be discussed preoperatively.

28.6 Critical Errors

- Failure to obtain screening mammogram in patient older than 35 years.
- Use of saline implant in patient younger than 18 years or silicone implant in patient younger than 22 years (based on FDA approval for primary augmentation; no age restrictions for reconstruction).
- Discussing surgical techniques with which you are not familiar.
- Not exhibiting a sense of caution when undertaking a single-stage augmentation/mastopexy.

29 Breast Reduction

Louis H. Poppler & Marissa Tenenbaum

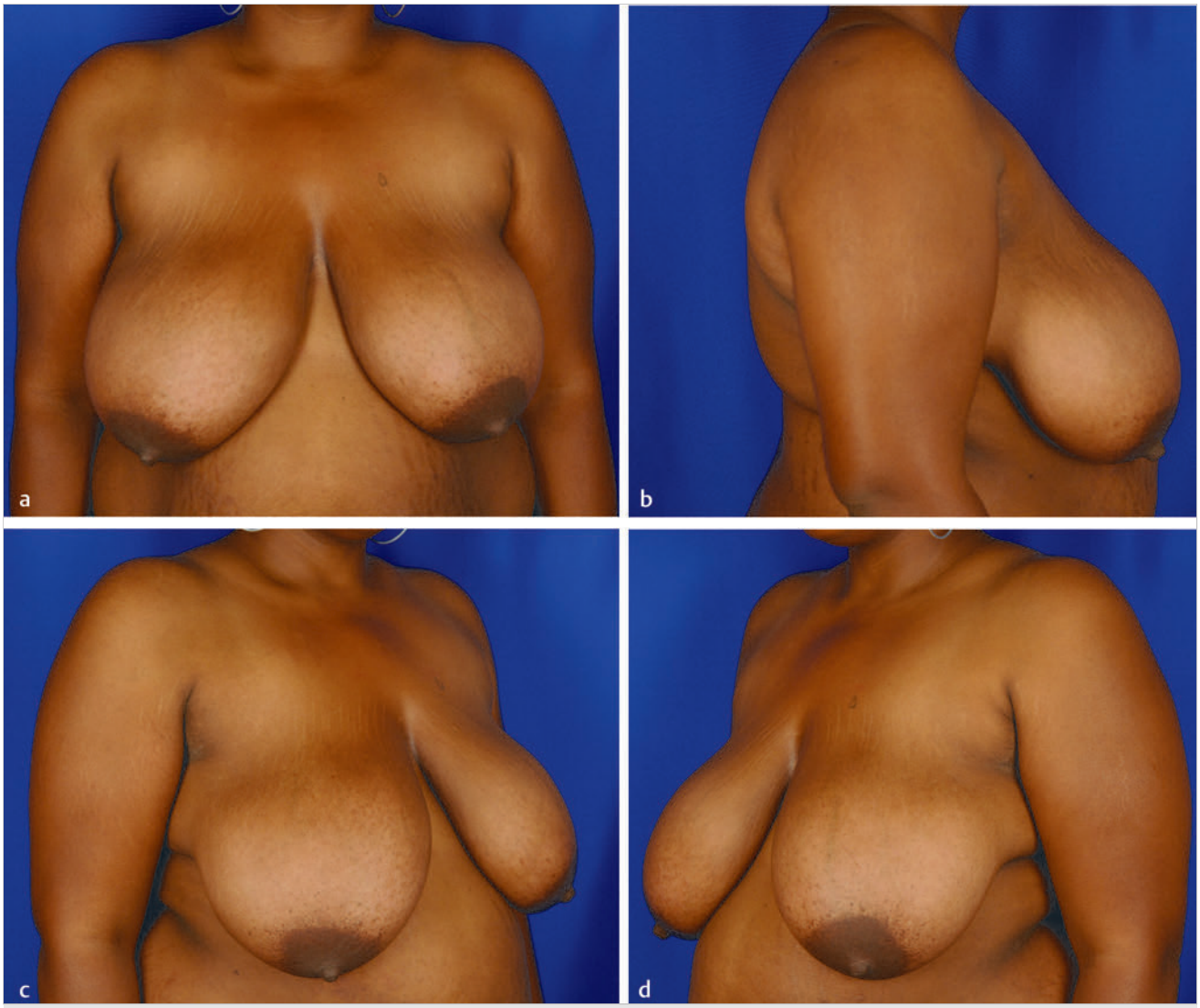

Fig. 29.1 A 49-year-old healthy woman presents for evaluation for breast reduction. She currently wears a size 48DD bra.

29.1 Description

- Obese woman with macromastia and asymmetry
  - Right breast larger than left.
  - Large, pendulous breasts consistent with reported bra size of 48DD.
  - Protuberant abdomen.
- Grade III ptosis: Regnault classification (see ▶ Table 26.1).

29.2 Work-up

29.2.1 History

- Age and symptoms
  - Pain associated with enlarged breasts: Back pain, neck pain, shoulder pain,
  - Grooving in shoulders from weight of bra.
  - Skin breakdown along inframammary fold.
- Determine desired cup size.
- History of scarring
  - May consider limiting incisions in patients with history of hypertrophic scarring/keloids. Informed consent includes discussing management of unsightly scars.
  - Patients must understand the possibility of unsightly scars from the procedure.
- Lactation potential
  - Preserve lactation potential in younger women, even if they state no intention to breastfeed.
  - Consider/offer delay of procedure until childbearing is completed because breast may change with pregnancy.
- Oncologic history: Family and personal history and risk factors for breast cancer
  - Obtain baseline mammogram preoperatively in all women 35 years of age or older.

29.2.2 Physical examination

- Current breast size and chest size: The larger the thoracic circumference, the larger the breast per cup size (i.e., a size 40B breast is larger than a size 34B breast).
- Location of fullness (i.e., lateral versus pendulous).
- Skin quality: Elastic versus thin and inelastic.
- Breast quality: Elastic versus fibrous.
- Nipple size
  - Ideal nipple diameter for a woman is 4 to 5 cm, depending on breast size.
  - The nipple is often larger in women with macromastia.
- Regnault classification of breast ptosis (see ▶ Table 26.1)
  - Classification based on position of nipple–areola complex (NAC) relative to inframammary fold (IMF).
- Nipple sensation: General and two-point sensation. May be reduced postoperatively or improved (because of decreased stretch on sensory nerves).
- Other areas of fullness: Appearance of lateral fat rolls or obese abdomen may be exacerbated by reduction.

29.2.3 Pertinent imaging or diagnostic studies

- *Breast cancer screening* if a woman is older than 40 years
  - Many authors recommend screening all women older than 25 years before surgery.
  - Preoperative mammograms (when indicated) and 3 to 6 months after reduction to establish new baseline.

29.2.4 Consultations

- Consider psychiatric/psychological consultation in women with gender identity issues.

29.3 Treatment

- Technique and scar length (Pick a technique and know how to draw it!)
  - Short scar: Possible in women with smaller breasts.
  - Lateral L: Only in patients with minimal breast ptosis and good skin elasticity.
  - Standard inverted-T incision (Wise pattern)
    - Most Versatile technique, but larger scar.
    - Allows reduction of lateral and ptotic breast tissue and gives great mobility for final nipple placement.
- Breast pedicle design
  - **Inferior**: Versatile, reliable, and traditionally *most common*
    - Noted to "bottom out" over time. Hence, NAC–IMF distance is kept short.
  - Bipedicle: Commonly vertically oriented.
  - Medial/superomedial: Allows less vertical shift of nipple.
  - Superior: Preserves superior fullness.
  - Lateral.
  - Free nipple graft: Required in patients with exceptionally large breasts (distance from sternal notch to nipple > 40 cm).
- Ethical considerations
  - Insurance documentation of amount of tissue (in grams) to be reduced.
  - Adjuvant procedures and insurance billing (i.e., axillary liposuction).

29.4 Complications

- Hematoma.
- Infection.
- Delayed healing (usually caused by excess tension).
- Breast asymmetry.
- NAC loss
  - The NAC should be removed and placed as a graft if there is concern over blood supply from the pedicle intraoperatively.
- Wide or hypertrophic scars.
- Fat necrosis.

29.5 Critical Errors

- Inadequate preoperative discussion to set expectations and determine patient preferences.
- Overreduction of breast tissue.
- Excess tension.
- Failure to appropriately manage a dusky areola intraoperatively, leading to NAC necrosis.

30 Gynecomastia

Gwendolyn Hoben & Marissa Tenenbaum

Fig. 30.1 A 16-year-old boy referred by his pediatrician for a 1-year history of bilateral gynecomastia.

30.1 Description

- Bilaterally symmetric, mildly enlarged breasts in a male patient.
- Minimal excess skin.
- Normal body habitus, without evidence of obesity.

30.2 Work-up

30.2.1 History

- Time course of breast development and changes.
- New onset of breast pain, lactation, or enlargement.
- Presence of testicular masses.
- Current and prior medication or drug use (i.e., marijuana)
  - Anti-androgens (spironolactone), anabolic steroids, HIV medications, diazepam, tricyclic antidepressants, antibiotics, digoxin, calcium channel blockers, furosemide, risperidone.
  - Alcohol, amphetamines, marijuana, heroin, methadone.

30.2.2 Physical examination

- Breast examination
  - Findings concerning for malignancy: Eccentricity, chest wall fixation, nipple discharge.
  - *Tenderness*: > 70% of cases of benign gynecomastia will have tenderness.
  - Presence of dense fibrous tissue.
  - Degree of skin excess
    - Differentiate from pseudogynecomastia.
- Other feminizing characteristics.
- Testicular examination.
- Thyroid examination.

30.2.3 Pertinent imaging or diagnostic studies

- When concerning breast examination findings are present:
  - Imaging: Mammogram and ultrasound are equally sensitive and specific.
  - Surgical oncology consult.
- Feminizing characteristics
  - Serum LH (luteinizing hormone), FSH (follicle-stimulating hormone), DHEAS (dehydroepiandrosterone sulfate), testosterone.
  - Adrenal scan, testicular ultrasound.
  - Karyotype to evaluate for Klinefelter syndrome (XXY).
  - Endocrine consult, genetics consult.
- Testicular mass
  - Serum testosterone, DHEAS, LH, estradiol.
  - Testicular ultrasound.
  - Urology consult, endocrine consult.
- Thyroid mass
  - Serum TSH (thyroid-stimulating hormone).
  - Endocrine consult.

30.3 Treatment

- Stop any contributing medications, treat underlying condition.
- Duration of gynecomastia
  - < 12 months: Observe
    - No FDA-approved pharmacotherapy.
  - > 12 months: Surgical management can be considered.
- Excision
  - Appropriate for fibrous lesions with accompanying excess skin.
  - Circumareolar excision.
  - Leave sufficient tissue deep to the nipple–areola complex to prevent nipple depression.
- Liposuction
  - Indicated for more glandular/fatty composition.
  - Incisions can be lateral, at inframammary fold, or periareolar.
  - More difficult to remove the fibrous tissue below the nipple–areola complex
    - Combination with ultrasonic techniques or open approaches may be helpful.
- Ultrasound-assisted liposuction
  - Can use higher-energy settings to treat more fibrous tissue.
  - Do not excise excess skin concomitantly, assess at follow-up to allow maximal skin retraction.
- Pathology evaluation:
  - < 1% risk for atypical ductal hyperplasia.
- Postoperative period
  - Compression garment: Wear for at least 4 weeks.

30.4 Complications

- Nipple depression or “crater deformity”: Due to over-resection of tissue.
- Hematoma/seroma.
- Inadequate resection with liposuction-only approach.

30.5 Critical Errors

- Failure to fully assess for underlying causes of gynecomastia that require treatment.
- Failure to assess fibrous versus fatty nature of the tissue to determine when liposuction is appropriate.
- Failure to assess skin excess to determine need for skin excision.

Part 7

Section VII. Trunk

7

31 Ischial Pressure Sores

Neil S. Sachanandani & Thomas H. H. Tung

Fig. 31.1 A 35 year paraplegic male with a right-sided ischial decubitus wound.

31.1 Description

- Stage IV ischial pressure ulcer with exposed bone and fibrinous slough.

31.2 Work-up

- Clean, pink granulation tissue at wound base with no evidence of gross contamination.
- Multiple scars indicative of prior surgical management with likely posterior thigh and gluteal rotation flaps.

31.2.1 History

- Risk factor assessment: Age, *nutritional status*, *comorbid conditions* (diabetes, vascular disease), ambulatory status, spinal cord injury, spasm and previous treatment, *continence* (urine and fecal), *tobacco* and substance abuse, presence of shear forces, mental status
- Support network
  - For treatment and continued care.
  - Home environment and any pressure-reducing devices.
- Current wound and skin care regimens.
- Previous wounds and interventions.
- History of current wound: Duration, previous infection, changes in size.

31.2.2 Physical examination

- Location and dimensions of wound, quality of surrounding tissues, focused sensory examination.
- Presence of spasm, moisture, soilage.
- Evidence of infection.
- Pressure ulcer staging (▶ Table 31.1).

31.2.3 Pertinent imaging or diagnostic studies

- Laboratory tests: Complete blood count (CBC), complete electrolyte panel, albumin/prealbumin, hemoglobin A_{1C}, erythrocyte sedimentation rate (ESR), C-reactive protein (CRP).
- Magnetic resonance (MR) imaging: Osteomyelitis is suggested by the presence of T2 hyperintensity and low intensity on T1 images; sensitive and specific for osteomyelitis.

Table 31.1 Pressure ulcer staging

Stage	Findings
I	Intact skin with nonblanching erythema, usually over a bony prominence.
II	Partial-thickness dermal loss. Appears as a shallow open ulcer with a red–pink wound bed without slough, or as a serum-filled bullous lesion (intact or ruptured).
III	Full-thickness tissue loss. Subcutaneous fat may be visible. Bone, tendon, or muscle is not exposed; these are prefascial wounds. May have undermining.
IV	Full-thickness tissue loss through the fascia with exposed bone, tendon, or muscle. Often includes undermining and tunneling.

- Tissue biopsy: For pathology in chronic wounds and for culture.
  - Bone biopsy may be useful to rule out osteomyelitis, especially if suggested on MR imaging.

31.2.4 Consultations

- Internal medicine and nutrition: Optimize medical status.
- Physical therapy, physical medicine and rehabilitation: Manage rehabilitation of patient.
- Social work.
- Orthopedic surgery, general surgery, urology: May be involved in débridement and surgical management of associated issues.
- Infectious disease: Assistance in management of infection and antibiotic treatment.

31.3 Treatment

- Educate patient and family: Cannot be over-emphasized. Prevention is critical.
- Optimize underlying medical status
  - Optimize *nutrition*: Supplements as appropriate.
  - Control/eliminate *spasm* (baclofen, diazepam, and dantrolene).
  - Prevent contractures (physical therapy, tenotomy).
  - Long-standing wounds should raise concern for *Marjolin ulcer*.
    - Multiple biopsies along periphery.
- Eliminate pressure
  - Turning every 2 hours and lifting for 10 seconds (seated) every 10 minutes: Reduces the cycles of ischemia and reperfusion, prevents breakdown.
  - *Avoid shearing* during transfers.
  - Low-air-loss mattress; Proper cushion or wheelchair.
  - *Seat mapping* to evaluate for localized pressure.
- Manage infection
  - **Débride** all nonviable tissues and bone.
  - Antibiotic treatment when indicated.

31.3.1 Wound care

- Dressings: Can decrease bacterial burden
  - Silver sulfadiazine.
  - Dakin solution (sodium hypochlorite)
    - Short-term use for local *Pseudomonas* infection.
  - Negative-pressure wound therapy.
- Application of growth factors (e.g., becaplermin [Regranex; Healthpoint Biotherapeutics, Fort Worth, TX]).

31.3.2 Surgical management

- Stage I and II ulcers: Usually treat with medical management only.
- Stage III and IV wounds often require surgical intervention, but treat only if conditions are optimized to prevent recurrence.
  - MR imaging and bone biopsy negative for osteomyelitis → dressing changes and schedule for coverage.

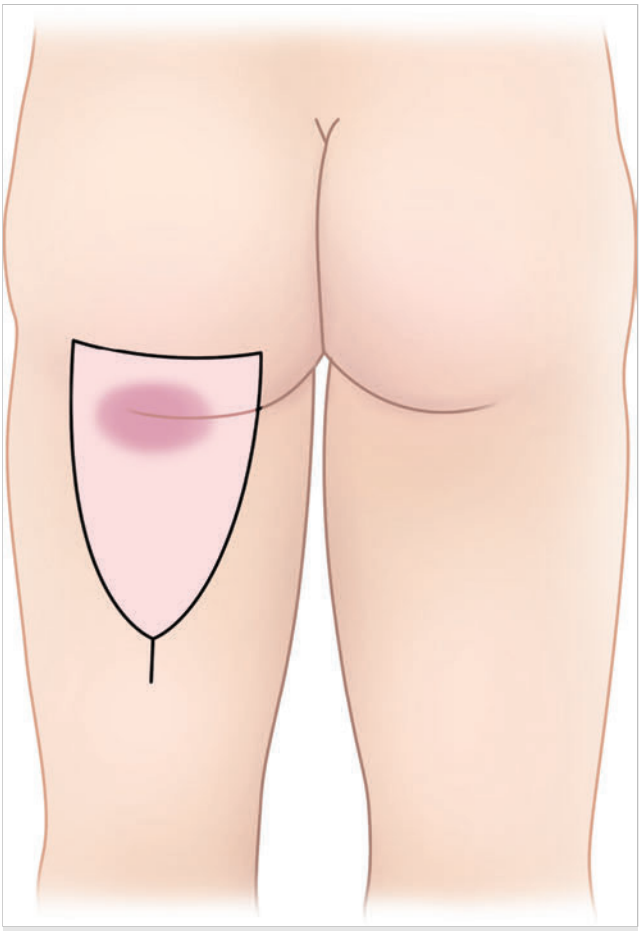

Fig. 31.2 Hamstring musculocutaneous v-y advancement flap.

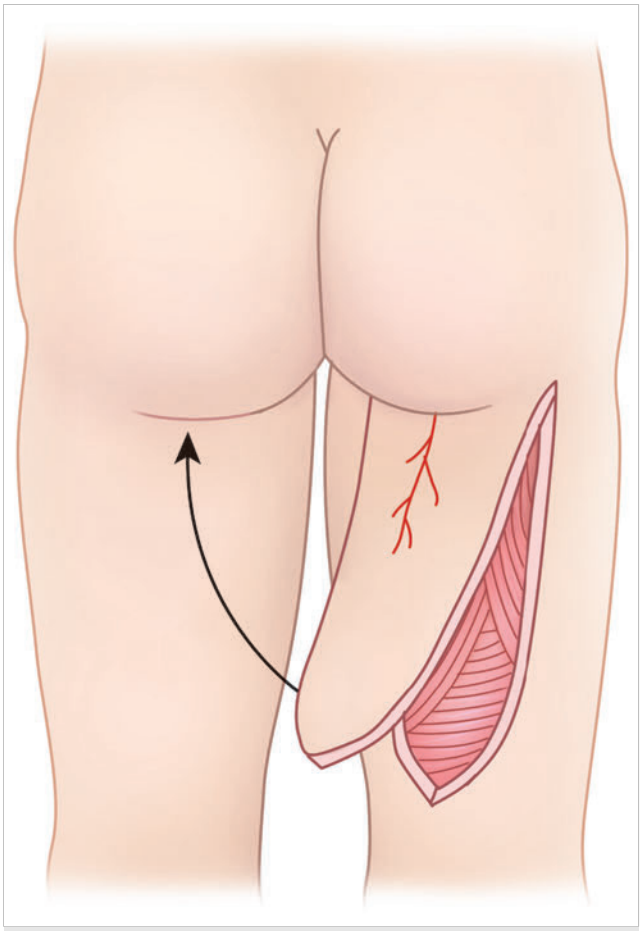

Fig. 31.3 Posterior thigh fasciocutaneous flap. This may be superiorly based (as shown) or based medially/laterally to allow advancement in a superior direction.

- MR imaging confirms osteomyelitis of the sacrum, ischium, or trochanter → resection of the affected bone, potentially 6-week course of intravenous antibiotics, potentially 6 weeks of recombinant platelet-derived growth factor (PDGF), followed by definitive closure.

- Always **consider future procedures** in operating room planning.
  - Very high level of recurrence in patients with pressure sores.
  - *Flaps should be larger than needed to allow re-elevation and advancement.*
- Flap options by location
  - Ischium
    - Hamstring musculocutaneous V-Y advancement flap (▶ Fig. 31.2).
    - Posterior thigh fasciocutaneous flap (▶ Fig. 31.3).
    - Tensor fasciae lata V-Y advancement flap.
    - Gluteal rotation flap.
    - Lateral and anterolateral thigh fasciocutaneous flaps.
    - Gracilis myocutaneous flap.
    - Pedicled rectus abdominis myocutaneous flap.
  - Sacrum
    - Gluteus maximus rotation flap (▶ Fig. 31.4).
    - V-Y advancement flap based on superior gluteal vessels.

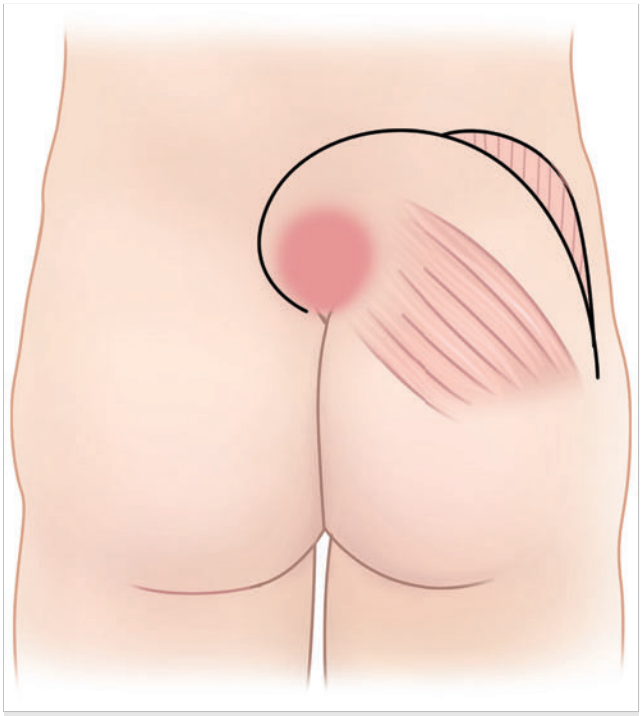

Fig. 31.4 Gluteal rotation flap. This may be performed with fasciocutaneous or musculocutaneous tissue.

  - Lumbosacral flap.
  - Superior gluteal artery perforator (SGAP) flap.
- Trochanter
  - Tensor fasciae latae flap.
  - Vastus lateralis flap.
  - Gluteal flap.
  - **Girdlestone procedure**: Proximal femur resection with vastus lateralis interposition.

31.4 Complications

- Hematoma/seroma.
- Wound dehiscence.
- Infection.
- *High recurrence rates* after flap closure: 13 to 82% over 5 years
  - Poor compliance leads to recurrent or new pressure ulcers over time.
  - Must plan on multiple repeat surgeries in the future: *Design large flaps that can be readvanced or rotated and reused.*

31.5 Critical Errors

- Failure to control bacterial colonization of wounds, treat infection, or adequately débride before surgical closure.
- Designing a flap that is too small for closure or does not anticipate need for re-elevation and reuse of the flap in the future (because of likely future recurrence).
- Failure to adequately manage whole patient or to recognize wound etiology.
- Failure to biopsy chronic wound/evaluate for Marjolin ulcer.

32 Body Contouring after Massive Weight Loss

Simone W. Glaus & Marissa Tenenbaum

Fig. 32.1 A 57-year-old woman requests body contouring following massive weight loss.

32.1 Description

- Breasts
  - Grade III ptosis with significant deflation (see ▶ Table 26.1).
  - Mild volume asymmetry (L > R).
  - Striae superiorly.
- Trunk, abdomen, buttocks
  - Well-healed abdominal laparoscopic incisions (difficult to visualize).
  - Redundancy of skin and fat in the lower abdomen extending onto the flanks and lower back.
  - Ptotic gluteal region.
- Medial thighs: Ptotic, redundant tissue with poor skin quality and elasticity.
- Arms: Upper arm "bat wing" deformity.

32.2 Work-up

32.2.1 History

- Original and current body mass index (BMI)
  - BMI: weight (kg) /[height (m)]^2.
- Obesity classification (▶ Table 32.1)
- Weight loss timeline
  - How much over how long?
    - Should be within 10 to 15% of goal weight.
  - Length of time weight has been stable
    - Weight must be stable over a 6-month period prior to body contouring procedures.
    - Exception is for panniculectomy or breast reduction if hindering exercise and further weight loss.
- Method of weight loss, including bariatric procedures
  - Should know example procedures and their physiologic consequences/nutritional deficiencies in case you are asked.
  - *Restrictive:* Laparoscopic banding (Lap-Band), vertical banded gastroplasty.
  - *Malabsorptive:* Biliopancreatic diversion ± duodenal switch.
  - *Combination restrictive–malabsorptive:* Roux-en-Y gastric bypass.
- Current diet and exercise habits, nutritional supplementation, symptoms of nutritional deficiency (e.g., fatigue, hair loss, poor wound healing, neuropathy).
- Current and pre-weight-loss-medical and psychiatric comorbidities.
- Risk factors for poor wound healing (e.g., smoking, steroids and immunosuppressive medications).

32.2.2 Physical examination

- Comprehensive assessment of body contour, skin and tissue quality, degree of ptosis and/or deflation.

Table 32.1 Obesity classification

Description	Body mass index
Overweight	25–30
Obesity	30–35
Severe obesity	35–40
Morbid obesity	40–50
Super obesity	> 50

- Presence of breast masses.
- Presence of abdominal scars, hernias, Lap-Band port.
- Signs of nutritional deficiency (e.g., pale mucous membranes, brittle nails and hair).

32.2.3 Pertinent imaging or diagnostic studies

- Laboratory analysis: Complete blood count (CBC), electrolytes with albumin, prealbumin, and blood urea nitrogen (BUN)/creatinine, liver function tests (LFTs), prothrombin time (PT), partial thromboplastin time (PTT) ± micronutrients (e.g., iron, vitamin B_{12}, thiamine).
- Guided by physical examination results and type of bariatric procedure.

32.2.4 Consultations

- Nutritionist: If concern for nutritional deficiencies.
- Hematology: Prior history of deep venous thrombosis (DVT).

32.2.5 Critical topics for discussion

- Expected scars
  - Many are long, with some visible when patient clothed.
  - Dog ears may be evident.
  - Inability to achieve "perfection."
- Patient priorities and staging of procedures for safety
  - Decide what *you* are comfortable offering in terms of grouped procedures and length of operating time.
  - Avoid procedures with conflict tension forces.
  - Most procedures should be performed within a 6-hour time period.
- Potential complications, including serious complications (see Complications).
- Revision policy
  - Discuss costs and timing after initial procedure.
  - There is a high likelihood that the patient will request a revision following the the initial procedure.

32.3 Treatment

- General sequence for reconstruction: There is no "right" answer.
  - Tailor to patient needs and budget.
  - *Example:* (1) trunk, abdomen, buttocks, lateral thighs; (2) upper thorax, breasts, arms; (3) medial thighs; (4) face.
- Wait a minimum of 3 to 6 months between stages.
  - Wait 6 to 12 months between trunk, buttocks, lateral thighs and medial thighs.
- Intraoperative management issues
  - DVT prophylaxis (sequential compression devices, post-operative antithrombotics).
  - Positioning (padding pressure points, pillow under knees, preventing hyperextension or extreme flexion).
  - Patient temperature (warm fluids, warming blankets).
  - Intravenous fluids (monitor blood loss, urinary catheter).

32.3.1 Procedures (descriptions of typical procedures, their markings, and the surgical technique for each region)

- Trunk, abdomen, buttocks, lateral thighs
  - Vertical abdominoplasty (see Case 38), circumferential belt lipectomy, lower body lift.
  - Treat as one unit for best results. Markings frequently made with patient standing.
  - Optimize positioning of scars in relationship to anatomical landmarks (i.e., within bikini line).
  - More aggressive with anterior and lateral resections than with posterior regions.
- Upper thorax, breasts, arms
  - Upper thorax: Direct excision of upper back rolls.
  - Breasts: Mastopexy ± augmentation (see Case 28), reduction (see Case 29)
    - Breast borders (e.g., lateral border, inframammary fold) are frequently lost in patients with massive weight loss and need to be redefined.
    - Traditional techniques are frequently insufficient. Longevity may be improved when shaping relies more on glandular manipulation (parenchymal plication, dermal suspension, autoaugmentation) than on simple redraping of the skin envelope.
    - Augmentation, if used, should be conservative in this population, given the relatively unstable skin envelope.
  - Arms: Brachioplasty alone versus staged liposuction + brachioplasty
    - Upper arm excess in patients with massive weight loss crosses the axilla onto the chest wall, so excision must also extend to lateral chest wall.
    - Incision design should attempt to prevent linear scar contracture (e.g., Z-plasty at axilla; ▶ Fig. 32.2).
- Medial thighs
  - *Vertical medial thigh lift* (more effective than horizontal medial thigh lift) ± liposuction.
  - Do not perform in patients with history of DVT or preexisting lymphedema.
  - Avoid injury to saphenous vein and lymphatics of femoral triangle.
  - Tack structures to deep (Colles) fascia.
  - Avoid a horizontal scar technique to reduce risk for labial spreading.
- Face (see Cases 15 and 16): Standard rhytidectomy techniques with modifications
  - Skin redundancy exceeds SMAS (superficial musculo-aponeurotic system) redundancy.
  - More skin undermining and less SMAS elevation typically required.

32.4 Complications

- Typical: Hematoma, seroma, wound dehiscence, skin necrosis, infection, persistent laxity or laxity within a year, need for revision surgery.
- Potentially devastating
  - DVT, pulmonary embolism: This is a major safety issue.
    - Appropriate prophylaxis.
    - Early recognition and diagnosis.
    - Treatment (e.g., anticoagulation, filter).
  - Disruption of lymphatic drainage, labial spreading (medial thigh lift).
  - Nerve injury
    - Ulnar nerve, medial antebrachial cutaneous nerve (brachioplasty).
    - Lateral femoral cutaneous nerve (abdominoplasty).
  - Over-resection: Avoid if possible with careful tailoring before definitive excision.
    - Temporary dressing (i.e., vacuum-assisted closure) may allow decrease in edema before repeated attempt at closure.
    - Skin graft may be placed until tissues stretch and allow re-excision.

Fig. 32.2 Brachioplasty incision.

32.5 Critical Errors

- Safety is a critical issue.
  - Avoid unsafe practices.
  - Inadequate DVT prophylaxis, too many procedures (> 6 hours).
- Inappropriate patient selection (e.g., before weight stabilization or when nutritional deficiencies exist).
- Inability to discuss proposed technique
  - Be prepared to discuss the markings, positioning, and surgical steps for any technique you mention.

33 Major Liposuction

Justin B. Cohen & Terence M. Myckatyn

Fig. 33.1 A 41-year-old woman presents to the clinic to discuss possible surgical options to improve the appearance of her "saddlebags."

33.1 Description

- Significant, diffuse lipodystrophy noted bilaterally in "saddlebag" regions of upper lateral thighs.
- Skin redundancy and residual adiposity noted on the central trunk.

33.2 Work-up

33.2.1 History

- Weight stability.
- Medical comorbidities.
- Patient concerns, expectations, and goals of treatment.

33.2.2 Physical examination

- Evaluate regions of suboptimal contour, asymmetry, lipodystrophy.
- Evaluate skin quality and tone (thickness and elasticity): Pinch test.
- Examine for hernias, diastasis.

33.3 Treatment

- Liposuction is a contouring procedure.
  - Best in areas of thick, elastic skin with underlying contour irregularity of fat.
  - Does NOT address cellulite or obesity.
  - Does NOT resect skin.
- Perform preoperative markings with patient upright to determine treatment areas and asymmetries, and outline **zones of adherence**.
- Target *deep fat layer* and *cross-tunnel* to prevent contour irregularities.
- *Wetting solution* technique (▶ Table 33.1)
  - Lidocaine, epinephrine, and bicarbonate solution added to saline or lactated Ringer solution.
  - Provides anesthesia and hemostasis.
  - Maximum lidocaine with epinephrine: 35 mg/kg.
- Liposuction modality
  - *Suction-assisted* liposuction (SAL): Traditional liposuction technique.
  - *Power-assisted* liposuction (PAL): Motorized oscillating hand piece.
  - *Ultrasound-assisted* liposuction (UAL): Ultrasonic energy is applied after wetting solution to emulsify fat before aspiration.
    - Ideal for fibrous regions: Buttocks, lumbar region, gynecomastia.
    - Precautions to avoid cutaneous thermal injury.
  - *Laser-assisted* liposuction (LAL).
- Fluid management for **large-volume** liposuction (**critical safety issue**)
  - Replace preoperative deficits.
  - Employ superwet or tumescent technique.
  - **Administer maintenance intravenous fluid (IVF) + IVF replacement of 0.25 mL/1 mL of aspirate over 5 L.**
  - Titrate IVF to patient's clinical picture (e.g., urine output, vital signs).
  - Maintain intraoperative fluid ratio: (IVF + infiltrate)/aspirate = 1.2.
  - Older technique (Pitman): IVF + infiltrate = 2 × aspirate.
  - 25 to 30% of infiltrate is removed with aspirate.
- If large-volume liposuction (≥ 4 to 5 L) is performed, it must be done in an acute-care hospital or accredited facility.
  - Monitor vital signs and fluid balance with Foley catheter. Overnight inpatient observation.
  - Warm patient, fluids, and operating room to avoid hypothermia.
  - Dilute lidocaine further if greater volume of infiltration is necessary.
- Deep venous thrombosis (DVT) prophylaxis
  - Mechanical: sequential compression devices.
  - Ambulate day of surgery.
  - Chemoprophylaxis not standardly required.
- Postoperative care
  - Early ambulation.
  - Compression garments for 4 to 6 weeks.

Table 33.1 Wetting solutions for liposuction

Technique	Infiltrate	Estimated blood loss (% volume)
Dry	None	20–45
Wet	200–300 mL per area	4–30
Superwet	1 mL of infiltrate per 1 mL of aspirate	1
Tumescent	2–3 mL of infiltrate per 1 mL of aspirate (or to skin turgor)	1

33.4 Complications

- Excessive ecchymosis, discoloration, hematoma, or blood loss related to disruption of vasculature.
- Fat embolus, DVT, or pulmonary embolus.
- Fluid shifts, pulmonary edema.
- Lidocaine toxicity.
- Seroma.
- Skin necrosis.
- Thermal injury (UAL).
- Contour deformities.
- Prolonged paresthesias.
- Infection.
- Perforation of abdominal viscera.

33.5 Critical Errors

- Lidocaine toxicity (dosing > 35 mg/kg).
- Failure to monitor fluid balance.
- Failure to require inpatient monitoring after large-volume liposuction.
- Failure to take precautions against thermal injury with UAL.
- Adding significant liposuction to an already extensive reconstruction involving other procedures, resulting in extensive operative times.

34 Abdominal Wall Defect

Michael J. Franco & Ida K. Fox

Fig. 34.1 A 55-year-old man with a history of exploratory laparotomy and ventral hernia repair with mesh now presents with recurrence.

34.1 Description

- Large midline abdominal wall hernia consisting of myofascial defect with overlying skin.
- The rectus abdominis muscles have migrated laterally.
- There is no evidence of visceral incarceration.

34.2 Work-up

34.2.1 History

- Etiology of defect: Congenital, previous surgery, trauma, resection.
- Duration of defect, management thus far.
- Nutritional status.
- History of smoking.
- Steroids or immunosuppressive medications.

34.2.2 Physical examination

- Body mass index (BMI): weight (kg)/[height (m)]^2.
- Abdominal wall defect description
  - Location
    - Midline or lateral.
    - Upper, middle, or lower abdomen.
  - Tissue defect
    - Skin and subcutaneous tissue.
    - Myofascial.
    - Full thickness.
  - Size of defect.
  - Condition of surrounding tissues.
- Preexisting incisions.
- Pertinent comorbid conditions (diabetes, autoimmune diseases, coronary artery disease, etc).

34.2.3 Pertinent imaging or diagnostic studies

- Computed tomography of the abdomen with contrast may be helpful to delineate the extent of the defect, the related anatomy, and other issues (e.g., bowel adhesions, abscesses).
- Pulmonary function testing should be performed if there is preexisting respiratory compromise or suspicion for loss of domain from a large hernia.

34.2.4 Consultations

- General surgery
  - May need to excise skin present on bowel, lyse adhesions, and repair any iatrogenic bowel injury during this initial process to obtain access for reconstruction.

34.3 Treatment

- Preoperative preparation should include weight loss, smoking cessation, and correction of malnutrition.
- It is best to delay abdominal reconstruction for at least 6 months after initial injury or surgery to minimize inflammation and edema.

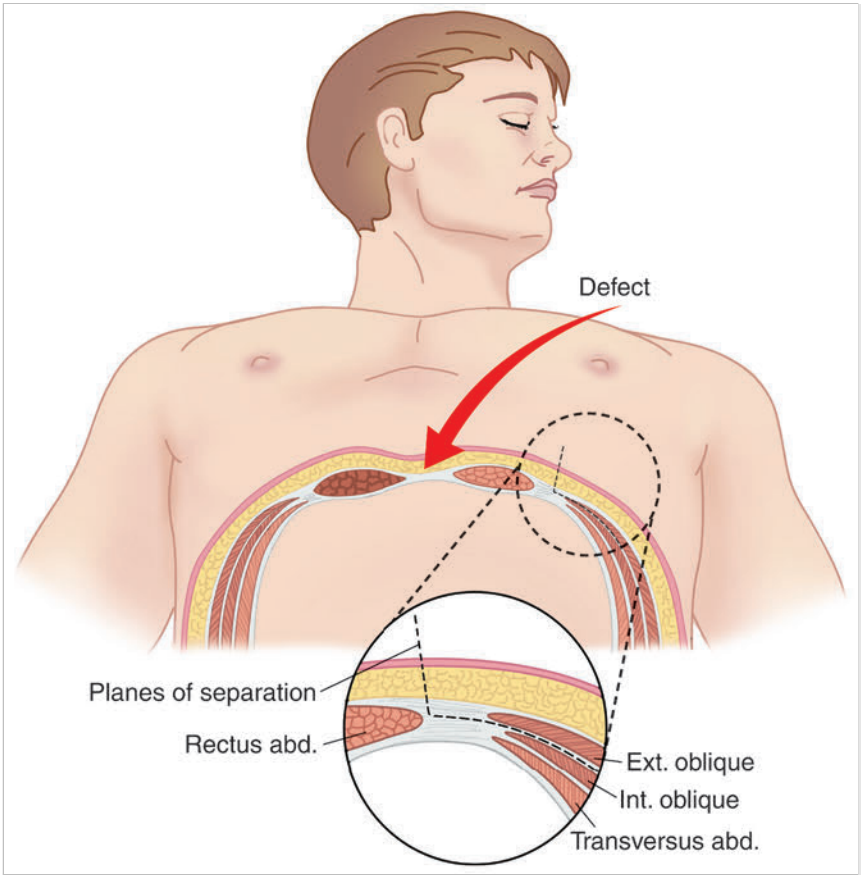

Fig. 34.2 Planes of separation: indicated by the dashed line as it proceeds posteriorly to the posterior axillary line between the external and internal oblique muscles.

34.3.1 Reconstructive options

- Decision influenced by the tissue defect, size of defect, and location.
- Skin and subcutaneous defects
  - Primary repair.
  - Local tissue rearrangement.
  - Skin graft.
  - Tissue expansion can be performed for large defects, with a skin graft over the defect as a temporizing measure.
- Myofascial defects
  - Primary repair: Only for small defects with significant skin laxity.
  - Prosthetic material for reconstruction of fascia with overlying skin flap coverage
    - Polypropylene mesh (nonabsorbable).
    - Acellular dermal matrix (biological).
  - **Components separation:** Useful for central defects up to 20 cm in width (▶ Fig. 34.2 and ▶ Fig. 34.3)
    - The hernia is taken down and separated from the abdominal flaps.
    - Skin flaps are elevated laterally from the abdominal musculature to the anterior axillary line. Leaving perforators to overlying skin intact whenever possible may improve perfusion of this skin flaps.
    - The external oblique aponeurosis is incised vertically 1 cm lateral to the semilunar line from the costal margin to the inguinal ligament. The external oblique is raised off the internal oblique in a relatively avascular plane, up to the midaxillary line.
    - If additional advancement is needed, the posterior rectus sheath may be incised, and the rectus muscle may be separated from this layer.
  - Tissue expansion
    - Components separation is not possible in all cases (e.g., lateral defects).
    - An expander can be placed between the external and internal oblique muscles.
- Full-thickness defects
  - Primary repair: Small defects with adequate tissue laxity only.
  - Pedicled flaps.
    - Rectus abdominis: Superiorly based (upper abdominal defects) or inferiorly based (lower abdominal defects).
    - External oblique: Defects of upper two-thirds of the abdomen.

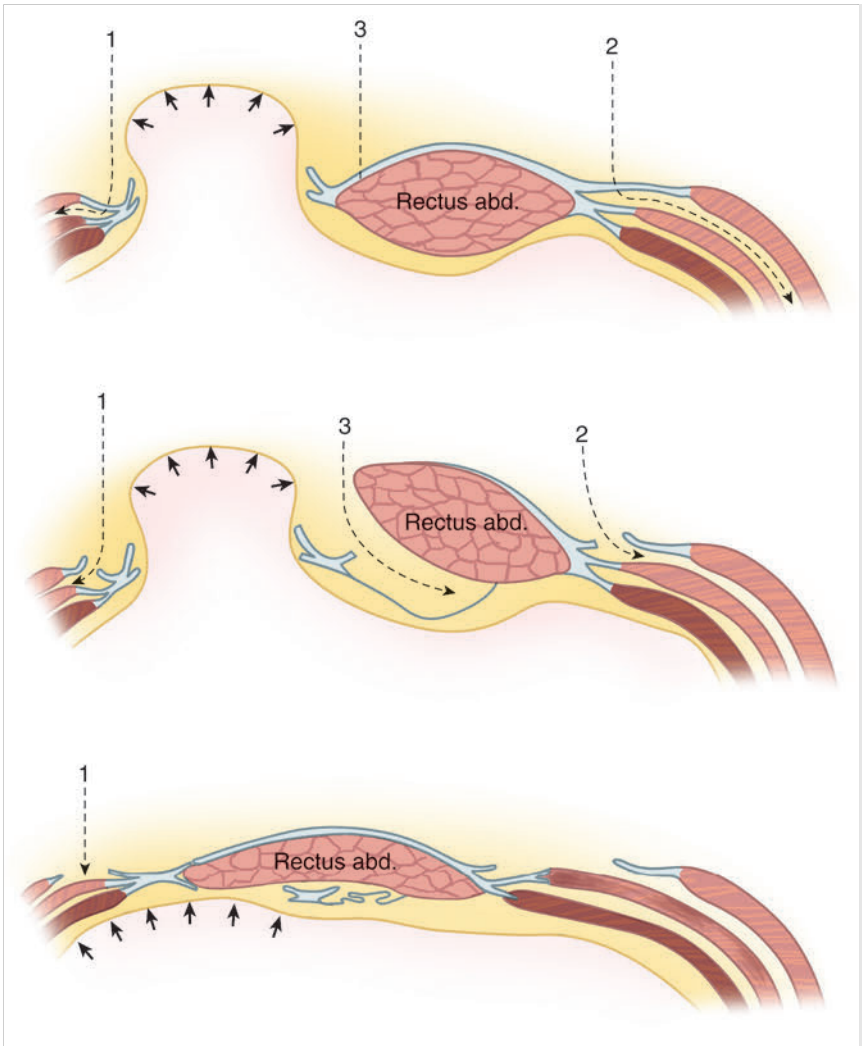

Fig. 34.3 Components separation technique. External oblique is incised lateral to the semilunar line and released from the internal oblique (*dashed lines 1 and 3*). Posterior rectus sheath is released (*dashed line 3*). The resulting myofasciocutaneous flaps are advanced toward the midline.

  - Latissimus dorsi: Lateral defects of the upper two-thirds of the abdomen.
  - Tensor fasciae latae: Defects of lower two-thirds of the abdomen.
  - Rectus femoris: Defects of lower two-thirds of the abdomen.
- Free flaps: For very large defects (e.g., Tensor Fasciae Latae, latissimus dorsi)
  - Most commonly used recipient vessels: Superior epigastric, deep inferior epigastric, deep circumflex iliac, internal thoracic, and saphenous vein loop grafts.
- Peak airway pressures are measured by the anesthesia team during closure. If peak airway pressure increases will not allow closure, mesh interposition may be necessary.
- If the abdominal wall defect is in a radiated field, nonradiated tissue will be needed (distant pedicled or free flap) for reconstruction.

34.4 Complications

- Wound infection.
- Delayed wound healing.
- Dehiscence.
- Recurrence.

34.5 Critical Errors

- Failure to optimize medical status before surgery.
- Failure to eliminate risk factors for recurrence (e.g., weight loss, smoking cessation, other).
- Inability to describe in detail the surgical option chosen.
- Inadequate preparation for complications (i.e., bowel perforation).
- Failure to evaluate for hernias preoperatively.
- Failure to consider backup or salvage measures when closure is not possible.

35 Sternal Wound Infection

Louis H. Poppler & Thomas H. H. Tung

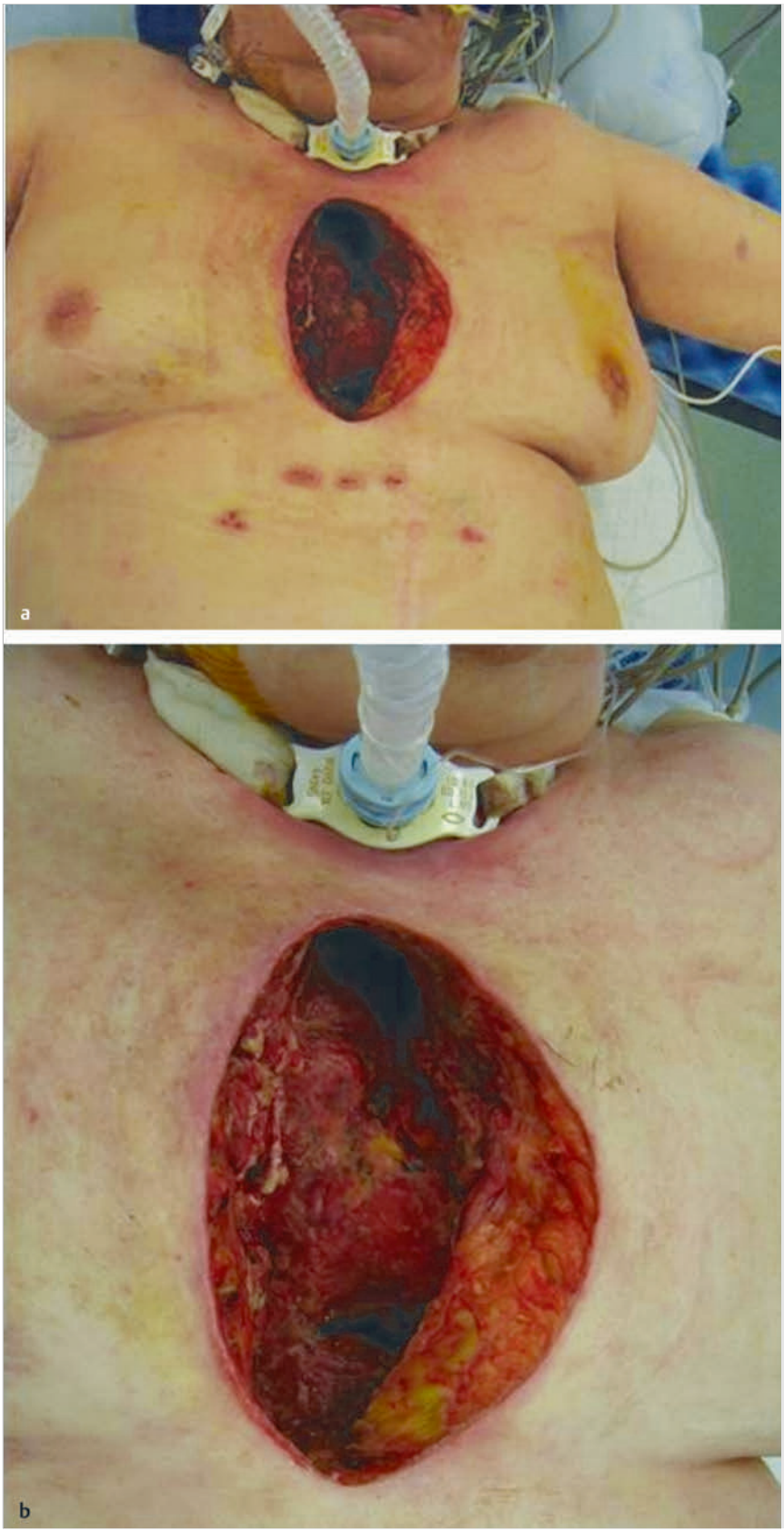

Fig. 35.1 Intraoperative consultation on a 67-year-old woman who had undergone three-vessel coronary artery bypass (left internal mammary and saphenous vein grafts) with subsequent sternal infection and wound dehiscence.

35.1 Description

- Patient with evidence of an anterior midline chest wall wound measuring roughly 15 × 8 cm.
- The sternal edges and mediastinum are exposed without evidence of gross purulence or extensive necrotic tissue.
- No vascular grafts are visible.

35.2 Work-up

35.2.1 History

- Etiology: Sternal wound infection (following median sternotomy), tumor resection, radiation (ulcers, osteoradionecrosis).
- Duration of wound.
- Current wound care.
- Comorbidities: Respiratory insufficiency, sepsis, cardiac disease.
- Review previous operative reports (e.g., vessels used, ribs resected).

35.2.2 Physical examination

- Vital signs: Is the patient stable?
- Size and depth of defect.
- Presence of infected or necrotic tissue.
- Exposed grafts, vascular devices, or mediastinum.
- Prior surgical scars on chest or abdomen.
- Congenital abnormalities: Poland syndrome, pectus excavatum/carinatum.

35.2.3 Pertinent imaging or diagnostic studies

- Chest X-ray: Presence of sternal wires and evaluation of lung fields.
- Computed tomography: Evaluation for deep abscesses if persistent fevers and sepsis.
- Magnetic resonance imaging: Most useful in chronic sternal defects for evaluation of extent of infection and/or osteomyelitis.
- Angiography: Allows study of available vessels and their patency.

35.3 Treatment

35.3.1 Goals

- Débride all nonviable tissue, achieve clean wound.
- Restore stability and structure.
- Protect vital structures and provide durable coverage.
- Obliterate dead space.
- Achieve cosmetically acceptable result.

35.3.2 Pattern of presentation

- Acute: First postoperative week
  - Sternal instability, serosanguinous drainage, dehiscence.
  - Return to operating room, drain, and débride to healthy bone. If there is good-quality bone, the sternal wires can be tightened or replaced. Otherwise, remove wires and close with vascularized tissue (e.g., bilateral pectoralis major myocutaneous flaps).
- Subacute: Second to fourth postoperative weeks
  - Purulent mediastinitis, fever/sepsis, leukocytosis.
  - Decompress wound at bedside or in the operating room. Follow with local wound care (dressing changes or vacuum-assisted closure [VAC]).
  - Once wound controlled, take to operating room. Débride exposed cartilage and sternum to healthy tissue. Close with flaps.
- Chronic: Treatment after the fourth week
  - Chronic osteomyelitis and sinus tracts.
  - Radical débridement and removal of foreign bodies. Institute local wound care with VAC or dressing changes.
  - Once wound is clean, cover with flaps.
  - Long-term intravenous antibiotics.

35.3.3 Flap coverage options

- Pectoralis major
  - Workhorse flap for sternal coverage. May disinsert muscle at the humerus for additional length.
  - Muscle flap (based on thoracoacromial vessels), turnover muscle flap (based on internal mammary perforators), or musculocutaneous flap.
  - Bilateral flaps sutured together provide sternal stability.
  - Flaps based on thoracoacromial pedicle may not reach inferior sternum. Turnover flaps cover inferior sternum but cannot be used if internal mammary vessel has been transected.
- Omentum
  - Based on left or right (preferable) gastroepiploic vessels.
  - Tunneled into the thoracic cavity over the costal margin or through the diaphragm.
  - Excellent for coverage of exposed grafts and vascular devices and the inferior part of the sternum. Requires intra-abdominal access for harvest.
- Rectus abdominis
  - Muscle or musculocutaneous (vertical rectus abdominis myocutaneous [VRAM]) flap.
  - Excellent coverage of the inferior sternum.
  - Bipedicled flap consisting of pectoralis major continuous with ipsilateral rectus abdominis (based on thoracoacromial and deep inferior epigastric artery [DIEA] pedicles, respectively) may be used if bilateral internal mammary artery (IMA) pedicles and omentum unavailable.
- Latissimus dorsi
  - Can be used for limited defects.
  - As a free flap, provides wide coverage.

35.4 Complications

- Hematoma
  - Most commonly due to early start of anticoagulation.
  - Platelets and fresh frozen plasma can be transfused if indicated.
  - Usually requires operative evacuation.
- Seroma
  - Can be minimized with liberal use of drains.

- Infection
  - Most likely due to incomplete initial débridement or wound preparation.
  - Decompress and institute local wound care.
- Flap failure
  - Ensure that the dominant vessel to the flap has not been sacrificed in a previous operation.
  - May need to create another flap for coverage.

35.5 Critical Errors

- Failure to cover exposed vascular grafts.
- Inadequate débridement of necrotic/infected tissue.
- Not ensuring intact vascular supply to proposed flap.
- Not leaving in drains or taking out drains too soon.

36 Chest Wall Defect

Gwendolyn Hoben & Ida K. Fox

Fig. 36.1 A 46-year-old woman with a history of right breast cancer and radiation therapy. She presents with an open chest wound and exposure of several ribs.

36.1 Description

- Large chest wall defect, including the inferior portion of the pectoralis major, lateral portion of the serratus, and the fourth and fifth ribs.
- Clear evidence of osteomyelitis (with exposed, necrotic bone).
- Healthy-appearing tissue in lateral wound.
- Left mastectomy scar.

36.2 Work-up

36.2.1 History

- Coronary artery disease
  - History of coronary artery bypass grafting: Possible absence of **internal mammary artery**.
- Pulmonary disease (chronic obstructive pulmonary disease [COPD], asthma): Increased risk for respiratory compromise in the absence of chest wall skeletal reconstruction.
- Previous history of chest, back, or abdominal surgery/trauma: Potential compromise of specific flaps.
- Other comorbidities.
- Tobacco use.
- Nutritional status.
- Etiology of chest wall wound/deformity
  - Traumatic, oncologic, infectious, radiation, congenital.
  - If oncologic, benign versus malignant: History of (or plan for) **radiation therapy**.

36.2.2 Physical examination

- Define defect or mass: Location, depth, fixed or mobile.
- Perform lymph node examination.
- Assess muscle involvement in the chest: Is the pectoralis major involved?
- Assess abdomen for hernias, diastasis recti.
- Evaluate back musculature and soft-tissue laxity.
- Assess for chest wall, back, or abdominal scars.

36.2.3 Pertinent imaging or diagnostic studies

- Computed tomography (CT) to evaluate extent of mass, wound, or deformity and any involved or absent structures.
- Angiography (or magnetic resonance/CT angiography) if uncertain about vascular anatomy.
- Pulmonary function tests may be indicated: Help determine need for reconstruction in small defects.

36.2.4 Consultations

- Cardiac/thoracic surgery for assistance in débridement and management of chest wall reconstruction.

36.3 Treatment

- Complete resection and débridement of all tumor, nonviable tissues, and infection.
- Reconstruction of potential missing layers: Pleural cavity, thoracic skeleton, soft tissues.
- Obliteration of intrathoracic dead space with soft tissue (pedicled muscle or omental flaps over chest tube)
  - Latissimus dorsi, pectoralis major, serratus anterior, rectus abdominis, omentum.
  - May require new thoracotomy incision to inset: Ensure pedicle is not strangled or twisted.
- Skeletal defect reconstruction
  - Skeletal support is generally needed in defects involving more than four consecutive ribs.
    - Smaller defects may require reconstruction if severe pulmonary disease present.
    - Larger defects may not require reconstruction in setting of radiation-induced chest wall fibrosis (stiffens chest wall, resulting in greater stability and less paradoxical motion) or location under scapula.
  - Reconstructive options
    - Autogenous: Pectoralis major, latissimus dorsi, rectus abdominis, serratus anterior, omentum.
    - Alloplastic: Mesh (polypropylene, ePTFE [expanded polytetrafluoroethylene]), methylmethacrylate, bone grafts.
    - Split-rib, iliac crest, or fibula grafts.
    - Hardware.
- Soft-tissue coverage
  - Locoregional or free flaps.
  - Latissimus flap
    - Can reach contralateral axillary fold.
    - If thoracodorsal pedicle is injured or unavailable, may be pedicled on serratus branch of the lateral thoracic artery.
    - With thoracotomy, latissimus muscle may be compromised.
  - Serratus anterior flap
    - Good for anterior and posterior chest coverage.
    - Risk for scapular winging if entire muscle removed.
    - May be compromised if prior thoracotomy.
  - Pectoralis major flap
    - Useful for superior–anterior chest.
    - Based on internal mammary artery or pectoral branch of the thoracoacromial trunk.
    - Prior coronary bypass (loss of internal mammary artery) may limit options.
  - Omentum
    - Useful in coverage of exposed pericardium.
    - Requires entrance to abdominal cavity. Concomitant hernia risk.
    - Excellent backup option because it is far from the zone of injury and will not be injured in a primary reconstruction with more local flaps.
  - Rectus abdominis flap
    - Good for anterior chest wall.
    - If internal mammary is not available, the flap can be based on the eighth intercostal vessels.

36.4 Complications

- Flail segment: Avoid with adequate skeletal reconstruction/stabilization.
- Infected mesh: Requires mesh removal.

  - Inflammatory process may result in fibrosis of sufficient mechanical stability to obviate the need for mesh replacement. If there is significant concern for infection, non-biologic materials should not be used.
- Hematoma/seroma: Requires prompt drainage.
- Donor-site morbidity, including hernia, scar/contracture, wound dehiscence, hematoma/seroma.

36.5 Critical Errors

- Failure to recognize on CT gross lymphadenopathy or disease progression altering resectability of the primary lesion.
- Inadequately assessing a patient's cardiac history to determine if the internal mammary artery is intact.
- Failure to assess need for skeletal reconstruction.

37 Perineal Reconstruction

Noopur Gangopadhyay & Ida K. Fox

Fig. 37.1 (a-b) A 44-year-old woman with recurrent vulvar cancer has just undergone wide local excision of tumor and now requires reconstruction.

37.1 Description

- Wide resection of perineal contents, including mons pubis, vulva, and clitoris.
- Resection area extends to urethral and vaginal orifices.

37.2 Work-up

37.2.1 History

- Personal or family history of cancer.
- Previous radiation treatment or exposure.
- Previous urinary incontinence.

37.2.2 Physical examination

- Evaluate surgical defect and classify as partial (anterior, lateral, posterior, upper two-thirds) or total loss of vagina.
- Evaluate for dead space, hernias, fistulas, infection, devascularized tissue, regional lymphadenopathy; examine abdomen and lower extremities to assess possible reconstructive options.
- Assess radiation effects to surrounding tissues.

37.2.3 Pertinent imaging or diagnostic studies

- Assess transferrin, albumin, and prealbumin levels.
- Computed tomography to evaluate nodal spread in the pelvis.
- Positron emission tomography (PET) has improved sensitivity to detect small nodal metastasis.

37.2.4 Consultations

- Oncologic surgeon: Wide local excision with pelvic lymph node dissection, as indicated.
- Radiation oncologist: Evaluation for postoperative or intraoperative radiation therapy, including possible placement of brachytherapy catheters at time of tumor resection.
- Medical oncologist: Consider need for neoadjuvant chemotherapy.

37.3 Treatment

37.3.1 Goals of therapy

- Promote rapid wound healing.
- Decrease pelvic dead space and restore pelvic floor.
- Reestablish normal sexual function and body image.

37.3.2 Reconstructive options

- Vertical rectus abdominis myocutaneous (VRAM) flap
  - Access via midline laparotomy incision.
  - Cover defects of anterior or posterior vagina by insetting flap along wound margins.
  - Can be tubed for circumferential vaginal reconstruction.
  - Based on deep inferior epigastric artery.
- Gracilis myocutaneous flap
  - Examine femoral pulses preoperatively to evaluate patency of inflow vessel (medial femoral circumflex artery).
  - Useful if laparotomy incision not required for oncologic resection and in total vaginal reconstruction.
  - Consider bilateral flaps for large defects and to create a neovagina.
- Pudendal thigh (modified Singapore) flap (▶ Fig. 37.2)
  - Reconstruct anterior or lateral vaginal defect.
  - Useful when considering postoperative sensation.
  - May be unilateral or bilateral.
  - Based on posterior labial vessels and posterior labial branches of pudendal nerve.

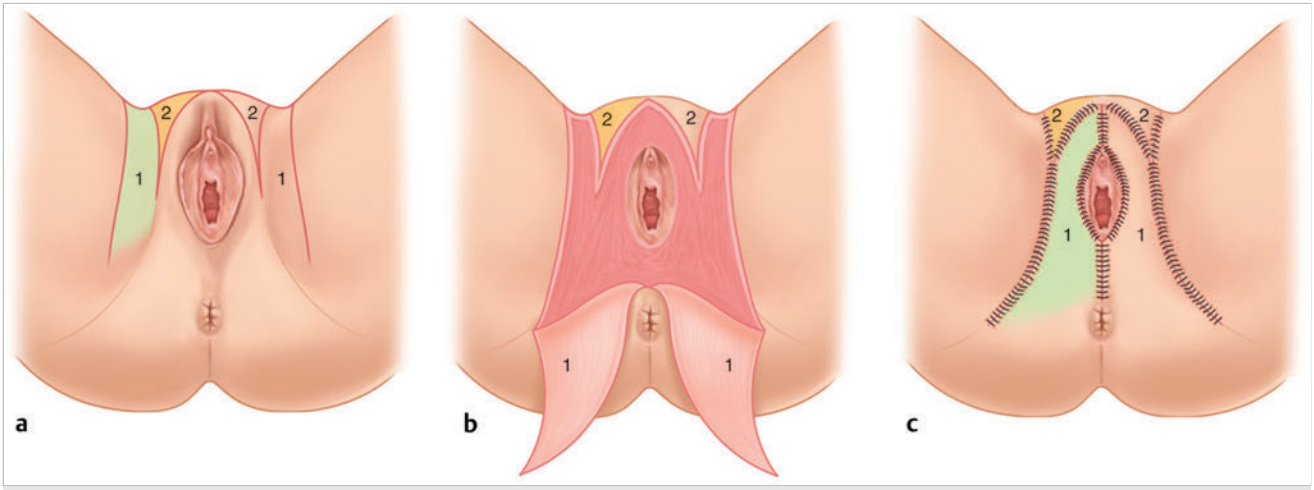

Fig. 37.2 Pudendal thigh flap.

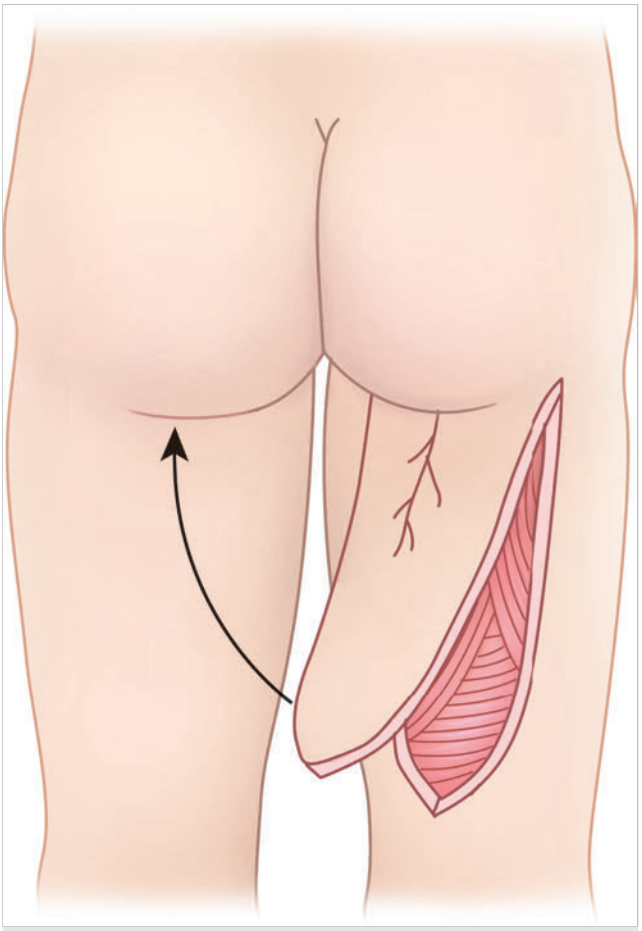

Fig. 37.3 Thigh flap.

- Thigh flap (▶ Fig. 37.3)
  - Useful for defects confined to perineum.
  - Can be designed anteriorly, posteriorly, laterally, or medially
    - Most frequently posteriorly based.
  - Does not provide sufficient bulk for large defects.
  - Difficult to mobilize in obese patients.

37.4 Complications

- Pressure to the flap can result in partial flap loss, wound dehiscence, and delayed healing.
- Seroma accumulation in dependent areas.
- Venous congestion due to pedicle kinking during inset.
- Distal third of skin paddle for gracilis myocutaneous flap may be unreliable.
- Pudendal thigh flap may be damaged by irradiation and suboptimal for reconstruction.

37.5 Critical Errors

- Inadequately filling soft-tissue defect left in the perineal cavity after resection.
- Failure to discuss with patient postoperative goals for sexual function (creation of neovagina, sensation, other).
- Failure to account for previous abdominal and lower extremity scars leading to injury to pedicles for flap reconstruction.
- Attempts to reconstruct the perineum with skin graft will result in a high rate of failure in an irradiated bed.

38 Abdominoplasty

Elizabeth B. Odom & Terence M. Myckatyn

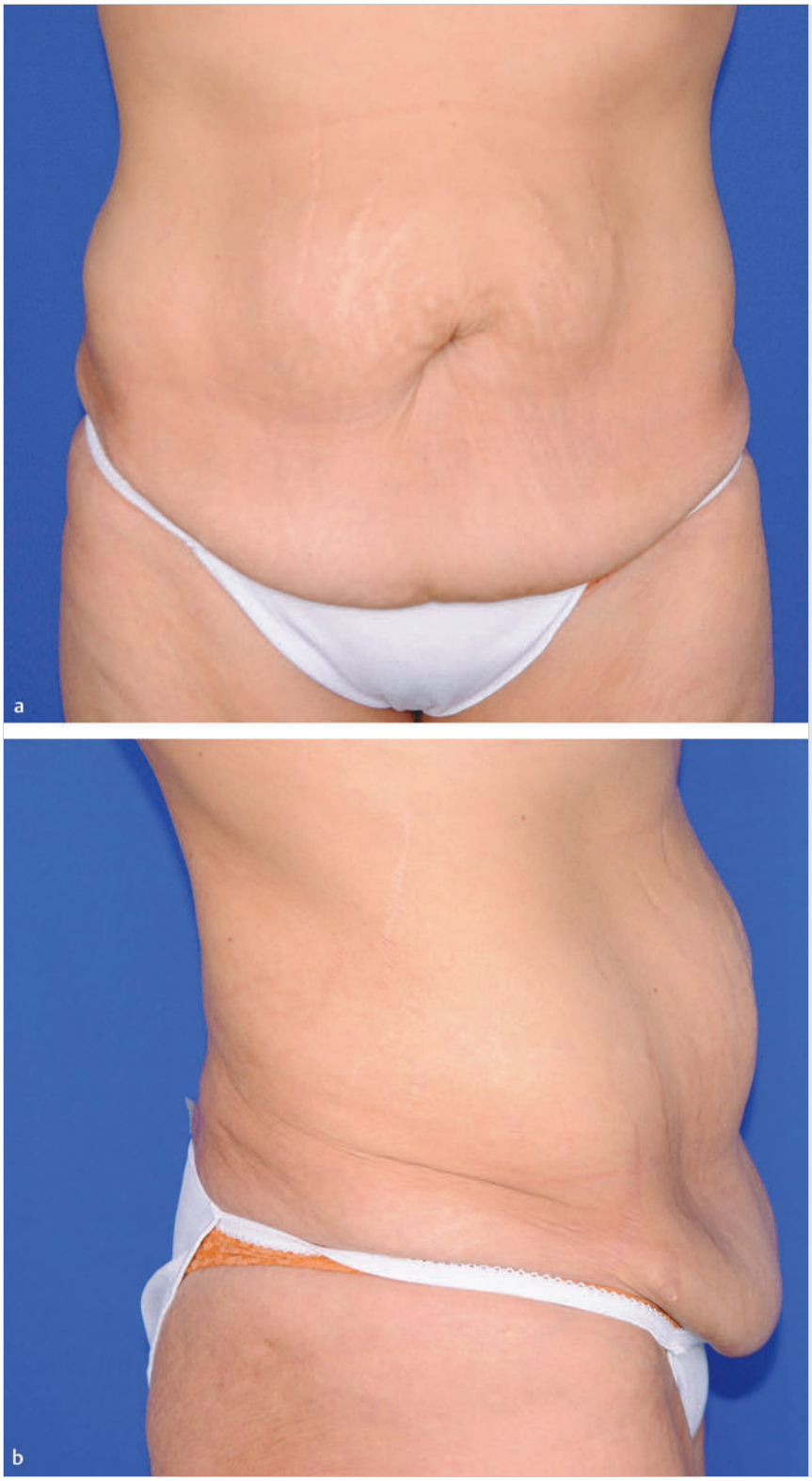

Fig. 38.1 A 39-year-old woman with two previous pregnancies and a 40-lb weight loss has excess abdominal skin and subcutaneous tissue and multiple striae.

38.1 Description

- Excess skin and subcutaneous tissue of the central abdomen.
- Laxity of the abdominal wall musculature (consistent with weight loss and pregnancies).
- Residual localized adiposity of both flanks.

38.2 Work-up

38.2.1 History

- Assess patient suitability for the procedure and general anesthesia, as well as risk factors for deep venous thrombosis (DVT) and wound-healing problems.
- Previous abdominal surgery (including laparoscopic surgery).
- History of pregnancies and their effect on the abdomen. Possibility of future pregnancies.
- History of weight changes: Weight should be stable and within 10 lb of final desired weight for ~ 3 months before surgery.
- Heart disease, peripheral vascular disease, diabetes, steroid use, connective tissue disease.
- Smoking history: Must stop smoking 6 weeks before surgery.
- History of DVT or pulmonary emboli (PE).

38.2.2 Physical examination

- Examine excess skin and soft tissue with the patient in the standing, sitting, and supine positions.
- Document any hernias, diastasis recti, or asymmetries.
- Note and document the location and size of all abdominal scars.
  - A thorough understanding of the abdominal blood supply is essential.

38.2.3 Pertinent imaging or diagnostic studies

- Complete blood cell count (CBC), basic metabolic panel, prothrombin time (PT)/international normalized ratio (INR), activated partial thromboplastin time (aPTT) may be considered.
- Urine β-human chorionic gonadotropin level to confirm absence of pregnancy.
- Albumin/prealbumin level to assess nutritional status (especially in patients with weight loss).
- Urine cotinine level to gauge patient compliance with smoking cessation (if indicated).

38.2.4 Consultations

- If an abdominal wall defect or hernia is encountered on examination, a general surgery consultation may be made for intraoperative assistance.

38.3 Treatment

38.3.1 Preoperative management

- Smoking cessation for 6 weeks before the operation.
- Strict glucose control if the patient is diabetic. Confirm satisfactory weight loss and correction of malnutrition (if indicated).
- Incision markings made preoperatively
  - Efforts made to keep incision well hidden under clothing (bikini line).
  - Markings made transversely at the level of the pubic bone, extending laterally and superiorly toward, but staying just inferior to the anterior superior iliac spine.
- With the patient flexed at the waste, perform a pinch test of the abdominal apron to predict the amount of skin that may be removed to determine the superior incision.
- Initiation of sequential compression devices preoperatively to minimize the risk for venous thrombosis.

38.3.2 Standard abdominoplasty technique

1. Full inferior incision is made and taken straight down to the muscular fascia.
2. Skin and fat are elevated away from the underlying fascia to the umbilicus.
3. Umbilicus is incised circumferentially, with dissection down to the rectus sheath.
4. Elevation of skin and fat continued to the costal margins laterally and the xiphoid centrally.
5. Identify the degree of diastasis within the rectus fascia and mark the area to be imbricated.
6. Place permanent interrupted sutures along the marked area of plication that runs from the xiphoid to the umbilicus and from the umbilicus to the pubis. A second layer of reinforcing running permanent suture may be utilized.
7. The waist is flexed to ~ 60 degrees, and the amount of skin and fat that can be resected to allow a tension-free closure is marked and resected. Preoperative markings cannot be trusted to determine the superior margin of the resection.
8. Jackson-Pratt drains should exit through the hair-bearing skin of the pubic region.
9. The level of the umbilicus is marked, and an opening is created through the skin and subcutaneous tissue to transpose and inset the umbilicus.
10. The superficial fascia is closed with semipermanent sutures, followed by the deep dermal and subcutaneous layers.
11. An abdominal binder is placed.

38.3.3 Variations to technique

- Concomitant liposuction with abdominoplasty
  - May be used primarily in the flanks following a standard abdominoplasty for concomitant contouring, staying deep to the superficial fascia layer to maintain the subcutaneous vascular network.
  - Should be performed before the abdominoplasty procedure because it will redistribute contours and create redundancy in overlying tissue.
- Brazilian technique: Full-thickness liposuction is performed along the flanks and the inferior pannus. Above the umbilicus, liposuction and undermining are limited to the tissue deep to the superficial fascia to minimize damage to the blood supply through the subcutaneous vascular network. Lateral dissection is minimized during the abdominoplasty to decrease the risk for vascular compromise in regions where

more extensive liposuction has been performed. Skin of the inferior pannus may then be excised.
- Fleur-de-lis: An additional vertical incision is added to allow removal of supraumbilical horizontal skin excess.
- Mini abdominoplasty: Performed in patients with primarily a diastasis recti and a modest excess of infraumbilical tissue. A 12- to 16-cm incision is made with a conservative excision of skin and fat. The umbilicus is not typically excised, but it may be "floated" with its stalk severed and displaced inferiorly.
- Reverse abdominoplasty: Less conventional technique, performed in patients with excess supraumbilical skin or a subcostal scar. A transverse inframammary incision is made, and dissection is carried inferiorly with excision of superior abdominal fat and skin.

38.3.4 Postoperative management

- Encourage early ambulation because of increased risk for DVT.
- DVT chemoprophylaxis
  - Weight-based enoxaparin regimen beginning within 8 hours after surgery and continuing throughout the inpatient stay has been shown to decrease the risk for DVT and PE in high-risk patients (i.e., those with a body mass index [BMI] > 40, smoking history, oral contraceptive use, family or personal history of DVT, or known coagulation disorder) and those with a hospital stay of ≥ 4 days.
  - Lower-risk patients may benefit from chemoprophylaxis and should be assessed on an individual basis after a prolonged case (> 6 hours) or prolonged postoperative stay (> 4 days).
- Maintenance of patient in a flexed position for several weeks postoperatively to minimize tension on wound margins.

38.4 Complications

- Patient dissatisfaction: Candid discussions regarding expectations, scar quality, and potential wound problems must occur before the operation.
- Common complications include contour imperfections, marginal wound necrosis, infection, seroma, hematoma, wound dehiscence, hypertrophic scars/keloids, and umbilical malposition.

38.5 Critical Errors

- Failure to provide DVT prophylaxis leading to DVT, PE, or death.
- High-volume liposuction or lengthy procedure (> 6 hours), which may compromise patient safety.
- Inadequate preoperative discussion of the possibility of poor or imperfect outcome, the possible need for revision, and how such cases may be handled (e.g., payment).
- Failure to consider previous abdominal or chest wall scars that may have disrupted blood supply. Tissue medial to lateral abdominal scars may be compromised.
- Failure to examine for abdominal wall defects or hernias may lead to bowel injury during abdominoplasty.
- Excision of marked specimen without confirming that abdomen can be definitively closed, causing excess tension on wound margins or inability to close the wounds.

Part 8

Section VIII. Burn

39 Acute Burn Injury

Amy M. Moore & Ida K. Fox

Fig. 39.1 (a,b) 8 year old presents to the emergency department after sustaining burns from campfire explosion.

39.1 Description

- Flame burn injury to portions of the face, the left chest, and left arm.
  - Superficial and deep partial-thickness burns.
  - Approximately 20% of body surface area.
  - Possible circumferential involvement of the forearms.
- Concern for inhalational injury.

39.2 Work-up

39.2.1 History and physical examination

- Trauma evaluation
  - ABCs (airway, breathing, circulation): Assess for critical injuries during the primary survey.
- Mechanism of injury
  - *Flame:* Most common. Can lead to superficial to deep burn, depending on degree of exposure.
  - *Oil or grease* burns: Must be careful not to underestimate severity of such burns. Oil will continue to burn over lengthy periods of time if not washed off immediately.
  - *Electrical* (high or low voltage): Raises concern for deeper injury to the underlying structures. Greater concern for compartment syndrome and rhabdomyolysis.
  - Enclosed versus open space: Enclosed locations increase likelihood of inhalational injury.
- Inhalation injury
  - Examine for singed facial hair, soot in airway.
  - History of asthma or chronic obstructive pulmonary disease (COPD) can compromise oxygenation.
  - Any significant concern warrants intubation.
- Extent of burn
  - *Rule of nines* (▶ Fig. 39.2): Calculation of extent based on second- and third-degree burns. Does not include first-degree burns.

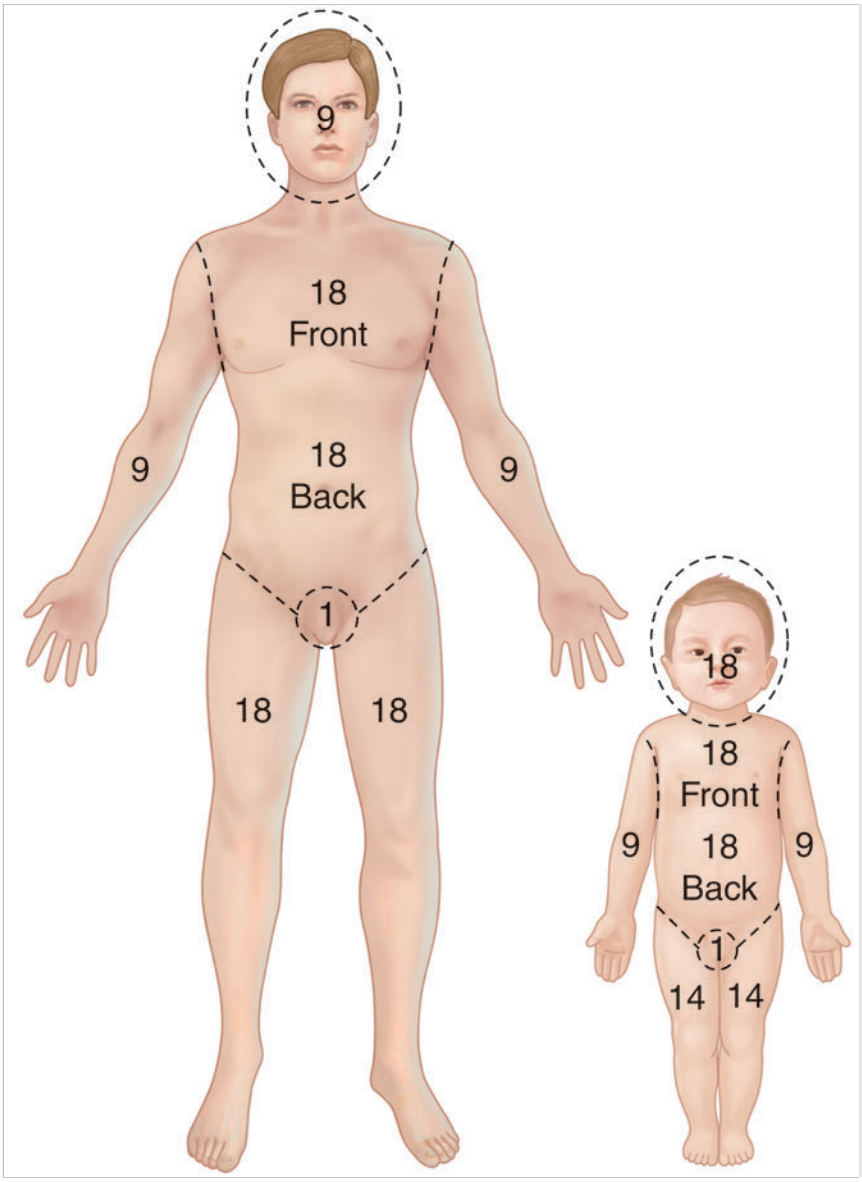

Fig. 39.2 Rule of nine for estimation of burn injury. Note the increase in proportion of the size of the head in children.

- Assess depth of burn: Partial (superficial or deep) versus full thickness.
- If electrical: Identify entrance and exit wounds to determine path of injury.

- Extremities involved
  - Circumferential burns: Assess need for escharotomies or fasciotomies.
  - Compartment syndrome (see Case 40)
    - Compartmental pressures may be measured with STIC pressure monitor (Stryker; Kalamazoo, MI).
    - Concern if pressures > 30 mm Hg.
  - Assess distal perfusion.
- Face involved
  - Eyes: consider ophthalmology consult.
  - Cartilage exposure: Assess for presence of exposed tissues.

39.2.2 Diagnostic studies

- Chest X-ray.
- Carboxyhemoglobin level: Treat with supplemental oxygen.
- Electrocardiography, heart monitor: especially in the patient with an electrical burn.
- Urine creatine kinase level: when concern for myoglobinuria exists.

39.3 Treatment

- Secure the airway if you suspect inhalation injury.
  - Supplemental oxygen if patient not intubated.
  - Intravenous (IV) access for maintenance and resuscitation fluids.
- Resuscitation: Adjust formula for adequate urine output (child, 1 to 2 mL/kg per hour; adult, 0.5 to 1 mL/kg per hour).
  - *Parkland formula:* 4 mL/kg per % burn per 24 hours
    - % Burn = total second-degree and deeper burns.
    - Apply formula for burns > 20% of body surface area.
    - Give half of IV fluids in first 8 hours, second half over next 16 hours.
- Early débridement: Remove dead skin and tissue to fully assess extent of burns.
- Escharotomies (see Case 40): Incisions designed to optimize function of extremities and chest, minimize morbidity and contracture.
- Fasciotomies in the patient with an electrical burn: Bone continues to conduct heat and may lead to continued soft-tissue necrosis.
- Nutrition: Metabolic demands are increased, enteral feeds are ideal.
  - Place feeding tube if patient not taking adequate nutrition orally or if intubated.
- Dressings and topicals: After débridement, multiple options exist.
  - Face: Antibiotic ointment 3 times daily.
  - Ears and nose: Mafenide (Sulfamylon; Mylan Pharmaceuticals, Morgantown, WV) because of improved cartilage penetration.
  - Body and extremities: Apply silver sulfadiazine (Silvadene; Pfizer, New York, NY) to areas 2 times daily.
- Splinting, early range of motion (ROM) with occupational therapy.
- Tangential excision and grafting
  - As soon as patient is stable, plan for multiple trips to the operating room.
  - Surgeries performed in a warm environment.
  - Begin with largest areas first.
  - Address hand burns by 14 days and address the face last.
- Surgical end points: 2 to 3 hours of operating time or transfusion of 10 units of blood (packed red blood cells).
- Graft options: Cadaver, xenograft, autografts
  - Split- versus full-thickness grafts.
  - Meshed versus sheet grafts (consider sheet grafts for face and hands and across joints).

39.4 Complications

- Burn sepsis: Fevers, change in mental status, hypotension, change in wounds.
- Scar/contracture: Avoid with early excision and grafting, splinting, ROM, compression garments.
- Electrical burns: cardiac arrhythmias, myoglobinuria, muscle necrosis.

39.5 Critical Errors

- Failure to recognize inhalation injury and secure airway.
- Failure to recognize other concomitant injuries and trauma.
- Not performing escharotomies with circumferential burns and/or fasciotomies with electrical burns.
- Failure to excise and graft deep partial- and full-thickness burns.

40 Hand Burn

David T. Tang & Ida K. Fox

Fig. 40.1 A 28-year-old man involved in a house fire has sustained noncircumferential flame burns to both upper extremities. After initial stabilization and resuscitation, his cutaneous burns still require management.

40.1 Description

- Noncircumferential second- and third-degree burns to the upper extremity.
- Dorsal hand and fingers involved.
- No significant palmar burns present (not shown in photograph).
- Neurovascular status is intact distally.

40.2 Work-up

40.2.1 History

- Age, gender, handedness, and occupation of the patient.
- Timing and mechanism of burn injury
  - **Thermal:** Type of burn (flame, contact, scald, steam, grease); duration of contact; associated injury; tetanus status; suspicion of abuse.
  - **Chemical:** Type of chemical (alkali, acid, organic compound); duration of contact; neutralization attempted.
  - **Electrical:** Type of current (AC or DC), voltage, duration of contact, pathway of current flow.
- Previous injury or surgery to the hand in question.
- Manual demands of daily living and overall lifestyle.
- Past medical and surgical history.
- Medications and allergies.
- Social history, including smoking status and substance abuse.

40.2.2 Physical examination

- Initial assessment of hand burns pertains to vascular perfusion and to the depth and distribution of the burn injury.
  - Hand is scrubbed of any soot, dirt, or debris.
  - Potentially constricting jewelry and watches are removed.
- Acute injury
  - Location and total surface area of burn injury.
  - Depth of burn injury (first-degree, superficial second-degree, deep second-degree, third degree).
  - Exposure of deep structures (e.g., tendons, bones, neurovascular structures).
  - Vascular status of hand.
  - Motor and sensory function.
  - Compartment syndrome: Limb-threatening condition
    - Mostly seen in combined crush or other significant injury (otherwise see notation on eschartomy below, which is more pertinent to isolated burn mechanisms of injury).
    - High index of suspicion necessary.
    - *Pain out of proportion to injury, especially with movement.*
    - Five P's (late signs): *p*ain, *p*allor, *p*aresthesias, *p*aralysis, *p*ulselessness.
    - Intracompartmental pressures > 30 mm Hg require intervention.
    - Needle pressure gauge (STIC pressure monitor; Stryker, Kalamazoo, MI) if concerned about compartment syndrome.
  - Underlying fracture assessment.
- Secondary reconstruction
  - Status of soft-tissue coverage (thickness, durability, sensibility, elasticity).
  - Active and passive range of motion (ROM) of each joint.
  - Presence of contractures
    - Discern intrinsic from extrinsic joint contracture.
  - Assess degree of soft-tissue deficit.

40.2.3 Pertinent imaging or diagnostic studies

- Standard radiography (three views of the hand).
- Angiography if required for planned free tissue transfer reconstruction.
- Blood work: Complete blood cell count (CBC), electrolytes, blood urea nitrogen (BUN), creatinine, international normalized ratio (INR), partial thromboplastin time (PTT), glucose, blood type.
- Consider arterial blood gases for associated inhalational injuries or certain chemicals.
- Cardiac enzymes, urine myoglobin, creatine kinase, 12-lead electrocardiography for electrical burn.

40.2.4 Consultations

- General surgery or critical care team if burns are extensive.
- Poison control center if chemical is involved and management is unclear.

40.3 Treatment

40.3.1 Acute burn management

- ABCs (airway, breathing, circulation) and primary survey
  - Ensure that initial life-threatening concerns regarding airway, breathing, and circulation have been managed
  - Proper acute advanced burn life support (ABLS)/advanced trauma life support (ATLS) guidelines should be adhered to before hand burns are managed.
- Escharotomy (▶ Fig. 40.2)
  - Indications
    - Necessary in clear-cut, full-thickness circumferential burns.
    - Partial-thickness circumferential burns that may cause compartment syndrome with onset of post-resuscitation edema.
    - Clinical signs consistent with vascular compromise.
    - Pain on passive extension, flexed posturing, decreased capillary refill, decreased pulses, cyanosis, and neurologic change.
  - Performed emergently in operating room or at bedside to prevent further soft-tissue death due to vascular compromise.
  - Incisions designed to minimize morbidity and optimize eventual hand function.
- Fasciotomy
  - Indicated following high-voltage electrical injury (> 1,000 V) or severe burn injury.
  - Decompression of the carpal tunnel should also be considered.
  - Fascial compartments.
  - Forearm (▶ Fig. 40.3)

Fig. 40.2 Escharotomies of the hand and forearm.

  - There are 3 compartments: Volar, dorsal, lateral (mobile wad).
- Hand (▶ Fig. 40.4)
  - The 10 fascial compartments of the hand must be assessed and released, if necessary.
  - Dorsal interossei (4 compartments), palmar interossei (3 compartments), adductor pollicis, thenar, and hypothenar.
  - Can be achieved through carpal tunnel release, 2 dorsal incisions, thenar and hypothenar incisions.
  - If fingers are threatened, midaxial incisions over nondominant sides may be performed.

- Burn eschar excision
  - Consider a brief period of observation (~ 3 days) until the depth of the burn injury is well demarcated to avoid unnecessary excision of healthy tissue.
  - Early excision advantages
    - Improved ultimate hand function.
    - Reduced risk for abnormal scarring.
    - Reduced number of reconstructive procedures.
    - Decreased length and cost of hospital stay.
    - Reduced pain and complications associated with prolonged immobilization.
  - Late excision (3 to 6 weeks) advantages
    - Early excision is more complex and time-consuming.
    - No significant difference in ultimate hand function.
    - Preservation of all residual, viable dermal elements.

40.3.2 Skin resurfacing

- Temporary skin replacement
  - Cadaver allograft.
  - Biobrane (nylon mesh + thin silicone membrane; UDL Laboratories, Rockford, IL).
  - TransCyte (porcine collagen–coated nylon mesh with human cultured fibroblasts; Advanced BioHealing, New York, NY).
- Permanent skin replacement
  - Split-thickness skin graft (sheet or meshed)
    - Meshed grafts: Trunk, upper arm, and forearm.
    - Sheet grafts: Dorsum of the hand and fingers.
  - Full-thickness skin graft: Palmar surface (glabrous skin).

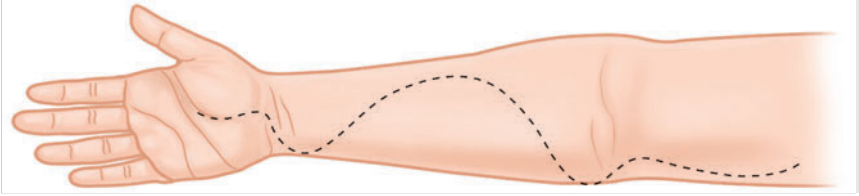

Fig. 40.3 Fasciotomies of the forearm.

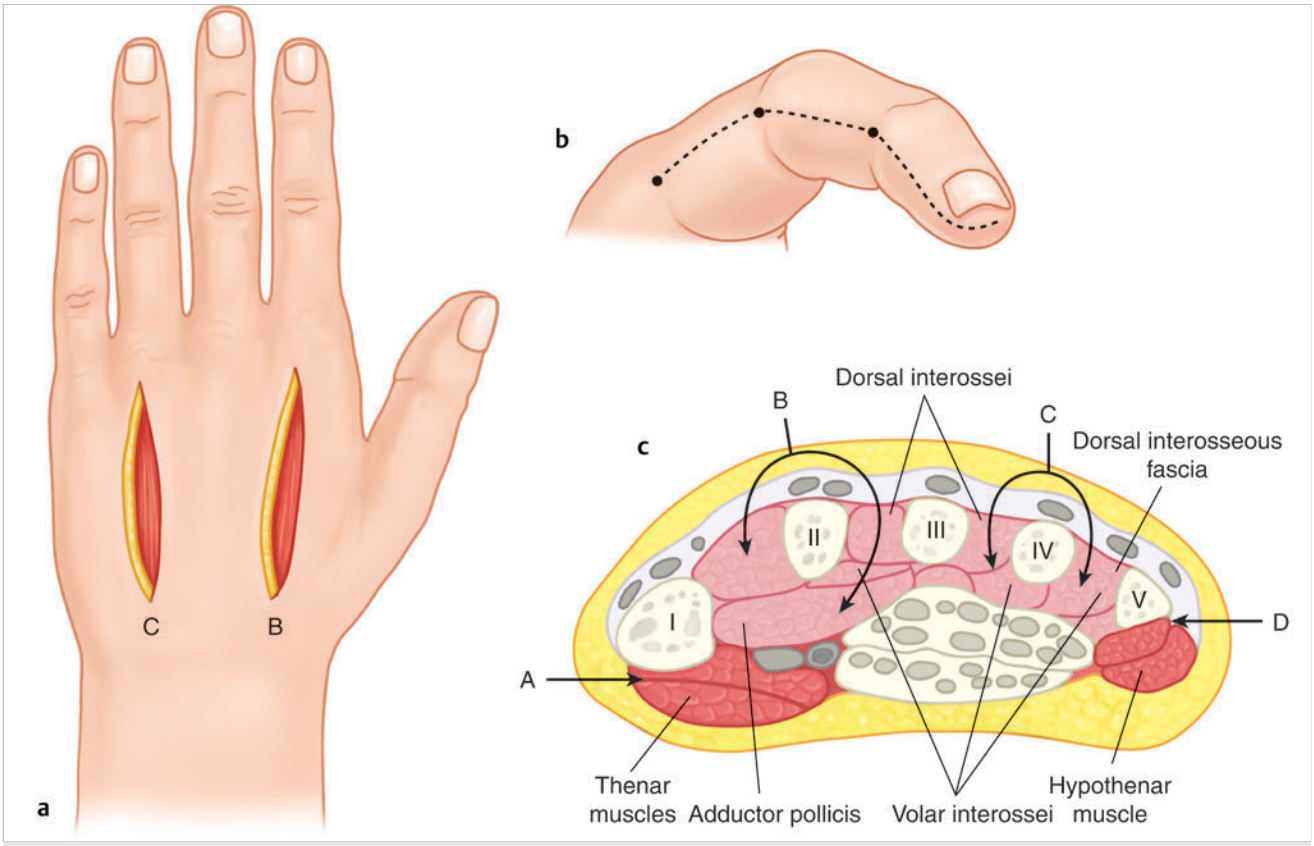

Fig. 40.4 Fasciotomies of the hand. A. Markings for incisions to achieve access to dorsal interossei. B. Midaxial incisions over non-dominant sides of the finger. C. Axial cross-section demonstrating sites for compartment release.

- Nonautogenous materials
  - AlloDerm (human cadaveric acellular allogeneic dermal matrix; LifeCell, Bridgewater, NJ)
  - Integra (bovine collagen dermal regeneration scaffold; Integra, Plainsboro, NJ).
  - Apligraf (bovine collagen + human-derived fibroblasts bilayered living skin equivalent; Organogenesis, Canton, MA).
  - Dermagraft (human-derived fibroblast bilayered bioabsorbable living skin equivalent; Advanced BioHealing, New York, NY).
- Cultured epidermal autograft
  - Cultured epidermal sheets from skin biopsy of the patient.
  - Expensive, require 2 to 3 weeks to culture, and are thin and unstable.

- Flap reconstruction options
  - Local flaps.
  - Pedicled flaps.
  - Free flaps
    - Fasciocutaneous.
    - Muscle flap + split-thickness skin graft.

40.3.3 Prevention of secondary injury

- Edema control: Early motion and elevation.
- Physical therapy and rehabilitation.
- Splinting to prevent contractures (static, static–progressive, dynamic).
- Continuous passive motion devices.
- Kirschner wires across joints (inherent risk for infection).

40.3.4 Secondary burn management

- Hypertrophic scarring and contracture bands
  - Compression garments.
  - Silicone sheet therapy.
  - Early active motion therapy.
  - Appropriate splinting.
  - Intralesional steroid injections.
  - Scar band release and Z plasty reconstruction.
  - Scar band release and skin graft reconstruction (split-thickness or full-thickness skin graft).
- First web space contracture release
  - Skin + adductor pollicis fascia contracture release.
  - First dorsal interosseous muscle release, if needed.
  - Adductor pollicis muscle release at origin, if needed.
  - Soft-tissue reconstruction
    - Local flaps: Four-flap Z-plasty (▶ Fig. 40.5), V-M plasty, five-flap Z-plasty.
    - Regional flap: Reverse radial forearm, reverse posterior interosseous artery (PIA).
    - Free flap: Lateral arm flap, radial forearm flap from contralateral arm.

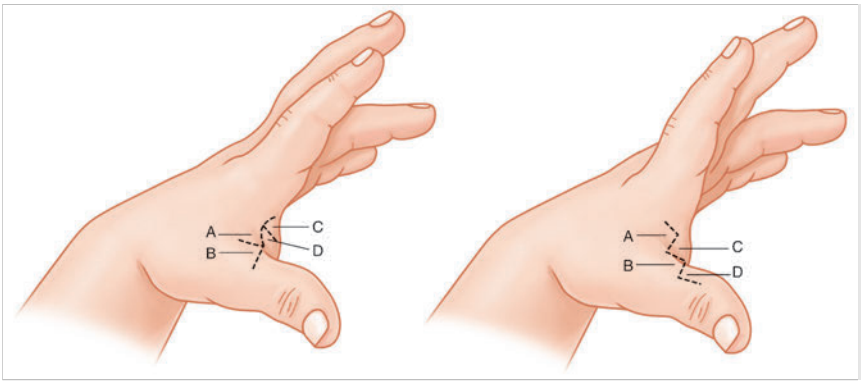

Fig. 40.5 Reconstruction of a first web space contracture with four-flap Z-plasty.

40.4 Complications

- Failure of reconstruction (poor graft take, partial or total flap loss).
- Hypertrophic scarring.
- Burn scar contracture.
- Claw hand deformity: Inadequate splinting, therapy, or early operative management.
- Wound breakdown.
- Infection.

40.5 Critical Errors

- Failure to perform early escharotomy or fasciotomy as needed.
- Poor design of escharotomy or fasciotomy, exposing critical structures or inadequately releasing tissues.
- Inadequate assessment of all compartments of the hand or extremity, especially in circumferential burns.
- Poor graft choice (meshed grafts on the hand instead of sheet grafts to minimize contracture, especially over joint surfaces).

41 Scalp Burn Reconstruction

Gwendolyn Hoben & Albert S. Woo

Fig. 41.1 (a,b) A 26–year-old man burned in a house fire requesting reconstruction following initial treatment of scalp burns.

41.1 Description

- Irregular scarring and alopecia to the right occipital scalp
  - Extension to the superior neck and retroauricular region.
  - Defect involves ~ 25% of normal hair-bearing scalp surface.

41.2 Work-up

41.2.1 History

- Etiology of scar, including mechanism and depth of burns.
- Time interval since injury and reconstruction.
- Medical comorbidities
  - Wound- healing problems.
  - Smoking history.
  - Bleeding disorders.
- Social support network.

41.2.2 Physical examination

- Assess size of scar and degree of scalp laxity.
- Assess directionality of remaining hair.
- Assess for other scars or affected body regions.

41.3 Treatment

- Establish patient expectations for reconstruction.
  - Correction of alopecia (bring in new *hair-bearing* tissue).
  - Improvement in hairline.
  - Improvement in facial appearance (excise grafted regions and replace with local tissue, if possible).

41.3.1 Flap coverage

- Viable option for smaller defects of the scalp.
- Scalp tissue has less mobility than tissue in other parts of the body.
- Large flaps should be designed to optimize result and minimize tension.
- Common flap options: Rotation, advancement (V-Y), transposition, pinwheel, Orticochea.

41.3.2 Tissue expansion

- Defects of up to 50% of the scalp can be reconstructed.
- Preferred technique for scalp reconstruction.
- Multiple expanders may be used for a single defect. More than one expansion may be performed.
- Incisions are designed perpendicular to axis of expansion, can be placed within lesion to allow future excision.
- Subgaleal placement.
- Internal ports are less convenient but have a lower risk for infection compared with external ports.

41.3.3 Expansion technique

- Begin ~ 2 weeks after tissue expander placement; continue at weekly intervals.
- With each session, fill until patient experiences discomfort or notable skin changes occur.
- Continue until sufficient skin to cover defect.
  - Available tissue = dome of expander – base width of expander.
  - Create flap ~ 20% larger than the defect to account for recoil.
  - Second stage should be performed once adequate expansion is achieved.
- Design flaps with a combination of advancement and rotation based on at least one named vessel as the pedicle.
- Facilitate flap advancement and tension-free closure with galeal scoring at 1-cm intervals.
  - Score in a direction perpendicular to the direction of desired tissue gain.
  - Use caution because scoring may compromise vascularity of overlying skin.
  - Approximately 1 mm of additional lengthening is achieved per score.
- *Do not excise dog ears.* These settle over time.

41.3.4 Reconstruction by region

- Anterior scalp defects: Goal is to re-create anterior hairline.
  - Tissue expansion.
  - Advancement ± rotation, V-Y advancement, rhomboid flaps.
  - **Orticochea flaps** (▶ Fig. 41.2)
    - Two flaps based on superficial temporal vessels to fill defect.
    - One large occipital flap to fill donor-site defect.
- Parietal scalp defects: More scalp mobility present than anteriorly
  - Tissue expansion.
  - V-Y advancement, rhomboid flaps for sideburns.
  - Rotation ± advancement, bipedicled fronto-occipital flaps.
- Occipital scalp defects
  - Tissue expansion.
  - Rotation ± advancement flaps.
  - Orticochea three-flap technique.
- Vertex scalp defects: Limited scalp mobility here.
  - Tissue expansion.
  - Pinwheel (▶ Fig. 41.3), rhomboid, rotation ± advancement flaps.
  - Large rotation flaps requiring nearly complete scalp undermining.
- Nearly complete scalp defects: Complete coverage with hair-bearing skin may not be possible. Goal may simply be scalp coverage with healthy tissue.
  - Free tissue transfer
    - Muscle flaps create nice contour with atrophy (e.g., latissimus dorsi).
    - Omentum, radial forearm, anterior lateral thigh.
  - Integra (bovine collagen dermal regeneration scaffold; Integra, Plainsboro, NJ) and split-thickness skin graft.
- Hair transplant
  - Remains an option if adequate hair-bearing scalp is available.
  - Requires excision of hair-bearing regions of the scalp with direct closure of donor site.
  - Transplant can be performed with separation of hair into naturally occurring follicular units. These are separately inserted into regions of alopecia.
    - Micrograft: 1 to 2 hair follicles.
    - Minigraft: 3 to 6 hair follicles.

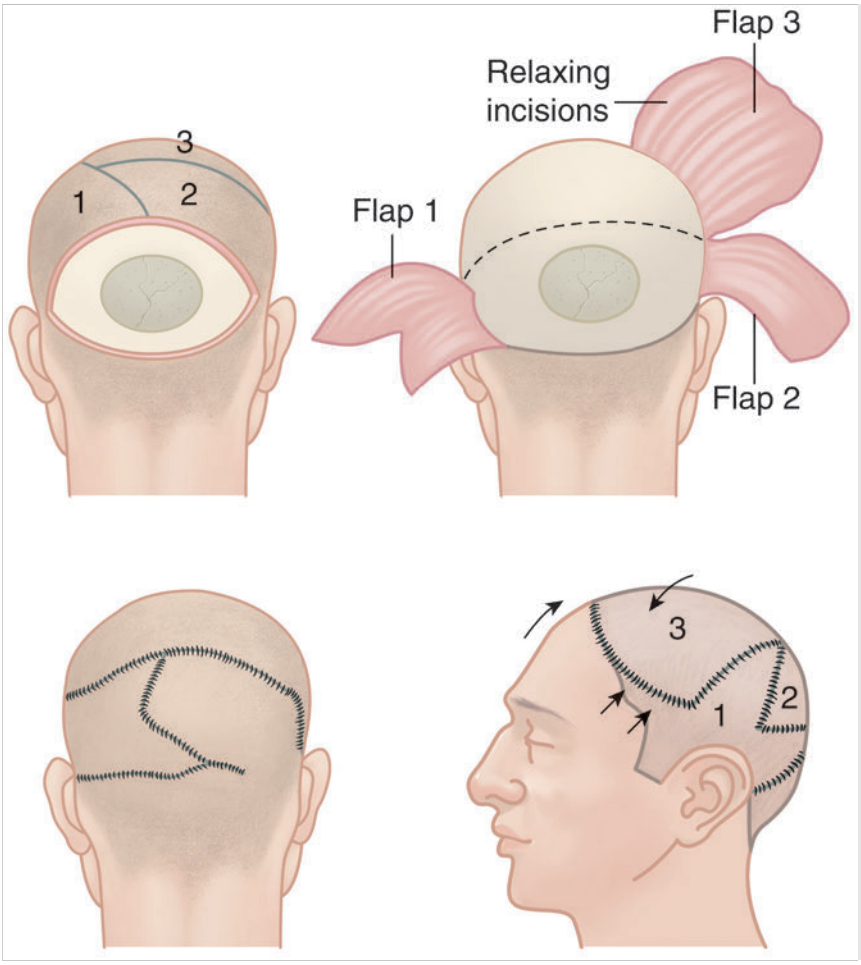

Fig. 41.2 Orticochea three-flap technique for coverage of large defects of the scalp.

Fig. 41.3 Multiple pinwheel flaps for closure of circular defect.

41.4 Complications

- Expander exposure
  - Exposed implants must be removed.
  - If significant expansion has already taken place, the expander should be removed and the tissues should be advanced as much as possible.
- Infection: When an expander is involved, this should be removed and the tissues advanced.
- Hematoma, seroma.
- Expander puncture and deflation.
- Skin necrosis.
- Insufficient tissue to reconstruct the entire defect: Advance flaps and re-expand.

41.5 Critical Errors

- Incision for tissue expander placement in the hair-bearing scalp meant to be expanded.
- Failure to assess skin when filling expander.
- Failure to advance the flaps when removing an infected or exposed expander.
- Excision of entire defect before advancing the flaps and determining if there is sufficient tissue for coverage.
- Poor design of flaps (i.e., flaps that are too small to correct the defect).

42 Neck Burn Contracture

Gwendolyn Hoben & Albert S. Woo

Fig. 42.1 A 14-year-old girl with a history of burns from a house fire several years prior enters with difficulty moving her neck.

42.1 Description

- Extensive burn contracture involving the neck, breasts, and anterior trunk
  - Evidence of previous split-thickness grafts to the neck.
  - Multiple tethering bands.
  - Limitation in neck rotation: ~ 50 degrees of lateral rotation.
  - Limitation in extension: 30 degrees of cervical superior extension.

42.2 Work-up

42.2.1 History and physical examination

- Mechanism, depth, and extent of previous burns.
- Time interval since injury and reconstruction performed.
- History of drooling, difficulty eating, speech deficiencies.
- Identify contracture bands.
- Assess for donor-site availability.
- Medical comorbidities.

42.2.2 Pertinent imaging or diagnostic studies

- Mandible series: Assess for mental (chin) retrusion.
- Preoperative anesthesia assessment: May be an airway challenge given reduced extension.

42.3 Treatment

42.3.1 Surgical planning of involved areas

- Neck contracture
  - Establish improved range of motion and release significant contractures.
  - Restriction of movement may affect skeletal maturation and speech.
- Mental retrusion
  - Consider sliding genioplasty (when skeletally mature).
- Chest and breast contractures
  - Breast reconstruction options (see Cases 26 and 27) may be considered (upon skeletal maturity or if significantly affecting development of the breast).

42.3.2 Surgical management

- Scar excision
  - Respect aesthetic subunits.
    - Lower lip and chin.
    - Submental.
    - Anterior neck unit.
  - Scoring of the platysma or full excision may be needed for full contracture release.
  - Z-plasty of individual contracture bands unlikely to give sufficient functional improvement.
- Graft coverage
  - Each aesthetic subunit should be grafted separately.
  - **Full-thickness grafting**
    - Possible donor sites: Abdomen, thigh, back.
    - May consider preoperative tissue expansion to cover larger sites.
    - Improved aesthetic outcome and reduced risk for contracture.
  - Split-thickness grafting
    - Performed as sheet grafts to minimize contracture.
    - Thigh or back would be appropriate donor sites.
    - Higher risk for contracture recurrence.
    - Poor aesthetic outcome.
  - Integra (bovine collagen dermal regeneration scaffold; Integra, Plainsboro, NJ)
    - No donor site, but needs additional skin grafting.
    - Advantageous in consideration for later reconstruction of the chest and breast burns.
    - Poor aesthetic outcome.
    - High risk for recurrence.

Flap coverage

- Local pedicled flaps
  - Supraclavicular flap: For less extensive burn defects.
  - Occipital artery flap: Donor site would require grafting.
  - Dorsal scapular flap
    - Bilateral flaps may be harvested for larger burns.
    - Donor site would require grafting.
- Free flaps
  - Appropriate options: Radial forearm, anterolateral thigh flap.
  - Good aesthetic outcome.
  - High rate of morbidity.
- Postoperative management
  - A neck brace is beneficial to minimize shear with movement.
  - Tisseel (fibrin glue; Baxter Healthcare, Deerfield, IL), vacuum-assisted closure (VAC) may be helpful adjunctive measures to maintain graft adherence.
  - Nutritional issues must be considered.
    - How will patient eat postoperatively?
    - Regular diet, nasal feeding tube, percutaneous endoscopic gastrostomy (PEG)/gastrostomy-tube feeding.

42.4 Complications

- Contracture recurrence.
- Loss of graft secondary to inadequate prevention of shearing.

42.5 Critical Errors

- Poor operative procedure (e.g., using split-thickness graft when a full-thickness graft is possible and yields a better result).
- Absence of postoperative plan to prevent graft loss (e.g., neck brace, possible feeding tube).
- Lack of early anesthesia involvement
  - The airway can be very difficult in the presence of significant neck contracture.
- Failure to recognize that multiple procedures will be required to restore range of motion and aesthetic appearance.

Part 9

Section IX. Hand

43 Flexor Tendon Laceration

Justin B. Cohen & Thomas H. H. Tung

Fig. 43.1 A 20-year-old right hand–dominant man presents to the emergency department with a laceration sustained while he was trying to open a broken mason jar. (Image shows patient attempting to flex at the interphalangeal joint of the thumb.)

43.1 Description

- Laceration over the volar first web space, extending onto the thenar eminence and resulting in injury to the flexor tendon in zones T2 and T3.
- Physical examination reveals inability to actively flex the thumb at the interphalangeal (IP) joint. No other range of motion (ROM), sensory, or strength deficits noted.

43.2 Work-up

43.2.1 History

- Mechanism of injury (e.g., sharp, blunt, avulsion).
- Position of hand and affected digit at time of injury (flexed vs extended).
- Time elapsed since injury.
- Hand dominance.
- Occupation.
- Previous hand injuries.
- Any associated injuries and medical comorbidities.

43.2.2 Physical examination

- Cascade of the hand
  - In the resting position, the fingers are flexed, with the degree of flexion increasing from the radial to the ulnar side.
  - Disruption of the cascade due to abnormal extension of a digit signifies flexor tendon injury.
- Tenodesis effect
  - Passive extension of the wrist causes flexion at the metacarpophalangeal (MCP) and IP joints.
  - Abnormal extension of a digit signifies flexor tendon injury.
- Assess flexor digitorum superficialis (FDS) and flexor digitorum profundus (FDP) function separately along with flexor pollicis longus (FPL).
  - FDS: Flexion of finger at proximal interphalangeal (PIP) joint while holding all other digits in extension.
  - FDP: Flexion of finger at distal interphalangeal (DIP) joint while holding PIP joint in extension.
  - FPL: Flexion of the thumb at IP joint while holding proximal phalanx and MCP joint in extension.
- Sensory and vascular examination.
- Partial tendon laceration results in weakness, limited movement, triggering of pain with flexion.

43.2.3 Pertinent imaging or diagnostic studies

- X-ray of hand with three views (anteroposterior, lateral, oblique): Evaluate for bony injury and foreign bodies.

43.3 Treatment

- Advanced trauma life support (ATLS) protocol.
- Antibiotics and tetanus prophylaxis.
- If unable to perform flexor tendon repair immediately, any visible tendons may be tagged with suture and the skin may be closed.
  - The patient should be splinted with the wrist and MCP joints in flexion to minimize retraction.

43.3.1 Flexor tendon repair

- Timing
  - Ideally, flexor tendons should be repaired as soon as possible. Immediate exploration is warranted if nerve or arterial damage is suspected.
    - In order to avoid staged tendon grafting for zone 2 injuries, flexor tendons should be repaired within 72 hours. Longer delays in repair have been reported for injuries outside of zone 2 with variable outcomes.
  - Delays > 6 weeks require tendon substitution procedures (tendon grafts, tendon transfers) or salvage procedures (tenodesis, capsulodesis, arthrodesis).
- Flexor tendon repairs should be performed in the operating room with a tourniquet.

43.3.2 Technique

- Exposure obtained by incorporating existing laceration into an appropriate incision. For the digits, Brunner zigzag incisions or Bunnell midaxial incisions are utilized.
- Cut end of tendon is retrieved by flexing the wrist and milking the forearm with tendon passers or an 8 French pediatric feeding tube.
- Tension-free repair is performed by approximating the cut ends and blocking the proximal end from retracting by passing a needle through skin and intact tendon proximal to the injury.
- Repair is performed with a core suture ± epitendinous suture.
  - Core suture
    - Multiple techniques described (e.g., modified Kessler, Tajima, Bunnell, Strickland, cruciate; ▶ Fig. 43.2 and ▶ Fig. 43.3).

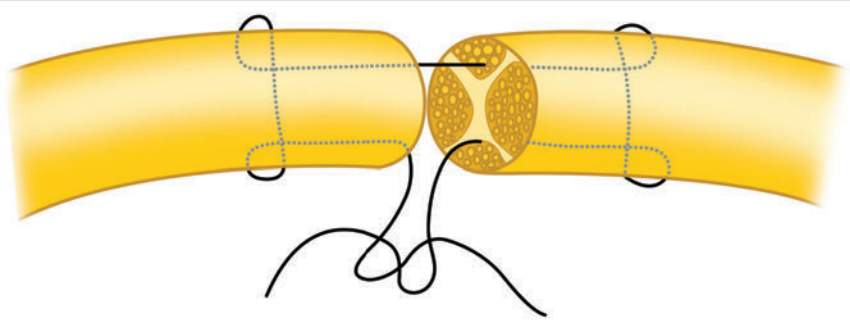

Fig. 43.2 The modified Kessler two-strand core suture repair.

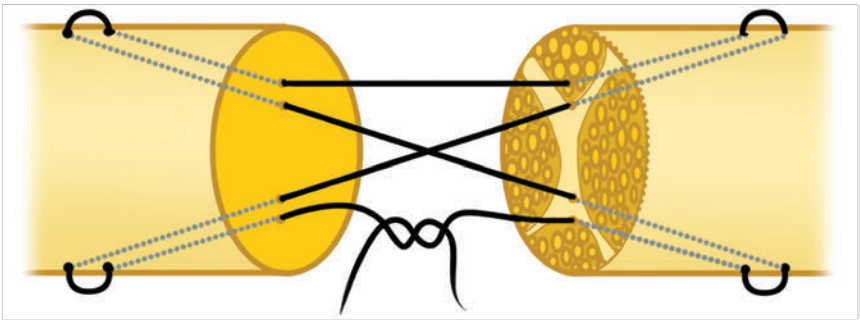

Fig. 43.3 The cruciate-type four-strand core suture repair.

  - Strength of repair increases with number of strands and size of suture.
  - Four-strand repair with 3–0 or 4–0 permanent braided suture typically used (e.g., Ethibond [braided polyester]; Ethicon Endo-Surgery, Blue Ash, OH).
- Epitendinous suture (optional)
  - Multiple techniques described (e.g., simple, locking, crisscross locking, inverted mattress; ▶ Fig. 43.4).
  - 6–0 permanent monofilament suture typically used (e.g., Prolene [polypropylene]; Ethicon).
- Following repair, the tendon is examined to ensure free and smooth range of motion.
- The A2 and A4 pulleys should be reconstructed if disrupted to avoid bow-stringing of tendon.
- Partial tendon lacerations: > 60% need operative repair.
- Hand is splinted in a dorsal extension-blocking splint.

43.3.3 Flexor tendon reconstruction

- Flexor tendon grafting used if delay in treatment or segmental tendon loss
  - Typically used grafts are palmaris longus, plantaris, long toe extensor, extensor indicis proprius, or extensor digiti minimi.
- Two-stage reconstruction
  - First stage involves resection of flexor tendon leaving 1-cm distal cuff and proximally 2-cm distal to the lumbrical origin. Silicone tendon implants (Hunter rod) are threaded through the pulleys and secured to the tendon edges.
  - Second stage undertaken 3 months later; involves excision of Hunter rod and replacement with tendon graft into the newly created sheath. Usually, proximal connection to neighboring FDP is made with tendon weave.

43.3.4 Postoperative therapy

- Hand therapists should be involved.
- Early controlled mobilization is critical to prevent tendon adhesions and improve repair strength.
- Protocols include passive motion programs (e.g., Kleinert, Duran) and active motion programs (e.g., Strickland).
  - Duran protocol
    - Day 3: Operative dressing removed, dorsal protection splint placed, hourly exercises within the splint of passive extension of PIP and DIP joints independently.
    - Week 4: Dorsal blocking splint removed and replaced with elastic cuff with flexion retraction; active flexion and passive extension begun.

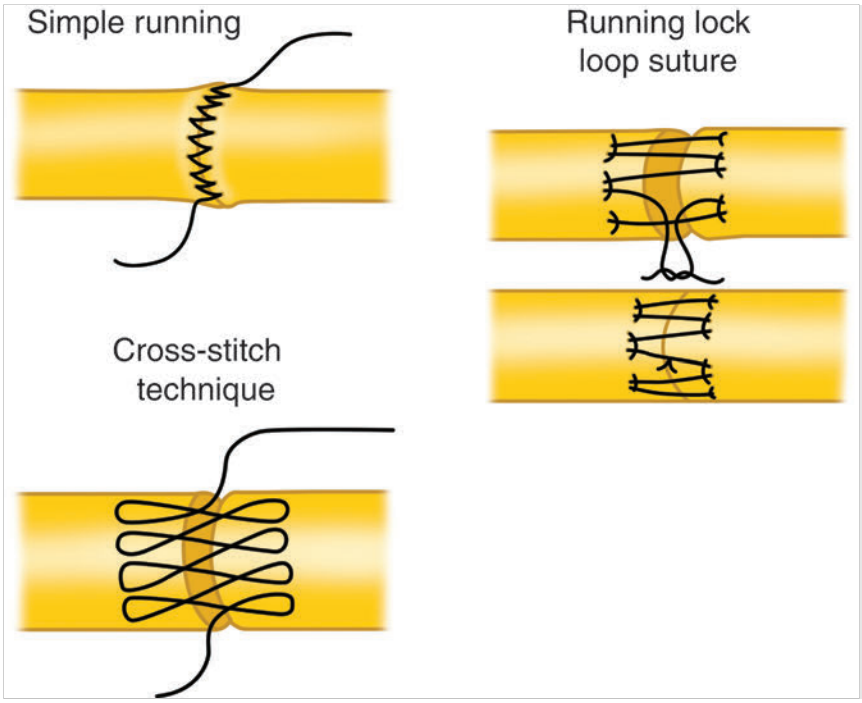

Fig. 43.4 Various epitendinous suture techniques for flexor tendon repair.

  - Week 5: Wrist cuff discontinued; blocking and fisting exercises begun with active extension and flexion.
  - Week 8: Progressive strengthening with putty and no heavy lifting.
  - Week 12: Full use of hand allowed.

43.4 Complications

- Hematoma.
- Tendon rupture: May require immediate re-repair versus tendon grafting or tendon transfer.
- Adhesions: Hand therapy is critical to prevent them. If necessary, surgical release of adhesions may be performed.
- Joint contractures.
- Quadriga effect: Flexion deformity of repaired digit and incomplete flexion of other digits due to shortening of FDP tendon.
- Lumbrical plus finger: Paradoxical PIP joint extension with flexion of the fingers due to retraction of FDP tendon or an excessively long tendon graft.

43.5 Critical Errors

- Missed injury: Nerve, vascular, or other tendon injuries missed on physical examination. Failure to isolate FDS and FDP tendons separately.
- Inadequate splinting to protect the flexor tendon repair.
- Failure to institute appropriate early ROM protocol.
- Failure to repair critical pulleys (A2, A4) at the time of tendon repair.

44 Soft-Tissue Defect of the Hand

David T. Tang

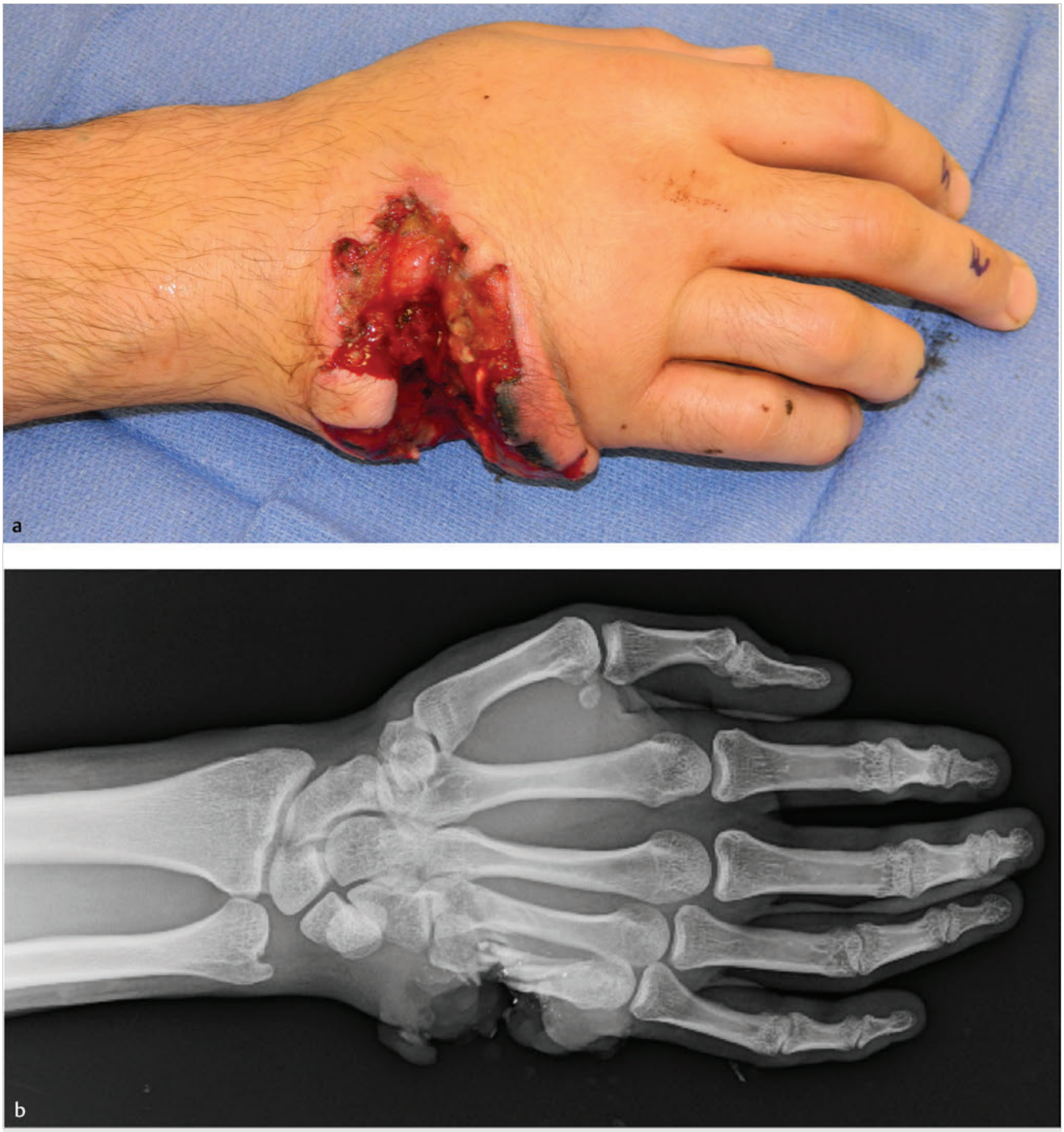

Fig. 44.1 A 32-year-old right hand–dominant man sustained a through-and-through gunshot wound to the ulnar aspect of the right hand.

44.1 Description

- Ulnar hand soft-tissue defect secondary to acute gunshot trauma.
- No vascular compromise distally.
- Fractures of the fourth and fifth metacarpals.
- Presumed injury to extensor (and possibly flexor) tendons of ring and small fingers.
- Likely neurovascular injury to ulnar digits.

44.2 Work-up

44.2.1 History

- Age, gender, handedness, and occupation of the patient.
- Timing and mechanism of soft-tissue deficit
  - Trauma: Associated injuries, underlying fractures, dislocations, neurovascular insult.
  - Infection: Nature of infection (bacterial, fungal, other); operative management to date (incision and drainage); antimicrobial medications; local versus systemic signs and symptoms.
  - Tumor ablation: Tumor pathology, margins, planned radiation and chemotherapy.
- Previous injury or surgery of the hand in question.
- Manual demands of daily living and overall lifestyle.
- Past medical and surgical history.
- Social history, including smoking status and substance abuse.

44.2.2 Physical examination

- Location and size of soft-tissue deficit.
- Specific deficits (tendon, nerve, muscle, skin).
- Wound status (infection, vascularity, exposed structures, nonviable skin).
- Vascular status of hand (intact palmar arch).
- Motor function (discern musculotendinous deficit from neurologic deficit).
- Sensory function.

44.2.3 Pertinent imaging or diagnostic studies

- Standard radiography (three views of the hand).
- Computed tomography if further detail required regarding bony structures (especially carpal bones).
- Angiography if clinical Allen test is unclear regarding patency of palmar arch.

44.3 Treatment

44.3.1 Critical principles

- Wound control, with eradication of infection and establishment of a stable, reliable wound bed, is a necessity.
- Consider patient's overall medical condition, general manual demands, and patient-directed priorities for reconstruction.
- When possible, replace critical tactile surfaces with like tissue that has the potential for reinnervation.
- Select the simplest form of reconstruction to minimize patient morbidity.

44.3.2 Treatment options

- Skin graft (split thickness or full thickness)
  - When possible, use full-thickness grafts to decrease secondary contracture, improve graft durability, and improve aesthetics.
- Local flaps
  - Transposition flaps: Z-plasty, rhomboid flap.
  - Advancement flaps: V-Y advancement.
  - Axial pattern flaps: First dorsal metacarpal artery flap, neurovascular island flap.
- Regional flaps
  - Cross-finger flaps: Standard, innervated, reverse cross-finger, cross-thumb flaps.
  - Fillet flap: Use "spare parts" from nonviable segments of injured tissues.
  - Radial forearm flap: Fasciocutaneous, fascia only, or innervated.
  - Reverse radial forearm flap.
  - Reverse ulnar artery flap.
  - Reverse posterior interosseous artery flap.
- Distant flaps (pedicled)
  - Abdominal/epigastric flaps.
  - Groin flap.
- Distant flaps (free)
  - Temporoparietal fascia flap.
  - Scapular and parascapular flaps.
  - Latissimus dorsi muscle flap.
  - Serratus anterior muscle flap.
  - Lateral arm flap.
  - Dorsalis pedis flap.

44.4 Complications

- Failure of reconstruction
  - Poor graft take, partial or total flap loss.
- Hand stiffness
  - Joint contractures, tendon adhesions, edema.
- Infection.
- Donor site morbidity.

44.5 Critical Errors

- Performing nonviable procedures (e.g., skin graft on bone or exposed tendon).
- Failure to carefully consider functional demands of the patient when selecting a strategy for reconstruction.
- Negligence in informing patient of additional surgical stages that may be required for definitive reconstruction (e.g., contracture release, tenolysis, flap thinning) and time necessary before return to work.

45 Radial Nerve Injury

John R. Barbour & Ida K. Fox

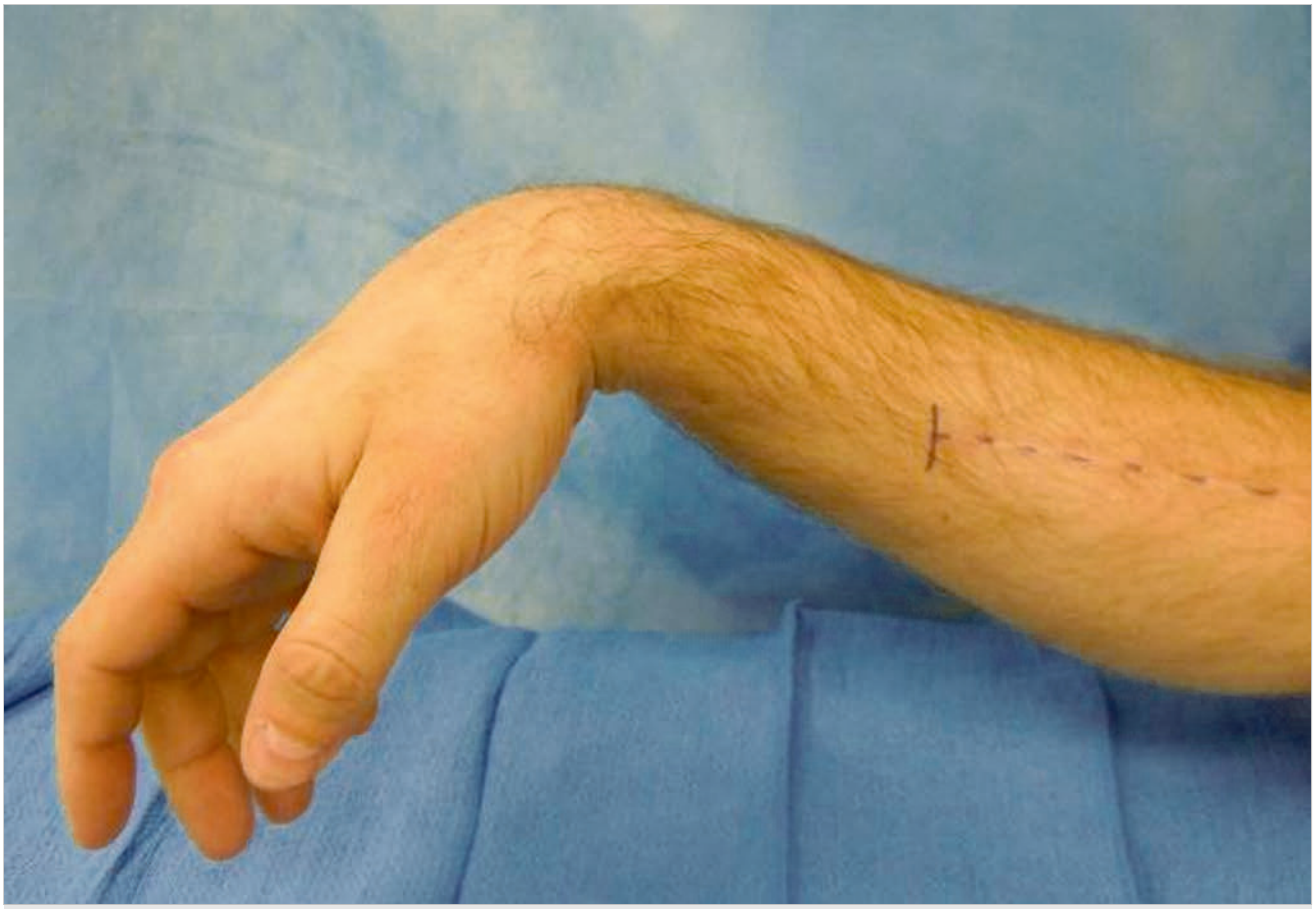

Fig. 45.1 A 28-year-old man presents with the inability to straighten his fingers and wrist. He has a history of a high-speed motorcycle crash and a midshaft humerus fracture.

45.1 Description

- Right upper extremity: Loss of wrist, finger, and thumb extension (radial nerve palsy).
- Injury likely at the midhumeral level, given the history of previous trauma at that site.

45.2 Work-up

45.2.1 History

- Critical points
  - Open versus closed mechanism of nerve injury will dictate initial treatment.
    - In a closed injury pattern, watchful waiting is most appropriate.
    - An open injury points to nerve transection, and direct exploration is usually indicated.
  - Time since injury will further determine available treatment options (at 1 to 2 years after injury, muscle cannot be reinnervated).
- Associated pain and/or stiffness.
- Medical comorbidities.

45.2.2 Physical examination

- Evaluate for any scars suggestive of open injury or previous surgery.
- Evaluate for stiffness, edema, hypersensitivity, and other signs of complex regional pain syndrome CRPS.
- Evaluate radial nerve motor function proximally to distally (i.e., check ability to extend elbow, wrist, fingers at the metacarpophalangeal joint, and thumb to determine level of injury).
- Evaluate the other upper extremity nerves and muscles that you might use as donor material for subsequent nerve or tendon transfers.
- Complete sensory examination, including two-point discrimination.
- Evaluate for Tinel sign: This may help in identifying the site and level of injury.

45.2.3 Pertinent imaging or diagnostic studies

- X-rays of the fracture helpful in confirming level of injury.
- For a closed injury pattern, **electrodiagnostic tests, including electromyography (EMG) at 3 months, may be helpful** in ascertaining nerve recovery.
  - *Fibrillations:* Indicate some motor injury.
  - **Motor unit potentials (MUPs):** Indicate recovery.

45.3 Treatment

- Based on type of nerve injury
  - Classification of nerve injury (▶ Table 45.1).
  - Timing of presentation: Several different management strategies are reasonable.

Table 45.1 Classification of nerve injury

Seddon	Sunderland	Fibrillations	Motor unit potentials (MUPs)	Improvement without intervention
Neurapraxia	I	–		+
Axonotmesis	II	+	+	+
	III	+	+	+/–
	IV	+	–	–
Neurotmesis	V	+	–	–
	VI	+	Depends on injury	Depends on injury

- In general, all patients with nerve dysfunction will benefit from physical therapy to assist with maintaining passive range of motion as well as manage any edema, pain, or other problems associated with the inciting injury.
- A wrist cock-up splint is particularly useful for placing the hand in a position of function so that some use can be made while the patient awaits surgery and recovery.
- Any associated pain syndromes must be aggressively managed; this may require medications, such as gabapentin (Neurontin; Pfizer, New York, NY).

45.3.1 Acute open injuries associated with nerve dysfunction

- Require nerve exploration because one must assume that there may be a nerve transection.
- Open humeral fractures have radial nerve laceration in 60% of cases.
  - Primary (≤ 24 hours), delayed primary (≤ 1 week), or secondary (> 1 week) repair is reasonable, depending on the mechanism of injury.
  - If there is a significant crush component, delayed repair will allow the injured nerve to demarcate so that so that the appropriate length of damaged nerve may be trimmed away.
- Repair directly or repair with interposed nerve graft is reasonable.
- In the case of a relatively subacute presentation and/or proximal nerve injury, nerve transfer procedures are also a reasonable option.
- Distal tendon transfers are reasonable, as well.

45.3.2 Acute closed injuries associated with nerve dysfunction

- Following closed humeral fracture, function will return by 3 to 4 months in > 75% of cases. Therefore, immediate exploration is contraindicated.
- Monitor clinical examination.
- If no functional improvement 12 weeks after injury, *perform EMG.*
  - Fibrillations and *MUPs present*: Indicates nerve is recovering, and continued watchful waiting is appropriate.

- Fibrillations present, *no MUPs:* Requires operative intervention to regain function. Options include direct repair and repair with graft or nerve transfer procedures, as noted above. Distal tendon transfers are reasonable, as well.
- If recovery slows, even with MUPs noted on EMG, consider release at known compression point (i.e., arcade of Frohse).

45.3.3 Principles of nerve repair

- Ensure neural repair is *outside the zone of injury* (bread loaf back to healthy nerve).
- Ensure **tension-free repair**, not dependent on posture.
  - If repair under tension, then perform interpositional nerve grafting.
- Protect branches to the brachioradialis, extensor carpi radialis longus, and extensor carpi radialis brevis ~ 5 to 6 cm proximal to elbow.
- Ensure absence of compression or acute turns in nerve (due to scar, fracture, callus, other).

45.3.4 Principles of tendon transfers for radial nerve palsy

- Low radial nerve palsy
  - With low radial nerve injuries, wrist extension is maintained.
  - Thumb extension: **Palmaris longus (PL)** (or flexor digitorum superficialis [FDS] of ring finger) → **extensor pollicis longus (EPL) transfer.**
  - Finger extension: **Flexor carpi radialis (FCR) → extensor digitorum communis (EDC) transfer.**
- High radial nerve palsy
  - Loss of wrist extension, finger extension, and thumb extension.
  - Wrist extension: **Pronator teres → extensor carpi radialis brevis** transfer.
  - Thumb extension: **PL (or FDS of ring finger) → EPL transfer.**
  - Finger extension: **FCR → EDC transfer.**

45.3.5 Prognosis

- Closed nerve injuries that do not require surgical intervention may recover quite quickly, depending on the degree of nerve injury. With a simple *neurapraxia*, return to normal function is rapid and complete in 90% of cases (often within 2 to 8 weeks).
- With *axonotmesis*, recovery will likely be complete but will take longer (e.g., months).
- Recovery after operative repair varies depending on the repair done.
  - Nerve repair, graft, or transfer will take time.
  - Nerve regeneration occurs at a rate of an inch per month.
  - Especially with nerve transfers, extensive physical therapy is required to retrain.
  - If tendon transfers are performed, a period of immobilization to protect the repair and then later therapy and motor retraining are necessary.

45.4 Complications

- Infection.
- Wound dehiscence.
- Unfavorable scarring.
- Incomplete functional recovery.
- Complex regional pain syndrome (CRPS, formerly reflex sympathetic dystrophy).

45.5 Critical Errors

- Failure to explore an open injury with concomitant nerve palsy is generally considered inappropriate. (Sub bullet) Close injuries are more often a neurapraxia that will recover without surgical intervention.
- Immediate exploration in the scenario of a closed nerve palsy.
- Failure to recognize that timing of injury is critical
  - After more than 1 to 2 years following injury, the muscle cannot be reinnervated, and a nerve repair, graft, or transfer will fail.
  - In cases of late presentation, tendon transfer salvage procedures are the only option for restoring function.

46 Dupuytren Contracture

John R. Barbour, Albert S. Woo, & Ida K. Fox

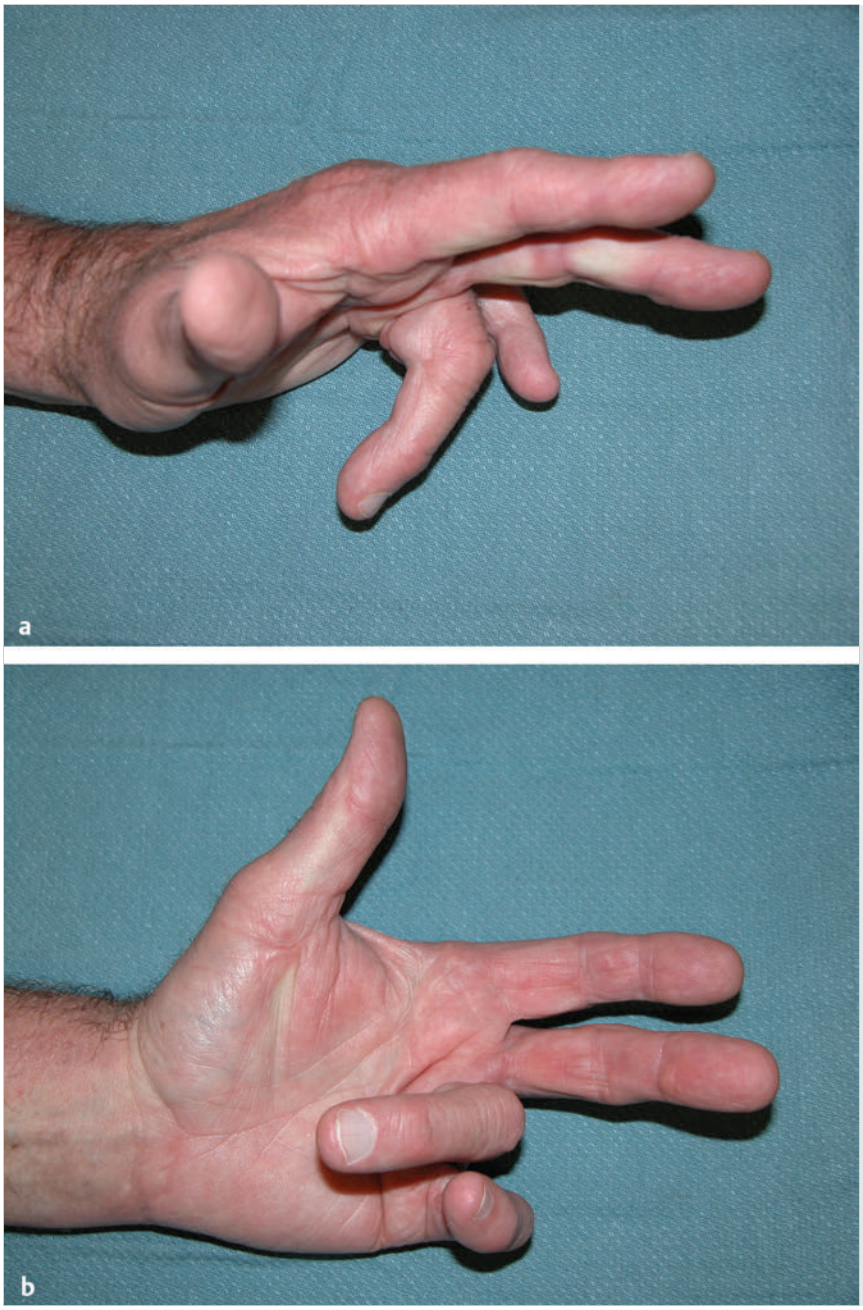

Fig. 46.1 A 59-year-old Caucasian man presents with progressive loss of motion of the left ring and small fingers. He is unable to straighten the joints actively or passively.

46.1 Description

- Flexion contracture of the ring and small finger metacarpophalangeal (MCP) and proximal interphalangeal (PIP) joints with palmar and digital cords is consistent with Dupuytren contracture.

46.2 Work-up

46.2.1 History

- Symptoms and degree of impairment of activities.
- Age at presentation and duration of disease. Dupuytren diathesis denotes patients with a young age at onset, strong family history, and high incidence of ectopic disease.
- Family history of Dupuytren disease.
- Ethnicity: More prevalent in northern Europeans and Japanese.
- Plantar or penile fibrosis.
- Risk factors: Alcohol, epilepsy medications, diabetes mellitus, smoking.
- Previous surgical treatment for the condition.
- Trauma to the palm can result in traumatic palmar fasciitis.

46.2.2 Physical examination

- Observe presence and location of pits, nodules, and cords.
- Palpate for asymptomatic nodules and cords.
- *Tabletop test:* Patient is unable to lay the palm flat on a rigid surface.
- Note the digits and joints involved and measure the degree of contracture.
- Observe for any adduction contracture of thumb.
- Measure joint range of motion and note any fixed joint contractures. Simultaneous MCP joint flexion with interphalangeal joint extension points to the absence of fixed joint contractures.
- Assess integrity of extensor mechanism.
  - Flex wrist and MCP joint to create *tenodesis effect.*
  - An extensor lag indicates that the central slip is attenuated, and postoperative extension splinting may be required. The patient should be cautioned that full extension of the affected finger will likely not be regained.
- Sensory examination of all digits.
- Sites of ectopic disease.
- *Garrod nodes* (nodules on dorsum of PIP joint) and *knuckle pads* (fibrosing lesions on dorsum of PIP joint).
- Ledderhose disease (plantar fibromatosis).
- Peyronie disease (penile fibromatosis).

46.3 Treatment

- Observation of disease that does not affect function and/or quality of life.
- Relative indications for intervention
  - MCP joint flexion contracture of 30 degrees.
  - Any flexion contracture of the PIP joint.
  - Adduction contracture of the thumb that interferes with activities of daily living or leisure activities.
- Treatment of joint contractures
  - MCP joint: Collateral ligaments are stretched in flexion. Therefore, these joints return to their normal position after release of the Dupuytren cord.
  - IP joint:Joint contracture at this level may require additional procedures to release join level scarring from long-standing disease.
  - PIP joint: Fixed joint contractures may occur in patients with severe, long-standing disease. Capsuloligamentous release may be required, although its efficacy has not been proved.

46.3.1 Surgical options

- Needle fasciotomy
  - The cord is percutaneously sectioned with a 25-gauge needle.
- Closed manipulation can further break up the cord.
- Enzymatic fasciotomy
  - Relatively new technique.
  - Collegenase *Clostridium histolyticum* (Xiaflex; Auxilium Pharmaceuticals, Horsham, PA) is injected at the point of maximum bowstringing of the palpable cord.
  - After 24 hours, the patient returns for closed digit manipulation to rupture the cord.
- Segmental aponeurectomy
  - Segments of the diseased cord are removed through multiple small incisions.
- Local fasciectomy
  - A portion of the diseased cord is removed.
- Regional fasciectomy
  - Diseased cords and fascia are excised.
  - Skin incisions (▶ Fig. 46.2): Numerous options exist.
  - If closure is not possible after the digit has been straightened, the wound can be left to heal secondarily, a full-thickness skin graft can be placed, or locoregional flaps can be used (e.g., rotational flaps, cross-finger flaps.)
- Dermofasciectomy
  - Diseased cords and fascia are excised along with the overlying skin.
  - The wound is closed with a full-thickness skin graft.
  - Performed in recurrent disease, for replacing flaps with uncertain viability, and in patients with Dupuytren diathesis.

46.4 Complications

- Wound-healing problems.
- Hematoma.
- Vascular and nerve injury
  - Laceration can occur at time of release.
  - Straightening a severely contracted joint may cause traction injury.
- Flare reaction: Stiffness, pain, and edema.
- Complex regional pain syndrome (formerly Reflex sympathetic distrophy): Stiffness, pain, edema, and vasomotor changes
  - Management includes pain control and/or stellate sympathetic ganglion block,
- Tendon rupture, especially with enzymatic fasciotomy,

Fig. 46.2 Common incisions used for exposure. (Adapted from Shaw RB, Chong AKS, Zhang A, et al. Dupuytren's disease: history, diagnosis and treatment. Plast Reconstr Surg 2007;120(3):44e–54e.)

46.5 Critical Errors

- Inattention to critical structures during intervention
  - Neurovascular structures may be displaced superficially and toward the midline of the digit by the spiral cord and should not be assumed to be in their normal position.
  - If transected, the digital neurovascular structures should be repaired.
- Failure to inform the patient about the risks of intervention, including the chance of recurrence (2 to 60%), need for vigorous therapy postoperatively, possible need for prolonged wound care and dressing changes, and risk for neurovascular and/or tendon injuries.
- Absence of a reasonable plan for coverage, if skin cannot be closed at time of release.

47 Syndactyly

Michael C. Nicoson & Thomas H. H. Tung

Fig. 47.1 A 2-year-old boy presents to the clinic with fusion of the long and ring fingers.

47.1 Description

- Complete, likely simple, syndactyly involving right long and ring fingers.

47.2 Work-up

47.2.1 History

- Patient's current hand function
  - Symmetric/asymmetric use of hands.
  - Grasping style.
- Known medical comorbidities.
- Family history of syndactyly or other associated condition (autosomal dominant or sporadic).
- Difficulties during pregnancy.

47.2.2 Physical examination

- Perform full body examination.
  - Other congenital anomalies may have not yet been diagnosed. Consider syndromic etiology if appropriate.
  - Evaluate feet to rule out additional digits with syndactyly.
- Perform complete hand evaluation.
  - Assess for extent and location of webbing, as well as for the number of digits involved.
    - Assess for polydactyly.
    - Evaluate for digital deviation in the radial or ulnar plane (*clinodactyly*).
  - Examine contralateral hand for comparison.
  - Thoroughly evaluate entire upper extremity.
- Classification
  - Simple/complex
    - *Simple syndactyly*: Finger fusion only by a *skin bridge.*
    - *Complex syndactyly*: Finger fusion involving *bone connection.*
  - Complete/incomplete
    - *Complete* syndactyly: Fusion involves entire length of the finger to distal tip, including nail fold.
    - *Incomplete* syndactyly: Fusion does not involve nail fold, but web depth is distal to normal position.
  - **Complicated:** Includes polydactyly.

47.2.3 Pertinent imaging or diagnostic studies

- **Hand radiography:** Image both hands to assess for underlying skeletal deformity, complex polydactyly, or hidden digit (*synpolydactyly*).
- Angiography may be useful in complex cases or for streamlining surgical planning.

47.2.4 Consultations: Based on individual patient presentation

- Occupational therapy, physical therapy.
- Potentially: Genetics, cardiology, hematology

47.3 Treatment

- Surgery is indicated to optimize hand function.
  - Allows normal digital growth and development of pinch/grasp mechanism.
- Timing of surgery
  - Typically, **12 to 18 months of age** is standard.
    - Minimize anesthesia risks, increase hand size, decrease incidence of scar contracture.
  - **Border digit** syndactyly should be released earlier (**~ 6 months of age**) to prevent rotatory and angular deformities.
- Goals of surgery
  - Create a more normal web space to improve function and aesthetic appearance of the affected digit.

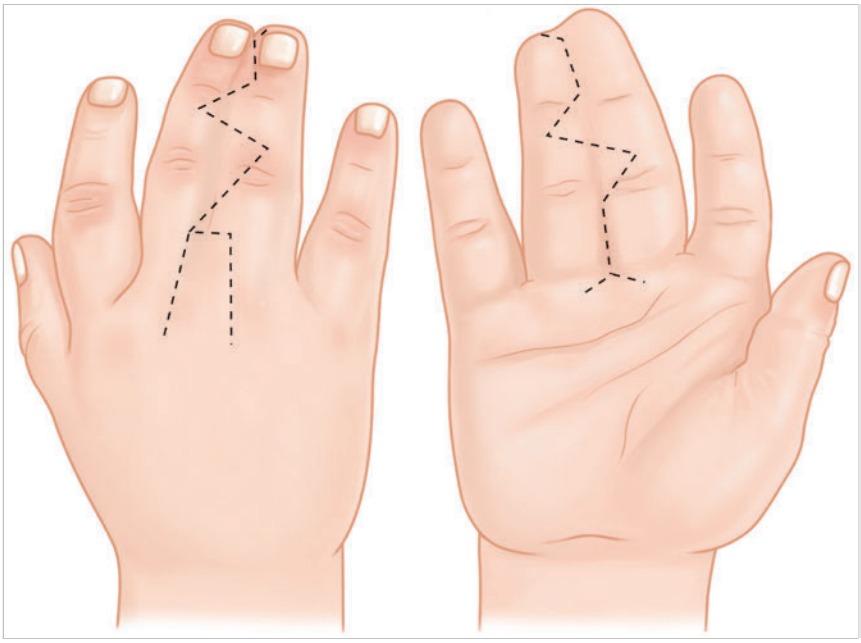

Fig. 47.2 Representative surgical markings for syndactyly release.

- For multiple web syndactyly, traditionally release only one side of an affected digit at a time to prevent vascular compromise of digits.
- Surgical markings: Many different techniques exist. One representative technique is discussed.
  - Use proximally based **dorsal skin flap** to line new web space. *Avoid scars in web space* (▶ Fig. 47.2).
  - Design interdigitating, opposing, zigzag pattern flaps for digital separation.
  - Use templates to design full-thickness skin grafts (e.g., groin, antecubital fossa, hypothenar eminence) to resurface the areas not covered by skin flaps.

47.4 Complications

- Skin graft loss: Significant areas of loss should be excised and regrafted.
- Digital necrosis: Most severe complication
  - Avoid tight or overly compressive dressings.
  - Must pay careful attention to preservation of the digital artery and nerve.
- Web space abnormalities ("web creep").
- Scar contracture: Treat by early excision and regrafting, splinting, range of motion.
- Nail deformity.
- Joint instability and angulatory deformity in cases of complex syndactyly.
- Hypertrophic scarring, keloid formation.

47.5 Critical Errors

- Failure to evaluate for and work up additional anomalies.
- Failure to revise skin graft loss, resulting in severe scar contracture.
- Performing syndactyly release at an inappropriate age (< 4 months).
- Operating on both sides of an affected digit at the same time
  - Only one side at a time should be operatively approached to avoid vascular compromise and flap failure.
  - When both sides are necessary, these procedures should be staged.
- Using split-thickness skin grafts rather than full-thickness skin grafts for skin coverage
  - Results in increased rates of contracture.

48 Metacarpal and Phalangeal Fractures

Aaron Mull & Amy M. Moore

Fig. 48.1 A 28-year-old left hand-dominant man presents with hand pain after striking someone with his left hand. The X-ray is shown above. On examination, overlapping of the patient's ring and small fingers is noted while he makes a fist.

48.1 Description

- Oblique extra-articular fracture of ring finger metacarpal shaft with angulation, rotation, and shortening,

48.2 Work-up

48.2.1 History

- Mechanism of injury (e.g., sharp, blunt, avulsion).
- Time elapsed since injury.
- Possible contamination during injury (e.g., oral contamination, farm injury).
- Hand dominance.
- Occupation.
- Smoking status.
- Inquire about prior hand injuries or operations.

48.2.2 Physical examination

- Assess for skin lacerations/injury, degree of contamination, and viability of soft tissues.
- Examine for possibility of open fractures and joint involvement.
- Assess for angulation and rotation of digit while the patient makes a fist (i.e., scissoring).
- Assess for neurovascular integrity of the affected digits.

48.2.3 Pertinent imaging or diagnostic studies

- X-ray of hand with three views (anteroposterior, lateral, oblique): Evaluate for bony injury and foreign bodies.
- Dedicated finger views for phalangeal fracture.

48.3 Treatment

- Closed reduction for metacarpal and phalangeal fractures should be attempted.
- Closed reduction of metacarpal neck fractures can be performed with the **Jahss maneuver**.
  - Metacarpophalangeal (MCP) joints flexed to 90 degrees and a volar force against the distal fragment with a compensatory dorsal force against the proximal metacarpal fragment.
- With adequate reduction, immobilize joint above and below fracture.
  - "Intrinsic plus" splinting with wrist extended to 30 degrees, MCP joints flexed to 80 to 90 degrees, interphalangeal joints in extension.
  - Keeps the collateral ligaments on stretch and decreases joint stiffness.
- Weekly X-rays to assess reduction up to 3 weeks.
- Operative indications
  - Unstable reduction or irreducible deformity.
  - Rotational deformity with scissoring on examination.
  - Significant angulation
    - Angulation at the metacarpal neck > 15 degrees in the index and long fingers, > 30 to 40 degrees in the ring finger, or > 40 to 50 degrees in the small finger requires intervention.
    - The carpometacarpal joints of the small and ring fingers have more mobility than those of the long and index fingers and therefore tolerate more degrees of angulation.
  - Intra-articular displacement > 1 to 2 mm and/or > 30% of articular surface involvement.
  - Open fracture.
  - Bony shortening (> 3 mm).

48.3.1 Operative techniques

- Closed reduction/percutaneous pinning
  - Preferred operative method of treatment for phalangeal fractures.
  - Crossed Kirschner (K)-wires across fracture site or intramedullary K-wires for metacarpal fractures.
- Open reduction/internal fixation
  - Open reduction for displaced or nonreducible fractures.
  - Dorsal approach for phalangeal condylar or intra-articular fractures.
  - Dorsal longitudinal incision over metacarpal; protect extensor tendon.
  - Thin dorsal plate and screws.
  - Lag screw fixation if oblique or spiral shaft fracture.
- Postoperative treatment
  - Immobilize fracture for 4 weeks.
  - K-wires usually removed at 4 weeks.
  - Passive and active range of motion initiated once K-wires removed and patient is nontender over fracture (evidence of healing on examination).

48.4 Complications

- Malunion.
- Nonunion.
- Tendon adhesions from approach and/or tendon attrition from prominent plate.
- K-wire malpositioning, migration, infection.

48.5 Critical Errors

- Not recognizing open injuries: Specifically, wounds over the dorsum of the metacarpal heads (i.e., "**fight bite**") or other soft-tissue injuries.
- Failure to follow fractures treated with closed reduction and splinting closely, resulting in loss of reduction and malunion.
- Not correcting angulation and/or rotation with operative reduction.

49 Carpal Tunnel Syndrome

Minh-bao Le, David T. Tang & Susan E. Mackinnon

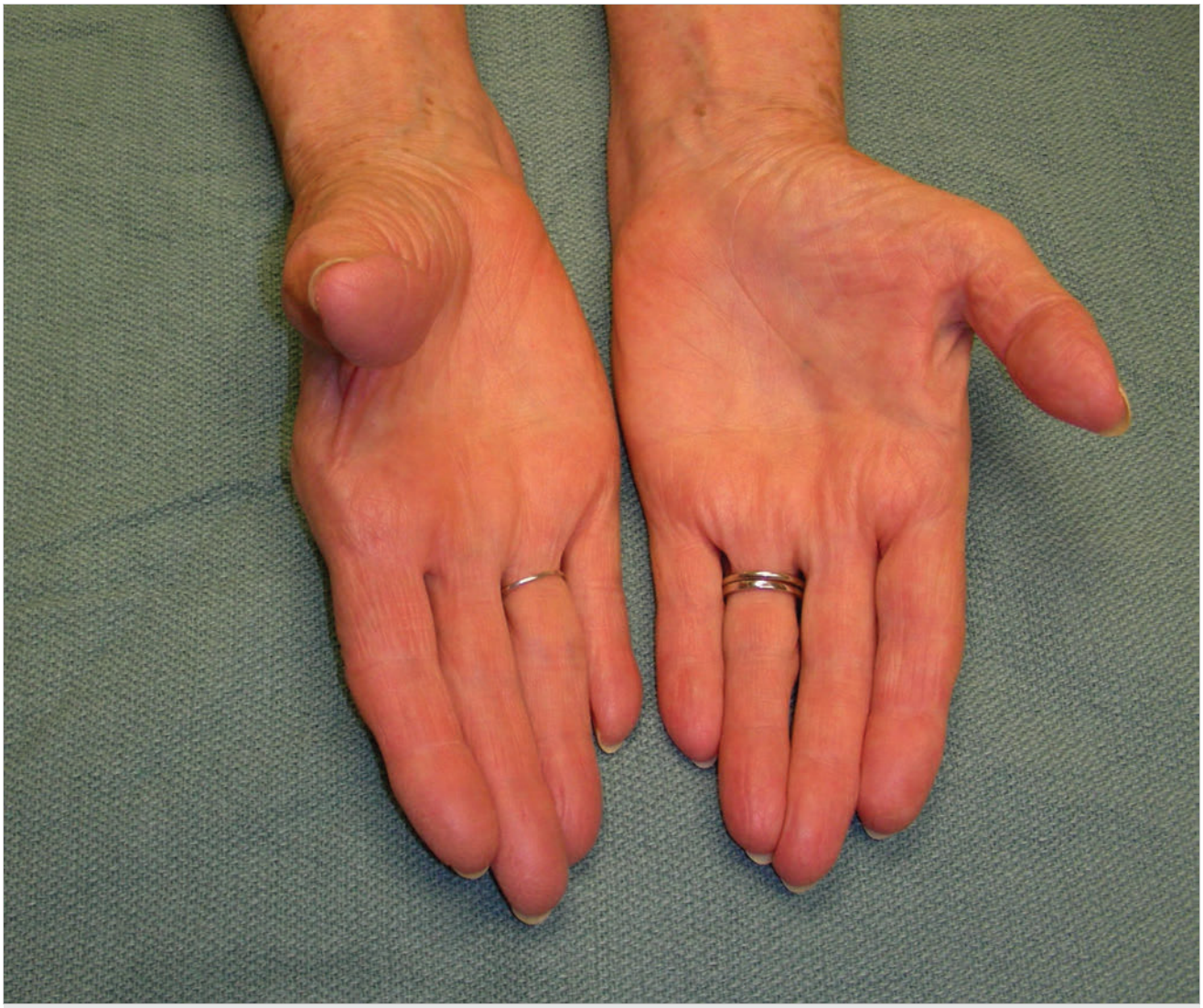

Fig. 49.1 A 73-year-old right hand–dominant woman with a 6-month history of increasing numbness over the thumb and index finger of the right hand.

49.1 Description

- Findings consistent with median nerve distribution of the right hand
  - Possible carpal tunnel syndrome.
- Moderate thenar atrophy visible on the right hand in comparison with the opposite side.

49.2 Work-up

49.2.1 History

- Length of time that symptomatology has been present and has been affecting the patient throughout the day.
- Measures previously taken to prevent symptoms (e.g., splinting, positioning, avoidance of activities).
- Pertinent symptoms consistent with nerve compression
  - Nocturnal pain, numbness, tingling in the thumb and one or more radial fingers.
  - Daytime paresthesias elicited with activities involving prolonged wrist flexion and/or extension.
  - Need for shaking and wringing the hands to alleviate symptoms.
  - Gritty sensation or numbness in fingers, grip and pinch weakness, diminished finger dexterity with a history of dropping objects.
  - Cold intolerance, dryness, and unusual textures in the radial digits.

49.2.2 Physical examination

- **Tinel sign:** Percussion elicits tingling over distribution of the affected nerve.
- **Phalen maneuver:** Maintaining wrists in full flexion for 60 seconds results in tingling over the median nerve distribution.
- Lack of two-point discrimination, weakness and/or atrophy of the thenar musculature.
- Examination of soft tissues for skin and muscle atrophy, manual muscle strength testing, grip and pinch testing, percussion of all major peripheral nerves, assessment of deep tendon reflexes, and assessment of blood flow to each hand.
- Semmes-Weinstein monofilament or vibrometry.
- Cervical spine and entire upper extremity examination, active motion of the cervical spine and all major joints in both upper extremities to rule out cervical radiculopathy or thoracic outlet syndrome.

49.2.3 Pertinent imaging or diagnostic studies

- Electrodiagnostic studies (EDS): Nerve conduction studies, electromyography
  - Area of controversy: American Academy of Orthopaedic Surgeons recommends EDS for all patients considering carpal tunnel release, and many surgeons routinely obtain EDS to determine patient's baseline degree of severity. In contrast, other authors state EDS should be used only as a baseline for monitoring unexpected outcomes and excluding other associated neurologic conditions.
- Ultrasound: Can identify increased cross-sectional area of the median nerve, but validated normal ranges need to be established.
- Magnetic resonance imaging: Controversial to use in patients with carpal tunnel syndrome. Allows the underlying anatomy to be established to prevent potential damage to the median nerve during carpal tunnel release in patients with abnormal anatomy. Also rules out other pathology, such as a ganglion, hemangioma, or bony deformity.
- X-ray: Can detect unsuspected wrist pathology.

49.3 Treatment

- Nonsurgical: Local steroid injection, splinting, oral steroids.
- Surgical: Recommended treatment after nonsurgical treatments have been tried and failed or in patients who opt out of nonsurgical treatment
  - Open carpal tunnel release versus endoscopic carpal tunnel release
    - No definitive data that one method is superior to the other.
    - Reportedly, endoscopic carpal tunnel release results in less postoperative pain and decreased time to return to functional activities, both procedures have equivalent results at 1 year postoperatively.

49.4 Complications

- Structural injuries
  - Injury to the median nerve.
  - Injury to the motor branch and palmar cutaneous branches of the median nerve.
  - Laceration of the superficial palmar arterial arch.
- Hypertrophic scar formation, scar tenderness.
- Pillar pain (deep-seated pain or ache over the thenar and/or hypothenar region).
- Incomplete release of the transverse carpal ligament.
- Tendon or nerve adhesions.
- Infection.
- Wound hematoma.
- Finger stiffness.
- Transient neurapraxias.

49.5 Critical Errors

- Failure to recognize pathology that mimics CTS, such as median nerve compression in the forearm, thoracic outlet syndrome, or cervical radiculopathy.
- Incomplete release of the transverse carpal ligament.

50 Tendon Transfers

John R. Barbour & Ida K. Fox

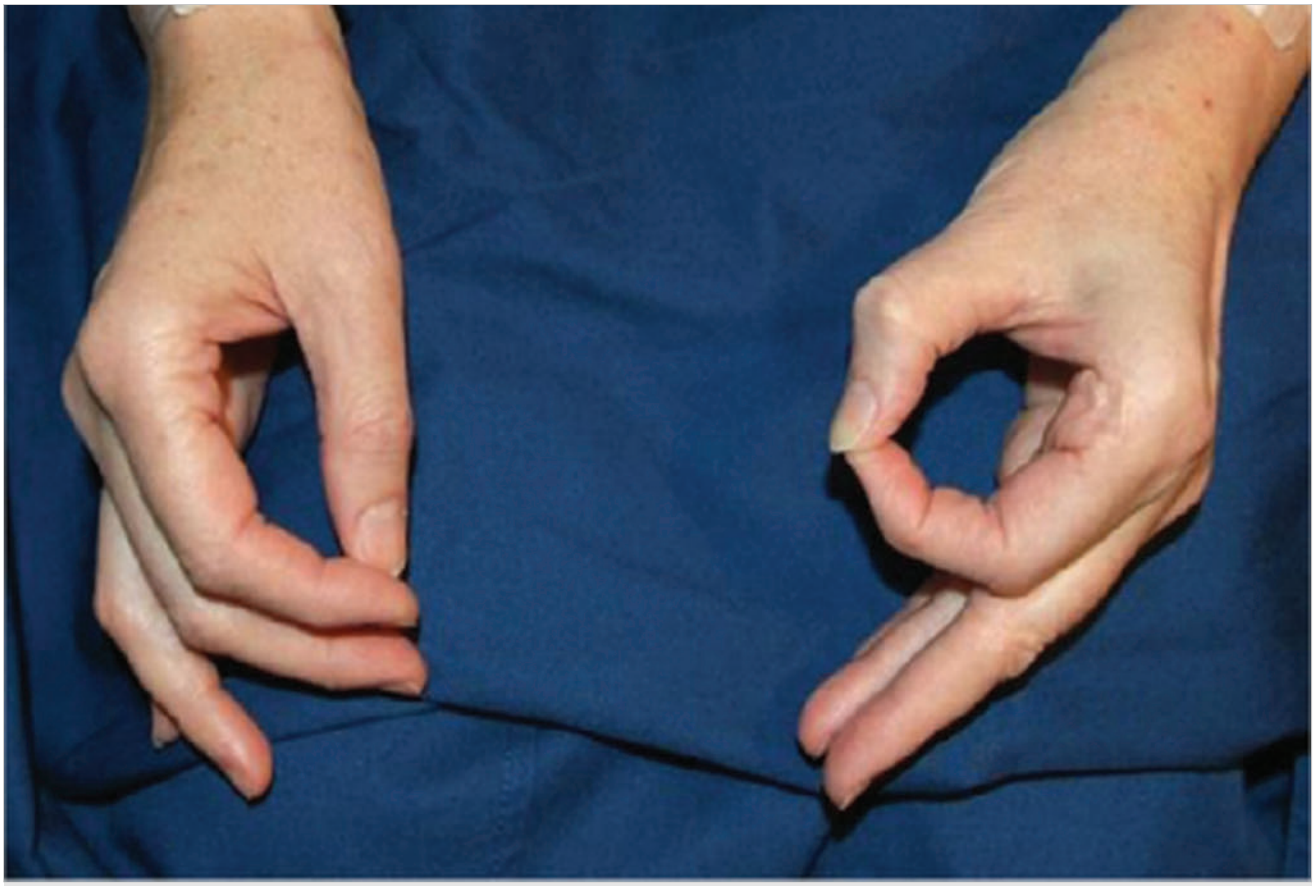

Fig. 50.1 A 47-year-old man sustained a deep penetrating stab wound to the right arm 1 year ago. The hand is at rest, and the patient is unable to actively flex thumb interphalangeal and index or long finger distal interphalangeal joints.

50.1 Description

- Findings consistent with incomplete median nerve palsy
  - Intact flexion at proximal interphalangeal joints .
  - Loss of distal interphalangeal joint flexion of index and long finger and interphalangeal joint of thumb.
  - Loss of thumb palmar abduction.
  - Flexion present in right ring and small fingers.

50.2 Work-up

50.2.1 History

- Age, gender, handedness, and occupation of the patient.
- Timing and mechanism of injury
  - Trauma: Associated injuries, underlying fractures, dislocations, neurovascular insult.
  - Infection: Nature of infection (bacterial, fungal, other), operative management to date (incision and drainage), antimicrobial medications, local versus systemic signs and symptoms.
  - Tumor ablation: Tumor pathology, margins, planned radiation and chemotherapy.
- Previous injury or surgery to the hand in question.
- Manual demands of daily living and overall lifestyle.
- Past medical and surgical history.
- Social history including smoking status and substance abuse.

50.2.2 Physical examination

- Location and type of original injury.
- Functional deficit.
  - Motor function (discern neurologic function based on motor examination findings).
  - Sensory function.
- Vascular status of hand (intact palmar arch).

50.2.3 Pertinent imaging or diagnostic studies

- Standard radiography (three views of the hand).
- Computed tomography if further detail required regarding bony structures (especially carpal bones).

50.2.4 Consultations

- Physical/occupational therapy
  - If joints are not sufficiently supple, they must be loosened, preferably by hand therapy.
  - If hand therapy fails, surgical release of the joints may be required before tendon transfer.

50.3 Treatment

- Tendon transfers allow improved functionality of an otherwise dysfunctional extremity, usually as the result of major nerve palsy.
- Restoring motions like pinch and grip can significantly improve the function of an extremity.

50.3.1 Preparation

- Timing after an injury depends on the likelihood of reinnervation and nerve recovery.
- Determining if adequate recovery is likely is mandatory before tendon transfer is considered as a reconstructive option. Electromyography performed immediately and then again at 6 to 12 weeks helps to determine which functions may be expected to recover.
- An exception may be made for *radial nerve palsies*, even if recovery is still possible.
  - Tendon transfer can act as a substitute during regrowth of the nerve.
  - Tendon transfers can add power to normal reinnervated muscle function.

50.3.2 Principles

- Consider restoring at least protective sensation before or at the time of tendon transfer.
- To restore functional motion to a hand or forearm, a suitable donor must be available. A reinnervated muscle is considered a poor choice for a donor.
- Select donor muscles that provide a synergistic action to the function to be restored.
  - Wrist extensors and finger flexors are an example of a synergistic group.
  - Wrist flexors and thumb/finger extensors.
  - Extensor indicis proprius and extensor pollicis longus.
- The strength, excursion, and redundancy of the brachioradialis make it a frequent choice as a donor for multiple functions.
  - The pronator teres is a good replacement for wrist extension.
- Work capacity corresponds to the cross-sectional area of the muscle, whereas excursion is related to muscle fiber length.
- Although not optimal, in cases in which an appropriate donor cannot reach the desired recipient, an interposed tendon graft is acceptable.
- Donors should be used to provide one function and should cross one joint.
  - If crossing more than one joint is needed, stabilization of one joint is advised to maximize function.

50.3.3 SEACOAST mnemonic

- The mnemonic SEACOAST is a valuable tool for the principles of tendon transfers.
  - Synergistic transfers.
  - Expendable donor muscle.
  - Adequate strength.
  - Contractures need releasing.
  - One tendon, one function.
  - Adequate amplitude (length).
  - Straight line of pull.
  - Tissue equilibrium.

50.3.4 Functions and the tendons commonly used for reconstruction

- **Thumb opposition:** Extensor indicis proprius, flexor digitorum superficialis, abductor digiti minimi.

- **Thumb flexion:** Pronator teres, brachioradialis, flexor digitorum superficialis.
- **Thumb extension:** Brachioradialis, extensor indicis proprius, palmaris longus.
- **Finger flexion:** Brachioradialis, extensor carpi radialis longus, adjacent profundus.
- **Finger extension:** Brachioradialis, flexor carpi ulnaris, flexor carpi radialis, adjacent finger extensor, extensor indicis proprius.
- **Wrist extension:** Brachioradialis, pronator teres.
- **Wrist flexion**: Rarely reconstructed.
- **Elbow extension:** Posterior deltoid, biceps.
- **Elbow flexion:** Pectoralis major, triceps, latissimus, forearm flexor mass (Steindler).

50.3.5 Donor muscles and common recipients

- **Brachioradialis:** Extensor carpi radialis brevis, flexor digitorum profundus, flexor pollicis longus, extensor digitorum communis, extensor pollicis longus.
- **Extensor carpi radialis longus:** Flexor digitorum profundus.
- **Pronator teres:** Extensor carpi radialis brevis, extensor pollicis longus.
- **Flexor carpi ulnaris:** Extensor digitorum communis.
- **Flexor carpi radialis:** Extensor digitorum communis, extensor pollicis longus.
- **Extensor indicis proprius:** Extensor pollicis longus, opponens pollicis.
- **Palmaris longus:** Extensor pollicis longus.
- **Flexor digitorum superficialis:** Opponens/abductor pollicis, flexor digitorum profundus, A1 pulley tenodesis.
- **Abductor digiti minimi:** Opponens pollicis.
- **Biceps:** Reroute/reinsert, triceps.
- **Triceps:** Biceps.
- **Posterior deltoid:** Triceps.
- **Pectoralis major**: Biceps.
- **Latissimus dorsi:** Biceps.

50.4 Complications

- The greatest risk is a gradual loosening of the transfers with loss of maximal excursion.
- Wound problems: Delayed healing, wound breakdown, adhesions, infection (all 1 to 2%).
- All extremity surgery has the potential for inciting complex regional pain syndrome, although this is rare following tendon transfers unless the patient has a previous history.

50.5 Critical Errors

- Relative contraindications
  - Use of muscle–tendon units with less than grade M5 strength.
  - Use of muscles that have been previously damaged and are undergoing reinnervation.
- Transfers planned in individuals with progressive neuromuscular diseases should be carefully considered before proceeding because the underlying disease process may affect the transferred unit.
- Satisfactory results are difficult to achieve in transfers performed to produce motion in less-than-supple joints.

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