Management of Ear Trauma

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KEYWORDS

• Auricle • Hematoma • Helix • Tragus • External auditory canal • Cartilage • Perichondritis • Avulsion

KEY POINTS

- The ear is prone to varying degrees of trauma given its position in the maxillofacial region.
- Understanding the anatomy of the ear remains paramount when repairing the ear.
- Reconstruction can take place in a staged approach to provide the best esthetic and functional outcomes.

INTRODUCTION

Facial trauma remains a common initial presentation in many emergency departments and urgent care facilities. Because of its delicate anatomy and prominent position, the ear remains a common structure that is routinely damaged. External ear injuries include simple and complex lacerations, hematoma formation, as well as varying avulsive injuries. Health care providers must also assess these patients for middle ear injuries and possible temporal bone injuries during the examination. Once an initial evaluation has been completed, treatment and repair of the injuries may proceed accordingly.

ANATOMY

The anatomy of the ear can be subdivided into 3 sections: the external ear, middle ear, and inner ear. The outer ear includes the auricle (**Fig. 1**) and the external auditory meatus, which leads into the external auditory canal (EAC), terminating at the tympanic membrane. The auricle is supported by elastic cartilage. Overlying the anterior portion of the cartilage is tightly adherent skin and connective tissue. The posterior ear consists of thicker skin that is slightly more mobile. The lobule of the outer ear consists of no cartilage. Medial to the tympanic membrane is the middle ear. This area includes the tympanic cavity and 3 bony ossicles, the malleus, incus, and stapes. The middle ear also connects to the pharynx by way of the eustachian tube. The inner ear also contains the cochlea, vestibule, and semicircular canals.

The temporal bone (**Fig. 2**) protects the middle ear and is divided into 4 distinct areas: the squamous, tympanic, mastoid, and petrous portions. The squamous portion is flat and continues toward the zygomatic process of the temporal bone. The mastoid portion contains the mastoid process and comprises the posterior aspect of the temporal bone. Medial to the mastoid process and lateral to the styloid process is the stylomastoid foramen, from which the facial nerve (cranial nerve [CN] VII) exits. The tympanic portion, inferior to the squamous region, houses the external auditory meatus. The petrous portion of the temporal bone lies on the interior of the temporal bone and encases the contents of the middle and inner ear. In addition, the petrous portion of the temporal bone is the densest bone in the human body. The internal acoustic canal is located within the petrous portion of the temporal bone and houses the facial nerve, vestibular cochlear nerve, and labyrinthine artery.

The external ear receives its blood supply from branches of the external carotid artery. These branches include the posterior auricular, superficial temporal, occipital, and maxillary (the deep auricular branch, which supplies the deep aspect of the EAC and tympanic membrane) arteries. Several nerves contribute to the innervation of the ear (**Fig. 3**). The skin of the auricle is supplied

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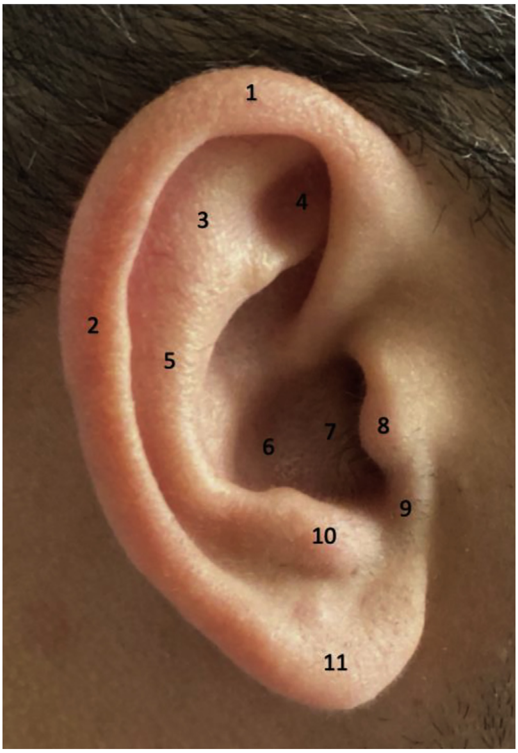

Fig. 1. Auricle of right ear: 1, helix; 2, tubercle of auricle; 3, crura of antihelix; 4, triangular fossa; 5, antihelix; 6, conchal bowl; 7, external acoustic meatus; 8, tragus; 9, intertragal notch; 10, antitragus; 11, lobule of ear.

by the greater and lesser occipital nerves (branches of the cervical plexus), the auriculotemporal nerve (branch of the trigeminal nerve), and branches of the vagus (CN X) and facial nerves for the deeper aspects of the auricle and external auditory meatus. Branches of the glossopharyngeal nerve (CN IX) may also contribute to innervation of the auricle or skin overlying the mastoid process.

SOFT TISSUE INJURIES OF THE EAR

The Advanced Trauma Life Support protocol should be followed for all patients with trauma, beginning with the primary survey and resuscitation. After initial stabilization of the patient's injuries, if indicated, a comprehensive maxillofacial examination can proceed as part of the secondary survey. If there is a noted otologic injury, it should not be addressed until a thorough clinical and radiographic evaluation is completed. Common trauma to the external ear includes abrasions, lacerations, auricular hematomas, and partial/total avulsions.

Adequate anesthesia must be obtained before attempting any repair. For small lacerations, local anesthetic infiltration can be sufficient. However, for more complex repairs, providers should consider nerve blocks. In the past there was concern for necrosis of the overlying soft tissues and cartilage if local anesthesia with epinephrine was used; however, the literature has not supported this concern and has shown that local anesthesia with epinephrine can be used in acral areas such as the ear. Studies have shown a measurable decrease in the arterial inflow immediately following administration of local anesthetics with epinephrine, but overall perfusion of the soft tissue and cartilage are not affected. The use of epinephrine-containing local anesthetics maximizes the effectiveness and duration of the anesthetic, provides hemostasis, and serves to potentially decrease total operating time.[1] Because the ear is innervated by several nerve branches, a ring block can be used to provide adequate anesthesia (**Fig. 4**). The vasculature is superficial in this area, so providers should always aspirate before injection. If the superficial temporal artery is accidently punctured, firm compression should be applied to prevent the risk of hematoma formation.

After anesthesia is obtained, care should be taken to adequately clean and irrigate the wound of any foreign bodies or debris. Simple lacerations not involving the cartilage are usually closed via primary closure (**Fig. 5**). Occasionally, irregular skin edges can be trimmed to allow better reapproximation of the wound edges. Closure can be obtained with either a fine 5-0 nonresorbable or resorbable suture. It is recommended to use resorbable sutures when repairing soft tissue injuries in children. After closure is obtained, bacitracin ointment is recommended for the first 5 days postoperatively to keep the surgical site moist and prevent eschar formation or infection.

Complex lacerations of the ear almost always involve cartilage exposure (**Fig. 6**). Motor vehicle collisions, ballistic injuries, and animal/human bites are common causes for these injuries. The ear has a robust vascular supply, as previously mentioned, and thus even the smallest areas of attached tissue should be reapproximated if feasible. Tacking sutures should be placed with caution to avoid compromising the vascular supply. These sutures can also help with surgical/anatomic orientation during reapproximation. When repairing the cartilage, figure-of-eight sutures should be placed to prevent overlapping of the cartilaginous segments.[2] Depending on the amount of edema or if any trauma is involving the EAC, a Xeroform packing or other similar material can be placed into the canal to help prevent stenosis. If there is any concern for a contaminated wound, prophylactic antibiotics can be prescribed to prevent

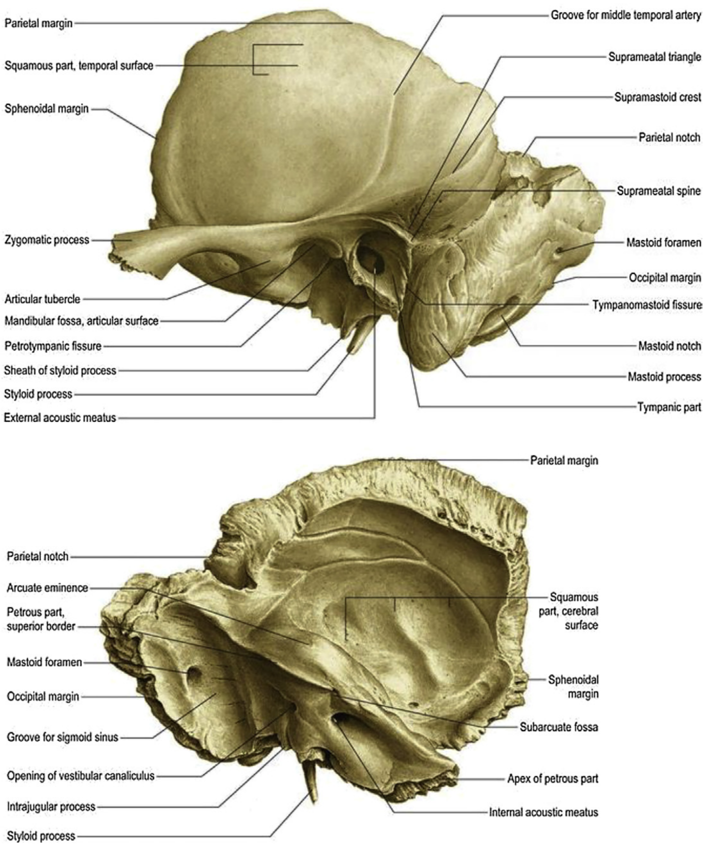

Fig. 2. Temporal bone. (*From* Waschke J, Paulsen F (eds). Sobotta Atlas of Human Anatomy. 15th ed, Elsevier, Urban & Fischer; 2015; with permission.)

perichondritis. The preferred oral antibiotic remains ciprofloxacin because it covers the main cause of perichondritis, *Pseudomonas aeruginosa*.[3] Common intravenous antibiotics include Zosyn (piperacillin and tazobactam), select carbapenems, or fourth-generation cephalosporins.

Another common injury after trauma to the external ear is the auricular hematoma. Although any form of trauma can lead to an injury of this nature, wrestlers, boxers, and mixed martial artists are most commonly susceptible. The sequela of leaving this injury untreated is classically known as a cauliflower ear. Trauma caused by shearing forces to the pinna of the ear disrupts the perichondrium from the underlying cartilage. The perichondrium is responsible for supplying blood and nutrients to the cartilage. A hematoma then forms in the subperichondrial space. If untreated, the hematoma can lead to infection, necrosis, or loss of cartilage.[4] The resulting hematoma, if not drained, stimulates new and asymmetric cartilage to form, resulting in a cauliflower ear. Treatment success

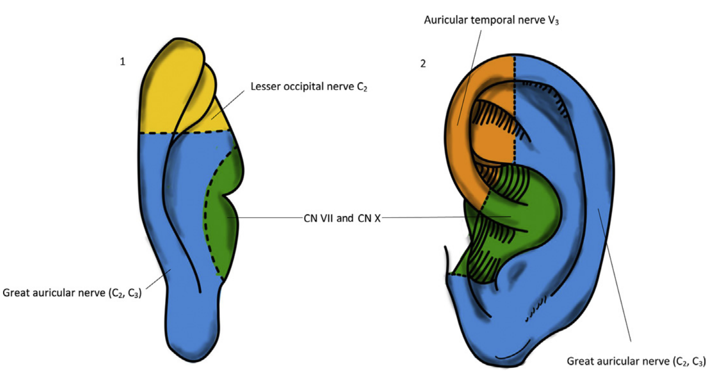

Fig. 3. Sensory innervation of the ear. (1) Medial surface of the pinna. (2) Lateral surface of the pinna CN VII and CN X.

Fig. 4. Ring block anesthesia of the ear. Two points of needle entry as depicted by the green dots; at the superior aspect of the helix and inferior aspect of the ear lobe. The skin should be prepped before injection. From the superior point, the needle is advanced, traversing anterior to the tragus, aspirating along its path. Local anesthesia is administered while carefully drawing the needle back. Without removing the needle, it is then redirected posteriorly following the same principles of delivery in the anterior aspect. Next, the inferior aspect of the ring block is completed. Again, the needle should remain in the superficial plane while aspirating along its insertion path. Of note, the superficial temporal artery lies anterior to the tragus, superficial to the zygomatic process of the temporal bone. Firm pressure needs to be applied in case of accidental puncture to prevent hematoma formation.

is determined by timely and appropriate drainage of the hematoma. Methods such as needle aspiration or simple incision and drainage have both been successful. An 18-gauge needle is sufficient for drainage of a hematoma, ideally placed over the greatest area of fluctuance. If the patient presents greater than 6 to 8 hours after the hematoma has formed, the blood may have already started coagulating.[4] If no blood is able to be aspirated, the procedure should transition to an incision and drainage. An incision can be made along the hematoma, large enough to provide adequate drainage. After the hematoma is evacuated and thorough irrigation has been completed, a compressive dressing should be placed to prevent dead space and allow reattachment of the perichondrium to the cartilage. A Xeroform bolster (**Fig. 7**), cotton rolls, magnets, and silicone dressings have all been used in clinical practice with success.[5] Quilting sutures, which pass through the external skin and the cartilage, can also serve to reattach the perichondrium. A common disadvantage is that several sutures must be placed for greatest effect. A Glasscock ear dressing can also be placed to avoid any further trauma. Repeated trauma and long-standing cauliflower ear can obstruct the EAC and interfere with hearing.[6] In addition, reconstruction of the cauliflower ear often results in poor outcomes because of the altered blood supply and exuberant fibrocartilage. Thus, urgent treatment of an auricular hematoma is always recommended.

Avulsive injuries range in their severity. Partial avulsions of the ear, even if attached by a small pedicle, should have this pedicle preserved and be repaired because a successful outcome is possible because of the vascular richness of the ear. Depending on the extent of the avulsion, the distal soft tissue edges of the pedicled segment might need to be trimmed to bleeding edges to remove avascular areas likely to necrose. The upper third of the ear is the most prone to avulsive injuries. Although any trauma can lead to avulsive injuries, animal/human bites often leave the most severe esthetic deficits. Reattachment of an intact or near-intact partial avulsion of the external ear as a free graft is often initially satisfying, but the likelihood for successful revascularization remains extremely low, especially for avulsions greater than one-third of the auricle.[7] In partial avulsions, where reattachment is not possible, primary closure should be obtained of the lacerated tissues in preparation for future reconstructive surgery (**Fig. 8**). If there is minimal cartilage exposed, careful undermining of the adjacent skin can be done to aid in full-coverage closure.

Total avulsion injuries of the ear are a time-sensitive emergency. First and foremost, if any attempt is made to reattach the avulsed ear, it must be thoroughly cleaned and free of any contaminants. Cold saline to irrigate the tissues and a well-vascularized tissue bed are vital. Any devitalized tissue or exposed cartilage should be conservatively excised. The soft tissues should be explored for any suitable vessels for microvascular repair. Depending on the mechanism of avulsion, vessels might not be available to proceed with microvascular repair. If feasible, the avulsed ear can be reattached as a composite graft. The use of hyperbaric oxygen treatment has been referenced in the postoperative care of patients undergoing a composite graft. Although there is

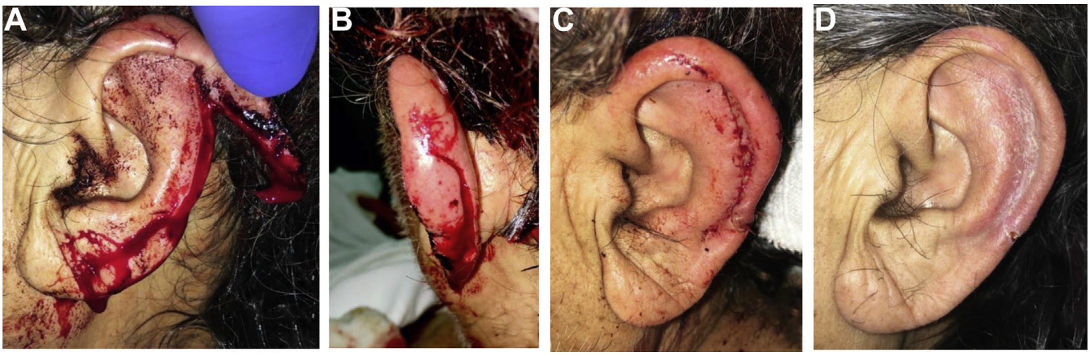

Fig. 5. Simple laceration repair. (*A*) Patient sustained full-thickness laceration from a knife attack confined to the helix of the ear. (*B*) There was no disruption of the cartilage, although it was minimally visible because of the full-thickness nature of the laceration. (*C*) The injury was irrigated and repaired with 5-0 fast-absorbing gut sutures. (*D*) Patient at his 2-week follow-up appointment.

no definitive timeline for treatment, the goal remains to stimulate angiogenesis, reduce free radical formation, and inhibit venous congestion.[8] Failure of composite grafts and other reattachment techniques can limit the options for future reconstruction. Microvascular repair of the ear can recreate the arterial blood supply to the ear, but this method is involves challenges. The first case of successful repair was documented by Pennington et al.[9] Several considerations were also noted that contributed to success of the procedure. The avulsed ear is to remain cool and the available vessels tagged. Venous grafts were used to prevent tension on the anastomoses. The anastomosis of vein grafts to the artery and concomitant vein in the avulsed ear were completed on the surgical bench, followed by arterial revascularization first.[10] Postoperative venous congestion remains a common reason for failure because finding suitable veins is challenging. Systemic anticoagulation and/or leech therapy can help avoid complications of venous congestion.[11] Another principle used for total ear avulsions is the pocket principle. The ear undergoes dermabrasion, is reattached, and then is placed into a pocket within the posterior auricular space. The ear undergoes revascularization for approximately 3 to 4 weeks before being uncovered.[12]

CLINICAL CARE POINTS: SOFT TISSUE TRAUMA

- Comprehensive head and neck evaluation to assess for other missed injuries
- Thoroughly irrigate soft tissue trauma, prophylactic antibiotics if warranted (ie, grossly contaminated wound, animal/human bite)
- Limit excision of exposed cartilage or loose skin
- If hematoma is present, place a bolster after drainage to prevent cauliflower ear deformity

COMPLEX RECONSTRUCTION OPTIONS

Numerous options are available for reconstruction of auricular injuries. Treatment depends on

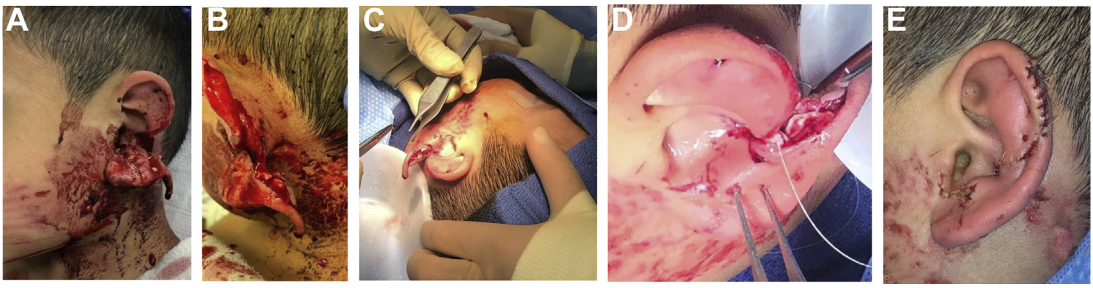

Fig. 6. Complex ear laceration. (*A*) A 6-year-old boy with macerated full-thickness laceration through the ear from dog bite. (*B*) Laceration involving helix, antihelix, cartilage. (*C*) Sutures to orient position of cartilage and soft tissues. (*D*) Reapproximation of cartilage with 5-0 Monocryl sutures in figure-of-eight fashion. (*E*) Superficial skin closure with resorbable 5-0 fast-absorbing gut sutures.

Fig. 7. Application of Xeroform bolster. Xeroform is placed on the lateral and medial aspects of the ear after trauma and secured with a monofilament, nonresorbable suture. This method serves to prevent reaccumulation of blood in the perichondrium of the ear. Bolsters stay in place for approximately 3 to 7 days after treatment.

the location of the defect and adjacent anatomy. In the upper third, full-thickness defects of the helix/antihelix, up to 2.5 cm, can be converted to a wedge defect, Burow triangle, or star defect and closed primarily (**Fig. 9**).[12,13] Significant loss in the upper third of the ear requires a new cartilaginous framework. Donor cartilage can be harvested from the conchal bowl, contralateral ear, nasal septum, or rib. However, cartilage has no vascular supply to support a full-thickness skin graft (FTSG) or splint-thickness skin graft (STSG); therefore, if there is lack of healthy skin to cover the cartilage grafts, a temporoparietal fascia flap or other soft tissue flap must be raised to cover the cartilage grafts as part of the reconstruction. The temporal fascia is thin, richly vascular (superficial temporal artery and vein), and highly flexible.[14] An STSG or FTSG can then cover the temporoparietal fascia flap. Full-thickness skin grafts help maintain volume, height, and the complex shape of the ear to produce the most aesthetic outcome.[15] The supraclavicular areas, preauricular and postauricular areas, and inner arm serve as common donor sites. In the middle third, the posterior auricular tissues (**Fig. 10**) can be advanced and placed over the defect.[16] When considering this type of advancement, surgeons should assess the availability of the soft tissue and the patient's existing hairline. If there is suspicion for inadequate tissue quantity, tissue expanders can be placed (**Fig. 11**). Placement of tissue expanders prevents transposing part of the patient's hairline to the reconstructed part of the ear. Cartilaginous grafting might also be necessary to support the soft tissues. However, this increases treatment time because tissue expanders require a minimum of 4 to 8 weeks to achieve the level of expansion desired. In the lower third of the ear, there is no cartilage. The lobule is composed of soft tissue and has the ability to be manipulated more than other parts of the ear. Lobule defects up to 50% can be closed primarily with little esthetic compromise.[17]

Pedicle and bipedicle flaps are also options for ear reconstruction. The middle postauricular region is thinner and not likely to be hair bearing,

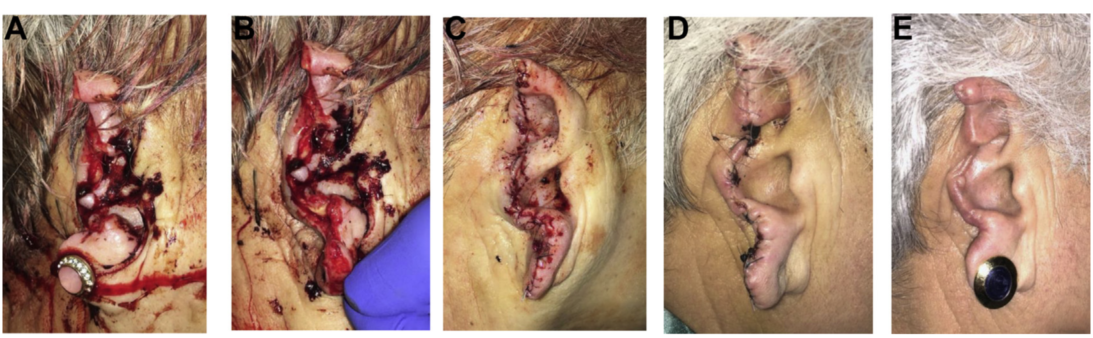

Fig. 8. Partial ear avulsion. (*A*) Patient sustained trauma from a pit-bull attack resulting in avulsion and loss of the posterior half of the external ear. (*B*) Remaining soft tissues were without evidence of maceration or necrosis. Exposed cartilage near the EAC. (*C*) Given the extent of the trauma, the decision was made to close the skin edges primarily with plan for delayed reconstruction. (*D*) Patient at a 1-week follow-up. Minimal eschar to wound. (*E*) Patient at her 1-month follow-up. There is no exposed cartilage or evidence of nonhealing wound.

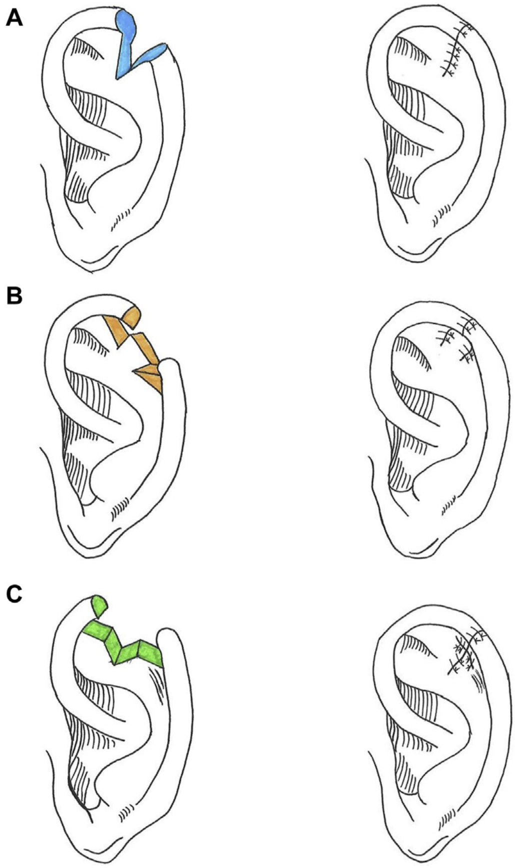

Fig. 9. Repair of helical defects. (*A*) Wedge defect and repair. (*B*) Burow triangle defect and repair. (*C*) Star defect and repair.

which allows considerable versatility in reconstruction options.[18] Pedicle rotational flaps allow appropriate coverage of surgical defects (ie, Mohs surgery) or helical reconstruction for injuries caused by trauma (Fig. 12). Bipedicle reconstruction, such as the tube flap, is also reliable. Here the postauricular tissue is raised to the subcutaneous layers, folded inward, and transposed to the defect. Postoperatively, it remains pedicled to its base to maintain perfusion. After maturation in 3 weeks, the flap is severed from its superior pedicle and inset into the native ear, and a few weeks later the inferior pedicle is severed and inset.[19] Although both preauricular and postauricular tissue can be harvested, less morbidity is seen with the use of postauricular tissue.

However, circumstances sometimes prevent any primary or secondary reconstruction of the ear. Failure of a composite ear reattachment or microvascular repair leaves the patient without a viable ear. Similarly, congenital conditions such as microtia or hemifacial microsomia also result in a poorly developed or absent ear. Auricular prosthetics (Fig. 13) provide an option for the patient to regain a symmetrically esthetic appearance. Synthetic materials can be used to create a replica mold of the unaffected contralateral ear.[20] The prosthesis can then be anchored to titanium bone implants placed in the temporal bone. Bone-anchored hearing aids can be integrated into the prosthetic as well.[21] This method eliminates the need for additional cartilage grafting and lessens the risk of infection, graft failure, or other possible surgical morbidity.

INJURIES TO ADJACENT STRUCTURES/ ANATOMY

Supporting structures of the ear are also susceptible to trauma. Tympanic membrane rupture is a perforation in the membrane separating the middle and external ear. The use of cotton tip applicators (Q-tips) has been the leading cause of these injuries. Water trauma, assault, and acute otitis media are also causes of tympanic membrane rupture.[22] Management of these injuries is usually supportive and, in some cases, short-

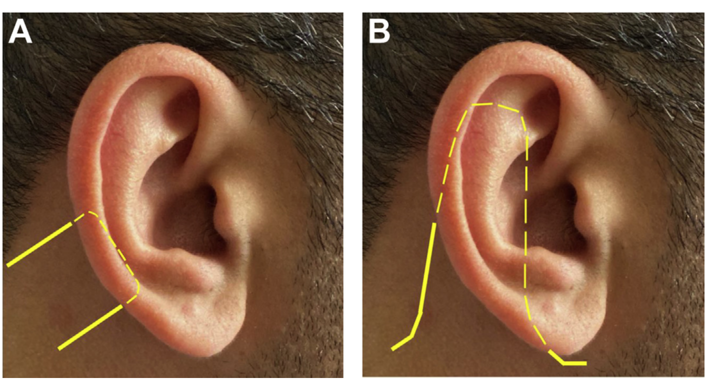

Fig. 10. Postauricular tissue advancement. The postauricular soft issue can provide many formulations for coverage of auricular defects. (*A*, *B*) Common examples of how a postauricular pedicle flap can be raised to address defects of the middle ear.

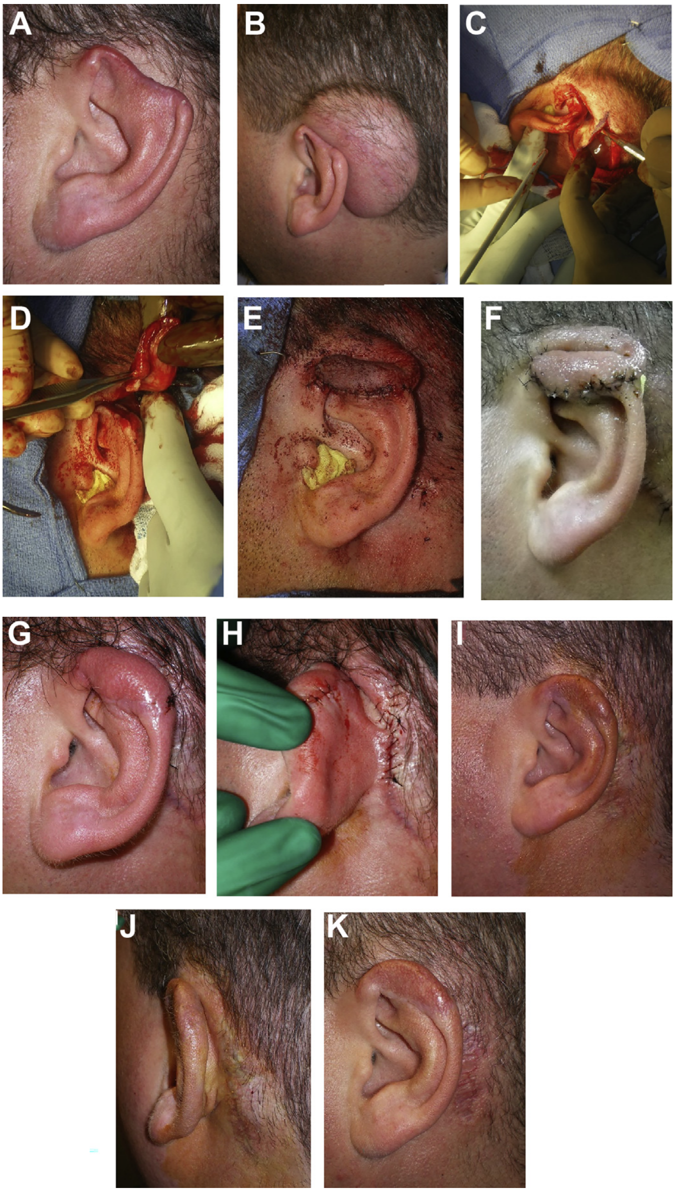

Fig. 11. Three-stage reconstruction of ear. Stage I, 0 months. Stage II, 3 months. Stage III, 4 months. (*A*) Patient with full-thickness avulsion of tissue after motor vehicle collision. (*B*) Tissue expander placed postauricular to defect to allow for adequate soft tissue. (*C*) Tissue expander removed. (*D*) Soft tissue flap raised superiorly and rotated to superior aspect of helix. (*E*) Flap adapted to superior helix and folded on itself to recreate the anterior and posterior surfaces. (*F*) Five days postoperatively. No evidence of wound breakdown or necrosis. (*G*) Local tissue rearrangement of the flap. (*H*) Closure of the posterior ear and retroauricular tissues. (*I*) Profile view at 10 days after surgery. (*J*) Posterior view at 10 days after surgery. (*K*) Profile view 4 months after final reconstructive surgery.

term otic suspension antibiotics drops can be prescribed. If the perforation is large, early surgical repair might be indicated.[23] Blunt head trauma also causes most temporal bone fractures. Intracranial hemorrhage, facial nerve weakness or paralysis, cerebrospinal fluid (CSF) otorrhea, hearing loss, and vertigo are recognized symptoms depending on the severity and pattern of the fracture. If there is any form of facial nerve function, surgical intervention is rarely indicated. Total paralysis has a more guarded prognosis.[24] Decompression of the facial nerve should be performed in a time frame of no more than 2 weeks from onset of injury to ensure the best chance of recovery.[25] CSF otorrhea is another complication of temporal bone fractures. Most CSF leaks close spontaneously within a week. Nonsurgical recommendations include head of bed elevation and neutral body positioning. Antibiotics should be prescribed to prevent meningitis. Persistent leaks may require surgical intervention,[24] which can be done via lumbar drain placement or an endoscopic transmastoid approach.[26]

Fig. 12. Reconstruction of right ear with bipedicle flap after human bite. (*A*) Scarring and defect of the lower half of the helix. (*B*) Harvest of retroauricular soft tissue to reconstruct the helical defect. (*C*) Full-thickness dissection of the remaining helix. (*D*) Placement of Xeroform dressing to prevent adhering of the bipedicle flap to the post-auricular soft tissue. (*E*) Posterior view of bipedicle flap. (*F*) Takedown of superior portion of bipedicle flap 5 weeks after initial surgery. (*G*) Appropriate shape and perfusion of the reconstructed helix with inset of superior portion of bipedicle flap. (*H*) Excision of the stump of the superior portion of the bipedicle flap from the post-auricular space and inset of the superior portion of the bipedicle flap into the native helix. (*I*, *J*) Closure and reconstruction using the superior portion of the bipedicle flap from the lateral and posterior view. (*K*, *L*) The inferior portion of the bipedicle flap has been divided and inset and contoured to reform the ear lobule. Patient at 10 days after this procedure.

CLINICAL CARE POINTS: EVALUATION OF TEMPORAL BONE FRACTURE

- Paralysis of the facial muscles caused by facial nerve injury
- Hearing loss
- Dizziness/loss of balance
- Drainage of CSF

Many challenges exist when evaluating and treating ear trauma. Treating providers should always remember to take a thorough history, note preexisting conditions, and evaluate all clinical and radiographic information present. If there are any

Fig. 13. Total ear prosthetic. Bilateral ear prosthetic reconstruction because of extensive facial burns. (*A*) Right ear implants with custom bar to support prosthesis. (*B*) Right ear prosthetic. (*C*) Left ear implants with custom bar to support prosthesis. (*D*) Left ear prosthetic. (*Courtesy of* Aristides Tsikoudakis, DMD, Fresno, CA.)

findings that warrant higher-level care, the appropriate consulting team should be promptly notified. Any delays can drastically alter the available treatment options and leave the patient with semi-permanent to permanent losses.

DISCLOSURE

The authors have nothing to disclose.

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