Pediatric Soft Tissue Injuries to the Head and Neck

Energetic, curious, and often awkward, young children commonly sustain soft tissue injuries to the head and neck region. The prepubescent and early teenage years are filled with sporting activities that can lead to maxillofacial soft tissue injuries. Younger and older children alike are susceptible to motor vehicle collisions and interpersonal violence, with subsequent head and neck soft tissue injuries. Abrasions, lacerations, and avulsive injuries in the maxillofacial region may be challenging to repair. Although the natural elasticity of the facial tissues (both soft and hard tissue), abundant padding, and prominence of the skull provide significant anatomic protection, children commonly sustain significant soft tissue injuries to the face and neck, and to a lesser degree to the bony skeleton. Additionally, the introduction of several governmental safety regulations leading to the implementation of mandatory airbags, along with the use of seat belts, child seats, helmets, and mouth guards, has directly led to a decrease in significant maxillofacial fractures. Even with such anatomic and environmental protective factors in place, children occasionally sustain significant soft tissue injuries to the face and neck that require the expertise of a plastic surgeon. To successfully manage pediatric soft tissue and maxillofacial injuries, the clinician must have a firm grasp of the physiologic and psychological principles associated with facial injuries.

The face is the most important presenting part of our bodies and thus plays a major role in the development of a child's self-esteem and the manner in which we interact with others. The face is the child's window to the outside world and the subject of peer interaction.

The challenges associated with pediatric soft tissue injuries are always compounded by the potential adverse effects on future growth and development. Despite adequate repair, permanent disfigurement may be caused by subcutaneous tissue damage resulting from hematoma formation, infection, or associated fat and subcutaneous atrophy after a contusion. The scars that are produced by such injuries remain forever, and parents often have a difficult time accepting this fact.

The principles of facial trauma management are similar for all age groups: to restore and preserve function while achieving optimal cosmetic results and minimizing scar formation by placing all of the anatomic landmarks in their proper locations. However, reconstructive techniques for children must be modified to accommodate their unique anatomic differences, which include rapid healing, fragile psychology, and the potential for future deformity in relation to altered facial growth. Minor soft tissue injuries are the most common facial injuries in children and encompass a spectrum that includes ecchymosed tissue, contusions, abrasions, lacerations, avulsions, massive degloving injuries, and burns. Fortunately, most injuries may be repaired on an outpatient basis using local anesthesia with sedation. However, if the injuries are extensive it is advisable to use general anesthesia for better control of the repair environment and to optimize the outcome.

PRINCIPLES OF PATIENT MANAGEMENT AND SOFT TISSUE REPAIR

Patients with facial and neck injuries often sustain serious associated trauma to other portions of their bodies that may require more urgent attention. The priorities of emergency trauma care must always be airway maintenance, control of breathing, and circulation. Evaluation of cranial and maxillofacial soft tissue injuries should begin while the patient is being stabilized.

Children with significant facial injuries are often more frightened by medical personnel than they are by the actual pain of their injuries. Therefore crucial

factors to consider during the initial clinical contact should include reassuring the patient, gaining his or her trust, and achieving mutual cooperation if possible. To reiterate, the child is frightened and apprehensive; thus the plastic surgeon must be able to comprehend the psychosocial issues and control the situation in an unobtrusive manner.

Photographic documentation should be a part of the initial evaluation, especially if the child is to be treated on an outpatient basis. Photographing wounds before and after treatment is useful for addressing potential medicolegal matters, to assist the parents with future insurance claims, and to serve as a safeguard against possible litigation involving the causative parties. If child abuse is strongly suspected, those impressions should be recorded and reported to child welfare agencies, social services, or the police, either directly or through the hospital's administrative channels.

Through a comprehensive and accurate history, insight may be gained into the nature of the soft tissue injury and whether associated osseous injuries are also present. Many simple abrasions, lacerations, and avulsions are isolated soft tissue injuries. If the clinician suspects an embedded foreign body or associated maxillofacial fracture, radiographic studies are indicated. Typically a panoramic view of the mandible, Waters' views of the facial bones, and standard oblique views of the mandible are all helpful; however, the final results may be suboptimal and computer scans are then indicated. Severe maxillofacial injuries warrant a CT scan of the brain, thus providing an opportunity to obtain a concurrent maxillofacial CT scan for clear definition of osseous injuries. Skull radiographs are obtained when there is a history of head injuries.

After the history and physical examination are completed, accurate wound analysis is vital. Occasionally, a child may be surprisingly cooperative; an attentive parent who is holding the child's hand while talking to him or her can be exceedingly helpful to the examiner. However, if parental anxiety is high, this may become a significant obstruction to care, in which case it is appropriate to ask the parent to leave the treatment area. Forcible restraint of a child should be avoided, if at all possible, but in some circumstances sedation and bundling with a papoose restraint may become necessary if a child is uncooperative. A thorough history of food intake should be obtained before administering anesthesia. If not contraindicated, a combination of narcotics and tranquilizing drugs will typically produce optimal results within 15 minutes. A dissociative anesthetic such as ketamine provides excellent anesthesia with little effect on respiration.

Local anesthetic combined with the surgeon's preferred vasoconstrictor is administered via a 25-gauge needle before the wound is cleansed and meticulously inspected. To minimize discomfort, local anesthetic should be administered through the margins of the wound rather than through the surrounding skin. Regional nerve blocks may prove particularly useful in the closure of lacerations involving the forehead, cheeks, lips, and chin. In addition, a regional block provides the advantage of minimizing tissue damage and anatomic distortion to already traumatized skin, and this will help to minimize scar formation. Just above the eyebrow, local infiltration of the supraorbital nerve effectively anesthetizes a major portion of the forehead. Upper lip, lateral portions of the nose, and adjacent tissue can be blocked by anesthetizing the infraorbital nerve located at the midpapillary line. Anesthetic block of the mental nerve, located between the first and second bicuspids, effectively anesthetizes the lower lip and surrounding chin.

Optimal treatment of facial injuries depends on a thorough initial evaluation and detailed characterization of the injury in the medical records. More than any other area of the body, facial injuries require accurate acute care. On initial presentation, the many delicate structures of the face must be properly prepared

to minimize tissue loss, functional loss, and scarring. Although in many instances scar revision may be necessary despite satisfactory management, complications following acute facial injuries will be predictably minimized if the treatment is properly performed. After irrigation, it may be helpful to thoroughly infiltrate the wound with 2% xylocaine with epinephrine, 1:100,000, followed by placement of a saturated gauze compress over the wound. As with all superficial wounds, the edges need to be retracted to explore the depth of the wound, which may include embedded foreign bodies, hematomas, or fractures. Factors such as the condition of the surrounding tissue, the location of the injury, the angle of the defect in relation to relaxed skin tension lines, and the involvement of significant structures must also be taken into account. To prevent future cosmetic deformities, irrigation and evacuation of deeply embedded foreign bodies must be particularly meticulous and extensive. This typically requires loupe magnification for optimal exploration.

Soft tissue injuries may involve multiple nerves, parotid ducts, lacrimal ducts, and other critical facial structures. Lacerations must be thoroughly irrigated with normal saline solution and conservatively debrided; abrasions must be cleaned. Injuries that extend across the margins of the lips, nostrils, eyelids, or external ears will benefit from tattooing of significant anatomic structures to facilitate anatomic alignment before closure. These areas require particular attention, planning, and proper alignment. If an eye injury is suspected, early ophthalmologic consultation is essential. Facial debridement must be conservative, because there is a greater chance that questionable tissue will survive here than in other areas of the body. Wound closure should be preceded by beveling or slight undercutting of the skin margins to counter scar separation and depression. Muscular tissues, fascial layers, and other subcutaneous tissues must be well approximated with plain or chromic catgut, or with synthetic absorbable sutures such as Dexon or Vicryl. With knots buried beneath the dermis, absorbable sutures in the deep layers of the dermis will provide adequate closure in many cases. The planning and execution of proper skin closure in pediatric patients is imperative. Precise approximation with delicate sutures may be completely destroyed in the event of suture removal in an agitated or otherwise uncooperative patient. Although an in-tracuticular repair or continuous running suture may facilitate future removal of sutures with minimal residual tissue damage, use of fast-absorbing catgut, adhesive strips such as Steri-Strips, or Dermabond (Ethicon, Inc., Somerville, NJ) for skin closure may be even more advantageous. It is recommended that absorbable synthetic suture material be used at all times in children, if possible, to eliminate the need for suture removal, thus avoiding the possibility of further injury to the child. As has already been mentioned, scars tend to spread in the pediatric population. Therefore, in the presence of any tension at all or if sutures are left in place for too long, there is a tendency for suture marks to become permanent. For this reason, deeper tissues must be meticulously closed to minimize the tension on cutaneous elements. Under special circumstances, if it is necessary to use permanent nonabsorbable skin sutures, it is preferable to remove those that are visible within 3 to 5 days.

UNUSUAL CLINICAL PROBLEMS Hematomas

The formation of hematoma may be attributed to the rupture of dermal or subdermal blood vessels as a result of blunt injury. Small hematomas are treated with warm compression, and conservative management will usually suffice. However, large hematomas may require aspiration with a fine needle 7 to 10 days after injury if liquefaction occurs. Often a hematoma is indicative of more significant underlying bone injury, and the examining physician must be

cognizant of this possibility. One particular chronic injury warrants special mention; cauliflower ear is the delayed consequence of recurrent blunt trauma to the auricle that results in repeated formation of subperichondrial hematomas.[1] These collections create a chondroinductive matrix for chon-droblasts contained within the elevated perichondrium. Chondroblasts then form ectopic cartilage within the area, inducing significant deformity of the helical shape of the ear.[1] Acute management includes incision and drainage of any auricular hematomas. Meticulous hemostasis must be attained followed by primary closure. In the event of a large hematoma, a suction drain may be left in place for several days. Chronic posttraumatic heterotopic cartilage can be directly excised through a postauricular approach. A compression dressing is then applied to maintain proper tissue contour and avoid further bleeding after any vasoconstrictive medication has been completely metabolized.[1]

Abrasions

Similar to burn injuries, mechanical abrasions also vary in thickness. Superficial abrasions should be thoroughly cleaned after local anesthesia is administered and adequately covered with a non-adhering dressing such as petrolatum-based antibiotic ointment, or triple ointment. To prevent scar formation, abrasions should be cleaned twice daily with tap water and a mild soap. Partial-thickness abrasions extend into the dermis. Stellate edges should be sharply cleaned and scrubbed with an antimicrobial soap under local anesthesia.[2] Conservative management of such injuries is paramount. Many will heal with a much diminished scar if initially treated with a petroleum ointment and protected with a nonabsorptive sterile dressing. Again, twice-daily gentle cleansing with soap and water is recommended. If after 1 year the scar is red and raised, a tunable dye laser may effectively decrease local vascularity and therefore discoloration. Hypertrophic scars can be diminished by the addition of intralesional steroid injections to increase collagenase activity within the wound.[2] Full-thickness abrasions are a result of a significant blunt trauma; therefore the examiner must be alert to potentially complicating associated injuries. After proper wound debridement and copious irrigation with sterile saline solution, primary closure is performed when possible. Although local advancement flaps are often needed to properly achieve wound coverage, they should be delayed.[3] When traumatic tattooing is noted, it is essential to remove all foreign debris. After complete debridement of all embedded materials, antibiotic coverage is strongly recommended. There are two available management options if an abrasion heals while retaining embedded bodies. Small areas may be excised and primarily closed. Larger areas are best treated with a combination of laser and direct particle excision, potentially via an 18-gauge needle. Small pigmented materials may be obliterated with the repeated use of a Q-switched laser. A $C0_2$ laser may be helpful in bringing deep debris to the surface.[3] If the debris is in a more superficial location, dermabrasion and scrubbing with a surgical brush are effective debridement tools.

Loss of Soft Tissue

Injuries resulting in the loss of soft tissue are usually treated at the time of the emergency evaluation and management. The main principle in these circumstances is to resurface the area with similar tissue to minimize contamination and maximize outcome. The use of grafts and flaps is indicated to change an open wound to a closed wound. It is also recommended that the surgeon in the emergency situation avoid creating a secondary deformity to correct an already existing one in working on local tissue coverage. Good

clinical judgment and surgical skills are essential for treating such injuries. To avoid further contamination, open areas with denuded soft tissue should be covered until the surgeon arrives on the scene.

COMMON CLINICAL INJURIES IN CHILDREN Dog Bites

In the pediatric population, animal bites continue to be a significant source of facial trauma, with more than 1 million bites occurring annually from dogs alone.[4] Although bites commonly occur anywhere on the body, they are particularly challenging when they involve the face. The face is a common site of injury; the animals are often the same height as the children, and they reach directly to the face with their bites. Medical management should include prophylaxis for tetanus, prophylactic antibiotics, and rabies precautions. Wdd animals must be considered rabid, and if possible the brain of the offending animal should be examined for the presence of antibodies to rabies. If possible, the patient should be treated with prophylactic rabbit immune globulin and human diploid cell rabies vaccine (HDCV) when indicated. However, if HDCV is not available, duck embryo vaccine may be substituted. If the bite is from a nonimmunized or questionably immunized domestic animal, the animal may need to be quarantined for 10 days. If illness or odd behavior is not observed within this period, no treatment is required. Dog bites, which represent the vast majority of bites, have reported infection rates as high as 29%. The typical offending organism is *Pasteurella multocida.* This and other common pathogenic canine flora usually respond to antibiotics within the penicillin family. Augmentin (penicillin and clavu-lanic acid) usually provides adequate coverage. As a second line of defense, cefoxitin is recommended. Human bites have more significant infection rates, which are usually attributed to anaerobic *Streptococcus* or *Eikenella corrodens.*[4] Susceptibility and drug therapy are similar to that for animal bites *(Fig. 11-1).*

On inspection, the wound must be copiously irrigated with saline solution and either a surgical preparation or antibiotic solution. Debridement of facial wounds must always be minimal; devitalized and shredded tissue should be removed to create a viable wound margin for closure with the appropriate suture material. Irregular margins may be used to create a broken line for closure and reduce the need for unnecessary debridement of viable tissue. Because of the significant aesthetic sensitivity of the facial region, all dog bites should be closed primarily if possible. However, wounds with a very high possibility of infection, or those more than 12 hours old, should undergo delayed primary repair.[4] In the event of significant soft tissue loss or underlying bone injury, the patient should be taken to the operating suite for copious irrigation and further removal of devitalized tissue.[5] Within 24 hours of debridement, the patient should undergo any further debridement if required and secondary reconstruction if necessary. In the case of significant tissue loss, local tissue flaps and thin skin grafts may provide well-vascularized coverage of the wound. However, such grafts should not be placed over infected or contaminated wounds in the acute care setting because of the substantial risk of infection.

- **ANIMAL BITES:**

A. Evaluation:

- The nose, mouth, and parotid gland areas are the primary targets for dog bites. The better the blood supply to the wound, and the easier it is to clean the wound – the lower the risk of infection. Most deaths in children occur due to hemorrhage from the great blood vessels of the neck.

B. Emergency care:

- Copiously irrigate the facial wound with isotonic sodium chloride solution. Excise macerated or necrotic tissue.

- Check the child's shot record to see when the last tetanus shot was given. If child has not had a tetanus booster within 5 years, another one will need to be administered within 3 days. If there is any possibility of rabies, the dog should be carefully observed for 10 days for any signs of sickness.

C. Definitive care:

- The dog bite injury should be documented with photographs and diagrams, if necessary. Proper medical treatment for dog bites requires an understanding of the canine oral bacteria which cause infections. The most common aerobic bacteria in bite wounds are: Pasturella, alpha-hemolytic Streptococci, and Staphylococcus aureus – occurring in 20 to 30 percent of infected dog bite wounds. The most common anaerobic organisms are Bacteroides and Fusobacterium – which are found in up to 41% of dog bite wounds.

- X-rays may be necessary to determine underlying bone or joint injury, because dogs can exert a tremendous force when biting.

- Animal bites should be separated into high risk and low risk groups when deciding on whether to suture the wounds or provide antibiotic coverage. Proper bite wound care includes: inspection, debridement, irrigation, and if indicated – closure.

- High-risk wounds generally require antibiotics. The bite wound should be cleansed carefully and irrigated with normal saline under pressure using a 19-gauge blunt needle, and a large syringe. Bacterial cultures obtained at the time of injury are not useful, because they do not predict infections. High-risk wounds include: wounds of the hand or foot; deep puncture wounds; surgically debrided wounds; wounds involving the joints, ligaments, tendons, and bones; dog bites where treatment has been delayed more than 12 hours; and bites in immunocompromised patients. High-risk wounds should not be sutured, but should receive antibiotic treatment. In that case, a beta-lactam antibiotic, such as Augmentin, should be prescribed for at least 10 days.

- Low-risk wounds include bites to the face and body. After a thorough search for damaged salivary ducts, facial nerve, and blood vessels – many facial wounds can be sutured. Low-risk wounds may be sutured, especially in the face.

- If the wound is less than 6 hours old, and the margins of the wound are clearly delineated – then close the wound with fine interrupted sutures. If the wound is more than 6 hours old, closure of the wound may be deferred to prevent infection and wound dehiscence.

- Appropriate tetanus and rabies prophylaxis should be provided based on the child's medical history. Rabies vaccine must be administered, unless it can be proven that the animal was not rabid. If the animal can be observed, it will develop signs of rabies in 10-14 days – if it is rabid. Antibiotics are always administered in cases of animal bites.

Lacerations

Facial lacerations may involve multiple nerves, parotid ducts, lacrimal ducts, or other critical facial structures. Lacerations must be thoroughly irrigated, inspected, and properly debrided. Injuries that extend across margins such as the lips, nostrils, eyelids, or external ears require particular attention, planning, and proper alignment. If there is any suspicion of eye injury, an early ophthalmologic examination is imperative.[6] Facial debridement should be minimal. Wound closure should be preceded by beveling or slight undercutting of the skin margins to counter scar separation and depression. Muscular tissues, facial layers, and other subcutaneous tissues may be well approximated with plain or chromic catgut, or with synthetic absorbable sutures such as Dexon or Vicryl. With knots buried beneath the dermis, absorbable sutures in the deep layers of the dermis will frequently provide adequate closure.

Experienced surgeons are well aware of the fact than an anatomically well-approximated deep layer is the key to a well-healed superficial wound. Planning and executing proper skin closure in the pediatric patient is essential. Two of the most common adverse effects of a delicate facial closure are infection and hematoma. For this reason, meticulous attention to hemostasis and copious irrigation are crucial before final epidermal closure. Epidermis is reapproximated with interrupted sutures to facilitate precise anatomic orientation. Although an intracuticular repair or a continuous running suture may permit easy removal with minimal residual tissue damage, the use of Steri-Strips or Dermabond may be even more advantageous.

Despite the surgeon's best efforts against all other complicating factors, a precise approximation with delicate suturing may be completely destroyed if suture removal is attempted in an agitated or otherwise uncooperative patient. Thus in an uncooperative child, fast-absorbing 6-0 or 5-0 catgut sutures are acceptable (reinforced with Steri-Strips). In a cooperative adolescent child, interrupted monofilament nylon is recommended. The use of resorbable synthetic sutures should always take priority in infants and children to avoid the need for suture removal

Scalp Injuries

Because of the extensive vascular supply to the scalp, wounds to this area may produce significant blood loss. Application of a Kerlix compression bandage will facilitate adequate hemostasis. If an arterial bleed is identified, the surgeon should suture-ligate the damaged vessel.[7] Extensive shaving is unnecessary in the event of scalp injuries, and adequate control of hemorrhage can typically be achieved with a single layer of running, interlocking 3-0 chromic sutures. Associated skull fractures must always be suspected, and thorough palpation and inspection should be undertaken for any full-thickness scalp wound. Layers of the scalp include skin, connective tissue, galea aponeurosis, loose areola, and periosteum.[7] It is essential to close scalp injuries in layers. Every effort should be made to reapproximate the galea, because failure to close this layer may lead to future development of a subgaleal hematoma.[7]

Eyebrow Injuries

Lacerations of the eyebrow should not prompt one to shave the remaining hair.[6] Eyebrow lacerations should be closed meticulously in layers with careful alignment of the margins. Because the hairs of the eyebrow run oblique to the skin surface, any potential incision for further debridement should follow the line of the eyebrows to limit further hair loss. Careful approximation in layers is vital. One must be sure that there are no sutures abrading the cornea, because diis represents a critical problem.

Eyelid Injuries

In patients with eye pain or through-and-through lid lacerations, the examiner must first rule out potential ocular injury. Lacerations of the eyelid must be delicately approximated, followed by layered closure. If proper apposition can be obtained by closure of the tarsal plate and the pre-tarsal muscles that occupy the middle layer, the conjunctiva may be left unrepaired.[6] The gray line at the tarsal margin must be carefully reapproximated to restore the normal curvature of the eyelid margin. The borders of the tarsal plate must also be realigned for the accurate reestab-lishment of form. Fine nonabsorbable sutures may be used when indicated to close the final layer, and removed within 48 hours. If significant tissue loss complicates the closure process, it may be necessary to employ plastic surgical techniques to mobilize sufficient conjunctiva for closure.

Lacerations to the upper lid can damage the insertions of the levator aponeurosis or Muller's muscle onto the tarsal plate resulting in ptosis. Such cases must be identified preoper-atively so the detached eyelid elevators may be properly advanced to the tarsal plate at the time of laceration repair. Any injury to the lower lid poses an increased risk of increased scleral show and ectropion formation. Although proper tissue realignment during repair decreases the risk of such complications, in some cases cartilage grafting, lateral canthopexy, or tarsal strip grafting is required to provide additional support.

Lacrimal Duct Injuries

Lacerations involving the medial canthal region are assumed to have an associated lacrimal duct injury. If both ends of the ducts can be identified, the severed ends should be realigned, splinted internally, and repaired over a Silastic rod.[6] Dissection to locate residual portions of the duct must be meticulous, because traumatic dissection will likely aggravate the injury and may result in permanent damage.

External Ear Injuries

- In the highly vascular structure of the ear, proper repair typically results in excellent healing. Such lacerations require acute debridement of injured cartilage, followed by placement of perichondral support sutures. Repair of the ear should employ fine nonabsorbable sutures in a three-layer closure to approximate the cartilage and skin. If the ear is completely detached, the remaining cartilage should be preserved within a subcutaneous pocket in the mastoid region for future reconstructive efforts.[2] As a result of shearing forces on the mucoperichondrium, signif-icant hematomas may form. These must be evacuated early, with a conforming pressure dressing subsequently applied to maintain normal ear contour.[2] **EAR INJURY:**

A. Evaluation:

- Examine the ears for injury or CSF leak. A shearing force or blow to the ear can result in “cauliflower ear.” This problem is caused by a subperichondrial hematoma – which should be aspirated immediately.

- Blood or pain in the external auditory canal may indicate a mandibular condylar fracture. During an otoscopic examination, appearance of a tympanic membrane rupture or hemotympanum (bleeding eardrum) may also suggest a basilar skull fracture.

B. Emergency care:

- Carefully clean and debride ear injuries. Anesthetics without vasocontrictors should be used to prevent ischemia of ear tissue.

- The main goal of treating an ear injury is protecting cartilaginous structures. Treatment of otohematomas involves repeated aspiration and compression to prevent fluid accumulation. Any subperichondrial hematoma should be aspirated with an 18-gauge needle, and a compression dressing should be applied for 7-14 days. Any ear injury should be splinted by placing cotton balls between the ear and head – and then wrapping with a circumferential dressing around the head.

C. Definitive care:

A linear laceration of the ear usually requires closure in 3 layers – the cartilage, perichondrium, and skin. Avulsions and amputations of the ear tend to heal well after reattachment, because the ear has a highly vascular pedicle.

Nasal Injuries

Penetrating lacerations and avulsion injuries of the nose all result in a potential functional as well as cosmetic problem. Repair within this area must be precise because the nose and surrounding tissue is extremely vascular. Cartilage and skin should be approximated with fine nonabsorbable interrupted sutures.[5] For repair of the nasal mucosa, an absorbable suture should be employed. Significant cosmetic landmarks such as epidermal-mucosal junctions, nasal fold junctions, or critical angles in jagged lacerations should be aligned first to decrease the incidence of deformity.[8]

Cheek Injuries

Deep cheek lacerations require a multilayered closure. Because such laceration may penetrate the oral cavity, a comprehensive head and neck examination is imperative to rule out this possibility.[8] Wounds should be carefully irrigated and, if they extend through the oral mucosa, a separate row of nonabsorbable sutures must be placed for proper closure. Cheek lacerations may represent damage to the facial nerve. A thorough examination of the nerve must be carried out before intervention. If the nerve is lacerated, a primary anastomosis should be performed at the time of laceration repair if the two ends are readily identified.[9] Injuries to the cheek may be further managed with nasolabial advancement flaps, Limberg flaps, and cervical-facial flaps[8] (see Fig. 11-2).

Located between the parotid gland and the oral mucosa opposite the second upper molar, any laceration of the anterior parotid gland may damage this duct. If parotid duct injury is suspected, the orifice of Stensen's duct should be probed.[9] If an injury is identified, the probe should indicate the distal cut end of the parotid duct. The proximal cut end of the duct may be located by the expression of saliva from the gland. A catheter should be positioned through the area of laceration via Stensen's duct, and the duct should be repaired over the catheter.

PAROTID GLAND INJURY:

The parotid gland is located superficially in the cheek, and is vulnerable to facial trauma. A clear discharge from a cheek wound indicates parotid gland injury. Patency of the parotid duct should be ensured by milking the parotid gland, and observing the flow of saliva from Stensen’s duct (located in the cheek opposite the upper first molar).

To determine if the parotid duct was transected, a small catheter is placed in the parotid duct orfice. If there is duct transaction, the cathether will exit out of the distal end of the duct and become visible in the wound area. The proximal end of the severed duct may be identified by massaging the gland to express saliva. The severed ends can then be reconnected.

A severed parotid duct can be anastamosed over the exploratory catheter using 7-0 monofilament sutures. The catheter may be left in place for 5-7 days to ensure duct patency.

Nerve Injuries

Most vulnerable to injury, the facial nerve and its function must be thoroughly evaluated before local anesthetic is administered. Additionally, facial nerve injuries result in the most serious functional and aesthetic defects.[7] Sensory nerves such as the supraorbital and infraorbital nerves may be injured subsequent to trauma; however, the resultant hypesthesia typically causes only

minimal long-term effects. If the posterior half of the parotid gland suffers a deep laceration, it should be assumed that the major branch of the facial nerve has been divided. If the main nerve trunk or one of the five major trunks has sustained a clean, sharp division, it can be acutely repaired with microanastomotic techniques. If substantial nerve loss precludes proper primary anastomosis, the nerve ends should be identified and tagged for potential grafting at a later date. Anterior to the lateral canthus, nerve repair is generally unnecessary because there is sufficient crossover from the opposite side. Peripheral branch injury may present as an inability to raise the eyebrows (frontal branch), inability to close the eyelids (malar), smoothness of the cheek (infraorbital), inability to smile (buccal), and inability to frown (marginal mandibular).

Lip Injuries

Surgical management of lip lacerations is similar to that for full-thickness abrasions. Particular care must be taken to align three important labial structures: the orbicularis oris muscle, the white line, and the red line. These important anatomic landmarks can be delineated with tattoo marks or tacking sutures to help facilitate meticulous alignment.

An interrupted or figure-of-eight monofilament absorbable suture should be used to approximate the pars marginalis of the orbicularis oris muscle.[1] Poor reparative efforts in this area will lead to both abnormal lip movement and muscle bulging lateral to the bite area. A white roll marks the border between the red line and the surrounding skin of the lip. Failure to properly align this structure may result in marked lip deformity, which is usually apparent from several feet away. This structure should be the first area to be precisely realigned during closure efforts. The second area to be approximated should be the red line, which forms the junction between the wet and dry mucosa of the lip. Failure to properly realign this structure results in a vertical distortion of the lip vermilion as well as chapping and scabbing of the lip postoperatively as a result of eversión of the wet mucosa into the dry mucosa area. Full-thickness wounds to the lip require careful closure of the oral mucosa with absorbable suture material to prevent contamination of the wound with oral flora. After repair, patients should rinse their mouths five times daily with a peroxide-based antimicrobial mouthwash. Defects greater than one third of the lip should be allowed to undergo delayed closure after complete debridement.[2] Prior to division of the lip margin, the vermilion border should be carefully identified and tattooed, with the first sutures placed to align this crucial margin. Of note, a common problem in the management of lip injuries is the problematic identification of landmarks in the setting of edema, abrasions, obliterations, or local anesthetic injections that typically follow significant trauma.

Avulsions

Blunt trauma that produces full-thickness loss of the skin and all underlying tissue constitutes an avulsion. Such injuries in the pediatric population are treated in a manner similar to that of adult avulsion defects. When skin grafting is required, special consideration must be given to the choice of donor site. Keeping in mind patient age relative to puberty, a graft that will subsequently be hair bearing is to be avoided unless specifically indicated. The lateral aspect of the anterior abdominal wall, medial aspect of the thigh, and inner aspect of the upper arm remain minimally hair-bearing areas in most individuals. Many soft tissue defects on children's faces can be repaired with rotation or transposition flaps taken from adjacent areas. Large pedicle flaps from distant donor sites have largely been discouraged.[7] Although many defects of a pediatric patient's

facial soft tissues may be managed on a nonemergent basis, two particular events merit special mention.

An avulsion of the eyelid is a true surgical emergency. Immediate coverage is required to prevent further corneal damage, decreased visual acuity, and exposure keratopathy.[6] Acute care consists of an ophthalmologic consultation, placing an antibiotic patch over the cornea, and covering the eye with a nonpermeable occlusive eye shield. Trapping moisture within the orbit should prevent dryness and further desiccation of the superficial corneal layers. The lid may be reconstructed using any of a variety of techniques, as long as all three layers of the lid are replaced. Conjunctiva may be replaced with adjacent or cross-lid conjunctiva. Free conjunctival grafts consisting of oral mucosa or palatal mucosa also function effectively. The middle lamella, or tarsus, is reconstructed using nonvascularized cartilage grafts or via tarsal plate advancement. Skin may be replaced by local flap advancement or full-thickness skin grafting.

Complete avulsion or amputation of the ear requires immediate microvascular reconstruction using vein grafts to anastomose at least one ear artery and two ear veins to either the superficial temporal or occipital vessels. When successfully completed, repair typically results in the full restoration of the external ear structure. Delayed management of avulsed ears likely requires total ear reconstruction employing either a Medpor implant (Porex Surgical Products Group, Newnan, GA) covered with skin or temporal parietal fascia. Partial avulsions may be treated with sharp debridement followed by a local advancement flap such as the Antia-Buch advancement flap. More significant defects require harvesting cartilage from the opposite ear and covering the free cartilage graft with a temporal parietal flap and full-thickness skin graft.

Thermal Burns

There are three phases of burn injury management: (1) cleaning and debridement, (2) tissue grafting, and (3) reconstruction.[10] After resuscitation, the wound is allowed to demarcate before being thoroughly debrided. First-degree burns are best treated conservatively with localized care and bacitracin ointment. Second-degree burns of the face are best treated with antibiotic ointment and subsequent coverage with a moist, semiocclusive dressing. Although most facial burns may be dressed with bacitracin or occasionally silver sulfadiazine, second- and third-degree auricular burns should be treated with Sulfamylon, which penetrates down to the cartilage and gives excellent coverage for *Pseudomonas* infection. Noninfected third-degree facial burns may be treated initially with application of a bilaminated layer margin such as Integra.[10] This will facilitate the development of a granulation bed onto which a graft may eventually be placed.

Chronic thermal burn injuries may have associated functional deficits. Resultant scar contracture and deformity are often a challenge to correct. In general, 6 to 12 months after injury the child is usually ready for reconstruction.[10] When multiple procedures are required, the recommended sequence for reconstruction is as follows: eyelids, perioral tissues, neck, chin or cheek, and then all remaining tissues. The use of medium-thickness (0.014 to 0.018 mm) or full-thickness grafts is advised for improved color match and decreased effect of contraction. For the eyelids, early tarsorrhaphy should be considered for protection of the globe as well as to prevent contracture with eventual development of ectropion.[6] Severe burns to the nose require a three-layer reconstruction. Mucosal lining may be achieved with local mucosal advancement flaps or grafts. Cartilage may be replaced with auricular, septal, or

costochondral cartilage. Superficial skin can typically be replaced with local vascularized advancement flaps or unaffected forehead skin.

Accurate reconstruction of the lip is often challenging. In our opinion, the best options are mucosal advancement flaps of buccal mucosa, advancement of tissue from the opposite lip, or free microvascular tissue transfer. Significant burns of the cheeks are best reconstructed with a cervicofacial flap and possible tissue expansion. Focal burn alopecia may be repaired using a careful combination of serial burn excision, tissue expansion, and micrografting of hair implants. Significantly damaged ears can be reconstructed by excising the burn, covering the cartilage with a temporoparietal flap, and then resurfacing the ear with a skin graft. For large burns that involve more than half the neck, a deltopectoral flap with or without tissue expansion may be necessary. Contouring pressure dressings are strongly encouraged. For the ears, these dressings may be required for 1 to 2 years.

EMERGENCY EVALUATION OF FACIAL TRAUMA:

- First, perform a primary survey and assess airway, breathing and circulation. Note that mobile fracture segments, edema (swelling), hemorrhage (bleeding), vomitus, bone fragments, and foreign bodies may cause obstruction of the airway. The airway is always the first priority in treatment of the trauma patient. In any trauma patient, be sure to obtain cervical spine x-rays to rule out neck injury. A complete set of vital signs including: temperature, pulse, blood pressure, and pulse oximetry should be obtained on every patient.

- Second, perform a thorough trauma physical examination.

- Third, inspect the face inspected for symmetry, swelling, or ecchymosis (bruising). The face is palpated bimanually in an orderly fashion – beginning at the cranial vault, then proceeding to the forehead, orbital rims (bone surrounding the eyes), zygomatic arch (cheek bone), maxillary alveolus (upper jaw bone), and the mandible (lower jaw). Numbness of the infraorbital, supraorbital, and mental nerve distributions may indicate a cut or stretched nerve. Gently palpate the nasal area for crepitus, tenderness, or subcutaneous emphysema (air). Swelling, ecchymosis (bruising), crepitation (fine crackling), and facial asymmetry may indicate an underlying fracture. Look for enopthlalmus (sunken-in eyes), exopthalmus (protruding eyes), periorbital ecchymosis, and postauricular ecchymosis (bruising behind the ears - Battle's sign). Note that Battle's sign is associated with basilar skull fractures. Examination of the inside of the ear with an otoscope may reveal a hemotympanum (bleeding of the eardrum), which indicates either a basilar skull or temporal bone fracture.

- Fourth, check for maxillary, mandibular, and zygomatic fractures. Check for maxillary Le Forte fractures by grasping the maxilla intraorally, and attempt to gently "rock" it back and forth. Movement of the maxilla indicates a fracture.

Check for mandibular fractures by having the patient attempt to bite on a tongue depressor while you gently twist it – mandibular fracture patients cannot accomplish this task.

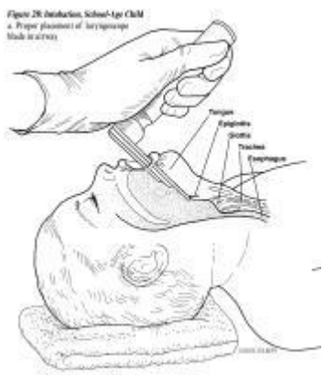
Examine the zygomatic (cheekbone) region by visual inspection, external palpation, and intraoral palpation. Palpate intraorally above the buccal surface of the upper molars to differentiate a zygomatic arch fracture from tenderness.

- Fifth, perform an intraoral examination. Check the oral cavity for dentoalveolar trauma. It is important to account for all teeth, since the patient

may have aspirated or ingested them. Check to see that the patient's bite is normal. The mandible should not deviate to any side during opening.

- Sixth, inspect for signs of nerve deficit. Cranial nerve VII (facial nerve) controls the muscles of facial expression and should be checked by having the patient smile, frown, wrinkle the forehead, and close the eyes tightly. The three branches of cranial nerve V (trigeminal nerve) should then be examined, since it controls sensation to the face.
Eyebrows that cannot be raised, and eyelids that cannot be closed – injury to the temporal and zygomatic branches of the facial nerve.
Inability to frown – injury to the marginal mandibular branch of the facial nerve.
Inability to smile – injury to the buccal branch of the facial nerve.
Wrinkles on the cheek – infraorbital nerve injury (a branch of the trigeminal nerve).

- The following screening questions can help evaluate sites of injury:
"Where does your face hurt?" This helps uncover hidden problems.
"Do you notice a difference in vision?" Binocular diplopia (a different image in each eye) is often caused by impaired extraocular muscle movement due do an orbital bone fracture. Monocular diplopia (two images seen by the same eye) usually results from retinal detachment or globe rupture.
"Do your teeth fit together?" Most maxillary or mandibular fractures will cause a malocclusion (a poor fit of the teeth).
"Does it hurt when you open your mouth?" Pain during opening can indicate that a fracture has occurred – perhaps in the zygoma, mandible, or elsewhere.



EMERGENCY MANAGEMENT OF FACIAL TRAUMA:

- The primary survey should be conducted rapidly, with evaluation of the ABC's of Airway, Breathing, and Circulation.

- The first priority in managing a child with trauma is ensuring that the airway is clear and open. Foreign objects and blood must be removed from the airway. Carefully suction blood and debris from the oropharynx. Presume that a cervical spine injury exists until excluded. One method of controlling the airway in such cases is the jaw thrust maneuver. Pulling the tongue forward also opens the airway. A patient who is awake and free of cervical spine injury may be allowed to sit up and lean forward - and use a suction device himself.

- Note that orotracheal intubation may be necessary to manage the airway in an unconscious patient. In addition, intubation should be considered if oxygen desaturation occurs. The usual approach for airway intubation in a facial trauma

case is the rapid sequence oral intubation technique, with the Selick maneuver. Using a nondepolarizing muscle relaxant such as Vecuronium may prevent the elevation of intracranial pressure in the presence of head trauma. Intubation should be performed with the head in the midline and cervical immobilization. Oral intubation with in-line stabilization of the C-spine has now been incorporated into the ATLS protocol. Cricothyrotomy may be needed in patients who have massive pharyngeal edema.

- Assessment of breathing and circulation are next. The evaluation of circulation includes monitoring the child's pulse, perfusion, blood pressure, and oxygen saturation (pulse oximetry). Vascular access should be obtained and isotonic crystalloid boluses, 20 ml/kg, are administered as needed.

- Control of hemorrhage is the next priority. Intranasal packing may help if direct pressure does not stop severe epistaxis (nasal bleeding).

- **ANESTHESIA:**
- The facial nerve (cranial nerveVII) provides motor innervation to the muscles of facial expression. The facial nerve divides into the temporal, zygomatic, buccal, mandibular, and cervical branches.

- Sensory innervation of the face derives almost entirely from the trigeminal nerve (cranial nerve V). The trigeminal nerve is divided into three sections: the ophthalmic division, the maxillary division, and the mandibular division (which are mixed sensory and motor nerves). Four regional nerve blocks can be used to treat injuries to the outside of the face: the supratrocheal, supraorbital, mental, and infraorbital. By using nerve blocks, there is decreased systemic toxicity and less volume-related tissue distortion. For injuries to the mucosal membranes of the nose, cocaine 5% is the topical anesthetic agent of choice – which can be introduced with a cotton-tipped applicator.

- Lidocaine 1%, with or without epinephrine, is commonly used for facial local anesthesia. Local anesthetics have a low margin of safety between the effective dose and the toxic dose. The lethal dose for many local anesthetics is only 3 times that of the effective dose. The maximum safe dose of lidocaine for a child is 4.5 mg/kg per dental appointment. Bupivicaine (Marcaine) is an amide local anesthetic with a high toxic potential, and should not be used in children. Lidocaine is less toxic than many other local anesthetics, because its interactions with the cardiac sodium channel are "fast in – fast out," whereas a local anesthetic such as bupivicaine is "fast in – slow out." When sedating a child, the local anesthetic dose should be lowered to decrease the risk of toxicity and complications.
- **WOUND DECONTAMINATION, EXPLORATION, AND CLOSURE:**
- Removing bacteria and devitalized tissue is critical in wound treatment. Irrigation with an 18-gauge catheter attached to a 60 ml syringe is required for wound irrigation. Use normal saline to irrigate facial wounds. Wounds that have gross contamination should be carefully scrubbed with a fine-pore sponge, because foreign particles which are allowed to remain in the skin can cause "tattoing." Devitalized tissue needs to be removed, using a number-15 blade or iris scissors. The skin surrounding the wound may then be prepared with a 1% solution of provodine iodine, and the laceration area draped in a sterile fashion before suturing.

- After adequate anesthesia and wound cleansing has been provided, explore the wound with tissue forceps or tip of a scalpel blade to search for

foreign bodies and sources of bleeding. Radiographic film can be used to visualize foreign bodies – especially glass and gravel.

- Wounds of the face may be closed up to 24 hours, but ideally within 8 hours after the injury, in healthy children. Wound edges should not be ragged or irregular, so it may be necessary to remove a small amount of devitalized tissue to create perpendicular wound edges prior to suturing. To avoid tension on the skin sutures, the wound edges may need to be undermined with a scalpel blade before they can be approximated. Simple interrupted sutures (6- monofilament) should be used for most skin closures. The wound edges should be everted during suturing to prevent a future wound edge concavity. Small wounds that are under minimal tension may be closed with “skin glue” (butyl-2-cyanoacrylate).

- Prophylactic coverage with a cephalosporin is usually necessary to prevent infection of the face after trauma. A first-generation cephalosporin acts on most skin flora.

If bone has been exposed through an intraoral or cutaneous laceration, then antibiotics are definitely indicated. A sinus blow-out fracture also required antibiotics. Penicillin acts on most mouth flora.

Antibiotic ointment should be applied for the first 2 days after the skin repair. Washing and showering can begin 24 hours after the repair. Facial sutures are removed 4-5 days after placement, but eyelid sutures are removed 3-4 days after placement. Sutures placed in the ear are left in place for 11-14 days.