Pediatric Facial Plastic and Reconstructive Surgery

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Chapter 18: Soft Tissue Trauma in Children

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Historically, there have been progressive improvements in the management of injuries to children that extend from the initial emergency management and triage through improved pediatric care. Improved overall patient assessment, as well as specific wound assessment (Table 1), have led to emphasis on proper early management. Over the last several years not only have techniques been improved but the materials with which to work have shown progressive development with new suture materials and refinements in the swedged on needles available. Instrumentation is not only known to the specialist but is becoming generally available in the emergency room where not too long ago this was not always the case. The specialist has contributed greatly to the education of those in emergency medical services as the development of emergency room medicine has come about. A deignated pediatrics emergency room has been a major contribution to the care of the injured child. There has been increased knowledge of wound healing, improved prognostication of outcomes, and more sophisticated management of complications.

Table 1. Wound analysis

Type of wound	Contamination
Location of wound	Foreign bodies
Landmarks	Blood supply
Facial nerve	Nonviable tissue
Parotid duct	Skin margins
Direction of laceration	Local tissue shock
Angle of laceration	Crushing injuries.
Condition of tissue	

Soft tissue trauma in the child extends from bruises and abrasions through lacerations, avulsions with major tissue loss, and the associated maxillofacial injuries. Bites and electrical burns require special attention. The etiology of the trauma has become more and more complex as mechanization has become widespread, extending from modes of transportation to various recreational vehicles. If not actually participating, the child is often taken along and encouraged to participate before he is able to handle the power and velocity. Without safety devices, the small child in particular can become a projectile, leading to serious injury. Space heaters are not confined to lower income homes and remain a source of burns, particularly when clothing is ignited. There are innumerable electrical appliances, which often fascinate the young child and become sources of electrical burns, particularly of the oral commissure. Although increased awareness exists, there seems to be an ever-lasting number of animal bites. It seems appropriate to mention, as we emphasize safety devices in automobiles, the cooperation of the American Academy of Otolaryngology - Head and Neck Surgery and the American Society of Plastic and Reconstructive Surgery in bringing these issues to the attention of the public in 1991.

General Considerations

The reconstructive surgeon must have a fair knowledge of wound healing and the ability to anticipate various stages of healing, both for his own management and for reassurance to the child or parent. Wound healing is covered in a most scholarly manner by Koopmann in Chapter 20 of this book.

Although much research and advanced study have been devoted to wound healing, there is little in the literature comparing specifically the healing of infants and children to adults. Most observations, as with my own, are from practical clinical conclusions as one follows the child through the healing period.

In general, children heal rapidly but with the thinner skin, increased vascularity, greater elasticity, abundance of fat, and growth adding to tension, scars tend at least to spread more than in adults. In the observations of the senior author, there is no greater tendency to true hypertrophy. Various authors state frankly that hypertrophic scars are more common in children, but I am impressed that these and keloids result in relatively the same proportion as they do in the adult population, all etiologic factors being taken into consideration. There is a very real tendency for these scars to spread and appear, in later phases of healing, to have hypertrophied, but these will soften and will then present later simply as a scar that has spread.

Stitch marks are more common in children, influencing the recommendations for suture techniques.

Emergency Consultations

Starting at the beginning, the physician doing facial plastic surgery, must be willing to come as soon as possible to see the injured child, making early assessments and assuming a leadership role if this is not already assumed by someone else. Early arrival is a major consideration and plays a large part in the reassurance of the child and the parent and allows an orderly decision-making process. Perhaps before any medical treatment, establishing some control and cooperation from all emergency room personnel and with the parent should be emphasized. Personnel should be trained to present a caring, reassuring, and calm atmosphere. As pediatric emergency rooms have developed, these personnel are usually quite skilled in this important early phase of management. It is not within the scope of this chapter, but early assessment, extending from the airway and hemorrhage through multiple injuries and general conditions, must be made. Determination must then be made as to whether the child can be managed in the emergency room or office or will require general anesthesia and repair in the operating theater (Table 2). In brief, the child is frightened and the parents are anxious. Parental guild and anger become major factors in how smooth the state of management goes.

A basic set of instruments, which the senior author recommends and which can be carried in a coat pocket folder, includes two small skin hooks (Storz N4700), Brown-Adson multiple teeth forceps (Storz N5420), Webster needle holder (Storz 5712) or the small needle holder from Anthony Products P0404 (Storz), and small Bishop-Harmon forceps (Storz PE1500). Even sterile packets of some suture materials can be brought to the emergency room by the surgeon along with a camera. Photographing the wound before and after surgical

cleanup may be vital for medical documentation, assisting the parents in insurance claims, and serving as a safeguard against any type of litigation. Even a simple automatic camera with flash captures the severity of the injury. For revisions, time for analysis and more sophisticated photographs become easier. It takes a particular conscientiousness to realize the importance of emergency photographs. The surgeon should carry his own camera, having it available for all emergency situations.

Table 2. Wound management

- Cleansing
  - Irrigation
  - Scrub brush
- Removal of foreign bodies
- Hemostasis
- Debridement
  - Minimal
  - Preparation of skin edge
    - Beveled margin
    - Uniform thickness
- Wide undermining
  - Beveled laceration
  - Trapdoor laceration
  - Reduction of skin tension
  - Readjustment of tissue
- Management of deep scar
  - De-epithelization
  - Release of contracture
  - Exercise
- Suture technique
  - Layered closure
  - Interrupted subcuticular closure
- Skin suture
  - Interrupted, spring loop
  - Continuous subcuticular (intradermal)
- Surgical dressing
  - Fine mesh gauze
  - Antibiotic ointment
  - Wound support
  - Pressure
  - ± Tissue drain
- Delayed reconstruction
  - Skin grafts
  - Skin flaps
  - Release of contracture
- Dermabrasion
  - Immediate
  - Delayed
- Antibiotics
- Intralesional steroids.

The degree of cooperation one can get from a child is astounding. Most of the time it is surprising how well the child will cooperate, if managed and handled appropriately. Sedation and bundling with a papoose become the next consideration. With an adjusted parent, the parent holding the child's hand and talking with him can be helpful. Many children, after the excitement of the injury, the frantic parent, the frantic drive to the hospital, and considerable crying, will simply go to sleep in exhaustion once they realize they are not being hurt. After initial irrigation at least, if not surgical preparation, it seems helpful to irrigate the wound thoroughly with 2% Xylocaine and adrenaline 1:100.000 and then to put a gauze compress saturated with this anesthetic in the wound. This technique has been used for years. More recently a topical mixture of tetracaine, adrenaline, and cocaine (TAC) has proven effective. Injection should be made through the laceration. This is often less painful and it avoids injecting through the contaminated skin. It is best to accomplish this before it is necessary to clamp any significant bleeders.

Quite often the patient has been seen "elsewhere" and the laceration may have been repaired, sometimes quite well but often omitting a layered closure. We strongly prefer that the laceration not be repaired so that appropriate layered closure can be carried out, but more particularly so that the deep wound can be thoroughly explored, both for foreign bodies and fractures. Often fractures can be approached through the laceration and it is better to have the usual, rougher management of the bone reduction before the delicate skin closure is carried out. The two greatest problems for this delicate closure are infection and hematoma. For this reason, in the fresh laceration, interrupted sutures are used so that, if necessary, opening the wound for drainage may not destroy the entire closure. Many of these wounds will require a simple tissue drain. After massive irrigation with saline, particularly if the nasal or oral cavity has been injured, we prefer irrigating with a surgical bacitracin solution. The wound must be thoroughly explored for foreign bodies with particular consideration being given to glass, paint, wood chips, and asphalt. After anesthesia, the use of the scrub brush may be helpful, both for skin margins and abrasions (Table 2).

Techniques

After the above general evaluation and preparation, specific techniques can be carried out. Wound analysis is most vital, including the condition of the tissue surrounding the laceration, the location and angle of the cut, and the involvement of vital structures, including anatomic margins (Table 1). The angle and direction of the laceration in regard to relaxed skin tension lines and major landmarks or folds may enter into the initial analysis and repair. Lacerations that extend across margins, such as the lip, nostrils, eyelids, or external ears, require particular attention to proper alignment. Vital structures may include major vessels, the facial nerve, or the parotid duct. If there is any question regarding eye injuries, it is important to get early ophthalmologic consultation, preferably in the emergency room, if this is possible.

Debridement should be minimal, or not at all, if there is a question about the structures involved or the viability of the tissues.

Wound closure is preceded by appropriate preparation of the skin margins. The skin margins are beveled or slightly undercut to assist in eversion in an attempt to counter scar separation and depression. For the beveled cut, the exposed dermis opposite the angle of the

cut is beveled in the wrong direction and must be cut away. On the side of the angle, the exaggerated beveling often requires a slightly more vertical cut matching the opposite side. It is vital that undermining be carried out on both sides of the wound with the thickness of the elevated tissue being the same on both sides. This allows appropriate skin closure not influenced by the deep tissues, which are closed separately. This preparation of the skin edges serves also for minimal debridement for foreign particles that may be ground into the wound. For the trapdoor laceration, one of the most frequently omitted portions of the repair is undermining the disturbed tissue opposite the trapdoor. This equalizes the tension and assists in closure. The margins of the wound and the deep tissue can be handled independently and generally the deep sutures are brought forward and down. Beneath the trapdoor flap, some sutures passed parallel to the flap are utilized by tacking these to the deep wound, preventing the common "humping" on the side of the trapdoor. As we have mentioned, wounds in children tend to spread and, if there is any tension at all or the sutures are left in too long, there is a tendency for stitch marks. For this reason the deep tissues must be meticulously closed and all tension possible reduced - "what counts is what is underneath". The senior author very strongly disagrees with the admonition that deep or subcuticular sutures create strangulation. If these are properly and delicately placed, and not overdone, they do not create anywhere near the degree of strangulation that skin sutures produce when closed under tension. Also, without the deep sutures, it is necessary to leave the skin sutures in longer. Again, one tries to prevent the tendency toward stitch marks in children; therefore, it is preferable to get the skin sutures in children, which are tied without tension, out within 3 to 5 days. With the active child, or if tension-reducing dressings are not practical, some of the sutures may be left in as long as a week. This is particularly true for the common cut beneath the chin, which is so often struck again and may break open. Certainly there is a tendency to spread, for this possibly most common laceration in children. In this area, this is compounded by the associated contusion when the child falls. In the deep tissues, we use both vertical and interrupted sutures and sometimes horizontal or parallel mattress sutures as the first "tension-reducing" sutures. These are passed in the deep tissue or, if necessary, lateral to the wound margin in the deep dermis lateral to where the interrupted subcuticular suture will be placed. Again, because of the tendency to spread, we have on occasion used permanent suture material, such as mersilene, but we are not comfortable with this, having seen permanent materials exude eventually or create irregularities that are permanent. For this deep suture we are now using either 4-0 vicryl (polyglactin 910) by Ethicon or 4-0 PDS (polydioxanone) also by Ethicon. These can be obtained with either a half-curved cutting needle or a round noncutting needle. In the majority of instances we prefer the cutting needle and we use 4-0 Vicryl on a PS-5 needle or PDS, which is even slower absorbing.

The interrupted subcuticular suture we have advocated is appropriately placed with the knot buried and to deliberately evert the incision or laceration lines from the surface. This means that the needle has to be placed slightly closer to the skin surface lateral to the wound than at the skin margin. This suture should bring the skin edges together but there may be some unevenness of the skin surface or level of the two skin egdes, thus requiring the fine nylon skin sutures without tension. In the experience of the senior author, if only the interrupted subcuticular suture is placed, it allows more blood and serum to microscopically separate the two skin edges, and surgical tapes do not correct any differences in the skin level or assist in maintaining eversion. Therefore, we use interrupted spring loop knots, the spring loop suture, and may alternate these with simple surgical twists. We are currently using either Dermalon 5-0 or 6-0 with a CE-2 needle or Ethilon 5-0 or 6-0 on a PC-1 needle.

All wound edges are delicately handled, preferably with the skin hook. To manage small flaps and points of tissue, the Bishop-Harmon forceps may be utilized without crushing, but quite frankly do not serve as well in the practiced hand as the skin hook does for everting the skin margin. The Brown-Adson multiple toothed forceps are used for larger tissue handling. We are depending heavily on the deep closure to prevent separation and depending on the skin sutures only for refinements.

For angled lacerations with pointed flaps, we have continued to use the "corner" stitch for angles less than 80° to 90°. This suture is passed through the skin, comes out on the margin subcuticularly, across the point of the flap subcuticularly, and then subcuticularly passed to emerge through the skin close to the original insertion. Care should be taken that the two sutures through the skin surface are not too far apart, thus avoiding a wide stitch mark. For near right angled lacerations or obtuse angles, the suture is carried straight across, bisecting the angle.

Bites

Bites continue to be a significant source of facial trauma with over one million bites occurring annually from dogs alone; 70% of those seen in the pediatric population are on the face and neck. In addition to salivary contamination the open wound can collect further debris en route to the emergency room. The old saw that "dog bites are cleaner than human bites" cannot influence management.

Medical management must include tetanus, prophylaxis, rabies precautions, and wound infection prophylaxis or treatment, depending on the age of the wound at presentation. Wild animals should be considered rabid and if possible the brain of the biting animal should be examined for the presence of antibodies to rabies. If possible the patient should be treated with rabbit immune globulin and human diploid cell rabies vaccine (HDCV). If no HDCV is available, then duck embryo vaccine may be substituted. If the bite is from a nonimmunized domestic animal then the animal may be observed for 10 days. If no illness or unusual behavior is observed, no treatment is required.

Dog bites, which comprise the vast majority of bites, have infection rates as high as 29% and are generally secondary to *Pasteurella multocida.* This and other pathogenic canine flora usually respond to penicillin, the first-line drug for prophylaxis and treatment. Tetracycline may be a reasonable alternative in adults but should not be given to children. Instead, IV cefoxitin is recommended. Human bites have a higher rate of infection than do animal bites, usually secondary to anaerobic streptococci or *Eikenella corrodens.* Susceptibility and drug therapy are identical to that in animal bites. The wound itself must be thoroughly irrigated with massive saline solution and either a surgical prep solution or antibiotic solution. There is frequently further tissue damage from the crushing action of the injury and shearing forces create wound irregularities and fragmentation of the margins. Debridement should be minimal but devitalized, and shredded tissue should be removed, creating a better wound margin. Irregular margins can be utilized to effect a broken-line closure and reduce the need for unnecessary sacrifice of tissue. Simple lacerations may be closed directly and avulsion injuries may be repaired with local flaps or require a free skin graft. If there are great concerns, either all or part of the wound may be left open for drainage. Wounds clearly infected, or those greater than 12 hr old, should have delayed repair

awaiting a more favorable wound without infection. Further debridement may be necessary for this second closure.

Thermal Burns

The management of thermal burns is a subject in itself. In brief, there are three phases of burn care: (a) cleaning and debridement, (b) skin grafting, and (c) reconstruction. After supportive care is initiated, the wound is allowed to demarcate. Debridement is then performed, usually requiring a general anesthetic for children. Following debridement the wound is dressed with silver sulfadiazine until a healthy bed of noninfected granulation tissue appears. The appearance of this granulation tissue heralds the second phase, that of skin grafting. This usually occurs 10 to 20 days after the injuury. Medium thickness (0.014 to 0.018 mm) grafts are recommended to improve color match and minimize contraction. Once graft take is established, conforming splints or molds are placed to further minimize wound contracture and hypertrophic scars.

Generally 6 to 12 months after the injury the child is ready for reconstruction. The primary goals here are to restore function and cosmesis. The order of priorities when multiple procedures are involved is as follows: eyelid, perioral, neck, chin/cheek, then the remainder of the face. The ear requires some special consideration. Sulfamylon is used on the ear for its penetrating effect and in the effort to salvage all cartilage possible. Sulfamylon or silver sulfadiazine may be painful around the eues and here Polysporin ointment may be used. Polysporin may also be used on limited, superficial, partial-thickness burns. For the eyelids, early tarsorrhaphy should be considered, both to protect the globe and to prevent contracture with ectropia. On the nose, alar rim contracture is common and prevention may require early full-thickness skin grafts. Consideration should be given to plastic stents in the nostrils and ear canals. Extra care should be given to prevent erosion of the ala and columella by intranasal tubes. Septal perforations and the loss of the columella have occurred.

Contouring pressure dressings are strongly recommended. For the ear these dressings may need to be worn 1 to 2 years. Despite the inconvenience and question of compliance, these dressings are particularly important in children. Pressure garments and clear, molded plastic masks are sometimes used.

Tissue expansion has recently been shown to be a useful adjunct in head and neck burn injury reconstruction.

Electrical Burns

Electrical burns in infants and children are common and usually the result of placing an electrical wire in the mouth. Perhaps the most common site of injury is the lateral commissure. Initial treatment is supportive care, tetanus prophylaxis, and the administration of fluids and antibiotics as indicated. Arguments for primary debridement and reconstruction continue to be presented. In our observation, this has either led to greater debridement than later proved to be necessary or, after primary reconstruction, additional tissue loss, either at the surface or in the depths of the wound. We advocate the conservative approach of delayed eschar removal after demarcation has occurred to prevent the unnecessary removal of viable tissue. Oral splinting should be initiated early to prevent contracture; this alone may yield

surprisingly good results. After healing by secondary intention, reconstruction can be accurately planned, measurements can be made comparing the normal and abnormal sides, and then planned skin and mucous membrane flaps, grafts, or advancements can be carried out. The key to these procedures is overcorrection to compensate for postoperative wound contracture. Measurements from the midline to the commissure of the normal and abnormal sides are important in planning.

Postoperative Care

Support to the wound is vital in the child, again hoping to capitalize on the increased proliferation of fibroblasts in children, and prevention of wound spreading. Some form of sterile, elastic tension-reducing strips are recommended over a strip of Telfa after placing Polysporin ointment on the wound. Of late we have been using Suture Strips Plus (Genetic Laboratories), which have a desirable elastic quality. On top of this, for the primary dressing, pressure is applied extending from a "clinker" built, elliptical dressing to wraparound head and neck dressings, depending on the site of the injury. This is tival to prevent postoperative hematoma and to reduce the initial edema. These dressings must be changed frequently or, after the wound is inspected, it is possible to leave on the surgi-strips only for another 48 hr. Dressings are changed and the sutures removed on the 3rd and 5th days. Support remains on the wound with antibiotic ointment and telfa for 1 week and after this, surgi-strips alone may be used for another 3 weeks. The parents must be instructed to remove the surgi-strips from each end of the tape toward the laceration to prevent separating or widening the wound.

The good academic reasoning for not using antibiotics in the sterile wound are sound. However, from the practical standpoint, most lacerations are contaminated or potentially contamined no matter what the degree of care and delicate closure of the wound, so all can be lost if infection occurs. Several generations of antibiotics now exist and can be specific for particular bacteria. Initial treatment is usually empirical unless suppuration exists and cultures can be taken. Generally a broad-spectrum antibiotic, either Keflex or ampicillin, is used. If an intravenous line is established a bolus of antibiotics is given IV intraoperative and oral antibiotics are administered for at least an additional 72 hr. Dosage is dependent upon the age and weight of the patient. Tetanus injection depends on the inoculation history of the child.

Despite a large number of skin flora present, only *Staphylococcus aureus* and *Streptococcus pyogenes* have significant potential for infection. Appropriate antibiotics, especially after culture, may include nafcillin, methicillin, cefazolin, cloxacillin, cephalexin, or trimethoprim/sulfamethoxazole. As *Pseudomonas* is frequently present in the external auditory canal one should consider coverage of this organism when the canal is traumatized and infection is present or likely. Appropriate antibiotics include aminoglycosides or ceftazidime, which are given intravenously. Although ciprofloxacin would be an appropriate oral antibiotic, its safety and effectiveness in children and adolescents under 18 has not yet been established.

In regard to tetanus, the *Clostridium tetani,* the anaerobic gram positive, spore-forming bacilli is antibiotic resistant and extremely resistant to antiseptics. They generally live in the necrotic tissue, making adequate wound debridement imperative. Proper immunization at this point depends on the inoculation history of the patient.

Most surgeons use some form of antibiotic ointment or cream on their surgical dressings. For the dressing we prefer a fine mesh gauze impregnated with the antibiotic, or telfa placed over the wound, which is lightly covered with the antibiotic.

There is a greater argument for not using antibiotics in the clean, secondary revision; however, we would leave this decision up to the reasoning and personal security or insecurity of the surgeon in that all precise revisions can be marred with either infection or hematoma.

Complications

Minor complications are the tendency in the child for spreading of the scar and visible suture marks. Major complications, such as poor healing due to inanition as a result of multiple injuries, severe infection with potential bacteriemia, and allergic reactions leading to anaphylactic shock, require close attention in consultation with the appropriate specialist.

Infections and hematoma are intermediate in severity and everything possible should be done to prevent them. Thus, we have regularly used antibiotics, as discussed, above, and advocate meticulous hemostasis. A drain is most often not necessary but should one be indicated later it is applied. In the acute wound, only interrupted sutures are used so that only the necessary number may be removed to establish drainage without disrupting the entire wound, as would be necessary with a continuous suture.

In scar revision, wherever possible, we like the continuous subcuticular suture but do not advise this for the acute injury. A simple way to later combine removal of stitch marks with the broken-line repair or "W-plasty" is shown. Note the stepped closure and the need to remove a triangle of skin at each end of the excision to compensate. For revisions the soft tissue techniques described, are carried out after 6 months or preferably 1 year. Waiting until older childhood years or young adults years may be advisable, depending on the child's cooperation balanced with the psychic trauma and disfugurement may create. This requires judgment tempered by wisdom coordinating not only the maturity of the wound but the cooperation of the child and parents, along with the parents' anxiety and concern.

Hypertriophic scars stay within the margins of the original wound and tend to soften or clear. Keloids, on the other hand, proliferate beyond the original wound and increase with time. Keloids may be symptomatic with itching and burning, which may be difficult to control in the child and may add to the increased tissue reaction from scratching, leading to more severe keloid formation.

Keloid management has been addressed elsewhere by the senior author. Besides meticulous handling of the closure, one should stimulate as little as possible new tissue reaction outside the lesion into the normal tissue. Intralesional injection and intralesional excision are therefore in order. Kenalog injection and pressure dressings are chief additions to management. Topical steroids may help with itching and in a minor way assist in preventing buildup. After one's own second failure or recurrence, strong consideration should be given to systemic steroids, in addition to the above, and low-dose radiation therapy starting immediately after wound closure. We are more and more aggressive with initiating injections as soon as there is any hint of increased reaction in the healing wound.

Summary

This chapter has attempted to give the reader a practical approach to the management of soft tissue injuries in children. Some technical expertise is vital to the proper management of these wounds. Meticulous attention to detail, starting with the emergency consultation, can prevent unnecessary loss or disturbance of tissue and avoid the need for secondary reconstruction and a second operation for the child.

An attempt has been made to address aspects of the subject peculiar to children. In our times severe injury occurs at any age but statistically, if one includes teenagers, the frequency and severity increases as the child enters the teens. Often there is too much, and too early, personality expression with high-powered vehicles, as the teenager needs to observe his rite of passage.

Soft tissue trauma in children requires early wound management as well as the overall handling of the injured and frightened child and perhaps, no less important, the concerned, anxious, and sometimes angry parent. The objective is the prevention of immediate complications and long-term disfigurement. One should document the severity of the injury with photographs. Because of the visibility of the face and the importance to the growing child's self image, considerable attention should be given to this aspect of the injury, to the preparation of the parents for the healing period, and to the possibility of secondary revisions.

From the beginning maximum attention should be given to the primary repair with the exploration and preparation of the skin margins and meticulous layer closure. Most secondary repairs should not be carried out before 6 months and often a 1-year waiting period is preferable. With time, anticipated secondary repair may become unnecessary. There is no need to wait until adulthood to repair these secondary scars, which carry considerable psychological implications; however, there is the practical aspect of waiting until the child is able to cooperate and has been adequately prepared by the physician, his staff, and the parents.

The general considerations, surgical techniques, and management are similar for children and adults, requiring the whole spectrum of scar prevention and reconstruction. As a rule, with a child it is probably better to do the simplest repair possible at the time of the injury and reserve complicated scar camouflage techniques, Z-plasties, and regional flaps for the secondary repair.