PEDIATRIC FRACTURES

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INTRODUCTION

The largest pediatric trauma study to date was presented by Landin in 1983. He reviewed 8,682 pediatric fractures over a 30 year period in Malmo, Sweden. After a thorough analysis of the patients in this impressive study, he presented statistical data correlating a variety of patient parameters with the injury patterns. Fractures of the tibia and ankle each accounted for 5% of all cases reviewed, and fractures of the foot accounted for 8% of these patients. Sixty-three percent of these fractures occurred in the male population.

On a smaller scale, the records of the authors' exposure to podiatric emergency room cases have also been reviewed over the past two years. Over 90% of the foot and ankle trauma presenting to the emergency room at Northlake Regional Medical Center, Tucker, Georgia, is referred to the podiatry service. Pediatric injuries accounted for roughly 18% (129/713) of the patient population. A breakdown of injury patterns is presented in Table 1.

Although the pediatric population is small, there are some general statements which can be made from this data. Similar to Landin's study, the majority (57%) of the patient population were males. Fractures accounted for greater than 25% of the recorded cases, with ankle trauma representing 44% of these cases. As expected, 90% of ankle injuries occurred during sporting events.

PEDIATRIC FRACTURES

The familiar adage "Children are not small adults" is especially true when dealing with trauma in this patient population. The major difference between pediatric and adult fractures is the presence of growth plates (physis). These plates have the consistency of rubber, and act as a shock absorber in long bones. The growth plates, which consist primarily of cartilage, separate the epiphysis from the more cancellous metaphyseal region. Due to the fragile nature of cartilage, this structure is

Table 1

Two year review of pediatric emergency room visits, Northlake Regional Medical Center, Tucker, Georgia.

INJURY	MALE	FEMALE	TOTAL
Fractures			
Ankle	10	6	16
Metatarsals	4	2	6
Calcaneus	2	1	3
Talus	0	3	3
Hallux	2	1	3
Lesser Digits	0	2	2
Tibial	1	1	2
Lateral Ankle Injuries	22	18	40
Lacerations	13	5	18
Puncture Wounds	7	4	11
Contusions	6	9	15
Nail Pathology	2	1	3
Heel Pain	3	0	3
Post-op Complications	2	0	2
Tarsal Coalitions	0	1	1
	74	55	129

Figure 1A. Multiple metatarsal fractures seen in a 2 year old patient. Note the classical "greenstick" appearance of the second metatarsal.

Figure 1B. Satisfactory alignment of the patient in Figure 1A following closed reduction.

more susceptible to injury than the stronger surrounding soft tissues (i.e. ligaments, joint capsule). In fact, bone in a child is also weaker than soft tissues. The classic terms of "greenstick" and "torus" fractures occur due to the elastic property of young bone. (Figure 1A) The periosteum of a child, which is significantly thicker than in an adult, possesses great strength and a more active osteogenic potential. Due to this fact, the periosteal tissue provides an excellent soft tissue hinge to facilitate closed reduction of pediatric fractures. (Figure 1B)

In the initial evaluation of pediatric trauma, radiographic examination is essential to rule out physeal injuries. Often, physicians will spend time studying x-rays in an attempt to decide what is normal versus abnormal. Contralateral views are often necessary to help answer these questions, and should be used with prudence in these situations.

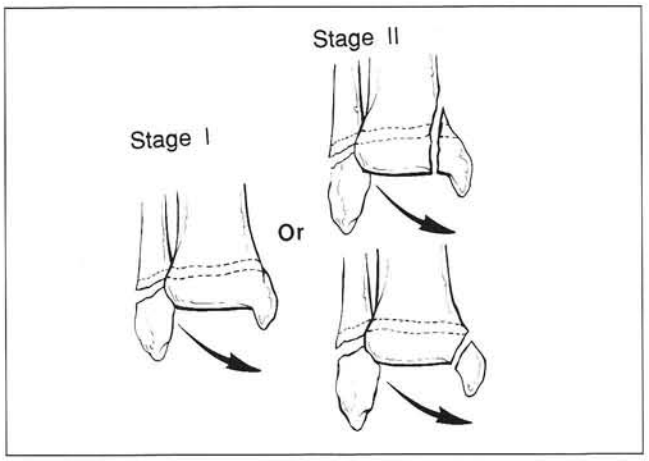
FRACTURE CLASSIFICATION

The classification of pediatric fractures has generally been adapted and modified from established adult fracture classifications. Salter and Harris, in 1963, introduced a classification system for physeal injuries that applies to any physeal region of a long bone. Their classification provides an anatomic description of pediatric fractures, and is separated into five unique patterns.

The Salter-Harris system, however, does not relate the classification to the mechanism of injury, and therefore does not assist in the understanding of fracture-reduction techniques. Ogden presented two additional injury patterns to the traditional Salter-Harris classification, and at present, seven injury patterns are accepted.

Since 1960, Lauge-Hansen has been the most widely accepted and utilized adult ankle fracture classification system. This system correlates the position of the foot with the mechanism of injury. In 1976, Dias and Tachdjian introduced a new pediatric classification for ankle fractures consisting of four patterns. This classification system provides both an anatomic description of injury pattern as well as the mechanism of action, and correlates the Salter-Harris patterns with Lauge-Hansen's original descriptions. (Figures 2A-D, 3)

A golden rule to remember when treating children is "children do not sustain sprain injuries." The presentation of lateral ankle injury will commonly mimic a Grade I/II ankle sprain. The distal fibular physis does not usually ossify until 18-20 years of age, and until this time, the growth plate will fail prior to a ligamentous injury. Although generalized edema and pain can



Figures 2 A-D. Dias-Tachdjian classification of pediatric ankle fractures. **A.** Supination-inversion.

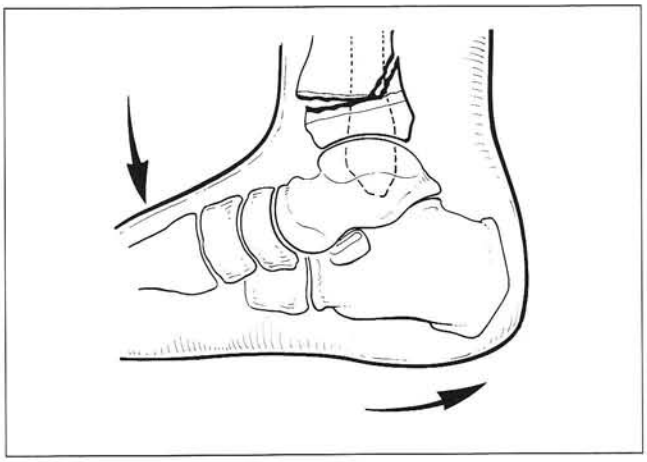


Figure 2B. Supination-plantar flexion.

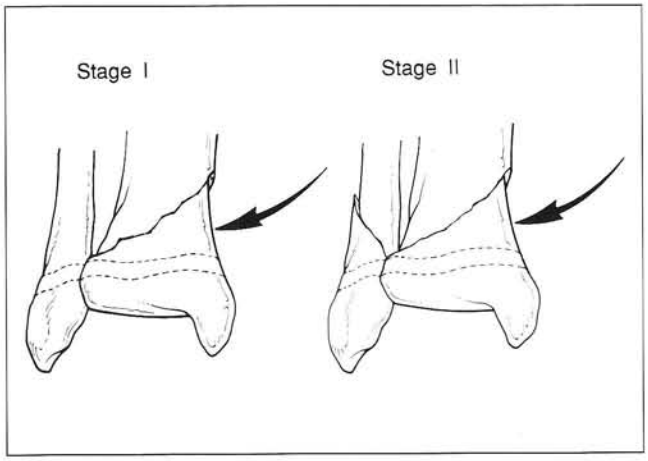


Figure 2C. Supination-external rotation.

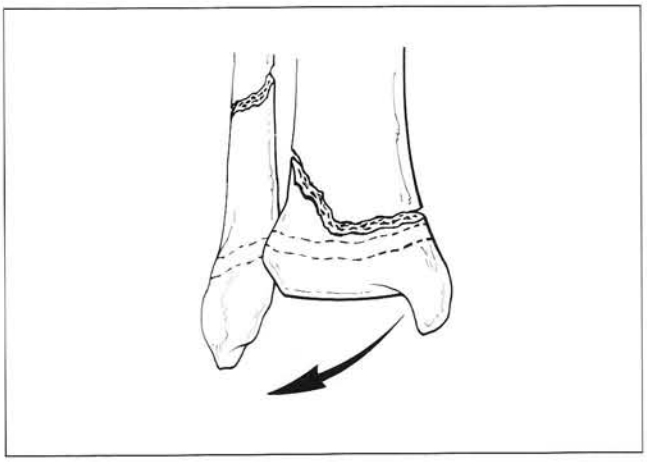


Figure 2D. Pronation-eversion.

potentially mask an accurate diagnosis, these are commonly Salter-Harris I injuries, and not ligamentous injuries. This is confirmed by direct palpation on the distal fibula.

JUVENILE TILLAUX AND TRIPLANE FRACTURES

Two other interesting pediatric fractures are occasionally encountered, and have been described in the literature - the Juvenile Tillaux fracture (Salter-Harris III), and the Triplane fracture. The distal tibial physis consists of three separate ossification sites. At the age of 13 to 15 in females and 15 to 17 in males, this physis closes asymmetrically over a period of 18 months. The middle portion is the first to ossify, followed by the medial side, and finally the lateral side. Injury during this 18-month period, particularly external rotation of the foot within the ankle mortise, can result in these isolated fracture patterns.

The Juvenile Tillaux fracture occurs after the middle and medial centers have fused, which leaves the insertion of the anterior inferior tibiofibular ligament on the tibia vulnerable to an avulsion force. The triplane fracture can involve several tibial fragments, depending on the timing of ossification in relation to the injury. If only the middle portion of the distal physis has fused, then an external rotation injury can result in 3 to 4 fracture fragments involving the medial and lateral centers. After ossification of the medial center, this will only involve two separate fragments.

Figure 3. Pronation-eversion ankle fracture in a 12-year-old patient, as classified by Dias-Tachdjian.

Figure 4A. Triplane fracture in a 14-year-old patient. Note the Salter-Harris III pattern on the DP projection, and the Salter-Harris II pattern on the lateral projection.

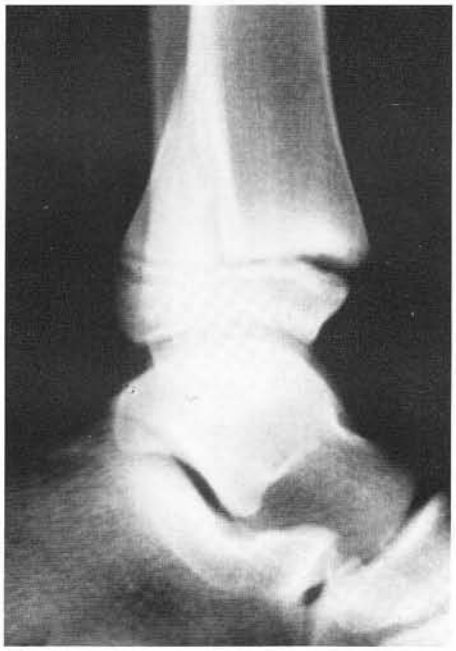


Figure 4B.

The triplane fracture is actually a Salter-Harris IV injury, however, it resembles a Salter-Harris II on lateral projection x-rays, and a Salter-Harris III on the DP projection. (Figures 4A, 4B) Banks proposed that closed reduction of this injury is the treatment of choice, unless significant malalignment persists after attempted reduction. Growth arrest after this type of injury is usually inconsequential, as the physis is already in the process of ossification.

FRACTURE MANAGEMENT

Pediatric fractures can be treated with either open or closed methods. Anatomic reduction of the physeal plates and articular surfaces is paramount to avoid growth arrest and degenerative joint disease. The mechanism for growth arrest was presented initially by Salter and Harris in laboratory animals. Fractures causing a gap across the growth plate actually fill in with bone during healing, fusing the metaphysis and epiphysis together.

Spiegel, in a review of 237 tibial fractures, stated that a physical gap of greater than 2 mm within a growth plate after closed reduction necessitates ORIF. In a retrospective study, Kling reported that 85% of the patients with this type of injury exhibited growth arrest due to inappropriate treatment with only closed reduction. In open reduction of these fractures, care should be taken to avoid the growth plate. Internal fixation should be confined to either the epiphyseal or metaphyseal regions, without traversing the physis. When the physis cannot be avoided, only smooth

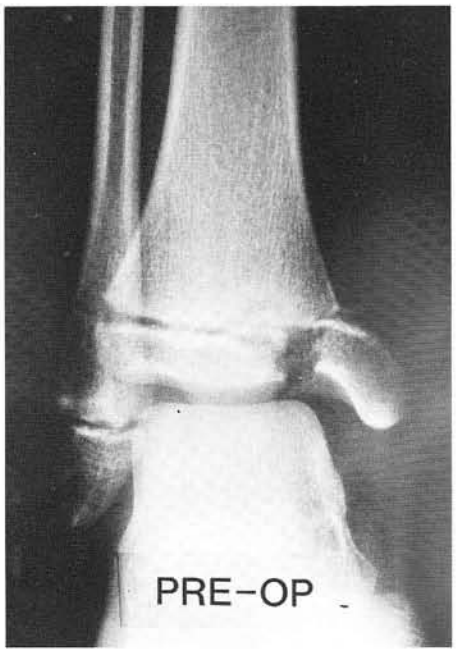
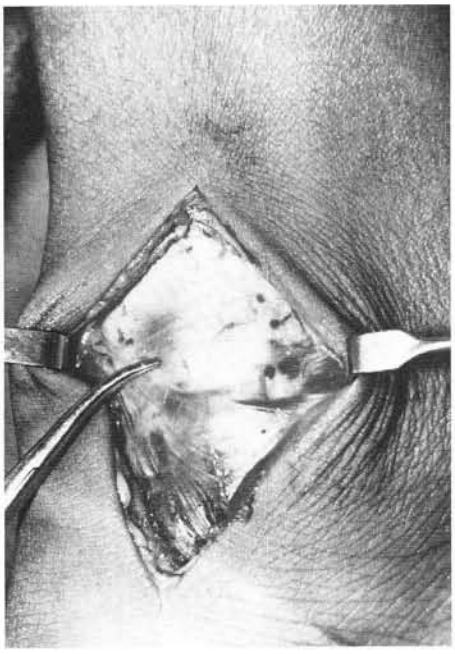


Figure 5A. Salter-Harris III injury in an 11-year-old patient, classified as a Supination-Inversion injury (Dias-Tachdjian). This patient was taken for ORIF.



Figures 5B, 5C. Exposure of the deep fascia reveals the epiphyseal plate (grayish ring) and fracture site.

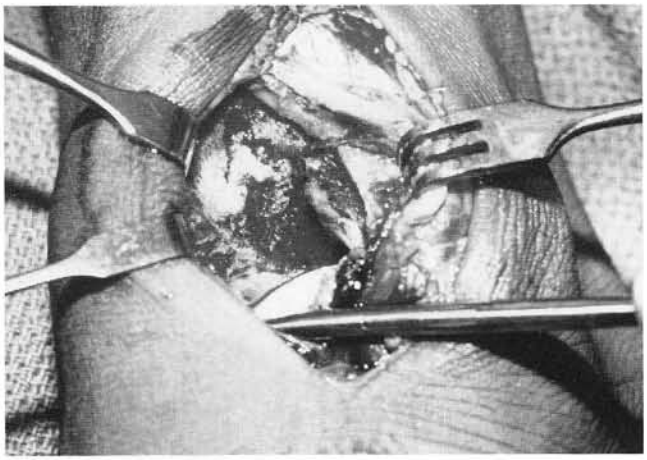


Figure 5C.

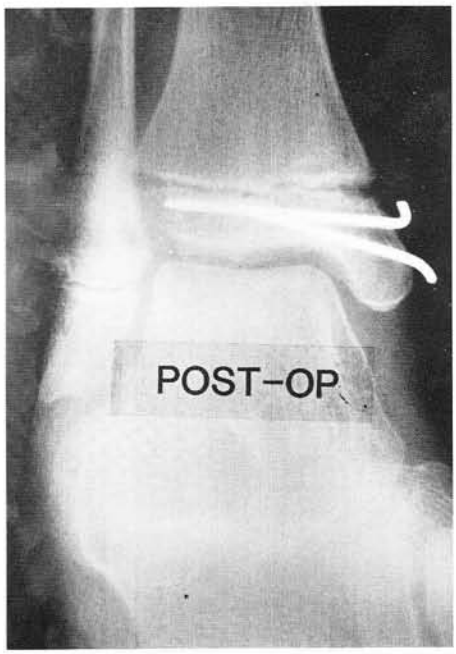


Figure 5D. Satisfactory reduction with crossed K-wires within the epiphysis.

Kirschner wires should be used to stabilize these injuries. (Figures 5A-D)

Although it is commonly stressed that children are resilient and heal much better than adults, caution must be taken when dealing with growth plate injuries. Growth arrest is much more dramatic and debilitating in younger children, and these injuries must be treated carefully. Follow-up of physeal injuries should be maintained for at least two years. If possible, communication with

the patient until skeletal maturity is reached is ideal, allowing the physician to monitor growth and initiate further treatment if necessary.

SOFT TISSUE TRAUMA

Evaluation and treatment of lacerations and puncture wounds is often a frightening experience for children, and can prove to be frustrating to the physician. Often, these wounds need to be explored, debrided, and occasionally sutured. When possible, Steri-strips should be utilized for skin closure in children if functional healing is not compromised. (Figure 6)

Figure 6. Removal of a glass fragment from the plantar heel of a two-year-old patient (36 lbs) with the use of 15 mgs of Versed for oral sedation.

Appropriate and timely treatment of these patients is commonly facilitated with the use of oral sedation. The authors' sedative agent of choice is Midazolam (Versed), administered 0.5-1.0 mg/kg. After dilution in a juice or a carbonated beverage, this form of sedation is well-tolerated. The onset of action is usually between 10-20 minutes, at which time the patient's respiratory function should be monitored.

CHILD ABUSE

In some unfortunate situations, children will present to an office or emergency room having sustained trauma which is out of proportion to the given history. Unfortunately, child abuse is prevalent within any population, and will occasionally present to a podiatrist for medical treatment. Last year, 2.7 million children were reported as abused or neglected in the United States alone. If multiple injuries are present in young children (<3 yrs.), or appear to be in different stages of healing, child abuse should be suspected. Physicians suspicious of these situations are legally obligated to report these findings to the Department of Social Services. These reports are protected by the Good Samaritan Act, and will not only serve to protect the physician requesting further investigation, but will ultimately serve to protect these children which are subject to abuse.

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