Ankle fractures in children are the third most common fracture involving the growth plate after finger and distal radial physeal fractures. The ligamentous anatomy and the complex progression of physeal closure in the distal tibial and fibular physes predispose children to age-specific patterns of ankle fractures.

**Epidemiology**

Peterson et al. reported that distal tibial physeal fractures represented 11% (104) of all 951 physeal injuries seen during a ten-year period. Children are at risk for physeal ankle injury in sports requiring sudden changes in direction, such as basketball, soccer, and football. Scooters and skateboards are also associated with a high risk of ankle injuries.

There is evidence to support a higher risk of athletic injuries in obese children. Body mass index (BMI) is an important risk factor for ankle sprain in high-school football players. Zonfrillo et al. conducted a case control study, including 180 children with nonspecified ankle injuries and 180 control subjects, and found a significant (p < 0.0001) association between overweight children (a BMI percentile of ≥95) and ankle injury.

**Anatomy**

The ankle is a hinge-type joint that is formed from the articulation of the talus with the distal ends of the tibia and fibula. The distal tibial ossification center appears at six to twenty-four months of age. The distal tibial physis closes during an eighteen-month period centrally, then medially, and finally laterally with closure complete at the chronologic age of fifteen years in girls and seventeen years in boys. Growth in the distal tibial physis contributes 40% of tibial length or approximately 3 to 4 mm/yr. There is minimal longitudinal growth from the distal end of the tibia after the age of twelve years in girls and fourteen years in boys.

The distal fibular ossification center appears at nine to twenty-four months of age, and the distal fibular physis closes approximately one to two years following the distal tibial physis. It is important to remember that the fibular growth plate should be at the same level as the ankle joint on antero-posterior radiographs.

Accessory ossicles may mimic a fracture on radiographs (Fig. 1). The os subtibiale is an accessory ossification center of the medial malleolus present in 0.9% to 20% of individuals.
and the os subfibulare, an accessory ossification center of the fibula, is present in 2.1% of individuals. When a child’s ankle is injured, the classic teaching is that the weaker physis usually fails prior to the stronger ligamentous complex; however, ligamentous injury may be more common than previously reported. When subjected to rotational forces, the anterior inferior tibiofibular ligament and the posterior inferior tibiofibular ligament may lead to an avulsion fracture (Fig. 2). When the distal tibial physis is open, these injuries generally result in Salter-Harris type-I or II injuries, but as the physis closes from central medial to anterolateral at puberty, transitional fracture patterns emerge as ligaments avulse bone adjacent to the remaining open physis.

Evaluation

History and Physical Examination
A complete history and physical examination are critical in diagnosing physeal ankle injuries. High-energy injuries, such as motor vehicle accidents, should raise concern for a possible physeal crush injury that may not be evident on initial radiographs.

The physical examination should include the entire lower extremity as there are reports of physeal injuries and premature physeal closure with ipsilateral tibial diaphyseal fractures. In patients with an obvious deformity, the foot position will indicate the direction of the deforming force and this knowledge assists in fracture reduction. Swelling, ecchymosis, and skin tenting are assessed, and the ankle must be visualized circumferentially to exclude a possible open fracture. Urgent reduction is required when the soft-tissue envelope is in jeopardy secondary to excessive skin tenting. The vascular, motor, and sensory examination should be performed prior to and following any reduction maneuver.

Imaging

Anteroposterior, mortise, and lateral radiographs are required to fully evaluate the ankle. The mortise radiograph is particularly important to evaluate fractures without obvious deformity as the tibiofibular overlap might disguise a minimally displaced fracture. The routine use of stress views is not recommended as they are unlikely to change the treatment, are uncomfortable, and cause increased radiation exposure.

Advanced imaging is recommended for accurate diagnosis, preoperative planning, and assessment of reduction for intra-articular fractures. Horn et al. compared computed tomography (CT) scans with radiographs in a cadaver model of juvenile Tillaux fractures. They reported that CT scans and radiographs are accurate to within 1 mm 50% of the time, but
CT scans are more sensitive at detecting fractures displaced >2 mm. CT scans also improve the surgeon’s ability to accurately plan screw placement for the treatment of triplane fractures.

Magnetic resonance imaging (MRI) provides fine detail of bones and soft-tissue structures and does not involve radiation. Carey et al. compared radiographs and MRI scans for fourteen patients with suspected physeal injuries. They reported that the MRI scans led to a change in the Salter-Harris classification for two of the nine patients with fractures seen on radiographs, and they identified radiographically occult fractures, which changed the management in five of fourteen patients. In contrast, Petit et al. compared radiographs with MRIs for twenty-nine patients with physeal ankle injuries. Only one patient was misclassified with radiographs, and there were no changes in the treatment plans because of the MRI scans. Lohman et al. studied sixty children with acute ankle injuries with both conventional radiography and MRI. Radiographs produced five (18%) of twenty-eight false negatives for fractures compared with MRI, but no complex ankle fracture was missed and the MRI did not change the treatment plan in any case.

Radiography is the imaging standard for pediatric ankle fractures. The role of MRI remains unclear, but it may be useful to identify occult fractures, assess for premature physeal closure, or identify sources of persistent pain after fractures have healed.

Classification

Pediatric ankle fractures are classified by either the mechanism of injury or anatomic classification schemes. The Salter-Harris classification system is simple and reproducible, and it remains the most widely used system for children’s ankle fractures. The fracture is classified according to its relationship to the physeal (Fig. 3). Type VI involves open injuries with physeal loss and has been added to the original Salter-Harris classification system. The Dias-Tachdjian (Fig. 3) mechanism of injury classification is based on the foot position at the time of injury and the direction of the force. This classification system is useful to facilitate fracture reduction.

Triplane ankle fractures are transitional fractures that occur toward the end of growth and are not easily classifiable with the Salter-Harris or Dias-Tachdjian systems. The classic triplane fracture consists of three parts: a rectangular fragment of distal tibial epiphysis, a large fragment that includes the remainder of the epiphysis with a metaphyseal spike, and the tibial shaft. Two, three, and four-part triplane fractures have been described (Fig. 4). Shin et al. described intra-articular and extra-articular intramalleolar variants of the triplane fracture (Fig. 5).

The juvenile Tillaux fracture is also a transitional fracture. The anterolateral distal tibial physeal is the last portion of the distal tibial growth plate to close, and the anterior inferior tibiofibular ligament produces an avulsion of an epiphyseal fragment during an external rotational injury.

Treatment

The decision to treat pediatric ankle fractures is based on the fracture type, amount of displacement, and the ability to restore and maintain the alignment of the physeal and the congruity of the ankle joint. If a satisfactory closed reduction can be achieved and maintained, internal fixation is unnecessary; however, if closed reduction is unsuccessful, open reduction with or without skeletal fixation is warranted.

Before a closed reduction is attempted, the child must be comfortable and relaxed with either intravenous sedation or...
general anesthesia to facilitate the reduction and reduce the risk of further physeal injury. Ideally, the reduction should be achieved in one attempt, but Barmada et al. could find no evidence to support the concept that multiple reduction attempts caused a physeal injury⁶⁰. Leary et al. found a trend of increased primary physeal closure with more reduction attempts, but the difference was not significant⁶¹.

**Distal Tibial Salter-Harris Type-I Fractures**

Spiegel et al. reported that Salter-Harris type-I distal tibial fractures represented 15.2% (thirty-six) of all 237 ankle fractures in the children in their study who had a mean age of 10.5 years⁶², whereas Leary et al. reported only a rate of 3% (four of 124 fractures)⁶³. In children, distal tibial physeal fractures are rarely severely displaced without a concomitant fibular fracture.

We recommend immobilization in a below-the-knee cast, or a walking boot, for three weeks as it is an effective treatment for minimally displaced Salter-Harris type-I distal tibial fractures. If there is concern about patient compliance or if the fracture is unstable, an above-the-knee cast may be preferable.

Displaced Salter-Harris type-I fractures should have closed reduction with immobilization in a below-the-knee cast. Radiographic follow-up is recommended in the first week following injury to ensure that there is no recurrent displacement. We have found that patients may be transitioned to a walking cast or boot at three to four weeks.

**Distal Tibial Salter-Harris Type-II Fractures**

Spiegel et al. reported that Salter-Harris type-II distal tibial fractures were the most common, comprising 38% (ninety-one) of all 237 pediatric ankle fractures in their study⁶⁴. Leary et al. found type-II fractures in 32% (forty) of 124 pediatric ankle fractures⁶⁵.

A nondisplaced Salter-Harris type-II distal tibial fracture may be immobilized in a short or long leg cast for three to four weeks, followed by weight-bearing in a cast or walking boot for two to three weeks. Patients with Salter-Harris type-II fractures should be evaluated clinically and radiographically for a possible rotational deformity. Phan et al. reported that fourteen (61%) of twenty-three patients had external tibial rotation deformities after their distal tibial physeal fractures healed⁶⁶.

There is controversy as to what represents an acceptable reduction for displaced Salter-Harris type-II fractures. Spiegel et al. reported that older children (an average chronologic age of twelve years and seven months) sustaining type-II fractures were unable to remodel angular abnormalities⁶⁷. Six (9%) of sixty-six patients with adequate follow-up examinations had angular deformities of >5°. The inability to anatomically reduce Salter-Harris type-I and II distal tibial fractures is often caused by interposed soft tissue, particularly the peristeum. Grace described three patients in whom the anterior tibial neurovascular bundle interposition blocked closed reduction of Salter-Harris type-II distal tibial fractures⁶⁸.

Barmada et al., in a study of forty-four patients with Salter-Harris type-I and II distal tibial fractures, noted that premature physeal closure occurred in 60% (twelve) of twenty fractures with >3 mm of physeal widening after closed reduction and in 17% (four) of twenty-four fractures with <3 mm of physeal widening after reduction⁶⁹. The authors suggested that...
the removal of interposed periosteum to close the physeal gap may reduce premature physeal closure.

Phieffer et al. used a rat model to determine the effect of interposed periosteum on physeal bar formation and leg-length discrepancy. They reported a small but significant (p < 0.05) leg-length discrepancy in a physeal fracture group with interposed periosteum compared with a group of fractures without interposed periosteum. It is unclear whether this has clinical importance.

Rohmiller et al. reviewed ninety-one type-I and II fractures to determine if the mechanism of injury was related to premature physeal closure. The overall rate of premature physeal closure was 39.6% (thirty-six of ninety-one), and patients who developed premature physeal closure had greater residual displacement (mean and standard deviation, 3.2 ± 2 mm) following treatment than those who did not (mean, 2 ± 1.5 mm) (p = 0.007). The treatment types were compared, and open reduction

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**Fig. 4**

**Figs. 4-A through 4-G** Triplane fractures. **Fig. 4-A** Two-part fracture with the medial malleolus attached to a large metaphyseal spike. **Fig. 4-B** Two-part fracture with the medial malleolus attached to the shaft fragment. **Fig. 4-C** Three-part fracture with the epiphysis completely detached from the shaft, and the medial malleolus on the large metaphyseal spike. **Fig. 4-D** Three-part fracture with a completely detached medial malleolus. **Fig. 4-E** Three-part fracture with the medial malleolus attached to the shaft fragment, and a separate anterolateral epiphyseal free fragment. **Fig. 4-F** Rare four-part so-called quadriplane variant with a double metaphyseal spike as described by van Laarhoven and van der Werken. **Fig. 4-G** Four-part fracture with free medial malleolus and anterolateral epiphyseal fragments.
Fig. 5-A, 5-B, and 5-C Intramalleolar triplane fracture variants as described by Shin et al.\textsuperscript{34}. Fig. 5-A Intra-articular fracture exiting at the junction of the plafond and medial malleolus. Fig. 5-B Intra-articular fracture exiting in the articular portion of the medial malleolus. Fig. 5-C Extra-articular fracture.

resulted in the lowest residual displacement (mean, 1.8 ± 1.3 mm), but this was not significant ($p = 0.39$). The authors advocated for operative treatment for fractures with $>2$ mm of displacement to remove interposed periostem.

Leary et al. reported premature physeal closure in 25% (ten) of forty type-II fractures\textsuperscript{37}. They noted no premature physeal closure with Salter-Harris type-I fractures. They concluded that Salter-Harris type-II fractures of the distal end of the tibia are more serious than previously believed as they may cause premature physeal closure leading to angular deformities and limb-length discrepancies. There is little evidence to support routine open treatment to remove interposed periostem in fractures displaced <3 mm following reduction; however, the rate of premature physeal closure in fractures displaced >2 to 3 mm is as high as 60% and warrants consideration for open treatment to remove interposed soft tissue.

**Distal Tibial Salter-Harris Type-III and IV Fractures**

Type-III and IV distal tibial fractures are problematic as both articular incongruity and premature physeal closure must be considered\textsuperscript{37}. Spiegel et al. reported that forty-six of fifty-two of these fractures occurred on the medial side of the tibial plafond\textsuperscript{3}. The mean age of the children was eleven years and ten months for those with a type-III fracture and eleven years and six months for those with a type-IV fracture, whereas Kling et al. reported that Salter-Harris type-III fractures occurred in children between eight and ten years old\textsuperscript{42}.

Type-III and IV fractures result from supination inversion injuries, which are similar to Lauge-Hansen supination adduction injuries in adults\textsuperscript{38,43}. A study by de Sanctis et al. suggested that the physeal compression occurring during Salter-Harris type-III and IV fractures might also result in concomitant type-V injury to the proliferative layer of the phys\textsuperscript{44}. Schurz et al. reported that the adduction mechanism of injury causing Salter-Harris type-III and IV injuries caused greater physeal damage than the abduction and distraction forces that result in type-II and III fractures\textsuperscript{45}.

Nonoperative treatment is reserved for nondisplaced Salter-Harris type-III and IV distal tibial fractures. A short leg cast is recommended, and careful radiographic surveillance is necessary in the first weeks following injury. Kling et al. recommended radiographic follow-up for at least two years after injury, but preferably until the patient is skeletally mature\textsuperscript{42}.

There is consensus that displaced Salter-Harris type-III and IV fractures should be treated with open reduction and internal fixation\textsuperscript{36,44,46}. Salter and Harris recommended “accurate” and “perfect” reductions for type-III and IV fractures, respectively\textsuperscript{27}. Kling et al. found that patients treated with anatomic open reduction and internal fixation were less likely to have premature physeal closure than those treated by closed means ($p = 0.027$)\textsuperscript{44}. Leary et al. treated fractures with $>2$ mm of displacement with open reduction and reported a premature physeal closure rate for Salter-Harris type-III and IV fracture of only 13%\textsuperscript{42}.

Cottalorda et al. reviewed the cases of forty-eight patients with Salter-Harris type-II (thirty) or type-IV (eighteen) distal tibial fractures\textsuperscript{47}. All fractures were displaced >1 mm, meeting their operative indications, and were treated with open arthroscopy and fracture reduction under direct visualization with screw (forty-six) or pin (two) fixation. They reported forty-five good and two fair results, and only one patient with angular deformity (6° of varus) at a mean follow-up of 3.25 years. Schurz et al. advocated for open reduction in all displaced epiphyseal fractures regardless of age\textsuperscript{46}. Their study found good outcomes in 89% (seventy-three) of eighty-two patients with type-III and IV fractures. There is not clear scientific evidence for what represents an acceptable reduction in pediatric intra-articular ankle fractures. The commonly accepted “2-mm rule” is not based on clinical or experimental evidence, yet several studies have demonstrated good results with operative treatment\textsuperscript{42,44,45,46,47,48}.

**Salter-Harris Type-V Fractures**

These injuries involve axial or shear loading that damages the proliferative zone of the phys\textsuperscript{47}. Several studies have noted that undiagnosed Salter-Harris type-V injuries may contribute to the high rate of growth disturbance associated with type-III and IV fractures\textsuperscript{44,45}. No specified treatment algorithm exists for these injuries. Radiographic follow-up is beneficial for any patient with major axial or shear force to the ankle, despite initially normal radiographic findings.
**TABLE I Recommendations for Care**

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Grade</th>
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<tbody>
<tr>
<td>Nondisplaced ankle fractures in children are effectively treated with cast immobilization for three to six weeks.</td>
<td>B</td>
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<tr>
<td>To prevent iatrogenic physeal injury, no more than two closed reduction attempts should be performed.</td>
<td>C</td>
</tr>
<tr>
<td>All pediatric ankle fractures should be followed for one year to assess for growth disturbance. This is also true for any child with a severe axial load (even with normal findings on radiographs) that is concerning for a Salter-Harris type-V physeal injury.</td>
<td>B</td>
</tr>
<tr>
<td>Surgeons should remove interposed periosteum in a Salter-Harris type-II distal tibial fracture when 3 mm of physeal widening is evident after reduction.</td>
<td>B</td>
</tr>
<tr>
<td>Nonoperative treatment should be reserved for completely nondisplaced or stable, anatomically reduced Salter-Harris type-III and IV fractures.</td>
<td>B</td>
</tr>
<tr>
<td>Two millimeters is the acceptable amount of residual articular step-off in pediatric distal tibial fractures.</td>
<td>C</td>
</tr>
<tr>
<td>Children less than fourteen years old should not operate a lawnmower or be present in a yard where a lawnmower is in operation.</td>
<td>B</td>
</tr>
<tr>
<td>Triplane fractures with &gt;3 mm of initial displacement or &gt;2 mm of residual articular step-off should undergo open reduction and internal fixation.</td>
<td>C</td>
</tr>
<tr>
<td>Bioabsorbable fixation is a safe alternative to metallic implants for some pediatric ankle fractures.</td>
<td>C</td>
</tr>
<tr>
<td>Arthroscopy is useful in assessing articular reduction when transitional ankle fractures are treated operatively.</td>
<td>C</td>
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</tbody>
</table>

*Grade A indicates good evidence (Level-I studies with consistent findings) for or against recommending the intervention; Grade B, fair evidence (Level-II or III studies with consistent findings) for or against recommending the intervention; Grade C, conflicting or poor-quality evidence (Level-IV or V studies) not allowing a recommendation for or against the intervention; and Grade I, there is insufficient evidence to make a recommendation.

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**Salter-Harris Type-VI Distal Tibial Fractures**

Lawnmower injuries account for many pediatric open ankle fractures and may cause Salter-Harris type-VI fractures. Approximately 600 of these preventable injuries occur yearly, and most involve riding lawnmowers. The mower blades may cause massive soft-tissue trauma and may remove a portion of the physis. Loder et al. reviewed 114 lawnmower injuries in children and reported eighty-seven unsatisfactory results at an average follow-up interval of 1.9 years. They concluded that children who are less than fourteen years old should not operate power lawnmowers or be allowed in the yard while it is being mowed, and under no circumstances should passengers be allowed on riding mowers.

Open pediatric ankle fractures should be treated with appropriate antibiotics and tetanus prophylaxis followed by irrigation and meticulous debridement of devitalized tissue and foreign material. Necessary soft-tissue reconstruction ranges from split-thickness skin-grafting to free tissue transfer. Treatment of these injuries with vacuum-assisted closure devices has shown a trend to reduce the number of free flaps and revision amputations needed for these injuries compared with traditional dressing changes. We recommend a multidisciplinary team approach to treat these injuries.

**Triplane Fractures**

Spiegel et al. reported that triplane fractures are relatively uncommon, representing only 6.3% (fifteen) of 237 ankle fractures in their series, and they occurred in adolescents with a mean age of thirteen years and five months. There are case reports of triplane fractures occurring with ipsilateral extremity injuries and rare fracture patterns. In what we believe is the largest series of triplane fractures evaluated with CT and multiplanar reconstruction, Brown et al. reported that the most common pattern was the two-part fracture (thirty-three of fifty-one fractures). Extrarticular medial malleolar fractures were seen in 24% (twelve) of the fifty-one fractures, which is more common than previously reported. Fractures without articular involvement are more amenable to nonoperative treatment.

Minimally displaced and extra-articular triplane fractures may be treated with reduction and long leg immobilization. Reduction is commonly accomplished by internally rotating the foot, while the rare medial fracture requires abduction. Ertl et al. reported difficulty in reducing fractures with >3 mm of initial displacement, and Schnetzler and Hoernschemeyer recommended open reduction and internal fixation for fractures with >3 mm of initial displacement or >2 mm of residual intra-articular step-off. There is not definitive support for these recommendations, but authors have correlated long-term results with the accuracy of reduction. Ertl et al. showed a trend toward worsening symptoms at the time of the long-term follow-up (average, six years) for fractures involving the tibial plafond with >2 mm of displacement. Weinberg et al., in an evaluation of fifty children with triplane fractures, including thirty who had operative treatment and twenty who had nonoperative treatment, reported that all patients were doing well after a mean follow-up of 7.4 years.

We believe that triplane fractures with >2 mm of weight-bearing articular surface step-off visualized on a CT scan are best treated with a closed reduction. If anatomic reduction can be obtained by closed means, percutaneous screws may aid in...
maintaining reduction while immobilized. If a step-off of <2 mm cannot be achieved and maintained by closed reduction, open reduction with internal fixation should be performed. Arthroscopically assisted reduction and fixation has been described with good results\textsuperscript{66-68}. We recommend postreduction CT if the surgeon is unsure of the articular reduction, as long-term outcomes seem to be improved with a more accurately reduced articular surface\textsuperscript{46,64,65}.

**Juvenile Tillaux Fracture**
The Tillaux fracture occurs in adolescents nearing the end of distal tibial physeal closure. Spiegel et al. reported that these injuries represented only 2.5% (six) of 237 pediatric ankle fractures, occurring at an average age of thirteen years and five months\textsuperscript{3}. Articular congruity is the primary consideration for treatment decisions. Nondisplaced and minimally displaced fractures may be treated with immobilization in a long or short leg cast. Reduction is usually achieved with internal rotation. For fractures with >2 mm of residual displacement measured by CT scan following an attempted closed reduction, anterior capsular interposition should be considered\textsuperscript{69}. Open reduction and removal of the capsule may be necessary, and a single screw parallel to the physis is usually sufficient for fixation (Fig. 6). Kaya et al. reported excellent results at thirty-two to seventy-five months of follow-up for ten fractures with >2 mm of displacement that were treated operatively without attempted reduction\textsuperscript{70}. Case reports have described arthroscopically assisted reduction of Tillaux fractures, but there is no evidence to suggest this method is superior to open reduction\textsuperscript{68,71-73}.

**Fibular Fractures**
Distal fibular fractures may occur in isolation or in association with distal tibial fractures. Ligamentous injuries may be more common than previously thought on the basis of a recent study of children's ankle injuries evaluated with magnetic resonance imaging\textsuperscript{16}. Eighteen children clinically diagnosed with Salter-Harris type-I distal fibular fracture injuries underwent MRI. Fourteen of them had sprains, eleven had osseous contusion, and none were found to have a growth plate injury.

Displaced fractures with associated distal tibial fractures are usually reduced and stable once the tibia is realigned. If the fibula remains unstable, then Kirschner wire fixation may be used. If the patient is nearing skeletal maturity, traditional treatment with a plate is appropriate. Syndesmotic screws are not commonly required for physeal ankle fractures as the distal syndesmotic ligaments are typically intact.

**Accessory Ossification Center Injuries**
Case reports have described children with symptomatic os tibiale and os subfibulare\textsuperscript{74} (Fig. 1). These symptoms generally resolve with activity modification and immobilization in a short leg cast for three to four weeks. An additional one to two weeks of immobilization may be necessary if the child remains symptomatic. Authors agree that surgical intervention to remove the ossicle is exceedingly rare\textsuperscript{74,75}.

**Metallic and Bioabsorbable Fixation**
Internal fixation implants for ankle fractures in children are Kirschner wires or small-fragment metallic screws. Transepiphyseal screw fixation increases the force and contact pressure across the tibiotalar joint compared with controls in adult and pediatric cadaver models (p < 0.007)\textsuperscript{76}. These forces return to prefixation levels when the screws are removed, suggesting that removal of fixation might be beneficial in children.

Bioabsorbable fixation is reported to be safe and effective in treating pediatric ankle fractures\textsuperscript{77}. These results are promising, as bioabsorbable fixation would obviate the need for a second procedure to remove the fixation. Bioabsorbable implants are more expensive than metallic implants, and according to a cost analysis, a clinician would need to remove 54% of the metallic implants used for trimalleolar ankle fractures to break even.
with the initial cost of bioabsorbable implants. Bioabsorbable implants may be a practical way to eliminate the need for removal of the fixation, but there is no clear evidence yet to support this recommendation.

**Complications**

**Osteochondral Defect**

Osteochondral defect of the talus following ankle sprains and fractures is an increasingly common diagnosis. Clinicians should suspect an osteochondral defect in any child who has persistent pain following an ankle injury. MRI is the gold standard for evaluating cartilage injury and provides excellent osseous detail as well. Treatment may be either open or arthroscopic surgery and includes osteochondral defect stabilization, microfracture, or drilling of the involved cartilage area.

**Compartment Syndrome**

Extensor retinaculum syndrome is a compartment syndrome unique to pediatric ankle fractures. In one report, six patients with distal tibial physeal fractures (four type-II and two triplane fractures) presented with severe ankle pain and swelling, a hypoesthetic first web space, weakness of the extensor hallucis longus and extensor digitorum communis, and pain with passive toe flexion. Extensor retinaculum release and fracture fixation relieved pain and weakness, but two patients had persistent altered sensation in the first web space. There are case reports of traditional lower-leg compartment syndromes after pediatric ankle fractures as well.

**Growth Arrests**

Injury to the distal tibial physis can result in premature physeal closure, causing angular deformity or a limb-length discrepancy (Fig. 7). Lalonde and Letts evaluated twelve children with ankle fractures with a growth arrest. Observation, bar excision, epiphysiodesis, and corrective osteotomies were used to treat the growth arrest. Lalonde and Letts advocate close radiographic follow-up, MRI if necessary, to evaluate for physeal bar formation, and excision of the physeal bar if <50% of the physes is involved. CT or MRI may also be used to detect “secondary tethers,” such as incomplete bar resection or recurrent bars in cases of insufficient growth restoration. Radiographs can be followed for the presence of Park-Harris growth lines, which should parallel the physes if normal growth resumes. Angular deformity is detected when lines are not parallel (Fig. 8).
Overview
In summary, nondisplaced pediatric ankle fractures may be managed with immobilization and radiographic follow-up. Articular step-offs of >2 mm that are detected by radiographs or CT scan following closed reduction should prompt consideration for open reduction with internal fixation as needed. Children should be followed for one year after injury to detect growth abnormalities, but some physicians may choose to follow them until they are skeletally mature. A complete summary of recommendations for care is given in Table 11.

References
41. Cotlalomedes II, Béranger V, Louahem D, Camilleri JP, Launay F, Diméglio A, Bourrelle S, Jouve JL, Bollini G. Salter-Harris type III and IV medial malleolar fractures: