Periosteal Tension Band Fixation of a Pronation External Rotation Type Fracture of the Ankle in a Child

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Abstract: Interposed soft tissues can block the anatomical reduction of displaced physeal fractures in children and may necessitate surgical removal. The authors describe a new technique in which they surgically freed the interposed distal-based periosteal flap in an irreducible Salter-Harris type II fracture in a 6-year-old boy and then used this flap in a tension band mode to stabilize the fracture. The thick periosteal flap was held under tension and was reattached to the tibial metaphysis using a 3.5-mm cortical screw and a multi-spiked soft tissue washer. The fracture healed satisfactorily, and the patient regained his ankle function and range of motion by 2 months. Periosteal tension band fixation achieves good skeletal stabilization and avoids more than 1 surgical incision.

Pediatric ankle fractures account for approximately 5% of pediatric fractures and 15% of physeal injuries. Pronation eversion external rotation injuries represent 18% of pediatric ankle injuries and are characterized by a Salter-Harris type II fracture of the distal tibia with a lateral or posterolateral Thurston-Holland fragment associated with a short oblique fracture of the fibula 4 to 7 cm above the tip of the lateral malleolus. Accurate anatomical repositioning of the physis is important to prevent premature physeal closure. Closed manipulative reduction of the distal tibial physeal in these injuries is not always successful. Periosteal interposition is often responsible for the failure of closed treatment and requires operative removal from the fracture site to achieve good reduction. This periosteal sleeve avulsion and interposition usually occurs at the metaphyseal spike (ie, on the opposite side of the Thurston-Holland fragment). The authors describe a technique for stabilization of these fractures through an approach that is used for removing the interposed periosteum on the medial side.

Materials and Methods
The authors describe a technique they used for a 6-year-old boy who fell off a bicycle and sustained a pronation eversion external rotation injury to his left ankle. Radiographs revealed a Salter-Harris type II fracture of the distal tibia and a fracture of the distal diaphysis of the fibula. Initial radiographs showed the...
tibial Thurston-Holland fragment to be on the posterolateral aspect and the metaphyseal spike on the anteromedial aspect (Figure 1). The child was taken to the operating room, and manipulative reduction failed to achieve anatomical reduction of the distal tibial fracture. The authors then performed an open reduction and internal fixation of the fracture using the technique described below.

**Surgical Technique**

While under general anesthesia, the patient is positioned supine on a radiolucent operating table. A closed manipulation of the fracture is attempted with sustained longitudinal traction and gentle correction of the deformity. Image intensifier radiographs are used to check for adequacy of the correction with regard to translation and angulation at the fracture site. If the medial physis appears widened, it is most likely due to periosteal interposition, and an open reduction should be considered. Prophylactic antibiotics are administered intravenously. A thigh tourniquet is used for better visualization of the surgical field (Figure 2A). The extremity is prepared with 2% alcoholic chlorhexidine solution and draped above the knee for optimal judgment of alignment of the lower extremity.

The fracture site is approached medially through a longitudinal skin incision made directly over the distal tibial physis (Figure 2B). The great saphenous vein and saphenous nerve run close to the incision site in the subcutaneous plane under the anterior skin flap and should be protected. This approach allows for adequate visualization of the distally based periosteal flap wedged between the metaphyseal spike and the physis (Figure 2C). This flap of the periosteum is freed from the fracture site, taking care not to damage the physis on which it rests.

Once the periosteum is lifted out, anatomical reduction of the fracture can be achieved by gentle traction and manipulation. The thick, distally based flap of the periosteum is now pulled proximally over the tibial metaphysis and held under tension with a tissue-holding forceps. A 2.5-mm drill bit is used to drill a hole in the distal tibial metaphysis proximal and parallel to the distal physis. This hole passes through the tensioned periosteal flap and the 2 cortices of the tibia. After measuring and tapping this hole with a 3.5-mm tap, a bicortical 3.5-mm small fragment cortical screw is inserted through this periosteum over a multitspiked soft tissue washer (Figures 2D, 3).

This fixation may be supplemented with a 1.25-mm smooth K-wire from the anterolateral epiphysis, aimed diagonally across the physis into the posteromedial metaphysis (Figure 4). The tip of this wire is kept outside the skin to facilitate easy removal in the clinic. Live screening with an image intensifier is used to confirm the adequacy of reduction and stability of fixation. The medial ankle wound is sutured with 3.0 undyed subcuticular vicryl, and a waterproof dressing is applied. The extremity is immobilized in a well-padded, below-knee resting cast, and the patient is mobilized non-weight bearing with crutches for 4 weeks postoperatively. At this time, the supplementary K-wire is removed in the clinic, and radiographs are taken to confirm satisfactory maintenance of reduction.
The patient is followed up at regular intervals (4, 8, and 24 weeks postoperatively) with repeat radiographs to assess fracture healing. Long-term follow-up with serial radiographs to detect any premature distal tibial physeal closure is recommended for 2 to 3 years.

RESULT
At 2-month follow-up, the current patient was walking with a normal gait with full range of motion in the ankle and subtalar joints. Radiographs at this stage were satisfactory (Figure 5). Serial radiographs showed satisfactory fracture healing with no evidence of premature physeal closure at 24 weeks.

DISCUSSION
The distal tibial physis is the second most commonly injured physis in the long bones.

Closed reduction can be successful in the management of some of the displaced distal tibial physeal fractures. An inability to reduce this fracture anatomically by longitudinal traction and gentle correction of the clinical deformity is an indication for open reduction. Accurate reduction of the displaced physis is vital in preventing partial or total premature physeal closure. Manipulation has to be gentle because excessive shear forces can damage the physis. Angulation in the coronal plane needs to be corrected adequately because the distal tibial physis has limited potential to remodel any residual deformities in this plane.

The small metaphyseal Thurston-Holland fragment can occasionally get lodged between the tibia and the fibula, making closed reduction difficult. The presence of interposed soft tissue, especially the thick periosteum, may also hinder closed reduction in pediatric fractures. The periosteal disruption and interposition occur on the convex side of the deformity. The periosteum on the side of the Thurston-Holland fragment (concave side) retains continuity. With this pattern in mind, careful interpretation of intraoperative radiographs is necessary to detect periosteal interposition and subtle physeal widening.

In the past, Salter-Harris type I and II fractures of the distal tibia were considered innocuous injuries with a low risk of growth abnormalities. However, recent reports suggest that the risk of premature physeal closure may be as high as 39.6% with these injuries. Based on the mechanism of injury, pronation type injuries have a higher risk of premature physeal closure (up to 54%). Physeal damage may occur from shear forces that occur at the time of the injury and from excessive shear forces during manipulation attempts. New bone deposited into the physis by the interposed periosteum may be a contributing factor to the development of bony bars within it with subsequent partial or total premature physeal closure and growth abnormalities. Gentle manipulation and open removal of the periosteum with anatomical repositioning of the physis may minimize the risks of a premature physeal closure.

Following open reduction, these fractures should be adequately stabilized internally because subsequent remanipulation of a redisplaced fracture may be not be successful due to rapid fracture healing, and such attempts may cause further physeal damage. Various methods have been described for internal fixation of Salter-Harris type II fractures in children. Screw fixation from the Thurston-Holland fragment to the rest of the metaphysis and fixation with crossed smooth K-wires are the most common techniques. However, once the interposed periosteum is freed from the medial side, fixing a Thurston-Holland fragment on the fibular side of the tibial metaphysis diagonally across with a screw inserted purely under radiographic control can be extremely challenging. This fragment is usually small, and it is often difficult to get good-

Figure 4: Intraoperative anteroposterior (A) and lateral (B) radiographs of the ankle.

Figure 5: Anteroposterior (A) and lateral (B) radiographs of the ankle 2 months postoperatively.
quality intraoperative images of this fragment due to the presence of the fibula and the syndesmotic joint. For the satisfactory placement of a screw into or from this fragment, a further skin incision and soft tissue dissection are required on the lateral side. This approach risks damaging the relatively undamaged portion of the distal tibial periosteum, perichondral ring, and physis.

The authors’ technique allows the surgeon to remove the interposed periosteum and stabilize the fragment through a single surgical approach. This fixation can then be supplemented with small diameter smooth K-wires when deemed necessary.

The potential risks of this technique include injury to the physis, injury to the saphenous nerve and vein, infection, and the prominence of the screw head and washer over the subcutaneous medial surface of the tibia.

**CONCLUSION**

Periosteal tension band fixation is a useful technique in the management of pediatric ankle fractures. It achieves good skeletal stabilization and avoids the need for a second surgical incision.

**REFERENCES**