An Analysis of Suboptimal Outcomes of Medial Malleolus Fractures in Skeletally Immature Children

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Abstract

We retrospectively analyzed cases of intra-articular medial malleolar fractures in skeletally-immature patients (Salter-Harris III and IV) with suboptimal outcomes at St. Louis Children's Hospital and Shriner's Hospital for Children. Common causes of poor outcome were fracture malunion or malreduction and physeal damage. Malreductions of only 2 mm does not appear to be tolerated and the concept of "remodeling" does not apply to these fracture patterns. Based on this study, we recommend fracture reduction and fixation if there is greater than 1 mm of fracture step-off.

Ankle fractures in skeletally immature individuals are common injuries, accounting for 5% of all pediatric fractures,[1] and 25% to 38% of all physeal injuries.[2] These injuries are more common in boys, with a peak incidence in children between the ages of 8 and 15 years. In children, ligaments are generally stronger than the ankle physes, so injuries that result in ligamentous disruption in adults are more likely to result in physeal injuries in children. Most ankle fractures in the pediatric population involve the lateral aspect of the ankle joint, are minimally displaced, and heal uneventfully. However, intra-articular Salter-Harris III and IV medial malleolar fractures occur, and they carry a much more guarded prognosis.[3-8] The mechanism of injury for many of these intra-articular medial malleolar fractures, according to the classification by Dias and Tachdjian,[9] is one of supination and inversion. Complications of delayed union, malunion, growth arrest, and arthritis have been described and most authors have recommended performing anatomical reduction to prevent them.[1,5,7,10] The plasticity and remodeling capabilities of the growing pediatric skeleton do not reliably predict good outcomes.

We retrospectively reviewed cases of intra-articular medial malleolar fractures with suboptimal outcomes at

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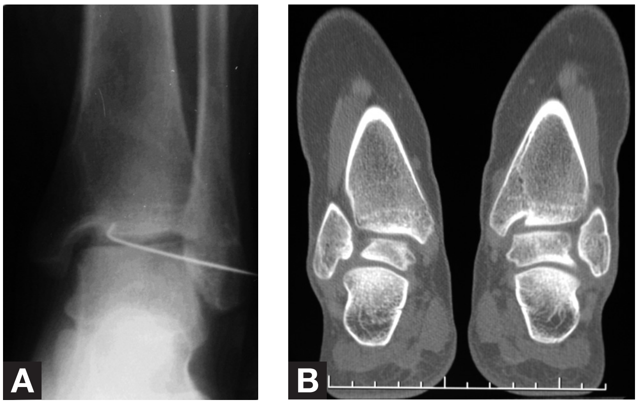

Figure 1. (A) Anteroposterior and lateral radiographs of left ankle show medial malleolar fracture after open reduction and internal fixation with bioabsorbable screws. Note irregularity in weight-bearing articular surface medially (arrow). (B) Coronal image of bilateral ankles shows irregularity in articular surface secondary to malreduction of medial malleolar fracture. (C) Anteroposterior and lateral radiographs of left ankle 2 weeks and 4 months, respectively, after medial malleolar osteotomy for correction of medial malleolus fracture malunion.

Figure 2. (A) Mortise view of right ankle shows displaced medial malleolus fracture. (B) Mortise view of right ankle 4 months after open reduction and internal fixation (ORIF). (C) Mortise view of right ankle 16 months after ORIF and 1 week after hardware removal. (D) Coronal image of right ankle after hardware removal shows fracture malunion secondary to medial physeal arrest. (E) Anteroposterior (AP) radiograph of bilateral ankles obtained with patient standing 6 months after medial malleolar osteotomy performed to correct malunion. Note varus alignment of ankle mortise. (F) AP and lateral radiographs of right ankle after distal tibial osteotomy to correct varus deformity of right ankle. (G) AP radiograph of right tibia shows anatomical alignment of ankle joint 1 year after distal tibial osteotomy.

our institution and analyzed cases of Salter-Harris III or IV[11,12] fractures in skeletally immature individuals. In this article, we report on their outcomes and complications.

Materials and Methods

A medical record search at 2 children's hospitals (St. Louis Children's Hospital and Shriner's Hospital for Children). was undertaken to identify all patients with ankle fractures over a 6-year period (1996–2001). Criteria for inclusion in this study were all skeletally immature patients with open distal tibial physes with Salter-Harris III or IV medial malleolar fractures. Triplane and Tillaux fractures were excluded from analysis. The medical records of these individuals were then further scrutinized for suboptimal outcomes, defined by presence of persistent ankle pain, refracture, growth arrest, arthritis, or the need for secondary reconstructive procedures. Only those patients with medical record evidence of a suboptimal outcome were analyzed in our study.

The inpatient and outpatient medical records of these patients were reviewed to determine patient demographics, injury mechanism, concomitant injuries, management (primary and secondary), complications, and presence of pain. All available radiographs were reviewed to confirm fracture type and fracture alignment.

Results

Twenty-four patients (13 males, 11 females) were included in the study. Mean age was 10.1 years (range, 2-14 years). Mean postinjury follow-up was 46.3 months (range, 9-122 months). The left ankle was involved in 15 patients and the right ankle in 9 patients; no patient had bilateral intra-articular ankle fractures. One patient had concomitant musculoskeletal injuries to other extremities and 2 patients

Figure 3. Anteroposterior and lateral radiographs of left ankle show severe degenerative joint disease secondary to medial malleolar fracture.

had concomitant ipsilateral talar neck fractures. Of the 24 cases, 17 (71%) involved higher energy mechanisms, such as motor vehicle crashes, off-road motorcycling, all-terrain vehicle use, fall from a height or trampoline, or pedestrian versus motor vehicle accident, and 3 involved the more common, lower energy twisting mechanism. In 4 cases, the injury mechanism could not be ascertained from the medical records. One patient was involved in litigation related to the ankle fracture. Initial management for these ankle fractures was casting (8 patients) and open reduction and internal fixation (ORIF) (16 patients). Of the 24 patients, only 4 underwent initial fracture management at our 2 institutions; the other 20 were referred from outside institutions. Review of injury radiographs revealed 4 Salter-Harris III fractures and 16 Salter-Harris IV fractures; 4 fractures could not be classified.

We used the medical records and radiographs to identify suboptimal outcomes: 13 cases of fracture malunion or malreduction (Figure 1); 14 cases of arrest/physeal bar/leg-length discrepancy, 7 cases of bony bar, and 9 cases of ankle varus (Figure 2); and 8 cases of expected or resultant leg-length discrepancy that required surgical management (either contralateral epiphysiodesis or ipsilateral leg-lengthening procedure). Mean age of these patients was 9.9 years (range, 2-14 years).The medical records and radiographs revealed 47 causes for the suboptimal outcomes. Eight of the 13 (61%) fracture malunions were associated with a growth arrest. Other causes of suboptimal outcomes were pain or stiffness (14), refracture (2), osteomyelitis (1), heel cord contracture (1), talar avascular necrosis (1), and nonunion (1). In 7 cases, there was radiographic or arthroscopic evidence of joint arthrosis; mean age of these patients was 10.8 years (range, 9-13 years [Figure 3]). There was no relationship between Salter-Harris fracture type and outcome or complications.

Secondary reconstructive procedures performed after initial fracture management, excluding implant removal procedures, included 8 distal tibial varus–correcting osteotomies (6 acute corrections, 2 gradual corrections), 7 contralateral epiphysiodeses, 6 ipsilateral distal tibial epiphysiodeses, 3 malunion takedowns, 2 revision ORIFs for nonunion (both on 1 patient), 1 revision ORIF for refracture, 1 physeal bar resection, 1 ipsilateral leg-lengthening procedure, 1 heel cord–lengthening procedure, 1 ankle arthrodesis, and 1 distal tibial osteoarticular allograft reconstruction.

Discussion

The growing pediatric skeleton can remodel fracture deformities in certain areas. Guidelines for managing pediatric distal radial metaphyseal fractures, the most commonly managed pediatric fracture, allow for 20° of apex dorsal or apex volar angulation in children under the age of 10 years.[13] There may be a temptation to apply similarly forgiving guidelines to other pediatric fractures. However, intra-articular medial malleolus fractures tolerate malreduction poorly.

Kling and colleagues[5] studied 33 acute distal tibial Salter-Harris III and IV fractures and found that 19 of 20 (95%) managed with accurate ORIF healed without a growth disturbance, and 5 of 9 (56%) managed conservatively developed a bony bar. The authors recommended performing anatomical reduction of these fractures to prevent a bony bar. Cass and Peterson,[6] who also studied Salter-Harris III medial malleolus fractures, found that 9 of 18 (50%) developed a bar that required operative management for angular deformity or a limb-length discrepancy. Barmada and colleagues[7] found a 38% (3/8 fractures) incidence of premature physeal closure with medial malleolus Salter-Harris III and IV fractures. In our study, fracture malunion was highly correlated (7/11, 64%) with the added complication of growth arrest, reinforcing the importance of anatomical reduction of the physis.

Distal tibial angular deformities have been shown in cadaver models to change the tibiotalar[14] and subtalar[15] joint contact forces—a condition that would presumably lead to early tibiotalar and subtalar arthritis. Sugimoto and colleagues[16] found that varus tilt of the tibial plafond may play a role in chronic ligamentous instability of the ankle. Ramsey and Hamilton[17] demonstrated in a cadaver model that lateral talar displacement of 1 mm decreased the tibiotalar contact area by 42%. Caterini and colleagues[8] studied 68 patients with distal tibial physeal injuries. At a mean follow-up of 27 years, they found an association between Salter-Harris III and IV injuries and a fair or poor result, as well as radiographic evidence of early-onset arthritis. Of the 24 patients in our study, 8 (33%) had a varus deformity that required a correcting osteotomy, and 7 (29%) showed early signs of osteoarthritis. We advise closely following up all medial malleolar fractures for these complications.

Of the 24 patients in this study, 19 (79%) had significant complications: malunion, arthritis, physeal arrest, and combinations thereof. Five of the 19 (26%) had arthritis. Mean age of the 19 patients was 10.8 years (range, 9-13 years). None of the younger patients developed arthritis. All the patients who developed arthritis had undergone hardware removal. Thirteen of the 24 (54%) patients in this study had a malunion; mean age of these 13 patients was 9.1 years (range, 2-13 years). Of the 10 children who developed physeal arrest, 7 (70%) also developed a bony bar, and 6 of these 7 (86%) ended up undergoing opening wedge osteotomy for varus correction. Of the 19 patients with significant complications, 10 (53%) had more than 1 significant complication.

The complication of varus deformity of the distal tibia can be satisfactorily corrected with a distal tibial osteotomy. Early-onset arthritis, however, presents a much more difficult situation with very limited surgical options. Anatomical alignment of the articular surface should be paramount in the management of these fractures, with alignment of the growth plate being an important but secondary concern.

Our review of the medial records revealed that evaluation of fracture reduction had been difficult, particularly in younger individuals, because of incomplete ossification of the medial malleolus. High-quality anteroposterior, lateral, and mortise radiographs are essential in assessing displacement of these fractures, and we recommend computed tomography or magnetic resonance imaging when there is a question regarding the adequacy of reduction on plain radiographs. We have also observationally noted plastic deformity of the fracture fragment, which potentially can lead to malreduction of the articular surface despite near anatomical alignment of the distal tibial cortex. Although closed reduction and percutaneous pinning of medial malleolar fractures constitute a viable management option when radiographic visualization is adequate and the anatomical alignment of the fracture fragments is clear, we caution against a false sense of appropriate reduction and recommend open reduction with direct visualization should any question remain.

This study had several limitations. First, it was subject to the inherent weaknesses of a retrospective review. In 21 of the 24 (88%) cases studied, the complications were referred to our institution several months to years after the index injuries, and therefore, the exact details of the injuries and their initial management were not available to us. Length of follow-up varied significantly, and several patients were lost to follow-up within a few months of being treated at our institution. Surgical decision-making, including use of criteria for osteotomies and epiphysiodeses, was not standardized, but was left to the discretion of the attending pediatric orthopedic surgeon. Our study encompassed a wide variety of medial malleolar injuries, ranging from low-energy twisting mechanisms to high-energy open fractures. We hope that this study may serve as a springboard for a more comprehensive study that will better define the prognosis and surgical decision-making involved in these types of fractures.

In skeletally immature individuals, intra-articular medial malleolar fractures can have complications; primarily fracture malunion, growth arrest, and early-onset arthritis. Vigilance is required in the management of these fractures. High-quality radiographs are essential and computed tomography or magnetic resonance imaging may be required for adequate visualization of an incompletely ossified medial malleolus. Malreductions are not tolerated well and we recommend direct visualization of the fracture and the joint surface when anatomical reduction cannot be ascertained.

Authors' Disclosure Statement

The authors report no actual or potential conflict of interest in relation to this article.

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