CASE REPORT

Late Ankle Reconstruction in a Child with Remote Traumatic Medial Malleolus Loss: Clinical and Radiographic Outcomes

Ethan Ponton[1], Ali Bakkai[2], Douglas J Courtemanche[3], Anthony P Cooper[4]

Abstract

Aim: This article aims to describe a novel surgical technique for medial malleolar reconstruction in a young child.

Background: Severe open ankle injuries that result in bone and soft tissue loss carry a high risk for complications, especially in children who are still growing. These injuries can cause abnormal growth patterns, degenerative diseases, and recurrent instability. Cases of medial malleolar reconstruction have been previously described but none in a child this young.

Case description: We present a case of an 13-year-old girl who suffered an open injury to the medial distal tibia with traumatic loss of the medial malleolus at the age of 2 and later suffered a Salter-Harris II fracture to the ipsilateral distal fibula. She presented with varus alignment, a leg length discrepancy, premature asymmetrical growth arrest, chronic non-union of the distal fibula physeal fracture, and severe attenuation of the deltoid ligament. Her secondary deformities were managed with distal fibula osteotomy and fixation, distal tibial hemi-plafond corrective osteotomy, and medial malleolus reconstruction with iliac crest autograft. Her leg length discrepancy was corrected by epiphysiodesis of the contralateral distal femur and proximal tibia. At the 2-year follow-up, the alignment was well maintained, the graft was healing well, and the patient reported no pain and being able to walk and play sports without a brace.

Conclusion: Surgical reconstruction of the medial malleolus with correction for abnormal angulation and leg length discrepancies is critical to promoting healthy growth patterns and quality of life for paediatric patients. This severe open ankle injury can be successfully managed by distal fibula osteotomy and fixation, distal tibial intra-articular osteotomy, and medial malleolus reconstruction with iliac crest autograft.

Clinical significance: This novel technique is an effective method for the surgical management of paediatric traumatic medial malleolar bone loss in children who are skeletally immature and are at risk of complications due to further growth.

Keywords: Growth arrest, Iliac crest autograft, Lawn mower injury, Leg length discrepancy, Medial malleolus reconstruction, Physeal fracture, Severe open ankle injury, Traumatic bone loss, Varus deformity.

Strategies in Trauma and Limb Reconstruction (2022): 10.5005/jp-journals-10080-1552

Background

Ankle fractures account for about 5% of all paediatric fractures.[1] While rare, fractures that result in loss of the medial malleolus are more common in younger, skeletally immature children and therefore carry a higher risk of complications: They can result in a medial physeal bar, which leads to varus angulation and leg length discrepancies, and predispose the physis to premature arrest and the talus to instability and degenerative arthrosis.[2–5] The medial malleolus also contributes to maintaining normal tibiotalar joint characteristics, and fractures can significantly decrease contact area, increase contact pressure,[6] and lead to ankle instability.[7] Fractures resulting in loss of the medial malleolus are rare and are most commonly caused by lawnmowers, farm machinery, boat propellers, snowmobiles, and gunshot wounds, and all cases require surgical intervention.[8] Others have described cases of medial malleolar reconstruction in older children and adults, but none in a child who suffered their injury this young.

We present a case of traumatic medial malleolar bone loss successfully treated by distal fibula osteotomy and fixation, distal tibial intra-articular osteotomy, and medial malleolus reconstruction with iliac crest autograft. The patient's mother was informed that details concerning her daughter's case would be submitted for publication, and she gave consent.

Case Description

We present a case of a 13-year-old girl who sustained a remote right ankle injury at the age of 2 from a riding lawn mower injury. She sustained an open injury to the medial distal tibia with traumatic loss of the medial malleolus; the fracture was classified as Gustillo-Anderson 3B. This was managed with immediate debridement

[1,4]Office of Pediatric Surgical Evaluation and Innovation, British Columbia Children's Hospital, University of British Columbia, Vancouver, British Columbia, Canada; Department of Orthopaedics, University of British Columbia, Vancouver, British Columbia, Canada

[2]Department of Orthopaedics, University of British Columbia, Vancouver, British Columbia, Canada; Department of Orthopaedics, British Columbia Children's Hospital, Vancouver, British Columbia, Canada

[3]Department of Surgery, University of British Columbia, Vancouver, British Columbia, Canada; Division of Plastic Surgery, British Columbia Children's Hospital, Vancouver, British Columbia, Canada

Corresponding Author: Anthony P Cooper, Office of Pediatric Surgical Evaluation and Innovation, British Columbia Children's Hospital, University of British Columbia, Vancouver, British Columbia, Canada; Department of Orthopaedics, University of British Columbia, Vancouver, British Columbia, Canada, e-mail: externalfixators@cw.bc.ca

How to cite this article: Ponton E, Bakkai A, Courtemanche DJ, *et al*. Late Ankle Reconstruction in a Child with Remote Traumatic Medial Malleolus Loss: Clinical and Radiographic Outcomes. Strategies Trauma Limb Reconstr 2022;17(2):131–135.

Source of support: Nil

Conflict of interest: None

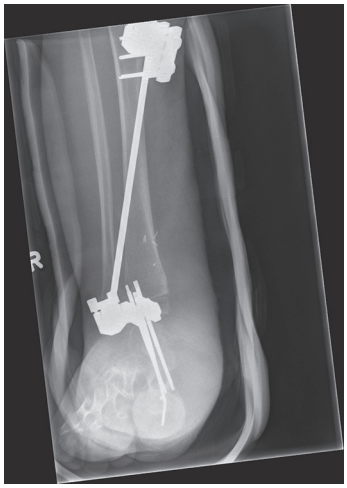


Fig. 1: Anteroposterior (AP) radiograph of the ankle with external fixator *in situ* immediately after treatment for the initial injury

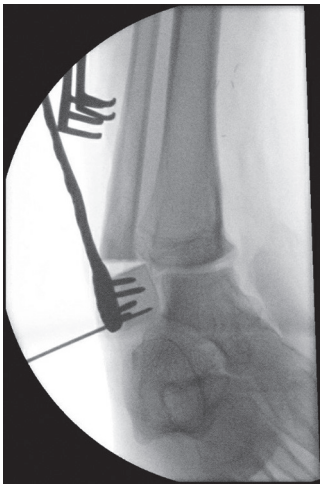
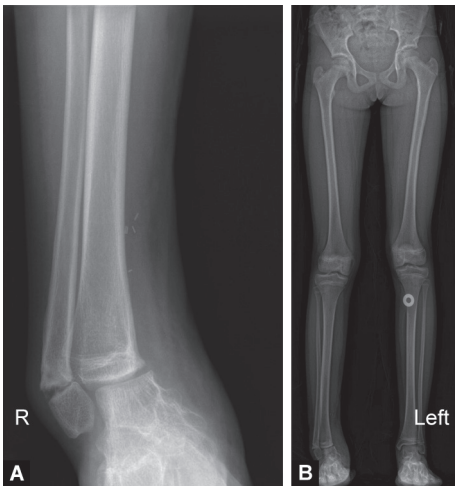


Fig. 3: Fibular osteotomy was performed at the level of the physis. The fibular plate was fixed initially to the distal fragment, and the plate was then reduced onto the fibular shaft to restore anatomical fibular alignment



Figs 2A and B: (A) Preoperative AP radiograph of the ankle showing progressive varus deformity, medial talar shift, and fibular deformity; (B) EOS AP hips to ankle demonstrating varus deformity ankle and leg length discrepancy

Fig. 4: After restoration of fibular alignment, the incongruity of the distal tibial articular surface was demonstrated

and a spanning external fixator (Fig. 1). The wound was closed with latissimus dorsi free tissue transfer and split thickness skin graft. She did well in the postoperative period and had the external fixator removed a few months later. Eight years later, she sustained a Salter-Harris II fracture of the right distal fibula while quad biking. She was placed in an Aircast Boot. Following this injury, she was found to have developed a progressive varus deformity of the right ankle (Fig. 2A) and a leg length discrepancy with the right lower limb shorter than the left (Fig. 2B). MRI scan of the right distal tibia and fibula showed a premature asymmetrical growth arrest involving the medial distal tibial growth plate, chronic non-union of the distal fibula physeal fracture, and severe attenuation of the deltoid ligament.

Given that the patient was developing increasing pain and difficulty weightbearing, especially on uneven surfaces, the multidisciplinary team made the decision to address the varus ankle deformity and reconstruct the medial malleolus. At this time, the patient was 11-years-old. The operation was performed in conjunction with the original plastic surgeon who elevated the existing flap and exposed the medial aspect of the ankle. This was necessary to protect the circulation to the flap and ensure viable soft tissue at wound closure following completion of the skeletal reconstruction. Via a separate lateral incision, a closing wedge osteotomy was performed at the level of the physis of the distal fibula, which was fixed with a fibular locking plate (Fig. 3). After correcting the distal fibular alignment, the talus was reduced under the tibial plafond. It became clear that there was an asymmetrical deformity to the tibial plafond, with varus malalignment of the medial half of the plafond only (Fig. 4). An intra-articular osteotomy of the medial half of the plafond was performed in order to correct this deformity (Fig. 5). Iliac crest bone graft was used as an opening wedge. An appropriately sized tricortical iliac crest autograft with preserved apophysis and gluteal fascia was obtained in order to reconstruct the medial malleolus and the deltoid ligament. The medial border of the distal tibia was decorticated as was the wall of the graft in order to promote bony union. The tricortical graft was placed with the apophysis oriented inferiorly and fixed to

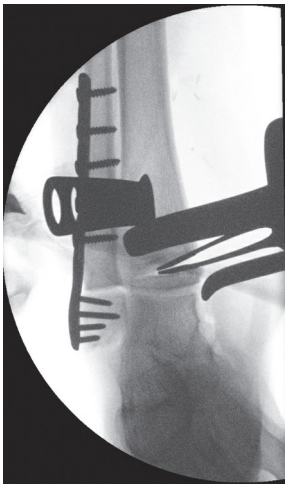


Fig. 5: Intra-articular osteotomy was performed to restore congruency of medial articular surface

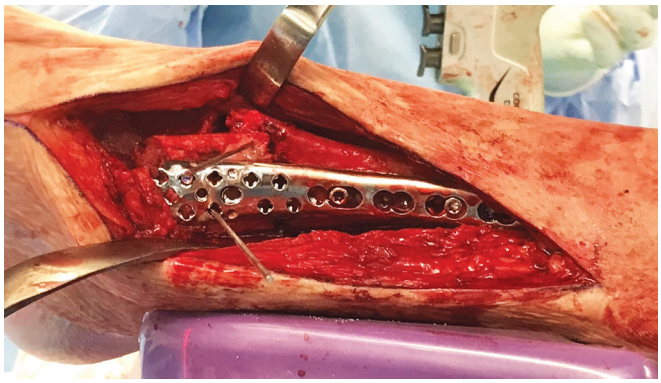
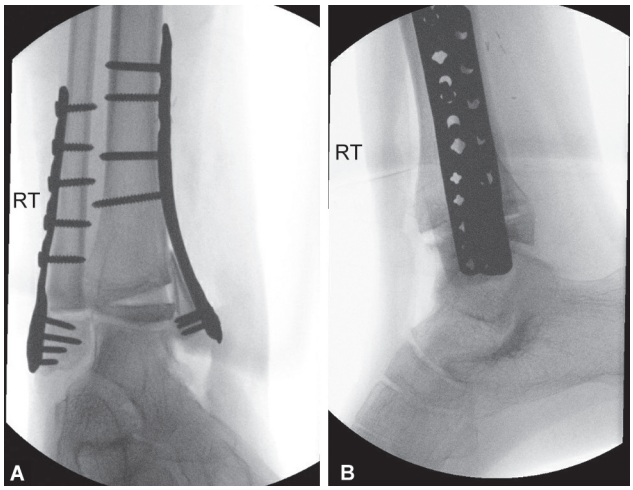


Fig. 6: Intraoperative image showing temporary fixation of the inverted iliac crest graph



Figs 7A and B: (A) Immediate intraoperative AP and lateral; (B) Immediate intraoperative AP and radiograph after insertion of iliac crest wedge and inverted tricortical iliac crest graph fixed with locking plate. *Note:* The apophysis of the iliac crest is not well demonstrated but extends below the tip of the medial plate to restore the shoulder of the medial malleolus

the distal tibia using a medial distal tibia anatomic locking plate (Figs 6 and 7). The gluteal fascia was sutured to the periosteum/deltoid

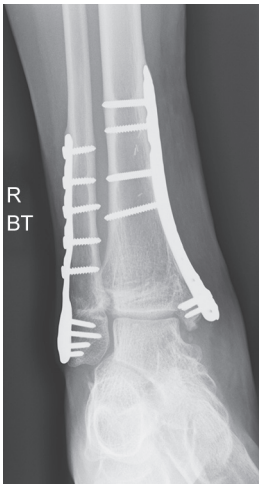


Fig. 8: Latest AP radiograph at 18 months post-procedure demonstrating closed physis, maintenance of medial malleolus, normal articular congruency, and normal alignment

Fig. 9: AP hips to ankle radiograph at 18 months post-procedure demonstrating equal leg length and normal anatomical alignment

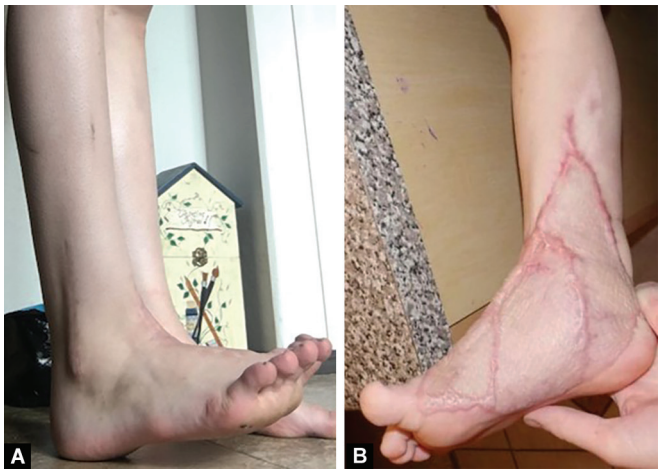
insertion on the talus in order to reconstruct the medial deltoid ligament. The original skin-grafted latissimus flap was re-inset. There were no wound healing complications. Postoperatively, the patient was immobilised in a full cast for a period of 6 weeks with no weightbearing on the right lower limb. After 6 weeks, she was allowed to start gradual weightbearing while using an ankle brace.

Three months following surgery, standing frontal EOS radiological images of the pelvis and lower limbs were taken. Calculation of the projected leg length discrepancy confirmed the right leg would be shorter than the left by more than 3 cm at skeletal maturity. Five months later, the patient underwent a percutaneous drill epiphysiodesis of the left distal femur and proximal tibia to equalise the leg length discrepancy. No formal epiphysiodesis of the distal tibia was performed because screws were placed on either side of the growth plate. As such, there was no need to perform an epiphysiodesis as this would arrest any further growth.

Two-year follow-up after the medial malleolus reconstruction of the right ankle and epiphysiodesis of the left distal femur and left proximal tibia showed a leg length discrepancy of 1.1 cm, healing of the osteotomy sites, and neutral alignment of the ankle

Table 1: Patient-reported outcome measures (PedsQL)[9]

PRO date	*PRO timepoint*	*Physical functioning total*	*Emotional functioning total*	*Social functioning total*	*School functioning total*	*Psychological functioning total*	*QOL total*
August 12, 2019	Baseline	87.5	95	75	65	78.33	81.52
February 1, 2020	6 months	71.43	100	100	70	89.29	83.33
August 23, 2020	12 months	81.25	60	80	55	65	70.65
February 16, 2021	1.5 years	68.75	70	85	70	75	72.83



Figs 10A and B: (A) Clinical photographs at 2 years post-procedure demonstrating active dorsiflexion range; (B) Clinical photographs at 2 years post-procedure demonstrating well-healed skin graft and latissimus dorsi flap

(Figs 8 and 9). Clinical assessment showed that she is doing well so far. She reported no pain in the right ankle and that she does not use the ankle brace most of the time. She feels her right ankle is stable, and she has been able to return to sporting activities. Her post-surgery health-related quality of life scores as measured by the PedsQL tool were consistently within 1 standard deviation of the population mean for healthy children.[9] Her scores on all subscales as well as overall quality of life scores are described in Table 1. Soft tissue coverage remains stable, and there is no scar contracture that might contribute to further malalignment (Fig. 10).

Discussion

Severe open ankle fractures that involve both skeletal and soft tissue loss require a multidisciplinary approach by both orthopaedic and plastic surgeons for optimal outcomes. Our guiding principles were to correct the alignment, maintain that alignment, and prevent further abnormal growth. Our approach was to restore the fibula first with an anatomically specific fibula plate. The fibula osteotomy at the level of the growth plate was performed both to treat the non-union at the apex of the deformity and to create an epiphysiodesis of the distal fibular growth plate in order to avoid future fibular overgrowth. We then performed a hemi-plafond elevation to restore the distal tibia alignment. Finally, we reconstructed the shoulder of the medial malleolus to lock the talus under the tibia and prevent further subluxation. Epiphysiodesis on the contralateral side was later performed to equalise the leg length discrepancy.

Although various bone autograft donor sites are possible, the iliac crest is ideal for paediatric patients; children have very low complication rates and minimal donor site pain, and the iliac crest possesses osteoconductive, osteogenic, and osteoinductive properties.[10] Wu successfully used a fibular head composite tendon bone flap to reconstruct the medial malleolus; however, these grafts come with relatively significant donor site morbidity and a risk of perineal nerve palsy.[11] It is still debated in the literature whether reconstruction of the deltoid ligament is required, but we found it necessary for our patient. Boyer et al. also deemed it necessary in their case due to their patient having persisting ankle instability; they used the biceps tendon.[12] Abbo et al. performed ligament reconstruction and used gluteal fascia;[13] we also used the gluteal fascia. While both Nithyananth et al. and Abbo et al. successfully used screws to fix the iliac crest graft to the medial malleolus site, we used plates to fix the graft.[13,14] Kow et al. used an antiglide plate,[15] whereas we used anatomic locking plates. We used an anatomic fibular locking plate to restore the fibular alignment by fixing the distal portion first and then fixing the distal construct onto the proximal fibular shaft. We then used an anatomic distal medial tibial locking plate, taking advantage of the small diameter locking screw pattern distally to rigidly fix the medial malleolar fragment into an anatomical position. It is important to decorticate the medial cortex of the tibia to encourage bony integration of the graft.

Also note the attention required to the soft tissue coverage at the initial injury at age 2 and the ongoing involvement of the plastic surgeon to ensure a healthy soft tissue environment supporting the ankle reconstruction.

This case is unique because of the very young age (2-years-old) of the patient when she suffered her traumatic ankle injury that removed the medial malleolus, and because she had an additional insult to the same ankle when she suffered the Salter-Harris II fracture from the quad bike accident. These caused varus alignment and partial growth arrest. The patient is now 2 years post-procedure, and the desired outcome has been maintained. She does not have any osteoarthritis of the ankle, the talus is centered on the tibia, and the leg length discrepancy has been reduced to 1.1 cm, with the potential for further correction. She does report a mild painless limp, which could be related to the residual leg length discrepancy. The varus deformity has been corrected and well maintained, her ankle is still neutral, and there is no evidence of shortening of the fibula. She reports being able to walk normally without using a brace, has normal health-related quality of life, no ankle instability or pain, and she is enjoying being able to horseback ride and play badminton.

Conclusion

Although they are uncommon, severe open ankle fractures that result in loss of the medial malleolus and soft tissue can have severe impacts on skeletally immature children. Surgical reconstruction of the medial malleolus is necessary to correct and maintain proper

alignment. Here, we have shown that this severe open ankle injury can be managed by distal fibula osteotomy and fixation, distal tibial intra-articular osteotomy, and medial malleolus reconstruction with iliac crest autograft.

Clinical Significance

This novel technique is an effective method for the surgical management of paediatric traumatic medial malleolar bone loss in children who are skeletally immature and are at risk of complications due to further growth.

Orcid

Ethan Ponton https://orcid.org/0000-0002-4891-4800
Douglas J Courtemanche https://orcid.org/0000-0003-3720-9302
Anthony P Cooper https://orcid.org/0000-0002-7864-2981

References

1. Kay RM, Matthys GA. Pediatric ankle fractures: evaluation and treatment. J Am Acad Orthop Surg 2001;9(4):268–278. DOI: 10.5435/00124635-200107000-00007.
2. Cass J, Peterson H. Salter-Harris Type-IV injuries of the distal tibial epiphyseal growth plate, with emphasis on those involving the medial malleolus. J Bone Jt Surg 1983;65(8):1059–1070. PMID: 6630250.
3. Peterson HA, Jacobsen FS. Management of distal tibial medial malleolus type-6 physeal fractures. J Child Orthop 2008;2(2):151–154. DOI: 10.1007/s11832-008-0091-3.
4. Peterson HA. Physeal fractures: Part 2. Two previously unclassified types. J Pediatr Orthop 1994;14(4):431–438. DOI: 10.1097/01241398-199407000-00003.
5. Mayr JM, Gerhard PR, Wolfgang LE. Reconstruction of part of the distal tibial growth plate with an autologous graft from the iliac crest. J Bone Jt Surg 2000;82(4):558–560. DOI: 10.1302/0301-620x.82b4.9760.
6. Lareau CR, Bariteau JT, Paller DJ, et al. Contribution of the medial malleolus to tibiotalar joint contact characteristics. Foot Ankle Spec 2015;8(1):23–28. DOI: 10.1177/1938640014546862.
7. Khan U, Smitham P, Pearse M, et al. Management of severe open ankle injuries. Plast Reconstr Surg 2007;119(2):578–589. DOI: 10.1097/01.prs.0000246506.58128.ec.
8. Peterson H. Physeal fractures: Part 3. Classification. J Pediatr Orthop 1994;14(4):439–448. DOI: 10.1097/01241398-199407000-00004.
9. Varni JW, Burwinkle TM, Seid M, et al. The PedsQL™* 4.0 as a pediatric population health measure: feasibility, reliability, and validity. Ambul Pediatr 2003;3(6):329–341. DOI: 10.1367/1539-4409(2003)003<0329:tpaapp>2.0.co;2.
10. Clarke A, Flowers MJ, Davies AG, et al. Morbidity associated with anterior iliac crest bone graft harvesting in children undergoing orthopaedic surgery: a prospective review. J Child Orthop 2015;9(5):411–416. DOI: 10.1007/s11832-015-0698-0.
11. Wu S. Clinical study of reconstructing the medial malleolus with free grafting of fibular head composite tendon bone flap. Chin J Traumatol Engl Ed 2008;11(1):34–36. PMID: 18230289.
12. Boyer MI, Bowen V, Weiler P. Reconstruction of a severe grinding injury to the medial malleolus and the deltoid ligament of the ankle using a free plantaris tendon graft and vascularized gracilis free muscle transfer: case report. J Trauma 1994;36(3):454–457. DOI: 10.1097/00005373-199403000-00042.
13. Abbo O, Accadbled F, Laffosse J-M, et al. Reconstruction and anticipatory Langenskiöld procedure in traumatic defect of tibial medial malleolus with type 6 physeal fracture. J Pediatr Orthop B 2012;21(5):434–438. DOI: 10.1097/BPB.0b013e328348da0d.
14. Nithyananth M, Cherian VM, Jepegnanam TS. Reconstruction of traumatic medial malleolus loss: a case report. Foot Ankle Surg 2010;16(2):e37–e39. DOI: 10.1016/j.fas.2009.07.004.
15. Kow RY, Yuen JC, Ahmad Alwi AA, et al. Surgical reconstruction of an open medial malleolus fracture using a novel technique: a case report. JBJS Case Connect 2019;9(2):e0163–e0163. DOI: 10.2106/JBJS.CC.18.00163.