Reconstructive Shelf Arthroplasty as a Salvage Procedure for Complex Fifth Tarsometatarsal Joint Complex Injuries: A Case Review and Discussion

Andrew J. Rosenbaum, MD, Ralph Zade, MD, Ernest Chesina, MD, and Kaushik Bagchi, MD

Abstract

High-energy cuboid fractures are rare injuries that are commonly associated with other midfoot trauma. With displacement, operative intervention is critical to restore articular congruity and the length of the lateral column. Failure to achieve this predisposes patients to posttraumatic arthritis and deformity, often necessitating secondary procedures. Although primary open reduction and internal fixation is the standard of care for these injuries, at times the traditional principles of fracture fixation cannot be applied to cuboid fractures. We describe the case of a 45-year-old woman who underwent a reconstructive shelf arthroplasty of the cuboid and fifth tarsometatarsal joint for a severe injury to the lateral column of the midfoot.

Fractures of the cuboid bone are uncommon, with an annual incidence of approximately 1.8 per 100,000.[1] This is largely attributed to the inherent stability provided by its anatomy and position in the foot's lateral column, where it functions as a link between the lateral column and transverse plantar arch.[2] Regarding its anatomy, the cuboid is a pyramidal-shaped bone with 6 bony surfaces that provide tremendous stability—3 of these are articular, 3 nonarticular.

Although the cuboid bone is susceptible to low-energy avulsion injuries, injuries that occur in the setting of high-energy trauma are most concerning, as they often occur concurrently with other midfoot fractures and dislocations. These less common crush injuries are associated with comminution, articular disruption, and shortening of the lateral column.[3-5]Avulsion injuries occur via a twisting mechanism, while the more complex nutcracker fracture evolves via longitudinal compression of the lateral column, with the foot in a position of forced plantarflexion.[6] Other comminuted fractures occur from direct impact on the lateral aspect of the foot.

Management of cuboid fractures varies according to etiology, fracture displacement, and articular involvement. Conservative management is reserved solely for stable, nondisplaced fractures.[7] Unstable fracture-dislocations and those with associated lateral column shortening necessitate operative treatment, which attempts to restore anatomy, stability, and length of the foot's lateral column.[7-9] However, with the exception of open injuries, fractures tenting the skin, and injuries with concomitant compartment syndrome, the high-energy nature of cuboid fractures often precludes early surgical intervention, as the foot's soft-tissue envelope is too compromised. For this reason, operative intervention is often performed on a delayed basis only after recovery of the soft tissue.

In this case report and literature review, we describe a reconstructive shelf arthroplasty of the fifth tarsometatarsal (TMT) joint as a primary intervention for crush-type cuboid fractures with associated joint subsidence and lateral column shortening. The shelf arthroplasty, which was first credited to Konig in 1891, has historically been described as a remodeling operation using bone graft wedges for the treatment of nonconcentric acetabular dysplasia.[10] Although bone grafting is recognized as an effective means of addressing osseous voids in the setting of comminuted cuboid fractures, its specific application in the form of a shelf arthroplasty has not been described.[11] The patient provided written informed consent for print and electronic publication of this case report.

Case Report

An otherwise healthy 45-year-old woman presented to our institution's emergency department (ED) complaining of right foot pain after a motor vehicle accident. She was the restrained driver in a head-on collision. Primary survey revealed a swollen, ecchymotic, and tender right foot. Radiographs demonstrated fractures of her first, second, third, and fourth metatarsals, and a comminuted cuboid fracture with lateral column shortening and disruption of the fifth TMT joint (**Figure 1**).

Due to swelling, initial management consisted of soft-tissue management through the use of a well-padded splint. As this

Authors' Disclosure Statement: The authors report no actual or potential conflict of interest in relation to this article.

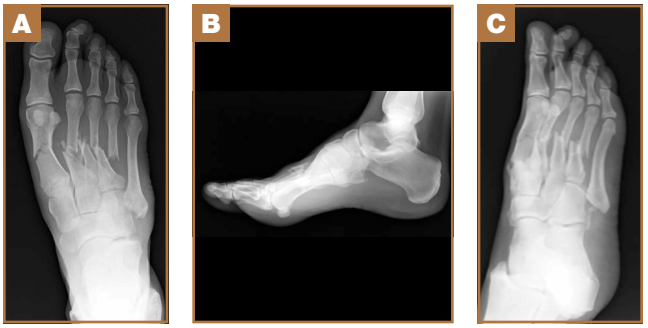

Figure 1. (A) Anteroposterior, (B) lateral, and (C) oblique radiographs of the right foot of a 45-year-old woman demonstrating fractures of the first, second, third, and fourth metatarsals. Additionally, a comminuted cuboid fracture is present with disruption of the fifth tarsometatarsal joint and lateral column shortening.

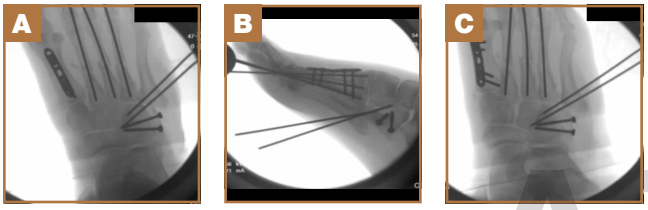

Figure 2. (A) Anteroposterior, (B) lateral, and (C) oblique radiographs of the foot immediately following open reduction and internal fixation of the first metatarsal; closed reduction and percutaneous pinning of the second, third, and fourth metatarsals; and a shelf arthroplasty of the cuboid and fifth tarsometatarsal joint with tricortical iliac crest bone graft.

was her only injury, she was instructed to remain non-weightbearing, ambulate with crutches, and return to our outpatient office for close follow-up. The need for delayed surgical intervention of her multiple foot injuries, due to her compromised soft-tissue envelope, was discussed prior to discharge.

Surgical intervention was performed 15 days after the injury, when the soft-tissue swelling had dissipated. The surgical plan included fixation of the multiple metatarsal fractures and lateral column reconstruction and stabilization. With regard to the lateral column, we obtained patient consent for several possible procedures, including fifth TMT joint closed reduction and percutaneous pinning, open reduction and internal fixation (ORIF), and TMT joint reconstruction with iliac crest bone graft (ICBG).

The metatarsals were addressed first via a dorsomedial incision, using a 5-hole 2.7-mm Limited Contact Dynamic Compression Plate (Synthes) to stabilize the first metatarsal and 2.0-mm Kirschner wires (K-wires) to maintain the length and alignment of the second, third, and fourth metatarsals (**Figure 2**). Closed reduction and percutaneous pinning of the fifth metatarsal was then attempted but abandoned because of persistent instability and subsidence of the cuboid in the proximal and plantar direction. ORIF was then attempted through a dorsolateral incision extending from just distal to the sinus tarsi to the base of the fourth metatarsal. However, the lateral cuboid was too comminuted to accommodate any fixation and prevent fifth TMT joint subluxation and lateral column shortening.

Autograft reconstruction of the lateral column was therefore performed, using radiographs of the patient's uninjured, contralateral foot as a template for our lateral column shelf arthroplasty (**Figure 3**). Based on this template, the length and alignment of the lateral column were provisionally maintained with two 2.0-mm K-wires placed between the fifth metatarsal and intact cuboid (**Figure 4**). Tricortical ICBG was then harvested through an anterior approach to the iliac crest and contoured accordingly to fill the osseous void. To facilitate graft incorporation, comminuted fragments of cuboid bone were removed, with the remaining bone decorticated. The graft was then fixed to the remaining cuboid with two 4.0-mm partially threaded cannulated screws (Synthes; Figures 2, 4). This construct restored the length of the lateral column and effectively buttressed the fifth TMT

Figure 3. Anteroposterior radiograph of the contralateral foot, which was used as a template to guide lateral column reconstruction.

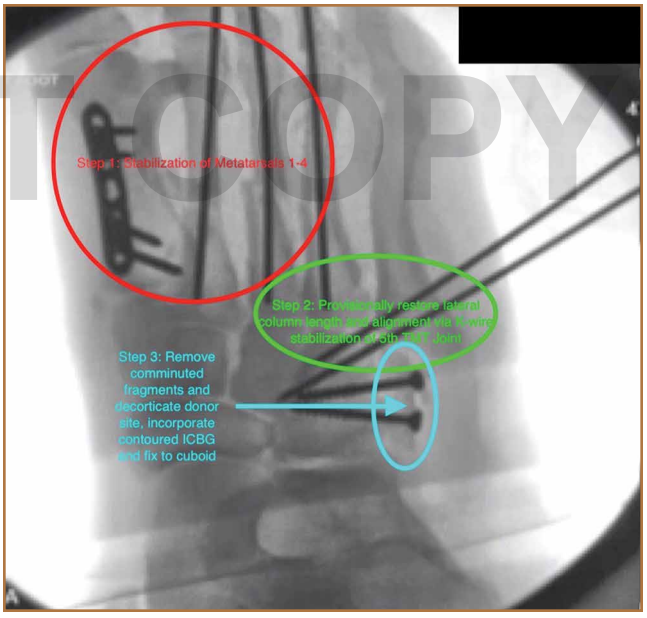

Figure 4. Depiction of the critical steps and surgical technique for a lateral column shelf arthroplasty. Following fixation of the medial and middle column injuries, the lateral column is lengthened and provisionally stabilized based on radiographs of the contralateral foot. These images also aid the surgeon in contouring of the iliac crest bone graft (ICBG), which bridges the osseous void within the lateral column. The ICBG is then fixed to the remaining cuboid with two 4.0-mm screws. Abbreviations: K-wire, Kirschner wire; TMT, tarsometatarsal.

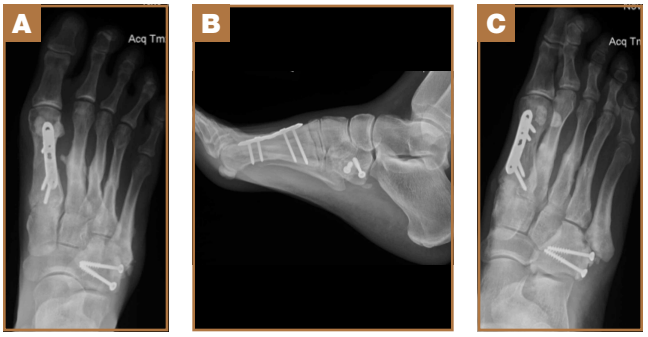

Figure 5. (A) Anteroposterior, (B) lateral, and (C) oblique radiographs of the foot at 12-month follow-up.

joint, preventing subsidence and dislocation of the TMT joint.

After a 2-day postoperative course in the hospital, the patient was discharged. She remained non-weight-bearing in a splint with Robert Jones cotton bandage. At her 2-week postoperative visit, all hardware was intact and there was no evidence of infection. Her sutures were removed and she was placed in a new splint. At the patient's 5-week postoperative visit, all K-wires were removed. At this time she remained non-weight-bearing but was transitioned into a controlled ankle movement (CAM) boot and was allowed to begin active and passive ankle exercises. At her 10-week follow-up, radiographs revealed appropriate interval healing and callus formation. The patient began weight-bearing as tolerated in the CAM boot at that time. At 12 weeks, she was transitioned into a hard-soled shoe for comfort and was allowed to ambulate in the footwear of her choice as tolerated. Her activity levels were slowly advanced, and, at her 12-month follow-up, the patient had returned to playing tennis in her recreational league with no residual sequelae (**Figure 5**).

Discussion

Although rare, cuboid fractures are critical to identify and can result in significant disability, as they are frequently associated with additional foot trauma, as demonstrated in this case.[1-4] When isolated cuboid fractures are present, further imaging must be performed, including additional radiographic views and computed tomography, to search for other injuries, such as TMT joint complex disruption.

Only those cuboid fractures that are low-energy, stable, or nondisplaced can be effectively managed conservatively.[12] In the presence of instability, articular incongruity, or lateral column shortening, operative intervention is warranted. Arthritic degeneration, pain, and deformity result from residual incongruity at the calcaneocuboid or TMT joints, or when lateral column length is not restored.[4-6,13] The latter leads to forefoot abduction and lateral subluxation of the lesser metatarsals, with ensuing posttraumatic pes planus or planovalgus deformity, which often necessitates secondary reconstructive procedures or arthrodesis.[14,15]

Stable reduction and restoration of lateral column length can be challenging, particularly in the setting of comminution and bone loss. Common methods of treatment involve lifting the dorsolateral cortex of the cuboid and buttressing the impacted articular surface with bone graft or bone graft substitutes. Fixation can be achieved with K-wires, small fragment plates and screws, and distraction external fixation.[11] The latter is a particularly beneficial technique, as it can be used independent of or in conjunction with ORIF.

In a study by Weber and Locher,[11] the short-term to midterm results of cuboid ORIF were assessed in 12 patients. Results were found to be good with respect to restoration of length, joint reconstruction, and overall return to function.[11] Admittedly, these authors at times employed a similar but conceptually different approach to our patient. In their 7 patients with severe comminution and lateral column shortening, corticocancellous ICBG was used. However, Weber and Locher[11] did not describe this as a shelf arthroplasty, but instead as an adjunct to primary ORIF.

In our case, the tricortical ICBG shelf arthroplasty was used as it is in the hip, as a salvage procedure. Although little is known about outcomes following shelf arthroplasty for lateral column reconstruction in the foot, a 50% failure rate has been observed in the hip.[16] As such, our preference was to perform an anatomic ORIF of the cuboid and lateral column, with the shelf arthroplasty only indicated if we were unable to achieve this. We believe that the need for tricortical ICBG in the treatment of cuboid fractures is indicative of a more severe injury and that it is a less optimal and more technically demanding intervention compared with primary ORIF. Furthermore, in other studies devoted to the treatment of cuboid fractures, patients requiring reconstruction with structural graft are not included in primary ORIF cohorts.[17]

As in the hip, suboptimal outcomes may occur when shelf arthroplasty is performed in the foot. There are additional considerations unique to the foot that surgeons must also contemplate when considering shelf arthroplasty. As demonstrated in the literature for adult-acquired flatfoot deformity, lateral column reconstruction is challenging and controversial and is associated with overload, pain, and the need to remove prominent hardware.[18] These complications may also occur after shelf arthroplasty for cuboid fractures.

The work by Weber and Locher[11] did not elucidate such considerations, and outcomes of ORIF and ICBG reconstruction were not compared. This is a limitation of their study, as differences in functional outcomes between the 2 procedures remain unknown. Given the degree of comminution that precludes ORIF and necessitates a graft reconstruction, we believe that the description of the shelf arthroplasty as a salvage procedure more accurately reflects the severity of injury. This may have implications regarding outcomes and patient expectations that the orthopedic surgeon must address. Future studies must further evaluate the outcomes of this technique, independent of and in comparison with ORIF.

Conclusion

In this case, we describe shelf arthroplasty for cuboid fractures. It is a reconstructive salvage procedure that is indicated when

ORIF cannot be achieved. This useful approach to a complex injury must remain in the armamentarium of orthopedic surgeons. As we have demonstrated, it can effectively restore a damaged lateral column, providing length and, in our case, enabling the patient to return to her pre-injury level of activity.

Dr. Rosenbaum is Fellow, Orthopaedic Foot and Ankle Surgery, Hospital for Special Surgery, New York, New York. Dr. Zade and Dr. Chesina are Residents, and Dr. Bagchi is Attending Surgeon, Division of Orthopaedic Surgery, Albany Medical College, Albany, New York.

Address correspondence to: Andrew J. Rosenbaum, MD, Hospital for Special Surgery, 535 East 70th St, New York, NY 10021 (email, andrewjrosenbaum@gmail.com).

Am J Orthop. 2016;45(1):E38-E41.

References

1. Court-Brown C, Zinna S, Ekrol I. Classification and epidemiology of midfoot fractures. *Foot*. 2006;16(3):138-141.
2. Sarrafian SK. Osteology. In: Kelikian AS, ed. *Sarrafian's Anatomy of the Foot and Ankle.* Philadelphia, PA: Lippincott; 1993:65-70.
3. Davis CA, Lubowitz J, Thordarson DB. Midtarsal fracture subluxation. Case report and review of the literature. *Clin Orthop Relat Res*. 1993;(292): 264-268.
4. Dewar FP, Evans DC. Occult fracture-subluxation of the midtarsal joint. *J Bone Joint Surg Br.* 1968;50(2):386-388.
5. Sangeorzan BJ, Swiontkowski MF. Displaced fractures of the cuboid. *J Bone Joint Surg Br.* 1990;72(3):376-378.
6. Hermel MB, Gershon-Cohen J. The nutcracker fracture of the cuboid by indirect violence. *Radiology.* 1953;60(6):850-854.
7. Early J, Reid J. Fractures and dislocations of the midfoot and forefoot. In: Heckman JD, Bucholz RW, Court-Brown CM, Tornetta P, eds. *Rockwood and Green's Fractures in Adults*. 7th ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2009:2120-2126.
8. Richter M, Wippermann B, Krettek C, Schratt HE, Hufner T, Therman H. Fractures and fracture dislocations of the midfoot: occurrence, causes and long-term results. *Foot Ankle Int*. 2001;22(5):392-398.
9. Borrelli J Jr, De S, VanPelt M. Fracture of the cuboid. *J Am Acad Orthop Surg*. 2012;20(7):472-477.
10. Love BRT, Stevens PM, Williams PF. A long-term review of shelf arthroplasty. *J Bone Joint Surg Br.* 1980;62(3):321-325.
11. Weber M, Locher S. Reconstruction of the cuboid in compression fractures: short to midterm results in 12 patients. *Foot Ankle Int*. 2002;23(11): 1008-1013.
12. Ebizie AO. Crush fractures of the cuboid from indirect violence. *Injury*. 1991;22(5):414-416.
13. Berlet GC, Hodges Davis W, Anderson RB. Tendon arthroplasty for basal fourth and fifth metatarsal arthritis. *Foot Ankle Int*. 2002;23(5):440-444.
14. Brunet JA, Wiley JJ. The late results of tarsometatarsal joint injuries. *J Bone Joint Surg Br.* 1987;69(3):437-440.
15. DeAsla R, Deland J. Anatomy and biomechanics of the foot and ankle. In: Thordarson DB, Tornetta P, Einhorn TA, eds. *Orthopaedic Surgery Essentials: Foot & Ankle*. Philadelphia, PA: Lippincott William & Wilkins; 2004: 18-23.
16. Berton C, Bocquet D, Krantz N, Cotton A, Migaud H, Girard J. Shelf arthroplasties long-term outcome: influence of labral tears. A prospective study at a minimal 16 years' follows up. *Orthop Traumatol Surg Res*. 2010;96(7): 753-759.
17. van Raaij TM, Duffy PJ, Buckley RE. Displaced isolated cuboid fractures: results of four cases with operative treatment. *Foot Ankle Int*. 2010;31(3): 242-246.
18. Grier KM, Walling AK. The use of tricortical autograft versus allograft in lateral column lengthening for adult acquired flatfoot deformity: an analysis of union rates and complications. *Foot Ankle Int*. 2010;31(9):760-769.