Cuboid Injuries

Ippokratis Pountos[1], Michalis Panteli[1], Peter V Giannoudis[1,2]

[1]Academic Department of Trauma and Orthopaedics, School of Medicine, University of Leeds, [2]NIHR Leeds Biomedical Research Center, Chapel Allerton Hospital, Leeds, UK

Abstract

Cuboid fractures are rare injuries. A number of different treatment methods have been proposed including plaster immobilization, open reduction, and internal fixation or external fixation. Bone grafting is commonly used to restore bony length. The majority of the current literature suggests that the loss of length of the lateral column and articular congruency are the two criteria opting for the surgical management of these fractures. Nevertheless, the exact indications and ideal management of these fractures are not established mainly due to the rarity of these injuries and the paucity of literature.

Keywords: *Cuboid fractures, lateral column, midfoot injuries, posttraumatic osteoarthritis*
MeSH terms: *Fractures, bone; osteoarthritis; tarsal joint*

Introduction

Fractures that involve the midfoot are rare and have an annual incidence of approximately 3.6/100,000 fractures.[1,2] From these, half involve the cuboid. Most commonly they are seen as isolated avulsion fractures, less frequently are combined with other midfoot fractures, dislocations or are associated with Lisfranc joint injuries.[3] Cuboid fractures in isolation represent a diagnostic challenge and are frequently missed as the majority of cuboid injuries are relatively minor.[4] The radiologic changes occurring in more serious injuries may also be subtle and easily overlooked. However, cuboid fractures have the potential to cause considerable deformity involving the foot arch, lateral column, and the function of the forefoot, and thus, a high index of suspicion is mandatory to prevent long term disability. This study aims to provide an overview of cuboid fractures and present their management.

Anatomy of the Cuboid

The cuboid is a wedge-shaped bone, and is a vital element of the lateral column; in fact, it is the only bone of the midfoot that supports the lateral column [Figures 1 and 2]. The importance of the cuboid stems from the fact that it is involved in all intrinsic movements of the foot.[5] It articulates with the calcaneus (proximal facet), lateral cuneiform (medial facet), and 4th and 5th metatarsals (distal facets). An additional articulation with the navicular exists in 25% of the population. The dorsal calcaneal and medial cuboid tuberosities, together with a network of strong ligaments, support the calcaneocuboid joint during weight bearing.[6] There is very little movement in the calcaneocuboid joint; all the movement of the lateral column occurs distally at the tarsometatarsal joints. The range of motion at the lateral tarsometatarsal joints is up to three times higher than that of the medial tarsometatarsal joints.[7]

The peroneal sulcus is located at the plantar surface of the cuboid and runs plantar wards and medially toward the insertion of the tendon in the first metatarsal bone. The cuboid acts as a fulcrum during the contraction of the peroneus longus. The lateral plantar artery provides the blood supply to the cuboid.

Mechanism of Injury and Diagnosis

The vast majority of fractures involving the cuboid are minor avulsion fractures. These represent ligamentous or capsular avulsions. Direct trauma can result in a fracture, but this rarely results in a complex fracture configuration. Isolated fractures of the cuboid are uncommon and mostly documented in case reports. An isolated fracture can occur as the result of indirect compression with axial force applied to a plantar-flexed abducted foot crashing the cuboid between the calcaneal and the bases of the 4th and 5th metatarsals.

How to cite this article: Pountos I, Panteli M, Giannoudis PV. Cuboid injuries. Indian J Orthop 2018;52:297-303.

Address for correspondence:
Mr. Ippokratis Pountos, Department of Trauma and Orthopaedics, Leeds General Infirmary, Clarendon Wing Level A, Great George Street, Leeds, LS1 3EX, UK.
E-mail: pountos@doctors.org.uk

Access this article online

Website: www.ijoonline.com

DOI: 10.4103/ortho.IJOrtho_610_17

Quick Response Code:

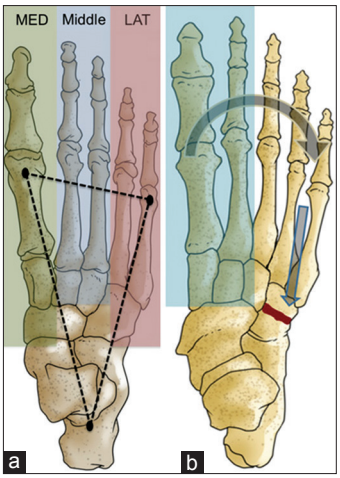

Figure 1: Diagramatic representation of (a) 3 columns of the foot and the weight-bearing triangle (b) Lateral column shortening leads to abduction and overpronation of the forefoot

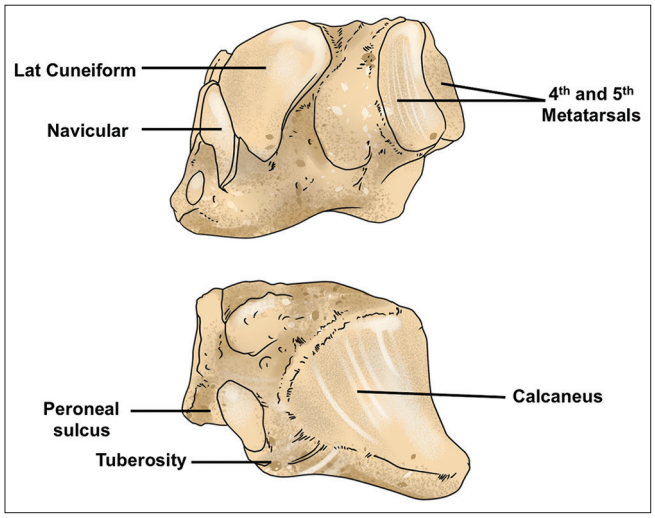

Figure 2: A line diagram showing anatomy of the cuboid

This is often referred to as a "Nutcracker" fracture. Stress fractures can occur more often in young athletes.[8] These are rare injuries that most commonly involve the lateral aspect of the cuboid.[8] The "Nutcracker" fracture requires close attention as it can disrupt the mechanical alignment of the foot.[9] Cuboid fractures are seen in conjunction with other complex injuries such as other hindfoot, midfoot or Lisfranc injuries.[3] Painful subluxation of the cuboid (referred as a cuboid syndrome) is often reported in ballet dancers and athletes.[10-12] This condition is hypothesized to occur from a disruption of calcaneocuboid joint. It is characterized by lateral foot and ankle pain, reduced forefoot mobility with the weakness of forefoot push-off and peroneus longus spasm.[12] Cuboid syndrome responds exceptionally well to conservative treatment and close manipulation of the cuboid can be diagnostic and therapeutic.[10,11]

Dorsolateral foot pain associated with swelling and ecchymosis following injury should raise suspicion of a cuboid fracture.[13] More severe injuries with or without concomitant trauma can even distort the normal anatomy. In young children, limping and antalgic gait with the inability to describe the nature and location of the pain is a common complaint. Cuboid fractures in children, especially of preschool age, are rare and probably unreported.[14,15] Englaro *et al*. in their study reported scintigraphic findings in the cuboid in nine out of the 56 children complaining of the midfoot pain of unknown etiology.[14] It is interesting that of these nine children, only four had radiographs at the time of first hospital visit to the hospital. In place of scintigraphy, ultrasound can also be used in such cases to establish the presence of an occult fracture.[16]

Plain radiographs (anteroposterior [AP], lateral, and medial oblique) are the baseline investigation. On the AP view, the medial and lateral columns can be adequately evaluated. The lateral view can be helpful in assessing the congruency of the calcaneocuboid joint. The oblique view best assesses the integrity of the tarsometatarsal joints. Imaging of the contralateral side can be performed for comparison when there is doubt. Stress and weight-bearing views can be obtained to rule out instability. Computed tomography scans can give further details of the fracture or better evaluate inter-osseous instability, while, in occult fractures, magnetic resonance imaging or scintigraphy can be used to visualize the fracture.

Classification of Cuboid Fractures

In clinical practice, cuboid fractures are most commonly classified according to the anatomic element involved. This often represents an arbitrary classification of a descriptive nature. Cuboid fractures can be described as stable or unstable, simple or comminuted, intraarticular or extraarticular, displaced or undisplaced or crush.

The Orthopedic Trauma Association has proposed a classification system dividing cuboid fractures (denoted as 76) into 3 main categories [Figure 3].[17,18] According to this classification, cuboid fractures can be extraarticular (Group A), involving either of the calcaneocuboid or metatarsocuboid joint (Group B) or represent complex injuries involving both major joint surfaces (Group C). This classification further subdivides these fractures according to their complexity, plane, and the part of the bone involved. Each group is denoted with numbers, and the higher the number, more significant is the nature of the injury. Group C fractures, in particular, represent significant crash injuries of the bone that involve the articular surfaces and can be either undisplaced (Type 1) or displaced (Type 2).

Despite the efforts to define the integrity and stability of the bone, a classification system that could guide surgeons in the appropriate management and predict the clinical outcome following these injuries does not exist.

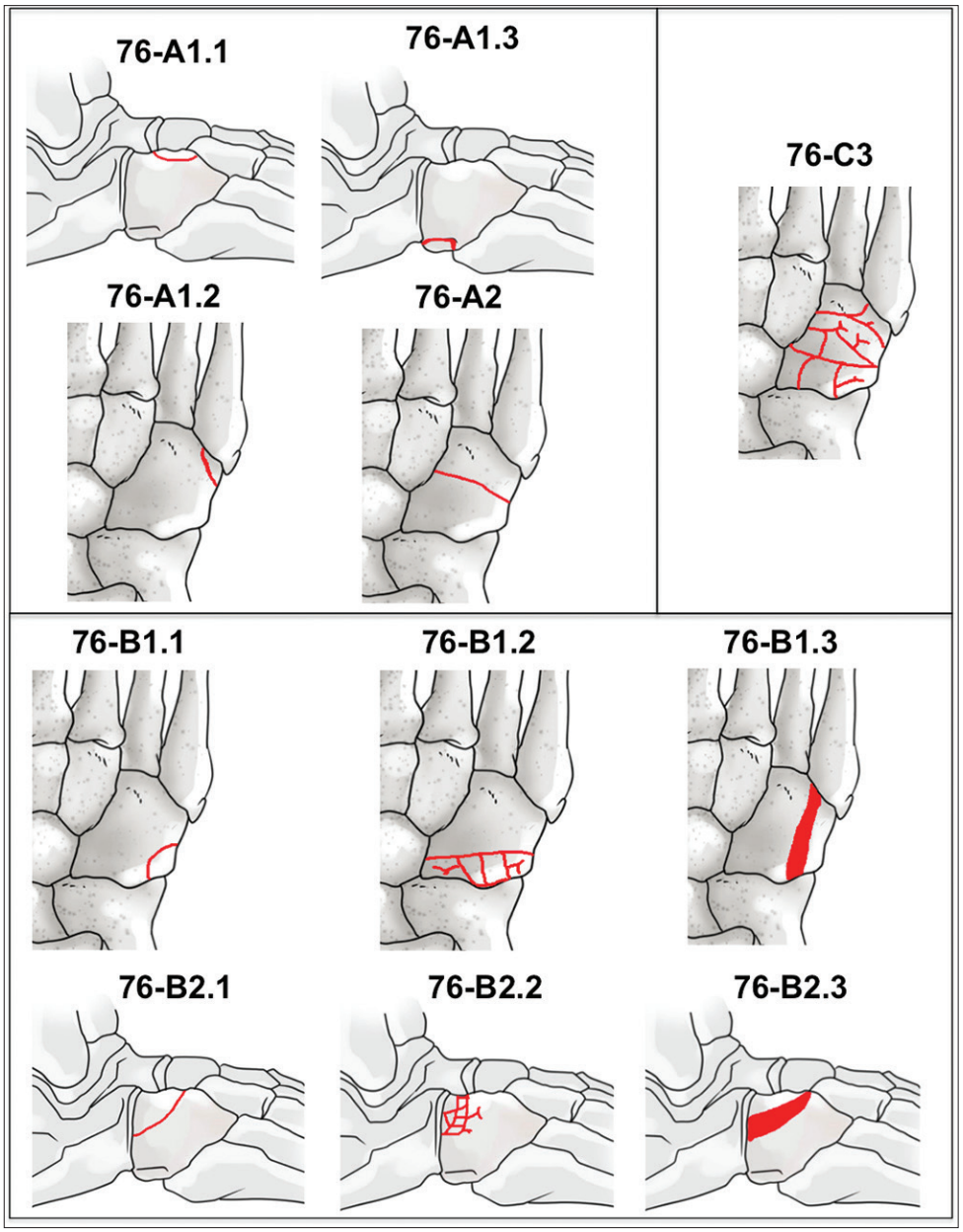

Figure 3: Orthopaedic Trauma Association classification of cuboid fractures

Treatment

The principle behind the surgical intervention for cuboid fractures is to maintain the length of the lateral column and restore the congruency of the articular surfaces. As the majority of these injuries are simple extraarticular fractures, surgical treatment is rarely required. Similarly, these injuries in children are treated conservatively, unless they represent part of major foot trauma.

Cortical avulsion fractures can be allowed to weight bear as tolerated in a walking boot. Late instability is a risk with these injuries, and hence, these patients should be followed till they are asymptomatic. Undisplaced fractures of the cuboid can be managed with nonweight bearing for 4–6 weeks in a well-molded below knee cast. Followup at 2 weeks with weight bearing or stress X-rays can be obtained to exclude the presence of an occult fracture, ligamentous injury or subluxation. With the improvement in the pain on clinical examination, the patient can be allowed to gradually weight bear.

Surgical treatment is reserved for compressed and intraarticular fractures and aims to restore the articular congruency and length of the bone. Bone grafting is often required as cancellous bone impaction is a common finding with these fractures.[19] The fixation can be achieved with the use of K-wires, 2.7 mm or 3.5 mm interfragmentary screws together with a mini-plate or the use of an external fixator.[13,19,20] The surgical incision is at the lateral border of the of the extensor Brevis muscle which will allow a good

exposure of the dorsolateral aspect of the bone. A distractor or external fixator can be used to restore the length of the lateral column (proximal pin on the calcaneus and distal pin at the 5th or/and 4th metatarsal).[21] The external fixator can be left in place for 6–8 weeks to facilitate healing and counteract the compressive forces exerted on the bone. In cases of cuboid subluxation or dislocation, the reduction can be achieved with the use of a threaded K-wire together with the use of an external fixator. The reduction can be maintained with either K-wires or screws running across the calcaneus and lateral cuneiform.

Postoperatively, the leg can be placed in a neutral cast for 6 weeks to minimize the compression forces exerted on the bone. Weight bearing should be avoided until bony and ligamentous stability is clinically evident. After 6 weeks, the leg can be placed in a walking boot, gradually building up the weight-bearing status. In cases where K-wires or an external fixator is used, these should be removed at 6–8 weeks.

A number of complications can be seen following the treatment of cuboid fractures. Pain, stiffness, and instability, reduced length of the lateral column and degenerative arthritis can occur.[19] Coalition with other midfoot bones can result in stiffness.[19] A reduction in the length of the lateral column would require lengthening with the use of bone grafting. Arthritic changes in the calcaneocuboid joint can be treated with fusion. Lateral column tarso-metatarsal osteoarthritis can severely limit a patient's mobility and lifestyle.[19,21] Treating these degenerative changes with bony fusion often leads to the poor functional outcome; tendon or ceramic interposition arthroplasty could allow some movement and provide pain relief.[21,22] Other complications following these fractures include loss of foot arch, osteonecrosis, pronation deformity and wound complications following surgery. Nonunion of the cuboid is rare and only reported as isolated case reports.[23]

Surgical Fixation: Outcomes

The majority of the evidence reporting on the functional outcomes following cuboid fracture fixation comes from case reports [Table 1].[1,9,19,20,23-29] The outcomes presented by these studies are favorable. In two small case series involving four patients each, the authors reported no complications and good function postoperatively.[23,27] Weber and Locher, analyzed the short outcomes of 12 patients treated surgically for cuboid fractures.[19] The authors reported no complications but noted a residual articular step in two patients and early degenerative arthritis in four cases. Interestingly, residual disability was reported in nine patients, but complaints were associated with the extent of initial trauma and concomitant injuries. Yu *et al*. reported similar results in a case series of six patients.[26] The authors reported fair results in four patients and good in two patients.

Discussion

The cuboid is a vital part of the lateral column, and fractures can disrupt the mechanical alignment and function of the whole foot. These injuries are merely found in isolation and are most often seen in complex midfoot injuries.[30,31] Sharma *et al*. have shown that the nutcracker fracture cannot occur in isolation but should be associated with other midfoot trauma, especially of the medial column.[32] Regarding the surgical management of these injuries, there is a general agreement that the disruption of the articular surface and loss of lateral column length are the most important decisive factors that one should consider before making a decision on how to manage these injuries. It is largely unknown how much cuboid length loss is acceptable or what size articular step is significant. However, once the need for surgery is established, open reduction and internal fixation with the use of mini-plates, and screws is a well-accepted method of fixation. Alternatively, external fixator could be used to maintain the length and alignment with satisfactory results.[21]

Based on our experience, we feel that these injuries are nearly never isolated injuries. They occur in association with Lisfranc injuries or other complex midfoot injuries [Figure 4]. Our decision making process is based on two findings as follows: (a) loss of 2 mm of lateral column length and (b) articular incongruency of >1 mm. The main goal is to restore the length of the cuboid; once this is achieved some articular congruence will be present. It is of interest that following reduction; there is often a significant bone void which can be considered for bone grafting. We appreciate there are advocates favoring fixation of the cuboid bone with plates. Our experience has shown that screw purchase is usually poor. For this reason, following restoration of the cuboid length and articular congruency, we use a bridging plate from calcaneus to the 4th metatarsal. Such approach provides optimum mechanical support promoting fracture healing. We understand that there might be advocates of nonoperative management or primary fusion for displaced cuboid fractures. Nonetheless, we feel that dealing with these injuries early could minimize the long term consequences associated with these fractures.[1,30,31]

Overall, the management of cuboid fractures is largely based on personal experience and beliefs. No high level of evidence is currently available to allow any safe recommendations. Examining the available literature, it should be noted that the clinical outcomes from the larger series are not as favorable as the ones presented in case reports. We believe that bigger scale studies comparing the outcome of primary arthrodesis versus bridging plating or external fixation or open reduction and internal fixation for severely comminuted fractures are needed. Hopefully, with the accumulation of more evidence, we may be able to shed some light in this area and allow clinicians and patients to make well informed decisions.

Table 1: Selected studies reporting outcome following cuboid fracture fixation

Study, year	Type of study	Demographics	Type of fracture	Surgical plan	Outcome
Sangeorzan *et al*., 1990[17]	Case series	4 patients, 3 male/1 female	Isolated cuboid fractures	K-wires and/or screws, bone grafting	No complications and good functional outcome
Brown and Rees, 1992[25]	Case report	45 female, inverted foot	Depressed proximal surface	Elevation of depression and bone graft, no metalwork used	Complete recovery
Hunter and Sangeorzan 1996[9]	Case report	33 male	Cuboid fracture and avulsion fracture of navicular	Bone grafting and calcanocuboid fusion	N/A
Kolker *et al*., 2002[28]	Case report	44 male	Complex midfoot injury with cuboid subluxation	ORIF	Full recovery at final followup
Weber and Locher, 2002[19]	Case series	12 patients, 7 male	Dorsolateral impaction of tarsometatarsal joints in 11 patients	ORIF with bone graft	No intra or postoperative complications
			Isolated or combined crush injury in 5 patients		OAFAS midfoot score 86, patients with low score complaints regarding associated injuries
					Residual articular step in 2 patients, 4 cases of early degenerative arthritis
					Residual disability in 9/12 patients
Manoj-Thomas and Gadgil, 2006[29]	Case report	58 male	Isolated cuboid fracture	Closed reduction and K-wires	No complications and good ankle and subtalar movement
Hermel *et al*., 2008[1]	Case report	26 female, RTA	Compression fracture, CC widened	Reduction with kyphoplasty balloon, not metalwork	Patient was lost on followup, but fracture reported healed at 10 weeks
van Raaij *et al*., 2010[27]	Case series	4 patients, 2 female/2 male	Isolated cuboid fracture requiring fixation	K-wires and calcium sulphate beads	No complication encountered
					Good function, mean OAFAS 84
					Minor pain complaints
Yu *et al*., 2012[26]	Case series	6 patients, 2 female/4 male	4 76-C1, 1 76-B1.2 and 176-B1.3>2 mm shortening in 5 cases	ORIF with bone graft	Fair results in 4 patients, good in 2
					1 superficial infection
Fenton *et al*., 2016[20]	Case series	192 fractures in 188 patients	Avulsion fractures 48%, extra-articular 13%, intraarticular 7%, tarsometatarsal 18%, lateral column 6%, bi-columnar 7%	Surgical management in 21 patients (ORIF in 19, Ex-fix in 2)	N/A
Ohmori *et al*., 2016[24]	Case Report	61 male, fall from 50 cm	Lateral column shortened by 6.5 mm. 3.5 mm depression of the tarsometatarsal joints	Joint surfaces and depressed fragments were elevated, bone graft used, LIPUS used, no metalwork used	At 6 months the patient could walk without pain

CC=Calcaneo-cuboid joint, N/A=Not available, ORIF=Open reduction and internal fixation, LIPUS=Low-intensity pulsed ultrasound, OAFAS=American Orthopaedic Foot and Ankle Score

Figure 4: (a) Computed tomography image, sagittal view of left foot demonstrating compression type injury of cuboid in association with other ipsilateral foot injuries. (b) Lateral radiograph; (c) anteroposterior radiograph; (d) Oblique radiograph of left foot at 12 month postoperative followup showing healing of 1st, 2nd, 3rd and 4th ray tarsometatarsal injuries that were reduced and stabilized with anatomical locking plates and screws

Conclusion

Cuboid fractures are rare injuries. The published literature supports the view that surgical fixation should only be attempted in cases where disruption of the articular surface and loss of lateral column length occurs. Evidence of the long term functional outcomes and ideal management of these fractures is lacking.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Hermel MB, Gershon-Cohen J. The nutcracker fracture of the cuboid by indirect violence. Radiology 1953;60:850-4.
2. Court-Brown CM, Zinna S, Ekrol I. Classification and epidemiology of mid-foot fractures. Foot 2006;16:138-41.
3. Worsham JR, Elliott MR, Harris AM. Open calcaneus fractures and associated injuries. J Foot Ankle Surg 2016;55:68-71.
4. Yu G, Yu T, Yang Y, Yuan F. Old nutcracker fracture of cuboid. Indian J Orthop 2013;47:310-2.
5. Main BJ, Jowett RL. Injuries of the midtarsal joint. J Bone Joint Surg Br 1975;57:89-97.
6. Bonnel F, Teissier P, Colombier JA, Toullec E, Assi C. Biometry of the calcaneocuboid joint: Biomechanical implications. Foot Ankle Surg 2013;19:70-5.
7. Ouzounian TJ, Shereff MJ. *In vitro* determination of midfoot motion. Foot Ankle 1989;10:140-6.
8. Yu SM, Dardani M, Yu JS. MRI of isolated cuboid stress fractures in adults. AJR Am J Roentgenol 2013;201:1325-30.
9. Hunter JC, Sangeorzan BJ. A nutcracker fracture: Cuboid fracture with an associated avulsion fracture of the tarsal navicular. AJR Am J Roentgenol 1996;166:888.
10. Martin C, Zapf A, Herman DC. Cuboid syndrome: Whip it good! Curr Sports Med Rep 2017;16:221.
11. Patterson SM. Cuboid syndrome: A review of the literature. J Sports Sci Med 2006;5:597-606.
12. Marshall P, Hamilton WG. Cuboid subluxation in ballet dancers. Am J Sports Med 1992;20:169-75.
13. Ebizie AO. Crush fractures of the cuboid from indirect violence. Injury 1991;22:414-6.
14. Englaro EE, Gelfand MJ, Paltiel HJ. Bone scintigraphy in preschool children with lower extremity pain of unknown origin. J Nucl Med 1992;33:351-4.
15. Senaran H, Mason D, De Pellegrin M. Cuboid fractures in preschool children. J Pediatr Orthop 2006;26:741-4.
16. Enns P, Pavlidis T, Stahl JP, Horas U, Schnettler R. Sonographic detection of an isolated cuboid bone fracture not visualized on plain radiographs. J Clin Ultrasound 2004;32:154-7.
17. Sangeorzan BJ, Swiontkowski MF. Displaced fractures of the cuboid. J Bone Joint Surg Br 1990;72:376-8.
18. Fracture and dislocation compendium. Orthopaedic Trauma Association Committee for Coding and Classification. J Orthop Trauma 1996;10 Suppl 1:v-ix, 1-154.
19. Weber M, Locher S. Reconstruction of the cuboid in compression fractures: Short to midterm results in 12 patients. Foot Ankle Int 2002;23:1008-13.
20. Fenton P, Al-Nammari S, Blundell C, Davies M. The patterns of injury and management of cuboid fractures: A retrospective case series. Bone Joint J 2016;98-B: 1003-8.
21. Russell DF, Ferdinand RD. Review of the evidence: Surgical management of 4th and 5th tarsometatarsal joint osteoarthritis. Foot Ankle Surg 2013;19:207-11.
22. Berlet GC, Hodges Davis W, Anderson RB. Tendon arthroplasty for basal fourth and fifth metatarsal arthritis. Foot Ankle Int 2002;23:440-6.

23. Britton E, Fazal MA. Nonunion of an isolated cuboid fracture: A case report. J Am Podiatr Med Assoc 2013;103:233-5.
24. Ohmori T, Katsuo S, Sunayama C, Mizuno K, Ojima T, Yamakado K, *et al.* A case report of isolated cuboid nutcracker fracture. Case Rep Orthop 2016;2016:3264172.
25. Brown JN, Rees AJ. Depressed fracture of the cuboid. A case report and a method of treatment. Foot 1992;2:173-5.
26. Yu G, Yu T, Yang Y, Li B, Yuan F, Zhou J, *et al.* Nutcracker fracture of the cuboid: Management and results. Acta Orthop Belg 2012;78:216-9.
27. van Raaij TM, Duffy PJ, Buckley RE. Displaced isolated cuboid fractures: Results of four cases with operative treatment. Foot Ankle Int 2010;31:242-6.
28. Kolker D, Marti CB, Gautier E. Pericuboid fracture-dislocation with cuboid subluxation. Foot Ankle Int 2002;23:163-7.
29. Manoj-Thomas A, Gadgil A. Nutcracker fracture of the cuboid: A case report. Eur J Orthop Surg Traumatol 2006;16:178-80.
30. Dewar FP, Evans DC. Occult fracture-subluxation of the midtarsal joint. J Bone Joint Surg Br 1968;50:386-8.
31. Tountas AA. Occult fracture-subluxation of the midtarsal joint. Clin Orthop Relat Res 1989;243:195-9.
32. Sharma S, Dhillon MS, Sharma G, John R. Nutcracker cuboid fractures are never isolated injuries. J Foot Ankle Surg (Asia Pacific) 2014;1:9-11.