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Original Article

Cuboid fracture: surgical treatment, midterm follow-up, and management algorithm

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Abstract

Objectives: Describe the epidemiology of cuboid fracture, the mechanisms of injury and associated injuries, the progression to osteoarthritis, and propose a surgical management algorithm.

Methods: A retrospective and descriptive study of patients with cuboid fractures operated on between 2009 and 2014. The variables analyzed were age, sex, mechanism of injury, classification, associated fractures, and osteoarthritis changes, among others.

Results: Twenty-seven patients were included: 19 men and eight women. The mean age was 41.3 years (range 25 - 62). The mean follow-up was 3.3 years. The mechanisms of injury were motor vehicle accidents and falls from height. Among the patients, 44.4% had lateral column shortening, and 81.5% involved calcaneal cuboid articular surface. Cuboid locking plates were used in 15 patients, and single screw fixation was used in four patients. Three patients required a bone graft. Degenerative changes were observed in calcaneocuboid and cuboid-metatarsal joints.

Conclusions: Cuboid fracture is an uncommon injury. In general, the injuries are caused by high-energy accidents. In our study, 40.7% of patients had an injury to the medial column. It is recommended the use of a cuboid locking plate for comminuted fractures, screw fixation for simple fractures, and a bridging plate or external fixation can be considered for most complex cases.

Level of Evidence IV; Retrospective Case Series.

Keywords: Cuboid fracture; Internal fixation; Open reduction; Chopart injury.

Introduction

Cuboid fracture is an infrequent rare injury. In the United Kingdom, an annual incidence of 1.8/10,000 is reported[1]. Classically, there are two mechanisms of injury: compressive or "nutcraker" and distractive or avulsion injury. There are also isolated cuboid fracture cases reported in the literature[2-5]. Its occurrence can generate other consequences, such as foot lateral column shortening with a secondary flat foot[6].

The Orthopaedic Trauma Association (OTA) classification describes two types of cuboid fracture: simple and comminuted[7]. Generally, the literature supports the conservative treatment of the nondisplaced cuboid fracture[8]. On the other hand, different methods for managing displaced injuries or with articular involvement are described, and there is no clear consensus in the literature about these treatments[2,5,6,9-11].

The objectives of this study are to describe the epidemiology of cuboid fracture, the mechanisms of injury and associated injuries, the progression to osteoarthritis, and propose a surgical management algorithm.

Methods

A retrospective and descriptive study (case series) based on clinical records and image files. This study was approved by the Institutional Review Board.

The database of patients admitted to our institution who required surgery to manage a cuboid fracture was reviewed.

The imaging study consisted of pre-and postoperative radiographs in anteroposterior (AP), lateral (L), and oblique views of the affected foot and pre-and postoperative

Study performed at the Hospital Clínico Mutual de Seguridad, Santiago, Chile.

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computed tomography (CT) scans (Impax PACS, AGFA HEALTHCARE, Mortsel, Belgium).

All patients were operated on with open reduction and internal fixation. A dorsolateral approach was used centered on the cuboid, and as required, it extended proximally to the tip of the fibula and distal to the fourth metatarsal base. Three different types of osteosynthesis were used according to fracture pattern: screws, locking plates, or bridging plates.

After surgery, the patient was instructed to use a cam walker boot, non-weight bearing, range of motion exercises, and foot raise. Sutures were removed after three weeks to start rehabilitation.

Results

Twenty-seven patients (19 men, eight women) with a mean age of 41.3 years (range: 23-62 years) with a diagnosis of displaced cuboid fracture were admitted and operated on. Most patients (25/27, 92.5%) were working compensation (Table 1).

In our series, two patterns or types of fracture related to articular involvement of calcaneocuboid joint or cuboid-metatarsal joint: fracture with involvement of one articular surface (13 patients), fracture with involvement of two articular surfaces (14 patients) were identified. There were no cases without articular compromise. Lateral column shortening was observed in 12 patients (44.4%). Twenty-two patients (81.5%) had associated midfoot injuries. The most frequent injuries were navicular fracture (11 patients), Lisfranc injury (10 patients), and six with cuneiform fracture (Figure 1).

Regarding the mechanisms of injury, the most frequent were motor vehicle accidents, falls from height, and crushing. Three cases required bone grafts due to severe bone loss and articular surface without a reconstruction option.

The mean radiological follow-up was 3.3 years (0.3 to 10.5). Fracture healing was observed in 100% of patients. Regarding the type of osteosynthesis used, 20 patients used locking plates: 15 used an anatomical cuboid 2.4 locking plate, and five used a locking 2.4/2.7 mm T plate. Three patients required a bridging plate and bone graft due to several comminution of the cuboid and articular surfaces. Four patients used only 2.7 screws. One patient required a temporary external fixator due to soft tissue involvement.

The type of osteosynthesis used was related to the fracture pattern observed. Due to this observation, a simple treatment algorithm was used for cuboid fracture management:

- **Type 1**: **Simple Fracture:** this is a fracture without comminution.
- **Type 2: Comminuted Fracture**: was divided into three types:
  - **Type 2A: Central comminution;**
  - **Type 2B: Articular comminution;**
  - **Type 2C: Burst fractures**.

Additionally, type 2B was subclassified into two types regarding the possibility of performing a stable reduction and fixation of the articular surface or not:

- **Type 2B: Articular comminution:**
  - **Type 2B1**: synthesizable articular surface;
  - **Type 2B2:** not synthesizable articular surface.

Due to this, the specific type of osteosynthesis and the need for bone grafts were according to the classification shown. As an example, the following cases are shown.

Case 1. A 23-year-old woman's left foot was crushed by a car wheel, resulting in a cuboid fracture with no reconstructable distal cuboid articular surface and body comminution (Figure 2). It was classified as a type 2B2 fracture. Resection of the bone and cartilage comminution were performed at the time of surgery, then an iliac crest structural autograft with preservation of periosteum was applied as cuboid-metatarsal joint surface reconstruction (Figure 3), and fixation performed with an anatomic cuboid locking plate (Figures 4 and 5).

Case 2. A 49-year-old woman suffers a forced inversion of her left foot. The CT scan (Figure 6) showed a cuboid fracture involving the calcaneal articular surface (Fracture Type 2B1). In the lateral approach to the cuboid, the articular

Table 1. Distribution of patients according to sex, injury mechanism, and fracture type

Variable	Value
Age (median)	41.3 y (range 23 - 62)
Sex	
Male	19
Female	8
Injury Type	
MVA	6
Fall from height	6
Crush	7
Sprain	8
Fracture pattern	
Partial articular involvement	14
Biarticular involvement	13

MVA: Motor vehicle accident.

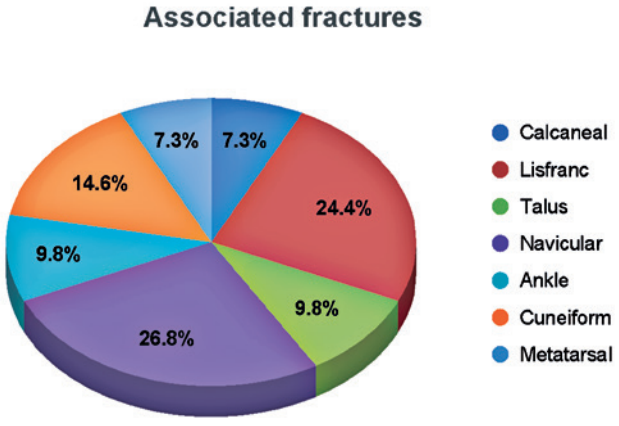

Figure 1. Associated fractures.

fragments were reduced temporarily with 1.6 Kirschner wires. The reduction was verified by direct vision using fluoroscopy. Once proper reduction was achieved, the fixation was performed with a locking cuboid plate. Postoperative control with a CT scan showed a satisfactory joint facet reduction (Figure 7).

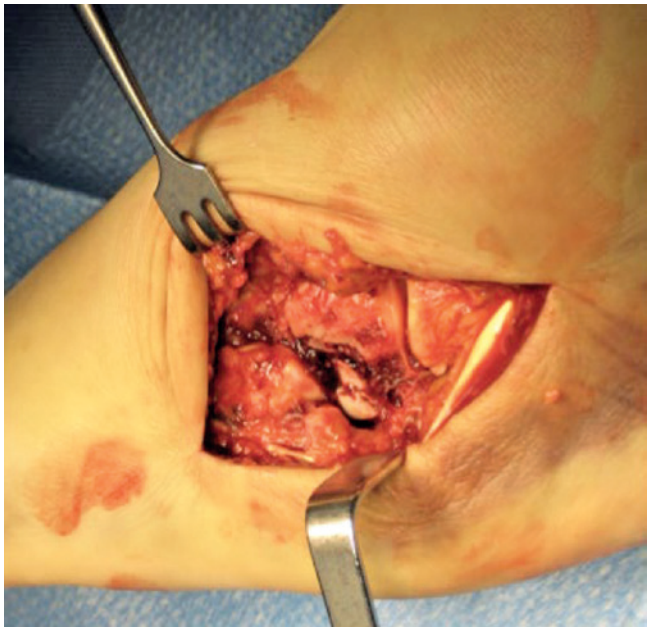

Figure 2. Cuboid fracture with no reduction distal cuboid articular facet.

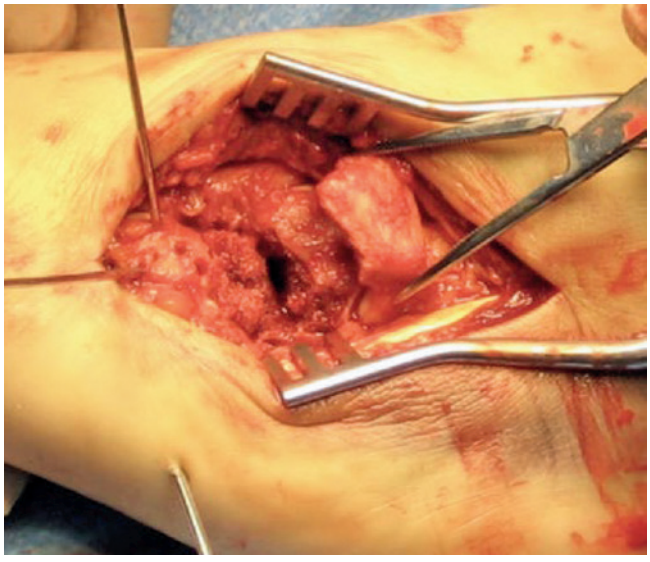

Figure 3. Iliac crest structural autograft, with preservation of periosteum, applied as cuboid-metatarsal joint surface reconstruction.

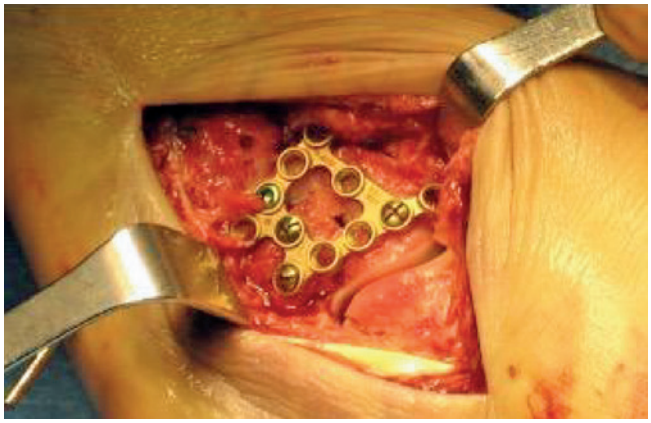

Figure 4. Cuboid fixation performed with an anatomic cuboid locking plate.

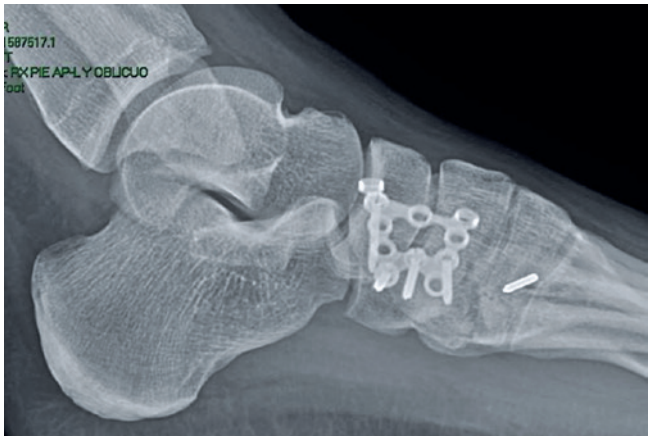

Figure 5. Postoperative radiograph showing reduced cuboid fracture.

Figure 6. Preoperative CT scan: cuboid fracture involving the calcaneal articular surface.

Figure 7. Postoperative CT scan with articular reduction.

At 3.3 years of follow-up, 81.5% of the patients showed signs of arthritis on radiographs, such as narrowing articular space, osteophytes, and geodes, among others. These signs were more frequent in those patients presenting with cuboid-metatarsal joint involvement (94.4%) vs. those the fracture compromised the joint facet with the calcaneus (55%).

One case of superficial wound infection required serial dressing changes and oral antibiotics. Another patient required plastic surgery coverage due to a poor soft tissue envelope caused by the initial injury (truck crash).

The treatment algorithm schematized in Table 2 is presented to standardize the management of the cuboid fracture. The type of osteosynthesis was suggested according to the type of fracture and joint involvement. The suggestion included the use of isolated screws for simple fractures, locking plates for more comminuted fractures, and bridging plates or external fixation for those high-energy burst fractures with articular destruction. For cases with articular involvement, the feasibility of reduction and osteosynthesis of the articular surface must be evaluated. If possible, a locking plate and central structural graft are suggested to support the reduction. If it was not possible to reduce the facet, it was proposed that an iliac crest graft with periosteum be used to replace the compromised joint surface. It is believed that it is a simple and reproducible algorithm, understanding that there may be cases where it is necessary to perform other procedures to achieve an adequate result.

Discussion

The cuboid fracture is an uncommon injury. In a retrospective series of 155 patients with midfoot fractures, Richter et al.[12] found 58 cuboid fractures. Shibuya et al.[13], in an epidemiological analysis of more than 280,000 foot and ankle fractures, report a 2.7% (n = 7,659) incidence of cuboid fracture.

Classically, two mechanisms of injury have been described: compression or "Nutcracker" and distractive or avulsive[14,15]. Also, isolated cuboid fractures have been reported in the literature[2-5]. Sangeorzan[2] in 1990 reported four cases of cuboid fracture treated surgically. In 2001, Miller[3] described the case of a patient treated non-surgically, and Van Raaij et al.[5] published their findings on four patients treated with internal fixation.

Usually, the nutcracker fracture would be more related to high-energy injuries[15,16]. Hermel and Gershon-Cohen described this fracture as caused by cuboid compression between the bases of the fourth and fifth metatarsals and the calcaneus due to plantar-flexion forces[15]. In our series, 27 patients had this type of fracture. No avulsion fractures were found in our sample. All patients had joint involvement of one or both articular surfaces. This could be because, in our study, 70.3% of the patients (19 of 27) presented high-energy mechanisms: falls from height, motor vehicle accidents, or crushing. In the literature, there are few reports of nutcracker fractures. Yu et al.[11] showed the results of a series of six patients with this type of fracture, while in another series, Weber and Locher[10] published their results in 12 patients with a mean follow-up of 27 months. In 10 years, Holbein[9] treated four patients with this type of fracture. Fenton et al.[17] described 12 patients with nutcracker fractures, of which three were submitted to cuboid open reduction and internal fixation and two with an external fixator.

The most frequent is that the cuboid fracture is accompanied by other foot injuries[6,14-16,18,19]. Hermel and Gershon-Cohen[14], in 1953, published five cases of nutcracker-type cuboid fractures, describing four associated injuries. Ten of the 12 patients in the series published by Martin Weber[10] had associated injuries. Our results are in line with the literature. Twenty-four of the 27 patients (88.9 %) presented associated midfoot injuries; the most frequent were navicular, Lisfranc, and cuneiform fractures. As previously noted, these findings are likely related to the high-energy mechanism in our series. Given this frequent association, a complete image study with AP, lateral and oblique radiographs, and a CT scan of the affected foot are indispensable in patient evaluation, along with a detailed physical examination.

Table 2. Management algorithm

Type 1 Simple fracture (non comminution)	**Type 2** Comminuted			
	Type 2A Central comminution	**Type 2B** Articular comminution		**Type 2C** Burst fractures
		Type 2B1 synthesizable articular surface	**Type 2b2** non synthesizable articular surface	
Without bone graft RAFI with screws	Central bone graft RAFI w/locking plate	Reduction articular surface Structural graft RAFI w/locking plate	Resection articular small pieces Iliac crest bone graft w/periosteum RAFI w/locking plate	Iliac crest bone graft w/periosteum External fixation or bridging plate

The cuboid fracture can compromise the integrity of the lateral column, composed of the calcaneus and fourth and fifth metatarsals[15,16]. The lateral column is the moving column of the foot[20,21]. It allows, among others, mechanical properties to improve stability in irregular surfaces and the absorption of energy in the stance phase of the gait cycle[15,20]. The cuboid fracture may lead to a lateral column shortening, which could generate a secondary flat foot[6,15]. It is, therefore, necessary to manage this injury to correct this shortening and restore the articular surface of the cuboid. For injuries without displacement, in general, the literature supports the conservative treatment[8]. Furthermore, different methods for managing displaced or articular compromise injuries have been described, and there is no clear consensus in the literature[2,5,6,9-11,17]. Sangeorzan[2] recommended the reduction and internal osteosynthesis for the injuries displaced or with comminution. In his report, Sangeorzan showed four cases and used different osteosynthesis according to the specific case: Kirschner wires, screws alone, or plates. In the series of 12 patients published by Weber[10], in eight patients, one or two plates were used, and in four just screws as a method of fixation. In our study, most patients required a plate for osteosynthesis: 20 of 27. A bridging plate was needed in three cases. As noted, 100% of our cases presented a compromise of one or both joint facets, usually with some degree of comminution. We believe that using a locking plate allows a fixation in the fracture reconstruction of the cuboid, obtaining the stability of the construct, which could improve consolidation and recovery of this area. This stability would allow for earlier rehabilitation than using a less stable fixation.

The use of bone grafts and which one to use are controversial topics in the literature. In seven of 12 cases presented by Martin Weber[10], an iliac crest graft was used to improve the bone support. Sangeorzan[2] used grafts in three of the four patients. In a more recent study, Yu et al.[11] used allograft without specifying how many patients required it. Holbein[9], in two of the four cases, required an iliac crest graft. In our series, three patients required an iliac crest graft. In the three cases, the cortical aspect of the graft replaced the articular surface of the cuboid, given the irreparable damage it presented. The replacement allowed a sort of "rebuilding" of this joint, thereby maintaining the length of the lateral column and avoiding the acute arthrodesis of the cuboid-metatarsal joint.

Osteoarthritis is another complication associated with this type of injury when the articular surfaces are compromised [5,6,15,16,22,23]. Howie[22] reported that four of five patients presented symptomatic osteoarthritis of the calcaneocuboid joint. On the other hand, Van Raaij[5], in a mean follow-up of 2.8 years, reported three patients with arthritis signs that did not require surgical management. In the Weber[10] series, with a mean follow-up of 27 months for the four patients with calcaneocuboid joint compromised, one presented signs of osteoarthritis. On the other hand, the same author points out that of the 11 patients with tarsometatarsal involvement, two presented symptomatology; they say that a longer follow-up was necessary. In our series, some differences were found compared with the literature. At 3.3 years follow-up, 81.5% of the patients showed signs of osteoarthritis on the control radiograph. These signs were more frequent in patients presenting cubo-metatarsal joint involvement vs those in which the fracture compromised the joint facet with the calcaneus (94.4% vs. 55%, respectively). A possible explanation for this finding is that they presented joint involvement with varying degrees of comminution in all cases. In addition, the joint articular surface was replaced in three cases with periostic iliac crest autograft. The involvement of this joint and the greater mobility of the lateral column could explain the progression of arthritic changes in these joints.

Our study has limitations, such as the retrospective case series design and the midterm follow-up, which should be complemented with a longer follow-up period to establish more definitive results.

Conclusion

Cuboid fracture is an infrequent injury and should be considered a complex injury given its importance in the conformation of the lateral column of the foot and its implications in the biomechanics of the gait cycle. There is an important association with other injuries, which it must rule out with the physical examination and the image analysis of both radiographs and CT scans. We present a management algorithm for this injury based on a long series of cuboid fractures, which we believe are simple to reproduce.

Authors' contributions: Each author contributed individually and significantly to the development of this article: FVG *(https://orcid.org/0000-0002-4283-2900) Conceived and planned the activity that led to the study, wrote the article, participated in the review process; LLS *(https://orcid.org/0000-0002-7010-7490) data collection, bibliographic review; MPH *(https://orcid.org/0000-0002-0859-6975) formatting of the article, bibliographic review; CUB *(https://orcid.org/0000-0002-2328-2835)interpreted the results of the study, participated in the review process; JBG *(https://orcid.org/0000-0001-9018-7021), and CBS *(https://orcid.org/0000-0001-8049-5098) Performed the surgeries; data collection, statistical analysis. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

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