The patterns of injury and management of cuboid fractures

A RETROSPECTIVE CASE SERIES

Aims
Although infrequent, a fracture of the cuboid can lead to significant disruption of the integrity of the midfoot and its function. The purpose of this study was to classify the pattern of fractures of the cuboid, relate them to the mechanism of injury and suggest methods of managing them.

Patients and Methods
We performed a retrospective review of patients with radiologically reported cuboid fractures. Fractures were grouped according to commonly occurring patterns of injury. A total of 192 fractures in 188 patients were included. They were classified into five patterns of injury.

Results
Type 1 fractures (93 fractures, 48.4%) are simple avulsion injuries involving the capsule of the calcaneo-cuboid joint. Type 2 fractures (25 fractures, 13%) are isolated extra-articular injuries involving the body of the cuboid. Type 3 injuries (13 fractures, 6.8%) are intra-articular fractures solely within the body of the cuboid. Type 4 fractures (35 fractures, 18.2%) are associated with disruption of the midfoot and tarsometatarsal injuries. Type 5 fractures (26 fractures, 13.5%) occur in conjunction with disruption of the mid-tarsal joint and either crushing of the lateral column alone or of both medial and lateral columns.

Fractures with significant articular disruption or with loss of length of the lateral column underwent fixation. This involved either internal fixation to restore the anatomy of the cuboid and/or restoration of the length of the columns with bridging constructs using internal or external fixation.

Conclusion
A classification system for fractures of the cuboid is proposed in relation to the mechanism of injury. The treatment of these fractures is described.

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Fractures of the cuboid are relatively uncommon with a reported annual incidence of 1.8 per 10 000 in the United Kingdom. Although they can occur in isolation, they may form a component of a more complex injury involving the whole of the midfoot and hindfoot, due to the intimate anatomical and mechanical relationships of the surrounding structures. To date, no system of classification of these specific injuries is in common use and there are no long term reports of outcomes following fractures of the cuboid.

The cuboid has six surfaces. Anteriorly two facets articulate with the fourth and fifth metatarsals, the medial surface articulates with the lateral cuneiform and occasionally the navicular, the posterior surface with the calcaneum. The dorsal surface is bare. The plantar surface has the peroneal sulcus anteriorly and contains attachments of the long and short plantar ligaments. As a result, the bony architecture of the cuboid forms an essential contribution to overall function of the foot. The articulation between the cuboid and the fourth and fifth metatarsals makes the largest contribution to dorsiflexion and plantar flexion of the midfoot and also a primary contribution to pronation and supination. The calcaneo-cuboid joint makes a further contribution to pronation and supination. Thus any disturbance of the articular relationships of the cuboid can lead to a profound disruption of the movement and biomechanics of the midfoot.

Moreover, both the static and dynamic function of the foot are influenced by the integrity of the cuboid. Loss of length of the lateral
column results in abduction of the forefoot and planus deformity with compensatory eversion of the hindfoot.4

The current literature on fractures of the cuboid consists of case series describing the patterns of injury and their management and involve either isolated fractures5,6 or more commonly to the cuboid in relation to complex injuries involving either the mid-tarsal joint or the tarsometatarsal joints.7,8 Although the AO/OTA classification system includes fractures of the cuboid, it only distinguishes between comminuted and simple fractures.9 There remains no commonly used classification system to describe injuries to the cuboid or mid-tarsal joint and little long-term outcome data following these injuries.

Our main purpose is to describe the pattern of fractures of the cuboid seen within a Foot and Ankle unit of a Major Trauma Centre and to provide a classification system for these injuries. We have attempted to correlate the patterns of these fractures with the mechanisms of injury. Additionally, we have described the rationale of treatment and principles in dealing with these fractures and have reviewed the current literature relating to the outcomes following such varied injuries.

Patients and Methods
Our institution is a tertiary teaching hospital and the Major Trauma Centre for the region serving a population of approximately 1.8 million. We manage the whole spectrum of foot and ankle injuries as well as receiving complex referrals from outlying units. This was a retrospective study of records over a six-year period beginning in January 2008. All plain radiographs and CT scans of the extremities are routinely reported by dedicated musculoskeletal radiologists in our institution, and we performed a search of the Patient Archive and Communication System (Impax PACS, AGFA HEALTHCARE, Mortsel, Belgium) for radiology reports containing the terms “cuboid” and “fracture” for both plain radiography and CT images. We excluded patients with chronic or fatigue injuries. All imaging was then reviewed and the patterns of injury were identified and grouped together. Details of any subsequent operations were recorded from the theatre records.

Results
A total of 192 fractures of the cuboid in 188 patients were identified. They could be divided into five broad groups ranging from simple avulsion fractures to injuries involving the midfoot (Fig. 1). Their frequency, mechanism, treatment, and outcomes as described in the current literature are summarised in Table I.2,5,8,10,11

Type 1 - avulsion fractures. The most common pattern of injury involves an avulsion from the cuboid, adjacent to the calcaneo-cuboid joint (Fig. 2). This was seen in 93 fractures (48.4%). These occur with inversion of the hindfoot and adduction of the forefoot combined with external rotation of the tibia resulting in avulsion of the calcaneocuboid portion of the bifurcate ligament.12 These patients were all managed symptomatically. No further imaging is required.

Type 2 - extra-articular fractures. There was a fracture of the cuboid which did not extend to involve the tarsometatarsal or calcaneocuboid joints in 25 feet (13%) (Fig. 3). These fractures represent injuries to the lateral column where the forces transmitted lead to failure of the cancellous bone of the body of the cuboid but are insufficient to produce additional bony injury elsewhere in the midfoot. Either this is as a result of an axial load transmitted through the fourth and fifth metatarsals or to an injury involving abduction of the forefoot relative to the hindfoot. In 13 feet, there was an associated avulsion fracture at the base of the fifth metatarsal. Most of these injuries involved a fracture of the body of the cuboid. None of these patients underwent surgical treatment as the length of the lateral column was maintained and the articulations of the cuboid were intact.

Type 3 - intra-articular fractures. A total of 13 patients (6.8%) sustained an isolated fracture of the cuboid involving the tarsometatarsal or calcaneocuboid joints in 25 feet (13%) (Fig. 3). These fractures represent injuries to the lateral column where the forces transmitted lead to failure of the cancellous bone of the body of the cuboid but are insufficient to produce additional bony injury elsewhere in the midfoot. Either this is as a result of an axial load transmitted through the fourth and fifth metatarsals or to an injury involving abduction of the forefoot relative to the hindfoot. In 13 feet, there was an associated avulsion fracture at the base of the fifth metatarsal. Most of these injuries involved a fracture of the body of the cuboid. None of these patients underwent surgical treatment as the length of the lateral column was maintained and the articulations of the cuboid were intact.

Type 4 - fractures with associated disruption of the tarsometatarsal complex. A total of 35 patients (18.2%) had a fracture of the cuboid with an associated injury affecting the tarsometatarsal complex. These involved extra-articular
injuries to the articulation of the cuboid with the fourth and fifth metatarsals. These injuries can result from a direct crush injury to the midfoot or as an indirect rotational injury. The cuboid fractures as the bases of the fourth and fifth metatarsals dislocate dorsally producing a shearing fracture through the dorsum of the cuboid (Figs 5 and 6).

Type 5 - fractures with associated mid-tarsal disruption. These fractures are subdivided into two further types dependent upon whether there is comminution and loss of length of the lateral column alone, or loss of length of both the medial and lateral columns.

Type 5(a), the crushing of the cuboid with disruption of the lateral column. A total of 12 (6.3%) patients sustained an injury to the lateral column when the forefoot was forcibly evverted on the hindfoot subjecting the cuboid to a compression injury. This produces a multi-fragmentary fracture with shortening of the lateral column. It is seen in conjunction with an avulsion injury of the navicular tuberosity (Fig. 7). Three of these feet were managed by internal fixation of the cuboid, with one patient also requiring stabilisation of the avulsion of the navicular. A further two were managed by restoration of the length of the lateral column using an external fixator from the calcaneum to the shaft of the fifth metatarsal (Fig. 8). The remainder of this group, where the length of the lateral column was maintained and the articular surfaces congruent, were managed non-operatively with immobilisation and protected weight-bearing for six weeks followed by progressive weight-bearing and mobilisation.

Table I. Summary of the types of fracture of the cuboid, the frequency, mechanism of injury, treatment and outcomes from the literature

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Frequency (%)</th>
<th>Mechanism</th>
<th>Treatment</th>
<th>Outcomes (with reference)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Avulsion</td>
<td>48.4 (93/192)</td>
<td>Hindfoot inversion with forefoot adduction</td>
<td>Non-operative</td>
<td>Not previously described</td>
</tr>
<tr>
<td>2</td>
<td>Extra-articular</td>
<td>13 (25/192)</td>
<td>Axial load lateral column</td>
<td>Non-operative in our series</td>
<td>Not previously described</td>
</tr>
<tr>
<td>3</td>
<td>Intra-articular</td>
<td>6.8 (13/192)</td>
<td>Axial load across tarso-metatarsal or calcaneocuboid joint</td>
<td>ORIF +/- bone graft if articular depression</td>
<td>Mean AOFAS score 84 at 2.8 yrs$^5$</td>
</tr>
<tr>
<td>4</td>
<td>Tarsometatarsal</td>
<td>18.2 (35/192)</td>
<td>Midfoot rotation with lateral ray impaction on cuboid</td>
<td>ORIF tarsometatarsal complex, cuboid treatment as Type 3</td>
<td>Mean AOFAS score 82 at midterm follow-up$^6$</td>
</tr>
<tr>
<td>5a</td>
<td>Lateral column</td>
<td>6.3 (12/192)</td>
<td>Forefoot eversion on hindfoot</td>
<td>Restore lateral column length with ORIF or ex-fix</td>
<td>Mean AOFAS score 77.2 at 14 mths$^{10}$</td>
</tr>
<tr>
<td>5b</td>
<td>Bi-columnar</td>
<td>7.3 (14/192)</td>
<td>Axial load with midfoot extended</td>
<td>Restore medial and lateral column length and relationship with ORIF/bridge plating or external fixation</td>
<td>Mean AOFAS score 72$^{2}$</td>
</tr>
</tbody>
</table>

ORIF, Open Reduction Internal Fixation; AOFAS, American Orthopaedic Foot and Ankle Society Score$^{11}$
Type 5(b) was a crush fracture of the cuboid with disruption of the lateral and medial columns.

A total of 14 patients (7.3%) sustained an injury to the mid-tarsal joint with disruption of both the medial and lateral columns (Fig. 9). This was produced by a high energy axial load with the midfoot extended, resulting in gross disruption of the mid-tarsal joint and multi-fragmentary fractures of both the navicular and cuboid. In ten feet dislocation of the mid-tarsal joint was associated with comminution of the navicular and cuboid. In all, four of these were treated by temporary stabilisation to allow soft tissue recovery; this was achieved in three with an external fixator and in one with Kirschner (K)-wires. Of these 14 patients, fixation of the medial column was undertaken in all but one. In two cases this was performed with retrograde screws introduced from the first metatarsal to span the medial column. Restoration of the medial column was achieved in the remaining 11 patients using a plate either from the talus or the navicular to the medial cuneiform. In all, four of these were treated by temporary stabilisation to allow soft tissue recovery; this was achieved in three with an external fixator and in one with Kirschner (K)-wires. Of these 14 patients, fixation of the medial column was undertaken in all but one. In two cases this was performed with retrograde screws introduced from the first metatarsal to span the medial column. Restoration of the medial column was achieved in the remaining 11 patients using a plate either from the talus or the navicular to the medial cuneiform. Eight of the 14 patients required internal fixation to reconstruct the navicular. Six of the 14 patients had stabilisation of the lateral column, using external fixation in two (Fig. 10), a plate from calcaneum to the cuboid in three and screws to the lateral column in one.

Discussion

In this retrospective study, we describe the patterns of injury associated with fractures of the cuboid and have outlined how these injuries were managed in our institution. The strength of this study lies in the large number of fractures which we have treated and the significant proportion of fractures of the cuboid that are associated with injuries to the midfoot. We have proposed a practical classification which includes the spectrum of fractures involving the cuboid and the differing strategies for treatment of these injuries. Being a retrospective study, there are inherent limitations, principally an absence of outcome measures. However, this was not the primary aim of the study.

The study was completed in a tertiary referral Major Trauma Centre which may mean that the number of higher energy injuries (Types 4, 5a & 5b) was disproportionately represented. Nonetheless, the principles of treatment are unaffected by this bias, although we acknowledge that there is limited evidence to support the efficacy of the forms of treatment which are described. However, Pinney and Sangeorzan outlined the principles of management of midfoot injuries, particularly the importance not only of restoring the anatomical relationships, but also the lengths of the medial and lateral columns.

Avulsion injuries (Type 1) were the most common type of fracture in our study. These most commonly involve the calcaneocuboid joint. Andermahr et al. described a treatment algorithm for calcaneocuboid ligament injuries based on a varus stress radiograph, with patients in whom there was a large flake of bone and a calcaneocuboid angle > 10° requiring fixation. To our knowledge, there are no studies reporting outcomes following Type 1 fractures.

Isolated extra-articular fractures (Type 2) form a small proportion of the injuries. None of these injuries required fixation, possibly as the forces required to produce sufficient disruption to the lateral column as to necessitate fixation would have resulted in fractures elsewhere in the foot. A significant proportion of these patients had an associated avulsion fracture of the fifth metatarsal. Presumably, as the base of the metatarsal is avulsed, impaction on the cuboid
leads to failure of the body of the cuboid in compression. To our knowledge, this pattern of injury has not been described before and its significance in relation to long term outcome is unclear.

Similarly, isolated intra-articular injuries (Type 3) represent a small proportion of the injuries (6.8% in our series). None of the patients with this type of fracture required surgery as articular congruence and the length of the columns were maintained.

The management of isolated fractures of the cuboid has been described by a number of authors. Sangeorzan and Swiontkowski described four patients with displaced isolated fractures of the cuboid who underwent internal fixation. Three fractures were intra-articular and required cancellous bone graft in addition to internal fixation. They reported satisfactory clinical and radiological outcomes without formal outcome measures. The precise indications for surgery were not discussed. In the study by van Raaij et al four patients who underwent surgery for an isolated fracture of the cuboid are described. Fixation was obtained with threaded K-wires. Depressed articular fragments were elevated and supported with calcium sulphate beads. At mean follow up of 2.8 years the American Academy of Foot and Ankle Surgery (AOFAS) score was 84 points (67 to 100). Three patients had degenerative joint changes on radiographs at follow-up but none required further surgery.

We have divided fractures of the cuboid seen as part of complex injuries of the midfoot into three groups (Types 4, 5a and 5b). Ramelt, Grass and Zwipp have described a classification of mid-tarsal fracture/dislocations based on the pathomechanics and the direction of the dislocating force, identifying six types.

Type 4 injuries in our series are those associated with tarsometatarsal injuries. The tarsometatarsal components of these injuries were managed according to established principles. A total of three of 35 feet with type 4 injuries had displacement of the cuboid which was thought to be enough to warrant internal fixation. In Weber and Locher’s series of 12 patients, two had tarsometatarsal dislocation and four had an associated metatarsal fracture. The fractures of the cuboid were also managed with open reduction and internal fixation. At a follow-up of between 12 to 47 months the mean AOFAS score was 82 points (67 to 100). Only one patient, however, was reported as being pain free.

In Type 5 injuries, the mid-tarsal joint is disrupted in association with the fracture of the cuboid and there is disruption of the lateral column (Type 5a) or of both the medial and lateral columns (Type 5b). Type 5a fractures have previously been described as “nutcracker” fractures. In our group of patients with Type 5a fractures, five of 12 underwent surgery with internal fixation in three and external fixation to restore the length of the lateral column in two. Various authors in review articles emphasise the significance of restoration of the length of the lateral column and articular congruence; however, there are few reported outcomes in these patients. Yu et al described internal fixation of “nutcracker” fractures in six patients. The indication for surgery was shortening of the lateral column by > 1 mm; all were treated by internal fixation with allogenic bone graft. Four patients had a fair outcome and two a good outcome in relation to pain and function at a mean follow up of 14 months.

Type 5b injuries involve shortening of both columns owing to a high energy axial load through the midfoot. This results in disruption of the mid-tarsal joint with multi-fragmentary fractures of both the navicular and cuboid with or without varying degrees of mid-tarsal subluxation. Little is reported regarding the long-term outcome of these injuries. Schildhauer, Nork and Sangeorzan described the technique of medial bridge plating with reconstruction of the lateral column, as required, in patients with crush injuries to the midfoot. They reported no complications in seven patients. A total of three patients in Weber and Locher’s series sustained a fracture of the cuboid with a burst fracture of the navicular and two reported persistent pain at follow-up between 12 and 47 months. The mean AOFAS score was 89 points (77 to 100) in these three patients. Richter et al described the outcome following mid-tarsal fracture/dislocations in 60 feet treated over a 25 year period with mean follow-up of nine years. They emphasised the importance of an anatomical reduction and fixation to achieve good results. The outcomes in nine patients with mid-tarsal joint injuries were described by van Dorp et al. The mean AOFAS midfoot score was 72, four had persistent pain and disability at a mean follow up of 31.3 months.

We have presented the largest study of fractures of the cuboid to date. In so doing, we have attempted to provide a practical classification system which highlights that some of these fractures can occur as part of more significant injuries which require careful radiological investigation and complex management. We have correlated the type of fracture with the mechanism of injury and, where relevant, have outlined the surgical management and outcomes as described in the current literature. Future work should look at the long-term outcomes of fractures of the cuboid and complex mid-foot injuries which are treated operatively and non-operatively to help resolve uncertainties of management and the long-term outcome.

Take home message:
This is the largest series of cuboid fractures described and provides a classification system that emphasises the significant midfoot injuries that can be associated with cuboid fractures.

Author contributions:
P. Fenton: Initial concept, Data analysis, Writing the paper.
S. Al-Nammari: Data collection, Writing the paper.
C. Blundell: Preforming surgeries, Writing the paper and editing paper.
M. Davies: Performing surgeries, Writing and editing the paper.

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References


