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Review

Fractures of the anterior process of the calcaneum; a review and proposed treatment algorithm

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ABSTRACT

Background: There remains a lack of recognition of these fractures, which leads to a delay in diagnosis and appropriate management.
Methods: A comprehensive literature search was performed. Following inclusion and exclusion criteria, 23 studies were available for analysis.
Results: Delay in diagnosis is common and has a negative impact on outcome. If an APC fracture is suspected; anteroposterior, lateral and oblique plain radiographs should be requested. Further investigation with computed tomography or magnetic resonance imaging is indicated if plain radiographs are inconclusive and patient remains symptomatic. Non-operative measures are usually adequate for most undisplaced fractures, however surgical intervention maybe required for large, intra-articular fractures in the acute setting and for non-union.
Conclusions: A treatment algorithm is suggested that may help with the diagnosis and management of these injuries.
Level of evidence: Level IV.

Contents

Introduction

A fracture of the anterior process of the calcaneus (APC) can often co-exist with a lateral ankle ligament injury. Patients may complain of lateral pain distal and anterior to the tip of the fibula. Due to the high incidence of injuries to the anterior talofibular ligament (ATFL), whose anatomical location is in close proximity to

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the APC, an accurate assessment of these injuries can be difficult, unless a high index of suspicion is exercised. However, with a focused examination and appropriate investigations a fracture of the APC may be identified. Due to the high incidence of misdiagnosis or delayed diagnosis, it is difficult to ascertain the real incidence of this injury.

Anatomically the APC projects from the anterior aspect of the calcaneus towards the navicular bone, with the inferior distal aspect of the process articulating with the cuboid bone [1]. It may be of variable shape and size, with some individuals having a short and stout process whilst others are long and slender [2]. The process acts as the point of insertion for both the bifurcate ligament (joining the cuboid and navicular with the anterior process of the calcaneus) and the extensor digitorum brevis muscle (EDB).

A fracture of the APC is thought to occur from one of two mechanisms. An inversion motion of the plantar-flexed ankle is thought to increase stress at the insertion of the bifurcate ligament, with subsequent avulsion of a fragment of bone from the APC [3]. Thus, some believe this to mean that the injury is simply a chopart joint sprain. An alternative mechanism of injury is a forced dorsiflexion motion with the foot in eversion, with subsequent compression of the APC between the cuboid and the talus. This fracture is most commonly seen in females in their third to fourth decades [1], which has not been explained in the literature, however the authors postulate this may be a result of wearing high heeled shoewear.

Degan et al. [4] described a classification system for APC fractures based on the amount of fracture displacement and calcaneocuboid joint (CCJ) involvement. Type I fractures are non-displaced avulsion fractures with no CCJ involvement, with type II being displaced fractures but still no CCJ involvement, and type III fractures demonstrating displacement and CCJ involvement.

It is apparent that symptoms can persist for many months or even years. It is for this reason that these injuries present a challenge. Unfortunately, there is no clear consensus in the foot and ankle surgical community as to the correct management of these fractures once identified.

We performed a literature review to try and establish the appropriate investigation and management of APC fractures.

Methodology

A comprehensive literature search was performed, with no time limit to maximise the pool of work available, conforming to the PRISMA statement. The databases used were PubMed, CINAHL and EMBASE. The terms used for searching were; 'anterior calcaneus', 'fracture', 'anterior process', 'calcaneus', 'fracture' and 'management of' in human studies. This resulted in 590 articles. The article abstracts were reviewed, and those that were not involving humans, the management of APC fractures, nor had English translation if original articles were not in English were excluded. The search found a literature review of extra-articular calcaneal fractures [5], which provided further articles that were included, providing 23 studies available for analysis (Table 1).

Results

History and examination

Diagnosis of fractures of the APC is often delayed, due to the presentation mimicking an ankle sprain and the clinician not suspecting the injury. The patient will often present acutely with lateral foot pain, associated with swelling and ecchymosis. A detailed, focussed examination will localise the pain to the sinus tarsi or dorsal aspect of the CCJ with palpation of the inverted and plantarflexed foot. This will help differentiate pain associated with this injury from other soft tissue injuries. With an APC fracture the patient is specifically tender to digital palpation at a point level, and two centimetres anterior, to the tip of the lateral malleoli [4,6,7]. A delay in diagnosis, or to acknowledge the suspicion of an APC fracture, and to instigate initial immobilisation can lead to significant morbidity. Bradford and Larsen [7] reported that those patients who were diagnosed early and had appropriate treatment (non-weight-bearing and support with either a cast or elastic bandage) had a shorter average length of disability (7.5 weeks). In the nine cases that had delayed diagnosis or inappropriate initial management the average length of disability was four to six months [7].

Investigations

As these injuries are rarely suspected, inappropriate imaging may be requested or a minimally displaced fracture of the APC may not be recognised despite adequate views [8,9]. A common mistaken diagnosis is that of an os calcaneum secondarium, which is an accessory bone that demonstrates smooth, well corticated margins. It may be that the APC fracture may not be visible due to obstruction from the head of the talus [7]. With plain radiographs, these injuries are best assessed on a lateral or oblique foot view. If plain radiographs are not conclusive despite suspicion of an APC fracture, further investigation with magnetic resonance imaging (MRI), computed tomography (CT) or nuclear medicine bone scan may aid diagnosis (Figs. 1 and 2).

CT and MRI modalities have been reported to be of use for the assessment of fracture configuration, fracture displacement, joint involvement and localising an avulsed fragment [1]. MRI may be advantageous in detecting subtle or non-displaced fractures, and determining whether healing of the fracture is taking place, as well as identifying associated soft tissue injuries. With MRI, APC fractures are characteristically seen as a vertical linear hypo-intensity on T1 and T2-weighted images traversing the APC [10]. The sagittal plane is ideal for identifying APC fractures. CT imaging has proven beneficial in identifying the small avulsed fragments [1]. The use of ultrasonography (USS) has been reported [1] as a useful modality to visualise avulsed fragments, as well as assessing the bifurcate ligament, lateral collateral ligament complex of the ankle and the talonavicular ligament.

The use of local anaesthetic infiltrated to the area of discomfort has a diagnostic role in these injuries [6,11], particularly if appropriately targeted with imaging.

Management

The papers that were reviewed utilised differing outcome measures, typically descriptive terms for symptoms and the period of disability. To allow analysis of the results it was important to group the outcomes (Table 2). If the patients had persistent pain and/or swelling that caused disability their outcome was recorded as residual pain/swelling. Outcomes that were described as either asymptomatic, no disability, uneventful, residual or intermittent swelling/pain but not enough to warrant further medical advice were grouped into the satisfactory group. Patients that reported the ability to return to all pre-injury activities and/or sport activities were combined together.

Non-operative

The mainstay of management of these injuries is a period of immobilisation with a below-knee cast, brace or elastic bandaging. The period of immobilisation has varied within and between studies, and several papers suggest this lack of consensus and mobilisation too early contributed to non-union.

Table 1
Results from literature search.

Paper	Year	No. of patients	Management	Outcome	Average follow-up (months)	Time to surgery (months)
Christopher [20]	1931	3	2 non-operatively non-weightbearing, 1 weightbearing on crutches	2 satisfactory, 1 still in pain at 18 months	2 weeks–18 months	Not applicable
Bradford and Larsen [7]	1951	26	Non-operative	No diagnosis delay average disability 7.5 weeks, delayed diagnosis average disability lasted 4–6 months	Not documented	Not applicable
Gellman [17]	1951	6	Non-operative	Satisfactory, mild residual discomfort and swelling	3.25 (1.5–4.25)	Not applicable
Backman and Johnson [18]	1953	20	Non-operative	18 satisfactory, 2 residual discomfort but not enough for medical attention	6	Not applicable
Levine et al. [19]	1954	1	Delayed open excision	Asymptomatic	36	7
Garvin and Rominger [13]	1957	12	Non-operative	9 asymptomatic by 14 months, 3 not documented	Not documented	12 h–1.25 months
Dell [12]	1958	12	Non-operative	Symptoms settled after 2–8 months in those treated with immobilisation	6–96	Not applicable
Carey et al. [21]	1965	32	Non-operative	31 satisfactory (1 had asymptomatic n on-union)	72	Not applicable
Hunt [22]	1970	1	Open reduction and internal fixation	Satisfactory, back to running	12	12 h
Degan et al. [4]	1982	25	18 non-operative	Non-operative all resolved symptoms	Non-operative 9 years (1–23 years)	12.9 (5–24)
			7 delayed open excision	2/7 operative no symptom relief	Operative 4.1 years (1–10.6 years)	
Renfrew and El-Khoury [2]	1985	7	Non-operatively	3 uneventful, 4 not documented	5.6 weeks (4–8 weeks) for 3 patients	Not applicable
Hodge [23]	1998	1	Patient non-complaint, treated self with weightbearing in flat shoe for 3 weeks and then low heel shoe	Persistent swelling and intermittent pain	6	Not applicable
Robbins et al. [24]	1998	5	Non-operatively, 1 delayed excision	3 evidence of bone healing after early immobilization, 1 non-union, 1 fibrous union (excision case)	3–24	9
Trnka et al. [6]	1998	1	Delayed open excision	Satisfactory	12	10
Frey et al. [16]	2005	1	Delayed arthroscopic excision	Resolution of pain	12	10
Pillai et al. [25]	2005	1	Open reduction and internal fixation	Satisfactory, back to activities	24	48 h
Nilsson and Coetzee [8]	2006	1	Conservative	Excellent, back to activities	4	Not applicable
Pearce et al. [9]	2011	1	Open reduction and internal fixation	Excellent, return to full elite sports at 6/12	12	1.25
Lui [15]	2011	1	Symptomatic nonunion, endoscopic excision	Back to sports at 6/12	27	24
Ochman et al. [26]	2011	5	Open reduction and internal fixation. 3 delayed diagnosis	All fractures healed radiologically. Full functional recovery	29	Not documented
Kim et al. [27]	2012	12	Simple excision	10 excellent to good and return to sports	44.83 (15–120)	11.17 (2–24)
Taketomi et al. [14]	2013	1	Freshening of non-union site	Returned to sporting activities by 6 months	6	6
Halm and Schepers [11]	2016	6	Delayed open excision	4 complete resolution, 2 partial resolution	5.3 (3–9)	10 (6–14)

Of the 23 studies analysed, there were 181 reported cases of APC fractures; with 142 treated non-operatively and 126 of these patients reporting a satisfactory outcome (Table 2). One of the largest series of APC fractures was reported by Degan et al. [4], with 18 patients undergoing non-operative management with an average follow up of nine years (range of 1–23 years). All 18 patients reported a satisfactory clinical outcome, but it took an average of 101 weeks (range 3 weeks–60 months) to achieve this level. Dell [12] reported a series of 12 patients managed with non-operative management with all the patients having resolution of symptoms within a range of two to eight months. The satisfactory outcome was reinforced by a 12 patient series reported by Garvin and Rominger [13]. Nine patients reported relief of symptoms within a range of six weeks to 14 months with non-operative measures. Each study reported differing treatment regimens and the period of remaining symptomatic varied significantly. The authors warn that recovery from APC fractures may take longer than expected and patients may continue to have chronic mild symptoms.

Operative

The operative options are dependent on whether the presentation is acute or chronic, the surgeons experience and preference, as

Fig. 1. Anteroposterior and lateral plain radiograph demonstrating difficulty in assessing the anterior process of the calcaneus (APC).

Fig. 2. CT scan demonstrating APC fracture.

well as the size of the fracture fragment. The surgical procedure may be an open reduction and internal fixation (ORIF) of the fracture, or excision of the fracture fragment with either an open or arthroscopic approach.

There were 39 patients who underwent surgical management of their APC fracture from our literature review; 22 of which were delayed and only 17 were performed acutely. As Table 2 demonstrates 13 out of 17 patients reported they could return to sporting activities after acute ORIF and another two had a satisfactory outcome. With delayed surgery four out of 22 patients had residual symptoms and 15 had a satisfactory outcome. The delayed surgery group all underwent excision of the fracture fragment except one case described by Taketomi et al. [14]. These authors drilled the site of non-union with a 1.5 mm kirschner wire through an open incision. After four weeks of immobilisation the patient was allowed weightbearing, with improvement in pain after six weeks, able to do jogging at eight weeks and at six months had returned to sports with CT evidence of good union.

The technique of arthroscopic excision of the fracture fragment [15,16] was advocated to reduce operative morbidity and chronic symptoms associated with open surgical excision in those with delayed surgery.

Only a small number of papers documented the type of APC fracture, with type III described in 13 of the operative group, eight type II fractures and one type I fracture. The time for recovery from

Table 2
Summary of results from literature search.

Outcome					
Treatment	Residual pain/swelling	Satisfactory	Return to all activities/sports	Not specified	Number of patients
Acute surgery	–	2	13	2	17
Delayed surgery	4	15	2	1	22
Non-surgical (immobilisation)	2	126	1	11	140
Non-surgical (weightbearing)	2	–	–	–	2
Number of patients	8	143	16	14	181

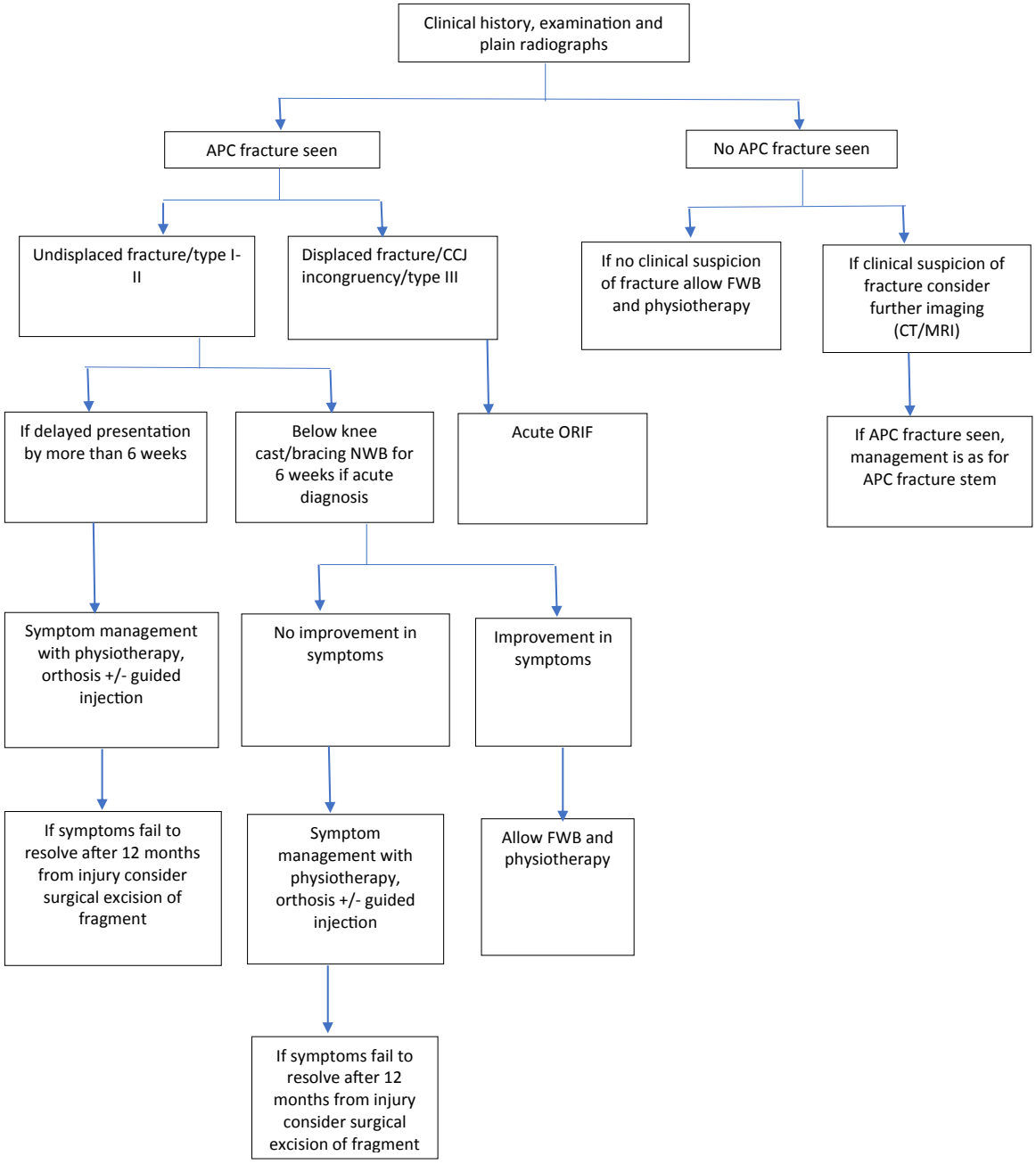
operative intervention maybe variable [4], however this may also be related to the delay to surgery, as there have been encouraging results from early surgical intervention [9]. As with the non-operative group, there was variability in the operative technique and postoperative protocol, as well as outcome measurements which makes it difficult to compare data.

Discussion

A fracture of the APC has been described as less significant than a sprain [17,18], and an avulsion type injury, whilst others claim it may cause long-term disability [4]. Treatment protocols have ranged from applying a bandage for two weeks, non-weight bearing cast immobilisation for four weeks, fixation of the fracture and excision for non-union of the fracture if the pain fails to settle [4]. The ineffectiveness of managing these injuries with strapping and physiotherapy was highlighted by Levine et al. [19].

There are no specific guidelines for the management of these injuries, with limited evidence in literature due to the rarity of its presentation. Whilst ORIF of large type III injuries can be considered in the acute setting, the majority of APC fractures can be successfully managed with cast immobilisation [4,15] whilst symptomatic, followed by physiotherapy. If symptoms fail to resolve with non-operative measures, these patients may require surgery. However, if there is delayed presentation of patients or delay in diagnosis, non-operative management is often futile as the symptoms typically

Table 3
APC treatment algorithm.



APC, anterior process of calcaneum; CCJ, calcaneocuboid joint; FWB, full weight bearing; CT, computed tomograthy; MRI, magnetic resonance imaging; NWB, non-weight bearing; ORIF, open reduction and internal fixation.

result from delayed or non-union of the fracture. Surgical excision of the non-united fragment may be required.

The series reported by Degan et al. [4] demonstrated that the type III fractures tend not to unite with non-operative treatment and non-union resulted in persistent symptoms requiring surgical excision of the fragments. Thus, the size and amount of displacement of the fracture may be the most reliable prognostic factor for this injury [15]. It is important to note that patients with these injuries should not be expected to be asymptomatic after six weeks of cast immobilisation, and the decision to perform surgery should not be rushed [4]. This was reiterated in other studies [13,16] that stated that despite adequate treatment of these fractures, patients may still have persistent pain for a variable period of time. With patients who have sustained a traumatic injury there could be damage to the neighbouring structures that can mask an APC fracture or if not treated appropriately may affect outcome [15]. Associated injuries may include fractures of the talus, calcaneus and navicular, as well as soft tissue injuries such as anterior talofibular ligament tears [10].

There is a lack of long-term studies evaluating the outcomes following operative intervention, with only a few small series and case reports in literature, with all configurations of fractures and mechanisms grouped together. Thus, there has been little evidence to substantiate acute operative intervention for these fractures apart from large type III fractures involving the CCJ. The concern with non-operative intervention for type III fractures is that if the fragment displaces into the CCJ it may cause cartilage damage and subsequent arthrosis [6].

Appropriate and timely diagnosis of this injury will avoid inadequate treatment of the fracture, such as early mobilisation, that leads to non-union and persistent symptoms [2,13,15,16]. The authors aim to increase the awareness of these injuries, and thus reduce the risk of misdiagnosis or delayed diagnosis. A treatment algorithm based on the evidence in literature and the authors experience is suggested (Table 3) to aid emergency medicine and orthopaedic practitioners. Whilst the authors do attempt to draw conclusions from the literature available to formulate a treatment algorithm, it is acknowledged case reports or case series were included in the literature review. Also, it is important to highlight that the outcomes of the papers were combined in a subjective manner that may lead to misinterpretation. The authors attempted to group the outcomes in a transparent manner to allow analysis, however without the use of standardised outcome measures in the papers reviewed, there is a risk of misrepresentation.

Take home message

- Delay in diagnosis is common and has a negative impact on outcome (22 weeks average delay in diagnosis from literature). High index of suspicion with an accurate history (mechanism of injury) and examination (palpation over sinus tarsi and CCJ) is required in the acute setting.
- If APC fracture suspected, anteroposterior, lateral and oblique plain radiographs should be requested and APC inspected.
- If plain radiographs are inconclusive, further investigation with CT or MRI is required.
- Undisplaced and minimally displaced fractures can be managed initially with non-operative measures (non-weight bearing in below knee cast or boot for six weeks). If symptoms fail to resolve by six months, surgical excision may be warranted (on average 33% of patients required this from this review)
- Acute surgical intervention indicated for large type III fractures to restore joint congruence and prevent chopart joint collapse, stress fractures associated with coalition or lateral column shortening and elite athletes requiring early return to sports.

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Conflict of interest

The authors have no conflicts of interest to declare.

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