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Lateral Talar Process Fracture combined with Calcaneal Sustentaculum Tali Fracture. Case series and proposal of a possible mechanism of injury

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ABSTRACT

Background: Lateral Talar Process fracture in association with a Sustentaculum Tali frac-ture is very uncommon and needs a high clinical suspicion, a thorough clinical examination, and a careful radiological evaluation. The mechanism of this combined injury is not clear yet, as only a few references in a small number of case series exist.

Methods: We present a series of four patients sustaining a Lateral Talar Process fracture, with a Sustentaculum Tali fracture in two of them. All patients were treated operatively, either with open reduction and internal fixation or with arthroscopic excision of the frag-ments in one case.

Results: All fractures treated with internal fixation were united, with very good to excellent results. The mean American Orthopaedic Foot and Ankle Society hindfoot score was 93.6 and the mean Foot and Ankle Disability Index score was 89.3. All patients returned to their previous activities with mild, occasional pain in two of them.

Conclusion: An association of a Lateral Talar Process and a Sustentaculum Tali fracture was observed in half of the patients. The mechanism of the combined injury may involve axial loading and subtalar subluxation. Once the articular surfaces commence shifting, if the force responsible for the instability continues to exert, the combined injury may occur. Therefore, if one fracture is encountered, CT scan images should be methodically scrutinised for the presence of the other fracture, especially, in patients with a mechanism of injury involving snowboarding or a fall from a height.

LEVEL OF CLINICAL EVIDENCE: IV

KEY WORDS: Talus; Os Calcis; Lateral Talar Process; Sustentaculum Tali; Fracture; Mechanism of injury

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Introduction

Isolated Lateral Talar Process (LTP) fractures are rare injuries, first reported by Marottoli in 1942, as quoted by Nicholas et al. [1]. Hawkins in 1965 [2], classified LTP fractures into three types. Type I consisted of a single large fragment. Type II was a comminuted fracture whereas; type III was a small or "chip" fracture of the tip of the LTP (**Fig. 1**). Another clas-sification widely used is the one proposed by McCrory and Bladin in 1996 [3], who subdi-vided LTP fractures in chip fractures (type I); large-fragment fractures (type II) and com-mi-nuted fractures (type III).

These injuries were generally associated with motor vehicle accidents, falls from a height or inversion injuries [2]. Starting from the 70s, as snowboarding became more popular, an in-creased incidence of LTP fracture was reported in athletes participating in this sport. Kirk-patrick et al. [4] prospectively documented that in 3213 snowboarding injuries 2.3% were LTP fractures. The unexpectedly high incidence of LTP fracture in snowboarders led to the term “snowboarder’s fracture” [1].

On physical examination, patients with an LTP fracture usually present with point tender-ness and marked swelling on the lateral aspect of the ankle, just distal to the lateral malleo-lus. On standard radiographic examination, the fracture is difficult to be appreciated and needs a certain amount of awareness to identify it [5]. As a conse-quence, this injury is fre-quently misdiagnosed as a lateral ankle sprain and overlooked at the initial presentation [3,6,7].

As far as the treatment is concerned, if the frac-ture is not displaced, it may be treated with im-mobilisation in a boot or cast for 6-8 weeks [2]. For comminuted or displaced fragments more than 2 mm, surgical reduction and fixation of the fracture should be attempted [8-10]. If this is not possible, early excision of the fragment(s) should be performed [7,10]. Late or missed treatment, nonunion, malunion, and overgrowth are associ-ated with poor outcome resulting in pain, func-tional impairment and subtalar osteoarthritis [7].

On the other hand, isolated Sustentaculum Tali (ST) fractures are also uncommon and often missed upon the first presentation [11-13]. Due to the strong trabecular structure and thick cortical bone, solitary fractures of the ST without addi-tional calcaneal injuries occur in less than 1% of all calcaneal fractures [14]. More frequently, they are associated with fractures of the medial fac-et of the subtalar joint, subtalar dislocations, or they are a part of more complex os calcis fractures [15,16].

Patients with ST fractures present with pain on the medial aspect of the hindfoot just distal and anterior to the medial malleolus. Pain might be elicited by passively moving the great toe. In standard radiographs, it is difficult to diagnose an ST fracture [17]. Therefore, a high index of suspicion is needed, especially, in patients with a history of subtalar dislocation, talar fracture, midfoot injuries or a fall from a height. The di-agnosis is finally made by per-forming a CT scan, which not only helps identify the Sustentaculum fracture but also identi-fies additional injuries. Surgery is indicated if the fragment is displaced more than 2 mm, if the medial facet is depressed, if there is a tendon entrapment or if the fracture also involves the posterior facet of the calcaneus [14].

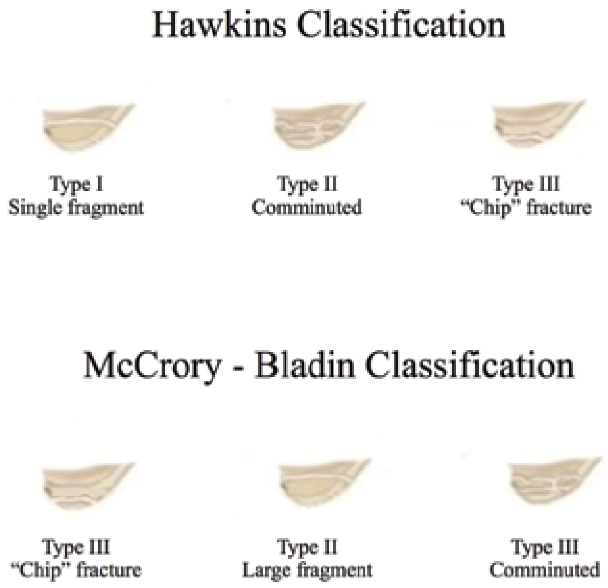

Fig. 1: Hawkins and McCrory - Bladin Classification

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Fig. 2: *Pre-operative CT Scan images. A and B) Large displaced LTP fracture in two pa-tients. C) Associated ST fracture in the third patient. D) Severely comminuted LTP fracture in the fourth patient.*

Materials and methods

Between August 2010 and May 2017, at our institution, we assessed four patients (all male) who sustained an LTP fracture associated or not with an ST injury.

They all complained about pain and inability to bear weight on their injured leg. After doc-umentation of the patients' demographic data and side of the injured foot, the mechanism of injury was inquired. A patient reported a twisting injury to his foot while playing football and three patients reported an axial impact of their foot after a fall from a height. Physical examination revealed marked swelling as well as point tenderness around the region of the lateral malleolus. The posterior tibial and pedal pulses were present, and no neurologic defi-cit was recorded. Standard anteroposterior and lateral radiographs of the ankle were taken. Due to irregularities at the contour of the LTP in both views, a CT scan was requested (**Fig. 2**). On the CT scan, a large displaced McCrory-Bladin type II LTP fracture was noticed in two patients. In one of them, due to the presence of a talar beak sign, further MRI was per-formed to rule out a concomitant tarsal coalition. In the other two patients, CT scan helped diagnose a combined injury; a comminuted relatively undisplaced McCrory-Bladin type III LTP fracture in association with a large ST fracture in one patient and a severely commi-nuted McCrory-Bladin type III fracture with a concomitant small avulsion ST fracture in the other. Their foot was temporarily immobilised in a back slab and placed on a Brown's splint.

Fig. 3: *LTP fragments after arthroscopic excision.*

All patients underwent surgery as soon as the swelling has subsided, no more than ten days. A tourniquet was placed at the thigh and was inflated at 300 mmHg. Prophylactic antibiotic was administered before the induction of anaesthesia.

Of the four patients, in three (75%), the LTP was accessed openly through a lateral hockey stick

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TABLE 1. *Patients' functional scores in relation to the fracture type at last follow up.*

	LTP Fracture Type[a]	ST Fracture	Treatment	AOFAS score	FADI score	Follow up (mo)
Patient I	Type II	No	ORIF	100	99	24
Patient II	Type II	No	ORIF	94	86.5	24
Patient III	Type III	Present	ORIF	87	82.4	60
Patient IV	Type III	Present	Arthroscopic Excision	N/A	N/A	5

[a]*McCrory-Bladin LTP fracture classification [3].*

incision, with the patients in a lateral decubitus position. The incision started two cm proximally and posteriorly to the tip of the lateral malleolus and ended two cm distally to the lateral malleolus. The calcaneofibular ligament was detached to visualise the fracture site.

In the patient with the associated tarsal coalition, the fragment was reduced and fixed with a staple, whereas, in the other patient with the McCrory-Bladin type II LTP fracture, the fragment was anatomically reduced and fixed with two cortical 1.5 mm mini-fragment screws. The calcaneofibular ligament was repaired, and the wound was irrigated and closed.

In the patient with the comminuted LTP and the combined ST fracture, the LTP fragments were minimally displaced and adequately big to consider internal fixation with three cortical 1.5 mm mini-fragment screws. The patient was then placed in a supine position, with the involved limb in a figure of four position. The concomitant ST fracture was accessed through a medial subtalar approach. After meticulous dissection and exposure of the frac-ture site, the fragment was stabilized with three cortical 1,5 mm mini-fragment screws. The deltoid ligament was reinforced, and the wound was closed in the standard fashion.

Finally, in the patient with the severely comminuted McCrory-Bladin type III fracture, the LTP fragments were excised arthroscopically. The patient was placed in a prone position. Superficial anatomic landmarks were drawn on the skin. Standard posterolateral and poster-omedial portals were created according to van Dijk [18] to access and remove an oversized os trigonum. An accessory lateral middle portal just distal and anterior to the tip of the fibu-la was created on the lateral foot as described by Frey et al. [19] to remove the fragments of the fractured LTP (**Fig. 3**). The concomitant ST avulsion fracture was considered too small to be removed or fixed.

Post-operatively, a back slab was applied, and prophylactic anticoagulation (Innohep 0.45 [Tinzaparin]; LEO Pharmaceutical Inc) was administrated for six weeks. At discharge, the back slab was exchanged with a full cast, and the patients were ordered not to bear weight. After three weeks, a walking boot was applied, and partial weight bearing of 15 to 20 kg was commenced. Patients began range-of-motion exercises avoiding inversion and eversion of the hindfoot. Progression to full weight bearing and muscle-strengthening exercises be-gun six weeks after surgery.

Results

At three months postoperatively, all patients were walking without crutches and reported no pain or disability and demonstrated full ankle and subtalar range of motion. The patient treated endoscopically, 5 months after surgery is very satisfied, full weight bearing without pain or instability and demonstrating full ankle and subtalar range of motion. For the re-maining patients, further follow-up was performed at 6 and 12 months after operation, and annually thereafter. The mean follow-up time was 28.25 months

Fig. 4: *Postoperative X-Rays at last follow up. Mild osteoarthritic changes at the subtalar joint can be observed in all patients treated with ORIF.*

(range, 5-60 months). Pa-tients were assessed clinically (pain, ankle and subtalar ROM) and radiologically. Evaluation of functional result was done using the American Orthopaedic Foot and Ankle Society (AOFAS) hindfoot score and the Foot and Ankle Disability Index [20,21].

At the most recent follow-up, the mean AOFAS score was 93.6 (range, 87 to 100) and the mean FADI score was 89.3 (range, 82.4 to 99; **Table 1**). One patient (33.3%) was extremely satisfied with the functional result, as he returned to the same level of activities before inju-ry, without reporting pain, swelling, or subjective limitation of hindfoot motion. The other two patients (66.6%) were very satisfied with the outcome, as they returned to their usual activities with having mild, occasional pain only during their recreational activities.

At radiological evaluation, in all patients treated with ORIF, fractures appeared united with-in six months after the surgery. At their latest follow-up (2 and 5.5 years after the injury) mild osteoarthritic changes at the talofibular joint and the medial talocalcaneal facets were observed (**Fig. 4**).

Discussion

An LTP fracture associated with ST fracture is a very rare injury, and there are only isolated references in a small number of case series.

F. von Knoch et al. [22] in 2007 documented one combined injury in 23 snowboarders with an LTP fracture. Mark Gatha et al. [23] in a small case series of 4 patients that sustained an ST fracture recorded one combined LTP fracture. Dürr et al. [14] in 2013 reported that over the course of 15 years, they treated operatively 31 patients for ST fractures. Accompanying injury to the LTP was seen in 23% of these patients. In our series, half of the patients had a combined fracture, although, no safe conclusions can be drawn, as the number of our cases is limited. Larger scale studies or retrospective analysis of existing series might reveal an increased incidence of this combined entity.

As far as the mechanism of the combined injury is concerned, it seems to be multifactorial and not fully defined. In literature, there are few reports describing the mechanism of each fracture in isolation and only scarce references of their association.

Sustentaculum Tali is the most stable part of the calcaneus, and high energy is needed to be fractured. It is a general belief that isolated ST fractures occur from axial loading and inver-sion of the hindfoot. Wuelker and Zwipp [13] by stud-

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ying the fracture anatomy of the axial-ly loaded calcaneus observed that with the hindfoot in inversion (varus) an isolated fracture of the sustentaculum could be produced. Gatha et al. [23] also report that the mechanism of injury seems to involve high-energy axial and varus loading with some component of rota-tion.

More controversy exists regarding LTP fracture. Huson, as quoted by Hawkins [2], pointed out that with heel inversion the posterior articulation of the subtalar joint becomes incon-gruent as the head of the talus shifts laterally and the lateral process of the talus shifts up-wards. As a consequence, the subtalar joint opens and, if the inverted foot comes into dorsi-flexion, a compression force is exerted on the lateral process.

Based on this study, Hawkins [2] formulated the suggestion that lateral process fracture is caused by forced axial loading of the talus when the inverted foot is severely dorsiflexed. However, Boon et al. [24] in their anatomical study, demonstrated that also external rotation was a crucial factor in producing this type of fracture. The importance of dorsiflexion and external rotation of the foot was mentioned even by Dimon [25]. He suggested that the an-terolateral portion of the articular surface of the talus is sheared off by a compressive force exerted by the posterior facet of the calcaneus when the foot is dorsiflexed and slightly ex-ternally rotated.

On the other hand, Funk et al. [26] refuted the consolidated mechanism of the involved injury. By subjecting dynamic inversion or eversion to ten axially loaded and dorsiflexed cadaveric leg specimens, they suggested that eversion and not inversion was necessary to produce an LTP fracture. They also stated that Boon's results were non-contradictory to theirs. Eversion and external rotation of an axially loaded dorsiflexed ankle may be independent injury mechanisms for an LTP fracture. Indeed, they explain that during a fall, the ankle may be subjected to forces with continuously changing vectors, and thus, a torque about a combined eversion/dorsiflexion/external rotation axis is not improbable.

It can be concluded, therefore, that the mechanism of injury of the combined fractures re-sembles a subtalar joint subluxation. Heel inversion causes a lateral shift of the head of the talus and incongruity of the posterior subtalar joint articulation. If an inverted and axially loaded foot is forced into dorsiflexion, an LTP fracture may occur [2]. However, as Boon et al. [24] stated, dorsiflexion and inversion in an axially loaded foot is not enough to produce an LTP fracture, but when the talocalcaneal congruency is disrupted, an external rotation force is also needed.

On the other hand, Funk et al. [26] in their cadaveric study noted that by subjecting their specimens in axial loading, eversion and ankle dorsiflexion, all resulted LTP fractures were intra-articular (McCrory-Bladin type II, III). Since the aforementioned fractures involved the posterior talocalcaneal joint surface, they postulated that these fractures have been caused by localised compression of the subtalar joint surface beneath the lateral process. Interestingly, in their experiments, no extra-articular LTP avulsion fractures were produced (McCrory-Bladin type I), probably because another mechanism of injury is needed to cause this type of LTP injury.

Based on these observations, we suggest that the combined fracture of the LTP and ST may result from two possible mechanisms. In both mechanisms, the common key is the forced axial loading, as from a fall from a height, motor vehicle accident or sports injury. If then, the axially loaded foot is subjected to continuous inversion, an ST fracture happens first, resulting in spontaneous subtalar joint subluxation. By applying more inversion, dorsiflexion and external rotation, the LTP could also fail. Another possible mechanism may involve continuous eversion in an axially loaded dorsiflexed foot. This time, by exercising compres-sion on the subtalar articular surface, the LTP could fail first, leading again to subtalar joint instability. If the oblique axial force continues, then an ST fracture may occur.

Conclusion

Isolated ST and LTP fractures are not common entities in clinical practice and literature. Moreo-

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ver, they are frequently missed and misdiagnosed as ankle sprains. Recently, the awareness of these two fractures has inclined due to the introduction of sports such as snowboarding and the increasing number of road traffic accidents. Nevertheless, their com-bination is still met only in isolated cases.

The mechanism of this combined injury is not clear yet. It seems that the common denomi-nator of these injuries is forced axial loading and subtalar subluxation. Indeed, in all cases, a loss of talocalcaneal congruity, leading to subtalar instability and subluxation, is needed to produce this entity. Once the articular surfaces start to move, if the force responsible for the instability continues to apply, the combined injury might occur. We propose that ST frac-tures in association with an LTP fracture may be caused by continuous inversion in an axi-ally loaded, inverted, dorsiflexed and externally rotated foot or from continuous eversion in an axially loaded and dorsiflexed foot. In reality, the combined injury might be more common than generally thought. In our series, half of the patients had a combined fracture, whereas, as mentioned before, Dürr et al. [14] in 2013, reported that almost a quarter of their patients had an association of an ST and an LTP fracture. Thus, when an LTP fracture is encountered, a meticulous study of the CT scan images is indispensable, in order not to miss a possible ST fracture and vice versa. Ⓐ

ABBREVIATIONS

LTP: Lateral Talar Process
ST: Sustentaculum Tali

COMPLIANCE WITH ETHICAL STANDARDS

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READY - MADE CITATION

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ΠΕΡΙΛΗΨΗ

ΣΚΟΠΟΣ: Τα μεμονωμένα κατάγματα της έξω απόφυσης του αστραγάλου και του υπερείσματος του αστραγάλου όχι μόνο είναι σπάνιες κακώσεις αλλά συχνά παραβλέπονται λόγω παρόμοιου μηχανισμού κάκωσης και όμοιας κλινικής εικόνας με τα διαστρέμματα της ποδοκνημικής. Ο συνδυασμός των δύο καταγμάτων είναι ακόμη περισσότερο ασυνήθης και χρειάζεται μεγάλη υποψία για την διάγνωσή του.
Σκοπός της παρουσίασης είναι να επισημάνουμε την παρουσία της κάκωσης αυτής και παραθέτοντας την υπάρχουσα βιβλιογραφία να προτείνουμε έναν πιθανό μηχανισμό κάκωσης για τον συνδυασμό των δύο καταγμάτων.
ΥΛΙΚΟ ΚΑΙ ΜΕΘΟΔΟΣ: Παρουσιάζουμε μια σειρά τεσσάρων ασθενών με κάταγμα του έξω φύματος του αστραγάλου και συνοδό κάταγμα του υπερείσματος του αστραγάλου σε δύο από αυτούς. Όλοι οι ασθενείς υποβλήθηκαν σε χειρουργική αποκατάσταση είτε με ανοικτή ανάταξη και εσωτερική οστεοσύνθεση ή με αρθροσκοπική αφαίρεση των τεμαχίων του έξω φύματος του αστραγάλου σε μία περίπτωση.
ΑΠΟΤΕΛΕΣΜΑΤΑ: Όλα τα κατάγματα που υποβλήθηκαν σε ανοικτή ανάταξη και εσωτερική οστεοσύνθεση πορώθηκαν με πολύ καλά έως εξαιρετικά αποτελέσματα. Όλοι οι ασθενείς επέστρεψαν στις προηγούμενες δραστηριότητές τους με ήπιο, περιστασιακό πόνο
σε δύο από αυτούς. Η αρθροσκοπική αντιμετώπιση, που εφαρμόστηκε στον τέταρτο ασθενή, επέτρεψε την άριστη επισκόπηση του έξω φύματος του αστραγάλου και την αφαίρεση των οστικών τεμαχίων με την όσο δυνατόν λιγότερη παρέμβαση στα μαλακά μόρια.
ΣΥΜΠΕΡΑΣΜΑ: Μετά από ανασκόπηση της βιβλιογραφίας καταλήξαμε στο συμπέρασμα ότι η συνδυασμένη κάκωση απαιτεί ένα μηχανισμό υψηλής ενέργειας με αξονική φόρτιση του ποδιού. Η παρουσία συντριπτικού ή μεγάλου τεμαχίου στην έξω απόφυση του αστραγάλου προϋποθέτει την εξάσκηση δύναμης βλαισότητας με την ποδοκνημική σε ραχιαία κάμψη. Η παρουσία αντίθετα ενός μικρού τεμαχίου στην παρυφή της έξω απόφυσης του αστραγάλου συναντάται μετά από εξάσκηση ραιβότητας, έξω στροφής με ραχιαία κάμψη της ποδοκνημικής. Κοινός παρονομαστής στο μηχανισμό κάκωσης των δύο καταγμάτων είναι η αξονική φόρτιση με υπεξάρθρημα της υπασταγαλικής άρθρωσης. Αν η δύναμη που ευθύνεται για την αστάθεια συνεχίσει να ασκείται μπορεί να προκύψει ο συνδυασμένος τραυματισμός. Επομένως, αν στον απεικονιστικό έλεγχο παρατηρηθεί ένα από τα κατάγματα, θα πρέπει να αναζητείται η ύπαρξη και του άλλου κατάγματος, ειδικά σε ασθενείς που παρουσιάζονται μετά από πτώση από ύψος ή κατά την ενασχόληση με «χιονοσανίδα».

ΛΕΞΕΙΣ ΚΛΕΙΔΙΑ: Αστράγαλος, Πτέρνα, Έξω φύμα αστραγάλου, Υπέρεισμα αστραγάλου, Κάταγμα, Μηχανισμός κάκωσης