



Talar-sided osteochondral lesion of the subtalar joint following the intra-articular calcaneal fracture: study via a modified computed tomography mapping analysis

Chayanin Angthong¹ · Andrea Veljkovic² · Wirana Angthong³ · Prasit Rajbhandari⁴

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Abstract

Introduction This study is to report the prevalence of osteochondral lesions in subtalar joint following intra-articular calcaneal fracture, including the relationship between fracture severity and lesion characteristics, using modified computed tomography (CT) mapping analysis.

Methods Thirty patients with intra-articular calcaneal fracture who were preoperatively imaged with modified CT mapping analysis were recruited. The presence of talar-sided osteochondral lesions (OLTS) of subtalar joint was noted with lesion area defined by Akiyama's mapping classification. Lesion severity was assessed via Ferkel's classification, and fracture severity via Sanders' classification.

Results Lesions were found in 28 patients (93.3%), mostly at anterior [16 (57.1%) lesions] or central [13 (46.4%) lesions] areas of posterior talar facet. Most common grade of lesion severity was grade I (mild) seen in 24 (80%) patients. Most fractures were classified as Sanders' grade III and IV with 12 (40%) and 12 (40%) patients noted, respectively. High severity of fracture denoted by Sanders' grade IV showed a trend of higher prevalence of OLTS at anterior and central sites of posterior talar facet ($P=0.181$). Lesion severity was significantly higher in patients with double lesions than patients with single lesions ($P=0.005$). However, OLTS were not significantly related with osteoarthritic changes in follow-up radiographs ($P>0.05$).

Conclusions The prevalence of OLTS is very high following intra-articular calcaneal fractures. Most lesions occur at anterior or central area of posterior talar facet and are more likely to occur in patients with higher fracture severity. Lesion severity was significantly higher in patients with double lesions than patients with single lesions.

Keywords Calcaneus · Fracture · Osteochondral · Talus · Arthritis · Computed tomography

Introduction

Calcaneus fractures are the most common fracture of the foot [1–3], with the two main fracture types being either extra-articular or intra-articular. When the fracture involves the articular surface of the posterior facet of the calcaneus or the talus, osteochondral lesions can occur on each side of the subtalar joint [4]. High prevalence of lesions on the posterior facet of the calcaneus has been reported [5]. However, little is known about the prevalence and characteristics of lesions on the talar side. The aim of this study is to report the prevalence of osteochondral lesions in the subtalar joint (OLTS) following intra-articular calcaneal fractures, including the relationship between fracture severity and lesion characteristics, using a modified computed tomography (CT) mapping analysis. The present study's hypothesis was that the high prevalence of talar-sided osteochondral lesion of talus

✉ Chayanin Angthong
chatthara@yahoo.com

¹ Foot and Ankle Surgery Unit, Department of Orthopaedics, Faculty of Medicine, Thammasat University, Pathum Thani 12120, Thailand

² Department of Orthopaedics, University of British Columbia, Footbridge Clinic 221-181 Keefer Place, Vancouver, BC V6B 6C1, Canada

³ Department of Radiology, Faculty of Medicine, Thammasat University, Pathum Thani 12120, Thailand

⁴ Department of Orthopedics, Grande International Hospital, Kathmandu, Nepal

(OLTS) could occur following intra-articular calcaneal fractures. The additional hypothesis was that the fracture severity and number of lesion could be the factors affecting the characteristics of lesion such as lesion area or lesion severity.

Materials and methods

A total of 30 patients with intra-articular calcaneal fractures who had received a preoperative CT were included for this study. Patients with poor bone condition due to osteoporosis with pre-injury diagnosis, Paget's disease, osteopetrosis, primary or secondary/metastasis bone neoplasm, renal osteodystrophy or incomplete data were excluded from the study. Baseline data of each patient were collected, including age, sex, injury mechanism, post-fracture bone mineral density (BMD), presence of OLTS, lesion severity via Ferkel's classification [6, 7] (Figs. 1, 2, 3, 4), lesion area via Akiyama's mapping classification [8] (Fig. 5), and fracture severity via Sanders' classification [9].

CT examinations were performed using a Philips Brilliance ICT 256 slice helical scanner (Philips Healthcare



Fig. 2 CT image in 3D reconstruction with a label (arrow) of the osteochondral lesion of talus in a same patient of Fig. 1

Medical System) or a SOMATOM Define AS 128 slice helical scanner (Siemens Healthineers) at our institution. A trained foot and ankle orthopedic fellow (research assistant) interpreted the CT findings with a modified mapping analysis via the combination of sagittal and coronal views and recorded the data. The two-dimensional (2D) and three-dimensional (3D) CT reconstruction images had been retrieved in the patients with the intra-articular calcaneal fractures in the author's current practice. Regarding this study, the research assistant initially interpreted the image

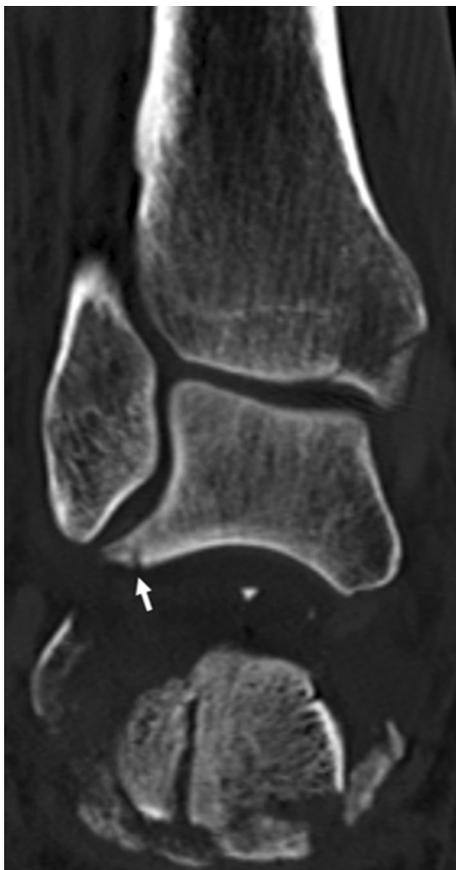


Fig. 1 CT image in coronal plane with a label (arrow) of the osteochondral lesion of talus (Ferkel's grade 3) in a right subtalar joint

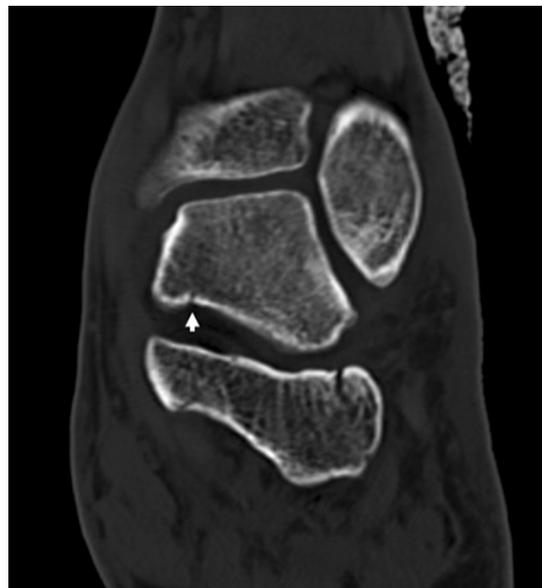


Fig. 3 CT image in coronal plane with a label (arrow) of the osteochondral lesion of talus (Ferkel's grade 2B) in a left subtalar joint



Fig. 4 CT image in sagittal plane with a label (arrow) of the osteochondral lesion of talus in a same patient of Fig. 3

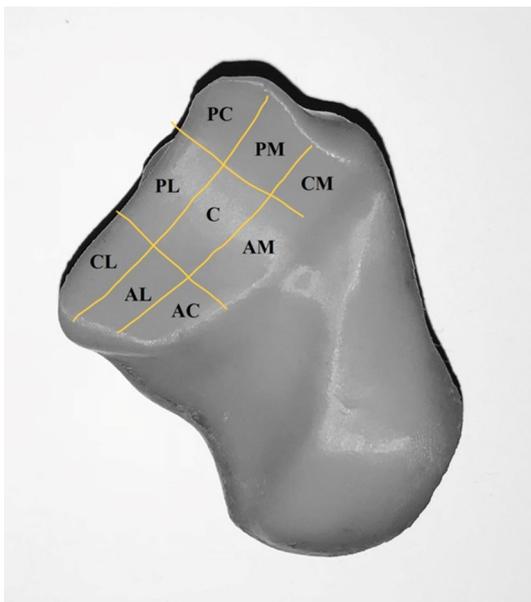


Fig. 5 The lesion area was recorded in accordance with the mapping classification of Akiyama et al. [8]

findings from 2D-CT images then the 3D-CT images would be used to interpret provided that the findings from 2D-CT images demonstrated the uncertain findings. The 3D-CT reconstruction image was also used to demonstrate the clear finding as in Fig. 2. In the case of equivocal findings, consensus of interpretation was reached by an experienced foot and ankle orthopedic surgeon and an experienced radiologist. The data were analyzed to elucidate the prevalence of OLTS following intra-articular calcaneal fractures, including the relationship between fracture severity and lesion characteristics assessed by CT. The follow-up plain radiographic

study was performed by a trained research assistant in order to record the presence of post-traumatic subtalar osteoarthritis based on the diagnostic criteria [10]. The overall study was approved by the institutional ethics committee.

Statistical analysis

Statistical analysis was implemented using the IBM SPSS software version 22.0 (SPSS Inc., Chicago, IL, USA). Outcome measures were calculated using *T* test, ANOVA for continuous normally distributed variables and Chi-square or Fisher's exact test for categorical variables. Pearson correlation analysis or Spearman correlation analysis was used to determine the relationship among the variables.

Results

The mean patient age was 46.2 years. There were 23 (76.7%) male and 7 (23.3%) female patients. High-energy mechanisms (for instance, traffic injury, fall from height over a patient's standing height) occurred in 29 (96.7%) patients, and low-energy mechanisms (for instance, simple fall, fall from height less than a patient's standing height) occurred in 1 (3.3%) patient. In accordance with the approved protocol of this study by the institutional ethics committee in our institute, the results about BMD were necessary to be reported in the present study. Only 2 (6.7%) patients had post-fracture BMD tests. The BMD testing results revealed that one patient had osteopenia (lumbar/proximal femoral T-score: 1.3/–1.4) and one patient had osteoporosis (lumbar/proximal femoral T-score: –2/–2.9). There were no significant differences in post-fracture BMD testing rate between the high-energy and low-energy injury patient groups (P value > 0.05). However, there likely was an inadequate number of patients to demonstrate the significant difference between the two groups.

In total, 30 lesions were found in 28 patients (93.3%). The majority of posterior facet lesions were located anterior [16 (57.1%) lesions] or central [13 (46.4%) lesions] (Fig. 5, Table 1). The most common grade of lesion severity was grade I (Table 2). The lesion severity was significantly higher in patients with double lesions than patients with a single lesion (P value = 0.005).

Fractures were classified as Sanders' grade III in 12 (40%) patients and as grade IV in 12 (40%) patients. Six patients (20%) had the Sanders' grade II fractures. There was a trend of double or more severe lesions with higher severity of fracture; however, these relationships were not significant (P value > 0.05). High fracture severity denoted by Sanders' grade IV showed a trend toward higher prevalence of OLTS at the anterior and central sites of the posterior talar facet (P value = 0.181). There were 22 patients

Table 1 The distribution of area with osteochondral lesion on the posterior facet of talus

Parameter	Number of patient	Percent
Lesion area ^a		
AM	6	21.4
AC	4	14.3
AL	2	7.1
PM	1	3.6
CM	2	7.1
C	6	21.4
CL	5	17.9
AL-AC	1	3.6
AM-AL	1	3.6
Total	28	100.0

^aThe lesion area was recorded in accordance with the mapping classification of Akiyama et al. [8]

who had complete follow-up data of radiographic findings via the ankle mortise views, calcaneal lateral and axial views with a mean follow-up time as 10.5 ± 11.8 months. There were 33.3%, 28.6%, and 38.1% of twenty-one patients with OLTS who had definite, possible, and no findings of the osteoarthritis in accordance with the evaluation of subtalar arthritis, modified from Kellgren–Lawrence classification of osteoarthritis. Definite: subtalar joint space narrowing, gross subchondral bone cyst-sclerosis, osteophyte formation (Kellgren-Lawrence grade II-IV); Possible: doubtful subchondral bone sclerosis, joint space narrowing (Kellgren-Lawrence grade I) [10]. There was no patient who had the osteoarthritic changes in the patient group with no OLTS. However, OLTS were not significantly related with osteoarthritic changes (P value > 0.05). The data used to support the findings of this study are included within the methods and results sections in this article.

Discussion

This study highlights the prevalence of OLTS following intra-articular calcaneal fractures, including the relationship between fracture severity and lesion characteristics assessed

by CT. It is also one of the first studies to report associated osteochondral pathology related to intra-articular calcaneal fractures. CT is a worthwhile investigation to better elucidate the presence, location, and severity of these osteochondral subtalar lesions which may be important in terms of their role on the formation of post-traumatic osteoarthritis of the subtalar joint related to intra-articular calcaneal fractures. Ball et al. found a significant decline in chondrocyte viability after intra-articular fractures of the calcaneus [4]. They proposed that this event may contribute to the development of post-traumatic arthritis [4]. The present study found that the post-traumatic subtalar osteoarthritis was identified in 32% of all follow-up patients. There were around 62% of the patients with OLTS who had definite or possible findings of the osteoarthritic changes. Despite this, there was no patient who had the osteoarthritic change in the patient group with no OLTS. However, OLTS was not significantly related with the osteoarthritic changes, but this would be from the short period of follow-up and limited number of patients in the present study.

High prevalence of OLTS was found in the present study. In current orthopedic practice, OLTS of the subtalar joint are less likely to be noticed and treated during surgery because index operative visualization offered via the conventional open reduction or percutaneous reduction techniques limit visibility and proper assessment of underlying osteochondral lesions. This brings to light the necessity of appropriate preoperative cross-sectional imaging and subsequent intraoperative techniques to effectively treat such small and difficult oriented lesions. Presently, arthroscopic procedures have been reported for its roles in the examination of the subtalar joint in patients with intra-articular calcaneal fractures [11]. Arthroscopic evaluation and arthroscopic assisted procedures may be the option to diagnose and treat OLTS. However, it would be beneficial if subtalar lesions could be noted preoperatively on CT allowing for strategic preoperative planning prior to the treatment of these OLTS during intra-articular calcaneal fracture reduction and internal fixation. In addition to the high prevalence of OLTS, high severity of fracture denoted by Sanders' grade IV showed a trend of higher prevalence of OLTS at the anterior and central sites of the posterior facet of the talus (P value = 0.181). This is consistent with findings from a previous study by

Table 2 The distribution of lesion severity of the osteochondral lesion on the posterior facet of talus [6, 7]

Lesion severity	Number of patient	Percent
Grade I: Intact roof/cartilage with cystic lesion beneath	24	80
Grade I and IIA ^a : Intact roof/cartilage with cystic lesion beneath; Cystic lesion with communication to the surface	2	6.7
Grade IIB: Open surface lesion with overlying fragment	1	3.3
Grade III: Nondisplaced fragment with lucency underneath	1	3.3

^aPatients with double lesions

Rothberg and Yoo [5]. They found that the most common lesion on the calcaneal side was confined to the distal, lateral aspect of the posterior facet [5]. They felt that this significant injury was derived from the depression of posterior calcaneal facet on the fracture edge of the calcaneal body during the index fracture event [5]. However, OLTS may occur in alternate locations that are not visualized during standard open reduction exposures. Lesions on the talar side might be derived from an initial injury resulting from the compression between the anterior aspect of posterior talar facet and the corresponding aspect on the calcaneal side. This mechanism was described in a previous study from Wong et al. [12]. They found the regions of peak stress corresponded to fracture sites of a typical patient with calcaneus fracture due to high compressive load [12]. The regions associated with accumulated compressive stresses were the same regions where OLTS were found in this present study. The OLTS might simultaneously occur at the same common area as a kissing lesion on both the calcaneal and talar side. Damage to the articular cartilage of the subtalar joint may occur at the time of the initial trauma [10, 13]. This kind of injury could be found in other areas of the foot [14].

Limitations were present in this study. First, there was a small number of patients in this study. A larger number of patients is necessary to substantiate the trend found in this study. Second, a longer follow-up with follow-up CT or magnetic resonance imaging (MRI) is necessary to demonstrate the role of OLTS on the formation of subtalar cartilage degeneration or post-traumatic subtalar joint osteoarthritis which is a noted postoperative complication following a calcaneal fracture [15]. Based on the results of the comparative analysis in a previous study, the Sanders CT classification remains prognostic; after a minimum of 10 years, grade III fractures were 4 times more likely to need a fusion than grade II fractures [16]. Third, there was no analysis of osteochondral lesions on the calcaneal side. This was caused by the difficult diagnosis of calcaneal-sided lesions which are obscured by the calcaneal fracture lines.

Conclusions

The prevalence of OLTS is high following intra-articular calcaneal fractures. A modified CT mapping analysis shows that most lesions have a trend to occur at the anterior or central aspect of the posterior talar facet and are more likely to occur in patients with higher fracture severity.

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Compliance with ethical standards

Conflict of interest Dr. Anghong reports personal fees from Menarini, personal fees from Amgen, personal fees from Smith & Nephew, outside the submitted work; Dr. Veljkovic reports grants from Wright medical, grants from Zimmer, grants from Acumed, grants from Ferring, grants from Synthes, grants from Arthrex, outside the submitted work; Dr. Anghong has nothing to disclose; Dr. Rajbhandari has nothing to disclose.

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