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Computed tomography (CT) of fractures of the ankle and foot: correlating fracture patterns with the presence of tenosynovial fat
Tenosynovial fat in ankle and foot fractures

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ABSTRACT

Purpose: To correlate ankle and foot fracture patterns with the presence of tenosynovial fat on computed tomography (CT).
Materials and Methods: In this retrospective, cross-sectional, observation study, two blinded musculoskeletal radiologists independently reviewed 89 CT scans of patients with ankle or foot fractures and recorded the presence of fat about Henry's knot, tibialis posterior tendon, and peroneus longus tendon.
Results: The agreement between the two readers ranged from excellent to substantial. Sixteen to 23 percent of fractures were associated with tenosynovial fat.
Conclusions: The finding of tenosynovial fat following ankle or foot trauma warrants a closer search for a fracture.

1. Introduction

Lipohemarthrosis is widely accepted as a pathognomonic sign of an intrarticular fracture [1–6]. Intra-articular fractures can lead to migration of fat and blood from the marrow cavity into the joint space [7]. Because fat is less dense than blood, a fat-blood interface forms and can be seen on radiographs or CT scanning as a fat-fluid level [7,8]. By comparison, the presence of tenosynovial fat following acute trauma, to our knowledge, has not been studied extensively. We have found one case report by Le Corroler et al [9] on wrist trauma, which notes the finding of tenosynovial fat as a sign of an occult fracture. The current study was performed to evaluate the frequency of tenosynovial fat in patients with foot and ankle trauma that had resulted in fractures.

2. Material and methods

This retrospective, cross-sectional, observation study was approved by an institutional review board. The CT scans of 89 patients with ankle or foot fractures secondary to trauma studied at our institution from April of 2008 to July of 2011 were reviewed. Patients were selected on the basis of availability of CTs scans for review and the documentation by imaging of a fracture. CT examinations with metal and other artifacts were excluded. Readers utilized only the axial images with bone (W/L setting: 2000/500) and soft tissue (W/L setting: 125/35) algorithms and windows. Two blinded musculoskeletal radiologists (Reader 1: 5years experience; Reader 2: 5years experience) individually recorded the presence of fat in tendon sheaths at three locations: Henry's knot (anatomical crossover between the flexor hallucis longus and flexor digitorum longus tendons), about the tibialis posterior tendon and/or about the peroneus longus tendon (Figs. 1–6). Fractures were subdivided according to location into: calcaneus, Lisfranc joint, malleolar, midfoot (cuboid, cuneiforms, navicular, metatarsal, not including the Lisfranc joint), and talus. Ankle fractures that were tibial plafond were excluded.

Cohen's kappa statistic [10] was calculated to estimate degree of agreement between the two readers when identifying the presence of tenosynovial fat. Kappa statistic is a chance corrected proportional agreement between categorical assessments.

3. Results

The agreement between the two readers ranged from excellent with respect to Henry's knot (Cohen's kappa=0.822) and about the tibialis posterior tendon (Cohen's kappa=0.863) to substantial about the peroneus longus tendon (Cohen's kappa=0.711). In all cases the disagreement was related to Reader 2 identifying more instances of tenosynovial fat than Reader 1.

Of the 89 patients evaluated, 35 had calcaneal fractures, 12 had Lisfranc fractures, 10 had malleolar fractures, 19 had midfoot fractures, and 13 had talar fractures. Sixteen percent of fractures were associated with tenosynovial fat, according to Reader 1, and 23% of fractures were associated with tenosynovial fat, according to Reader 2. Malleolar fractures were most often associated with

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Fig. 1. Axial view of the foot shows fat [Hounsfield Unit (HU): −98] around Henry's knot in this 28-year-old female with a calcaneal fracture.

tenosynovial fat for both musculoskeletal radiologists (Table 1). Tenosynovial fat was noted by both readers in 50% of the patients with malleolar fractures.

The data regarding the distribution of tenosynovial fat among Henry's knot, tibialis posterior tendon and peroneus longus tendon and the fracture pattern are shown in Table 2. Presence of tenosynovial fat in any of the three locations was not a good predictor of the type or location of fracture for either reader.

4. Discussion

Lipohemarthrosis is considered a pathognomonic sign of an intraarticular fracture [1–6]. Since fat floats on the accompanying blood, a fat-fluid level is present and can be demonstrated with all imaging modalities including conventional radiography, ultrasonography, CT scanning, and magnetic resonance imaging [11–14]. Lipohemarthrosis has been reported in cases of fractures about the knee, glenohumeral joint, elbow, and hip [2,7,11,15]. However, the presence of tenosynovial fat following acute trauma in the setting of a nearby fracture has not been well evaluated in the radiologic literature.

In our cases, the tenosynovial fat depicted on CT examinations presumably resulted from the extrusion of marrow into the tendon sheaths. To our knowledge, our series is the largest to date dealing with the presence of tenosynovial fat in patients following trauma to the ankle or foot and suggests the association of tenosynovial fat and a nearby fracture. Overall, 16% of fractures had associated tenosynovial fat, according to Reader 1 and 23% of fractures had associated

Fig. 2. Axial view of the foot shows fat (HU: −109) around Henry's Knot tendon in this 22-year-old male with a malleolar fracture.

tenosynovial fat, according to Reader 2. Malleolar and calcaneal fractures were most often responsible for the finding, although the majority of patients with either malleolar (50%) or calcaneal fractures (75%) actually did not exhibit tenosynovial fat.

Fig. 3. Axial view of the foot shows fat (HU: −120) around tibialis posterior tendon in this 29-year-old male with a midfoot fracture.

Fig. 4. Axial view of the foot shows fat (HU: −71) around tibialis posterior tendon in this 17-year-old female with a middle malleolar fracture.

Fig. 5. Axial view of the foot shows fat (HU: −78) around the peroneus longus tendon in this 38-year-old male with a midfoot fracture.

Our study included a relatively small sample size of 89 subjects. Further studies with larger numbers of subjects are required to validate our findings. The CTs examinations of the patients used in this study illustrated different fracture types. However, fractures of the tibial plafond were not included in our review, likely related to such fractures having external fixators placed prior to CTs scanning such that these studies had to be excluded owing to the presence of metal artifact. The limited sample size may have been the reason why the presence of tenosynovial fat in any of the three locations was not a good predictor of fracture type for either reader. A follow up study with a larger sample size should be done to confirm whether or not there is correlation between fracture pattern and the location of the tenosynovial fat.

Furthermore, our study included only those patients with fractures. Thus, our study does not prove that all patients with tenosynovial fat at Henry's knot or along the tibialis posterior or peroneus longus tendon have an underlying fracture, as we did not include subjects with ankle or foot trauma who did not have a fracture. In addition, this may have also introduced interpretation bias into the study as the readers may have overcalled tenosynovial fat. However, it does suggest that an additional search for an occult fracture should be performed if tenosynovial fat is present. As early evaluation of these occult fractures can impact the timing of proper orthopedic or surgical intervention, the characteristic imaging features of tenosynovial fat reported in our study may help to diagnose a potentially overlooked fracture.

5. Conclusion

Based on our results, most fractures of the foot are not associated with tenosynovial fat. Therefore, the absence of tenosynovial fat does not exclude a fracture. However, the presence of tenosynovial fat may be a diagnostic clue to a possible fracture, warranting a second look. We also conclude that the ankle or foot fractures most often associated with fat and blood products within the tendon sheaths are malleolar and calcaneal fractures.

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Fig. 6. Axial view of the foot shows fat (HU: −90) around the peroneus longus tendon in this 32-year-old male with a calcaneal fracture.

Table 1
Tenosynovial fat recorded by Reader 1 and 2

Fracture Type	Presence of Tenosynovial Fat (Reader 1)	Presence of Tenosynovial Fat (Reader 2)
Calcaneus ($n=35$)	7 (20%)	8 (24%)
Lisfranc ($n=12$)	0 (0%)	2 (8%)
Malleolar ($n=10$)	5 (50%)	5 (50%)
Midfoot ($n=19$)	1 (5%)	1 (5%)
Talus ($n=12$)	1 (8%)	3 (25%)

Table 2
Location of tenosynovial fat recorded by Reader 1 and 2; HK: Henry's knot, TP: Tibialis Posterior tendon; PL: Peroneus Longus tendon

Fracture Type	HK	TP	PL	HK & TP	HK & PL	TP & PL	HK, TP & PL
Calcaneus ($n=7$) Reader 1	2	3	2	0	0	0	0
Calcaneus ($n=8$) Reader 2	2	3	2	0	1	0	0
Lisfranc ($n=2$) Reader 1	0	0	0	0	0	0	0
Lisfranc ($n=1$) Reader 2	1	0	0	0	0	0	0
Malleolar ($n=5$) Reader 1	2	2	0	0	0	1	0
Malleolar ($n=5$) Reader 2	1	2	0	1	0	1	0
Midfoot ($n=1$) Reader 1	0	0	1	0	0	0	0
Midfoot ($n=1$) Reader 2	0	0	1	0	0	0	0
Talus ($n=1$) Reader 1	0	1	0	0	0	0	0
Talus ($n=3$) Reader 2	0	2	0	0	0	1	0

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