CHAPTER **27**

SUPERIOR PERONEAL RETINACULAR INJURIES IN CALCANEAL FRACTURES

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INTRODUCTION

Calcaneal fractures are devastating injuries with historically poor outcomes. Accounting for approximately 2% of all fractures, it is the most commonly fractured tarsal bone (1). This injury, resulting from an axial force being applied to the foot driving the talus into the calcaneus, is most commonly seen in males in the industrial sector and in motor vehicle accidents (2). As this occurs, it can result in injury of the superior peroneal retinaculum with subsequent displacement of the peroneal tendons (3).

Acute dislocation of the peroneal tendons are relatively rare injuries with a reported incidence of approximately 0.5% (4). The mechanism of these retinacular injuries and dislocations has been elucidated but not in the setting of these fractures (5). In addition to the blowout that occurs with the fracture, the reduction in height generates slack in the tendons that could excarbate subluxation especially in the presence of a flat or convex peroneal groove (2).

We sought to report the incidence of these retinacular injuries and tendinous subluxation and, or dislocations and demonstrate whether there was any association with specific fracture patterns. We also sought to emphasize the dynamic nature of this pathology and the clinical technique of diagnosis.

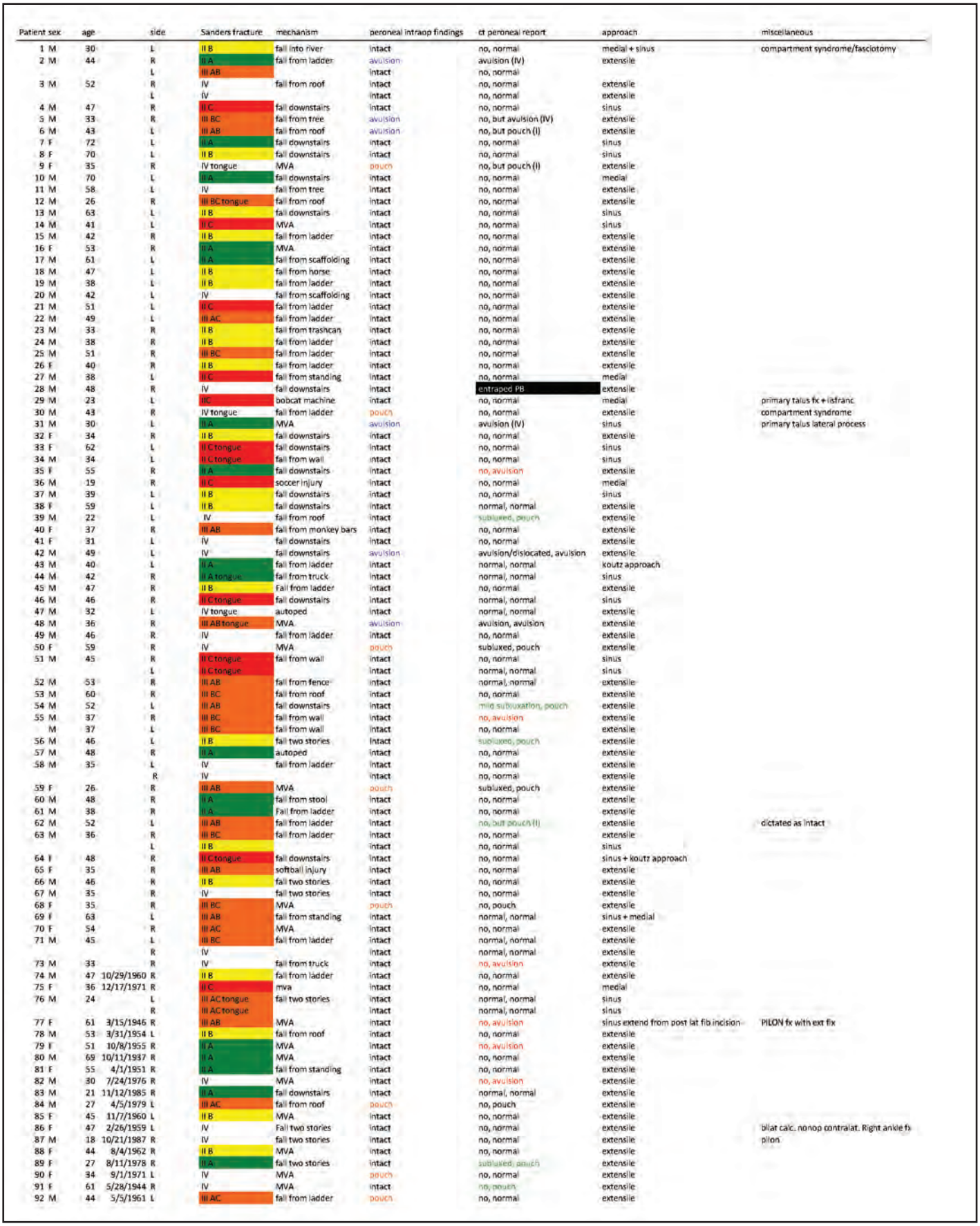
PATIENTS AND METHODS

Patients

After receiving institutional board review approval, patients were identified by reviewing all operative procedures performed by the primary author (JJF) from January 2006 to December 2012 abstracted from the medical records. One physician (KYK) also performed an additional search using the Current Procedural Terminology (CPT) code 28415, representing open treatment of calcaneal fracture. We initially identified 130 consecutive calcaneal fractures that were repaired by the primary author. Two physicians (KYK, DJF) then reviewed all these operative notes to determine the presence or absence of peroneal injury. In order to reduced the likelihood of missing any potential repairs one physician (KYK) performed the following additional CPT code searches: 27675 (representing repair of dislocating peroneal tendons without fibular osteotomy), and 27676 (representing repair of dislocating peroneal tendons with fibular osteotomy), and cross-referenced these searches with CPT code 28415. Our inclusion criteria comprised patients who acutely sustained intraarticular calcaneal fractures, had preoperative computed tomography (CT) images, and underwent open reduction and internal fixation. Exclusion criteria included calcaneal fractures that underwent primary fusion, patients with calcaneal fractures treated definitively with external fixation, patients under the age of 18 years, and fractures without subtalar joint involvement. There were 10 isolated tuberosity avulsion fractures (7.69%) without subtalar joint involvement, 16 fractures (12.31%) that underwent primary subtalar joint arthrodesis, 3 fractures (2.31%) isolated to the anterior process of the calcaneus, 2 patients (1.54%) who kept their preoperative CTs and could not be reached, and 2 fractures (1.54%) primarily treated with external fixation. Following application of our exclusion criteria, there remained 90 patients (78.26%) with 97 calcaneal fractures (74.61%).

Two physicians (KYK, DJF) reviewed all available diagnostic images including CTs and radiographs both of whom participated in the operations and were not blinded to the outcome of the study. Each fracture was classified according to the classification system described by Sanders et al (6).

The morphology and position of the peroneal tendons was then reviewed on the axial CT reconstruction to determine any abnormality. Following this, each accompanying CT report was reviewed to determine if the radiologist noted any abnormality with the peroneal tendons or the superior peroneal retinaculum. Finally, every operative report in these 97 cases was reviewed to determine whether the superior peroneal retinaculum or tendons were compromised clinically requiring surgical intervention. This very specific order was followed in order to reduce identification bias and to demonstrate that even among skilled musculoskeletal radiologists, its is rarely mentioned.



Patient	sex	age		side	Sanders fracture	mechanism	peroneal intraop findings	ct peroneal report	approach	miscellaneous
1	M	30		L	II B	fall into river	intact	no, normal	medial + sinus	compartment syndrome/fasciotomy
2	M	44		R	II A	fall from ladder	avulsion	avulsion (IV)	extensile	
				L	III AB		intact	no, normal		
3	M	52		R	IV	fall from roof	intact	no, normal	extensile	
				L	IV		intact	no, normal	extensile	
4	M	47		R	II C	fall downstairs	intact	no, normal	sinus	
5	M	33		R	III BC	fall from tree	avulsion	no, but avulsion (IV)	extensile	
6	M	43		L	III AB	fall from roof	avulsion	no, but pouch (I)	extensile	
7	F	72		L	II A	fall downstairs	intact	no, normal	sinus	
8	F	70		L	II B	fall downstairs	intact	no, normal	sinus	
9	F	35		R	IV tongue	MVA	pouch	no, but pouch (I)	extensile	
10	M	70		L	II A	fall downstairs	intact	no, normal	medial	
11	M	58		L	IV	fall from tree	intact	no, normal	extensile	
12	M	26		R	III BC tongue	fall from roof	intact	no, normal	extensile	
13	M	63		L	II B	fall downstairs	intact	no, normal	sinus	
14	M	41		L	II C	MVA	intact	no, normal	sinus	
15	M	42		R	II B	fall from ladder	intact	no, normal	extensile	
16	F	53		R	II A	MVA	intact	no, normal	extensile	
17	M	61		L	II A	fall from scaffolding	intact	no, normal	extensile	
18	M	47		L	II B	fall from horse	intact	no, normal	extensile	
19	M	38		L	II B	fall from ladder	intact	no, normal	extensile	
20	M	42		L	IV	fall from scaffolding	intact	no, normal	extensile	
21	M	51		L	II C	fall from ladder	intact	no, normal	extensile	
22	M	49		L	III AC	fall from ladder	intact	no, normal	extensile	
23	M	33		R	II B	fall from trashcan	intact	no, normal	extensile	
24	M	38		R	II B	fall from ladder	intact	no, normal	extensile	
25	M	51		R	III BC	fall from ladder	intact	no, normal	extensile	
26	F	40		R	II B	fall from ladder	intact	no, normal	extensile	
27	M	38		L	II C	fall from standing	intact	no, normal	medial	
28	M	48		R	IV	fall downstairs	intact	entraped PB	extensile	
29	M	23		L	IIC	bobcat machine	intact	no, normal	medial	primary talus fx + lisfranc
30	M	43		R	IV tongue	fall from ladder	pouch	no, normal	extensile	compartment syndrome
31	M	30		L	II A	MVA	avulsion	avulsion (IV)	sinus	primary talus lateral process
32	F	34		R	II B	fall downstairs	intact	no, normal	extensile	
33	F	62		L	II C tongue	fall downstairs	intact	no, normal	sinus	
34	M	34		L	II C tongue	fall from wall	intact	no, normal	sinus	
35	F	55		R	II A	fall downstairs	intact	no, avulsion	extensile	
36	M	19		R	II C	soccer injury	intact	no, normal	medial	
37	M	39		L	II B	fall downstairs	intact	no, normal	sinus	
38	F	59		L	II B	fall downstairs	intact	normal, normal	extensile	
39	M	22		L	IV	fall from roof	intact	subluxed, pouch	extensile	
40	F	37		R	III AB	fall from monkey bars	intact	no, normal	extensile	
41	F	31		L	IV	fall downstairs	intact	no, normal	extensile	
42	M	49		L	IV	fall downstairs	avulsion	avulsion/dislocated, avulsion	extensile	
43	M	40		L	II A	fall from ladder	intact	normal, normal	koutz approach	
44	M	42		R	II A tongue	fall from truck	intact	normal, normal	sinus	
45	M	47		R	II B	Fall from ladder	intact	no, normal	extensile	
46	M	46		R	II C tongue	fall downstairs	intact	normal, normal	sinus	
47	M	32		L	IV tongue	autoped	intact	normal, normal	extensile	
48	M	36		R	III AB tongue	MVA	avulsion	avulsion, avulsion	extensile	
49	M	46		R	IV	fall from ladder	intact	no, normal	extensile	
50	F	59		R	IV	MVA	pouch	subluxed, pouch	extensile	
51	M	45		R	II C tongue	fall from wall	intact	no, normal	sinus	
				L	II C tongue		intact	normal, normal	sinus	
52	M	53		R	III AB	fall from fence	intact	normal, normal	extensile	
53	M	60		R	III BC	fall from roof	intact	no, normal	extensile	
54	M	52		L	III AB	fall downstairs	intact	mild subluxation, pouch	extensile	
55	M	37		R	III BC	fall from wall	intact	no, avulsion	extensile	
	M	37		L	III BC	fall from wall	intact	no, normal	extensile	
56	M	46		L	II B	fall two stories	intact	subluxed, pouch	extensile	
57	M	48		R	II A	autoped	intact	no, normal	extensile	
58	M	35		L	IV	fall from ladder	intact	no, normal	extensile	
				R	IV		intact	no, normal	extensile	
59	F	26		R	III AB	MVA	pouch	subluxed, pouch	extensile	
60	M	48		R	II A	fall from stool	intact	no, normal	extensile	
61	M	38		R	II A	Fall from ladder	intact	no, normal	extensile	
62	M	52		L	III AB	fall from ladder	intact	no, but pouch (I)	extensile	dictated as intact
63	M	36		R	III BC	fall from ladder	intact	no, normal	extensile	
				L	II B		intact	no, normal	sinus	
64	F	48		R	II C tongue	fall downstairs	intact	no, normal	sinus + koutz approach	
65	F	35		R	III AB	softball injury	intact	no, normal	extensile	
66	M	46		R	II B	fall two stories	intact	no, normal	extensile	
67	M	35		R	IV	fall two stories	intact	no, normal	extensile	
68	F	35		R	III BC	MVA	pouch	no, pouch	extensile	
69	F	63		L	III AB	fall from standing	intact	normal, normal	sinus + medial	
70	F	54		R	III AC	MVA	intact	no, normal	extensile	
71	M	45		L	III BC	fall from ladder	intact	normal, normal	extensile	
				R	IV		intact	normal, normal	extensile	
73	M	33		R	IV	fall from truck	intact	no, avulsion	extensile	
74	M	47	10/29/1960	R	II B	fall from ladder	intact	no, normal	extensile	
75	F	36	12/17/1971	R	II C	mva	intact	no, normal	medial	
76	M	24		L	III AC tongue	fall two stories	intact	normal, normal	sinus	
				R	III AC tongue		intact	normal, normal	sinus	
77	F	61	3/15/1946	R	III AB	MVA	intact	no, avulsion	sinus extend from post lat fib incision	PILON fx with ext fix
78	M	53	3/31/1954	L	II B	fall from roof	intact	no, normal	extensile	
79	F	51	10/8/1955	R	II A	MVA	intact	no, avulsion	extensile	
80	M	69	10/11/1937	R	II A	MVA	intact	no, normal	extensile	
81	F	55	4/1/1951	R	II A	fall from standing	intact	no, normal	extensile	
82	M	30	7/24/1976	R	IV	MVA	intact	no, avulsion	extensile	
83	M	21	11/12/1985	R	II A	fall downstairs	intact	normal, normal	extensile	
84	M	27	4/5/1979	L	III AC	fall from roof	pouch	no, pouch	extensile	
85	F	45	11/7/1960	L	II B	MVA	intact	no, normal	extensile	
86	F	47	2/26/1959	L	IV	Fall two stories	intact	no, normal	extensile	bilat calc. nonop contralat. Right ankle fx
87	M	18	10/21/1987	R	IV	fall two stories	intact	no, normal	extensile	pilon
88	F	44	8/4/1962	R	II B	MVA	intact	no, normal	extensile	
89	F	27	8/11/1978	R	II A	fall two stories	intact	subluxed, pouch	extensile	
90	F	34	9/1/1971	L	IV	MVA	pouch	no, normal	extensile	
91	F	61	5/28/1944	R	IV	MVA	intact	no, pouch	extensile	
92	M	44	5/5/1961	L	III AC	fall from ladder	pouch	no, normal	extensile	

Figure 1. Patient demographics.

Technique

In order to inspect the integrity of the superior retinaculum, the blunt end of a Freer elevator was inserted in the caudal direction posterior to the fibular within the peroneal sheath (Figures 2, 3). The Freer elevator was then utilized to inspect for the presence of resistance confered by an intact superior retinaculum. The ability to simulate the subluxion/dislocation of the tendons with the Freer elevator from posterior to the lateral aspect of the fibula while within the sheath was a grossly positive finding that occurred either as a result of an osseous avulsion of the superior retinaculum at its fibula insertion, the avulsion of the fibrocartilagenous spike, or a full rupture of the superior retinaculum. The ability to visualize the tenting of the Freer elevator on the surface of the skin during this examination was evidence of redundancy of the superior retinaculum. We defined all these as clinically positive findings that were repaired.

In the absence of these findings without clinical suspicion of pathology and negative CT findings, the peroneal tendons were not visually inspected. The superior peroneal retinaculum was approached with a 3 cm linear incision just posterior to the fibula. Following subcutaneous dissection, the redundant superior peroneal retinaculum was identified and primarily repaired with #2.0 fiberwire suture in a pants-over-vest technique. Larger osseous avulsions underwent primary internal fixation with 2.0 or 3.0 cannulated screws. Small osseous avulsions were debrided, the superior peroneal retinaculum advanced over the lateral roughened fibular border to facilitate adherence, and fixated with 2.0 bone anchors.

RESULTS

There were 62 males (68.88%) and 28 females (31.11%) with a cumulative mean age of 43.39 years (range 19-72 years). The mean follow-up was 13.54 months (8.5-26 months). There were 52 type II fractures (53.61%), 17 (32.69%) of which demonstrated the A fracture line, 20 (38.46%) with the B fracture line, and 14 (26.92%) with the C fracture line. Of the 25 (21.65%) type III fractures, 10 (40%) demonstrated the AB fracture lines, 7 (28%) AC fracture lines, and 8 (32%) demonstrated the BC fracture lines.

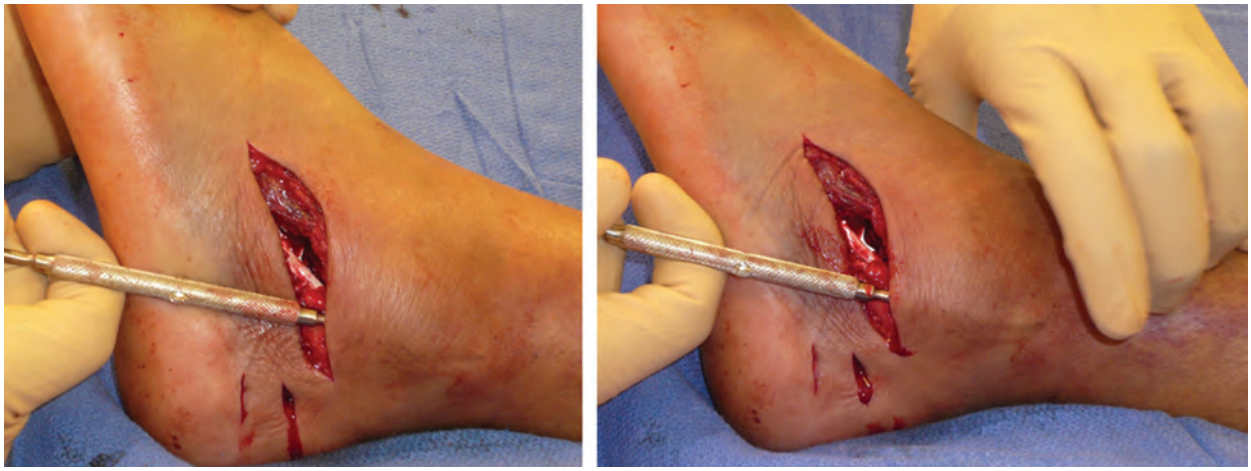


Figure 2. The orientation of the Freer elevator inserted within an intact peroneal sheath.

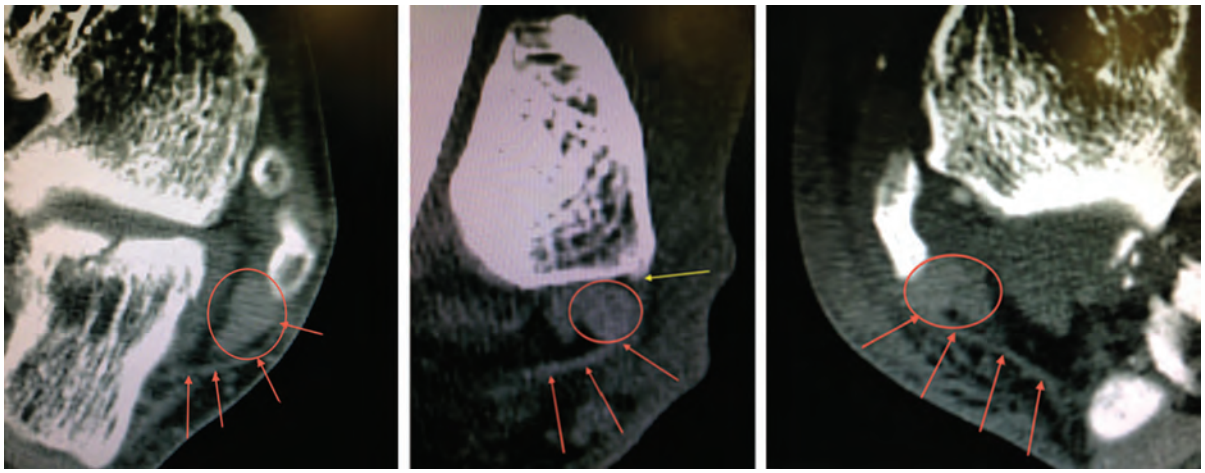


Figure 3. Intact superior retinaculum (orange arrows), intact tendons (orange oval). The intact fibrocartilagenous spike in the middle image (yellow arrow).

There were an additional 22 (22.68%) type IV fractures. Of the 97 cases, 13 (13.4%) required repair of the superior peroneal retinaculum. Six (37.5%) of these repairs were the result of frank avulsions of the superior retinaculum from the fibula with unconstrained peroneal tendons (Figure 4). This was seen in 2 II-A fractures (33.3%), 2 III-AB fractures(33.3%), 1 II-BC fracture (16.6%), and 1 type IV fracture (16.6%). The remaining 7 (53.85%) presented with clinical subluxation/dislocation and redundancy without avulsion or fracture of the fibula (Figure 5). This was seen in 4 type IV fractures (57.14%), 1 III-AB fracture (14.28%), 1 III-BC fracture (14.28%), and 1 III-AC fractures(14.28%).

Of the 6 avulsion, all of which were visualized on CT by the study investigators, 2 (33.3%) were not reported by the radiologist preoperatively. Of the 7 cases with clinical subluxation and redundancy requiring repair, only 2 (25%) were reported as such by the radiologist, and 5 (71.43%) were visualized on CT by the investigators.

Equally important were instances where a positive CT finding did not associate with a clinically postive finding. Of the 97 cases, there were 6 additional cases (6.18%) with evidence of peroneal subluxation with superior retinacular redundancy according to the investigators on CT, 4 of which (66.7%) were reported preoperatively by the radiologist. However, the superior peroneal retinaculum was clinically intact in all these cases. Similarly, there were 6 additional cases (6.18%) with avulsion fractures visible on CT at the fibular insertion of the superior peroneal retinaculum, none of which were reported by the radiologist. Again, none of these cases were associated with a positive intraoperative finding of instability.

DISCUSSION

Calcaneal fractures are devastating injuries with relatively poor outcomes depending on the fracture pattern. Combined in the setting of the missed traumatic superior peroneal retinacular injury with subluxation, the morbidity can be significant (7-9). Poor outcomes specifically pertaining to this have been reported specifically relating to the inability to resist inversion due to peroneal tenosynovitis. which can be a source of significant disability (3). Peroneal tendinopathy must be ruled out from subtalar joint pathology along the lateral course of the tendons.

It was our desire to elucidate the acute and specific findings to help in the identification of this pathology. Because of the relatively little attention it has received, this pathology is scarcely suspected, even among skilled musculoskeletal radiologists, as our findings demonstrated and as such without a high index of suspicion, it is easily missed. This was evident in instances where pathology was visualized on the CT by the study investigators without a comment from the radiologist. The reverse did not occur. Interestingly, there were instances where avulsion type fractures of the fibula at the peroneal insertion were noted on the CT; however did not clinically correlate with instability, highlighting the dynamic nature of this pathology. The ability to easily trace the peroneal tendons on CT along the entire posterior course along the fibula reduces the likelihood of identifying pathology clinically and intraoperatively. Conversely, indistinctness of the peroneal tendons may be the prodrome of injury as a result of hematoma within the peroneal sheath.

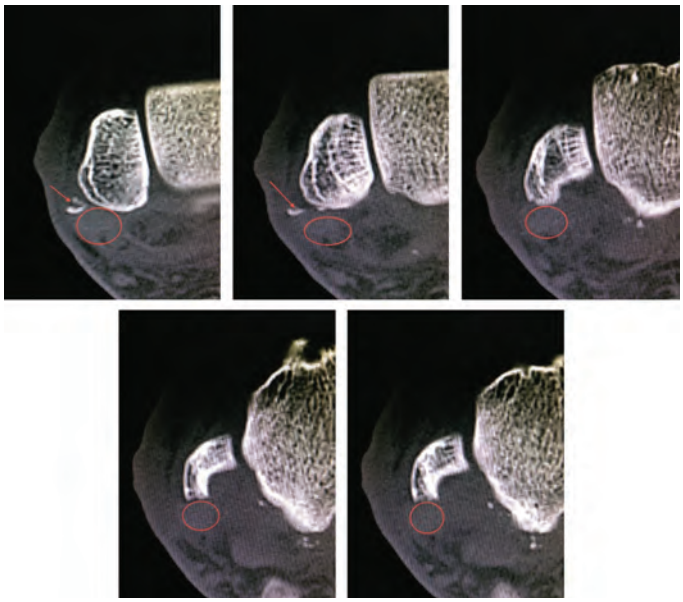


Figure 4. Avulsion (orange arrow)with subluxation and indistinctness of the injured peroneal tendons with blood within sheath (orange oval).

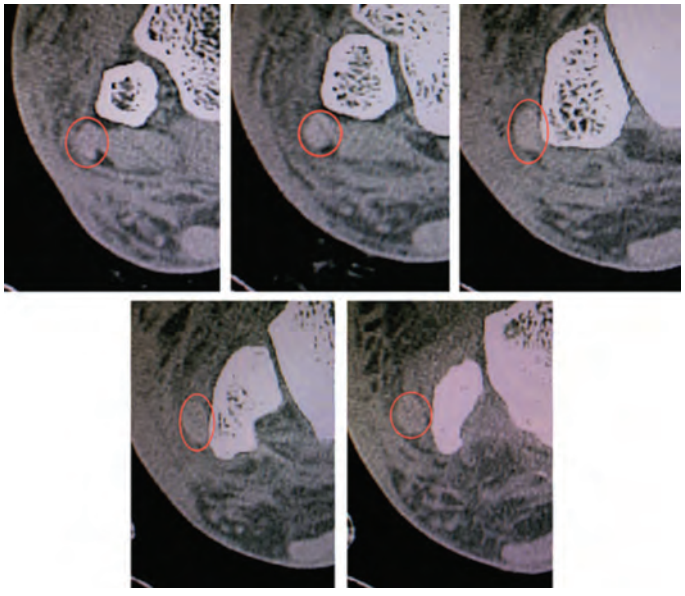


Figure 5. Grossly subluxed peroneal tendon traced by the orange oval along its course.

Ebraheim et al reported that 8 of 21 intraarticular calcaneal fractures presented with peroneal subluxaton or dislocation (10). The study investigators further added that there was no inherent advantage of a magnetic resonance image because of the dynamic nature of this pathology, a finding that corroborated ours.

Based on our exclusion criteria, the inclusion of those fractures that underwent primary repair may have increased the incidence further highlighting the importance of inspecting for this pathology. However, we suspected no clinical benefit of addressing the peroneal injury where the subtalar joint was fused.

The weaknessnes of our study are those inherent in any retrospective study in that we are limited by documentation performed prior to the initiation of the study. We performed no review regarding outcomes nor was it our intent so it is not possible to make any conclusions regarding the therapeutic effect of our intervention. In addition, the presence of retinacular redundancy does not conclusively make any claims that the fracture mechanism was the sole source of the redundancy as there are patients who develop peroneal tendon subluxation as their primary pathology, a concern less attributable to the avulsion types (11).

The fact that the study investigators were not blinded to the studies outcome could have resulted in the investigators over reporting their CT findings. Nonetheless, this did not influence the treatment as the study was retrospective in nature. There is also the remote posibility that the nonstandardized force utlized to inspect the retinaculam with the Freer elevator could potentially injure an otherwise intact retinaculum. The likelihood of this is low, considering the superior peroneal retinaculum was intact in 86.6% of our cases. Nonetheless, perhaps a more blunt instrument could have reduced this uncertainly. We also performed no null hypothesis although we saw an association in which the presence of the A fracture line in any capacity and type IV fractures similarly increased our suspicion of peroneal retinacular injury (12). There was no control group to elucidate as to whether there was a quantifiable clinical benefit of repair of the ligament in our cohort but as previously mentioned this was not our focus. Nonetheless, considering the incidence of vertebral injuries with calcaneal fractures primariy as a result of the mechanism of injury, our findings demonstrate an even higher comparable incidence and notes the importance of clinically inspecting for this pathology as we have described. Missing this pathology could pontentially further confound patient outcomes as previous reports have demonstrated (13).

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