Imaging of os peroneum fracture (or proximal displacement associated with peroneus longus full thickness tendon tear).

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• The peroneus longus tendon passes on one side of the peroneal tubercule, then entering the sole of the feet through a fibro-osseous tunnel (cuboid tunnel) beneath the cuboid bone.

• In 25 percent of the population, there is a sesamoid bone called os peroneum within the substance of the peroneus longus tendon at the level of the fibro-osseous tunnel.

• This ossicle is present in its fully ossified form in up to 20% of adults. It is bilateral in 60% of the cases and bipartite in 30% of the cases.
• Fracture or displacement of the os peroneum is a rare traumatic injury.

• The initial diagnosis of os peroneum fracture or proximal displacement associated with peroneal longus tendon rupture can be overlooked or delayed owing to
  – nonspecific symptoms,
  – confusion with a bipartite os peroneum
  – because of the ignorance of the signification of the displaced ossicle (particularly near the lateral malleolus).
Os peroneum has rounded edges in normal population.
- In about 25% of the normal populations (1) an os peroneum is located 7 mm proximal to 8 mm distal to the calcaneocuboid joint on lateral radiographs and from 9 mm proximal to 8 mm distal to the joint on oblique radiographs (1).

About 30% of all os peroneum are bipartite (2) (3).
- In this case os peroneum fragment separation is 2 mm or less (1). Rounded, smooth, sclerotic margins are consistent with multipartite os peroneum (3).

Fracture of the os peroneum may occur with (3):
- Direct trauma
- Inversion injury
- Strong muscle contraction or an inversion injury of ankle

Violent contraction of the peroneus longus muscle in response to a sudden inversion or supination motion is the most common mechanism which may lead to a compression of os peroneum against the cuboid bone, resulting in fracture and tearing of the peroneus longus tendon. (2) (4)
• Os peroneum may predispose the tendon to an attritional tear at the distal junction of the ossicle and tendon. Mechanical stress at this site, in combination with the oblique course of the tendon in the cuboid groove, may lead to tendon failure (2).

• Os peroneum fragment separation of 6 mm or more or displacement of the proximal fragment by 10 mm or more on a lateral radiograph or 20 mm or more on an oblique radiograph is associated with full-thickness peroneus longus tendon tear.

• Os peroneum fragment separation of 2 mm or less or proximal displacement of 8 mm or less was associated with normal tendons, partial-thickness tears, or tendinosis (1).

• Radiographic differentiation between a fractured os peroneum and a multipartite os peroneum can be problematic. In an acute setting, the fracture margins appear nonsclerotic and the bone fragments typically fit together like “pieces of a puzzle” (1).
• It is conceivable that remodeling of fracture fragments over time could give the appearance of a multipartite os peroneum (1).

• Follow-up radiographs are able to detect the progressive retraction of the posterior fragment(s), indicating a tear of the peroneus longus tendon (5).

**Ultrasound**

• With regard to US imaging of os peroneum fracture, little has been described in the peer-reviewed literature (6).

• The os peroneum fragments are hyperechoic at US. Posterior shadowing is present in large fragments; if the fracture fragments are extremely small, posterior shadowing can be absent.

• A fractured os peroneum shows irregular margins, as opposed to the smooth, well-defined margins of a bipartite ossicle. Although separate bone fragments can be seen with both bipartite and fractured os peroneum, the combination of a large gap with irregular margins, as well as pain or discomfort with transducer pressure, suggests os peroneum fracture (7).
Illustration of lateral foot shows os peroneum (long arrow) within the substance of the peroneus longus tendon (short arrows) at the level of the cuboid tunnel.
Case 1:

- The first case is a 45-year old woman who sprained her left foot. She felt severe pain on the lateral aspect of the ankle, but she was able to walk again. On physical examination, diffuse swelling and tenderness were detected on the lateral aspect of the left foot.

- Ultrasound (US) showed an ossified fragment (with posterior acoustic shadowing) in the region of the peroneus longus tendon at the level of the lateral malleolus. We noted also a complete peroneus longus tendon disruption with retraction defining a full-thickness tear.

- X-ray confirmed the os peroneum fracture and showed a proximal fragment at the level of the lateral malleolus and a smaller distal fragment plantar to the cuboid.
(a) US obtained in the long axis and (b) short axis view of the peroneus longus tendon shows big proximal hyperechoic fragment with acoustic shadowing, typical of bone (long arrow), retracted at the level of the lateral malleolus (LM).

(c) US obtained in long axis and (d) short axis of the distal fragment shows a smaller distal fragment (short arrow) which is less hyperechoic and with lesser shadowing at the level of the cuboid (Cu).
(e) US image obtained in the long axis of the peroneus longus tendon at the lateral aspect of the calcaneum (Ca) and (f) in short axis, at the level of the peroneal tubercle (^) shows loss of normal fibrillar tendon echostructure with abnormal hypoechogenicity in relation with full thickness peroneus longus tendon tear (* in a,e,f )
g) Lateral radiograph of the foot showing peroneal ossicle fracture with a big proximal fragment (short arrow) retracted at the level of the external malleolus, believed to be entrapped in the superior peroneal retinaculum. Smaller distal fragment (long arrow) is seen at the level of the cuboid bone (Cu). The fragments are separated by a distance of 72 mm and the distance from the most posterior fragment to the calcaneocuboid joint was 63 mm. Ca=calcaneum.
Illustration of lateral foot showing os peroneum fracture and proximal fragment (short arrow) retracted at the level of the lateral malleolus entrapped in the superior fibular retinaculum (SR) and a distal fragment (long arrow) plantar to the cuboid (Cu). IR=inferior fibular retinaculum, Ca=calcaneum.
Case 2:

- The second case is a 57-year old man who sprained his right foot one year before the present examination. He felt pain behind the lateral malleolus of the ankle, but he was able to walk again. On physical examination, tenderness was detected on the lateral aspect of the left foot.

- US showed an ossified fragment (with posterior acoustic shadowing) in the region of the peroneus longus tendon at the level of the lateral aspect of the calcaneum. We noted also a complete peroneus longus tendon disruption with retraction defining a full-thickness tear.

- X-ray confirmed the os peroneum fracture and showed a proximal fragment at the level of the lateral aspect of the calcaneum (calcaneal tubercule) and a smaller distal fragment plantar to the cuboid.
(a) US panoramic view in the long axis and (b) short axis view of the peroneus longus tendon (PL) shows big proximal hyperechoic fragment with acoustic shadowing, typical of bone (long arrow), retracted at the level of the calcaneal tubercle (^). Ca = calcaneum, (+) peroneus brevis tendon.

(c) US obtained in long axis of the distal fragment (short arrow), shadowing at the level of the cuboid (Cu).
(d) Oblique radiograph of the foot showing os peroneum fracture with a big proximal fragment (short arrow) retracted at the level of the lateral aspect of the calcaneum, believed to be entrapped in the inferior peroneal retinaculum. Smaller distal fragment (long arrow) is seen at the level of the cuboid (Cu) bone. The fragments are separated by a distance of 40 mm and the distance from the most posterior fragment to the calcaneocuboid joint is 36 mm.
Ca=calcaneum
The third case is a 40-year old man who severely sprained his right foot nine years before the present examination. At that time of the sprain, fracture of the base of the fifth metatarsal bone was reported. After treatment he continues to experience discomfort and pain at the lateral aspect of the ankle slowly increased with time.

US showed two ossified fragment in the region of the peroneus longus tendon at the level of the lateral aspect of the calcaneum. We also noted a complete peroneus longus tendon disruption with retraction defining a full-thickness tear.

X-ray confirmed the os peroneum fracture and showed a proximal fragment at the level of the lateral malleolus and a smaller distal fragment plantar to the cuboid.
(a) US obtained in the long axis and of the peroneus longus tendon (PL), at the level of the lateral aspect of the calcaneum (Ca), shows two proximal bone fragments (long arrows), retracted at the level of the inferior retinaculum. (b) US obtained in long axis of the peroneus longus, at the level of the cuboid (Cu) shows a distal fragment (short arrow). In between the two fragments there is a peroneus longus tendon (*) lost of normal fibrillar echostructure with abnormal hypoechogenicity in relation with full thickness tendon tear.
(c,d) Oblique radiograph (c in 2015 and b in 2006) of the foot showing os peroneum fracture with a proximal fragment, seen as double fragment at US, (large arrow) retracted at the level of the lateral aspect of the calcaneum (Ca). It is believed to be entrapped in the inferior peroneal retinaculum. Distal fragment (thin arrow) is seen at the level of the cuboid (Cu) bone. The fragments are separated by a distance of 38 mm and the distance from the most posterior fragment to the calcaneocuboid joint is 25 mm. This fracture was overlooked in 2006.

In 2006, at the moment of the initial injury, only the fractures of the base of the fifth metatarsal bone and cuboid were diagnosed.
Illustration of lateral foot showing os peroneum fracture and proximal fragment (short arrow) retracted at the lateral aspect of the calcaneum (Ca) entrapped at the level of the inferior fibular retinaculum (IR) and a distal fragment (long arrow) plantar to the cuboid (Cu). SR=superior fibular retinaculum.
The fourth case is a 62-year old woman who suffered a non-specific right ankle and foot trauma 4 months earlier to the present evaluation. No clinical data was available except lateral foot pain.

US showed a unique ossified fragment within the fibers of the peroneus longus tendon lateral to the calcaneum at the level of the inferior peroneal retinaculum. This was associated with a full thickness tendon tear distally to the fragment.

X-ray confirmed a unique ossified fragment at the lateral aspect of the calcaneum. This resulted from a full thickness peroneus longus tendon tear with retracted os peroneum entrapped at the level of the inferior peroneal retinaculum.
(a) US obtained in long axis and (b) short axis of the peroneus longus tendon shows loss of normal fibrillar tendon appearance and abnormal hypoechogenicity at the site of the tendon tear (*) distally to a retracted os peroneum (Osp). The Os peroneum is retracted at the level of the inferior peroneal retinaculum (arrows in a and b) as well as the proximally retracted tendon (+). Ca = calcaneum, (^) peroneus brevis tendon.
(c) Oblique radiograph of the foot and (d) anteroposterior radiograph of the ankle shows proximally displacement of os peroneum, 2.5 cm proximal to the calcaneo-cuboid joint on the oblique radiograph. LM = lateral malleolus, Ca = calcaneum, Cu = cuboid.
Illustration of lateral foot showing a unique ossified fragment at the lateral aspect of the calcaneum (Ca) retracted and entrapped at the level of the inferior peroneal retinaculum (IR, short arrow). This resulted from a full thickness peroneus longus tendon tear (long arrow) distal to the ossicle. Cu = cuboid, SR = superior retinaculum.
Case 5

• The fifth case is about a subject who suffered a right ankle sprain with lateral ankle pain.

• US not performed.

• X-ray of the right showed a unique ossified fragment at the lateral malleolus. This is believed to be due to a full thickness peroneus longus tendon tear with retracted os peroneum entrapped at the level of the superior peroneal retinaculum. X-ray performed 6 year before, showed os peroneum in anatomical place at the level of the cuboid tunnel before the tendon rupture.
(a) Oblique X-ray of the right foot with a unique ossified fragment (arrow) retracted at the level of the lateral malleolus (LM). This is believed to be due to a full thickness peroneus longus tendon tear with retracted os peroneum entrapped at the superior peroneal retinaculum.

(b) X-ray performed 6 year before, with os peroneum in anatomical place at the level of the cuboid tunnel.
Illustration of lateral foot showing a unique ossified fragment at the lateral malleolus retracted and entrapped at the level of the superior peroneal retinaculum (short arrow). This resulted from a full thickness peroneus longus tendon tear (long arrow) distal to the ossicle.
We propose different types of os peroneum fractures depending on:

- localization of the os peroneum fragment(s) on the superior or inferior retinaculum

- displacement of the entire os peroneum or fragmentation of the ossicle
Types 1 & 2

- Peroneal longus full thickness tear with os peroneum fracture

**Type 1**

Proximal fragment (short arrow) retracted and entrapped at the level of the inferior fibular retinaculum (IR) and a distal fragment (long arrow) plantar to the cuboid (Cu).

**Type 2**

Proximal fragment (short arrow) retracted and entrapped at the level of the superior retinaculum (SR), around the lateral malleolus and a distal fragment (long arrow) plantar to the cuboid (Cu).
Types 3 & 4

- Peroneal longus full thickness tear distal to integer os peroneum.

Type 3

Non fractured ossified fragment retracted and entrapped at the level of the inferior peroneal retinaculum (IR, Short arrow). No os peroneum in anatomical place. Association with peroneus longus full thickness tear. (long arrow)

Type 4

Non fractured ossified fragment retracted and entrapped at the level of the superior peroneal retinaculum (IR, Short arrow). No os peroneum in anatomical place. Association with peroneus longus full thickness tear. (long arrow)
Conclusion
• US in association with X-Ray are useful methods to diagnose peroneus longus tendon rupture associated with os peroneum fracture and os peroneum proximal displacement.

• This rare injury is important to know, because misdiagnosis can result in meaningful sequellae, including ankle instability and peroneal compartment syndrome.

• We propose 4 types of os peroneum fracture or proximal displacement associated with peroneus longus full thickness tendon tear:
  – Type 1: peroneal longus full thickness tear with os peroneum fracture and proximal fragment displaced at the level of the inferior fibular retinaculum.
  – Type 2: same as Type 1 but displaced at the superior fibular retinaculum.
  – Type 3: peroneal longus full thickness tear distal to integer os peroneum with displacement of a unique os peroneum at the level of the inferior peroneal retinaculum. No os peroneum visible at the level of the cuboid.
  – Type 4: same as Type 3 but displaced at the level of the superior peroneal retinaculum.


