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Case Report

Demystifying the status of fracture healing using tomosynthesis: A case report

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ABSTRACT

Radiography is the most common imaging method for assessing the progress of fracture healing. However, accurate assessment may be confounded by fracture complexity in which a combination of anatomic overlay and hypertrophic callous can be visually misleading. We present just such an instance in which delayed fracture healing was further elucidated using tomosynthesis.

Case report

A 75-year-old woman sustained a right second metatarsal base fracture while away on vacation, confirmed by radiography at an outside institution. The patient was treated with an orthopedic boot but continued to experience pain with palpation near the tarsal–metatarsal joint after she returned home, prompting her to seek further treatment at our institution 3 months later. Thus, our initial radiographic imaging was performed 3 months after the episode of trauma. The initial anterior-posterior (AP) radiograph was obtained using a standard angulation of the x-ray beam relative to the dorsum of the foot, showing apparent osseous bridging developing at the fracture site (Fig. 1A). However, a contemporaneous radiograph with modified x-ray beam angulation that was perpendicular relative to the sole of the foot showed a conspicuous fracture plane (Fig. 1B). The patient remained in the orthopedic boot but continued to have pain. Six months later, 9 months after the episode of trauma, the fracture again appeared healed on the standard AP radiograph (Fig. 2A), with evidence of linear sclerosis corresponding to the area of fracture. However, persistent conspicuity of the fracture plane remained apparent on the oblique view (Fig. 2B), raising the concern for delayed fracture union. Given this ambiguous radiographic appearance and the continuation of symptoms, tomosynthesis was recommended for further evaluation.

Subsequent lateral and oblique tomosynthesis views (Fig. 3A-E and Fig. 4A-E) were obtained using multiple low-dose exposures of the foot taken from tube angles of −35 to +35° by a mobile x-ray tube aimed at a stationary digital amorphous silicone flat-panel detector (GE Discovery XR656 with VolumeRad, GE Healthcare, Waukesha, WI). The resultant data set was then used to reconstruct 110 images in the lateral plane and 56 images in the oblique plane, measuring 1 mm in thickness, and using a filtered back projection technique to minimize radiation and artifact. These images revealed a previously unrecognized morphologic complexity

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Fig. 1 – (A) A 75-year-old woman with delayed fracture healing. The 3-month AP radiograph shows apparent osseous bridging of the second metatarsal fracture (black arrow). (B) With modified x-ray beam angulation, the fracture is now visible (black arrow).

to the fracture, with both oblique and transverse components. The transverse component had not been appreciated on the previous conventional radiographs and appeared to be contributing to the indeterminate appearance that had lead to the request for further imaging. More importantly, the tomography clearly demonstrated the absence of osseous bridging across either fracture plane, consistent with a diagnosis fracture nonunion.

Discussion

Traditionally, fracture healing has been followed using radiography to assess the preservation of fracture alignment and evaluate bony callus deposition and progressive disappearance of the principal fracture planes. In view of the relatively low monetary cost and radiation dose, as well as the efficiency and comparatively high diagnostic potential, radiography

Fig. 2 – (A) A 75-year-old woman with delayed healing fracture: At 6 months, the anterior–posterior projection demonstrates apparent osseous bridging at the fracture site (black arrow). (B) The oblique radiograph shows continued fracture conspicuity (black arrow), raising a concern for nonunion.

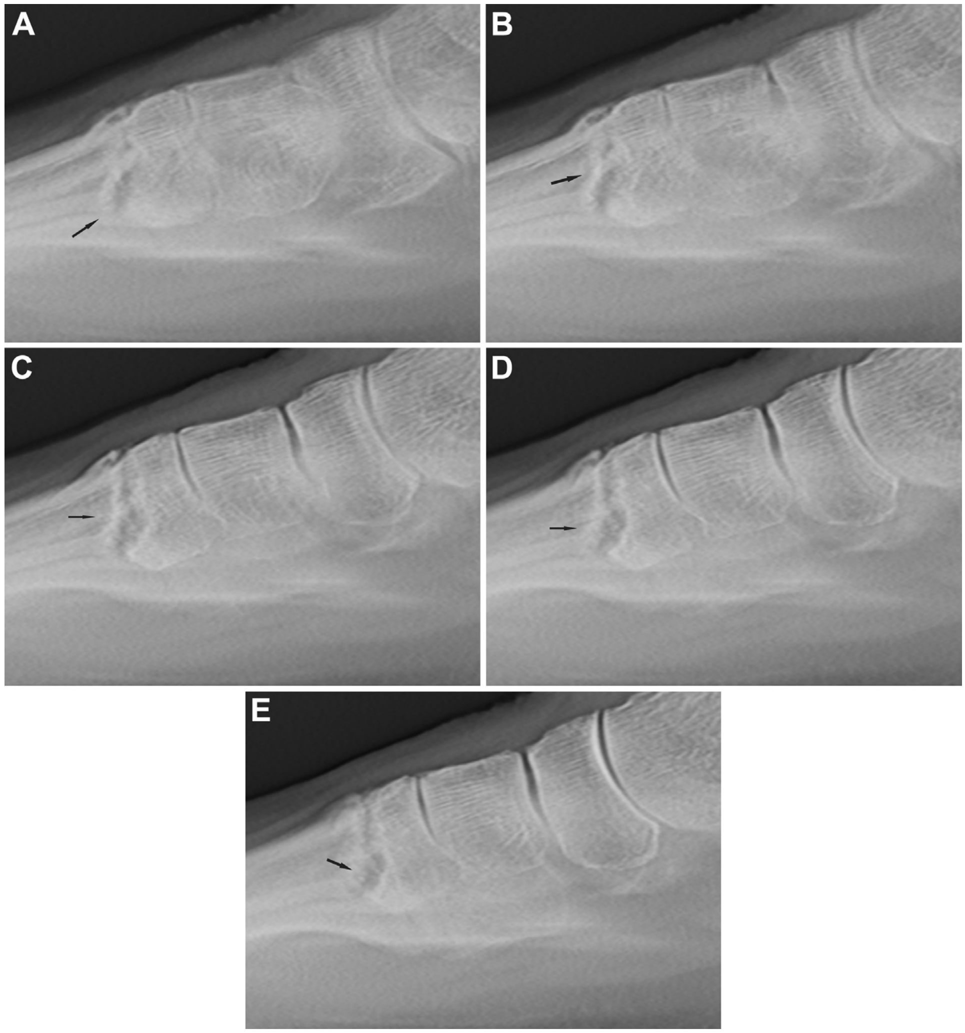

Fig. 3 – (A-E) Lateral tomosynthesis images of the second metatarsal demonstrate incomplete osseous bridging (black arrow).

remains a mainstay of musculoskeletal imaging. The difficulty arises when the suspected abnormality is so small, or the anatomy so altered, that the risk of undercharacterization arises. Often, the solution has been to proceed with computed tomography (CT) for such situations at greatly increased cost and radiation exposure.

Digital tomosynthesis is a modern adaptation of an archaic analog imaging technology wherein repeat low-dose radiographs were acquired at intervals using a mobile x-ray tube and a mobile film holder moving in synchrony [1,3]. By changing the body position within the imaging arc, tomographic images were obtained with a central plane in focus while eccentric or out-of-plane anatomy was blurred [2,3]. The aim of this technique was to minimize the conspicuity of anatomic overlap, thereby increasing visualization of the region of interest [3]. Digital tomosynthesis also uses a moving x-ray beam and a moving detector, but the data are acquired digitally and a computer algorithm is used to reconstruct the data set into images. Although this technique results in a slightly higher radiation dose to the patient than conventional radiography, the dose is significantly less than CT.

Although not widely used for musculoskeletal indications, tomosynthesis has been shown by Geijer et al to aid in scaphoid fracture detection, and by groups such as Hayashi et al and Aoki et al in the characterization of joint surface integrity [4,5]. Hayashi et al found that tomosynthesis detected more osteophytes and subchondral cysts in

Fig. 4 – (A-E) Oblique tomosynthesis images of the second metatarsal confirm incomplete osseous bridging (black arrow) and complex fracture morphology.

osteoarthritic knees than conventional radiography, and Aoki et al showed a higher detection rate for subchondral erosions using tomosynthesis (36.1%) compared with radiography (26.5%) in rheumatoid arthritis patients while incurring an average radiation dose of only 0.25 mGy compared with the 0.13 mGy of radiographs [5]. Similar to the case presented, the use of tomosynthesis is currently being investigated for its application in the evaluation of posttraumatic and postsurgical complications, with Göthlin and Geijer finding improved conspicuity of osteolysis affecting particular areas of total hip arthroplasy components [6].

Fig. 4 – (*continued*).

Although CT remains superior to tomosynthesis for the evaluation of bone, findings as exemplified by this case suggest that tomosynthesis may be a reasonable supplement to conventional radiography for certain indications, especially when the higher cost and radiation exposure of CT is unwanted.

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