

MARS ultra-high-resolution imaging for improved characterisation of pre- and post-operative scaphoid fractures

CASE STUDY

Purpose of the study: To evaluate the diagnostic potential of MARS spectral photon-counting CT in the quantitative and qualitative assessment of scaphoid fractures.

This study was done in association with:

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Introduction: The scaphoid bone is the most frequently fractured carpal bone, most commonly after a fall onto an outstretched hand. The diagnostic modalities used to detect a scaphoid fracture include plain radiograph, computed tomography (CT), magnetic resonance imaging (MRI), and bone scintigraphy. In this study we used a new high-resolution imaging modality, MARS, to analyse fracture non-union characteristics.

MARS uses a low power x-ray tube, photon counting detectors (Medipix3RX) and narrow energy ranges to differentiate and measure multiple materials (lipid, water and calcium) in a single scan. The smaller pixel size of the photon counting detectors (110 μm) enables visualisation and quantification of both cortical and trabecular density, as well as characterising the morphology of the fracture site. The scans are lower dose and can be retrospectively reconstructed in isotropic voxel sizes ranging from 60 μm to 500 μm .

We present three cases of scaphoid fracture non-union. These patients either had an x-ray or a CT scan to diagnose the fracture.



Image of the upcoming MARS arm scanner is indicative only

Conclusion: The MARS scanner is an ultra-high-resolution, low-dose (<0.05 mSv), 3D advanced imaging modality which produces high contrast images containing tissue composition information and reduced metal artifact, facilitating improved diagnostic potential.

Clinical relevance: The MARS scanner produces high contrast bone detail, as well as assessment of bone density and morphology at the fracture site. This increased level of detail and information can aid in treatment decisions, as well as surgical planning. Postoperative imaging evaluation of fracture fixation with metalware is often impaired by the metal artifact, which makes it difficult to evaluate the surrounding tissue. Due to reduced metal artifact and greatly improved visualisation of the bone-metal interface, MARS can be used to assess fracture healing and identify any metalware complications, such as implant loosening, migration of screw, or infection.

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Case study 1: A 56-year-old woman, who is right hand dominant, fell onto her outstretched hand hyperextending her wrist. The patient had x-ray radiographs, CT scans and a cone beam CT (CBCT) scan to assess fracture healing due to ongoing pain and tenderness of her left wrist. The MARS scan was performed seven months post injury.

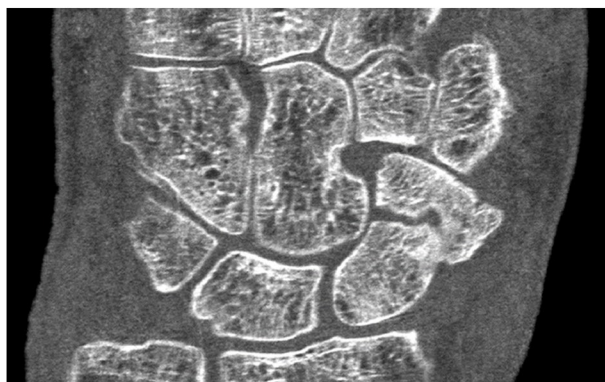


Figure 1: Coronal view of the left wrist showing a comminuted transverse fracture at the scaphoid waist.

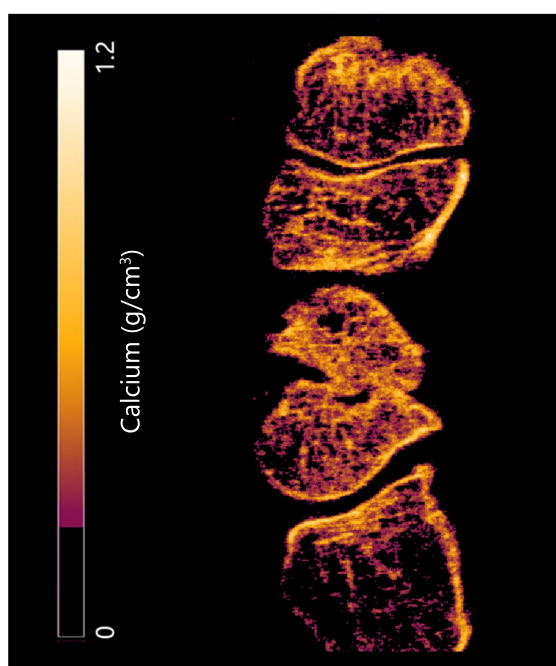


Figure 2: Sagittal calcium imaging demonstrates sclerosis of the scaphoid fracture site and humpback deformity. The colour code represents the density of the calcium.

Results: The MARS images show a comminuted transverse fracture at the scaphoid waist. Sclerosis was observed at the fracture margin seven months post injury indicating non-union. Sagittal images show collapse at the fracture site with humpback deformity. Proximal pole sclerosis was not observed.



Figure 3: 3D volume rendering of the patient's wrist differentiating soft tissue and bone.

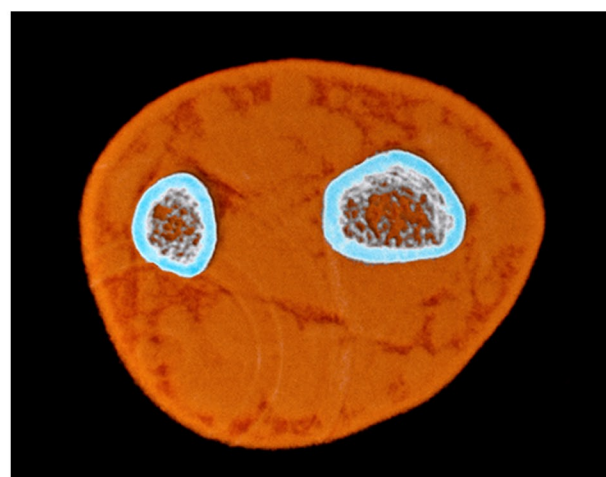


Figure 4: Transverse image of the patient's wrist highlighting bone segmentation.

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Case study 2: A 55-year-old right hand dominant male was troubled with chronic right wrist pain following a bike crash. The patient had radiographs and CBCT scan to monitor the progress of fracture healing. Twelve weeks post injury, the patient had a MARS scan.

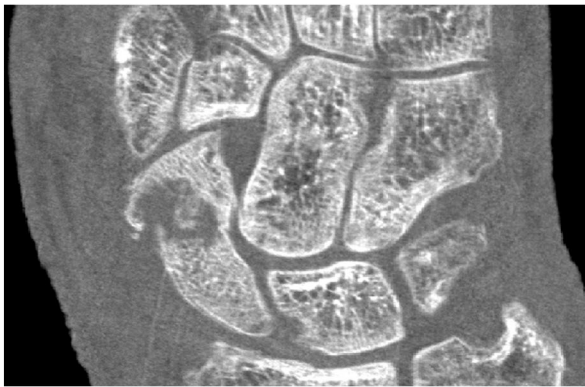


Figure 5: Coronal view of the right wrist demonstrates the separation between the fracture fragments.

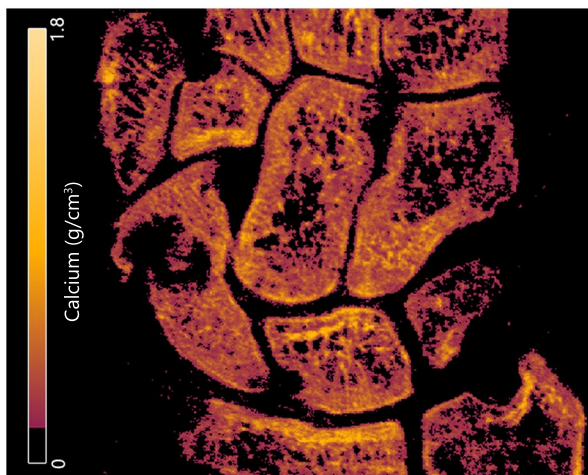


Figure 6: Sclerosis of the fracture margins was not observed on calcium imaging.

Results: The MARS images show non-union with displacement. Small bony fragments were observed at the fracture margin. The separation between the fracture fragments was more than 3 mm. Sclerosis was not observed.



Figure 7: 3D rendering of the calcium imaging of patient's wrist with scaphoid fracture.



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Case study 3: A 22-year-old man fell from his bike onto an outstretched hand injuring his left wrist. The patient had an open reduction and internal fixation. Two months post operation, the patient had a MARS scan.

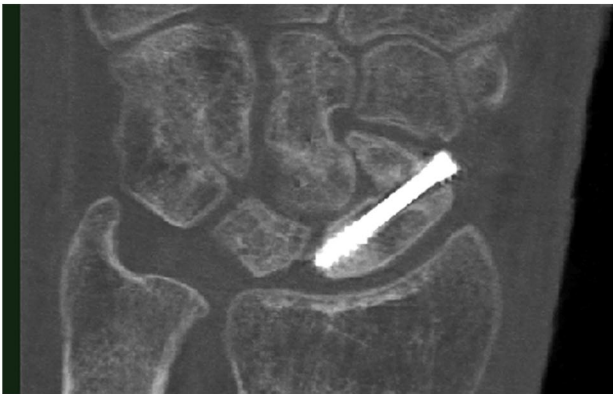


Figure 8: Coronal views of the left wrist show bone and soft tissue in the vicinity of the implant with reduced metal artifacts.

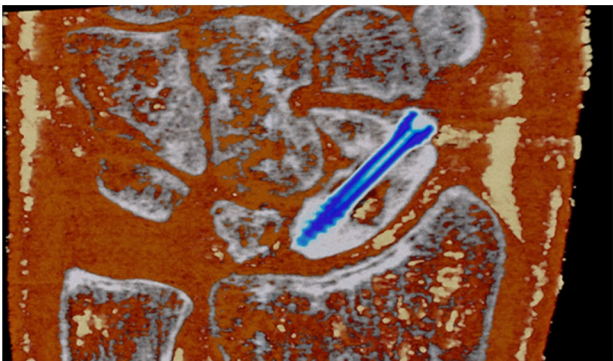


Figure 9: This image demonstrates differentiation of tissues, fat (yellow), soft tissue (orange red), bone (grey), and screw (blue).

Results: MARS images show reduced metal artifact at the bone-metal interface and visualisation of soft tissue in the vicinity of the implant. The MARS images show the impingement of the screw on the scaphotrapeziotrapezoidal (STT) joint. Sclerosis was observed at the proximal pole of the scaphoid suggesting avascular necrosis.

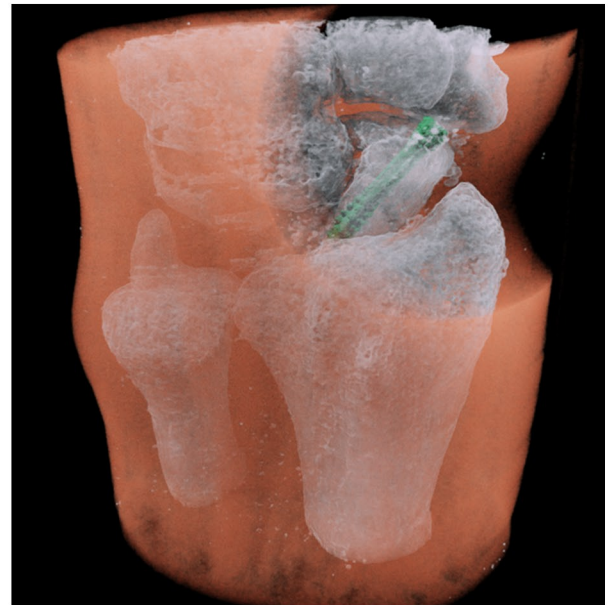


Figure 10: 3D volume rendering of the patient's wrist. The bone has been made slightly translucent to enable better visualisation of the position and orientation of the screw.



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