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Case Report

A Case Report of Abnormal Fracture Healing as Detected With High-Resolution Peripheral Quantitative Computed Tomography

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Introduction

Fracture healing is a complex repair process with the primary objective of restoring the mechanical function of the fractured bone *(1)*. Quantifying outcome in clinical fracture healing trials remains challenging *(2,3)*. Using high-resolution peripheral quantitative computed tomography (HR-pQCT) in combination with micro finite element analysis (μFEA), we previously described the typical healing of a distal radius fracture. This process consists of an increase in bone density of the trabecular compartment peaking at 6 wk post fracture, corresponding to the formation of a mineralized fracture callus *(4,5)*. In the present case report, we describe a patient who deviated from this usually observed pattern of fracture healing.

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Patient and Methods

Case Report

A 54-yr-old woman visited our emergency department with a displaced distal radius fracture of the left arm after a fall from standing height. After a successful closed reduction at the emergency room, the patient was treated by cast immobilization. Six weeks post fracture, the patient complained of increased pain, swelling, and stiff fingers. Physical examination revealed no neurological or vascular impairment. Standard radiographs showed incomplete consolidation of the fracture without secondary dislocation. Cast immobilization was continued for 2 more weeks. At the 8-wk outpatient clinic visit, a decreased motor function of the extensor muscles of the left wrist and all digits without sensory disturbances was observed. Radiographic examination showed delayed but progressing consolidation (Supplemental Fig. S1). Physical therapy was started. Three months after the fracture, the left lower arm was swollen and showed a purple discoloration. Active flexion and extension of the left wrist and digits were 0° in all axes, and active and passive movements of the left shoulder were limited. Electromyography of the left arm revealed conduction abnormalities of the radial nerve near the wrist, and ulnar and median nerve injuries at elbow level. Three months post fracture, the patient met the Budapest clinical and research criteria *(6)* for complex regional pain syndrome (CRPS) type 1. Subsequent multidisciplinary treatment consisted of graded exposure therapy, transcutaneous electrical nerve stimulation, amitriptyline,

dimethyl sulfoxide 50%, pregabalin, calcitonin, paracetamol, and tramadol. At the last follow-up, 3 yr post fracture, active motion of the left wrist was 0° in all axes and both spontaneous pain and allodynia were present, although the patient was able to use her affected hand to a greater extent during normal daily activities than before treatment.

Routine screening on osteoporosis with dual-energy X-ray absorptiometry and laboratory examination showed osteopenia at the lumbar spine and proximal femur, and secondary hyperparathyroidism (parathyroid hormone 8.0 pmol/L, ref. 1.3–6.8), due to vitamin D deficiency (25(OH) vitamin D: 33 nmol/L, ref. >75 nmol/L). With cholecalciferol supplementation, the latter was resolved by 12 wk post fracture (25(OH) vitamin D: 67 nmol/L, parathyroid hormone 4.5 pmol/L).

HR-pQCT Measurements

HR-pQCT is a low-dose radiographic imaging modality with an isotropic voxel size of 82 (XtremeCT-1; Scanco Medical AG, Brüttisellen, Switzerland). The high resolution enables the assessment of bone microarchitecture in vivo *(7)* and estimation of bone strength μFEA *(8)*.

HR-pQCT scans (XtremeCT-1) were performed at 1, 3, 6, 12, and 115 wk post fracture using the manufacturer's clinical in vivo settings (effective energy of 60 kVp, tube current of 900 μA, and 100-ms integration time), in accordance with the approved study protocol (NTR3821). From these images, bone density, geometry, and microarchitectural and μFEA parameters were derived *(4,5)*.

Results

Incongruent with the healing pattern observed with HR-pQCT described earlier *(4,5)*, a decrease in trabecular density was detected at 6 wk post fracture (–11.9 mgHA/cm^3), where the typical healing response showed an increase (median +35.4 mgHA/cm^3). This deviation was not restored even after 115 wk (Fig. 1A). Simultaneously, the

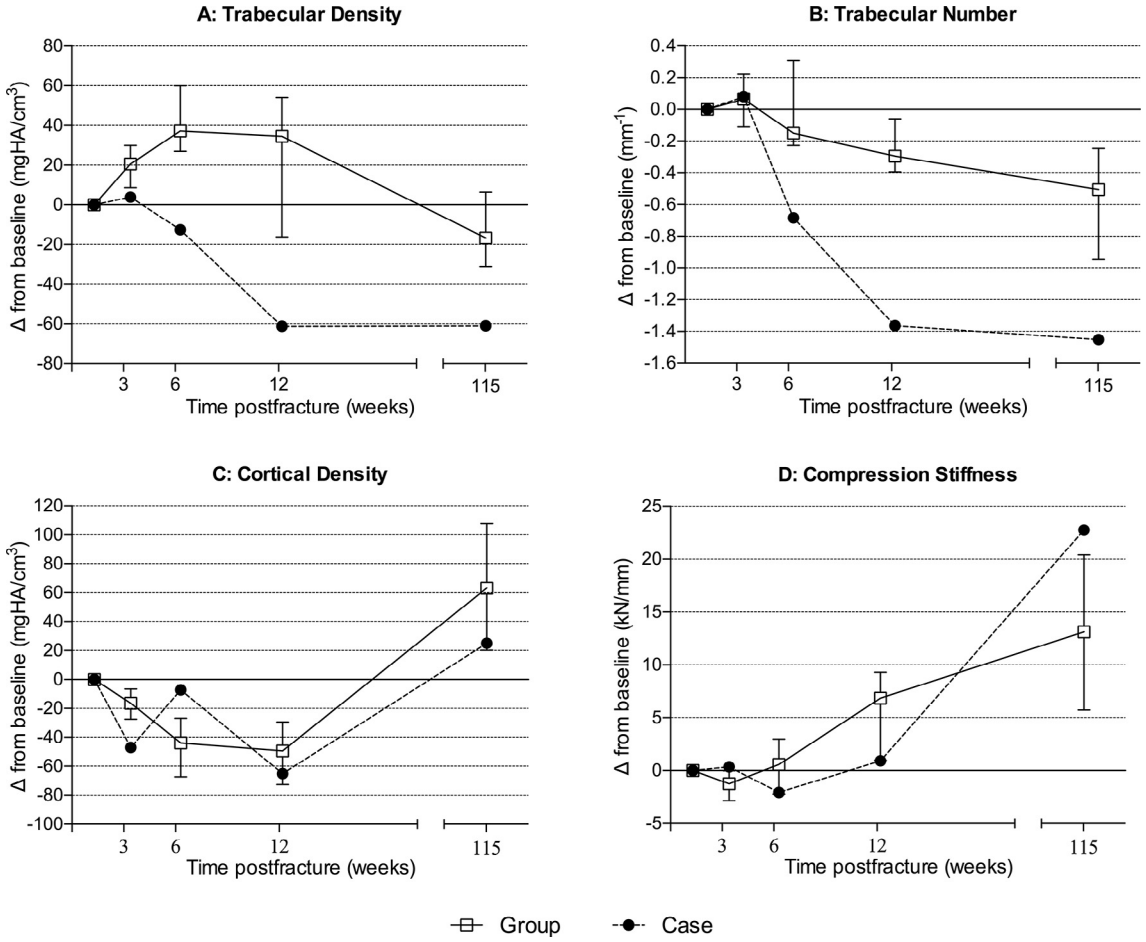

Fig. 1. High-resolution peripheral quantitative computed tomography-derived bone parameters of the presented case of abnormal fracture healing (black circles) compared to the other subjects of the study cohort (white squares, N = 14). In the case patient, the trabecular density is seen to decrease early in the healing process, persisting up to 115 wk (**A**), along with the trabecular number (**B**). In contrast to trabecular density, cortical density during fracture healing follows a normal pattern (**C**), which explains the restored compression stiffness (**D**). Data are presented as median with interquartile range. Scans were performed (on average) at 1, 3, 6, 12, and 115 wk post fracture.