

Case Report

## Occult Compression Fracture of Metacarpal Head without Evidence of Avascular Necrosis

Keiichiro Nishida<sup>a,b\*</sup>, Hiroyuki Hashizume<sup>c</sup>, Akihiro Matsukawa<sup>d</sup>, Kenzo Hashizume<sup>b</sup>,  
Yasunori Shimamura<sup>b</sup>, Yasuyuki Torigoe<sup>e</sup>, and Toshifumi Ozaki<sup>b</sup>

Departments of <sup>a</sup>Human Morphology, <sup>b</sup>Orthopaedic Surgery, <sup>d</sup>Pathology and Experimental Medicine,  
Okayama University Graduate School of Medicine, Dentistry and Pharmaceutical Sciences, Okayama 700-8558, Japan,  
<sup>c</sup>Kasaoka Daiichi Hospital, Kasaoka, Okayama 714-0043, Japan, <sup>e</sup>Torigoe Seikeigeka Clinic, Kurashiki, Okayama 710-0253, Japan

We report a case of 4th metacarpal head collapse of a 19-year-old healthy man. MRI revealed T1 low and T2 high regions in the collapsed 4th metacarpal head, as well as in the right 3rd and left 4th metacarpal head. Our initial diagnosis was occult compression fracture due to avascular necrosis, known as Dieterich's disease. However, pathological findings of surgically resected right 4th metacarpal head were compatible with transient osteoporosis and metacarpal head fracture followed by active tissue repair. The autologous osteochondral transplants from costochondral junction survived and maintained their size and shape even at 10-year follow-up.

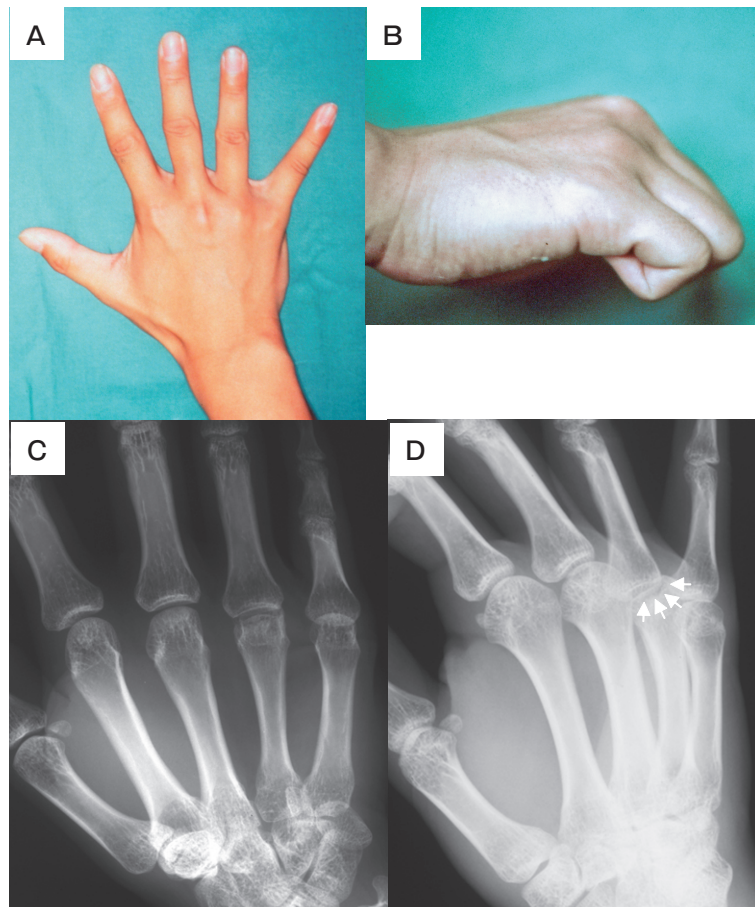
**Key words:** occult compression fracture, metacarpal head, avascular necrosis, osteochondral autograft

Occult compression fracture of the metacarpal head has been described in association with subsequent avascular necrosis (AVN) [1]. We report herein a case of metacarpal head collapse of the right 4th finger with the T1 low and T2 high regions revealed by MRI of a healthy 19-year-old male. Similar MRI findings were noted in the right 3rd and left 4th metacarpal head without fracture. They were initially diagnosed as a rare AVN of the metacarpal head; however, the pathological findings of the metacarpal head obtained at surgery showed no evidence of osteonecrosis. We also describe the 10-year clinical follow-up of the reconstruction surgery by costal osteochondral autograft for 4th metacarpal head. The patient was informed that data concerning the case would be submitted for publication, and he and his

father provided written consent.

### Case Report

A healthy 19-year-old, right-hand-dominant male presented to our hospital with a 3-month history of progressively worsening right-hand pain. He was a 1st-year automotive engineer, and he had had no other notable medical history including trauma. The pain was localized in the 4th metacarpophalangeal (MCP) joint, which showed restricted range of motion (70° of flexion and -15° of extension). There was slight swelling, but no redness or local heat in the 4th MCP joint. A standard radiograph showed collapse of the volar half of 4th metacarpal head (Fig. 1A, B). Laboratory values included normal serum chemistry, erythrocyte sedimentation rate, and C-reactive protein. Our initial diagnosis was an occult compression fracture due to AVN, known as Dieterich's disease [2].

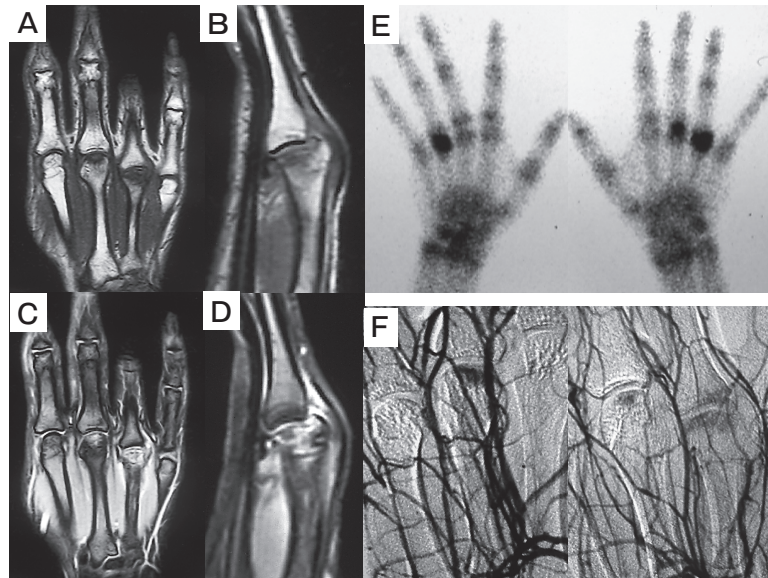


**Fig. 1** Pre-operative appearance of right hand, showing slight shortening of the 4th finger (**A**), and restricted range of motion of MCP joints (**B**). Preoperative radiographs show flattening of 4th metacarpal head (PA view; **C**), and collapse of the volar half of the head and subluxation of the joint (oblique view; **D**). There was no significant change in the 3rd metacarpal head. Arrows indicate collapsed area of volar side of metacarpal head.

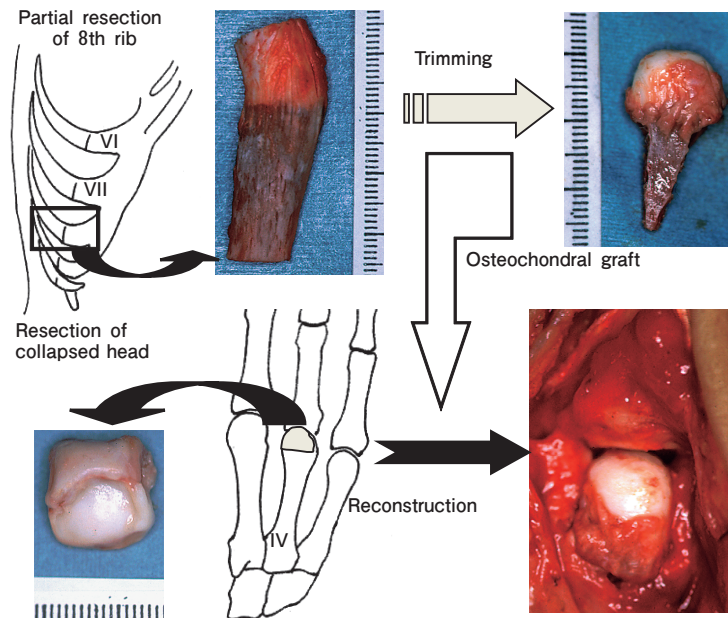
MRI scan revealed a diffuse bone marrow edema pattern in the right 4th metacarpal head, with low and high signal intensities on T1- and T2-weighted images, respectively. Similar appearances were found on the right 3rd metacarpal head (Fig. 2A–D). Bone scintigraphy of both hands with  $^{99m}\text{Tc}$ -hydroxymethylene diphosphonate ( $^{99m}\text{Tc}$ -HMDP) demonstrated increased accumulation of the radionuclide in the right 3rd and 4th, and left 4th metacarpal head (Fig. 2E). Unexpectedly, digital subtraction angiography (DSA) revealed venous pooling in the right 4th, as well as in the right 3rd and left 4th metacarpal heads (Fig. 2F).

The collapsed right 4th metacarpal head was surgically resected and replaced by an osteochondral autograft from the 8th rib of the right side (Fig. 3).

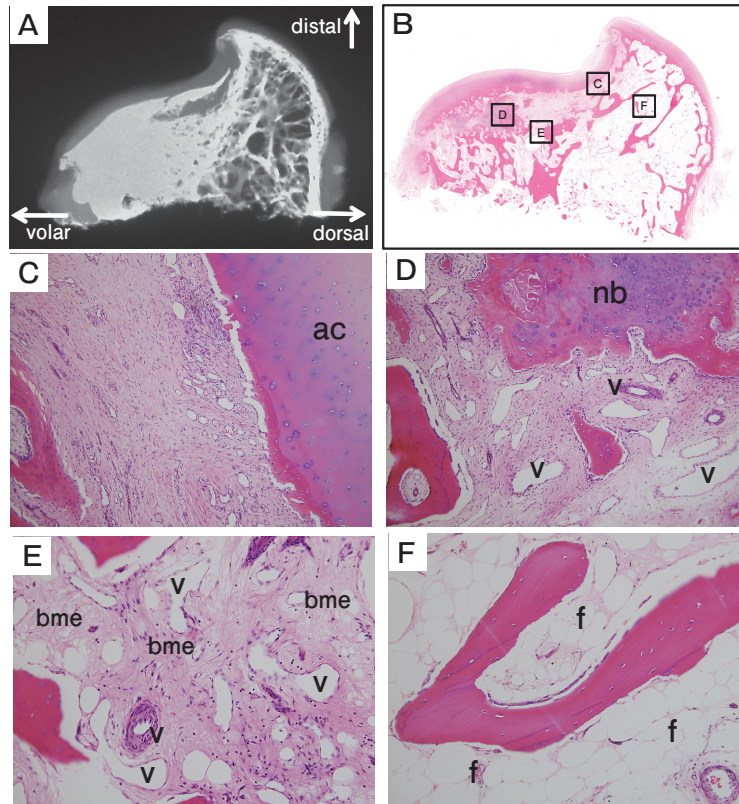
When the resected metacarpal head was compared radiographically and histologically with the preoperative MRI (Fig. 4A, B), the surface articular cartilage was found to be almost intact, and marked thinning of the subchondral bone was noted (Fig. 4C). At the collapsed site with fracture fragments of the cancellous bone, new bone formation, cartilaginous tissue, and fibrous tissue were found, which correspond to the T1-low and T2-low areas in the preoperative MRI (Fig. 4D). Next to the lesion, edema was present with abundant blood vessels and mild focal hemorrhage in the fatty marrow. These lesions corresponded to the T1-low and T2-high areas in the preoperative MRI (Fig. 4E). The remaining metacarpal heads without collapse showed severe osteoporosis



**Fig. 2** A-D: Preoperative MRI of right hand showing collapse of the right 4th metacarpal head, as well as mixed appearance with T1-low and T2-high area, and T1-low and T2-low area within the metacarpal head. MRI also revealed a T1-low and T2-high area at the subchondral region in the 3rd metacarpal head (A, C); A, B, T1-weighted image; C, D, T2-weighted image; A, C, coronal plane; B, D, sagittal plane; E-F, Preoperative bone scintigraphy with 99mTc HMDP (E) and angiography (F) of both hands showing significant hot spots in right 3rd and 4th and left 4th metacarpal heads (E), and delayed venous return in all 3 affected heads compared with the other intact metacarpal heads (F), respectively.



**Fig. 3** Surgical procedure of costal osteochondral graft. Graft was taken from the right 8th rib, and trimming was done to create the joint cartilage surface and bony stem. The collapsed right 4th metacarpal head was resected and replaced by the graft fixed with the intramedullary bone stem.



**Fig. 4** Sagittal view of soft tissue radiograph of surgically resected right 4th metacarpal head (A), paraffin-embedded section (B), and pathology at higher magnification of B (C, D, E, F); C, Thinning of subchondral bone and bone marrow replacement by fibrous tissue; D, New bone formation with osteoblastic lining cells at trabecular surface; E, Bone marrow edema and neovascularization in bone marrow, which correlates with T1-low and T2-high region, and T1-low and T2-low region in MRI, respectively; F, Thinning of the trabecular bone without any osteocyte cell death. ac, articular cartilage; nb, new bone formation; bme, bone marrow edema; v, blood vessel; f, fat cell; B-F, H&E stain.

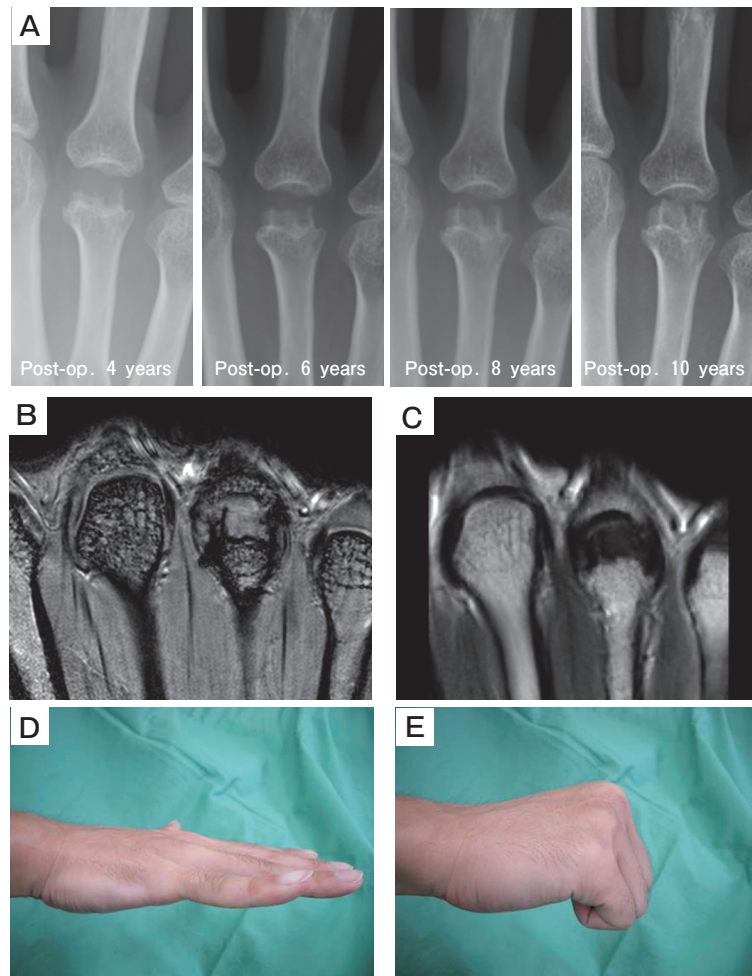
with scattered bone trabeculae (Fig. 4F). Throughout the specimen, there was no evidence of antecedent osteonecrosis with empty lacunae. These results were different from AVN, and they cumulatively suggested that latent bone fragility derived from increased intramedullary pressure and bone marrow edema might have predisposed the bone to an occult compression fracture of the 4th metacarpal head.

Annual follow-up was carefully done clinically, radiographically, and by MRI (Fig. 5). Radiographically, bone union was seen between the grafted bone and right 4th metacarpal bone at 1-year follow-up, and diffuse calcification was noted within the grafted cartilage after 3-year follow-up. At final follow-up, the calcification had extended further distally. No collapse of the right 3rd or left 4th metacarpal head occurred (Fig. 5A). Interestingly, the edematous areas seen at

the right 3rd metacarpal head spontaneously disappeared (Fig. 5B, C). At 10 years' follow-up, the patient had no motor pain or restricted motion of the right 4th MCP joint (Fig. 5D, E).

## Discussion

Metacarpal head fractures are rare conditions that usually occur intra-articularly as the result of axial loading or direct trauma [1]. They are classified into several categories: epiphyseal or ligamentous avulsions, osteochondral slices, two-part fractures occurring in different planes, comminuted fractures, boxer fractures, fractures with substance loss, and occult fractures with AVN [1]. The most probable cause of the collapse of the metacarpal head of our patient was AVN, which has been known as a rare finding first



**Fig. 5** **A**, Radiographic changes of grafted bone during follow-up. New bone formation occupied a large area of the costal cartilage, extending distally for 10 postoperative years, but the surface cartilage seems to have remained functional; **B**, **C**, MRI (3-T system, with surface coil) appearances of the grafted costal cartilage at final follow-up, showing T1-iso (**B**) and T2-low (**C**) cartilaginous pattern and cortical bone formation in the grafted costal cartilage; **D**, **E**, Postoperative range of motion of right hand at final follow-up, showing full extension (**D**) and full flexion (**E**) of MCP joints.

described by Dieterich or Mauclair around 1932 [2]; fewer than 50 cases have been reported in the world literature [3]. Although the etiology and natural history of the disease is not known, it can occur idiopathically [2-6], in association with trauma [7-9], from steroid use [10-12], and with systemic lupus erythematosus [13]. Our patient had no etiological or risk factors for AVN except for his relatively strenuous job as an automotive engineer.

The diagnosis of AVN is usually performed on standard radiographs [14], but recent reports have shown that MRI is a sensitive tool for diagnosing

AVN [3, 6, 8, 14, 15]. However, the diagnoses in these reports have not been based on clear evidence of histopathological findings for osteonecrosis, due to both the rarity of the disease and to the selected treatment procedure. In addition, the bone marrow edema pattern on MRI with diffuse low signal intensity on T1-weighted images and high signal intensity on T2-weighted images is not a specific finding for necrotic regions, and is similar to that of transient osteoporosis of the hip [16, 17].

In the present case, the MRI bone marrow edema pattern of the T1-low and T2-high regions in the col-

lapsed fragment correlated with the area of bone marrow edema with fibrovascular repair tissue. The diffuse low-signal-intensity area on the T1-weighted image might be partly a concomitant edema, due to the near collapse, and does not necessarily indicate enlargement of the necrotic area. The T1-low and T2-low regions within the collapsed fragment correlated with the living bone trabeculae and active bone formation with osteoblastic lining, indicating the potential for fracture healing, which correlated well with positive bone scintigraphy. The remaining dorsal part of the head showed osteoporosis with thin subchondral bone and scattered intramedullary trabeculae, but it was not accompanied by empty lacunae. These findings were compatible with transient osteoporosis and metacarpal head fracture followed by active tissue repair.

Wright and Dell reported that a main arteriole in the distal epiphysis was absent in 35% of specimens, making these metacarpal heads solely dependent on small circumferential pericapsular arterioles [18]. However, in our patient, DSA showed "venous pooling" rather than devascularization in the 3 affected metacarpal heads, indicating that there might be a delay in venous return, resulting in increased intramedullary pressure and hypoxia. These findings suggest for the etiology of the current case that blunt trauma to the metacarpal head area may have resulted in an occult microfracture without the patient's knowing it [8], compressing the periosteal blood vessels and delaying venous return. The increased bone marrow pressure might have caused bone marrow edema and transient osteoporosis, resulting in collapse of the right 4th metacarpal head. Follow-up of the right 3rd and left 4th metacarpal head with bone marrow edema of our patient also showed complete healing 1 year after surgery. These facts also indicate that some cases reported as Dieterich's disease might include bone marrow edema, insufficient subchondral fracture, or collapse due to bone fragility; some of these cases are asymptomatic and result in spontaneous regeneration without treatment [10].

Surgical intervention might be required if there is a collapse or deformity at the metacarpal head with clinical symptoms. However, the optimal treatment modality is still uncertain because of the relatively rarity of metacarpal head collapse. Several treatment methods are applicable, such as autogeneic and allogeneic

osteochondral transplantation, resection arthroplasty, free vascularized joint transfer, silastic implant arthroplasty, or autologous perichondral graft. Curretage and cancellous bone impaction to raise the articular cartilage is a realistic option [5, 6, 14, 19], but in our case we were concerned about stabilizing the fragment, bonding the bone and cartilage and future early degenerative changes [6].

Because our initial diagnosis was Dieterich disease, the collapse of the volar half of metacarpal head lead us to select an autologous osteochondral graft from the costchondral junction, first described by Brair *et al.* in 1928 [20]. However, Samman *et al.* [21] reported the overgrowth of an osteochondral autograft, and Peltomaki also suggested that growth variability of the condyle-ramus unit may be due to the amount of cartilage included in the grafts [22]. In the orthopedic field, Hasegawa and Yamano first reported proximal interphalangeal joint reconstruction using a graft of costal cartilage in 1992 [23], but the long-term follow-up results of this procedure were not reported. In the present case, autologous osteochondral transplants survived and maintained their size and shape even at the 10-year follow-up. The excellent outcome of our case might partly be due to the non-weight-bearing nature of the MCP joint, the location of the 4th MCP joint being protected by the neighboring fingers, the young age of the patient, and his change of occupation. It might be important for the survival of transplanted cartilage to be placed in a joint where it can be subject to as much physiological stimulation as possible. Interestingly, new bone formation occupied a large area of the costal cartilage, extending distally for 10 postoperative years, but the surface cartilage seems to remain functional. Although this is the longest follow-up of osteochondral autograft in the literature, further follow-up will be needed for longer-term, close observation of potential functional and morphological changes in the graft.

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