Reconstruction of the Ulnar Head With a Vascularized Second Metatarsal Head: Case Report

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A case of a young patient with avascular necrosis of the ulnar head following a severely displaced ulnar head fracture is presented. Treatment included debridement of the entire ulnar head, leaving the ulnar styloid, sigmoid notch, triangular fibrocartilage, and both distal radioulnar ligaments intact. The head of the ulna was reconstructed by transferring a vascularized second metatarsal head. At 4-year follow-up, the patient had a pain-free wrist with 45° active pronation and 65° supination. He resumed working without limitations as a manual laborer. We conclude that ulnar head reconstruction with a vascularized second metatarsal head is worthwhile in the setting of an unreconstructable traumatic defect, particularly when the sigmoid notch and distal radioulnar ligaments are preserved. *(J Hand Surg 2012;37A:1568–1573. Copyright © 2012 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words Bower, Darrach, microsurgery, second metatarsophalangeal joint, ulnar head replacement.

Dysfunction of the distal radioulnar joint is a troublesome condition. Loss of the ulnar head causes convergent instability of the ulna when loading the wrist in neutral.[1] Pain and multidirectional instability also occur. Prostheses are used to avoid these problems, but the results have varied.[2] Furthermore, limitations of 5 kg of lifting are recommended.[3,4]

A young patient who suffered ulnar head avascular necrosis after a fracture is presented. Because the sigmoid notch cartilage and the triangular fibrocartilage complex were preserved, the ulnar head was replaced by a vascularized second metatarsal head. The results at 4 years are presented.

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CASE REPORT

A 26-year-old man presented 3.5 months after having surgical treatment for a severely displaced oblique ulnar head and metaphyseal fracture caused by a punch press that hit the dorsum of his wrist. The patient reported pain with any motion of the wrist, especially when attempting to carry weight with the wrist in neutral. His range of motion was 30° of extension, 60° of flexion, 20° of pronation, and 20° of supination. Grip strength was 14 kg, 30% of his uninjured side. The plain radiographs showed nonunion of the ulnar head, and avascular necrosis was suspected (Fig. 1).

Possible treatment options were considered. In previous, unpublished studies, we found the second metatarsal head to closely match the ulnar head, provided it is oriented transverse to the forearm axis. Although the head of the metatarsal is rounded in both sagittal and coronal planes, it is not a perfect or a complete sphere. It has a 190° arc in the sagittal plane, but only a 30° arc in the coronal plane. Hence, a metatarsal head placed in the same axis as the ulna is congruent in neutral, but the new joint will collapse in pronation and supination. Furthermore, in the coronal plane, the metatarsal head is asymmetrical, with a slight medial tilt (Fig. 2). This is

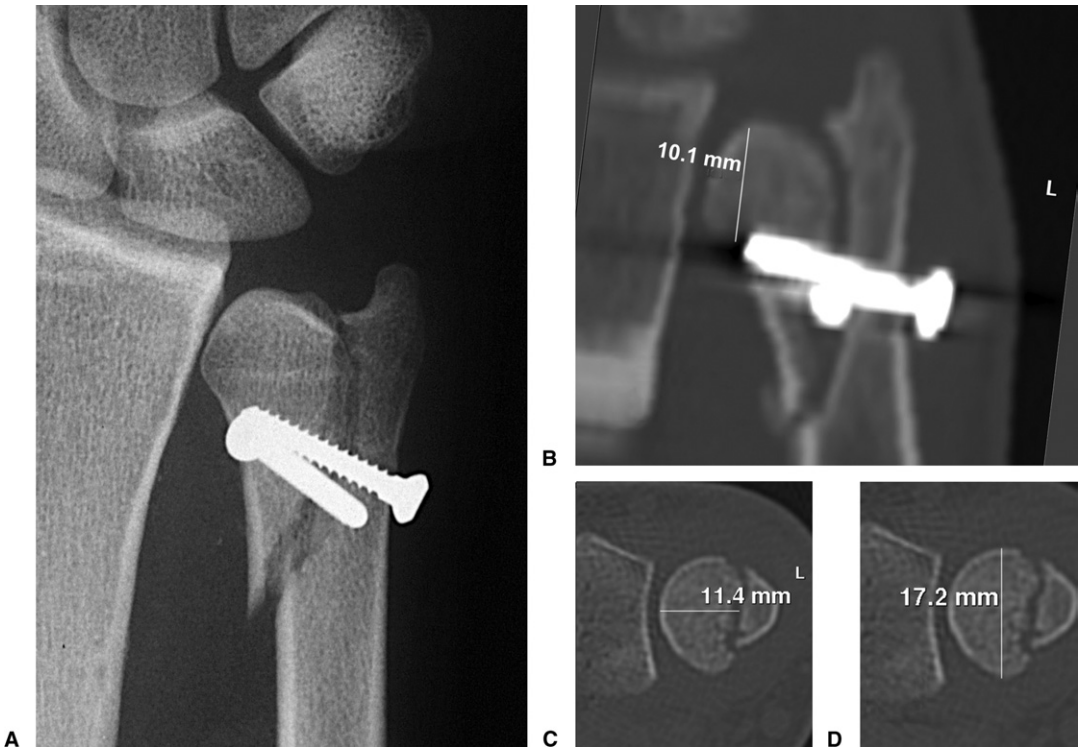

FIGURE 1: **A** Preoperative plain radiograph and **B**, **C**, **D** computed tomography scans indicating the size of the ulnar head defect in 3 planes.

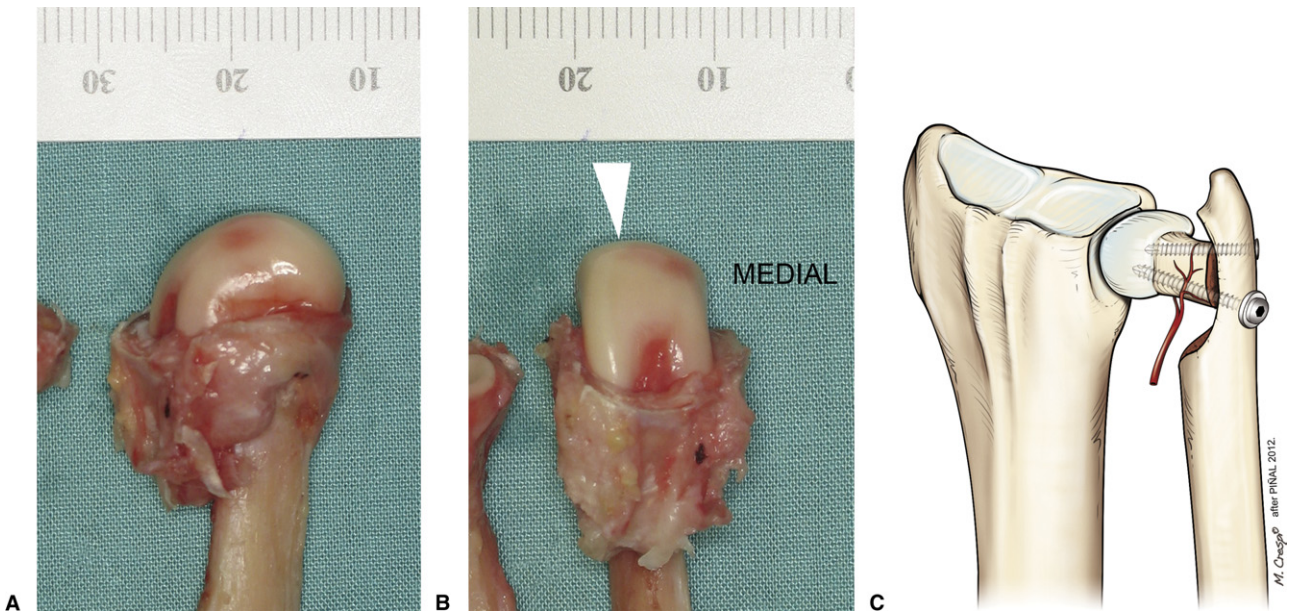

FIGURE 2: **A** The shape and size of the ulnar head closely resembles the head of the second metatarsal in the sagittal plane. **B** In the frontal plane, it is flatter and will not adapt properly to the shape of the ulnar head. Furthermore, the head is not perfectly rounded in the frontal plane but off-centered and more prominent in the lateral side (arrowhead), slanting toward the medial side. **C** The ulnar head morphology is matched only if the head of the metatarsal is positioned horizontally.

advantageous when matching the metatarsal head to the slanting of the sigmoid notch.

The preoperative computed tomography scan confirmed that the shape, size, and radius of curvature of the second metatarsal closely matched this patient's ulnar head (Fig. 3). The contralateral side was selected to match the tibial slanting to the shape of this patient's sigmoid notch—that is, a type I distal radioulnar joint.[5]

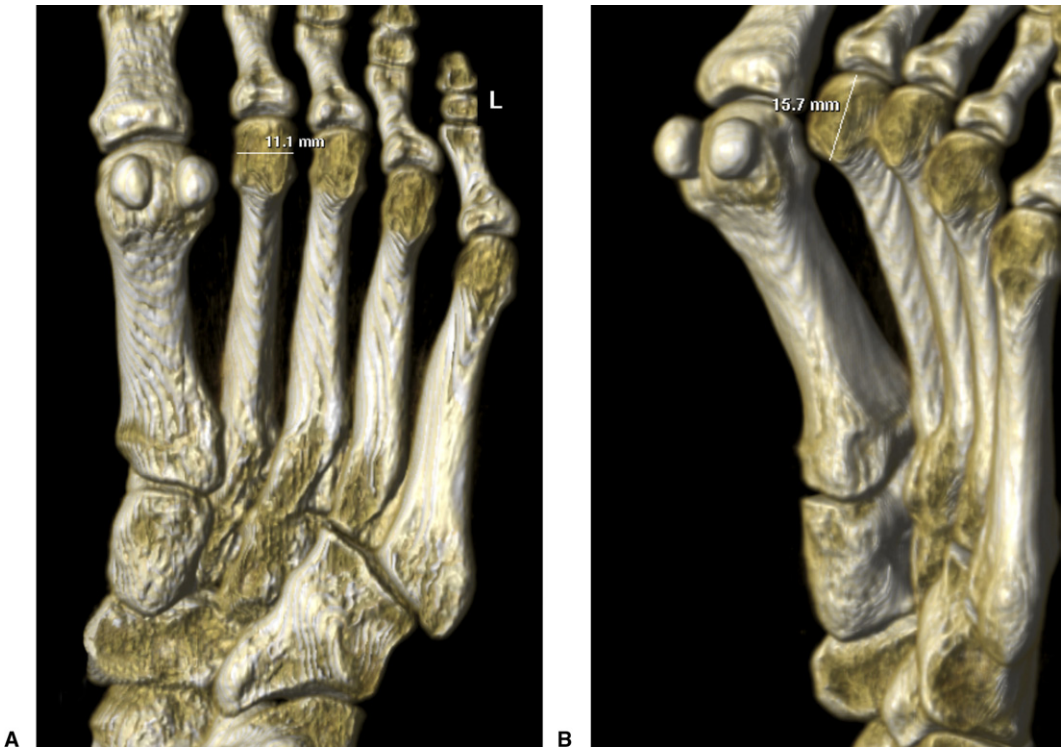

FIGURE 3: A Anteroposterior and **B** lateral computed tomography scan measurements of the metatarsal head (11.1 × 15.7 mm) revealed a near-perfect match of the ulnar head (11 × 11 × 17 mm).

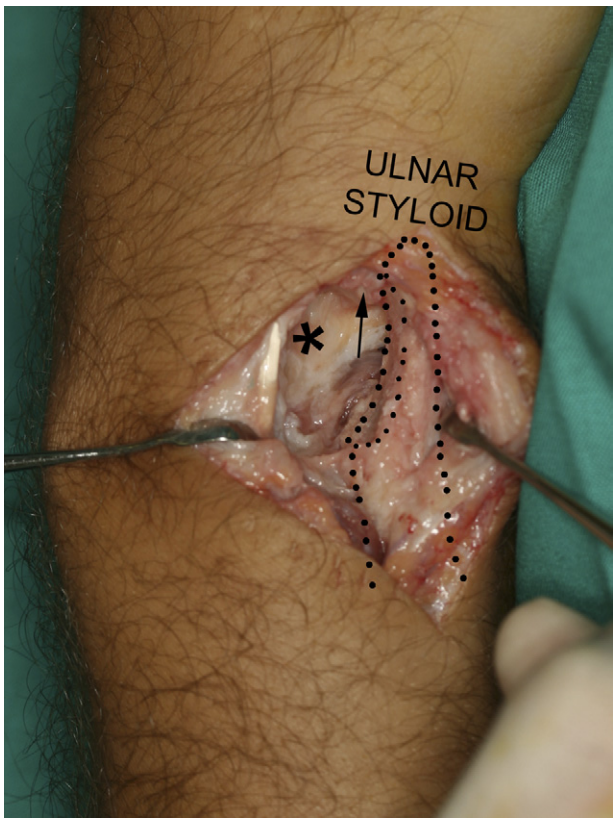

FIGURE 4: The sigmoid notch (asterisk) and the intact fibrocartilage (arrow) can be seen in this intraoperative photograph. The outlines of the ulna have been marked with dots.

First, we assessed the extent of avascular necrosis of the head of the ulna. It was devoid of soft tissue attachments, ununited, and fragmented into 2 pieces. Pathological report showed patchy necrosis. The sigmoid notch (including viable cartilage) was intact, and the triangular fibrocartilage complex was preserved (Fig. 4). Because the ulnar styloid was intact, we inferred that the volar-ulnar carpal ligaments were likewise intact, but we did not explore the radiocarpal joint.

The flap consisted of the head of the second metatarsal and an adjacent skin island for monitoring (Fig. 5). The foot was approached through a zigzag incision in the first web. A subcutaneous vein of the skin island and the soft tissues to the metatarsal were identified and isolated. Connections between the first dorsal metatarsal artery and the bone, including part of the medial collateral ligament, were preserved to maintain the bone's vascularity. The dorsal digital artery of the hallux, a branch of the first dorsal metatarsal artery, supplied the skin island. On the lateral side of the metatarsal, all soft tissue connections of the second metatarsal were divided subperiosteally. The bone was cut 15 mm proximal to the apex of the cartilaginous surface of the head, and subsequently, the flap was isolated on its pedicle. The tourniquet was released, and profuse bleeding from the metatarsal and the skin island was noted (Fig. 5).

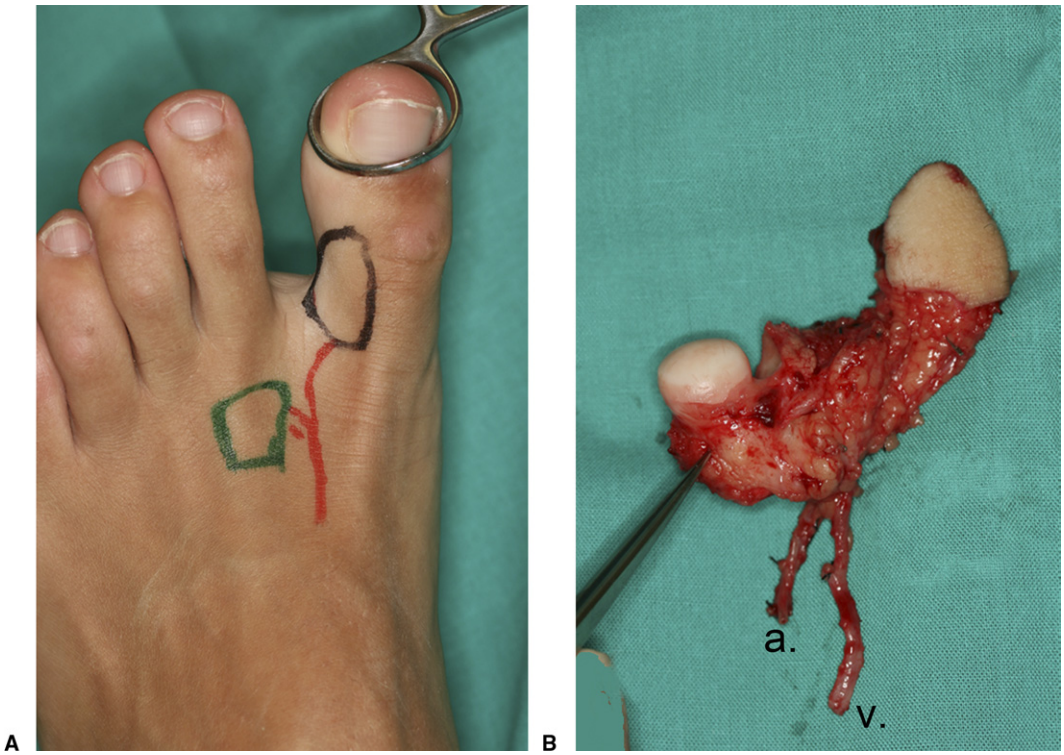

FIGURE 5: A A skin island from the dorsum of the hallux was included for monitoring purposes. **B** The harvested flap (a, first dorsal metatarsal artery; v, subcutaneous vein).

FIGURE 6: Revascularization of the skin monitor at the end of the surgery.

The shaft of the ulna was prepared for fixation. The metatarsal head was preliminarily fixed to the ulna with a Kirschner wire placed from the dorsal wrist. Full range of pronation and supination was tested. No instability nor impediments to motion were noted. Then, the flap was definitively fixed with a 1.5-mm and a 2.0-mm lag screw. A washer was used with the latter to avoid shattering the remaining thin ulnar metaphyseal bone. The head of the metatarsal did not have any tendency to subluxate; therefore, we did not reconstruct any soft tissue restraints. Before fixation of the bone, a volar–ulnar counter-incision was made in the space between the flexor tendons and the ulna to pass the pedicle to the volar wrist. The flap was revascularized by anastomosing the first dorsal metatarsal artery end-to-side to the ulnar artery, and the vein was anastomosed end-to-end to a local vein. Reperfusion took place immediately (Fig. 6). No attempt was made to interpose any tissue in the donor defect; rather, a syndactyly between the second and third toes was created to prevent collapse of the second toe. The length of the medial side of the third toe and lateral side of the second toe were incised in an opposing zigzag manner, designed so that the flaps interdigitated. Except for the foot closure, the surgery was completed by the senior author (F.P.) in 3 hours, 45 minutes.

The postoperative course was uneventful. The patient continued full lower extremity weight bearing after

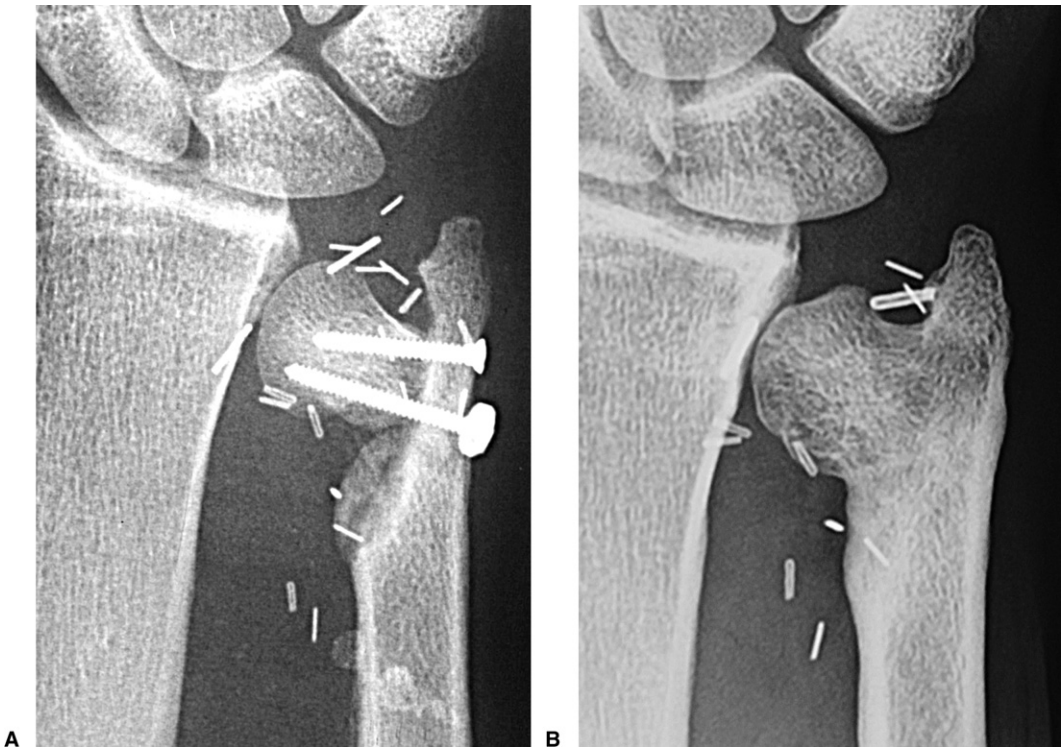

FIGURE 7: A Plain x-rays 8 months after the surgery at the time of hardware removal, and **B** at 4 years. Joint remodeling and slight narrowing, probably as a result of differences of congruency, are noticeable. Notice the lack of sclerosis or cyst at the head of the metatarsal.

surgery. Subcutaneous heparin was discontinued after 3 weeks when he resumed full ambulatory activities. The wrist was immobilized for 3 weeks in an above-the-elbow orthosis, blocking pronation–supination. Then, active and active assisted flexion and extension exercises of the wrist were prescribed. At the sixth week, active and assisted pronation and supination exercises were added.

The patient resumed full activity at 3.5 months but returned at 8 months with pain and swelling in the medial aspect of the wrist. On plain radiographs, the heads of the screws were prominent as a consequence of bone remodeling (Fig. 7A). These were removed, along with the skin monitor, under regional anesthesia. Three weeks later, he was able return to his previous work in a factory.

At 4 years of follow-up, he continued to be asymptomatic and worked in the same post that required him to lift large pieces of glass of up to 40 kg. His radiocarpal motion was essentially equal to that of the contralateral side (99%). He had active pronation of 45° and supination of 65° (61% of the contralateral side) with no instability. His grip strength with the elbow at 90° in neutral pronation–supination was 43 kg (81% of his contralateral side). The Disabilities of the Arm, Shoulder, and Hand score was 2, and the Patient-Rated Wrist/Hand Evaluation score was 1. Plain radiographs at 4 years showed some joint narrowing of the distal radioulnar joint space, which could suggest early osteoarthritis and hypertrophy of the graft–ulna interface (Fig. 7B). His foot was asymptomatic. His American Orthopaedic Foot and Ankle Society lesser toes score was 100 of 100 (Fig. 8).

DISCUSSION

In trauma surgery, attempts are made to preserve all structures vital for function, but the fate of large segments of devascularized bone is often nonunion and/or avascular necrosis.[6,7] When the ulnar head is irreversibly damaged, options are limited to a salvage procedure—including the Darrach, Bower, or Sauvé-Kapandji procedures—or ulnar head replacement. These can result in residual pain and limitations in grip strength and motion.[2] Our technique did not provide a normal joint, but it did avoid ulnar convergence during gripping and lifting and allowed the patient to resume his labor-intensive work.

In this patient, the ulnocarpal ligaments and the triangular fibrocartilage complex were intact. A possible option was the less-invasive Eclypse implant (Bioprofile, Grenoble, France).[8] Although the results are quite encouraging, long-term follow-up is needed, and the

FIGURE 8: Donor foot at 4 years.

prosthesis has not been tested in heavy laborers or young individuals for fear of loosening and/or sinking into the sigmoid notch.

Experimentally and clinically, transferred nonvascularized joints resorb,[9] whereas with vascularized joints, the cartilage is preserved long term.[10] Four cases of distal radioulnar joint reconstruction by transferring the entire second metatarsophalangeal joint are described[11] (Vilkki, presented at the 4th International Congress of the Asian Pacific Federation of Societies for Surgery of the Hand, 2002); however, in 3 of 4 cases, patients had dislocation and impingement.

Our case was unique because the defect consisted only of the ulnar head, and the stabilizing soft tissues were preserved. We therefore chose a biological tissue transfer, rather than a prosthesis. The properly oriented second metatarsal head closely matched the shape of the ulnar head, but careful preoperative planning was critical. Furthermore, the cosmetic deformity at the foot is minimal if the toe is not amputated.

For this procedure, the sigmoid notch and ulnocarpal ligaments must be preserved or be reconstructable. This surgical procedure is not indicated in degenerative scenarios because of cartilage erosion of the sigmoid notch. Despite the technical demands, it is a treatment option, particularly in young patients with damage limited to the ulnar head. Despite the good mid-term results, degeneration might occur; the metatarsal head resembles the ulnar head, but it is not a perfect match. This lack of precise congruity might explain the remodeling seen in the last plain radiographs (Fig. 7B). This phenomenon occurs in other clinical scenarios, such as after ulnar shortening, but in this case, this remodeling seems to be responsible for the hypertrophy in the metatarsal head–ulna junction to adapt to the load this joint supports. However, the joint changes at 4 years might also indicate early osteoarthritis. Thus, the procedure should be recommended with caution until further follow-up is obtained.

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