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Hand/Peripheral Nerve

Ulnar Head Reconstruction with Microvascular Second Metatarsal

Pedro C. Cavadas, MD, PhD
Alessandro Thione, MD, PhD

Background: The distal radioulnar joint along with the interosseous ligament of the forearm and the proximal radioulnar joint, form a functionally integrated system responsible for the pronation–supination of the hand. The distal ulna, the so-called ulnar head, is an integral part of this system. Apart from its well-known role in forearm rotation, the ulnar head is essential in transverse load transmission through the distal radioulnar joint upon resisted elbow flexion. Autologous reconstruction of ulnar head would theoretically be beneficial with respect to prostheses.
Methods: Three cases of ulnar head reconstruction with microvascular second metatarsal are reported herein including trauma, oncological, and congenital ethiologies.
Results: The clinical result was good without complaints of instability.
Conclusions: The cases included in this series, although heterogeneous, indicate that this treatment may be feasible also in postoncological resections and in congenital cases. *(Plast Reconstr Surg Glob Open 2017;5:e1284; doi: 10.1097/GOX.0000000000001284; Published online 13 April 2017.)*

INTRODUCTION

The distal radioulnar joint (DRUJ), along with the interosseous ligament of the forearm and the proximal radioulnar joint, form a functionally integrated system responsible for the pronation–supination of the hand. The distal ulna, the so-called ulnar head, is an integral part of this system. Apart from its well-known role in forearm rotation, the ulnar head is essential in transverse load transmission through the DRUJ upon resisted elbow flexion. Although important capsule-ligamentous structures contribute to the overall stability of the DRUJ, the anatomic integrity of the distal ulna is a prerequisite, especially during transverse loading with resisted elbow flexion.[1,2] The ulnar head is thus a primary forearm stabilizer, preventing radioulnar convergence.[1,3,4] There is increasing interest in prosthetic replacement of the head of the ulna (either monopolar ulnar head or bipolar DRUJ implants), although the longevity of these implants, especially in young, active patients, is a matter of concern.[5,6] In this subset of patients, autologous reconstruction would theoretically be beneficial, especially in a growing child.

From the Reconstructive Surgery, Clinica Cavadas, Hospital de Manises, Valencia, Spain.
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The authors reported previously the use of the second metatarsal (M2) bone free flap for distal ulna reconstruction in a complex trauma case.[7] Three cases are reported herein including trauma, oncological, and congenital ethiologies.

MATERIALS AND METHODS

Three male patients (ages 6–52 years) were operated on for reconstruction of the distal ulna. One case was a giant cell tumor of the distal ulna, one case was a traumatic destruction, and the third one was a congenital ulnar hypoplasia. Follow-up was 1.5–3 years.

Surgical Technique

Through a longitudinal incision in the ulnar border of the distal forearm, the bone defect was defined and regularized. The remnants of the triangular fibrocartilage complex (TFCC) were dissected, and the ulnar artery and venae comitantes were dissected as recipients. A size-matched length of the M2 was elevated as an osteocutaneous flap based on the dominant dorsal or plantar system. The M2 was inset with the plantar cartilage side of the head facing the sigmoid notch of the distal radius in neutral forearm rotation. Bone fixation was performed with a locking 2.4-mm plate. The remnants of the TFCC were either sutured to one collateral ligament of the metatarsal or fixed using a bone anchor after judging the most isometric point during pronation–supination. If no TFCC

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remnants were present, plans for a delayed formal TFCC reconstruction were made. Vascular anastomoses were performed end-to-side to the ulnar artery and end-to-end to the vena comitans. The skin island was inset in the main incision. The donor area was closed directly suturing the intermetatarsal ligaments in a manner similar to a standard second toe transfer if the toe was removed. If the patient chose to keep the toe, it was allowed to "float" in a shortened position.

All free flaps survived. One nonunion (child with Kirschner wire fixation) was successfully revised at 5 months post operation with a 2.0-mm plate and screws. All patients returned to their previous activities. No donor-site morbidity was reported by the patients.

RESULTS

Case 1

A 29-year-old male patient presented with a giant-cell tumor of the left distal ulna (Fig. 1). After ulnar head resection, the bone defect was 6 cm in length. A microvascular osteocutaneous flap, including the head and diaphysis of the M2 and a monitoring skin island, was harvested from the ipsilateral foot and transferred to reconstruct the defect (Fig. 2). Bone fixation was performed with a 2.4-mm locking plate. The TFCC was fixed to the nonarticular dorsal part of the head of the M2 with a bone anchor (at the limit of the articular cartilage), and the vascular pedicle was anastomosed end-to-side to the ulnar vessels. Healing was uneventful (Fig. 3). At 18 months of follow-up, the patient was asymptomatic and could lift a 24-lb dumbbell without difficulty (Fig. 4).

Fig. 1. Case 1. X-ray showing a giant-cell tumor of the ulnar head in a 29-year-old patient.

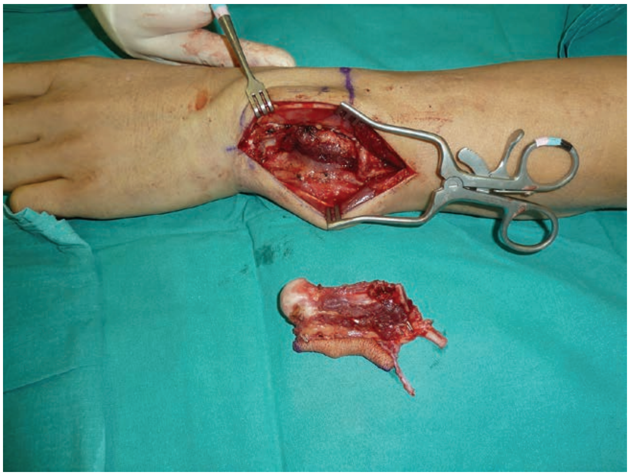

Fig. 2. Case 1. Intraoperative view after resection of 6 cm of the distal ulna. A vascularized M2 osteocutaneous flap was used for the reconstruction.

Fig. 3. Case 1. Postoperative x-ray at 1 year with healed bone. Note the bone anchor used for TFCC reattachment.

Case 2

A 6-year-old presented with a left type II ulnar hypoplasia, with unstable wrist (Figs. 5, 6). A 3.5-cm-long ipsilateral M2 bone flap was transferred to the distal ulna (Fig. 7). Fixation was initially done with Kirschner wires and later revised at 5 months with a 2.0-mm plate for nonunion (Fig. 8). Vascular anastomoses were performed end-to-end to the ulnar vessels. At 2 years post operation, the wrist is stable with metacarpal growth commensurate with that of the radius (Fig. 9).

Fig. 4. Case 1. Range of motion of the wrist at 18 months.

Fig. 5. Case 2. Ulnar hypoplasia with lateral wrist instability in a 6-year-old boy.

Case 3

A 52-year-old male patient presented with a subacute crushing injury of the left forearm, partially treated with an external fixator elsewhere. There was a highly comminuted distal metaphyseal radial fracture and destruction of the distal ulna (Fig. 10). The comminuted segments of the radial metaphysis and distal ulna were resected, leaving a 4-cm defect in the radius and a 7-cm defect in the ulna including the head. The bone defect was reconstructed with a double-barrel free fibular osteocutaneous flap with 2 independent skin monitoring islands. Bone fixation was performed with locking plates. The peroneal vessels were anastomosed end-to-end to the radial vessels. The ulnar head was reconstructed using a simultaneous ipsilateral osteocutaneous free M2 (Figs. 11, 12), fixed to the fibula and the ulna with a locking plate. The pedicle of the metatarsal flap was anastomosed end-to-end to the distal portion of the peroneal vessels in a "piggy-back" fashion. The ulnar styloid process with the attached TFCC was sutured to the collateral ligaments of the M2. At 3 years follow-up, the patient was able to comfortably lift a 24-lb dumbbell.

DISCUSSION

In the absence of the ulnar head, forearm pronation and supination are not substantially limited. The main functional consequence of the loss of the ulnar head is disruption in the transverse load-transmission capacity

Fig. 6. Case 2. Preoperative x-ray.

Fig. 7. Case 2. A 3.5-cm-long osteocutaneous M2 flap was used for distal ulna reconstruction.

of the DRUJ. The ulna converges toward the radius on attempted elbow flexion against resistance due to the unopposed pull of the brachialis muscle.[2–4] Prosthetic replacement of the distal ulna is the usual treatment, with good short- and mid-term results.[5,6] Long-term results, especially in young, active patients, are less predictable. Leaving the defect unreconstructed creates a Darrach-like situation, with substantial morbidity. Pediatric patients constitute a significant contraindication to prosthetic replacement and Darrach-like procedures. Autologous reconstruction of the distal ulna with M2 would

Fig. 8. Case 2. Postoperative x-ray at 18 months, after revision of a nonunion.

Fig. 9. Case 2. Clinical aspect at 2 years with lateral stability of the wrist.

be advantageous in these patients. Vascularized bone is known to heal and endure like native bone, and transferring the physeal cartilage allows growth. The overall morphology of the distal M2 does not closely match with that of the ulnar head (Fig. 12). The shape of both epiphyses can be assimilated to a cylinder, although with different orientation: the ulnar head cylinder is axially oriented perpendicular to the axis of the bone, whereas the M2 cyl-

Fig. 10. Case 3. Comminuted fracture of the radius and distal ulna in a 52-year-old patient.

Fig. 11. Case 3. After debridement of the comminuted segments, the defect was reconstructed with a double-barrel fibular flap and a M2 osteocutaneous flap.

inder is sagittally oriented, coplanar with the diaphyseal axis of the metatarsal.[8] This difference in the gross radii of curvature makes the reconstructed DRUJ incongruous. There is, however, an anatomical difference between the radii of curvature of the native ulnar head and the radial sigmoid notch, the latter being larger than the former, which is important in the mechanics of the DRUJ, and would make the incongruity of the reconstructed joint less of a problem.[9]

Reconstruction of the head of the ulna with a vascularized osteochondral free flap was reported by del Piñal et al.,[10] using the head of the M2 in a case of posttraumatic avascular necrosis of the ulnar head with excellent

Fig. 12. Case 3. Postoperative x-ray at 2 years showing bone healing.

result. The use of the whole M2 to reconstruct a traumatic segmental defect of the distal ulna was reported by the authors in a case report.[7] The cases included in this series, although heterogeneous, indicate that this treatment may be feasible also in postoncological resections and in congenital cases. The growth of microvascular epiphyseal–metaphyseal transfers is well documented in the literature,[11] although accurate prediction of the growth based on the normal growth of the native donor bone may not be realistic.

Stability of the reconstructed DRUJ may be a concern. In the cases presented herein, the TFCC was reattached in 2 cases with resultant good clinical stability. In the congenital case, no TFCC was identifiable, and capsular soft tissues were sutured to the collateral ligament stump of the M2. The clinical result was good without complaints of instability. Should instability be a problem after ulnar head reconstruction with a M2 flap, a formal DRUJ ligament reconstruction could be safely performed at a later stage.

The present study has weaknesses. The number of patients and the follow-ups are short. In the authors' practice, loss of the ulnar head is rare. The patients with a "failed Darrach" would be an indication to this technique. The authors have not yet performed this technique in that patient population. The main drawback of the technique presented herein is its technical complexity (compared with prosthetic replacement), requiring microvascular expertise. Indications would be any defect of the distal ulna shorter than 6 cm (the length of an average adult's M2) in a patient accepting the (limited) morbidity of losing the M2, given proper microvascular expertise of the surgeon. Longer series with longer follow-up are necessary before this technique can be widely recommended, although these preliminary results are promising.

Alessandro Thione, MD, PhD
Reconstructive Surgery Unit
Clinica Cavadas
Hospital de Manises
Paseo Facultades 1
46021 Valencia, Spain
E-mail: althione@gmail.com

REFERENCES

1. Hagert CG. The distal radioulnar joint. *Hand Clin*. 1987;3:41–50.
2. Scheker LR, Babb BA, Killion PE. Distal ulnar prosthetic replacement. *Orthop Clin North Am*. 2001;32:365–376, x.
3. Sauerbier M, Hahn ME, Fujita M, et al. Analysis of dynamic distal radioulnar convergence after ulnar head resection and endoprosthesis implantation. *J Hand Surg Am*. 2002;27:425–434.
4. Scheker LR. Implant arthroplasty for the distal radioulnar joint. *J Hand Surg Am*. 2008;33:1639–1644.
5. Berger RA. Implant arthroplasty for treatment of ulnar head resection-related instability. *Hand Clin*. 2013;29:103–111.
6. Bieber EJ, Linscheid RL, Dobyns JH, et al. Failed distal ulna resections. *J Hand Surg Am*. 1988;13:193–200.
7. Cavadas PC, Thione A. Skeletal reconstruction of the forearm with a double-barrel fibular flap and second metatarsal head. *Injury*. 2014;45:2106–2108.
8. Cavadas PC, Thione A, Martinez IE. Distal ulna reconstruction using the second metatarsal: anatomical study. *J Wrist Surg*. 2016;5:160–164.
9. Chen YR, Tang JB. In vivo gliding and contact characteristics of the sigmoid notch and the ulna in forearm rotation. *J Hand Surg Am*. 2013;38:1513–1519.
10. del Piñal F, Guerrero-Navarro ML, Studer A, et al. Reconstruction of the ulnar head with a vascularized second metatarsal head: case report. *J Hand Surg Am*. 2012;37:1568–1573.
11. Tsai TM, Ludwig L, Tonkin M. Vascularized fibular epiphyseal transfer: a clinical study. *Clin Orthop*. 1986;210:228–234.