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Reverse wedge osteotomy of the distal radius in Madelung’s deformity

F. Mallard\textsuperscript{a,b,*}, J. Jeudy\textsuperscript{a}, F. Rabarin\textsuperscript{a}, G. Raimbeau\textsuperscript{a}, P.-A. Fouque\textsuperscript{a}, B. Cesari\textsuperscript{a}, P. Bizot\textsuperscript{b}, Y. Saint-Cast\textsuperscript{a}

\textsuperscript{a} Hand Center, Village Angers Santé-Loire, 47, rue de la Foucaudière, 49800 Trelaze, France
\textsuperscript{b} Bone Surgery Dept, University Hospital, 4, rue Larrey, 49933 Angers cedex 9, France

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Summary Madelung’s deformity results from a growth defect in the palmar and ulnar region of the distal radius. It presents as an excessively inclined radial joint surface, inducing "spontaneous progressive palmar subluxation of the wrist". The principle of reverse wedge osteotomy (RWO) consists in the reorientation of the radial joint surface by taking a circumferential bone wedge, the base of which is harvested from the excess of the radial and dorsal cortical bone of the distal radius, then turning it over and putting back this reverse wedge into the osteotomy so as to obtain closure on the excess and opening on the deficient cortical bone. RWO corrects the palmar subluxation of the carpus and improves distal radio-ulnar alignment. All five bilaterally operated patients were satisfied, esthetically and functionally. Its corrective power gives RWO a place apart among the surgical techniques currently available in Madelung’s deformity.

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Introduction

Madelung’s deformity was first described in 1878 \cite{1} as "spontaneous progressive palmar subluxation of the wrist"; rarely symmetrical \cite{2}, showing female predominance, it expresses a local dysfunction of the distal radius growth plate. Its rarity (1.7% of congenital abnormalities \cite{3}) hinders the assessment of the various surgical options for improving esthetics and function and avoiding long-term extensor tendon tears. We describe an original reverse wedge osteotomy (RWO) technique for severe cases of Madelung’s deformity.

Surgical technique

RWO \cite{4} was developed to reorient the radial joint surface while reducing overall radius length as little as possible. The principle consists in reversing a bone wedge taken from the distal metaphysis of the radius, with a base cut from the excess of the radial and dorsal cortical bone and a vertex in the hypoplastic area.

Surgery is performed under locoregional or general anesthesia, with a brachial tourniquet. Henry’s anteroradial approach was used initially, but became increasingly radial with experience so as to better expose the dorsal and...
Figure 1  Surgical technique of RWO. a: drawing of RWO radial approach; b: dissection and protection of the sensitive branch of the radial nerve (revealed by dissector) and radial artery; c: radial periosteum detachment and brachio-radialis tendon release; d: track of RWO (blue lines) isolating a circumferential bone wedge with the base taken from the excess radial and dorsal cortical
ventral sides of the radius (Fig. 1a) and protect the sensitive branch of the radial nerve and the radial artery (Fig. 1b). The distal radius, is widely exposed by the longitudinal incision, periosteal detachment and release of the brachio-radialis tendon (Fig. 1c).

Between two oscillating saw cuts in the distal radius, a circumferential bone wedge is isolated with its base cut from the excess radial and dorsal cortical bone, with its vertex taking only about 1 mm of the deficient cortical bone (Fig. 1d and e). The wedge is then reversed into the osteotomy to obtain closure on the excess and opening on the deficient cortical bone, care being taken to ensure perfect contact of the bone section surfaces so as to reorient the radial joint surface (Fig. 1f).

Reduction is maintained by 1 or 2 oblique 1.2 mm-diameter wires (Fig. 1g). The first runs obliquely from the radial styloid across the epiphysis in the medullary canal of the wedge, then crosses the medial cortex of the radial metaphysis. A second proximal-to-distal cross wire is sometimes useful to reinforce the reduction.

Osteosynthesis is ensured by a locking plate, modeled to fit the ventral cortex and respect the dorsal displacement of the epiphysis induced by incorporating the wedge with screws on either side of the osteotomy (Fig. 1h).

Ulnar shortening osteotomy is sometimes necessary to resolve persistent ulnar-carpal impingement, and consists in cylindrical subtraction from the distal third of the diaphysis and plate osteosynthesis with three cortical screws around the osteotomy.

Immediate postoperative immobilization uses a palmar plaster cast followed by an orthosis that leaves the elbow and fingers free until consolidation is achieved. The orthosis allows early rehabilitation, followed by physiotherapy sessions as needed.

Planning is helped by a vectorial model based on the two radiologic assessment parameters, enabling the section angles to be calculated using a solver.

Clinical series

Eleven wrists in six female patients were operated on by a single surgeon between 1992 and 2010. One patient, operated on unilaterally, was lost to follow-up. The other five (4 right and 1 left handed) were operated on bilaterally and assessed by an independent examiner at a mean 7.9 ± 2.3 years (range, 7 months to 18.9 years).

Surgery was undertaken, on esthetic and functional (pain) grounds, at a mean patient age of 26.7 ± 2.2 years: 26.1 ± 3.2 years at first procedure and 27.3 ± 3.3 years at contralateral procedure. Three of the 10 wrists (30%) required complementary ulnar osteotomy for persistent ulnar-carpal impingement.

Flexion, pronation and supination were significantly improved (Wilcoxon test: T = 3, degrees of freedom [df] = 10, P = 0.01; T = 0, df = 9, P = 0.02; T = 2.5, df = 8, P = 0.02 respectively). Mean flexion was 56.0 ± 3.0° preoperatively versus 69.0 ± 2.7° postoperatively; pronation, 74.4 ± 5.3° versus 90.0 ± 0.0°; and supination 47.8 ± 11.3° versus 78.0 ± 2.1°. Mean prehension strength (24.9 ± 1.9 versus 24.2 ± 2.7 kg/F) did not change significantly (Wilcoxon test: T = 27, df = 10, P = 0.96).

Mean QuickDASH and PRWE functional scores at follow-up were respectively 19.5 ± 7.8 and 14.8 ± 7.4/100. All patients were satisfied, esthetically (Fig. 2a and b) and functionally, would undergo the procedure again and would recommend it at a mean 9.6 ± 0.3/10. All avoided heavy carrying postoperatively, citing fear and protection of the wrist. One, who had had to stop her work as a gardener due to pain, was able to go back to work after the operation.

Bone union was always achieved after 3 months. There was significant improvement on McCarroll’s five radiologic parameters for Madelung’s deformity assessment [5] (Fig. 3a and b).

The one complication in the series was hypoesthesia on the radial side of the thenar eminence, due to lesion of a terminal branch of the radial nerve following removal of the radial osteosynthesis plate. Material was removed in seven of the 10 cases, due to the patients’ young age or to discomfort caused by the plate.

Discussion

Madelung’s deformity results from a growth defect in the ventral and medial part of the conjunctive cartilage of the distal extremity of the radius. Segmental slowing of distal radial growth not only increases the palmar and ulnar orientation of the radial joint surface but also induces a helical, enveloping movement along the longitudinal axis of the forearm, passing through the area of maximal growth plate hypoplasia. An orthogonal approach is thus too simple for assessing and correcting the deformity.

RWO associates subtraction from the excess and addition to the deficient cortical bone, providing incomparable three-dimensional corrective power, with significant improvement, esthetically and in terms of flexion, pronation and supination (P < 0.05) and of McCarroll et al.’s radiologic criteria [5].

Other radial osteotomies have been described. Radial closure osteotomy, described notably by Ranawat, shortens the radius, increasing the difference between radial and ulnar lengths and the long ulna syndrome. dos Reis et al. [6] associated radius subtraction osteotomy to ulnar shortening, with good results, especially in terms of force, range of motion and esthetics, but increasing the shortness of the antebrachial segment associated with Madelung’s deformity.

In 1992, Watson et al. [7] described a technique based on the same principle of combined “opening-closing” osteotomy. There was a fundamental difference with respect to the technique described above, as the wedge was not circumferential around the whole metaphysis but rather a half of the epiphysis. This provided only frontal correction, as Watson et al. [7] reintroduced the wedge taken

bone, leaving an approximately 1-mm thickness at the thin edge; e: RWO using oscillating saw; f: RWO diagram: the isolated wedge is reversed into the osteotomy to obtain closure on the excess and opening on the deficient cortical bone; g: RWO stabilization by a temporary wire from the radial styloid; h: definitive osteosynthesis by modeled locking anterior plate.
from the radial half into the ulnar half of the osteotomy. RWO, being more proximal than Watson’s osteotomy, avoids direct aggression to the distal radio-ulnar joint, enabling the radial epiphysis to be moved backward so as to join the ulnar head.

Harley et al. [8] described a distal radius dome osteotomy with resection of Vickers’ ligament [9], conserving radial length and reorienting the radial joint surface in 3 dimensions. Its main limitation seems to us the highly intuitive nature of the surgical planning.

The opening osteotomy with free trapezoid bone graft described by Murphy et al. in 1996 [10] and modified by De Paula et al. [11] theoretically restores radial length and reorients the radial joint surface, but requires often difficult peroperative maneuvers and remote graft harvesting from the iliac crest. In case of insufficient correction, Murphy performs a second radial osteotomy at the diaphysis. Lengthening the antebrachial segment is a clear advantage, but entails a risk of complex regional pain syndrome; RWO seems easier technically, requiring no forced maneuvers or remote harvesting.

**Conclusion**

The corrective power of reverse wedge osteotomy is well adapted to the severe radial epiphyseal dystrophy of Madelung’s deformity. Clinical and radiological results are convincing. The flattening of the dorsal aspect of the wrist can be hoped to provide long-term protection against extensor tendon tear.

**Disclosure of interest**

The authors declare that they have no conflicts of interest concerning this article.

**References**