Modified Ilizarov technique in Madelung's deformity

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Background
Madelung's deformity is caused by arrest of growth on the ulnar side of the distal epiphysis of the radius. It results in palmar and ulnar tilt of the articular surface, volar translation of the hand and wrist, shortening of the radius, and dorsal subluxation of the ulnar head with incongruity of the distal radioulnar joint.

Patients and methods
Six patients with Madelung's deformity were treated with the Ilizarov method at the Orthopedic Department of health insurance hospitals. Correction was undertaken for pain in the case of two patients, because of impaired function in two, and because of bad cosmoses in another two patients. The cause of the deformity was congenital in four cases and acquired in two after fractures. The patients included five girls and one boy. The ages of the patients varied from 11 to 17 years, with an average age of 14.6 years.

Results
All patients were free from pain at follow-up. Supination improved by a mean of 30° and pronation by a mean of 10°. The mean improvement in flexion was 20°. Extension did not change. Radial and ulnar deviations were increased by a mean of 5 and 10°, respectively, and lengthening of the radius by a mean of 12 mm (6–25). Radiological measurement showed that the mean volar angulation had been reduced from 20 to 10° and ulnar inclination from 40 to 25°. The most common problem was minor pin-tract infection in all cases, which was treated with antibiotics. No loosening of pins or bone fracture occurred. There were no deep pin-tract infections or neurovascular injury.

Conclusion
The Ilizarov technique should be considered for the surgical treatment of Madelung's deformity in patients suffering from persistent pain when gradual correction and lengthening is indicated. The Ilizarov method is useful for obtaining correction of forearm deformity.

Keywords:
correction, Ilizarov, Madelung's deformity

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Introduction

Madelung's deformity can result in pain and decreased function of the wrist and hand. It is caused by arrest of growth on the ulnar side of the distal epiphysis of the radius. It results in palmar and ulnar tilt of the articular surface, volar translation of the hand and wrist, shortening of the radius, and dorsal subluxation of the ulnar head with incongruity of the distal radioulnar joint. These anatomical changes alter the biomechanics of the wrist and associated structures, resulting in a decreased range of movement, especially ulnar deviation and extension, decreased grip strength, and pain [1].

Madelung's deformity presents as a spectrum. It may affect the entire radius or it may affect only the distal radius. Extremities with involvement of the entire radius have a shorter radius and ulna, decreased length, and a more severe deformity compared with extremities with involvement of only the distal radius [2]. Ulnar tilt, lunate subsidence, and palmar carpal displacement are considered reliable and reproducible measurements for quantifying the severity of Madelung's deformity on radiographs [3].

The deformity presents in late childhood or adolescence, is more common in the female population, and is often bilateral. The deformity was classified by Henry and Thorburn [4] into four different etiological groups: (a) idiopathic or primary; (b) secondary, after trauma, infection, or tumor; (c) dysplastic, including dyschondrosteosis, hereditary multiple osteochondromatosis, Ollier's disease, and achondroplasia; and (d) chromosomal or genetic such as in Turner's syndrome.

Conservative methods of treatment are often ineffective and do not prevent progression of the deformity. A number of surgical techniques have been developed [5–7]. Dobyns *et al.* [7] divided these into three broad groups: first, those applied to the radius such as epiphysiodesis, corrective osteotomy, and physiolysis; second, those applied to the ulna such as epiphysiodesis,

excision of the head, shortening osteotomy, and creation of a pseudarthrosis with or without fusion to the radius; and third, combined techniques in which both bones are dealt with usually by one of the above-mentioned methods. None of the surgical techniques available has been shown consistently to improve grip strength, range of movement, or relieve pain.

The Ilizarov method permits for combined axis correction and/or distraction or compression. This is the method of choice for the treatment of nonunion of the forearm with concomitant shortening and axis deformity [8]. We have evaluated the results of osteotomy of the distal radius with subsequent bone lengthening and deformity correction by the Ilizarov technique in cases of Madelung's deformity.

Patients and methods

Between January 2006 and March 2008, six patients with Madelung's deformity were treated with the Ilizarov method at the Orthopedic Department of health insurance hospitals. They were not satisfied with the result of conservative treatment and underwent surgical correction using the Ilizarov technique. In two patients correction was undertaken for pain, in two because of impaired function, and in another two because of bad cosmoses. The cause of the deformity was congenital in four cases and acquired in two after fractures. The patients included five girls and one boy.

The ages of the patients varied from 11 to 17 years, with an average age of 14.6 years. The mean duration of follow-up after the operation was 16 months (9–26 months).

Operative technique

The Ilizarov apparatus was applied under general anesthesia in the operating room. A modified Ilizarov frame was constructed with two half-rings connected by threaded rods. Threaded half-pins were used: two in the proximal radius and two distal to the planned osteotomy close and parallel to the radiocarpal joint (Fig. 1). The frame was mounted to the pins with rancho cube fixation clamps. Transverse osteotomy was performed in the distal third of the radius, after which the frame was reassembled. Distraction and correction began on the seventh postoperative day. The rate of distraction was different and depended on radiographic evidence of regeneration and pain tolerability of the patients, ranging from 0.25 to 1 mm/day. In three cases we were forced to discontinue distraction temporarily, usually for 1–2 weeks, because of pain. After reaching the required length we stopped lengthening of the ulnar side and continued lengthening of the radial side to correct the palmar and ulnar deformities (Figs 2 and 3). After gaining full correction of the deformity, the frame was kept in place until consolidation of the gap. Patients were encouraged to perform exercises to mobilize the fingers, wrist, and forearm. They were advised to clean the frame and provide care to the pin site insertion. The frame was removed without anesthesia. Physiotherapy was advised after removal of the frame until full function had been regained.

Assessment

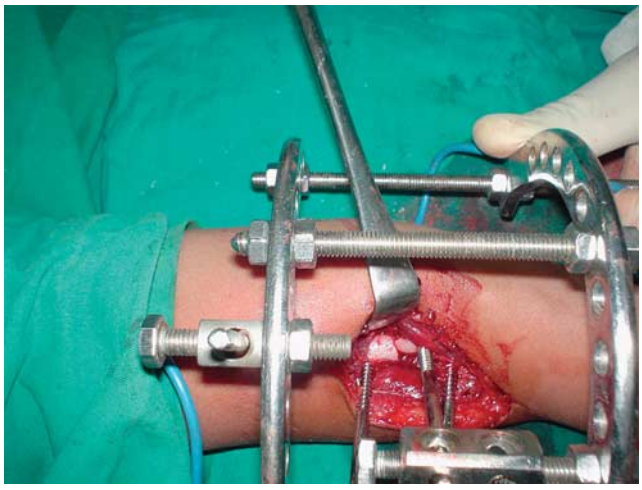
We assessed the patients for pain, grip strength, and goniometry of the wrist and forearm before and at follow-up. Supination and pronation were measured with the elbow at 90° and the shoulder in the neutral position. The range of movement of the wrist was measured with the patient seated; the elbow flexed to 90° and the forearm pronated [9]. From radiographs, the angle of the articular surface of the distal radius in relation to the long axis of the radius, carpal malalignment, and the degree of shortening of the radius were measured before and after operation. The patients were also asked whether the pain and appearance had improved and whether they were satisfied with the cosmetic and functional results.

Results

All patients were free from pain at follow-up. Supination improved by a mean of 30° and pronation by a mean of 10°. Flexion improved in four cases. The mean improvement in flexion was 20°. Extension did not change. Radial and ulnar deviation had increased by a mean of 5 and 10°, respectively, and lengthening of the radius by a mean of 12 mm (6–25). The mean duration of correction was 24 days. The mean period of consolidation was 39 days (25–55). Radiological measurement showed that the mean volar angulation had been reduced from 20 to 10° and ulnar inclination from 40 to 25°. The mean carpal malalignment (volar translation) was reduced from 8 to 3 mm. However, slight deformity and malalignment remained in two patients.

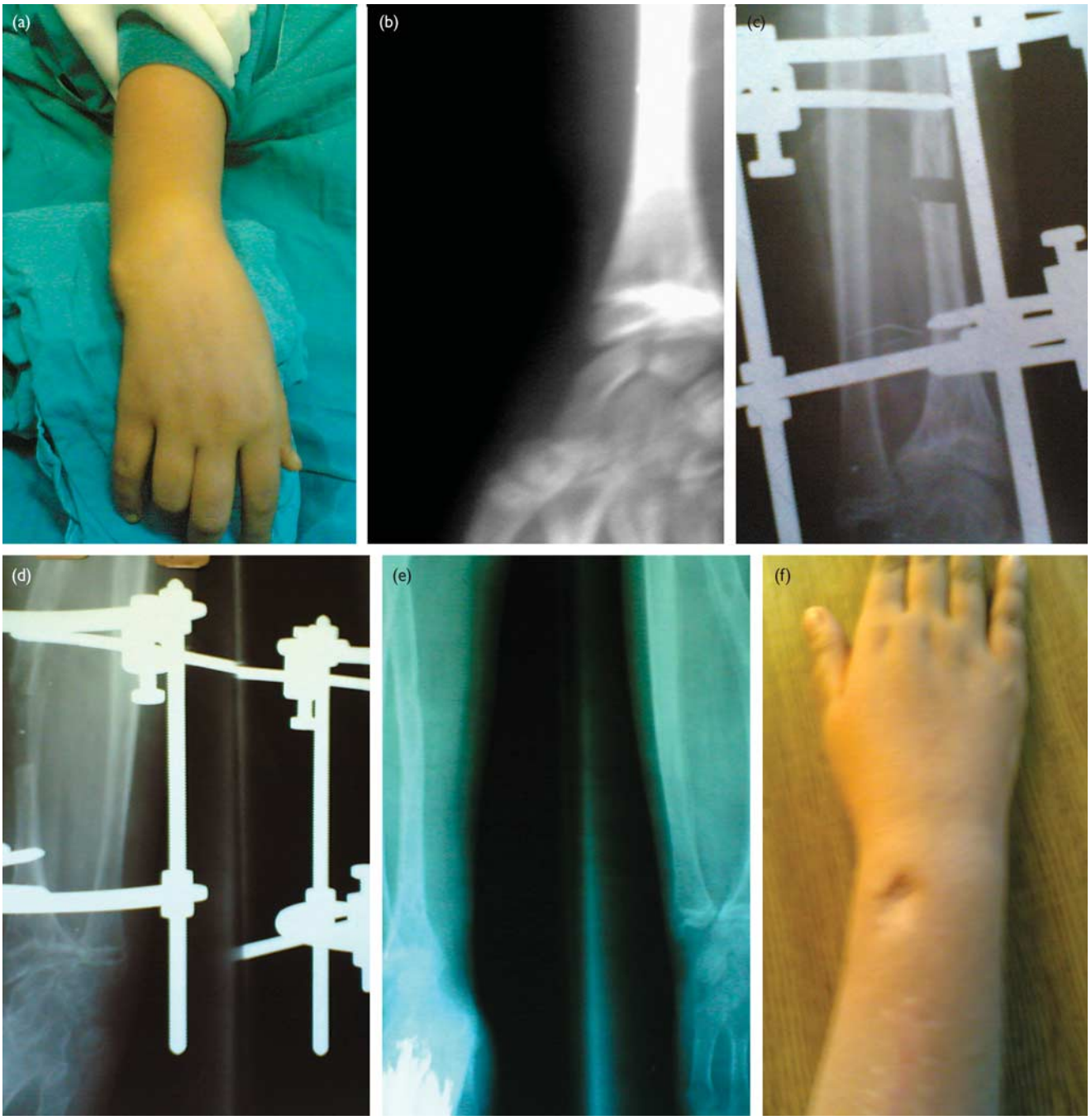
The most common problem was minor pin-tract infection, which was seen in all cases and which was treated with antibiotics. No loosening of pins or bone fracture occurred. There were no deep pin-tract infections or neurovascular injury. The rate of lengthening had to be

Figure 1



Photographs showing the Ilizarov frame applied intraoperatively.

Figure 2



(a) A 12-year-old girl with Madelung's deformity. (b–d) Radiographs showing follow-up of correction using the Ilizarov frame. (e) A radiograph showing complete consolidation after frame removal. (f) Photographs showing full correction of the deformity.

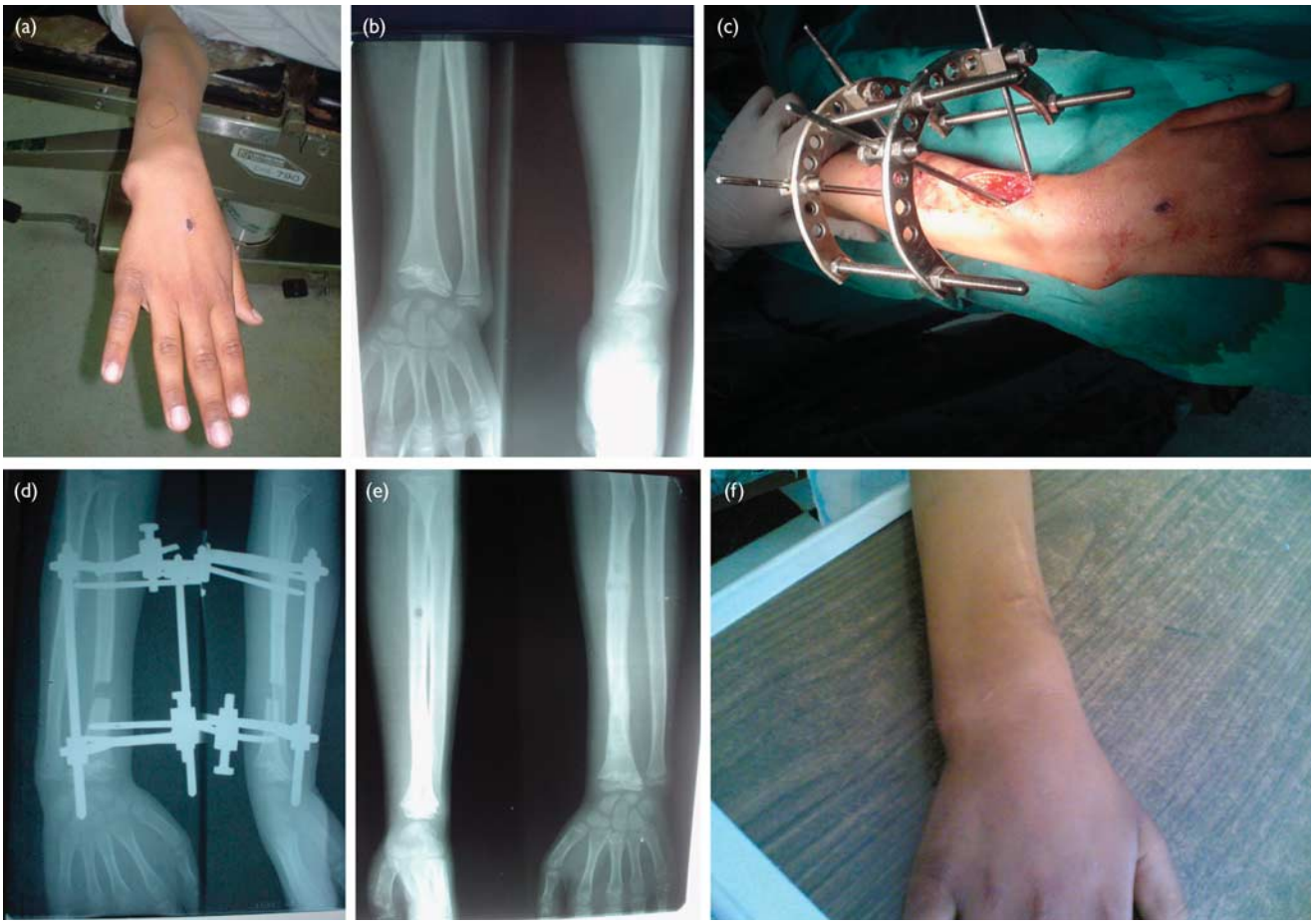
reduced to half of the lengthening speed for 1 week in three cases because of pain. After the pain had subsided, normal elongation was continued. No patient needed a bone graft. Overall, patients tolerated the procedure well and five patients were satisfied with the improvement in the appearance of their wrist (Figs 2 and 3).

Discussion

A number of anatomical changes occur in Madelung's deformity that result in biomechanical alterations leading to decreased range of movement, decreased grip strength, and often pain. Correction after skeletal maturity or towards the end of skeletal growth decreases the likelihood of recurrence of the deformity [10].

However, nonoperative management is ineffective in treating painful wrists and does not prevent progression of the deformity. Several surgical methods of treatment have been proposed, including early resection of the tether band before closure of the epiphysis [10] and early resection of the ulnar zone of the epiphysis of the distal radius and replacement with an autologous fat graft [11].

Figure 3



A 15-year-old boy with Madelung's deformity. (a) Photographs showing Madelung's deformity. (b) A radiograph showing Madelung's deformity. (c) Photographs showing the Ilizarov frame applied intraoperatively. (d) Radiograph showing follow-up of correction using the Ilizarov frame. (e) Radiograph showing complete consolidation after frame removal. (f) Photographs showing full correction of the deformity.

Resection of the head of the ulna may be needed once the epiphysis has fused. Excision of the distal ulna alone has also been reported [12–14] but may leave the carpus unstable. Ranawat *et al.* [15] used the Darrach procedure, with or without associated radial osteotomy, and Murphy *et al.* [1] studied patients who underwent had radial opening wedge osteotomy and observed no change in range of movement or grip. Procedures that involve resection of the ulnar head should be avoided in young patients as ulnar deviation and carpal dislocation may result [1].

White and Weiland [16] described a volar closing wedge osteotomy combined with a distal radioulnar arthrodesis and ulnar pseudarthrosis proximal to the arthrodesis (the Kapandji procedure). With this technique, relief from pain was significant but the range of movement did not improve. Harley *et al.* [17] described volar dome osteotomy.

Techniques involving physiolysis [10,11] obviously require an open growth plate. Surgery before closure of the physis may lessen the development of secondary changes in the carpus and allow some remodeling.

Osteotomy of the radius combined with shortening of the ulna has been reported [18]. It generally involves a biplane osteotomy with either a closing or opening wedge to correct the position of the surface of the joint or shortening of the ulna. As a consequence of the disease, the forearm is shortened in most patients, and therefore further shortening of the forearm bones is undesirable. The technique of shortening combined with a slight anterior angulation osteotomy of the ulna aiming to improve the appearance of the wrist and to relieve pain if present without compromising the function of the wrist is suitable only for mild cases of Madelung's deformity [19–24].

Bagatur *et al.* [25] found that lengthening of the forearm results in improved upper-extremity function, especially in activities requiring equal arm length, as well as in better cosmetic appearance if adequate soft tissue is preserved. The Ilizarov technique is an effective method for lengthening the ulna in children with radial longitudinal deficiency [26]. Villa *et al.* [27] and Lacher *et al.* [28] used a modified Ilizarov method, and both teams of researchers as well as de Billy *et al.* [29] have used the technique to lengthen an opening wedge osteotomy gradually. In both studies, Kirschner wires were used for fixation.

Houshian *et al.* [30,31] treated seven patients with Madelung's deformity by radial osteotomy with subsequent

lengthening and angular correction using the Ilizarov technique. Frames consisted of three half-rings and 4 mm threaded half-pins. Hinges were at the axis of the proposed osteotomy, ~2 cm proximal to the radial articular surface. Lengthening was performed, followed by angular correction. All patients were pain free at follow-up. Supination improved by a mean of 34°, pronation by a mean of 9°, and flexion by a mean of 15° [30,31].

In our work we made osteotomy more proximal in the radius, unlike in the series of Houshian *et al.* [31]. This gave enough space for pin insertion, and hence there was no loosening or fracture of the distal fragment. The Ilizarov technique restores the anatomy of the wrist to almost normal by repositioning the radioulnar joint and thereby reversing some of the biomechanical changes caused by the ulnar and volar shift of the carpus. However, there are still slight deformities and malalignments in the joints in some of the patients. Further, the carpal bones are deformed in long-standing Madelung's disease [31].

The use of half-pins instead of transfixation Kirschner wires allows a near-normal movement of the forearm and wrist during the prolonged period of external fixation [31]. The Ilizarov method offers the advantage of a minimally invasive technique with minimal dissection and therefore decreased risk of neurovascular and soft-tissue injury and infection; it is also adjustable [32].

The Ilizarov technique allows correction of the deformity in two planes, controlled by radiographs. There is no need for bone graft and the pins are removed without anesthesia. The slow correction by gradual lengthening allows the ligament complex of the distal radioulnar joint to adjust to the lengthened radius, thereby contributing to the stability of the joint. This may be the keystone for relief from pain. In our series, not only were pain, shortening, and deformity of the forearm reduced but function also improved considerably. The Ilizarov method is useful in obtaining corrections of forearm deformity.

Conclusion

The Ilizarov technique should be considered for the surgical treatment of Madelung's deformity in patients suffering from persistent pain when gradual correction and lengthening is indicated.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

References

1 Murphy MS, Linscheid RL, Dobyns JH, Peterson HA. Radial opening wedge osteotomy in Madelung's deformity. J Hand Surg Br 1996; 21:1035–1044.

2 Zebala LP, Manske PR, Goldfarb CA. Madelung's deformity: a spectrum of presentation. J Hand Surg Am 2007; 32:1393–1401.

3 Newmeyer WL, Molitor F, Manske PR. Madelung's deformity: quantitative assessment of x-ray deformity. J Hand Surg Am 2005; 30:1211–1220.

4 Henry A, Thorburn MJ. Madelung's deformity: a clinical and cytogenetic study. J Bone Joint Surg Br 1967; 49-B:66–73.

5 Mansat M, Lebarbier P, Cahuzac JP, Gay R, Pasquie M. Madelung's disease: a study of nine wrists operated on. Ann Chir 1979; 33: 669–675.

6 Watson HK, Pitts EC, Herber S. Madelung's deformity: a surgical technique. J Hand Surg Br 1993; 18:601–605.

7 Dobyns JH, Wood VE, Bayne LG. Congenital hand deformities. In: Green DP, editor. *Operative hand surgery*. Vol. 1. New York: Churchill Livingstone; 1988. pp. 512–536.

8 Wiktor Orzechowski, Leszek Morasiewicz, Szymon Dragan, Artur Krawczyk, Rosaw Kulej, Tomasz Mazur. Treatment of non-union of the forearm bones using distraction-compression osteogenesis. Orthop Traumatol Rehabil 2007; 9:357–365.

9 Van Andel CJ, Wolterbeek N, Doorenbosh CA, Veeger DH, Harlaar J. Complete 3D kinematics of upper extremity functional tasks. Gait Posture 2008; 27: 120–127.

10 Vickers DW. Premature incomplete fusion of the growth plate: causes and treatment by resection (physiolysis) in fifteen cases. Aust NZ J Surg 1980; 50:393–401.

11 Vickers D, Nielsen G. Madelung deformity: surgical prophylaxis (physiolysis) during the late growth period by resection of the dyschondrosteosis lesion. J Hand Surg Br 1992; 17:401–407.

12 Nielsen JB. Madelung's deformity: a follow-up study of 26 cases and a review of the literature. Acta Orthop Scand 1977; 48:214–219.

13 Darrach W. Habitual forward dislocation of the head of the ulna. Ann Surg 1913; 57:928–930.

14 Darrow JC, Linscheid RL, Dobyns JH, Mann JM III, Wood MB, Beckenbaugh RD. Distal ulnar resection for disorders of the distal radioulnar joint. J Hand Surg Am 1985; 10:482–491.

15 Ranawat CS, De Fior EJ, Straub LR. Made lung's deformity: an end-result study of surgical treatment. J Bone Joint Surg Am 1975; 57-A:772–775.

16 White GM, Weiland AJ. Madelung's deformity: treatment osteotomy of the radius and Lauentein's procedure. J Hand Surg Am 1987; 12:202–204.

17 Harley BJ, Brown C, Cummings K, Carter PR, Ezaki M. Volar ligament release and distal radius dome osteotomy for correction of Madelung's deformity. J Hand Surg Am 2006; 31:1499–1506.

18 Des Reis FB, Katchburian MV, Flaoppa F, Albertoni WM, Laredo Filho J Jr. Osteotomy of the radius and ulna for the Madelung deformity. J Bone Joint Surg Br 1998; 80-B:817–824.

19 Potenza V, Farsetti P, Caterini R, Tudisco C, Nicoletti S, Ippolito E. Isolated Madelung's deformity: long-term follow-up study of five patients treated surgically. J Pediatric Orthop B 2007; 16:331–335.

20 Salon A, Serra M, Pouliquen JC. Long-term follow-up of surgical correction of Madelung's deformity with conservation of the distal radioulnar joint in teenagers. J Hand Surg Br 2000; 25:22–25.

21 De Paula EJ, Cho AB, Junior RM, Zumiotti AV. Madelung's deformity: treatment with radial osteotomy and insertion of a trapezoidal wedge. J Hand Surg Am 2006; 31:1206–1213.

22 Feluś J, Radło W, Kowalczyk B. Results of the operative treatment in Madelung's deformity. Chir Narzadow Ruchu Orthop Pol 2006; 71:107–112.

23 Bruno RJ, Blank JE, Ruby LK, Cassidy C, Cohen G, Bergfield TG. Treatment of Madelung's deformity in adults by ulna reduction osteotomy. J Hand Surg Am 2003; 28:421–426.

24 Glard Y, Gay A, Launay F, Guinard D, Legré R. Isolated wedge osteotomy of the ulna for mild Madelung's deformity. J Hand Surg Am 2007; 32:1037–1042.

25 Bagatur AE, Doğan A, Zorer G. Correction of deformities and length discrepancies of the forearm in children by distraction osteogenesis. Acta Orthop Traumatol Turc 2002; 36:111–116.

26 Peterson BM, McCarroll HR Jr, James MA. Distraction lengthening of the ulna in children with radial longitudinal deficiency. J Hand Surg Am 2007; 32:1402–1407.

27 Villa A, Paley D, Catagni MA, Bell D, Cattaneo R. Lengthening of the forearm by the Ilizarov technique. Clin Orthop 1990; 250:125–137.

28 Lacher VG, Sennwald G, Frey HP. Use of the Ilizarov device for correction of extensive Madelung's deformity. Handchir Mikrochir Plast Chir 1995; 27:214–219.

29 De Billy B, Gastaud F, Repetto M, Chataigner H, Clavert JM, Aubert D. Treatment of Madelung's deformity by lengthening and relaxation of the distal extremity of the radius by Ilizarov technique. Eur J Pediatr Surg 1997; 7: 296–298.

30 Houshian S, Jergsholm PB, Friis M, Schroder H, Weeth R. Madelung's deformity treated with Ilizarov technique: a report of two cases. J Hand Surg Br 2000; 25:396–399.

31 Houshian S, Schrøder HA, Weeth R. Correction of Madelung's deformity by the Ilizarov technique. J Bone Joint Surg Br 2004; 86:536–540.

32 Paly D. Problems, obstacles, and complications of limb lengthening by the Ilizarov technique. Clin Orthop Relat Res 1990; 250:81–104.