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ORIGINAL ARTICLE
Hand/Peripheral Nerve

Does Distal Radio-ulnar Joint Configuration Affect Postoperative Functional Results after Ulnar Shortening Osteotomy?

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Background: Reverse oblique distal radio-ulnar joint (DRUJ) configuration is assumed to show inferior postoperative results in ulnar-shortening osteotomy due to osteoarthritis, as the joint force pressure in the DRUJ may be increased. An evaluation and comparison of the postoperative functional results with regard to clinical and radiographic signs of arthritis among different DRUJ configurations was carried out retrospectively.

Methods: Sixty-two patients after ulnar shortening osteotomy were included. The minimum follow-up was 5 years. Preoperative x-rays were assessed for the DRUJ configuration according to the Tolat classification, whereas postoperative radiographs were evaluated with regard to signs of osteoarthritis using the Kallgren-Lawrence-Score. Functional results were evaluated using the disabilities of the arm, shoulder and hand (DASH) and Mayo Wrist Score and measuring range of motion and grip strength.

Results: Significantly better functional results were found in patients with parallel configuration of the DRUJ (Tolat type 1 configuration) with regard to DASH score, grip strength, and supination compared with nonparallel configurations. In the Tolat type 1, configurated DRUJ mean DASH score was 9 compared with 18 in the Tolat type 2 and 3 groups. Apart from supination, no differences were observed in range of motion among groups.

Conclusion: Although long-term postoperative range of motion failed to display statistically significant differences between DRUJ configurations except for supination, better results regarding grip strength and DASH scores were seen in a parallel-aligned DRUJ configuration. Although onset of osteoarthritis does not seem to become apparent within the observation period, nonparallel aligned configuration predisposes to inferior results. *(Plast Reconstr Surg Glob Open 2018;6:e1760; doi: 10.1097/GOX.0000000000001760; Published online 13 April 2018.)*

INTRODUCTION

Ulnar shortening osteotomy (USO) is an established procedure to treat ulnar impaction syndrome (UIS). Positive ulnar variance may lead to mechanical damage of the triangular fibrocartilage complex (TFCC) and the adjacent joint surfaces, thus USO reduces intraarticular pressure while preserving anatomical joint surface. Furthermore, stabilization of the distal radioulnar joint (DRUJ) is achieved by increasing the ulno-carpal ligament tension and consecutive suspension of the TFCC.[1,2] Promising midterm results of USO have been reported for idiopathic and posttraumatic UIS. Various studies have shown pain relief, good postoperative range of motion, and good functional results after USO. The role of DRUJ configuration with regard to functional results remains controversial. Tolat identified 3 different types of the ulnar joint surface configuration. A type I DRUJ was described as a parallel alignment of the radioulnar joint surface. A type II DRUJ was defined as an oblique alignment and a type III DRUJ as a reverse oblique alignment.[3] The Tolat type 3 configuration has been associated with inferior functional results as the ulnar head is forced into the sigmoid notch, essentially causing osteoarthritis.[4] Biomechanical studies

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Received for publication November 5, 2017; accepted March 1, 2018.

DOI: 10.1097/GOX.0000000000001760

Disclosure: *The authors have no financial interest to declare in relation to the content of this article. The Article Processing Charge was paid for by the authors.*

found an increased peak pressures in the DRUJ after USO correlated to the length of ulnar shortening independent of the joint configuration.[5] Degenerative changes have also been observed more frequently in reverse aligned DRUJ in individuals without USO.[6] The aim of this study was to analyze the midterm functional results with regard to clinical and radiographic signs of osteoarthritis among patients displaying different types of DRUJ configurations after USO.

PATIENTS AND METHODS

Approval by the ethical committee was granted before this retrospective study. Informed written consent from each patient was obtained. Retrospective chart analysis revealed that between 2007 and 2012, 123 patients underwent USO for the treatment of UIS at this institution. Inclusion criteria were idiopathic or posttraumatic UIS and a minimum follow-up time of 5 years. Exclusion criteria were joint destruction "Arbeitsgemeinschaft Osteosynthesefragen" (AO) type C fractures, concomitant greater arc injury, Essex-Lopresti lesions, fractures, or dislocations of carpal bones and rheumatoid arthritis. Forty-five patients were excluded. Sixteen were lost to follow-up or refused participation in the study. Sixty-two patients could be included.

The operative procedures were performed by 4 different board-certified hand surgeons. All patients underwent wrist arthroscopy before USO, where the TFCC was assessed for injuries or degenerative changes according to the Palmer classification. At a mean time of 3.6 months (range from 1.7 to 6.2 months) after arthroscopy, a standardized diaphysal USO was performed using a 7-hole ulnar shortening plate (Recos Ulnar shortening system, KLS-Martin, Stuttgart, Germany). Postoperative ulnar variance was aimed to be neutral to -1 mm. Postoperative treatment included cast immobilization for 5 weeks then avoiding maximal weight bearing for another 6 weeks. Six weeks postoperatively, patients were referred to physiotherapy.

At the time of follow-up, the functional outcome was assessed using the Score for disabilities of the arm, shoulder and hand (DASH) and the Mayo Wrist Score. Grip strength was measured using a pneumatic grip strength dynamometer. An average of the 3 best results of 5 attempts was recorded. Range of motion and complications were recorded on a standardized documentation protocol. DRUJ inclination was measured in the preoperative posterior–anterior wrist x-rays according to the Tolat classification. Patients were divided into 3 groups according to the Tolat classification. A Tolat type 1 DRUJ was defined when the sigmoid notch was parallel or within ± 10° to the ulnar shaft axis. A Tolat type 2 DRUJ was defined when this angle was > 10° and a Tolat type 3 DRUJ when this angle was less than -10° (Fig. 1).[3] The ulnar variance was measured in the posterior–anterior pre- and postoperative x-rays using the method of perpendiculars.[7] The range of motion was measured for pro- and supination and for wrist extension and flexion using a goniometer. Results were compared with the nonoperated opposite wrist, and the difference in percentage was calculated. Furthermore, the latest postoperative radiographs were assessed according the Kellgren-Lawrence-Score for osteoarthritis. Statistical analyses were performed using SPSS version 14 (IBM, Armonk N.Y.). Kolmogorov-Smirnov test was used for the assessment of normal distribution. Differences between the groups were calculated with the Student's *t* test. A *P* value < 0.05 was considered statistically significant.

RESULTS

The mean follow-up time was 6.3 years (± 1.1). Thirty-eight patients were female, and 24 were male. The mean age of the patients was 53 years (± 14). In this cohort of 62 patients, a Tolat type 1 configuration was observed in 19 patients (31%) with mean inclination of the DRUJ of 6° (± 2.5°). Thirty-three patients had a Tolat type 2 configuration (53%) with a mean inclination of 17° (± 5°), and

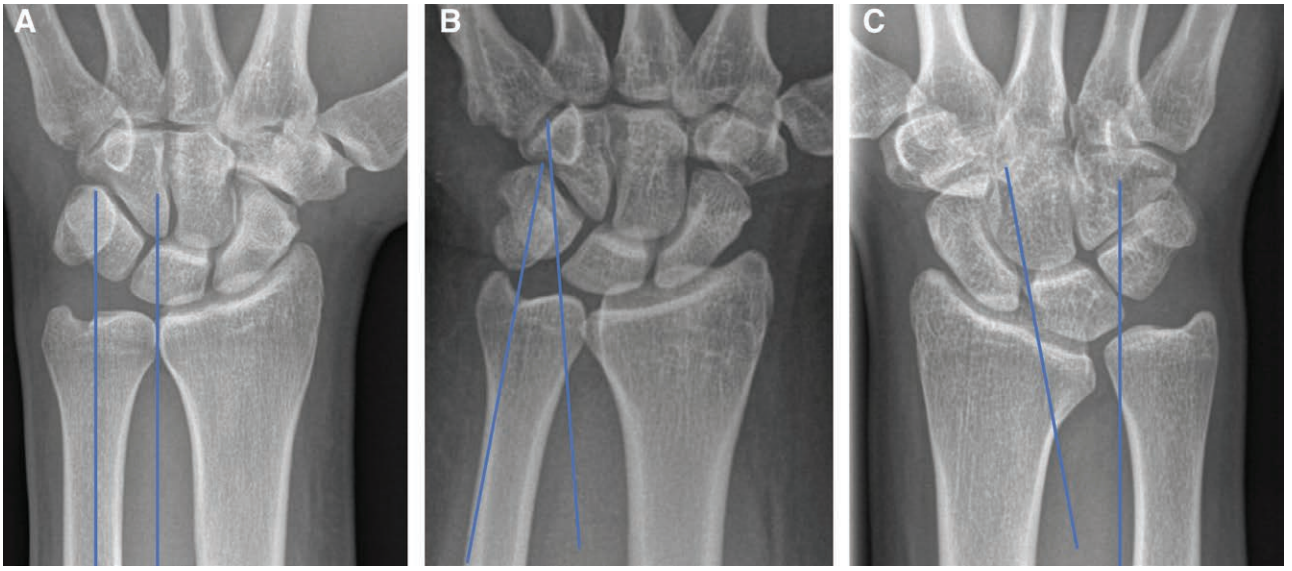

Fig. 1. Measuring DRUJ inclination. A Tolat type 1 (A) was observed in 31%, a Tolat type 2 (B) in 53%, and a Tolat type 3 (C) DRUJ in 16% of the patients.

Table 1. Patients Characteristics

Variable	Result
Follow up (y)	6.3 (± 1.1)
Sex (f/m)	38/24
Age (y)	53 (± 14)
Idiopathic/posttraumatic (%)	62/38
Tolat type (1/2/3) (%)	31/53/16
Implant removal (%)	35
Preoperative ulnar variance (mm)	3.2 (± 2.2)
Postoperative ulnar variance (mm)	-0.45 (± 2.6)

10 patients had a Tolat type 3 configuration (16%) with a mean inclination of -15° (± 4°). The overall inclination of all patients was 9° (± 13°). The baseline characteristics of the 3 groups (sex, age, indication type) were only different for age in the Tolat type 1 group with a mean age of 48 years (±7.6), whereas the Tolat type 1 and 2 groups had no difference in age (Table 1).

The mean preoperative ulnar variance was 3.2 mm (± 2.2 mm). The mean postoperative ulnar variance was -0.45 mm (± 2.6 mm). There were no statistical differences in pre- or postoperative ulnar variance among the 3 groups (Table 2).

Mean DASH score of the Tolat type 1 group was 9 (± 9.3). Mean DASH score of the Tolat type 2 group was 18.5 (± 12.5). The mean DASH score of the Tolat type 3 group was 18.6 (± 12; Fig. 2). Results and patient data are shown in Tables 1, 2.

Mean grip strength of the Tolat type 1 group was 0.63 kPa (± 0.14 kPa) and 0.44 kPA (± 0.19) in Tolat type 2 group and 0.54 kPa (± 0.15) in the Tolat type 3 group. Differences in DASH score and grip strength between Tolat type 1 and 2 and 1 and 3, respectively, were found to be statistically significant (Fig. 3). Differences between Tolat type 2 and 3 did not reach level of significance.

Range of motion for extension, flexion, supination, and pronation is shown in Table 2. In the Tolat type 1 group, patients had a significantly higher range of motion for pro-/supination compared with groups 2 and 3, but failed to show statistically significant differences for extension (Table 2). None of the opposite wrists displayed impaired range of motion or signs of osteoarthritis.

Table 2. Results of the 3 Groups According to the Classification of Tolat

Variables	Tolat 1	Tolat 2	Tolat 3
n	19	33	10
DASH	9 (± 9.3)	18.5 (± 12.5)	18.6 (± 12)
Mayo wrist (mean)	78 (± 12.1)	76 (± 16.2)	74 (± 14.3)
VAS	0.9 (± 2.6)	1.1 (± 1.8)	0.8 (± 2.3)
Grip strength (kPa)	0.63 (± 0.14)	0.44 (± 0.19)	0.54 (± 0.15)
Mean preoperative ulnar variance (mm)	3.5 (± 1.2)	3.1 (± 0.9)	3.4 (± 1.1)
Mean postoperative ulnar variance (mm)	-1.2 (± 0.7)	-1.1 (± 0.9)	-1.4 (± 1.0)
ROM pro/supination (%)	87 (± 7)	79 (± 12)	81 (± 11)
ROM extension/flexion (%)	95 (± 9)	98 (± 11)	92 (± 12)
Osteoarthritis (stage 0/1/1/3)	8/10/1/0/	12/20/1/0	4/6/0/0
Implant removal	8	11	3

VAS = Visual analog scale for pain; ROM = Range of motion.

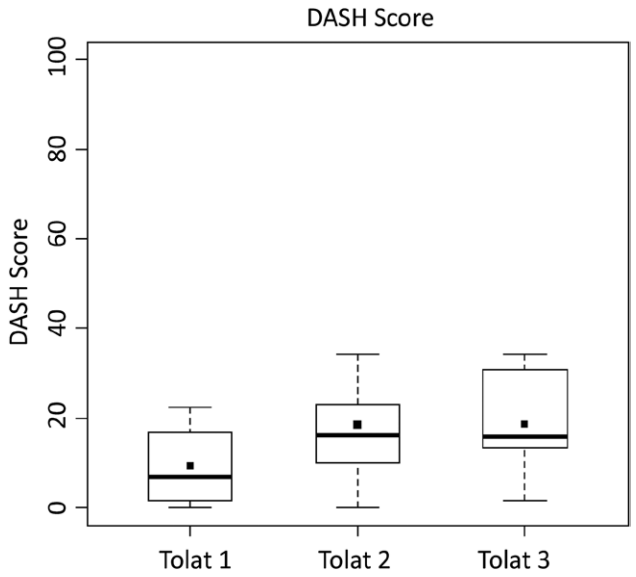

Fig. 2. Boxplots of the DASH score in 62 patients who underwent USO. Patients with a Tolat type 1 DRUJ had significant better DASH score than patients with a Tolat type 2 after a mean follow-up time of 6.3 years.

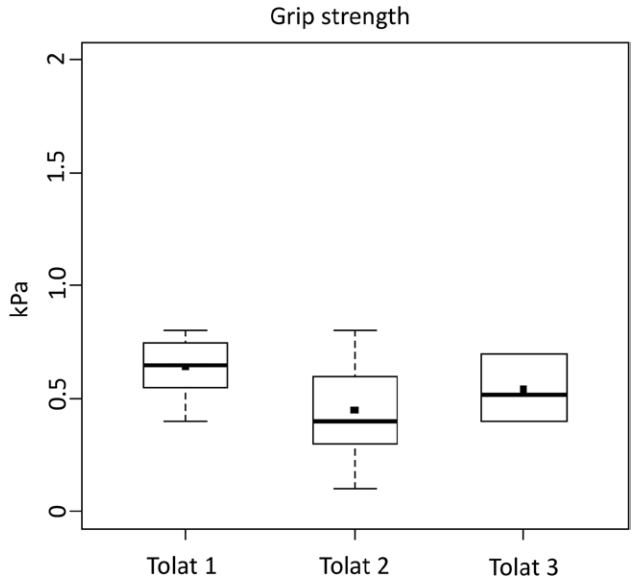

Fig. 3. Boxplots of the grip strength in kPa.

The observed stages of osteoarthritis are presented in Table 2; no statistically significant difference was observed among the 3 groups.

When grouping patients into either a posttraumatic or an idiopathic UIS category, no statistically significant differences in DASH score and grip strength were found (Fig. 4).

Plate removal was performed in 29 patients due to local irritations 1.5 years postoperatively.

DISCUSSION

In this retrospective study, a statistically significant difference could be found in the midterm functional results

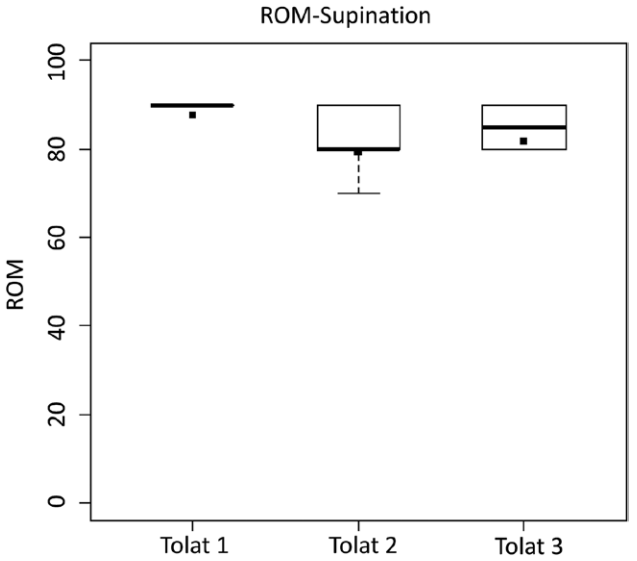

Fig. 4. Boxplots of the range of motion for pro-/supination in percentage compared with the opposite wrist.

after USO depending on DRUJ inclination. The prevalence of the different DRUJ inclination types is comparable with other studies.[8] Patients with a parallel-aligned (Tolat type 1) DRUJ had a better DASH score, grip strength, and a higher range of motion for pro-/supination than patients with an obliquely aligned joint surface (Tolat type 2 and 3). Other aspects of range of motion did not show significant differences between different DRUJ configurations. Although range of motion except for pro-/supination does not differ in different DRUJ configuration types, Tolat type 1 configuration resulted in higher DASH scores and grip strength. Although the difference in DASH scores may not be clinically relevant, the overall functional outcome was best in the parallel-aligned DRUJ configuration. Surprisingly in patients with a positive sigmoid notch inclination, an inferior functional result was observed despite the biomechanically anticipated greatest reduction of joint pressure. While in Tolat type III an increased joint pressure and thus an inferior functional result may be anticipated, the opposite assumption could not be proven in type II configurations. On the other hand, the inferior postoperative result of the Tolat type 2 group seems contradictory from a biomechanical point of view as a decrease of pressure would have been expected.

Functional results were most favorable in Tolat type I configuration. Radiographic results did not show significant osteoarthritis in any patient within the observation period. Development of osteoarthritis was evenly distributed among groups, although such observation period is too short for a final conclusion. Although midterm results are not sufficient to report on the occurrence of osteoarthritis, functional outcome is not directly related to radiographic signs of osteoarthritis.[9] There is, to the best of our knowledge, no biomechanical analysis specifically focusing on the joint pressures with regard to the different types of DRUJ configuration after USO. Thus, it is unclear if the inferior functional results of patients with an obliquely aligned DRUJ can be explained by alteration in joint pressure in the DRUJ or if other factors are causative. Unfortunately, this study cannot answer whether the inferior functional result in patients with an oblique DRUJ configuration (Tolat type 2) is caused by the USO or if patients with this configuration already had an impaired preoperative function as no preoperative functional assessment was performed. While the difference in DASH scores was significantly different, minimal clinically important difference for DASH is between 10 and 15 points, so there may be no clinical implications of the observed differences. The results of this study indicate that any incongruency in the DRUJ may be a negative predictive factor for the functional outcome after USO compared with parallel-aligned DRUJ configuration. As the joint force distribution in the DRUJ is not completely understood yet, careful patient selection is required including a discussion of a potentially inferior functional result if an incongruent DRUJ is present.

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REFERENCES

1. Nishiwaki M, Nakamura T, Nakao Y, et al. Ulnar shortening effect on distal radioulnar joint stability: a biomechanical study. *J Hand Surg Am.* 2005;30:719–726.
2. Werner FW, Palmer AK, Fortino MD, et al. Force transmission through the distal ulna: effect of ulnar variance, lunate fossa angulation, and radial and palmar tilt of the distal radius. *J Hand Surg Am.* 1992;17:423–428.
3. Tolat AR, Stanley JK, Trail IA. A cadaveric study of the anatomy and stability of the distal radioulnar joint in the coronal and transverse planes. *J Hand Surg Br.* 1996;21:587–594.
4. Sagerman SD, Zogby RG, Palmer AK, et al. Relative articular inclination of the distal radioulnar joint: a radiographic study. *J Hand Surg Am.* 1995;20:597–601.
5. Nishiwaki M, Nakamura T, Nagura T, et al. Ulnar-shortening effect on distal radioulnar joint pressure: a biomechanical study. *J Hand Surg Am.* 2008;33:198–205.
6. Hollevoet N, Verdonk R, Van Maele G. The influence of articular morphology on non-traumatic degenerative changes of the distal radioulnar joint. A radiographic study. *J Hand Surg Br.* 2006;31:221–225.
7. Goldfarb CA, Strauss NL, Wall LB, et al. Defining ulnar variance in the adolescent wrist: measurement technique and interobserver reliability. *J Hand Surg Am.* 2011;36:272–277.
8. de Runz A, Pauchard N, Sorin T, et al. "Ulna-shortening osteotomy." *Plast Reconstr Surg.* 2016;137:175–184.
9. Baek GH, Lee HJ, Gong HS, et al. Long-term outcomes of ulnar shortening osteotomy for idiopathic ulnar impaction syndrome: at least 5-years follow-up. *Clin Orthop Surg.* 2011;3:295–301.