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Decompression corrective osteotomy of the distal radius for treatment of the DRUJ-incongruency and impingement syndrome with focus on posttraumatic cases

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ABSTRACT

Introduction: Posttraumatic or congenital ulna-minus variance with altered shape of the sigmoid notch and increased tension of the distal oblique band of the interosseous membrane (DIOM) can lead to painful impingement in the distal radioulnar joint (DRUJ) during rotation and loading of the forearm. As an operative treatment concept, a new method was described in 2016. Its goal is to restore the osseous congruency, which is required for normal painless function. The hypothesis is based on remodelling of the joint surface and the decompression of the DRUJ by releasing the DIOM. The purpose of this study is to analyze the results of performed operations with detailed focus on posttraumatic cases.

Materials and Methods: : The indication for the operation is the impingement and incongruency in the DRUJ with ulna-minus variance. The surgical procedure is based on shortening and closed-wedge osteotomy of the distal radius with an ulnar translation of the radial shaft. Fifty-nine operations were performed between 2011 – 2022 on 52 patients (13 men, 39 women). Twenty-four patients were operated on the right side, 21 on the left side and 7 bilaterally. In 45 cases the operation was indicated because of congenital, in 12 cases due to posttraumatic incongruency and in 2 cases because of iatrogenic impingement after previously performed excessive ulnar shortening osteotomy. Modified Mayo-Wrist-Score, patient questioning, VAS and ROM were used to evaluate the results.

Results: Significant reduction of pain on VAS from 7.22 to 1.98 ($p < .001$) was achieved. The pre- and postoperative range of motion did not show any significant changes (mean total arc of motion 301,94° vs. 295,20°, $p = .300$). Specific complications we observed included a too distally performed osteotomy, DRUJ instability, de Quervainś tenosynovitis, persistent pain and conversion into an ulna-plus variance.

Conclusion: Under consideration of the indication criteria and correct execution of the osteotomy, in about 90 % of the cases this operation leads to good-to-excellent results with pain reduction and improvement of weightbearing and power. The preoperative examination, verification of the DRUJ stability and the radiological diagnostics are crucial for a good outcome.

Introduction

The Tolat type 2 morphology of the distal radioulnar joint (DRUJ) with ulna-minus variance and incongruency of the joint surfaces can lead to a painful impingement in the DRUJ during pronosupination and loading of the forearm, representing an increased risk of early degenerative changes [1]. The impingement syndrome is characterized by painful loading of the forearm together with early fatigue and loss of strength. The range of motion is usually not restricted. The incongruency can be of congenital, posttraumatic or iatrogenic origin. The main problem seems to be the increased tension of the distal oblique band of the antebrachial interosseous membrane (DIOM) and the reduced contact surface area in the DRUJ [2]. The DIOM is one of the providers of the DRUJ's stability, but it is not present in all patients [3–5]. The prevalence of the oblique (Tolat type 2) morphology is about 26 % [1]. Moreover, radioulnar impingement is rare in this population.

In 2016, a new operative method of treatment for the symptomatic primary and secondary radioulnar impingement syndrome was

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published by the senior author [6]. Its goal is to restore the osseous congruency, which is essential for the painless function. This distal decompression osteotomy of the radius is based on restoring the increased inclination of the sigmoid notch and detensioning the DIOM by shortening the radius and performing an ulnar shift of the radial shaft [2,6]. Using this method, joint preserving treatment method for the painful impingement syndrome was proposed as an alternative to other procedures dealing with this problem, such as a resection arthroplasty, hemiresection-interposition technique, Kapandji-Sauvé, ulnar head prosthesis or total DRUJ arthroplasty [7–15]. The purpose of this study is to retrospectively analyze the results of the performed operations with special focus on the posttraumatic patients' cohort.

Materials and methods

Operations mentioned in this study were all performed on patients of our institute. The data of the operated patients were retrospectively analyzed. All presented cases were based on the technique described by the senior author [2,6] and have not been published previously. Informed consent for the gathering, evaluation and publishing of all the pre- and postoperative data was obtained from all patients assessed in this study at the time of indication to the procedure and at the follow-up examinations. The study was conducted in accordance with the Declaration of Helsinki. Our research has been approved by the local medical ethics committee at the University of Szeged (Regional and Institutional Review Board of Human Investigations) under reference number 182/2019-SZTE.

The indication for the decompression osteotomy was based on the symptomatic radioulnar impingement syndrome. This was clinically examined by introducing rotation and simultaneous load imitation of the forearm (compression test). Using this test, a painful response was provoked in the DRUJ. The radiological assessment included a standard x-ray picture of the wrist (Fig. 1) with a central beam pointing to the radiocarpal joint and an optional additional p.-a. x-ray picture of the wrist under loading (in case of presumed dynamic ulnar variance). The congruency of the DRUJ was assessed using the Tolat classification [16]. All the cases showed a Tolat type 2 morphology of the DRUJ (mild to severe form). Initially, computed tomography was used in the planning of the shortening of the distal radius and to verify the sigmoid notch position (Fig. 2). It was however later determined that all the necessary landmarks for performing the osteotomy can be assessed in the standard x-ray picture. The CT scan is currently only used in inconclusive cases to exclude other bony pathology, primarily degenerative changes of the DRUJ. MRI is indicated in posttraumatic cases to rule out other missed ligamentous pathologies. Routine MRI seems to be unnecessary, since it usually shows only inconclusive changes, if any, mostly only intraarticular fluid in the DRUJ (Fig. 3).

Fig. 2. Preoperative CT scan showing the osseous incongruency in the DRUJ.

Prior to the operation, all the patients went through a series of non-operative treatments, including weight-bearing restrictions, splinting, physiotherapy and ergotherapy. Patients with persistent symptoms were indicated for the operation. Only symptomatic patients were operated. In case of bilateral incongruency of the DRUJ, only the symptomatic side was indicated for the procedure.

Our proposed decompression osteotomy was performed via the modified Henry approach with a closed radial-based wedge osteotomy, shortening of the distal radius, correction of the sigmoid notch position and ulnar translation of the radial shaft [2,6]. The most crucial step is to perform the proximal osteotomy beneath the ulnar head and the distal osteotomy beneath the sigmoid notch [2,6]. The amount of shortening, which differs from case to case, is assessed so, as to avoid a secondary impingement at the DRUJ. A standard volar locking plate for the distal radius is used to stabilize the osteotomy. The preoperative planning of the osteotomy and the postoperative stabilization is showed in Fig. 4. The achieved congruency after consolidation is showed in Fig. 5.

Fifty-nine operations were performed with the above-mentioned method on 52 patients (13 male, 39 female) between February 2011 and May 2022. Twenty-four patients were operated on the right, 21 on the left side and 7 patients bilaterally. In 45 cases we indicated the operation due to a congenital deformity of the DRUJ, in 12 cases due to posttraumatic changes and in 2 cases due to previously performed excessive ulnar shortening osteotomy. In the posttraumatic group 10 female (6 on the right side, 4 on the left side) and 2 male (both on the left

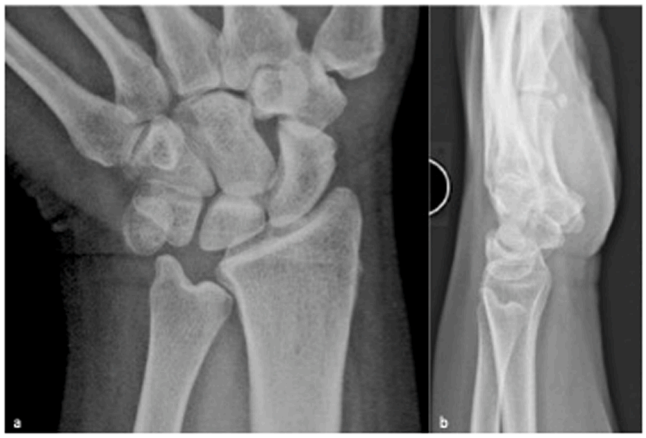

Fig. 1. Preoperative x-ray picture: (a) p.a. view, ulna-minus variance, Tolat type 2 morphology and incongruency of the DRUJ is seen; (b) lateral view.

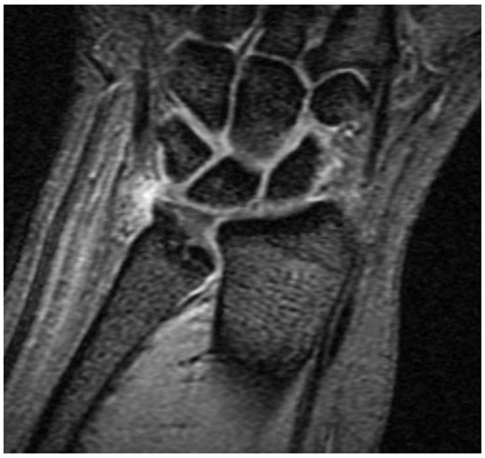

Fig. 3. Preoperative MRI, apart from the osseous incongruency no other pathology was observed.

Fig. 4. (a) Planning of the osteotomy and ulnar shift of the radial shaft: proximal osteotomy beneath the ulnar head, distal osteotomy beneath the sigmoid notch, radial-based wedge for restoring of the ulnar inclination and correction of the position of the sigmoid notch; (b) stabilization by volar locking plate.

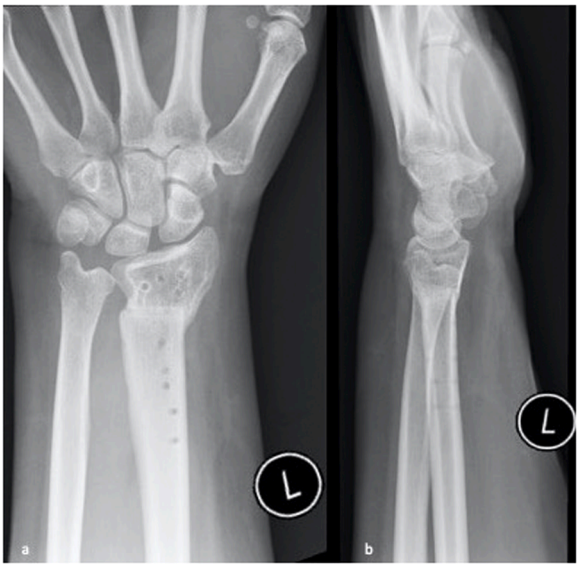

Fig. 5. After consolidation and hardware removal: (a) p.a. view; (b) lateral view.

side) patients were operated. The observed posttraumatic changes included increased inclination and incongruency of the sigmoid notch, as well as ulna-minus variance after forearm fracture in the childhood (either radius, ulna or both). The posttraumatic patients' demographics in shown in Table 1.

In 6 patients (all congenital cases) one or more wrist arthroscopies were performed in other institutions before referring them to us. These were inconclusive and did not lead to improvement of the patients' symptoms.

The mean age of all operated patients was 27.20 years (SD 10.04). The mean follow-up was 32.63 months (SD 29.27), median 24 months. In the posttraumatic group, the mean age of the patients was 24.32 years (SD 10,97) and the mean follow-up was 28,42 months (SD 26,69), median 24 months.

To assess the results, pre- and postoperative range of motion (ROM), visual analogue scale (VAS, scale 0 – 10) and modified Mayo-Wrist-Score was used [17,18].

Pain levels were obtained before and after each operation (n= 59). The postoperative range of motion was obtained in all cases (n= 59), we found 10 cases of preoperatively insufficient data regarding ROM (n= 49). The modified Mayo-Wrist-Score was postoperatively assessed in 41 cases (n= 41).

For statistical evaluation IBM SPSS Statistics 28.0.1.1 was used. For the significance of the VAS a non-parametric Wilcoxon Signed Ranks Test was used. For the evaluation of the ROM pre- and postoperatively, a

Table 1
Posttraumatic patients' group demographics.

Patient No.	Age	Year of operation	Operated side	Sex	Chronic illnesses	Previous fracture	Complications	Following procedures
1	14.3	2012	right	female	none	radius	None	hardware removal
2	14.9	2013	right	female	none	ulna	None	hardware removal
3	15.7	2014	right	female	none	multiple forearm fractures	DRUJ instability	reconstruction of interosseous membrane and DRUJ ligaments
4	19.6	2014	Left	female	none	ulna	None	hardware removal
5	34.2	2015	Left	male	none	radius	None	none
6	50.4	2015	right	female	none	radius	none	hardware removal
7	19.1	2016	right	female	none	radius	none	hardware removal
8	28.6	2017	Left	male	none	radius + ulna	none	hardware removal
9	16.9	2017	left	female	none	radius	none	hardware removal
10	18.9	2019	right	female	none	radius	none	hardware removal
11	23.7	2019	left	female	none	radius	none	hardware removal
12	35.7	2022	left	female	none	ulna	none	none

Paired-Samples T Test has been performed. Furthermore, to see whether there was a statistical correlation of the chosen parameters, Pearsońs Correlation Test has been performed.

Results

Preoperatively the mean on VAS was 7.22 (SD 1.55, range 1 – 10), postoperatively 1.98 (SD 2.22, range 0 – 8). These results were statistically significant ($p < .001$) (Fig. 6). Focusing on the posttraumatic group, the preoperative mean on VAS was 7.17 (SD 0.69, range 6 – 8), postoperatively 1.5 (SD 1.62, range 0 – 5) ($p = .002$).

The pre- and postoperative measurement of the range of motion of the wrist and forearm was done separately in a sagittal plane (extension/flexion) and rotation (supination/pronation), as well as the sum of the two, defined as the total ROM.

For the whole population, the mean preoperative ROM in sagittal plane was 138.06° (SD 21.62°) and postoperatively 132.96° (SD 26.85°), which was not statistically significant ($p = .178$). The mean ROM in pronosupination was preoperatively 163.88° (SD 18.83°) and postoperatively 162.24° (SD 21.72°), which also wasn't statistically significant ($p = .648$). The total mean ROM preoperatively was 301.94° (SD 32.39°) and postoperatively 295.20° (SD 44.23°), $p = .300$ (Fig. 7).

Results focused on the posttraumatic subgroup showed no statistically significant difference in the mean ROM in the sagittal plane preoperatively 138.13° (SD 13.61°) vs. postoperatively 139.38° (SD 10.16°) with $p = .861$. Similar results were found in the rotation: preoperative mean 172.50° (SD 14.88°), postoperative mean 170.00° (SD 7.56°), $p = .685$. Mean total ROM was 310.63° (SD 22.43°) preoperatively and 309.38° (SD 11.48°) postoperatively, $p = .902$.

The modified Mayo-Wrist-Score was used to categorize the patients' results into 4 categories. Out of the above-mentioned 41 obtained cases, 27 were marked as excellent, 8 as good, 3 as fair and 3 as poor. The results concentrated on the posttraumatic subgroup: 8 cases marked as excellent, 2 as good, 1 fair and 1 poor.

Using the Pearsońs test, statistically significant negative correlation was found between postoperative ROM in sagittal plane and rotation with the postoperative VAS ($r = -0.359$ / $p = .005$, $r = -0.531$ / $p < .001$, respectively).

The patients were also asked, should they have to decide again, knowing what they know now, the procedure and the pre- and postoperative protocol, would they agree to the operation again. In 87,8 % of cases we received a positive, in 12,2 % a negative answer. In the posttraumatic subgroup, the answer was in 83,3 % positive, in 16,7% negative.

Specific complications were also assessed. At the beginning of the implementation of our new operative method, there were 2 cases where

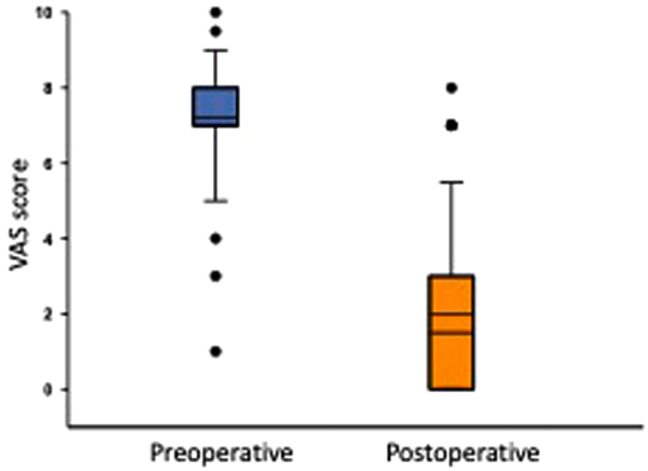

Fig. 6. Pain level pre- and postoperatively.

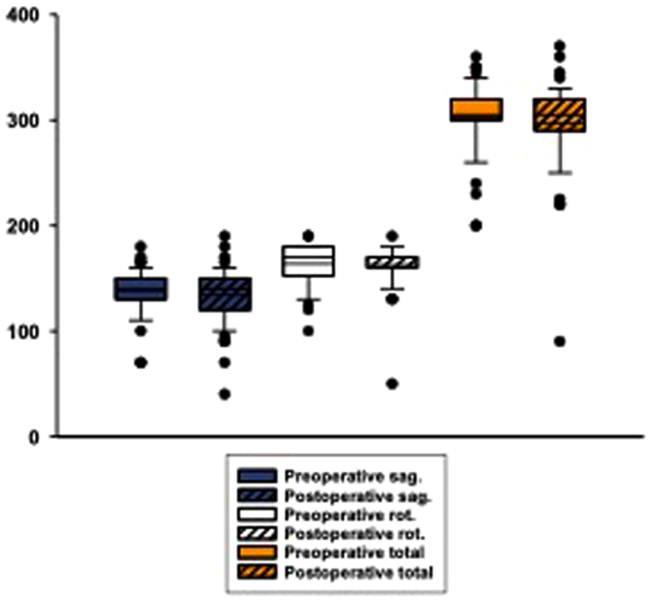

Fig. 7. ROM (in degrees) in sagittal plane (blue), rotation of the forearm (white) and ROM in total (orange) pre- and postoperatively.

the osteotomy was performed too distally (both patients from the congenital subgroup). Out of these patients, one underwent a hemiresection-interposition arthroplasty, which led to a pain free result. In the second case, a series of consecutive operations needed to be done to deal with persisting problems, that ended with a total DRUJ arthroplasty. In this patient a bilateral incongruency was observed and the osteotomy was performed on both sides. The first operation was successful without any complications, the second, contralateral, osteotomy ended up with the complications described above.

Another complication we experienced was the DRUJ instability in a patient where laxity of the joint was present preoperatively. This patient belonged to the posttraumatic subgroup and the preoperative incongruency was caused by multiple forearm fractures during childhood. In this case, reconstruction of the interosseous membrane with the tendon of m. brachioradialis and the reconstruction of DRUJ ligaments using palmaris longus graft was performed to stabilize the joint.

In one case (non-posttraumatic), extensive shortening of the radius was executed, which led to ulna-plus variance. Arthroscopy with debridement and denervation of the DRUJ had been done, but due to persistent pain and restricted ROM an ulnar head prosthesis was implanted.

Two male patients showed postoperative de Quervainś tenosynovitis due to the shift of the radius, which was treated by releasing of the first extensor compartment at the time of removal of the hardware after consolidation of the osteotomy and which led to painfree outcome.

Discussion

Pathognomonic sign of the DRUJ-impingement syndrome is the positive compression test [6]. This study presents the results of a treatment of this syndrome using distal, more-dimensional corrective osteotomy of the radius, focusing in detail on the posttraumatic subgroup.

Looking at the average age of the patients in our study, we observed, that the symptoms usually start at the beginning of the working phase of live, which usually means an increased strain on the DRUJ is required. This could explain, why both the congenital and posttraumatic deformity is not symptomatic earlier, but rather in the later stage. In 3 patients in the posttraumatic subgroup, the symptoms were present even 14 – 20 years after the trauma. Our patient collection shows, that

regardless of the origin and possible bilateral presentation, DRUJ-incongruency and ulna-minus variance does not necessarily lead to painful symptomatic state. The cause of this condition in congenital cases is not clear. The absence of the DIOM could be one of the reasons why the symptoms occur only in small group of people with ulna-minus variance and Tolat type 2 morphology of the DRUJ and should be subject for further investigation.

In case of childhood forearm fracture, care should be taken in follow-up examinations, since a disproportionate growth of the radius and/or ulna, possibly leading to a DRUJ incongruency and the symptoms described above, can occur.

The level of the osteotomy is of great importance. When too distally performed, the osteotomy can damage the joint capsule, cartilage, and may lead either to no improvement or even worsening of the symptoms. The two above-mentioned specific complications caused by excessively distal level of osteotomy should be therefore addressed as a technical failure in the execution of the osteotomy and not faults in the method itself.

The shortening of the radius should not be endeavored to achieve neutral ulnar variance, because of the risk of the conversion from ulna-minus to ulna-plus variance. We recommend the osteotomy to be performed with persistent ulna-minus variance at about 1 mm.

Concerning the translation between the distal radius and the radial shaft, a translation between 3 – 4 mm is preferred, but our observation shows that after performing the osteotomy, this position will usually be reached spontaneously.

The conventional x-ray picture of the wrist shows sufficient landmarks needed for correct osteotomy. The subject for discussion is the preoperative, computer-assisted 3D-planned osteotomy with suitable drill guide, as described by Estermann et al. [19]. This could be favored in case of additional pathology, e.g. in posttraumatic cases or in severe congenital deformation. In the vast majority of cases, the free-hand technique is safe and reliable in terms of financial and technical perspective.

Until now, when conservative treatment failed, we had no real joint preserving solution. Good results and motion improvement were described after ulnar lengthening procedures in patients with forearm deformities [20–22], however no significant movement restriction and difference was observed in our patient collection neither preoperatively nor postoperatively.

The other possible options are salvage procedures, such as hemiresection-interposition arthroplasty or Kapandji-Sauvé operation, or implant arthroplasty. These techniques have their indications and good results, however, in the predominantly young patient cohort with which we are dealing in this situation, preserving the original joint surface is a preferred method.

Our technique is aimed at restoring the congruency of the DRUJ and detensioning of the distal oblique band of the interosseous membrane through the ulnar shift of the radial shaft. According to our observation, preoperatively existing laxity, or instability of the DRUJ can worsen after the osteotomy [3,4,23,24]. Therefore, we consider an already preoperatively observed increased laxity and instability as a contraindication for this surgery.

Another goal of this method is to prevent or at least stop the worsening of the degenerative changes in the DRUJ, as this kind of deformity has a higher risk for early osteoarthritis caused by permanent overloading and irritative state [1]. We see this preventive character of this method in the decompression and remodeling of the DRUJ.

Conclusion

Patients came because of pain in the DRUJ in general without a movement restriction, hence the main goal of our treatment was focused on pain relief and preserving unrestricted motion. In accordance with our observation, the statistical assessment of the collected data showed a significant decrease of pain level in our patients after the procedure without compromising the range of motion.

A prerequisite for a successful execution of our osteotomy is a thorough preoperative clinical examination, radiological diagnostics, and correct planning of the level of the intended osteotomy.

Careful patient selection, correct osteotomy and perception of the contraindications can result in satisfactory results for both the surgeon and the patient.

Based on our results until now, this procedure leads to significant pain relief and satisfactory outcomes in most of the patients, where in the past no real solution could have been offered apart from waiting and performing a salvage procedure later. Additionally, from preventative point of view, one also might expect avoiding early degenerative changes. Interestingly enough, quite a lot of other surgeons, who followed this technique, reported similar positive experience. Furthermore, it is a procedure, which leaves other options open and does not burn any bridges.

CRediT authorship contribution statement

Petr Macháč: Formal analysis, Writing – original draft, Writing – review & editing. **Roman Wolters:** Methodology, Supervision, Validation. **René Schandl:** Supervision, Validation. **Hermann Krimmer:** Methodology, Project administration, Supervision, Validation, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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