Midterm Results of Semiconstrained Distal Radioulnar Joint Arthroplasty and Analysis of Complications

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Abstract

Range of motion and stability are important outcome parameters to assess function of the distal radioulnar joint (DRUJ), in particular pronation, supination, and weight-lifting capacity. The DRUJ semiconstrained implant developed by Scheker et al is intended to reproduce all the functions of the triangular fibrocartilage complex and the DRUJ. The aim of the study was to investigate the subjective, clinical, and radiographic results in 10 patients after primary implantation of the semiconstrained DRUJ arthroplasty following DRUJ derangement and painful instability, with an average follow-up of 3 years with a special focus on the complications. Standardized preoperative and postoperative evaluation included assessment of pain by a visual analog scale, radiographic examination, range of motion measurements, lifting capacity, and grip strength. The patient-perceived function was investigated using clinical score charts. Compared with the preoperative status, range of motion showed little change, while grip strength, lifting capacity, pain score, and patient-perceived functions improved significantly.

Keywords

- distal radioulnar joint
- semiconstrained implant
- arthroplasty

One patient developed an ulna stem loosening, while two patients had to be reoperated because of an irritation of the extensor tendons and the superficial radial nerve at the first dorsal compartment of the wrist. In this study, arthroplasty of the DRUJ using the semiconstrained DRUJ arthroplasty was found to result in satisfactory outcome.

Level of evidence: Level IV

The radius and the ulna articulate at the radioulnar joint, which is a bicondylar joint that consists of a proximal and a distal part. The distal radioulnar joint (DRUJ) is composed of the head of the ulna articulating with the sigmoid notch of the distal radius.¹ The DRUJ allows pronosupination along with the proximal radioulnar joint and plays a major role in weight bearing. When lifting an object against gravity with the forearm in neutral rotation, a transverse force runs from the ulnar insertion of the brachialis muscle up to the head of the ulna.

In the case of damaged or incongruent DRUJ, even by preserved pronosupination the lifting of a weight might provoke pain to the wrist.

The ulna supports the radius, and the two are connected by the annular ligament at the elbow and the triangular fibrocartilage complex (TFCC) at the wrist.^{2,3}

The pathologies affecting the DRUJ include degenerative, posttraumatic, and inflammatory arthritis. Typically, patients with DRUJ pathology experience ulnar-sided pain at the wrist, exacerbated by lifting relatively light objects.^{4,5}

Different surgical procedures have been developed to alleviate the impairment imposed by a dysfunctional DRUJ.⁶ Most surgical options remove to some extent the ulna head without

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replacement, largely ignoring the functional anatomy of the forearm.^{4,7-9} The most common surgical procedures include partial¹⁰ or complete resection of the distal ulna,¹¹ fusion of the distal ulna with proximal diaphysis interruption,⁹ ulna head replacement with ligamentous reconstruction of the TFCC,^{12,13} and Achilles tendon interposition.¹⁴ However, the DRUJ may remain painful after these procedures, particularly under load, often with instability and restricted mobility.¹⁵ The reason is impingement of the ulna stump with the radius, especially in active patients.¹⁶ The choice of treatment options for a postoperative dysfunctional DRUJ with residual pain and instability of the wrist remains limited.

The semiconstrained DRUJ prosthesis published by Scheker et al in 2001¹⁷ (Aptis Medical, Louisville, KY) is a total joint arthroplasty in cobalt chrome, in which a ball-in-socket system on the radius is combined with a stem within the ulna diaphysis.^{6,18,19} This implant fully replaces the two components of the DRUJ, the ulna head and the sigmoid notch, and provides stability replacing TFCC function.^{18,20-22}

The aim of the study was to investigate the subjective, clinical, and radiographic results after DRUJ arthroplasty with this semiconstrained DRUJ prosthesis.

We also took a special view of our complications to understand those complications due to the operating technique and those that might be linked to the specific design of the implant.

Patients and Methods

A retrospective analysis of patients who had DRUJ prosthesis implanted at our center from July 2010 to January 2014 and who gave written informed consent was conducted. Ethical approval was obtained through the regional ethic committee.

Table 1 Demographics and characteristics of study population

Patient	Sex	Age (y)	Indication for operation	Previous surgery	Complications
1	Male	64	Osteoarthritis	None	None
2	Male	51	Osteoarthritis	None	None
3	Female	46	Osteoarthritis and instability	TFCC refixation, ulna shortening	Nerve irritation
4	Male	62	Ulna stump impingement	Sauvé-Kapandji	Bone resorption with stem loosening, heterotopic ossification
5	Male	21	Osteoarthrosis and instability	Scaphoid resection, four-corner fusion	None
6	Female	54	Osteoarthritis	Ulna shortening	None
7	Female	51	Osteoarthritis and instability	Radius correction osteotomy	None
8	Female	50	Osteoarthritis	TFCC refixation, wrist denervation	Nerve irritation
9	Male	60	Ulna stump impingement	Wrist arthroscopy, wrist arthrodesis, Darrach procedure	None
10	Female	37	Osteoarthritis and instability	Wrist arthroscopy, TFCC refixation	None

Abbreviation: TFCC, triangular fibrocartilage complex.

Patient who were not willing or able to participate or who had a minimum follow-up of less than 12 months were excluded. A total of 10 arthroplasties were performed in 10 patients (5 females, 5 males). The average age of the patients at the time of surgery was 50 years (standard deviation [SD], 12.8 years). Five implants were inserted into the right hand and five into the left. Five patients had the operation in their dominant hands. Indications for joint replacement were osteoarthritis and/or instability of the DRUJ in eight cases and ulna stump impingement in two patients. Eight patients had at least one previous wrist operation. Detailed characteristics of the patients are given in ►Table 1.

Three surgeons performed all the arthroplasty procedures. The patients were assessed preoperatively and at the follow-up time point in February 2015 by an independent person. Subjective assessment was based on the visual analog scale (VAS) for pain (on a scale of 0–10 for severity), the Mayo wrist score, and the Krimmer wrist score questionnaire (in which a score of 100 means no disability and a score of 0 means complete disability).^{23,24} The range of motion (ROM) of the wrist was determined using a goniometer, and grip strength was measured with a Jamar dynamometer. Lifting capacity was assessed with progressive weights (1–30 kg) in neutral position and performance of a full pronosupination. Bilateral wrist parameters were recorded.

Radiographs were taken and assessed for heterotopic ossification and implant loosening.

Surgical Technique

The standard procedure for implantation of the semiconstrained distal radioulnar prosthesis has previously been described.¹⁷ In all cases, we used the standard technique.

Fig. 1 Pain on the VAS decreased significantly from 8.7 (SD, 1.8) preoperative to 2.9 (SD, 2.8) at the follow-up time point.

The size of the implants was templated preoperatively by the manufacturer.

Statistic

Data were analyzed using Statistical Package for Social Sciences (SPSS, Version 20 for Macintosh; Chicago, IL). Discrete values are expressed as counts (percentages), while continuous variables are given as both mean (SD) and median (interquartile range), as some of them did not follow a gaussian distribution. Nonparametric Wilcoxon signed-rank test was applied to test for differences between preoperative and postoperative measurements. All tests were two tailed; $p < 0.05$ was considered significant.

Results

It was possible to evaluate all 10 patients for a follow-up after an average of 32 months (range, 12–60 months).

Subjective Results

On the VAS scale, pain improved significantly from a preoperative mean of 8.7 (SD, 1.8) to 2.9 (SD, 2.8) ($p = 0.005$) (► **Fig. 1**). The Mayo wrist score was 43.5 (SD, 18.4) preoperative, compared with 78.5 (SD, 31.5) at the follow-up time point ($p = 0.007$). The Krimmer wrist score improved significantly from 18.9 (SD, 14.0) to 76.5 (SD, 22.7) ($p = 0.005$) (► **Table 2**).

Six patients went back to their previous job. Two patients went back to their previous job but with a 50% limit to the hours they were allowed to work every day. Two patients had to change their job.

Clinical Outcomes

Mean wrist extension improved from preoperative 47 degrees (SD, 13.7 degrees) to 52 degrees (SD, 19.2 degrees) at the follow-up time point, and mean wrist flexion improved from 48 degrees (SD, 10.9 degrees) to 53 degrees (SD, 25.8 degrees) ($p = 0.397$ and 0.673 , neither significant). Mean wrist pronosupination was 73/0/78 degrees (SD, 40.4 degrees) preoperatively and 88/0/84 degrees (SD, 14.0 degrees) at the follow-up time point ($p = 0.197$ and 0.057 , neither significant). The average grip strength was 2.3 kg (SD, 6.2 kg) (5.1 lbs [SD, 13.8 lbs]) preoperatively and increased significantly to 20.2 kg at the follow-up time point (SD, 12.8 kg) (45 lbs [SD, 28.2 lbs]) ($p = 0.005$). Lifting capacity increased significantly from 0.7 kg (SD, 0.7 kg) preoperatively to 11.4 kg (SD, 11.1 kg) at the follow-up time point ($p = 0.005$). The grip strength of the operated wrist was 68% of that of the contralateral limb (► **Fig. 2**, ► **Table 2**).

Radiological Results

Except of one patient, we saw no implant loosening. Two patients had ectopic bone growth at the top of the ulnar stem. One was asymptomatic and the other one is described in the “Complication” section.

Complications

One patient with a broad ulna intramedullary canal (>6 mm) had a stem loosening. In this case, heterotopic ossification

Table 2 Subjective results and clinical outcome preoperative and at follow-up time point

	Preoperative		Follow-up		p-Value
	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)	
Pain relief (VAS)	8.7 (1.8)	9 (1)	2.9 (2.8)	1.5 (5)	0.005 ^a
MWS (points)	43.5 (18.4)	42.5 (34)	78.5 (31.5)	80 (63)	0.007 ^a
KWS (points)	18.9 (14.0)	15 (10)	76.5 (22.7)	80 (38)	0.005 ^a
Extension (degrees)	47 (13.7)	40 (25)	52 (19.2)	55 (33)	0.397
Flexion (degrees)	48 (10.9)	50 (23)	53 (25.8)	50 (50)	0.673
Pronation (degrees)	73 (32.4)	90 (33)	88 (4.2)	90 (3)	0.197
Supination (degrees)	78 (13.4)	80 (20)	84 (10.8)	90 (13)	0.057
Grip strength (kg)	2.3 (6.2)	0 (1)	20.2 (12.8)	18.5 (23)	0.005 ^a
Lifting capacity (kg)	0.7 (0.7)	1 (1)	11.4 (11.1)	7.5 (19)	0.005 ^a

Abbreviations: IQR, interquartile range; KWS, Krimmer wrist score; MWS, Mayo wrist score; SD, standard deviation; VAS, visual analog scale.

^aStatistical significance at a level p -value < 0.05 .

Fig. 2 Comparison of pre- and postoperative data, flexion/extension, and pronosupination showed no significant change, (A, B), but grip strength and lifting capacity improved significantly (C).

was also seen at the ulna head level. This patient required a change of stem with the same maximal size (6 mm) and fixation with cement and a resection of the heterotopic ossification (►Fig. 3).

The final ROM was flexion/extension 20/0/40 degrees and pronosupination 90/0/70 degrees. VAS was 6 at the follow-up time point, grip strength was 20 kg, and lifting capacity was limited to 3 kg. No other operation was then required but the patient was mainly disturbed by the limited lifting ability.

One patient sustained a superficial radial nerve irritation and synovitis to the first dorsal compartment of the wrist due to a slightly long screw tip of the radial plate.

This was the third screw from proximal in a 20-size plate. This patient was treated by release of the first dorsal compartment of the wrist flattening of the protruding screw tip with a diamond burr (►Fig. 4). Interestingly, no clear synovitis was seen over the abductor pollicis longus (APL) and extensor pollicis brevis (EPB) tendons and the nerve did not show any macroscopic change. The patient improved after the procedure and the final VAS was 2, grip strength was 2 kg, lifting capacity was 2 kg, and pronosupination was 80/0/60 degrees.

One patient also had a superficial radial nerve irritation and synovitis to the first dorsal compartment of the wrist due to a slightly long screw tip of the radial plate. This was the second screw from proximal in a 20-size plate. This patient was treated by release of the first dorsal compartment of the wrist flattening of the protruding screw tip with a diamond burr (►Fig. 5). Some synovitis was seen over the APL and EPB tendon but no macroscopic changes were seen of the superficial radial nerve. The patient improved after the procedure and the final VAS was 5, grip strength was 15 kg, lifting capacity was 3 kg, and pronosupination was 90/0/90 degrees.

Discussion

Our study compared the subjective, clinical, and radiographic results preoperative and 1 to 5 years following implantation of a Scheker prosthesis. The results show a significant decrease of subjective outcomes evaluated with the Mayo and Krimmer wrist scores and a significant increase of clinical outcomes, such as grip strength and lifting capacity. In contrast, ROM showed no significant change. There are only a few reports with this kind of DRUJ arthroplasty in the literature with a small number of patients (►Table 3).

Surgical interventions for DRUJ osteoarthritis and instability frequently have unsatisfactory outcomes with residual pain and dysfunction. These procedures often do not adequately consider the anatomical functions of the joint leading to instability of the ulna stump; reduced weight bearing and reduced fist grip force are the most frequent complications. Without the support of an intact ulna head, the radius impinges against the remnant ulna when the forearm is bearing weight.¹⁶ Recent biomechanical studies revealed that excision of the ulna head disrupts the force transmission profile through the forearm, producing the biomechanical equivalent of a one-bone forearm.^{2,3} Hemiarthroplasties have reasonable outcomes only when the sigmoid notch and the capsular ligament complex are still intact.^{13,14}

The mean VAS pain score (0–10 scale) in our study decreased significantly from 8.7 (SD, 1.8) to 2.9 (SD, 2.8). In Scheker's

Fig. 3 Posteroanterior X-ray view shows heterotopic ossification and stem loosening in the ulna shaft (A). Postoperative X-ray after resection of heterotopic ossification and fixation with cement (B). X-ray at the follow-up time point shows no heterotopic ossification or stem loosening (C).

cohort, pain significantly decreased from 8.3 (SD, 1.2) to 2.7 (SD, 2.7) after surgery.¹⁸ Axelsson and Sollerman's cohort had a median postoperative VAS score of 0.3 versus a preoperative VAS score of 6.⁵ Overall, while limited in number, the different studies result in similar functional outcomes (► **Table 3**).

The patient-perceived function indicates a significant improvement after the implantation of the semiconstrained DRUJ prosthesis. Nine patients reported an improvement in their daily life activities, with increased strength, motion, and lifting capacity. These results are very similar to those reported in the other case series published previously.

Mean grip strength showed a significant improvement in our cohort from 2.3 kg (SD, 6.2 kg) (5.1 lbs [SD 13.8 lbs]) before surgery to 20.2 kg (SD, 12.8 kg) (45 lbs [SD, 28.8 lbs]) at the follow-up time point, representing 68% of the contra-

lateral strength in the operated wrist. Kachooei et al reported a postoperative mean grip strength of 47 lbs (SD, 15 lbs) on the operated side and 68 lbs (SD, 23 lbs) on the nonoperated side, representing 69% of the contralateral strength in the operated wrist.¹⁹

Three of our study patients needed a second operation due to postoperative complications. We observed one case of heterotopic bone formation at the ulna head directly related to the mobilization of the stem. In our view, the mobilization of the stem was due to the insufficient maximum diameter size of the stem (6 mm) in a patient with a large endomedullary canal. At the time of surgery, the stem looked stable, but on a long run, it loosened. Probably, we should have foreseen this issue and think about cementing the implant primarily. However, the availability of a thicker stem, even as a custom element, would prevent

Fig. 4 Wrist preoperative with a slightly long screw tip of the radial plate (A) and after wrist flattening of the protruding screw tip with a diamond burr (B).

Fig. 5 Second wrist with a slightly long screw tip of the radial plate preoperative (A) and after wrist flattening of the protruding screw tip with a diamond burr (B).

Table 3 Comparison of literature after implantation of semiconstrained distal radioulnar joint prosthesis

	Number of patients	Supination (degrees)	Pronation (degrees)	Grip strength (kg)	Complications
Scheker et al ²⁰	27	75	83	23 ^a	ECU tenosynovitis (<i>n</i> = 6), heterotopic ossification (<i>n</i> = 5), screw/cap loosening (<i>n</i> = 1)
Kachooei et al ¹⁹	13	51	64	21 ^a	Tendon irritation from protruding screw tip (<i>n</i> = 2)
Degreeef and De Smet ¹⁵	4	90	90	–	None
Bizimungu and Dodds ²¹	10	73	70	25 ^a	Not reported
Axelsson and Sollerman ⁵	9	80	70	21	Carpal tunnel syndrome (<i>n</i> = 1), de Quervain disease (<i>n</i> = 1), lateral elbow pain (<i>n</i> = 2)
Our study	10	84	88	20	Stem loosening and heterotopic ossification (<i>n</i> = 1), superficial radial nerve irritation (<i>n</i> = 2)

Abbreviation: ECU, extensor carpi ulnaris.

Note: Postoperative mean values of supination, pronation, and grip strength.

^akg converted from lbs.

this complication in the future. This complication of ours was treated successfully by changing the stem with a new cemented stem of the same size (6 mm) and resection of the heterotopic ossification. In Scheker and Martineau's series, postoperative complications were seen in 12 cases. The authors observed six cases of extensor carpi ulnaris (ECU) tendonitis, five cases of ectopic bone formation, and one screw/cap loosening. All complications were resolved surgically with good clinical course and patient satisfaction.²⁰ We did not observe any case of ECU tenosynovitis or cap screw loosening.

In our series, two patients sustained a superficial radial nerve irritation and synovitis to the first dorsal compartment of the wrist due to a slightly long screw tip of the radial plate. These two patients were treated by release of the first dorsal compartment of the wrist flattening of the protruding screw tip with a diamond burr. Kachooei et al reported two patients with tendon irritation from a protruding screw tip. They treated this adverse event as we did by debriding the tip of the screw tip.¹⁹

Axelsson and Sollerman reported on four postoperative adverse events. One patient required surgery for de Quervain disease 1 year after the arthroplasty, and one patient experienced transient carpal tunnel syndrome postoperatively. Two patients reported lateral elbow pain, which responded well to conservative treatment.⁵

Looking at the available alternative implants replacing the sigmoid notch and the ulna head, we found in literature the implant designed by Schuurman^{25,26} and the STABILITY system produced by Small Bone Innovation. The Schuurman's prosthesis differs from the Scheker prosthesis in that the radial component is not screwed but should attain osteointegration through its hydroxyapatite coating. This implant showed improvement in ROM and grip strength, and decreased pain scores comparable to that of the prosthesis designed by Scheker. However, most of these prostheses (7/19) had to be removed due to loosening, continuing pain, or at the request of the patient.^{25,26}

Regarding the STABILITY system, we found in literature only four cases and therefore it is impossible to draw any conclusion about the implant.²⁷

Our study is limited by the small number and heterogeneous group of patients. Given the complex nature of wrist pathologies that characteristically require a salvage procedure of the DRUJ, such variability is almost to be expected. In addition, only early results (1–5 years) following prosthesis implantation were available.

The semiconstrained DRUJ prosthesis investigated in our study is attractive because of its self-stabilizing design, alleviating the need for intact ligamentous support or an intact sigmoid notch. All patients except two had undergone previous wrist operations before the implantation of the Scheker prosthesis, which further highlights the promise this prosthesis holds in situations where traditional arthroplasties or other implants have failed. However, the relatively high rate of complications in our and similar study raises the question if the design of the implant could be possibly improved.

Conflict of Interest

None.

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