Midterm Functional Outcome of the Linked Semiconstrained Distal Radioulnar Joint Prosthesis

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Abstract

Background A painful unstable distal radioulnar joint (DRUJ) can seriously compromise hand and wrist function. The semiconstrained prosthesis was developed to restore DRUJ function. To date, most outcome reports are coauthored by the designer.

Questions Does independent reporting confirm the promising results of the semiconstrained DRUJ prosthesis? Are complication and failure rates acceptable?

Patients and Methods We evaluated patients with the semiconstrained DRUJ implant and a minimum follow-up of 2 years. We monitored patient satisfaction and function with functionality questionnaires and measured wrist range of motion, grip, and key pinch strength. Statistical analysis was done using descriptive statistics, Pearson correlation coefficients, linear and logistic regression.

Results We included 41 patients with 42 implants. Mean follow-up was 46 months (range: 24–102 months). Eighty percent of wrist had undergone previous surgery. We found a mean pronation of 83 degrees (0–90 degrees), supination of 70 degrees (0–90 degrees), flexion of 42 degrees (0–90 degrees), extension of 49 degrees (0–90 degrees), ulnar deviation of 24 degrees (0–60 degrees), and radial deviation of 14 degrees (0–40 degrees). Grip and key pinch strength were 20.1 (1–50 kg) and 6 kg (1–12 kg), respectively. Average patient-rated wrist and hand evaluation score was 42.7 (0–95), disabilities of the arm, shoulder and hand score was 38 (0–88), and visual analog scale score was 3.6 (0–8). We found a 43% complication rate (mostly minor: ulnar or radial tendinopathy, temporary hypoesthesia) with 24% reoperation and 92% prosthesis survival rate.

Conclusion The linked semiconstrained DRUJ prosthesis has its value in the surgical treatment of DRUJ failure. Currently, most implants are used in secondary surgery and multioperated wrists. More research is required to assess the value of the DRUJ prosthesis as a primary procedure.

Level of evidence This is a level IV, therapeutic study.

Keywords
- distal radioulnar joint
- joint replacement
- arthroplasty
- semiconstrained
- outcome
- complications

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The distal radioulnar joint (DRUJ) is composed of the radial sigmoid notch and the ulnar seat surrounded by soft tissue stabilizers. It has an essential role in wrist stability, motion, and weight bearing.[1–3] DRUJ problems are not uncommon with a prevalence of 12.3% for primary osteoarthritis and 27 to 49% for triangular fibrocartilaginous complex (TFCC) abnormalities, increasing with age.[4,5] They can cause pain, instability, weakness, and/or impaired range of motion (ROM), mostly in pro- and supination. Failure of the DRUJ may be not only caused by trauma such as distal radius fracture and TFCC tear but may also be due to nontraumatic conditions as rheumatoid arthritis, septic arthritis, ulnocarpal abutment or congenital abnormalities such as Madelung deformity.[6]

Injury to the DRUJ may cause severe disability with apparent reduction in quality of life. Many different procedures were introduced to restore DRUJ function and reduce pain such as Darrach and Sauve and Kapandji procedures and a variety of hemiresection interposition procedures.[7–10] All these procedures have one common biomechanical consequence: an "ulnar impingement syndrome" between the residual ulnar stump and radius, which may result in pain and locking.[11–13]

Alternatively, DRUJ prosthetic replacement with hemi- or total DRUJ arthroplasty may be considered. The hemiarthroplasties were introduced by Swanson, Herbert, van Schoonhoven, and Berger: an ulnar head implant articulates with the intact sigmoid.[14–17] Downsides are possible DRUJ instability due to the nonlinked aspect of the implant and proceeding painful degenerative joint arthritis of the radius against the ulna implant. These nonlinked implants require the original soft-tissue stabilizers of the wrist that are often in poor condition.[18] In constrained total DRUJ arthroplasty, both joint surfaces are replaced in a constrained manner, providing intrinsic stability without relying on those original stabilizers.

Three total DRUJ implants have been developed to date,[19–21] but the semiconstrained developed by Scheker et al (Aptis, Louisville, KY) is currently the most popular implant.[22] It is a semiconstrained linked arthroplasty that replaces the distal ulna with an ulnar stem and the sigmoid notch with a radial plate, allowing for a full ROM of wrist and forearm with joint inclination, translation, and rotation.[3]

With this study, we aim to evaluate midterm clinical results of these linked semiconstrained DRUJ replacements at our institution since its introduction in 2010. Does independent reporting of results confirm the promising results of this prosthesis? Are complication and failure rates acceptable?

Patients and Methods

Study Design

We performed a retrospective study on a chronologically maintained database of all the patients who received a linked semiconstrained DRUJ prosthesis between October 2010 and August 2018 with a minimum 2-year follow-up. The study was approved by our institutes review board and all patients included in the study consented to participate.

Patients were invited for clinical evaluation if no adequate recent minimum 2-year follow-up was available. Patients who were lost to follow-up or refused to participate in our study were excluded.

Demographics

Forty-seven patients were eligible for inclusion of whom six patients failed to sign the informed consent form or did not respond to our request for follow-up. As a result, 41 patients were included with 42 implants. Three prostheses were removed before the 2-year follow-up so they were excluded in the ROM and strength tests but will be discussed in the demographics, radiology, and complication section.

Demographic data and indications for DRUJ arthroplasty are summarized in ►**Table 1**.

In 21 patients, the problem had a traumatic onset with wrist fracture, distortion, or TFCC rupture. One patient had a dog bite resulting in radial osteomyelitis. Seven patients had relevant comorbidities: Madelung deformity ($n = 3$) associated with Léri-Weill syndrome ($n = 2$), Kienböck disease ($n = 2$), cerebral palsy ($n = 1$), and rheumatoid arthritis ($n = 1$). One patient with Madelung deformity had bilateral DRUJ implants. Grossly, the indications for the DRUJ replacement can be subdivided in DRUJ pain ($n = 32$; 76%) and DRUJ

Table 1 Demographic data and indications for DRUJ arthroplasty

Age; mean (range)	47 (25–74)
Sex; no (%)	
Male	7 (17)
Female	34 (83)
Side, no (%)	
Right	23 (55)
Left	19 (45)
Dominant side affected	23 (56)
Hospitalization time; average nights (range)	1.5 (1–3)
Follow-up time in months; mean (range)	46 (24–102)
Preceding trauma; no (%)	21 (51)
Comorbidities; no (%)	
Madelung deformity	3 (7)
Kienböck disease	2 (5)
Cerebral palsy	1 (2)
Rheumatoid arthritis	1 (2)
Indications for DRUJ arthroplasty	
DRUJ pain, no (%)	32 (76)
After previous surgery; no	26
Primary prosthetic replacement; no	6
DRUJ instability, no (%)	10 (24)
After previous surgery; no	8
Primary prosthetic replacement; no	2

Abbreviation: DRUJ, distal radioulnar joint.

instability ($n = 10$; 24%). Prosthetic replacement of the joint was preceded by previous surgical intervention in 34 wrists (80%) with an average of 3.2 procedures per wrist (range: 1–13). An overview of previous surgical procedures is listed in ►**Table 2**.

Assessment

Relevant postoperative clinical data related to DRUJ function were collected by the first author JW and last author ID according to a predetermined protocol: ROM, grip strength and key pinch strength. Both wrists were examined for comparison. ROM measurements included degree of wrist extension, flexion, ulnar deviation, radial deviation, and forearm pro- and supination. Grip strength was measured with a Jamar Hydraulic Hand Dynamometer (Asimov Engineering Company, Los Angeles, CA) and key pinch strength was measured between the index finger and the opposed thumb using a mechanical pinch gauge (Baseline Measurement, White Plains, NY).

Also, functional outcome was monitored: all patients completed the disabilities of the arm, shoulder and hand (DASH) questionnaire and the patient-rated wrist and hand evaluation (PRWHE) at the time of their postoperative clinical evaluation. Pain and satisfaction were measured with 10-point graded visual analogue scales (VAS). Each patient was asked if they would repeat the operation knowing what they know now at the clinical follow-up in a yes-or-no question as a poll for general satisfaction or regret of the implant surgery.

Return to work was noted by asking about the working conditions of the patients before and after placement of the prosthesis.

Radiographies were made during yearly follow-up. No other X-rays were made, unless clinically indicated. The most recent X-ray for each patient was used in our analysis.

Complications and their implication were evaluated by review of a chronologically maintained database.

The minimum follow-up for inclusion in data analysis was 24 months with a mean follow-up in our population of 46 months.

Data analysis was done using descriptive statistics, Pearson correlates, and linear and logistic regression. *p*-Values are shown were applicable.

Results

Objective Outcomes

An objective outcome overview is presented in ►**Tables 3** and **4**. Mean ROMs, grip strength, and key pinch strength are shown and correspond well to postoperative results reported in previous literature. In the 34 wrists without previous arthrodesis, the ROMs were slightly better. In patients with unilateral prosthetic replacement, we compared the prosthetic wrist with the nonprosthetic one using the average ratio of the ROM and strength tests. One patient with an afunctional contralateral wrist was excluded from this analysis.

The number of preceding surgeries was negatively correlated to prosthetic ROM and negatively correlated to the

Table 2 Surgical interventions before DRUJ replacement

Wrists with previous surgeries; no (%)	34 (80)
Procedures per wrist; no (range)	3.2 (1–13)
Wrist arthroscopy	11
Debridement	6
Drainage and synovectomy	1
TFCC repair	1
Scapholunate ligament repair	2
Lunotriquetral stabilization	1
Open TFCC repair	1
Fracture reduction	4
Pseudoarthrosis resection + SAKAI flap	1
Sigmoid notch plasty	1
DRUJ release	2
DRUJ stabilization	8
Hebert	3
Adam's	4
Gupta	1
Interposition procedures	2
Achilles tendon allograft	1
Hemiressection-interposition interposition	1
First extensor compartment release	2
Wrist denervation (AIN, PIN)	2
Ulnar nerve release	1
Ulnar styloidectomy	1
Ulnar shortening	9
Distal radial osteotomy	2
Revascularization os lunatum	1
Pisiformectomy	2
Proximal row carpectomy	3
Epiphysiolysis	1
Darrach	6
Sauvé-Kapandji	11
Arthrodeses	5
Total wrist arthrodesis	3
Chamay arthrodesis	1
CMC arthrodesis	1
Arthroplasties	5
CMC1-arthroplasty	1
Hebert ulnar head prosthesis	1
Ulnar Eclipse prosthesis	2
Radiocarpal prosthesis	1
Removal of material	15
Unknown	18
Wrists without previous surgery; no, (%)	8 (20)

Abbreviations: AIN, anterior interosseous nerve; CMC, carpometacarpal; DRUJ, distal radioulnar joint; PIN, posterior interosseous nerve; TFCC, triangular fibrocartilaginous complex.

Table 3 Postoperative ROM

	Flexion	Extension	Pronation	Supination	Ulnar deviation	Radial deviation
ROM ($n = 39$); mean (range)	42 degrees (0–90)	49 degrees (0–90)	83 degrees (0–90)	70 degrees (0–90)	24 degrees (0–60)	14 degrees (0–40)
ROM without arthrodesis ($n = 34$); mean (range)	48 degrees (10–90)	55 degrees (10–90)	87 degrees (70–90)	74 degrees (45–90)	27 degrees (2–60)	16 degrees (5–40)
Ratio (Prosthetic/native wrist); mean (range)	64% (0–167)	80% (0–167)	93% (0–100)	80% (0–100)	60% (0–125)	70% (0–154)

Note: Range of motion (ROM) measured at postoperative follow-up. First row contains mean ROM in the total population. Second row contains mean ROM in a subpopulation of patients without wrist arthrodesis. Third row contains the ratio of the ROM in the prosthetic wrist as opposed to the one in the native wrist.

Table 4 Strength tests

Grip strength (kg); mean (range)	20.1 (1–50)
Ratio (prosthetic/native); mean (range)	66% (11–160)
Key pinch strength (kg); mean (range)	6 (1–12)
Ratio (prosthetic/native); mean (range)	80% (25–120)

Note: Overview of grip and key pinch strength tests. The mean strength is shown in kilograms (kg) as well as mean ratio of strength in the prosthetic wrist as opposed to strength in the native wrist.

average ratios. Most of the separate correlations proved significant (Pearson correlates, $p < 0.05$, ►**Table 5**) suggesting that more prior interventions are associated with a reduced functional outcome.

At the time of surgery, 15 patients were professionally active in various sectors. Thirteen of them (87%) were able to resume the same employment afterwards. Twenty-one other patients were disabled before the prosthesis was placed of whom five were able to return to work after the operation due to increased functionality. Four patients were already retired at the time of surgery and all were able to resume normal daily activities after implant arthroplasty.

Subjective Outcomes

Average PRWHE score, DASH score 38, and VAS score are shown in ►**Table 6**. All three questionnaires showed a significantly (student *t*-test, $p < 0.05$) worse outcome when the DRUJ problem occurred at the dominant hand.

All but two patients reported they would repeat the operation knowing what they know now at clinical follow-up, resulting in an overall patient satisfaction of 95%. One patient with cerebral palsy and one patient whose prosthesis was explanted would not repeat the operation.

All three subjective outcomes were positively correlated to the number of preceding interventions. (►**Table 7**) This suggests that a high number of preceding surgeries predicts a worse subjective outcome, although this correlation was only significant for VAS ($p = 0.03$) and this significance disappeared ($p = 0.18$) when correcting for age in a linear regression analysis.

Comparison of objective with subjective outcomes revealed that ROM and strength are negatively correlated to all three subjective measurements in a significant way, suggesting that a poor functional outcome is associated with a poor subjective outcome. When correlating the average differences and average ratios between the prosthetic and nonprosthetic wrists to the subjective outcomes, these correlations appeared even stronger. (►**Table 8**)

Complications

We noted 22 complications in 18 wrists, which required 12 additional surgical interventions in 10 wrists that correspond to a 43% complication rate and 24% reoperation rate. (►**Table 9**). The most common complication (21%) was irritation of periprosthetic tendons caused by prominent screws. All were successfully treated with conservative measurements or screw replacement (►**Fig. 1**).

Three prostheses were removed at 15 months, 8 months, and 24 months, corresponding to a survival rate of 92% at an average follow-up of 46 months (►**Fig. 2**). This was due to persisting pain in two cases, with signs of aseptic loosening on radiological or nuclear investigations. One of these patients received a revision implant with good clinical result. The other patient had persistent pain, even after a one-bone forearm surgical procedure was added to stabilize the painful distal ulna. The third removal had recurrent tenosynovitis in multiple tendons after a good initial clinical evolution. A tenosynovectomy was unsuccessful and nuclear investigations suggested an aseptic loosening. The prosthesis was removed with good clinical evolution and resolution of pain. In all three cases, cultures taken preoperatively remained negative and an underlying infection was not found.

In all these complications, with or without further surgical intervention, insufficient resolution of complaints was reported by only four patients.

Using a linear regression analysis correcting for age, we found no significant correlation between the number of previous surgeries and the number of complications or the number of complications requiring surgery. Furthermore, a logistic regression analysis revealed that the number of previous surgeries is not associated with a higher risk for complications (odds ratio: 0.94 [0.71–1.26]) or higher risk for

surgery because of those complications (odds ratio: 1.06 [0.80–1.40]).

Radiologic Findings

In 41 wrists (98%), the radiographs at clinical follow-up of the implants revealed correct implant positioning without signs of loosening or periprosthetic fractures. Once, a skewed position was noted in a patient with persisting pain, for which the prosthesis was replaced as discussed above. The other two cases in which the prosthesis was removed, no obvious signs of loosening were observed on standard radiographic imaging and aseptic loosening was suspected using nuclear imaging. Heterotopic ossification without clinical impact was noted in four protheses. We found discrete radiolucency around the most proximal ($n = 1$) or distal ($n = 2$) radial screw in three prostheses, but none showed symptoms nor progression during radiographic follow-up. In one wrist, we found discrete radioopaque periprosthetic flakes, suggesting possible metallosis but again without clinical implications.

Discussion

The treatment of painful DRUJ arthritis can be challenging. The linked semiconstrained prosthesis developed by Luis Scheker replaces both the distal ulna with an ulnar stem and the sigmoid notch with a radial plate. In 2001, they reported promising outcome of the first 23 prostheses with a mean follow-up period of 15 months.[20] Since then, many centers reported their outcomes and in 2017, Moulton and Giddins performed a systematic review of 12 reports on 246 implants.[23] Despite the variability between patient populations, indications, and reported outcomes, all authors reported good clinical and subjective outcome with an overall survival rate of 97% at a mean follow-up period of 56 months. It is, however, worth mentioning that 5 of the 12 included papers containing 157 of the 246 (60%) included implants were authored by the designer of the prosthesis. Therefore, a clear need for reporting of results is required from independent centers and we try to meet this need with the current report on the result of 42 prostheses with a minimum 2-year follow-up.

The most important limitations of our report are its partial retrospective design and the lack of preoperative data. Also, we did not report weight-bearing capacity.[20] Most patients had multiple previous surgical interventions before they were referred to our tertiary hand surgery center which may have interfered with the clinical outcome in our population.

Nevertheless, we were able to report independent midterm outcome of a relatively large patient population, which contributes to the existing literature

Clinical outcome is generally very good, with a patient satisfaction rate of 95%. The average postoperative ROM and strength is certainly acceptable and corresponds with earlier outcome reports. Multiple previous reports confirmed significant clinical improvement after DRUJ replacement.[18,24–26] We compared the difference between both

Table 5 Correlation between number of previous surgeries and range of motion and strength

		Flexion	Extension	Pronation	Supination	Ulnar deviation	Radial deviations	Grip strength	Key pinch strength
No of previous surgeries	Prosthesis	−0.26 ($p = 0.10$)	**−0.36 ($p = 0.02$)**	**−0.44 ($p < 0.01$)**	**−0.39 ($p = 0.01$)**	**−0.34 ($p = 0.03$)**	−0.26 ($p = 0.10$)	−0.24 ($p = 0.14$)	**−0.45 ($p < 0.01$)**
	Ratio	**−0.45 ($p < 0.01$)**	**−0.44 ($p < 0.01$)**	**−0.46 ($p < 0.01$)**	**−0.42 ($p < 0.01$)**	**−0.44 ($p < 0.01$)**	−0.31 ($p = 0.05$)	−0.15 ($p = 0.36$)	−0.31 ($p = 0.05$)

Note: Correlation between the number of previous surgeries and objective measurements. Pearson correlates and corresponding *p*-values are shown for the outcome measurements in the prosthetic wrist (first row) and the ratio of outcome measurements in the prosthetic wrist to those in the native wrist (second row). Significant values ($p < 0.05$) are shown in bold caps.

Table 6 Questionnaires

	Total ($n = 39$)	Dominant ($n = 22$)	Nondominant ($n = 17$)	p-Value
PRWHE; mean (SD)	42.7 (28)	53.3 (27)	29.1 (25)	**0.006**
DASH; mean (SD)	37.9 (25)	45.9 (25)	27.4 (23.4)	**0.023**
VAS; mean (SD)	3.6 (2.7)	4.4 (2)	2.6 (2)	**0.047**

Abbreviations: DASH, disabilities of the arm, shoulder and hand; PRWHE, patient rated wrist and hand evaluation; SD, standard deviation; VAS, visual analog scale.
Note: Results of the patient-rated questionnaires. Mean scores of the PRWHE, DASH, and VAS score are shown for the total population ($n = 39$), for patients with prosthetic replacement at the dominant hand ($n = 22$) and for patients with prosthetic replacement at the nondominant hand ($n = 17$). p-Values are the result of a student t-test to compare the mean values in the dominant and nondominant groups.

Table 7 Correlation between the number of previous surgeries and questionnaire scores

	PRWHE	DASH	VAS
Age	**−0.39 ($p = 0.01$)**	−0.21 ($p = 0.20$)	**−0.38 ($p = 0.02$)**
Number of previous surgeries	0.24 ($p = 0.14$)	0.10 ($p = 0.54$)	**0.34 ($p = 0.03$)**

Abbreviations: DASH, disabilities of the arm, shoulder and hand; PRWHE, patient rated wrist and hand evaluation; VAS, visual analog scale.
Note: Pearson correlation coefficients and corresponding p-values are shown. Bold caps indicate significant correlations.

Table 8 Correlation between subjective outcomes (columns) and objective outcomes in the prosthetic wrist (rows)

	PRWHE	DASH	VAS
Flexion	**−0.51 ($p < 0.001$)**	**−0.52 ($p < 0.001$)**	**−0.34 ($p = 0.03$)**
Ratio	**−0.48 ($p < 0.01$)**	**−0.45 ($p < 0.01$)**	−0.36 ($p = 0.02$)
Extension	**−0.54 ($p < 0.001$)**	**−0.59 ($p < 0.001$)**	**−0.57 ($p < 0.001$)**
Ratio	**−0.52 ($p < 0.001$)**	**−0.48 ($p < 0.01$)**	−0.49 ($p < 0.01$)
Pronation	−0.31 ($p = 0.05$)	−0.31 ($p = 0.05$)	**−0.33 ($p = 0.04$)**
Ratio	−0.29 ($p = 0.07$)	−0.28 ($p = 0.08$)	−0.30 ($p = 0.06$)
Supination	**−0.53 ($p < 0.001$)**	**−0.54 ($p < 0.001$)**	**−0.34 ($p = 0.03$)**
Ratio	**−0.55 ($p < 0.001$)**	**−0.54 ($p < 0.001$)**	−0.35 ($p = 0.03$)
Ulnar deviation	−0.22 ($p = 0.18$)	−0.26 ($p = 0.10$)	−0.26 ($p = 0.10$)
Ratio	−0.30 ($p = 0.06$)	−0.29 ($p = 0.07$)	−0.27 ($p = 0.10$)
Radial deviations	**−0.53 ($p < 0.001$)**	**−0.47 ($p < 0.01$)**	**−0.57 ($p < 0.001$)**
Ratio	**−0.52 ($p < 0.001$)**	**−0.54 ($p < 0.001$)**	−0.51 ($p < 0.001$)
Grip strength	**−0.61 ($p < 0.001$)**	**−0.66 ($p < 0.001$)**	**−0.60 ($p < 0.001$)**
Ratio	**−0.67 ($p < 0.0001$)**	−0.68 ($p < 0.0001$)	−0.62 ($p < 0.0001$)
Key pinch strength	**−0.63 ($p < 0.001$)**	**−0.56 ($p < 0.001$)**	**−0.62 ($p < 0.001$)**
Ratio	**−0.74 ($p < 0.0001$)**	**−0.70 ($p < 0.0001$)**	−0.70 ($p < 0.0001$)

Notes: Correlation between subjective outcomes (columns) and objective outcomes (rows) in the prosthetic wrist. Ratio rows depict the correlation between the ratio of the prosthetic to the nonprosthetic wrist and the subjective outcomes.
Pearson correlation coefficients and corresponding p-values are shown. Significant p-values are indicated in bold caps.

wrists and found ratios (prosthetic vs. nonprosthetic) of 60 to 93% for ROM and strength. Also, we found a significant correlation between subjective and objective outcome, with grip and pinch force appearing more important than ROM. When using the ratios as an outcome parameter, these correlations proved even more significant. This suggests that an important determinator of patient experience is the extent to which the operated wrist functions as well as the normal wrist.

We found that the PRWHE and VAS scores were negatively correlated to age in a significant way. We think this is due to the fact that some of the younger patients in our population have had a complicated medical history concerning their included wrist, which ultimately led to placement of a prothesis at relatively young age.

Only one patient with rheumatoid arthritis was included in this study, with complaints arising from DRUJ degeneration as well as the radiocarpal joint. In such cases, Galvis et al

Table 9 Complications of DRUJ replacement

Complications and management	Quantity	Improvement during follow-up
ECU tendinopathy	4	4
No surgical intervention	3	3
ECU release + screw replacement	1	1
De Quervain tenosynovitis	4	4
No surgical intervention	2	2
Release	1	1
Radial screw replacement + release	1	1
ECRL tenosynovitis	1	1
Prominent screw replacement	1	1
EPB subluxation	1	1
No surgical intervention	1	1
EDM subluxation	1	1
EDM rerouting	1	1
Ulnar nerve paresthesia	2	2
No surgical intervention	2	2
Transient Dupuytren contracture	1	1
No surgical intervention	1	1
Arthrofibrosis	1	0
No surgical intervention	1	0
Painful hematoma	1	1
No surgical intervention	1	1
CRPS	1	0
Pain Clinic	1	0
Bony impingement on nuclear scan	1	0
Excision scaphoid and triquetrum fusion capitatum and lunatum	1	0
VISI	1	1
Chamay arthrodesis	1	1
Aseptic loosing	3	2
Tenosynovectomy, explantation	1	1
Explantation, one bone forearm	1	0
Revision	1	1
Total cohort	**22**	**18**
No surgical intervention needed	12	10
Surgical intervention needed	10	8

Abbreviations: CRPS, complex regional pain syndrome; DRUJ, distal radioulnar joint; ECRL, extensor carpi radialis longus; ECU, extensor carpi ulnaris; EDM, extensor digiti minimi; EPB, extensor pollicis brevis; VISI, volar intercalated segment instability.
Notes: Complications of linked semiconstrained DRUJ arthroplasty and their management.
Quantity: Number of times the complication occurred in the total population; Improvement: Number of patients reporting improvement in complaints during follow-up.

suggested to combine a total wrist arthrodesis with the DRUJ replacement,[27] which we performed as a primary procedure resulting in complete resolution of the patient's complaints.

A significant part (80%) of patients in our study underwent previous interventions preceding the DRUJ implant. Lans et al found a reoperation rate of 50% in DRUJ replacement after multiple wrist surgeries and suggested a more distal placement of the radial component after sufficient soft tissue mobilisation.[28] Martínez Villén et al reported persisting pain in two out of five multioperated patients.[29] A higher need for additional surgery in multioperated wrists is not evident in our study. Rampazzo et al reviewed 46

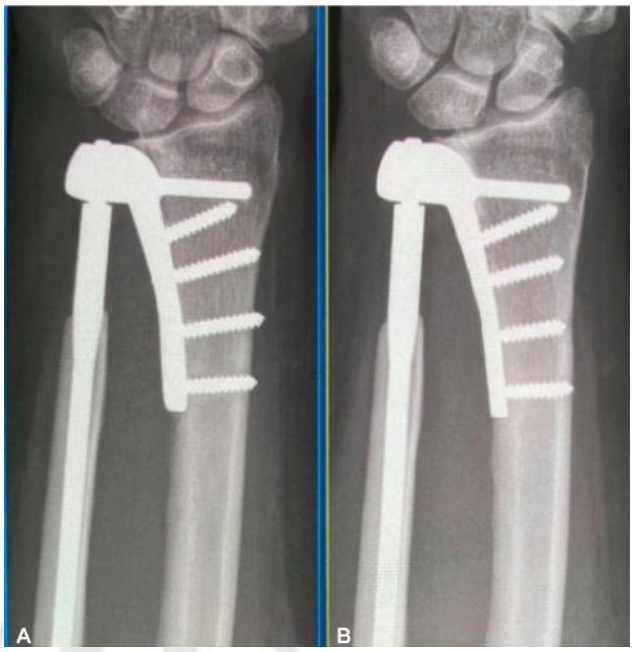

Fig. 1 Preoperative (A) and postoperative (B) radiographs before and after replacement of the three most proximal screws in a patient with a left-sided distal radioulnar joint prosthesis, who had complaints of radial tenosynovitis due to prominent proximal screws.

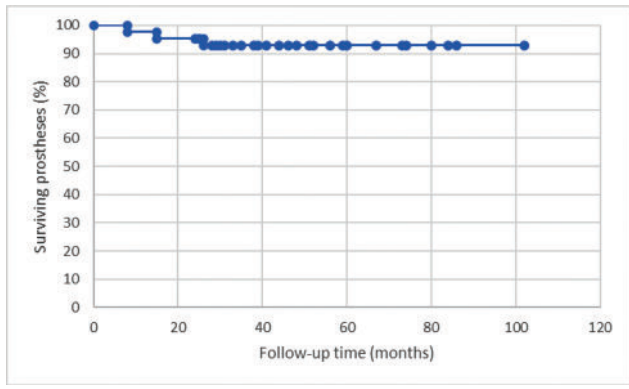

Fig. 2 Kaplan–Meier curve showing the percentage of surviving prostheses (Y-axis) as a function of follow-up time in months (X-axis).

arthroplasties in patients under 40 years and they did not find a significant correlation between functional results and patient age or number of previous procedures either.[25] Willis et al and Rampazzo et al did, however, suggest considering primary prosthetic replacement immediately after failure of conservative treatment to avoid multiple surgical procedures.[17,25]

Bellevue et al were the first to focus on complications after DRUJ replacement in the largest published case series to date. They reported 19 complications requiring 26 extra procedures in 15 of 52 wrists (29% reoperation rate).[30] Calcagni and Giesen found a reoperation rate of 21% in a systematic review in 2016.[22] DeGeorge et al report an overall complication rate as high as 44%, with a 16% reoperation rate.[31] The 43% complication rate with a 24% need for surgery in our study corresponds well with these reports as does the 93% implant survival rate at a mean 46-month follow-up.[23] All three cases of aseptic loosening presented early, within the first 2 years of follow-up. Linear regression analysis revealed no significant correlation between the number of previous surgeries and the number of complications or number of additional interventions for these complications. Tendinopathy caused by irritation over prominent prosthetic components is the most common complication and often a reason for further surgical intervention.[3,26,31–33] The risk for irritation of the extensor carpi ulnaris (ECU) can be addressed by elevating an ulnar-based adipofascial–retinacular flap to provide a barrier between the ECU tendon and the implant.[25] Tendon irritation by prominent screws should be prevented by avoiding too long screws and if present, it can be treated by limited surgery in day care: short screw replacement without unlinking the arthroplasty or screw tip resection under locoregional anesthesia. A subgroup analysis on wound-related complications by DeGeorge et al revealed a significant increase in patients with a history of rheumatoid arthritis or immunosuppression.[31] We found only one wound-related complication in our series, a painful hematoma in a patient on vitamin K antagonists.

In conclusion, we were able to report independent midterm outcome of a relatively large patient population, which contributes to the existing literature. The linked semiconstrained DRUJ arthroplasty had a valuable role in the therapeutic approach to severe DRUJ problems. Complications, although mostly minor resolving spontaneously or with minor intervention, are, however, not infrequent and should be included in the patients' consent to surgery.

Possibly, we may avoid the challenging situation of the multioperated wrist with complications as persisting pain and future research may therefore focus on primary DRUJ implant arthroplasty in isolated DRUJ arthritis.

Notes

Written informed consent was obtained from all subjects before the study.

J.W. and I.D. have provided guarantee for this manuscript.

Ethical Approval

Ethical approval for this study was obtained from the university hospitals institutional review board (S58242).

Authors' Contributions

I.D. was involved in protocol development, gaining ethical approval, patient recruitment, data analysis, and critical review of the first draft. J.W. wrote the first draft of the manuscript and was involved in patient recruitment, data analysis, literature research, writing the first draft and implementing the critical reviews of other authors in writing the final draft. M.V.N. and L.D.S. were involved in patient recruitment and critical review. All authors reviewed and edited the manuscript and approved the final version of the manuscript.

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Conflict of Interest
None declared.

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