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After failed radial head arthroplasty, what are the options? Risk factors and results of revisions in a multicenter study☆

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ABSTRACT

Introduction: Few multicenter studies have analyzed the outcome of revision surgery of radial head arthroplasties (RHA) in the medium term follow up. The objective is twofold: to determine the factors associated with revision of RHAs and to analyze the results of revision with 2 surgical techniques: isolated removal of the RHA or revision with a new RHA (R-RHA).
Hypothesis: There are associated factors of RHA revision and RHA revision results in satisfactory clinical and functional outcomes.
Methods: Twenty-eight patients were included in this multicenter retrospective study, with all surgical indications for initial RHA being traumatic/post-traumatic. The mean age was 47 ± 13 years with a mean follow-up of 70 ± 48 months. This series included two groups: the isolated RHA removal group (n = 17) and the revision RHA with new radial head prosthesis (R-RHA) group (n = 11). Evaluation was clinical and radiological with univariate and multivariate analysis.
Results: Two factors associated with RHA revision were identified: a pre-existing capitellar lesion ($p = 0.047$) and a RHA placed for a secondary indication (<0.001). Revision for all 28 patients resulted in improved pain (pre-op Visual Analog Scale 4.7 ± 3 vs. post-op 1.57 ± 2.2, $p < 0.001$), mobilities (pre-op flexion 118 ± 20 vs. post-op 130 ± 13, $p = 0.03$; pre-op extension −30 ± 21 vs post-op −20 ± 15, $p = 0.025$; pre-op pronation 59 ± 12 vs post-op 72 ± 17, $p = 0.04$; pre-op supination 48 ± 2 vs post-op 65 ± 22, $p = 0.027$) and functional scores. Mobility and pain control were, for stable elbows, satisfactory in the isolated removal group. When the initial or revision indication was instability, the DASH (Disabilities of the Arm, Shoulder and Hand = 10 ± 5) and MEPS (Mayo Elbow Performance score = 85 ± 16) scores were satisfactory in the R-RHA group.
Discussion: In the case of a radial head fracture, RHA is a satisfactory first-line solution without pre-existing capitellar injury, its results being much weaker in the case of ORIF failure and fracture sequelae. In case of RHA revision, isolated removal or R-RHA adapted according to the pre-operative radio-clinical exam.
Level of evidence: IV.

1. Introduction

Radial head arthroplasty (RHA) is indicated for fractures not accessible to osteosynthesis.[1,2] The number of RHAs has increased every decade and so has their revision.[3] The average number of revisions per 100 person-years of follow-up[3] is 2.53. Revisions are mainly performed before the third year with a revision rate of up to 30% in some series.[3,4] Although some studies show a higher revision rate with certain types of implants such as a press fit stem or a bipolar implant,[5] the literature does not point to a specific “ideal” implant type.[3,4,6,7] It is important to analyze all the characteristics that lead to the failure of a RHA, including the type of initial lesion,[8]

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the prosthesis used, the etiology of revision, and the radio-clinical assessment. The main etiologies for revision are loosening, condylo-radial impingement, instability and persistent stiffness.[3,4] Revision with a new implant (R-RHA) seems to give satisfactory results in the mid-term follow up and is the best therapeutic solution,[9] especially if clinical instability persists before revision. Conversely, removal of the prosthesis alone has shown good functional results and a low revision rate.[10–12] A multicenter study[13] with a large number of prostheses may allow us to analyze the factors associated with RHA revisions, which are often multiple and difficult to identify in small series.[14,15] Once these associated factors have been analyzed, it is important to know which strategy to adopt according to the preoperative/intra operative conditions and the etiologies of revisions.[16–18]

The purpose of our study was twofold: to determine the factors associated with RHA revisions in this multicenter series and to analyze the outcomes of revision, removal or RHA revision, based on preoperative and intraoperative datas.

The hypothesis was that there were risk factors for preoperative and intraoperative RHA revision and that RHA revision (isolated removal or R-RHA) yielded satisfactory clinical and functional results.

2. Methods

This retrospective multicenter study was performed with the approval of the ethics committee. These patients were from a study conducted by the French Society of Shoulder and Elbow Surgery (SOFEC) on radial head prostheses, including 310 patients from nine centers. The mean age was 48 years, with 55% male and a mean follow-up of 44.6 months. Between September 1998 and August 2012, 28 radial head prosthesis revisions (28 patients) were performed consecutively without lost to follow up (Fig. 1). We included all patients who had undergone radial head arthroplasty (RHA) for acute fracture not accessible to osteosynthesis or after failed osteosynthesis/traumatic sequelae of radial head. The primary RHA was either replaced with a new radial head prosthesis (R-RHA) or removed without new arthroplasty for each patient. The minimum follow-up was more than 2 years with clinical and radiological examination by an independent operator reviewer at each center. We excluded patients who had been reoperated without a change in the RHA (Table 1).

This series includes two different groups of patients: the removal-only group (n = 17) in which the initial implant was removed without a new implant being placed (Fig. 1) and the radial head implant revision (R-RHA) group (n = 11). All patients in the R-RHA group were treated with a new radial head prosthesis at revision. All revision prostheses were of the same design as the initial prosthesis, with the exception of one lost RHA (Fig. 2). The

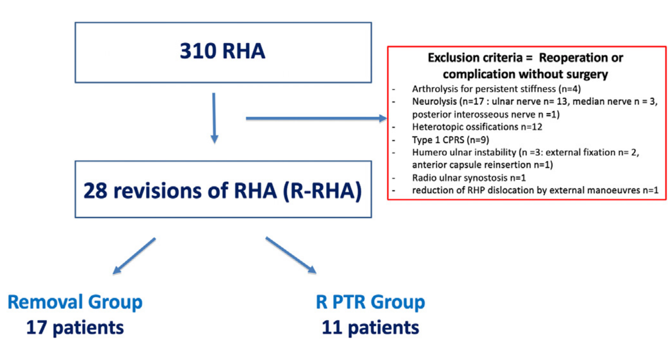

Fig. 1. Flow chart.

decision between simple removal and placement of a new prosthesis was multifactorial, analyzing the initial etiology, the cause of the revision, and the clinical and radiological workup mainly. This decision was most often made preoperatively or intraoperatively by the surgeon.

2.1. Diagnosis and imaging

For all patients, the initial indication for the prosthesis was listed (Table 1). Capitellar lesions at the time of the primary radial head arthroplasty were sought and classified into 3 categories based on the operative report: no initial lesion, less than 25% capitellar lesion at the time of the first RHA, or more than 25% capitellar lesion. To classify the causes of RHA failure, revised nomenclature of radial head arthroplasty failures[19] was used with four main criteria: symptomatic painful loosening,[20] persistent stiffness,[21] humero-radial impingement and persistent clinical instability.[22] Prosthetic infection was added as the 5th criterion, which was defined by lateral forearm pain associated with inflammatory scarring and an inflammatory blood test[23] (hyperleukocytosis, increased CRP). Evaluation was completed with a bone scan to look for septic loosening.

2.2. Surgical technique

All RTPs were performed by senior surgeons (9 centers). In each center, removal or R-RHA was performed. The same approach was used except for the posterior approach performed in Monteggia fractures[24] (n = 3). Bacteriological samples (minimum 5) were systematically collected and stored for 21 days. For patients in the removal group, the entire prosthesis was removed except in cases where it was inextricable due to the absence of acquired loosening/osteointegration. For these patients, the neck and head of the prosthesis were removed with a prosthetic stem in place in the shaft. The radial ascension test combined with the intraoperative radius joystick test of Soubeyrand[25] and stress radiography to check the integrity of the interosseous membrane, according to Smith[26] were performed by all surgeons. It is used to test the stability of the radius and to verify the absence of damage to the interosseous membrane and the absence of conflict between the radius and the capitulum.[25] Regarding periprosthetic infection, after removal of the prosthesis, probabilistic and then secondarily adapted antibiotic therapy was given on a long-term.

In case of persistent preoperative clinical instability, the lateral ligament and capsule were re-tensioned, and the position of the prosthetic stem and the size of the radial head were modified. In case of stiffness, reduction of the head size was performed, sometimes with additional release and removal of ossifications.

2.3. Clinical assessment

An independent surgeon clinically and physically examined the patients. Each center had its own independent examiner with a standard clinical and radiological protocol for all centers. Mobility was assessed using a standard goniometer. Pain was assessed on a scale of 0–10 preoperatively and at the last follow-up, with 0 corresponding to no pain and 10 to unbearable pain. Upper extremity function was assessed using the DASH score: Disabilities of the Arm, Shoulder and Hand.[27] Elbow function was specifically assessed using the MEPS questionnaire[28]: Mayo Elbow Performance Score.

2.4. Radiographic assessment

Radiographs of the elbow were taken preoperatively,

Table 1
Epidemiology.

	Total (n = 28)	Groups		P
		Removal Group (n = 17)	R-RHA Group (n = 11)	
Age at revision	53 ± 13	54 ± 10	52 ± 16	0.48
Gender (Female; Male)	11/17	11/6	6/5	0.7
Dominant side	13	8	5	0.8
Initial etiologies:				
- Isolated radial head fractur	11	7	4	0.67
- Monteggia lesion	3	2	1	1
- Terrible Triad	10	5	5	0.22
- Essex-Lopresti syndrome	4	3	1	0.69
Type of indication:				
- Acute fracture	13	8	5	0.68
- Failure of osteosynthesis	8	6	2	0.69
- Chronic/sequelae[a]	7	3	4	0.2
Etiologies of revisions:				
- Painful loosening	6	4	2	0.67
- Persistent stiffness	7	5	2	1
- Huméro-radial conflict	6	5	1	0.2
- Persistent clinical instability	8	2	6	0.029
- Infection	1	1	0	1
Cartilaginous lesion of the capitulum				
- None	6	1	5	0.022
- less than a quarter of the articular surface	15	10	5	0.7
- more than a quarter of the articular surface	7	6	1	0.19
- Average cartilage wear score	1.04 ± 0.7	1.3 ± 0.6	0.64 ± 0.7	0.027
Ulnar overload				
- Equal or less ulnar variance compared to the opposite side	16	8	8	0.23
- Increased ulnar variance compared to the opposite side	6	5	1	0.2
- Variance impossible to calculate because of fracture of the radial head of the wrist in lateral control	6	4	2	0.67

[a] Chronic = more than 3 months; Sequelae = malunion/proximal radius nonunion.

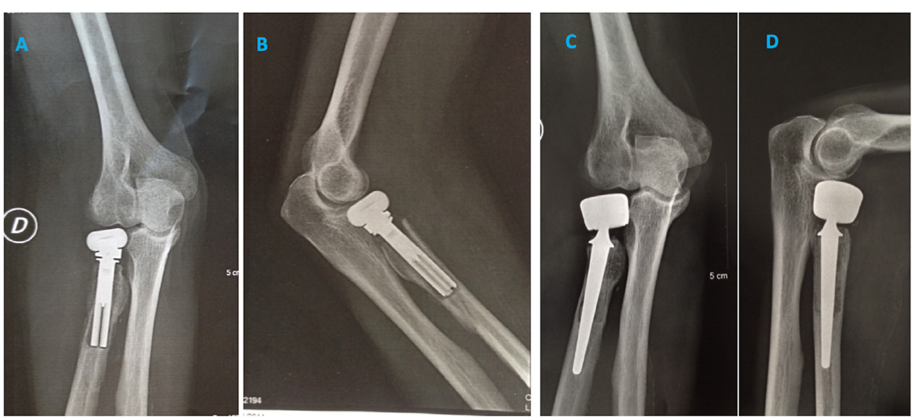

Fig. 2. Example of revision with a new radial head prosthesis (R-RHA)
A and B: Painful loosening of the monopolar pyrocarbon implant (MOPYC Tornier) with rupture of the cortex at the radial neck.
C and D: Revision with a new cemented bipolar radial head prosthesis (CRF 2 Tornier) with a longer stem.

immediately after surgery, and at the last follow-up. The same protocol was established for each center for radiographic evaluation of the elbow. Humero-ulnar osteoarthritis was classified according to Broberg and Morrey.[29] Implant loosening was assessed in 4 stages: stage 0 (no loosening), stage 1 (radiolucent lines without implant mobilization), stage 2 (radiolucent lines with implant mobilization), stage 3 (proximal cortical bone resorption). Ulnar variance was measured by comparison with the opposite side using the perpendicular method[30] (Table 1). The sigmoid incision of the ulna was used as a reference30–32 for radius length.

5.5. Statistics

Means and standard deviations were calculated for continuous variables. The Mann-Whitney *U* test was used to compare the 2 g2.5roups of patients. A 2-sided p value of <0.05 was considered to indicate a significant difference. For contingency table analysis, the Pearson chi-square test ($n > 5$) and the fisher exact test ($n < 5$) were used. Statistical analysis was performed using the Real Statistics Resource Pack (version 7.6) (2013–2021).

3. Results

Revision for all 28 patients resulted in improved pain (pre-op Visual Analog Scale 4.7 ± 3 vs. post-op 1.57 ± 2.2, p < 0.001), mobilities (pre-op flexion 118 ± 20 vs. post-op 130 ± 13, p = 0. 03; pre-op extension −30 ± 21 vs post-op −20 ± 15, p = 0. 025; pre-op pronation 59 ± 12 vs post-op 72 ± 17, p = 0.04; pre-op supination 48 ± 2 vs post-op 65 ± 22, p = 0.027) and functional scores.

3.1. Risk factors for revision radial head arthroplasty

The revision rate was 11% (n = 28) at a mean of 12 months (0.6−35 months). Two factors were associated with the revision rate: a pre-existing capitellum lesion (p = 0.047), regardless of its nature (less than 25%, (n = 5), greater than 25% (n = 2) and 1 case of fracture) and RHA in secondary indication of surgery (15/28 revision cases: 8 osteosynthesis failures and 7 fracture sequelae, p < 0.001). In the series, 171 RHAs were implanted as primary surgery (i.e., within 7 days of the trauma) and 39 RHAs as secondary surgery (failure of osteosynthesis, fracture sequelae, etc.), i.e. 8% (13/171) of revision for a primary RHA and 38% (15/39) for a RHA in secondary surgery on fracture sequelae or failure of osteosynthesis. Prosthesis type (uni- or bipolar; cemented or uncemented stem) or specific initial etiology (isolated fracture, Monteggia lesion, terrible triad, or Essex-Lopresti lesion) were not associated factors for revision.

3.2. Demographics

Etiologies were comparable between groups except for persistent clinical instability (6 patients (46%) in the R-RHA group vs. two patients (12%) in the removal group; p = 0.029). The number of patients without preoperative cartilage damage was greater in the R-RHA group (45.5% vs. 6% p = 0.022) (Table 1). CRF 2 long stem bipolar prosthesis was more present in the R-RHA group (6 patients) compared to the removal group (2 patients) (55% vs. 12%; p = 0.0299) (Table 2).

3.3. Complications of the revision procedure

Six complications were reported: two ossifications, two complex regional pain syndromes (CRPS) type 1, and two neurapraxias in the two groups. Regarding the 2 nerve injuries, recovery was spontaneous for the posterior interosseous nerve in the R-RHA group, whereas ulnar nerve neurolysis was required for the removal group.

3.4. Subgroup analysis

In the removal group, mobility was satisfactory, especially in pronation (77 ± 10°), supination (74 ± 11°), and extension (−14 ± 13°) with well-controlled pain (VAS 0.65 ± 0.9 and pain MEPS 39+/7). The 3 patients who underwent isolated prosthesis removal and had Essex Lopresti syndrome initially had a poor outcome with significant pain (mean VAS = 5) and a low MEPS score (mean 50 points).

Revisions of prosthetic arthroplasty with new prosthesis (R-RHA) gave satisfactory results for patients with ligament/interosseous membrane injury at the time of the first RHA surgery (DASH score = 10 ± 5 and total MEPS score 85 ± 16) or at the time of revision (R_RHA) for persistent instability (DASH score = 9 and total MEPS score = 84.)

Although present, humero-ulnar osteoarthritis was low in both groups. In contrast, the mean pain of patients with humero-ulnar osteoarthritis in the R-RHA group (n = 6) was 5.2 ± 3.

4. Discussion

Two risk factors for revision were found in this multicenter series of 310 PTRs: a preexisting capitular lesion at the time of primary RHA and RHA in secondary indication after primary surgery. The characteristics of the prosthesis, i.e. its cemented or not, short or long stem as well as its monopolar or bipolar head did not influence the prosthetic revision. Initial etiology of RHA were not risk factors for revision. The outcome of RHA removal is satisfactory in terms of pain and mobility. This is particularly true when there was a preoperative capitellar lesion at revision and the elbow was stable.[10,33,34] Conversely, R-RHA gives satisfactory clinical results when the elbow has initial or persistent instability without capitular osteoarthritis. The most complex situation remains an elbow with a history or persistent instability and a capitular lesion.

The literature shows that there are several risk factors for surgical revision of RHAs, which frequently occur early in the follow-up. Cristofaro[35] found a high risk of revision in the first

Table 2
Type of revised prostheses.

	Total (n = 28)	Groups: Removal Group (n = 17)	R-RHA Group (n = 11)
Type of prothesis:			
- Monobloc (3/49; 6%)	3	2	1
- Monopolar (7/131; 5%)	7	5	2
- Bipolar (18/130; 14%)	18	10	8
Stem fixation:			
Cemented (15/139; 11%)	14	10	4
Cementless: (13/171; 8%)	14	7	7
Stem length			
- Short (10/117; 9%)	10	7	3
- Long (18/193; 9%)	18	10	8
Arthroplasty name:			
CRF 2 bipolaire (8/67; 12%)	8	2	6
MOPYC (6/97; 6%)	6	4	2
SBI rHEAD bipolar (1/5; 20%)	1	1	0
Guepar (4/28; 14%)	4	4	0
Swanson (3/49; 6%)	3	2	1
SBI rHEAD monopolar (1/34; 3%)	1	1	0
Evolutive (5/30; 17%)	5	3	2

postoperative year, as in our series and that of Kachooei.[33] This observation is contrary to other upper and lower limb arthroplasties where the risk of revision increases with follow-up The results of revisions by isolated removal of the RHA in Cristofaro's study[35] were satisfactory and comparable to our results on mobility and pain. Schnetzke[36] et al. reported a series comparing osteosynthesis (n = 12) to RHA (n = 30) in complex dislocation fractures of the elbow. The size of the prosthesis head does not affect the results in this study. Young age and silastic prostheses were also risk factors for revision in a series of 29 revisions.[10] In our multicenter series, the silastic prosthesis was not a risk factor because of the small number of patients.

The second risk factor for revision was RHA in secondary surgery. There is no ideal solution for a difficult to reconstruct radial head fracture in a young patient. Prosthesis in first intention in the young patient is at risk of revision. Revision after failure of the osteosynthesis or non-union is also difficult and the patient should be informed.[35] In all these series, no type of prosthesis allows more or less revision, except for the risk factor of revision of the RHA with monobloc silastic prostheses.[10] No initial etiology was also found as a risk factor, unlike some series where the terrible triad and Essex Lopresti syndrome are risk factors.[8,37]

In case of symptomatic RHA, the strategy between removal or R-RHA is multifactorial. Terrible triads and Essex-Lopresti syndromes are often revised with a new implant (R-RHA)[34] to maintain elbow stability with good mid-term results.[38] In the Viveen series,[9] two-thirds of patients had good results with revision with long-stem bipolar RHA. These results are consistent with our study showing satisfactory functional scores of R-RHAs in cases of instability. R-RHAs seem to avoid late instabilities that can occur with RHA removal alone. However, Duckworth[10] shows us in a series with 45% of very unstable initial elbow lesions that the results of RHA removal in the short term (about 1 year) appear to be good. A longer-term study should be conducted. The absence of a radial head increases the load on the interosseous membrane[39,40] (IOM), resulting in radial ascension when the IOM is injured. In a series of equivalent fractures by Monteggia,[5] the results of secondary removal of the RHA were satisfactory. Removal of the prosthesis and release of the ulnar nerve yielded excellent results on elbow stiffness after RHA.[11]

The positioning of the implant[3,33] and its length[41] should be analyzed on preoperative radiographs. If incorrect positioning is identified, correction with a new implant may improve clinical symptomatology. It is known that excessive length leads to overload and pain,[20] especially if there are lesions of the capitulum, while shortening of the radius makes the implant unstable.[39] In our series, humero-ulnar osteoarthritis was greater in the R-RHA group. This may be explained by the increased load on the ulnar compartment.

Our study has several limitations. It is a retrospective multicenter study with a large number of surgeons (9 centers) and many different implants (monobloc, unipolar, or bipolar; cemented or uncemented stem). The initial and revision etiologies of RHA were numerous and heterogeneous, which reduces the power of this study. Risk factors for failure of a radial head prosthesis in trauma were analyzed and the description of revision was performed with a new prosthesis or isolated removal. It was not relevant to compare the isolated removal and revision radial head prosthesis (R-RHA) groups because of too much clinical variation between the two cohorts and the small number of patients. The decision to remove the implant or to re-implant a new arthroplasty (R-RHA) was left to the discretion of each surgeon, taking into account clinical and radiological datas. The chosen options were analyzed retrospectively. The inclusion period was long, but there were no lost to follow-up. The number of individuals lost to follow-up in the entire series of 310 initial prostheses was not known. Longer-term follow-up is needed, particularly in the isolated removal group, to assess clinical and radiological outcomes. The number of patients in this series is small, but this notion should be qualified because this is a series of RHA revisions with a correct number of patients compared to series in the literature.[10,33,35,36,42] This is a multicenter series with medium-term follow-up. This series showed two risk factors for revision and satisfactory revision results with 2 different techniques. Finally, some techniques were not evaluated. The radiocapitellar prosthesis, has shown good medium-term clinical results in radiocapitellar osteoarthritis,[43,44] but no publication reports the outcome of “totalization” of a RHA. A radiocapitular prosthesis cannot be recommended in the context of a failed radial head prosthesis. Some surgeons may perform other operations for complications of a RHA such as arthrolysis, total elbow replacement, etc. These procedures were also not evaluated in this study.

In conclusion, two risk factors for revision RHA were identified in this multicenter series: secondary surgery and capitellar injury. Prosthesis type and initial etiology did not influence revision in our series. The results in the isolated removal group on mobility and pain were satisfactory when the elbow was stable. A new arthroplasty (R-RHA) gives good clinical and functional results in cases of instability. In case of revision of a RHA, the primary etiology of the RHA, the etiology of the revision and the clinical and radiological examination must be meticulously analyzed in order to choose the best therapeutic option between no revision, removal of the prosthesis alone or R-RHA.

Ethical approval

Yes.

Consent to participate

Yes.

Consent to publish

Yes.

Authors contributions

All authors participated in the entire study.

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Availability of data and materials

All data is available.

Declaration of competing interest

None.

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