



Low return-to-sports rate after elbow injury and treatment with radial head arthroplasty

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Background: The aim of this study was to analyze sports participation after radial head arthroplasty among recreational athletes.

Methods: A total of 57 recreational athletes (mean age, 49 years; age range, 18–79 years) treated with radial head arthroplasty for non-reconstructible radial head fractures were included in this retrospective study. The return-to-sports rate and the time to return to sports were analyzed. The clinical and radiologic outcomes were compared between patients who returned to sports (group 1) and those who did not (group 2).

Results: After a mean follow-up period of 8.4 years (range, 2.5–16.4 years), 30 of 57 patients (53%) had returned to sports. The mean sports frequency significantly decreased from 5.2 ± 5.0 h/week to 2.2 ± 2.9 h/week after surgery ($P < .001$). In group 1, 83% of patients returned to the same sports activity whereas 17% changed to a less demanding sports activity. The mean time to return to sports was 158 days (range, 21–588 days). Patients who returned to sports had a significantly better Mayo Elbow Performance Score (MEPS) (84 ± 19 points vs. 63 ± 20 points, $P < .001$); Disabilities of the Arm, Shoulder and Hand score (16 ± 17 vs. 46 ± 22 , $P < .001$); and arc of flexion ($114^\circ \pm 32^\circ$ vs. $89^\circ \pm 36^\circ$, $P = .007$). A secondary radial head prosthesis ($P = .046$) and MEPS lower than 85 points ($P = .001$) were associated with a significantly lower return-to-sports rate. No differences regarding radiographic changes were found between the 2 groups ($P \geq .256$).

Conclusion: The return-to-sports rate after radial head replacement is low. A secondary radial head prosthesis and a worse clinical outcome (MEPS < 85 points) significantly increase the risk of not returning to sports after radial head arthroplasty.

Level of evidence: Level III; Retrospective Cohort Design; Treatment Study

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Radial head arthroplasty is established as the standard treatment for non-reconstructible radial head fractures with associated ligamentous injuries.^{8,21,23,26} Biomechanical studies have shown that metallic radial head implants restore elbow and forearm stability to levels approaching those of the native radial head.^{16,25} According to a review

by Heijink et al,¹³ the reported midterm to long-term functional results after primary radial head arthroplasty are favorable in about 85% of patients. Despite the good clinical results, complication rates of up to 30% have been reported with revision and implant removal rates of 8% at 4 years postoperatively.^{13,18,27} As radial head arthroplasty is often performed in young and active patients, the ability to resume sports after surgery should be an important factor to consider before the operation. However, no studies about the return-to-sports rate after radial head arthroplasty have been published. Therefore, the primary aim of this study was to analyze the return-to-sports rate after radial head arthroplasty in the general patient population. A secondary aim was to identify risk factors that decrease the return-to-sports rate after radial head arthroplasty.

Materials and methods

All consecutive patients treated between January 2001 and May 2014 were included in this retrospective, single-center study if they met the following inclusion criteria: (1) age of 18 years or older, (2) non-reconstructible radial head fracture and treatment with the same kind of uncemented, modular, metallic radial head prosthesis (Evolve; Wright Medical Technology, Arlington, TN, USA), (3) minimum clinical and radiologic follow-up period of 2.5 years, (4) sports participation before injury, and (5) written informed consent. Patients with open fractures or with pre-existing elbow disorders that were not related to the elbow injury were excluded. All patients in this study were recreational athletes.

Surgical procedure and rehabilitation

The radial head was approached using the Kocher interval between the extensor carpi ulnaris and the anconeus muscle. The radial collateral and annular ligaments were divided at the mid-portion of the radial head. If further exposure was needed, the radial collateral ligament was elevated off the lateral epicondyle and later reattached with suture anchors. Associated injuries of the coronoid, olecranon, and lateral and/or medial collateral ligament were managed as necessary to ensure a congruous stable elbow joint and to allow immediate postoperative functional rehabilitation. After surgery, the elbow was splinted in an above-the-elbow cast for 2 to 4 weeks. Postoperative rehabilitation started within 2 days postoperatively with active range-of-motion exercises out of the cast supervised by a physiotherapist. Full weight bearing and active and passive stretching and strengthening exercises were allowed after 6 weeks. The patients were given ibuprofen, 600 mg 3 times a day for 2 weeks postoperatively, for prophylaxis against heterotopic ossification (unless otherwise contraindicated).

Clinical evaluation

The functional outcome was assessed by determining the range of motion in terms of elbow flexion, elbow extension, forearm supination, and forearm pronation with a goniometer. The functional

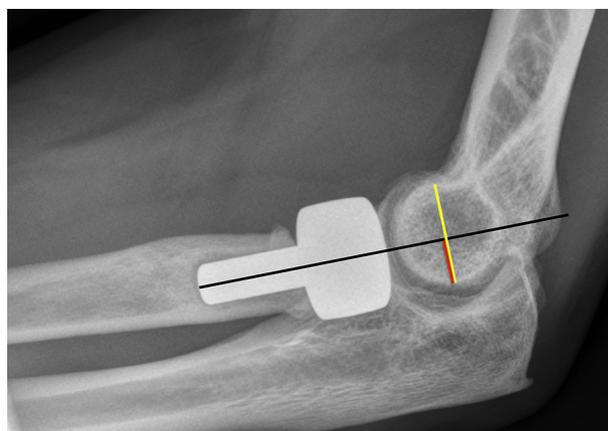


Figure 1 Radiocapitellar alignment was determined by the quotient of the red line and yellow line, which both run through the center of the capitellum and which are both perpendicular to the shaft axis of the stem (black line). For example, a quotient greater than 50% would indicate an anterior position of the radial head prosthesis.

outcome of the elbow was assessed using the Mayo Elbow Performance Score (MEPS).²⁴ At the follow-up visit, patients completed questionnaires with visual analog scales (VASs) (from 0 to 10) for pain at rest and for pain with activity; the Disabilities of the Arm, Shoulder and Hand (DASH) score¹⁵; and patient satisfaction (1, extremely satisfied; 2, satisfied; 3, slightly satisfied; 4, slightly dissatisfied; 5, dissatisfied; or 6, extremely dissatisfied). At final follow-up, patients were also asked to fill out a questionnaire on sports participation (type of sport) during the 12 months before surgery, sports participation after surgery, the time that they needed to resume full sporting activities, and the frequency of sports participation (hours per week). In the case of secondary radial head arthroplasty, patients were asked about their sports participation during the 12 months before primary surgery and sports activity after implantation of the radial head prosthesis. Complications and revision surgical procedures were assessed as well. The clinical outcome of patients who returned to sports (group 1) was compared with that of patients who did not return to sports (group 2). The type of sport was graded according to Allain et al¹ (grade I, “non-impact sports”; grade II, “high-impact sports”; grade III, “overhead sports with hitting movements”; or grade IV, “overhead sports with hitting movements and sudden stops”). The levels of sporting activity preoperatively and postoperatively were compared. If a patient participated in more than 1 sport, then the highest grade according to Allain et al was determined.

Radiographic evaluation

Preoperatively and at the follow-up visit, plain anteroposterior and lateral radiographs of the elbow were obtained. Two surgeons (M.S. and M.J.) evaluated the radiographs regarding (1) periprosthetic radiolucency, (2) radiocapitellar alignment, (3) ulnohumeral degeneration, (4) heterotopic ossification, and (5) osteopenia and/or abrasion of the capitellum. Disagreements in evaluation findings were resolved by consensus.

Periprosthetic lucency around the stem was graded according to the recommendations of Grewal et al¹⁰ and was rated as none,

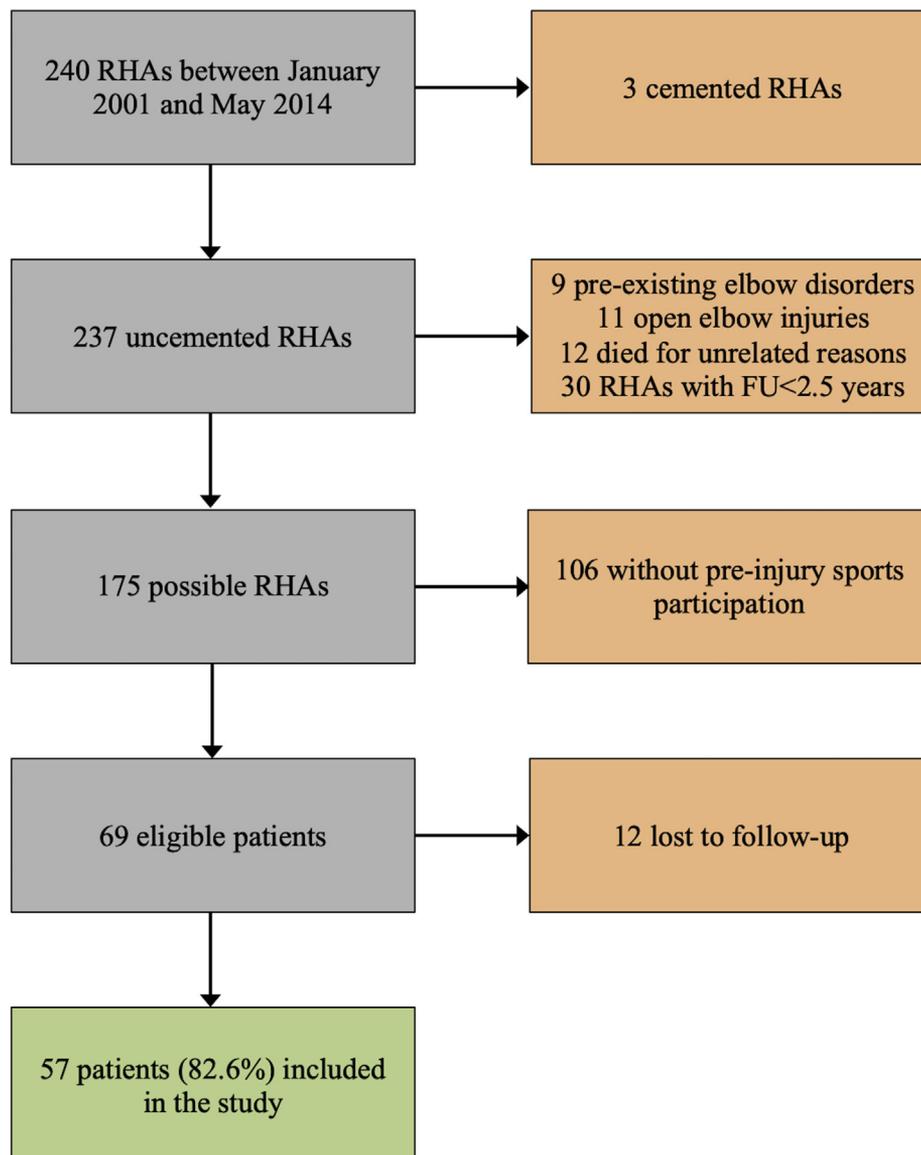


Figure 2 Flowchart illustrating patient selection process. *RHA*, radial head arthroplasty; *FU*, follow-up.

mild, moderate, or severe based on the number of zones and the amount of lucency observed. Radiocapitellar alignment of the radial head prosthesis was assessed on the lateral radiograph by the intersection of the axis of the prosthesis shaft and the center of the capitellum (Fig. 1). The degree of ulnohumeral degeneration was classified, with the system described by Broberg and Morrey,² as grade 0 (normal joint), grade 1 (slight degeneration), grade 2 (moderate degeneration), or grade 3 (severe degeneration). Heterotopic ossification was graded as present or absent. Capitellar osteopenia and/or abrasion was graded as none, mild, moderate, or severe.²⁰

Statistical analysis

Means and standard deviations were calculated for continuous variables. Differences between the preoperative and postoperative

means and between the 2 groups were calculated using the Student *t* test for continuous data. The level of significance was set at $P < .05$. The Pearson χ^2 test was used in the analysis of contingency tables. Prognostic factors for the return-to-sports rate were identified by determining the relative risk (RR) and results of the χ^2 analysis for 13 independent variables. These included patient-related factors (patient age > 65 years, 1 or more comorbidities, female sex, dominant side involved, and grade III or IV preinjury sports level according to Allain et al¹), injury pattern (unstable radial head fracture), surgical procedure (secondary radial head prosthesis), clinical outcome parameters (MEPS < 85 points and arc of flexion $< 100^\circ$), and radiographic parameters (moderate or severe radiolucency, moderate or severe glenohumeral degeneration, moderate or severe capitellar abrasion, and radiocapitellar alignment $\geq 65\%$ or $\leq 35\%$). Data were processed using SPSS software (version 22.0; IBM, Armonk, NY, USA).

Results

Patient characteristics

Fifty-seven elbows in 57 patients were included in this study (Fig. 2). Of the patients, 31 (54%) were men and 26 (46%) were women. The mean age of the study population was 49 years (range, 18-79 years). At least 1 comorbidity was present in 21 patients (37%), and the most frequent comorbidities were hypertension ($n = 13$, 23%) and type II diabetes mellitus ($n = 3$, 5%). The right side was injured in 20 patients (35%) and the left side, in 37 patients (65%). The dominant side was involved in 22 patients (39%).

The radial head fracture was graded as Mason type II in 1 patient (2%), type III in 16 patients (28%), and type IV in 40 patients (70%). In 17 patients (30%), a stable fracture of the radial head without associated dislocation of the ulnohumeral joint or instability of the forearm was found. A complex elbow dislocation with additional coronoid fracture, creating—by definition—a terrible-triad injury, was sustained in 26 patients (46%). Associated injuries were noted in 3 patients (fracture of the ipsilateral distal radius). In 5 patients (9%, all with terrible-triad injuries), treatment included an additional external hinge fixator, which was removed 4 weeks after primary surgery. In 48 patients (86%), primary radial head arthroplasty was performed after a mean of 6 days (range, 4-15 days), and in 9 patients (16%), radial head arthroplasty was performed secondarily

Table I Detailed types of sports and post-RHA changes

Level Sport		Before RHA	After RHA	
		No. of patients (%)	No. of patients (%)	
0	No sports	0 (0)	27 (47)	
I	Jogging	13 (23)	2 (4)	
	Walking	4 (7)	4 (7)	
	Nordic walking	3 (5)	1 (2)	
	Gardening	3 (5)	2 (4)	
	Cycling	22 (39)	6 (11)	
II	Fitness	22 (39)	7 (12)	
	Skiing	2 (4)	0 (0)	
	Horse riding	2 (4)	2 (4)	
	Gymnastics	0 (0)	0 (0)	
	III	Swimming	18 (32)	8 (14)
		Badminton	6 (11)	0 (0)
		Tennis	4 (7)	2 (4)
Bowling		3 (5)	2 (4)	
Climbing		3 (5)	2 (4)	
Table tennis		3 (5)	0 (0)	
Soccer		2 (4)	0 (0)	
IV	Canoeing	1 (2)	0 (0)	
	Contact sport	2 (4)	0 (0)	
	Water ball	1 (2)	0 (0)	
	Volleyball	1 (2)	0 (0)	
	Basketball	1 (2)	0 (0)	

RHA, radial head arthroplasty.

after a mean of 67 months (range, 2-195 months) following failed radial head osteosynthesis.

Clinical outcome and return to sports

After a mean follow-up period of 8.4 years (range, 2.5-16.4 years), the mean MEPS was 74 ± 22 points, the mean DASH score was 31 ± 25 points, and the mean arc of flexion was $102^\circ \pm 36^\circ$. Patients rated their pain at rest on the VAS as 2.1 ± 2.5 and their pain with activity on the VAS as 4.4 ± 3.1 . Satisfaction was rated as 1.9 ± 1.3 . A total of 30 patients (53%) returned to sports (group 1) after 158 days (range, 21-588 days), whereas 27 patients (47%) were not able to return to sports after surgery (group 2). Full sports information is provided in Table I. In group 1, 25 of 30 patients (83%) returned to the same sports level whereas 5 (17%) changed to a less demanding sports activity. A significant decrease from preoperative to postoperative sports level according to Allain et al¹ was observed ($P < .001$) (Fig. 3). In group 1, 18 of 30 patients (60%) participated in upper-extremity sports before injury, and 6 of these 18 patients (33%) had to switch to lower-extremity sports after injury. In group 2, 20 of 27 patients (74%) participated in upper-extremity sports before injury. Before surgery, the mean sports frequency was 5.2 ± 5.0 h/week. Overall, the mean sports frequency significantly decreased to 2.2 ± 2.9 h/week after surgery ($P < .001$) (Fig. 4). In group 1, 11 of 30 patients (37%) reduced their sports frequency and the mean sports frequency per week was comparable before and after radial head arthroplasty (4.5 ± 3.2 h/week vs. 4.3 ± 2.7 h/week, $P = .474$). In group 1, the functional outcome was significantly better for all scores ($P \leq .021$) compared with group 2, except pronation of the forearm ($P = .293$) (Table II).

Radiographic outcome

Radiographic evaluation showed that 16 patients (28%) did not have any sign of radiolucency around the stem whereas 15 (26%) had mild, 12 (21%) had moderate, and 14 (25%) had severe lucencies. The degree of ulnohumeral degeneration was rated as none in 12 patients (21%), mild in 22 (39%), moderate in 9 (16%), and severe in 14 (25%). No signs of capitellar abrasion were found in 11 patients (19%), whereas capitellar abrasion was mild in 29 (51%), moderate in 10 (18%), and severe in 7 (12%). In 19 patients (33%), heterotopic ossification was noted. Mean radiocapitellar alignment of $49\% \pm 18\%$ was determined. No statistically significant differences regarding these radiographic parameters were found between the 2 groups (Table III).

Risk factor analysis

A secondary radial head prosthesis (RR, 2.625; $P = .046$) and MEPS lower than 85 points (RR, 2.242; $P = .001$) were associated with a significantly lower return-to-sports rate

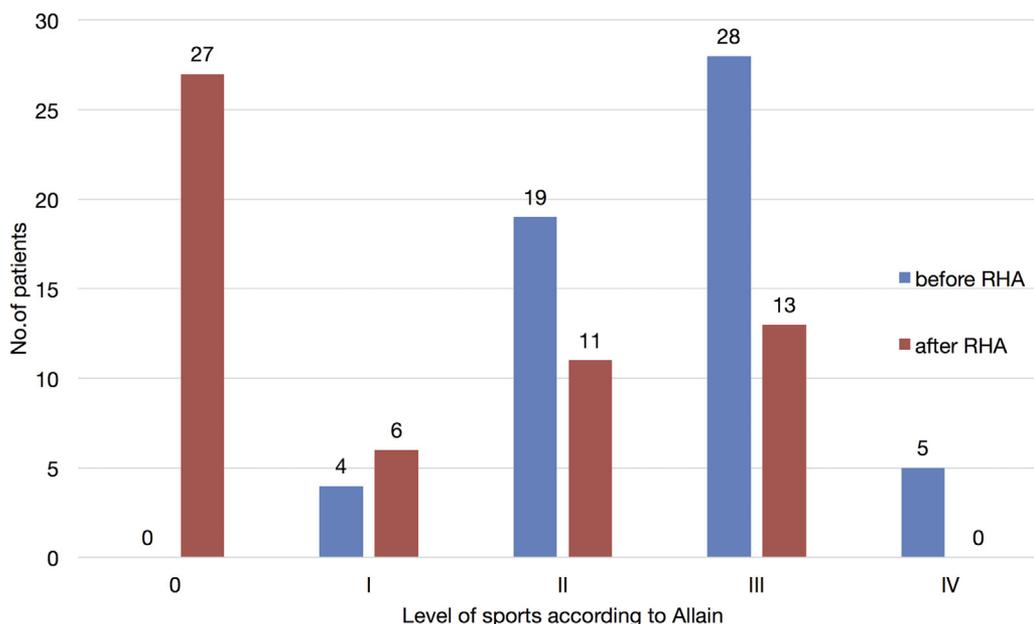


Figure 3 Comparison of preinjury vs. post-radial head arthroplasty (RHA) sports level according to Allain et al.¹

(Table IV). Male sex showed a trend toward lower return-to-sports rates (RR, 1.677; $P = .077$). The other factors were not associated with lower return-to-sports rates ($P \geq .158$).

revision surgical procedures were performed in 12 patients (21%) (5 in group 1 vs. 7 in group 2, $P = .594$). Complications and revision surgical procedures are detailed in Table V.

Complications and revision surgical procedures

Complications developed during the postoperative course in 16 patients (28%) overall, without a difference between the 2 groups (7 in group 1 vs. 9 in group 2, $P = .402$). A total of 16

Discussion

The aim of this study was to determine the outcome and return-to-sports rate 2.5 years after radial head arthroplasty. Only 30 of 57 patients (53%) were able to return to sports after surgery

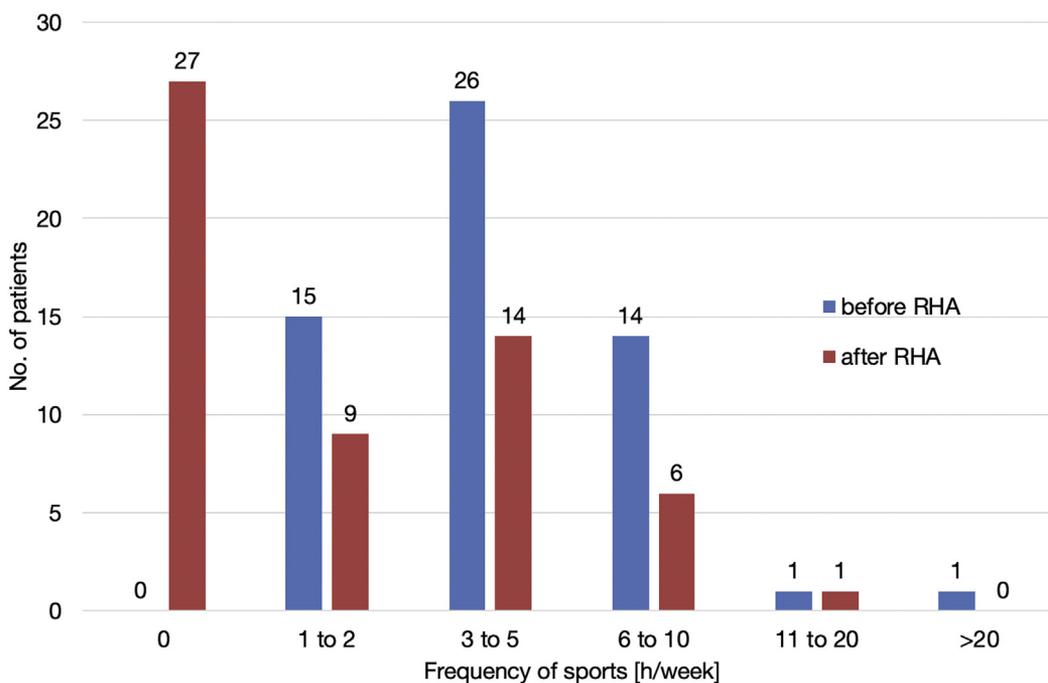


Figure 4 Comparison of preinjury vs. post-radial head arthroplasty (RHA) frequency of sports.

Table II Functional outcome in patients who did (group 1) and did not (group 2) return to sports

	Group 1, mean \pm SD	Group 2, mean \pm SD	<i>P</i> value
MEPS, points	84 \pm 19	63 \pm 20	<.001
DASH score, points	16 \pm 17	46 \pm 22	<.001
ROM, °			
Loss of extension	16 \pm 16	27 \pm 19	.021
Flexion	132 \pm 17	114 \pm 24	.003
Pronation	67 \pm 20	61 \pm 24	.293
Supination	79 \pm 16	60 \pm 31	.005
VAS _R score	1.1 \pm 1.8	3.3 \pm 2.6	.001
VAS _A score	3.0 \pm 3.1	5.9 \pm 2.4	<.001
Subjective outcome	1.5 \pm 0.9	2.4 \pm 1.4	.005

SD, standard deviation; *MEPS*, Mayo Elbow Performance Score; *DASH*, Disabilities of the Arm, Shoulder and Hand; *ROM*, range of motion; *VAS_R*, visual analog scale for pain at rest; *VAS_A*, visual analog scale for pain with activity.

with radial head arthroplasty. Overall, the sports frequency and the sports level according to Allain et al¹ were significantly decreased after surgery ($P < .001$). Of the 30 patients who returned to sports, 11 (37%) reduced their sports frequency and 5 (17%) changed to less demanding sports activities.

In the literature, satisfactory midterm results have been reported for a modular monopolar or bipolar prosthesis implanted for irreparable Mason type III or IV fractures. A flexion-extension arc of motion ranging from 85.5° to 132°, good results for the DASH score ranging from 7 to 24 points and MEPS ranging from 79 to 100 points, and low VAS scores for pain evaluation (from 0 to 2.2) have been reported in the literature.^{5,12,19,21,23} The overall functional outcome in our study (mean extension-flexion arc of motion, 102° \pm 36°; mean DASH score, 31 \pm 25 points; mean MEPS, 74 \pm 22 points; and mean VAS score for pain at rest, 2.1 \pm 2.5) is slightly worse than those functional outcomes reported in the literature. A total of 41 of 57 patients (72%) had unstable radial head fractures, which might be associated with slightly worse outcomes.

Reports about the return-to-sports rate after radial head arthroplasty are lacking in the literature. Indeed, a PubMed search revealed no published study about the return-to-sports rate after radial head arthroplasty. This finding is surprising given the young and active nature of this patient population. Before surgery, many patients will ask the surgeon whether they will be able to return to sports after surgery. Until now, no evidence has been available to answer this question reliably.

Reports on the return-to-sports rate after elbow injury are limited to elbow dislocations and radial head fractures without radial head replacement. After simple elbow dislocation, a high return-to-sports rate with return to play within 30 days in most athletes has been reported.⁹ Guzzini et al¹¹ reported that all 52 patients with a Mason type II injury returned to their pretraumatic sports level after 48 \pm 9 days. In 2017, Dunn et al⁷ reported the level of return to

Table III Radiographic outcome in patients who did (group 1) and did not (group 2) return to sports

	Group 1	Group 2	<i>P</i> value
Radiolucency, n (%)			.728
No	7 (23)	9 (33)	
Mild	8 (27)	7 (26)	
Moderate	6 (20)	6 (22)	
Severe	9 (30)	5 (19)	
Elbow arthritis, n (%)			.690
No	7 (23)	5 (19)	
Mild	11 (37)	11 (41)	
Moderate	6 (20)	3 (11)	
Severe	6 (20)	8 (30)	
Capitellar abrasion, n (%)			.256
No	4 (13)	7 (26)	
Mild	18 (60)	11 (41)	
Moderate	6 (20)	4 (15)	
Severe	2 (7)	5 (19)	
Heterotopic ossification, n (%)			>.999
No	20 (67)	18 (67)	
Yes	10 (33)	9 (33)	
Prosthesis seating, mean \pm SD, %	47 \pm 15	51 \pm 22	.453

SD, standard deviation.

upper-extremity activity in an active-duty military population. They examined 19 patients at an average follow-up of 3.7 years and reported that only about half the patients returned to their preinjury level of function. This is in accordance with the results of our study.

Most available studies regarding sports participation after joint replacement surgery concern hip, knee, and shoulder replacement. In those studies, high return-to-sports rates have been reported. In 2018, Hoorntje et al¹⁴ published a comprehensive review on the return-to-sports rate after total hip arthroplasty and reported an average return-to-sports rate of 82%. For anatomic total shoulder arthroplasty, a high return-to-sports rate (92.6%) has also been reported.²² Average return-to-sports rates after total knee arthroplasty have a high range, with reported rates from 36% to 89%.²⁸ Overall, the return-to-sports rates after total hip, knee, and shoulder replacement are much higher than the return-to-sports rate found in our study after radial head replacement after elbow injury. In this study, 41 of 57 patients (72%) sustained a complex elbow dislocation and almost half the patients (46%) sustained a terrible-triad injury. After these kinds of complex elbow injuries, the proportion of patients who require reoperation ranges from 0% to 54.5%, with most studies reporting that approximately 30% of patients experience the need for

Table IV Influence of patient-related factors, injury pattern, and functional and radiographic outcomes on return-to-sports rate

Factor	Relative risk	P value
Age > 65 yr (n = 10)	0.699	.226
Male sex (n = 31)	1.677	.077
Dominant side injured (n = 22)	0.943	.819
Comorbidity (n = 21)	1.143	.602
Grade III or IV preinjury sports level according to Allain et al ¹ (n = 33)	1.203	.462
Unstable radial head fracture (n = 41)	1.073	.804
Secondary radial head prosthesis (n = 9)	2.625	.046
MEPS < 85 points (n = 36)	2.242	.001
Arc of flexion < 100° (n = 18)	1.516	.158
Moderate or severe radiolucencies (n = 26)	0.839	.483
Moderate or severe glenohumeral degeneration (n = 23)	1.015	.955
Moderate or severe capitellar abrasion (n = 17)	1.169	.583
Radiocapitellar alignment ≥ 65% or ≤ 35% (n = 18)	0.923	.764

MEPS, Mayo Elbow Performance Score.

reoperation.⁶ Even if most patients can achieve a satisfactory outcome in terms of the MEPS, these injuries bear a high risk of chronic instability with a subsequently deteriorated clinical outcome.¹⁷ Detailed analysis of the results in our study revealed that a worse clinical outcome (MEPS < 85 points) was significantly associated with a lower return-to-sports rate. Therefore, it must be noted that the return to sports after joint replacement for osteoarthritis is totally different from the return to sports after radial head arthroplasty due to severe elbow trauma.

Recently, Burnier et al⁴ published a review about shoulder and elbow fractures in athletes. They stated that in an athletic population, especially with a high functional demand on the upper extremity, radial head arthroplasty should be reserved for cases in which the fractured radial head cannot be salvaged. Because of a lack of information in the literature, Burnier et al also concluded that too little is known about rates of implant loosening or capitellar wear in patients who continue to perform elbow-related sports activities after metallic radial head replacement.

Ulnohumeral degeneration, capitellar wear owing to oversizing of the radial head prosthesis, heterotopic ossification, and radiolucency lines around the stem are the most frequent radiographic alterations after radial head arthroplasty.^{10,13,23} It is still not known whether the level and type of sporting activity affect implant survival owing to differing stress moments acting on the artificial joint.³ The radiographic evaluation in our study revealed that 23 patients (40%) had moderate or severe glenohumeral

Table V Complications and revision surgical procedures

Complication	No. of patients (%)
Loosening or dislocation of radial head prosthesis	7 (12)
Pseudarthrosis of coronoid process	2 (4)
Persistent instability	1 (2)
Ulnar nerve syndrome	3 (5)
Median nerve syndrome	1 (2)
Post-traumatic arthrofibrosis	1 (2)
Complex regional pain syndrome	1 (2)
Revision surgery	
Exchange of prosthesis	3 (5)
Removal of prosthesis	8 (14)
Neurolysis of ulnar nerve	1 (2)
Re-osteosynthesis of coronoid process	2 (4)
Open arthrolysis	1 (2)
External fixator placement	1 (2)

osteoarthritis and 17 patients (30%) had moderate or severe capitellar abrasion. An interesting finding was that these radiographic changes did not affect the return-to-sports rate (RRs of 1.015 and 1.169, respectively). In this study, 26 patients (46%) had moderate or severe radiolucencies around the stem. However, no influence was found between the presence of radiolucency and the return-to-sports rate ($P = .483$). This finding is in agreement with the results of Marsh et al,²³ who reported favorable clinical outcomes from short- to long-term follow-up despite evidence of a high rate of radiolucencies around the stem.

Limitations

This study was limited by its retrospective, single-center study design. The retrospective study design introduced recall bias in terms of which sports activities patients performed before and after injury and when they restarted sports postoperatively. The study group consisted of patients with heterogeneous injuries ranging from isolated radial head fractures to complex elbow dislocations with terrible-triad injuries. There was no control group, and a power analysis was not performed. The senior author performed the clinical and radiographic follow-up examinations. He was aware of the patients' history, and this might have given rise to detection bias. Unlike some other investigations, our study included multiple kinds of sports. Furthermore, patients aged up to 79 years were included, and many of the sports were very low-demand activities including gardening and walking with no demands on the elbow. Patients may have stopped their activities because of increasing age and not because of the effects of radial head arthroplasty. The strengths of this study are the considerable number of patients and long mean follow-up period of 8.4 years.

Conclusion

Only half the patients with sports activity participation before injury return to sports after radial head arthroplasty. A secondary radial head prosthesis and a worse clinical outcome (MEPS < 85 points) significantly increase the risk of not returning to sports after radial head arthroplasty. The operative surgeon should be aware of this fact, and patients should be informed about the low return-to-sports rate after radial head replacement.

Disclaimer

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