International Orthopaedics (2019) 43:1917–1925
https://doi.org/10.1007/s00264-018-4173-7

ORIGINAL PAPER

Complications after radial head arthroplasty: a comparison between short-stemmed bipolar and monopolar long-stemmed osteointegrative rigidly fixed prostheses

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Received: 5 June 2018 / Accepted: 18 September 2018 / Published online: 29 September 2018

Abstract

Introduction To date, only a few studies have compared radial head prostheses (RHP) and their different anchoring principles. The aim of this study was to characterize concomitant injuries, necessary adjuvant procedures, complications, and radiological findings after implantation of two different types of RHP.

Methods Sixty-six patients with radial head fractures were treated with MoPyC (Tornier/France, 50 mm stem, monopolar) or SBI rHead prostheses (Small Bone Innovations/USA, 22-mm stem, bipolar) and followed up over 42 months (16–64 months). Primary objective was the detection of different loosening and explantation rates. In addition to the revision rate and the reasons for revision, we also used radiological findings to assess the dynamics of lysis phenomena.

Results Thirty-five patients (mean age 48 years; 22–73 years) were treated with the MoPyC, and 31 patients (mean age 47 years, 19–69 years) with the rHead prosthesis. Of these, 98% had a Mason 3 or 4 type of radial head fracture, and 94% showed concomitant injuries, which were addressed in 89% of cases by adjuvant procedures. The surgical revision rate was 20% (rHead 23%; MoPyC 18%). Significantly more of the rHead prostheses had to be explanted compared to MoPyC prostheses because of painful loosening (16% vs. 3%; $p = 0.029$). Predictors of subsequent loosening were significant radiolucent lines in the RHP over the first six months and an increase in width by two and a half times within the first 50 days after implantation.

Conclusion Complex radial head fractures are frequent and difficult to treat. The monopolar long-stemmed prosthesis showed significantly lower rates of painful loosening and explanation rates than the bipolar short-stemmed prosthesis.

Keywords MoPyC · rHead · Radial head prostheses · Bipolar RHP · Monopolar RHP

Introduction

Radial head fractures are the most common fractures of the elbow and account for 30% of all elbow fractures [1]. They usually occur during a fall on a pronated semiflexed elbow and are often associated with accompanying injuries. In dislocated radial head fractures (Mason type 4), ligamentous injuries can occur in as many as 87.5% of cases [1, 2]. The

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s00264-018-4173-7) contains supplementary material, which is available to authorized users.

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radial head plays an important biomechanical role as a secondary stabilizer against valgus stress and is needed for posterolateral rotation stability and even varus stabilization [3]. Therefore, osteosynthetic reconstruction of dislocated radial head fractures is considered the gold standard to avoid subsequent problems [4–9]. However, the possibility of reconstruction in cases involving comminuted and complex fractures is limited. In such cases, a radial head resection may be considered. Morrey et al. [2, 10] reported good clinical outcomes in cases without subsequent valgus instability. However, the integrity of the medial collateral ligament (MCL) is essential in these cases. Otherwise, the risk of secondary complications increases significantly [4, 11, 12]. In cases involving existing medial instability and unreconstructable fractures, prosthetic replacement is now considered the method of choice, with several authors describing good to excellent functional results [5, 13–16]. However, variable complication rates have been reported [17, 18]. Periprosthetic radiolucent lines progressive to symptomatic loosening as well as bone resorption at the proximal prosthesis collar have also been described in up to 72% of cases [19–21].

Currently, there are different designs of prosthesis with different anchoring principles available (monoblock vs. modular, monopolar vs. bipolar, osteointegrative vs. loose, fit vs. cemented) [7, 22, 23].

The design of the prosthesis does not appear to play any specific role in terms of the range of motion or function, although the complication rate has been shown to vary widely from 0 to 29% [8, 24–30]. However, very few studies have compared different designs of prosthesis, particularly in relation to complication and revision rates.

This study aims to compare complications, revision rates, and reasons for revision between two different types of radial head prosthesis (RHP) in acute radial head fractures treated primarily or as a salvage procedure by radial head arthroplasty. Primary objective was the detection of differences in loosening rates of the RHP and possible reasons. We therefore characterized concomitant injuries, necessary adjuvant procedures, complications, and radiological findings after implantation of two different types of RHP. To the best of our knowledge, no previous studies have compared these short-stemmed bipolar and monopolar long-stemmed osteointegrative rigidly fixed prostheses. Furthermore, it is necessary to define suitable predictors for potential loosening.

Patients and methods

Sixty-six patients were treated with RHPs between 2010 and 2014 and followed for a mean time period of 42 months (range 16–64 months). Minimum follow-up in study protocol was 12 months. Patients were divided into two groups, depending on the type of RHP used (Table 1). The types used were rHead (Small Bone Innovations (SBI), Morrisville, New-York, USA) for the period 2010–2013 and subsequently MoPyc (Tornier, Montbonnot Saint Martin, France) for the period 2012–2014. The MoPyC radial head prosthesis is a 50-mm monopolar prosthesis, consisting of a titanium stem and a pyrocarbon head; it extends beyond the radial tuberosity and, like the rHead prosthesis, is anchored osteointegrative and uncemented. Using a modular head and neck combination, this prosthesis can easily be implanted at the correct height at the lateral edge of the coronoid, in a manner which is independent of the radial neck resection line. The rHead prosthesis is bipolar, made of cobalt-chrome, is press-fit anchored, and has a short 22-mm stem which just reaches the proximal border of the radial tuberosity. The height of the prosthesis is defined by the selected radial head diameter and cannot be adjusted. The 66 procedures were carried out by two surgeons who were both experienced senior surgeons in orthopaedic and trauma surgery. Follow-up treatment was standardized and was defined by standard operating procedures. Splint immobilization was carried out for protective wound healing, and pain relief was given for one week. The rehabilitation protocol included hinged range of motion splinting with 20° extension and 120° flexion limit for six weeks. Full weight-bearing was allowed after ten weeks.

All patients who were treated with an RHP for acute radial head fractures, or as a salvage procedure, and provided informed consent were included in this study, which was approved by our Institutional Review Board (IRB Approval LAEKH-FF-1316).

The type of radial head fracture was graded according to the Mason classification [31]. Accompanying injuries were documented, and additional subsequent procedures were recorded. Complications were classified as either major (surgical revision required) or minor (surgical revision not required). The revision rate was calculated. Complications were recorded for all 66 patients. Consequently, we also were able to follow the pathology of our patients after RHP removal.

Radiological images collected during the study were systematically analyzed for signs of loosening, along with changes over time. Anteroposterior and lateromedial projections were analyzed for radiolucent lines and loosening in accordance with the protocol described by Popovic (Fig. 1) [21, 32]. Particular attention was paid to osteolysis and associated progression to loosening. In order to identify significant prosthetic loosening, it was necessary to observe a complete radiolucent line around the whole prosthesis. The width of such complete radiolucent lines in relation to the length of the prosthesis (= ratio in percent) was measured at three defined time points: post-operatively, after a mean of 50 days, and after 880 days (on average). In contrast, resorption just distal to the shaft neck was defined as stress shielding, a condition which should not normally have an effect on the anchorage of the prosthesis [33]. Overstuffing was defined as previously

Table 1 Patient characteristics. No statistical differences between groups could be identified

	All		SBI rHead		Tornier MoPyC	
	n	%	*n*	%	*n*	%
N	66		31	47	35	53
Female	25	38	12	39	13	37
Male	41	62	19	61	22	63
Age	48	(19–73)	47	(19–69)	48	(22–73)
Classification						
Mason 1	0	0	0	0	0	0
Mason 2	1	2	1	3	0	0
Mason 3	12	18	8	26	4	11
Mason 4	53	80	22	71	31	89
Indication						
Primary radial head arthroplasty	53	80	25	81	28	80
Failure of osteosyntheses	10	15	6	19	4	11
Unstable radial head resection	3	5	0	0	3	9
Mean follow-up (month)	42.2		53.3		32.4	

described [18] and was measured according to the joint line on X-rays, as shown in Fig. 1.

X-ray images were examined by two different radiologists. X-rays of inadequate projection quality were excluded from the investigation.

As nonparametric statistical test, the Wilcoxon signed-rank test was used, as well as the Student's *t* test for parametric statistical testing to evaluate differences between the two groups, and results are presented as the mean, minimum, and maximum. The chi-squared test was used for multivariate analyses, and $p \leq 0.05$ was considered to be statistically significant. All tests were two-sided. SPSS 22.0 software was used for all statistical analyses (SPSS Inc., Chicago, IL, USA).

Results

A total of 66 patients were treated by radial head arthroplasty. Of the 35 patients (53%; mean age 48 years; range 22–73 years) treated with the MoPyC prosthesis, 13 were female (37%) and 22 (63%) were male. The group treated with the rHead prosthesis featured 31 patients (47%; mean age 48 years (range 19–73 years)): 12 were female (39%) and 19 (61%) were male (Table 1). There were no significant differences between the two groups in terms of either age or sex. In total, 80% of all RHPs were implanted as primary treatment, 15% after osteosynthesis failure and 5% after a previous resection. The cause of implantation was a radial head fracture Mason

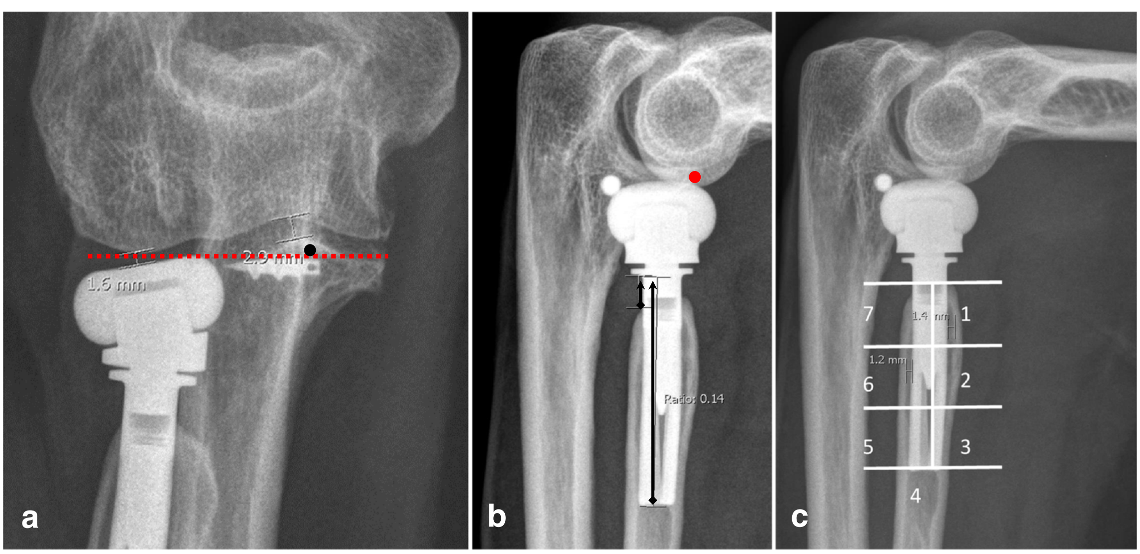

Fig. 1 **A** Measurement of the joint line in order to detect overstuffing: joint line (red line), coronoid process (dots). **B** Measurement of stress shielding at the RHP-Neck in % according to the length of the stem (in this case, the ratio is 0.14 and is therefore 14%)—gray scale; the coronoid process is shown as red dots. **C** Characterization of radiolucent areas in % according to the length of the stem

type 4 in 80% of cases, and Mason type 3 in 18% of cases. In one case (2%), the RHP was used as a salvage procedure after an osteosynthesis failure of a Mason 2 fracture. The mean follow-up period was 42 months (MoPyC 32 months; rHead 53 months). Detailed data are provided in Table 1.

In 61% of cases, the cause of radial head fracture was high-energy trauma; low-energy trauma was the cause of fracture in 39% of cases. The specific causes of trauma were as follows: a fall from more than 3 m in 33% of cases, a fall from a standing height in 39% of cases, sports-related injuries in 26% of cases, and a traffic accident in 2% of cases.

Accompanying injuries were found in 94% of all 66 patients. These included lesions to the medial and/or lateral collateral ligaments in 45% of cases and to the anterior joint capsule in 36% of cases. In addition, fractures of the coronoid process were detected in 35% of cases. Terrible-triad injuries, Monteggia-like fractures, and radial head fractures associated with disruption of the interosseous membrane (Essex–Lopresti) accounted for 48% of cases (Fig. 2). In 89% of cases, these concomitant injuries were addressed while implanting the RHP in a single-stage procedure. In 52% of patients, an additional ligament reconstruction was performed, and in 35% of patients, the capsule was fixed. Osteosynthesis of the coronoid and proximal ulna was carried out in 36% and 24% of cases, respectively. As part of the surgical approach, neurolysis of the ulnar nerve was required in 15% of cases (Fig. 3).

Complications and follow-up pathologies were divided into major (required surgical treatment) and minor complications (did not require surgery).

Overall, 74.2% of patients (MoPyC 71.4%; rHead 77.4%) demonstrated pathologies after injury, which required non-surgical treatment (minor complications): 39.4% demonstrated arthritic changes in the joint, 34.8% demonstrated temporal dysesthesia, and 16.7% had a remaining instability.

In total, 19.7% of cases had major complications and required revision surgery (MoPyC 17.1%; rHead 22.6%); $p >$ 0.05). The most frequent reason for revision was a painful loosening of the RHP (9.1%), followed by arthrofibrosis (joint stiffness, 4.5%). Loosening was significantly more frequent in 12 SBI rHead prostheses (38.7%) vs. 5 MoPyC prostheses (14.3%) ($p = 0.023$). Therefore, a total of six prostheses needed to be explanted (9%): five of the rHead (16.1%) prostheses and one of the MoPyC prostheses (2.9%). There was no correlation between accompanying injuries, fracture type, age, gender, or overstuffing to a painful loosening. Taking the different types of associated injuries into consideration, subgroup analysis revealed no significant correlation between loosening rate and concomitant lesions. Neither injuries to the ligamentous complex nor to the other bony structures around the elbow led to a higher rate of loosening. In total, 10% of all cases showed a positive ulnar variance and 17% showed a cubitus valgus; there was no significant difference between the two groups in this respect. The majority of these cases involved loose and explanted prostheses. Thus, all patients who underwent removal of the RHP showed a subsequent positive ulnar variance, and in 71% of cases, there was a subsequent cubitus valgus. A detailed summary of minor and major complications is given in Table 2.

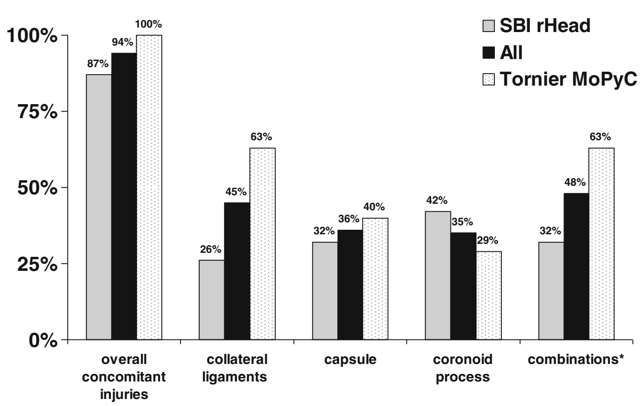

Fig. 2 Concomitant injuries to the radial head fracture. Asterisk denotes combinations: terrible triad fracture of the elbow, Essex–Lopresti, Monteggia-like lesions. Multiple nomination possible

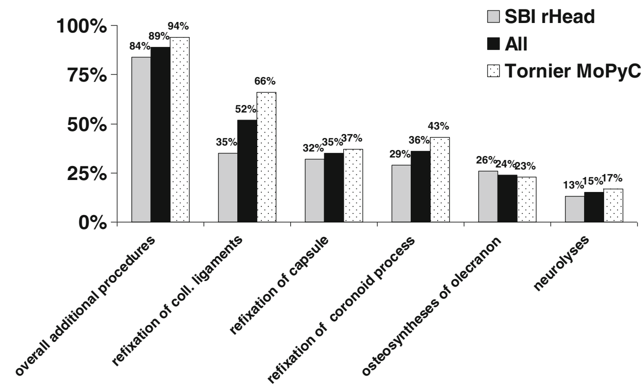

Fig. 3 Adjuvant procedures concomitant with radial head arthroplasty. Multiple nomination possible

Radiological findings

X-ray images were examined at three different time points: post-operatively, after a mean of 50 days, and at 880 days (on average). Overall, 14.3% of MoPyC ($n = 5$) prostheses and 38.7% of rHead prostheses ($n = 12$) showed a complete surrounding radiolucent line as a sign of loosening ($p = 0.023$) during the post-operative radiographic course. Asymptomatic loosening was apparent in 22.6% of the patients with rHead prostheses and in 11.4% of MoPyC prostheses. Because of symptomatic painful loosening of the rHead prostheses, 16% of patients ($n = 5$) had to be explanted compared to 3% ($n = 1$) with the MoPyC prostheses ($p = 0.029$). In total, 60% of all loose rHead prostheses were explanted during the first year after implantation.

Table 2 Complications: minor, non-surgical treatment; major, surgical treatment. Complications after removal of RHPs are included (e.g., cubitus valgus, positive ulnar variance). Significant differences between groups are marked by asterisk ($p < 0.05$)

Complications	Major complications (surgical treatment)						Minor complications (non-surgical-treatment)					
	RHP						RHP					
	SBI rHead ($n = 31$)		Tornier MoPyC ($n = 35$)		All ($n = 66$)		SBI rHead ($n = 31$)		Tornier MoPyC ($n = 35$)		All ($n = 66$)	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
None	24	77.4	29	82.9	53	80.3	7	22.6	10	28.6	17	25.8
Temp. dysesthesia incl. cubital tunnel syndrome	1	3.2	0	0.0	1	1.5	9	29.0	14	40.0	23	34.8
Infection	1	3.2	1	2.9	2	3.0	0	0.0	0	0.0	0	0.0
Arthrofibrosis	1	3.2	2	5.7	3	4.5	0	0.0	0	0.0	0	0.0
Osteophytes/arthrotic transformation	0	0.0	2	5.7	2	3.0	14	45.2	12	34.3	26	39.4
Remaining instability	0	0.0	1	2.9	1	1.5	4	12.9	7	20.0	11	16.7
Subluxation	0	0.0	1	2.9	1	1.5	0	0.0	0	0.0	0	0.0
Cubitus valgus	1	3.2	0	0.0	1	1.5	4	12.9	6	17.1	10	15.2
Positive ulnar variance	0	0.0	0	0.0	0	0.0	4	12.9	3	8.6	7	10.6
Transformation of the distal radioulnar joint	0	0.0	0	0.0	0	0.0	0	0.0	2	5.7	2	3.0
Chronic bursitis	1	3.2	0	0.0	1	1.5	0	0.0	1	2.9	1	1.5
Painful loosening*	5	16.1	1	2.9	6	9.1	7	22.6	4	11.4	11	16.7
	Multiple nomination possible						Multiple nomination possible					

*$p < 0.05$

The dynamics of bone resorption and lysis in patients which prostheses were subsequently explanted were investigated. The width of the complete surrounding radiolucent line was related to the length of the prosthesis (= ratio in percent). Overstuffing parameters, as well as stress shielding and loosening patterns, are described in Fig. 1. It was found that the first sign of osteolysis in the patients in which prostheses was subsequently explanted mostly occurred during the first 6 months; 67% of patients showed an increase of the radiolucent line from 6–9 to 17–20%, as measured at the prosthetic collar. The onset of lysis in the patients in which prostheses were subsequently explanted was always in Popovic zones 1 and 7 [21] (Fig. 1) on the prosthetic collar which then developed into a full radiolucent line throughout the whole RHP. All patients who showed such dynamic changes in radiolucent lines later presented with painful loosening. There was a mean marginal increase of 18% for the loosened prostheses over an average of 880 days. The average margin in zones 1 and 7 for fixed prostheses was 6–9% of the prosthesis length, whereas loose prostheses showed a margin of 20% (MoPyC) and 25% (SBI). All prostheses that had a 2.5-fold increase in the rim of the prosthesis collar within the first 50 days showed significant loosening in the future. A radiolucent line (> 2 mm in width) over the entire prosthesis was detected in all cases undergoing explantation. However, only 10% of patients with a radiolucent line of < 2 mm were affected by subsequent symptomatic loosening. Figure 4 shows the course of a case involving painful loosening over time.

In total, 42.5% of all prostheses showed resorption just distal to the shaft neck without a radiolucent line across the entire RHP; this is referred to as "stress shielding," which had no effect on anchorage of the prosthesis. There were no significant differences between the two groups in terms of mean height. Although the stress-shielding area for SBI rHead and for MoPyC was 2.7 mm on average, the proportion of stress-shielding area in correlation to the total shaft length differed. The stress-shielding area occupied 15% of the prosthesis length in the rHead prosthesis, and only 6% of the prosthesis length in the MoPyC prosthesis.

However, the explanted prostheses in both groups showed a collar area of 20% to 26% of the length of the prosthesis inserted in X-ray images; this was approximately twice as much as the asymptomatic average.

X-rays were investigated after each occurrence of overstuffing. This arose in 58% of SBI cases compared to 9% of the MoPyC prostheses ($p < 0.001$). If overstuffing occurred, on average, the RHP was fitted only 1.8 mm (SD ± 1.1 mm) above the joint line on X-rays. There was no correlation between overstuffing and painful loosening or other major complications.

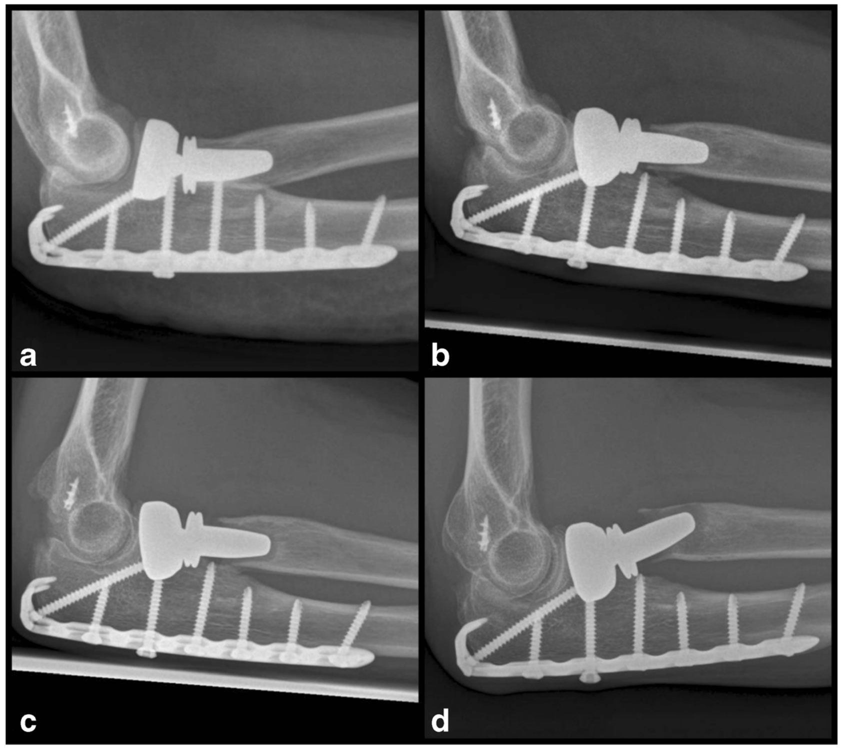

Fig. 4 A 33-year-old woman with a radial head fracture (Mason type 4), fracture of the proximal ulna, and rupture of the medial collateral ligament (MCL). She was treated with an SBI rHead RHP, osteosynthesis of the proximal ulna, and MCL reconstruction. **A** Postoperatively—press-fit, no overstuffing, and no oversizing. **B** At 3 months—the beginnings of osteolysis in zones 1 and 7—radial neck. **C** At 6 months—radiolucent line throughout the whole RHP and progressive dynamic in zones 1 and 7. **D** At 25 months—symptomatic dislocation. The RHP has been removed

Discussion

Using a large number of patients for the first time, we describe a comparison of these two specific prosthesis models with respect to radiological loosening patterns. The MoPyC RHP shows significantly lower loosening rates and lower explantation rates compared to the rHead RHP. We performed subgroup analysis to identify potential non-implant-related reasons and identified the radiologic dynamics of the loosening. There was no correlation between accompanying injuries, fracture type, age, gender, or overstuffing to a painful loosening so that we state that loosening is an implant-specific phenomena in this context.

According to the literature, accompanying injuries can occur in as many as 87.5% of patients [1, 2]. The complex radial head fractures seen in our patients showed a comparably high rate of accompanying pathologies, and a corresponding need for adjuvant procedures, in over 90% of cases. Of particular note was the need to reconstruct the MCL and, depending on the fragment size of the coronoid process, to ensure posterolateral rotational stability, especially against the background of the radial head as a secondary valgus stabilizer. According to the severity of injury (80% Mason type 4 fractures), a high number of pathologies should be expected during postoperative follow-up. Overall, 74% of patients had minor complications after trauma that were not treated surgically (for example, arthroses and temporal dysesthesia). In 19.7% of cases, surgical revision surgery was carried out. In comparison, the current literature reports the use of revision surgery in 26–40% of cases [8, 28–30].

We identified one clear difference between the two types of RHP: 14.3% of X-ray images from patients receiving the MoPyC RHP showed signs of loosening, compared to 38.7% of patients receiving the rHead RHP. Accordingly, a significantly higher rate of symptomatic loosening of the bipolar short-stem prosthesis SBI rHead was evident, compared to the monopolar MoPyC RHP. Because of this, five cases involving the SBI rHead RHP (16%) had to be explanted, compared to only one case involving MoPyC RHP (3%). No correlation between accompanying injuries, fracture type, age, gender, or overstuffing to painful loosening was observed in our patients so that we state that the reason is implant specific. The MoPyC group had a shorter follow-up period compared to rHead, because of the sequential therapy study protocol, whereas both groups had mean follow-up period over 12 months, a mid follow-up of 42.2 months, and 85% of all had a follow-up over 24 month. Significant loosening and complications occurred in most of the cases during the first year after surgery, and no accumulation of complications or loosening was seen in the later follow-up. Of the five SBIs which were removed, four were within the follow-up of the MoPyC RHP. This leads us to the conclusion that the performed follow-up was appropriate. Only one RHP was explanted after the average follow-up of the MoPyC. This RHP showed significant loosening early within the follow-up period of the MoPyC, but the explantation was performed when significant pain and ROM deficit occurred and this timepoint was after the average follow-up of the MoPyC. In conclusion, we can state that the higher loosening rate of the SBI rHead seems to be implant specific. All patients who underwent subsequent removal of the RHP showed positive ulnar variance and in 83% of cases a cubitus valgus.

Predictors of subsequent loosening included signs of RHP lysis as early as the first six months after surgery and an increase in width of the fully surrounding radiolucent line by a factor of two and a half within 50 days. Loosening was present in all prostheses in which these signs were evident. In contrast, limited stress shielding was seen in 42.5% of all RHP cases, which was not related to the fitting itself. This phenomenon is evident in the existing literature in up to 92% of cases. However, there seems to be a dynamic and critical expansion of such lytic areas. We distinguish the lysis directly only on the prosthesis collar, also referred to as stress shielding and in contrast a complete radiolucent line around the entire prosthesis. Popovic also described this [21] in the defined zones 1 and 7, but without quantification. Due to the shorter stem of the SBI prosthesis, these radiolucent lines become critical much earlier. In this context, Flinkkila et al. described the follow-up of 42 short-stem prostheses; loosening was present in 28% of cases and 21% had to be explanted [19]. Other studies have also reported that the critical part of a stem is likely to be the ending in front of the radial tuberosity and that problems in this area can lead to higher loosening rates in short-stem prostheses [7, 19, 34]. Detailed studies of short-stem bipolar RHPs are very rare. Popovic advised caution in the use of these bipolar RHPs because of "major bone loss" [21]. In another paper, Rotini et al. reported that 36% of patients fitted with bipolar RHPs showed "radiolucent areas" around the stem as a sign of loosening [35]. Riet et al. further described loosening in 66% of patients fitted with this form of prosthesis [36]. With regard to the monopolar prosthesis design, there are only two previous studies relating to the MoPyC RHP and showing lysis only in terms of stress findings [33, 37]. Stress shielding per se occurs independently of the prosthesis design, although critical lysis is significantly more frequent in RHPs with proximal force introduction (e.g., in the rHead RHP) in contrast to the long-range anchorage of the MoPyC RHP [38]. While MCL valgus stability can be well restored in all models, the use of monopolar prostheses (MoPyC) leads to higher primary stability, thus conveying biomechanical advantages in situations of fracture [6, 38, 39]. A monopolar implant is more effective in stabilizing the radiocapitellar joint than a bipolar RHP [40]. The most common reason for removing a well-fixed RHP is painful loosening [41].

Outcomes between smooth and porous stem metal modular radial head implants are equivalent [42], but it is shown that tight-fitting implants with short stems are more prone to painful loosening [43]. Laumonerie et al. identified loosening in 40% vs. 16% and osteolyses in 80% vs. 46% when comparing short- and long-stem implants. Bipolar and press-fit RHPs with short stems led to unsatisfactory mid-term outcomes in terms of loosening in the treatment of acute fractures of the radial head [14, 34, 44]. In contrast to this, midterm results of the MoPyC RHP bipolar short-stem prostheses appear to be satisfactory in terms of loosening rates, and are equal to or improve upon clinical results [33, 37, 45]. We saw a higher rate of overstuffing in the rHead group of patients, but with no correlation to subsequent painful loosening. If overstuffing occurred, on average, the RHP was fitted only 1.8 mm (SD ± 1.1 mm) above the joint line on X-rays. Difficulties with the implantation guide and the surgical equipment used could have exerted an influence. The height of the prosthesis is defined by the selected radial head diameter and cannot be adjusted. Therefore, resection at the radial neck needs to be carried out at a defined height, which is dictated by the resection guide. Considerably higher rates of overstuffing, loosening, and bone loss have been reported for bipolar rHead prostheses [21, 35, 36]. Overstuffing can lead to 2.2 times higher revision rates and can influence the lifetime of the prosthesis [18]. In this study, we could not prove these findings, maybe because of the sample size.

The *limitations* of this study relate to its single-center nature and the sample size. The minimum follow-up in study protocol was 12 month, but in general, the mid follow-up is 42.2 months. Over 85% show a follow-up over 24 months. The MoPyC group had a shorter follow-up period compared to rHead, because of the sequential therapy study protocol, whereas both groups had at least a 12-month follow-up. Significant loosening and complications occurred in most of the cases during the first year after surgery, and no accumulation of complications or loosening was seen in the later follow-up.

In conclusion, complex radial head fractures are associated with a high number of accompanying pathologies, which, in the majority of cases (58%), represent the cause of postoperative sequential pathologies and revision surgery. Prosthesis-related complications introduced by radial head prostheses—in particular painful loosening—were evident in 9% of our cases. The MoPyC RHP shows significantly lower loosening rates and lower explantation rates compared to the rHead RHP.

Compliance with ethical standards

Study is based on institutional review board (IRB) approval. The study was approved by our institutional review board (IRB Approval LAEKH-FF-1316) and all patients provided informed consent.

Conflict of interest No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article. On behalf of all authors, the corresponding author states that there is no conflict of interest.

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