



# Primary cemented bipolar radial head prostheses for acute elbow injuries with comminuted radial head fractures: mid-term results of 37 patients

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## Abstract

**Background** Radial head arthroplasty represents a widely accepted treatment for elbow injuries with non-reconstructible radial head fractures. The aim of this retrospective multicenter study was to assess mid-term results of patients with clearly defined elbow injuries including type III fractures of the radial head according to Mason's classification type III after primary arthroplasty using a cemented bipolar design.

**Materials and methods** In 45 cases a primary cemented bipolar arthroplasty of the radial head was implanted for elbow injuries combined with an acute Mason type III radial head fracture. In all patients associated fractures were detected with preoperative CT scans and ligamentous injuries were evaluated and both were addressed intraoperatively based on a standardized algorithm. Patients with associated injuries other than coronoid fractures and collateral ligament tears were excluded from this study to obtain a more homogenous sample. Clinical and radiological assessment was performed on thirty-seven patients at an average of 5.6 years postoperatively.

**Results** DASH Score, functional rating index of Broberg and Morrey, Mayo Elbow Performance Score, and Mayo Modified Wrist Score confirmed good-to-excellent results in most of the patients. Compared to the unaffected arm range of motion and grip strength were slightly reduced. No elbow instability or loosening of the prosthesis, and minor degenerative changes were detected in a few cases.

**Conclusion** Primary cemented bipolar arthroplasty for type III fractures according to Mason's classification in an elbow injury pattern only including associated coronoid fractures and/or ligamentous tears resulted in good-to-excellent mid-term results. These results suggest that primary bipolar radial head arthroplasty combined with distinct treatment of all associated injuries provides good functional outcomes concerning range of motion, elbow stability, and strength in this cohort. However, the associated injuries may influence clinical and radiological outcome and need to be detected, classified, and treated carefully.

**Keywords** Elbow joint · Radial head prosthesis · Upper extremity · Fracture · Results

## Introduction

Accounting for one-third of all elbow fractures radial head fractures are common [1]. Whereas well-accepted algorithms exist for simple fractures, the treatment of fractures with a

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high level of comminution remains a subject of debate. As frequently being part of complex injury patterns these injuries are seen combined with other fractures or ligament tears around the elbow or forearm in more than 75% of the patients [2, 3]. In general, the treatment goals for radial head fractures are the restoration of elbow stability, preservation of elbow motion as well as forearm rotation, and maintenance of the radial length [4]. However, comminuted fractures are prone to result in complications after surgical reconstruction [1]. When reconstruction of the radial head is not feasible, resection of the radial head alone or in combination with radial head arthroplasty has been advocated [5, 6]. However, numerous complications have been described after the sole resection of the radial head [1]. Besides the interosseus membrane and the collateral ligaments an intact radial column provides significant stabilization of the elbow joint [7, 8]. Hence, when non-reconstructible radial head fractures are combined with medial collateral or interosseous ligament tears or elbow dislocations radial head arthroplasty is mandatory [1]. Recent studies have revealed that stability, load transfer, and kinematics can be restored by radial head arthroplasty [5, 9]. The height of the radial column is rebuilt, and valgus/varus stability is provided. Also, forearm stability is ensured [10]. The currently available implant designs are categorized primarily according to head and stem design. Whereas monopolar and bipolar concepts exist, implants also differ concerning the mode of fixation in non-cemented and cemented designs [5, 11].

Even though radial head arthroplasty represents a common procedure for complex radial head fractures and short-term results are encouraging, mid- and long-term results for the different types of implants are sparse. Furthermore, most studies include patients with primary arthroplasty, as well as arthroplasty secondary to a failed open reduction and internal fixation [7, 12]. Apart from this, most investigations contain inhomogeneous cohorts with a wide variety of concomitant osseous and ligamentous injuries and even more complex injury patterns such as Monteggia fractures, Monteggia-like lesions/equivalents, or Essex-Lopresti injuries. The aim of this retrospective multicenter study was to determine mid-term results of patients with elbow injuries including acute type III radial head fractures according to Mason's classification treated with Judet's bipolar cemented arthroplasty. Furthermore, cases with associated injuries other than coronoid fractures and collateral ligament tears were excluded from this study to obtain a more homogenous sample. To our knowledge this study represents one of the largest series of patients treated with this implant.

## Materials and methods

This retrospective study was approved by the appropriate ethics committee, and all patients consented to participate in this study.

This study was performed at three major trauma centers. Patients were identified by searching them through the hospital database using the code for radial head arthroplasty in the German procedure classification system (OPS). Seventy-nine patients who were operated on in one of the participating trauma centers and potentially eligible for this study could be detected. Inclusion and exclusion criteria were primarily verified by the available patient information in the hospital database. Inclusion criteria were age over 18 years at the day of the injury and a diagnosed radial head fracture Mason III treated with a primary cemented bipolar radial head arthroplasty (CRFII, Tornier, Montbonnot, France). Included were all patients available for a follow-up of at least 2 years. Moreover, the existence of a preoperative CT scan to identify and classify related injuries and provide information for planning of the surgical procedure was mandatory. All types of coronoid fractures and all ligamentous injury patterns combined with a radial head fracture type Mason III were included. Exclusion criteria were patient presentation in the participating hospital more than 2 weeks after the injury. In addition, patients with secondary (delayed) radial head arthroplasty were excluded. Moreover, cases with Monteggia fractures, Monteggia-like lesions/equivalents, or Essex-Lopresti injuries have not been included. Also, cases with distal humerus and proximal ulna fractures, excluding fractures of the coronoid process, were not included. Taking into account these inclusion and exclusion criteria 45 patients who were eligible for this study could be identified. These patients were called for an up-to-date visit. Thirty-seven patients were available for clinical follow-up investigation and signed the consent form of the study. All of these patients could be included at final analysis and were assessed by the same experienced examiner in all three trauma centers. The examiner was blinded to the case history including correct extent of the injury and treatment method. In all patients classification of the radial head's fracture morphology was performed based on Mason's classification [13], as well as accompanied coronoid fractures using the Regan and Morrey classification [14] based on the preoperative CT scans by an experienced radiologist, blinded to all clinical information and outcomes. The follow-up investigation was performed from 2016 to 2017.

For clinical follow-up examination all patients were evaluated by use of the DASH Score [17], Broberg and Morrey's functional rating index [16], the Mayo Elbow

Performance Score (MEPS), and the Mayo Modified Wrist Score (MMWS) [15]. Using a standard full-circle goniometer range of motion (ROM) of elbow, forearm, and wrists was assessed bilaterally. Varus and valgus stability was evaluated in full extension and in elbow flexion of 30°. Posterolateral rotatory instability was detected using the pivot shift test [18] and categorized as normal, mild, moderate, or severely unstable. Using a Jamar dynamometer (Fabrication Enterprises Inc., White Plains, New York) grip strength was determined bilaterally thrice; data of the unaffected arm were used as control. Applying a correction factor of 1.07 for the dominant over the non-dominant hand the grip strength of the affected side was stated as a percentage of the control [19, 20]. Using a questionnaire established by Jungbluth et al. [19] patient satisfaction was evaluated. Using the visual analogue scale (VAS) pain at rest and during activity was assessed.

At the follow-up examination radiographs in two planes (a.p. and lateral) were taken of the affected elbow in all 37 patients. An experienced second radiologist, blinded to all clinical information and outcomes, evaluated all radiographs of the elbow for capitellar osteopenia, degenerative changes, and heterotopic ossifications. Capitellar osteopenia was graded as none, mild, moderate, or severe as presented by Lamas et al. [21]. Degenerative changes were graded as 0 (normal joint), 1 (slight joint space narrowing and minimum osteophyte formation), 2 (moderate joint space narrowing and moderate osteophyte formation), or 3 (severe degenerative changes with gross destruction of the joint) as suggested by Broberg and Morrey [16, 21]. As presented by Brooker et al. [22] heterotopic ossification was classified as I, II, III, or IV. As signs for periprosthetic loosening radiographs were evaluated for proximal resorption of the radial head, osteolysis, and radiolucent lines as described by Popovic et al. [23].

## Results

During the surgical procedure a cemented bipolar arthroplasty of the radial head (CRFII, Tornier, Montbonnot, France, also previously referred to as RHS bipolar radial head system or simply Judet's bipolar prosthesis) was performed in all patients. The arthroplasty was performed primarily in all patients at an average of 3.8 days (range 0–8 days) after the trauma. In this study 16 women and 21 men with an average age of 49.9 years (range 18–81 years) were evaluated. At an average of 5.6 years (67 months, range 28–120 months) after the last surgical treatment follow-up examinations were performed. All fractures had closed soft tissues, and the dominant arm was affected in 28 patients. The injuries were sustained due to falling from standing height ( $n=20$ ), falling from greater than standing height ( $n=8$ ), motor vehicle accidents ( $n=5$ ), and sports-related

accidents ( $n=4$ ). Six individuals were multiply injured. Twenty-three patients had an additional fracture of the coronoid process classified as type I in 16 cases, type II in seven cases. All type II coronoid fractures were subjected to closed or open reduction followed by osteosynthesis using independent lag screws. An associated posterior elbow dislocation was seen in 17 patients. In all of these patients except one the LCL (lateral collateral ligament) was torn. Four of these patients had an additional tear of the MCL (medial collateral ligament). All injuries to the LCL were addressed by reattachment to the lateral epicondyle using transosseous sutures or anchors. MCL refixation was not necessary in any patient due to reached elbow stability in all cases.

Three patients had an associated neurological deficit related to the initial trauma; to the radial nerve in two cases; and to the ulnar nerve in one case. All had resolved by the last follow-up without further surgery. No patient had associated vascular involvement.

All patients without ligamentous injuries received immediate passive motion and continuous passive motion (CPM) without restrictions out of the cast following the second day postoperatively. Physiotherapy including CPM was continued for a minimum of 6 weeks postoperatively. The immobilization was discontinued after 1 week, and motion without restriction was started. After reattachment of the LCL a hinged brace ( $n=9$ ) or hinged external fixator ( $n=3$ ) (Synthes GmbH, Umkirch, Germany) was applied for 6 weeks postoperatively without restriction of ROM. Lifting was restricted for 6 weeks postoperatively in all patients. To prevent heterotopic ossification indomethacin (75 mg/day) was administered for 3 weeks.

The DASH Score averaged 18.6 (5.8–55.8). With an average of 86.5 (55–100) the Broberg and Morrey functional rating index demonstrated a good result [13 excellent (35%), 17 good (46%), four fair (11%), and three poor (8%)]. With an average of 90.3 points (75–100) [26 excellent (70%), 10 good (27%), and one fair (3%)] an excellent result for the MEPS was attained. The MMWS averaged with a score of 87.3 (55–100) shows a good result [20 excellent (54%), 12 good (33%), three satisfactory (8%), and two poor (5%)]. A precise description of all injury patterns and outcome measurements is shown in Table 1.

Forearm pronation demonstrated a mean value of 83.9° (70° to 90°); supination was 82.5° (45° to 90°). Elbow flexion ranged from a mean of 12.5° fixed flexion (0° to 30°) to 131.7° (110° to 140°). Palmar flexion of the wrist was recorded with a mean of 73.7° (35° to 90°); dorsal extension showed a mean of 71.1° (40° to 90°). Grip strength showed a mean of 91.8% (86% to 99%) compared to the unaffected arm. Wrist or elbow instability was not observed in any patient. All patients demonstrated joint stability in the pivot shift test. The patient satisfaction questionnaire revealed that 34 out of the 37 patients were

**Table 1** Different injury patterns and outcome measurements after primary cemented bipolar radial head arthroplasty

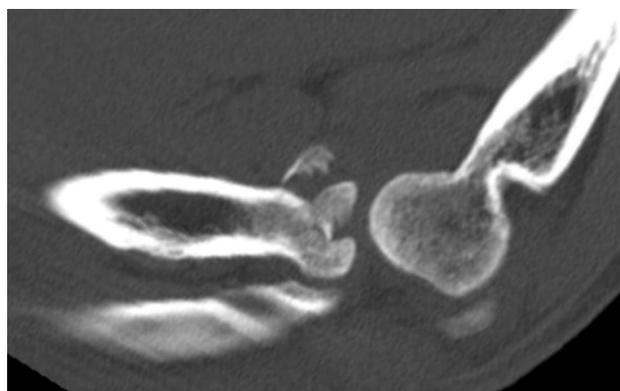
Mason type III associated	No. of patients	MMWS	MEPS	Broberg and Morrey	DASH	VAS at rest	VAS during activity
Without coronoid fracture or ligament injury	10	91.6	94	91.5	13.9	1.1	1.6
With coronoid fracture Morrey I, but without ligament injury	7	91.1	92.9	91.3	13.7	1.1	1.6
With coronoid fracture Morrey II, but without ligament injury	3	87.7	91.7	92	11.1	1	0.7
With posterior dislocation, but without coronoid fracture or ligament injury	1	85	90	88	18	1	2
With posterior dislocation, LCL rupture without coronoid fracture	3	83.7	86.7	79	22.4	1.7	2.3
With posterior dislocation, LCL rupture, and coronoid fracture Morrey I	9	83.4	83.9	82.9	24.8	1.4	3
With posterior dislocation, LCL rupture, MCL rupture, and coronoid fracture Morrey II	4	80.8	92.5	81.8	27.9	0.8	1.5

**Fig. 1** Male patient (26 years) with an isolated Mason type III fracture of the radial head. Radiographs and CT scans on the day of the injury

satisfied with the operative results and would undergo the procedure again. Based on the questionnaire restriction of movement was graded as not relevant in thirty patients. A return to the previous occupation and an equivalent athletic level as before the accident was reached in all cases. An average VAS of 1.2 (0–3) at rest and 1.9 (0–4) during activity was observed.

On the conventional radiographs no capitellar osteopenia, degenerative changes, or heterotopic ossifications were observed in twenty-four patients (65%). In ten patients (27%) mild osteopenia, grade 1 degenerative changes, and grade 1 heterotopic ossifications were observed (Figs. 1, 2, 3, 4). Three patients (8%) showed grade 2 degenerative changes and grade 2 heterotopic changes (Figs. 5, 6, 7, 8).

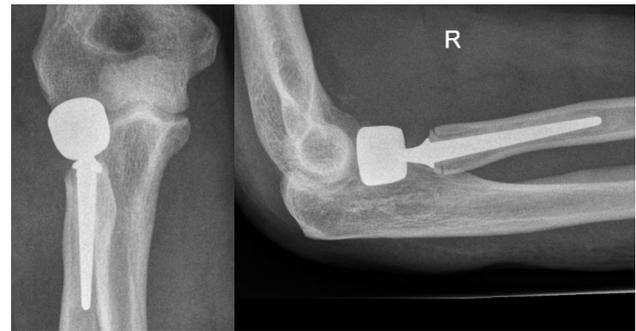
Overall, only one patient required a second surgical procedure. Irrigation and debridement was necessary due to

**Fig. 2** Male patient (26 years) with an isolated Mason type III fracture of the radial head. Radiographs and CT scans on the day of the injury**Fig. 3** Same patient after implantation of a cemented bipolar radial head prosthesis. Postoperative radiographs 2 days after the injury

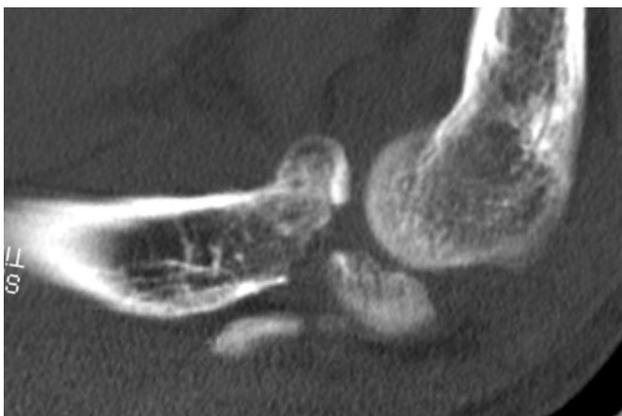
early wound infection. The wound healed within 14 days



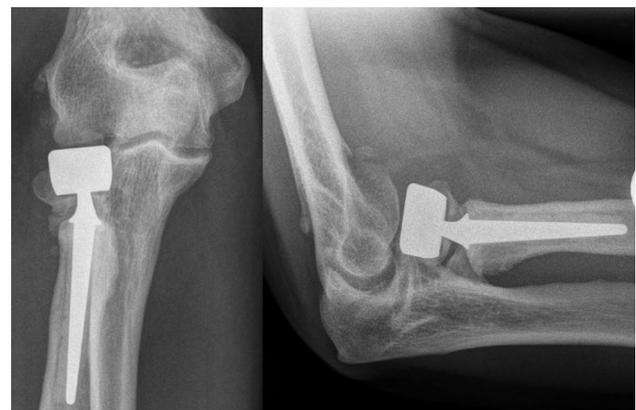
**Fig. 4** Same patient 55 months after the injury: grade 1 degenerative changes and grade 1 heterotopic ossifications at the elbow. Excellent functional results (ROM extension/flexion: 0°–0°–140°, pronation/supination: 90°–0°–90°). No signs of loosening of the radial head prosthesis



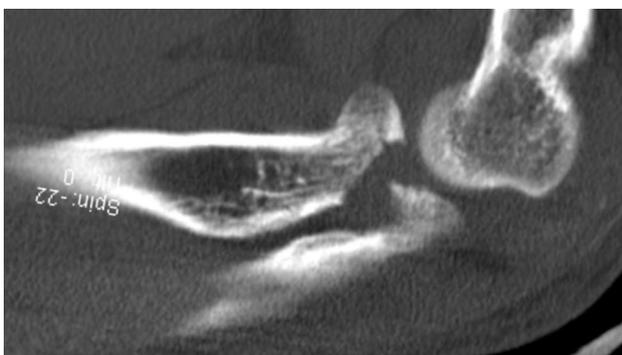
**Fig. 7** Same patient after implantation of a cemented bipolar radial head prosthesis. Postoperative radiographs 2 days after the injury



**Fig. 5** Male patient (49 years) with an isolated Mason type III fracture of the radial head. CT scans 1 day after the injury



**Fig. 8** Same patient 73 months after the injury: grade 2 degenerative changes and grade 2 heterotopic ossifications at the elbow, but good functional results (ROM extension/flexion: 0°–15°–140°, pronation/supination: 80°–0°–90°). No signs of loosening of the radial head prosthesis



**Fig. 6** Male patient (49 years) with an isolated Mason type III fracture of the radial head. CT scans 1 day after the injury

after revision. None of the prosthesis demonstrated radiological signs of loosening.

## Discussion

Elbow injuries combined with comminuted radial head fractures continue to pose a challenge in orthopedic surgery. Particularly, the radial head is considered an important secondary stabilizer of the elbow [24]. In cases of elbow injuries with comminuted and non-reconstructable fractures radial head arthroplasty has shown to restore elbow stability, especially if associated injuries to the collateral ligaments or interosseous membrane are present [7]. Previous studies have shown a correlation of fracture morphology and the probability of accompanied injuries. Overall, 75% of comminuted radial head fractures present with associated injuries [25].

Overall, the current study presents favorable mid-term results following primary treatment with the Judet's cemented bipolar radial head prosthesis for elbow injuries with acute fractures of the radial head. The majority of patients presented with good-to-excellent results in the scores selected, as well as for range of motion and grip strength 5.6 years after the last surgery. The overall complication rate and the rate of revision surgery were low. At the last follow-up in all patients wrist and elbow were ligamentous stable. Only mild degenerative changes and heterotopic ossification were observed in the majority of patients. Compared to the current literature, our clinical and radiological mid-term results with the Judet's cemented bipolar radial head prosthesis are similar or even better. However, there are only a few studies using the same type of prosthesis as in the current study, which makes direct comparisons more difficult.

Popovic et al. presented satisfactory mid-term results of 51 patients (nine acute Mason type II, forty-two acute Mason type III fractures) at a mean of 8.4 years postoperatively. In their case series in all patients the same cemented Judet's bipolar radial head prosthesis as in our study was implanted [23]. For the MEPS (83 points on average) 14 patients demonstrated excellent, 25 good, nine fair, and three poor results. Fifty-eight percentage of the patients presented radiographic signs of posttraumatic osteoarthritis. However, in the study conducted by Popovic et al. two patients with an associated fracture of the ipsilateral proximal humerus and six patients with Monteggia fractures and equivalents were included. This may be part of the reason for the higher rate of posttraumatic osteoarthritis (58% vs. 35%) and the slightly inferior clinical results compared to our study. These complex injuries, however, should be considered as separate entities [26]. In the current study a more standardized cohort was created by exclusion of Monteggia and equivalent injuries, as well as Essex-Lopresti injuries.

At an average of 8.8 years Burkhart et al. [7] found overall promising mid- to long-term results with the cemented Judet's bipolar radial head prosthesis. Of the 17 patients included in this study six reached excellent results, 10 good, and one fair according to the MEPS (mean 90.8). The mean DASH Score was 9.8. No patient demonstrated evidence of loosening of the prosthesis. In contrast to our study Burkhart reported on periarticular ossifications in 76% and on degenerative changes in 71% of the patients. Two prosthetic dislocations were seen immediately postoperatively that were most likely caused by overstuffing [7]. The lower rates in our study may be due to the standardized postoperative care and patient selection. Burkhart et al. included six Monteggia-like lesions and one Essex-Lopresti injury rendering the study cohort more inhomogeneous compared to the current study. Also, seven prostheses were implanted secondarily for trauma, and one for

treatment of a chondrosarcoma in this study influencing the results further. This is in contrast to our study, where all prostheses were implanted primarily [7].

In a more recent study Heijink et al. [27] evaluated mid-term results of 25 patients treated with a cemented Judet's bipolar radial head prosthesis at an average of 50 months. In contrast to our study the patient population was considerably more inhomogeneous and only eight patients were treated for acute fracture. Also, five of those underwent an additional procedure at the time of the radial head arthroplasty. Operations in the other 17 were for failed earlier treatment or posttraumatic sequelae. According to the MEPS, the excellent and good results accounted for 83%. Our clinical results are in line with those reported by Heijink. However, radiological results appear to be considerably better in our case series. In fact, patients with associated injuries were not particularly evaluated and excluded by Heijink et al. Furthermore, most of the patients in Heijink's case series involved delayed reconstructions which may have had an influence on radiological findings.

Why are our results considerably superior to the literature discussed? At first, this study had strict inclusion criteria resulting in a more homogenous patient population compared to most other investigations. To assess concomitant injuries around the elbow in all cases a CT scan was performed preoperatively leading to the detection and classification of all radial head and coronoid fractures. This is in contrast to the aforementioned studies. Therefore, outcomes were optimized by recognition and treatment of the complete injury complex including associated fractures and ligament injuries. By application of a standardized postoperative treatment a high level of comparability was achieved. This included early immediate physiotherapy out of the cast or in cases with ligamentous injuries with a hinged brace or hinged external fixator. Further strengths of our study are the large population of patients, the homogeneity of the injury pattern included, and the considerably long follow-up period. In order to reduce bias all follow-up examinations were performed by one experienced examiner not involved in the previous treatment. However, this study has the inherent limitations of a retrospective case series.

In conclusion, we were able to demonstrate good-to-excellent mid-term results of primary cemented bipolar radial head arthroplasty for elbow injuries including acute comminuted radial head fractures. According to the stability, motion, and strength achieved by primary cemented bipolar arthroplasty of the radial head, this procedure leads to an overall satisfactory clinical outcome. However, associated injuries may influence clinical and radiological outcome and their detection, classification, and treatment are crucial.

## Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

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