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ANATOMICALLY CONTOURED STEM RADIAL HEAD PROSTHESIS: A PROSPECTIVE CASE SERIES IN YOUNG ADULTS WITH UNRECONSTRUCTIBLE MASON TYPE III RADIAL HEAD FRACTURES

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ABSTRACT:
Background: Radial head arthroplasty (RHA) is commonly used when a Mason type III radial head fracture cannot be reliably reconstructed. Contemporary evidence indicates clinically important differences among implant designs and fixation strategies, but the specific technical behavior of anatomically contoured stems in young adults remains insufficiently characterized. [1,4-9]
Objective: To evaluate stem-specific intraoperative findings and early radiological and functional outcomes after primary RHA using an anatomically contoured, pre-bent stem in young adults with unreconstructible Mason type III radial head fractures.
Methods: In this prospective observational case series, 15 consecutive patients aged 21-44 years underwent primary RHA and were followed for 12 months. Prospectively recorded variables included insertion characteristics, cortical impingement, additional canal preparation, initial press-fit stability, sizing mismatch, stem alignment, Mayo Elbow Performance Score (MEPS), visual analogue scale (VAS) pain, elbow and forearm range of motion, radiocapitellar congruity, radiographic findings, and complications. Outcomes were summarized descriptively.
Results: Mean age was 31.9 ± 6.8 years; 10 patients (66.7%) were male and the dominant limb was involved in 9 (60.0%). Smooth stem insertion occurred in 11 patients (73.3%), and adequate initial press-fit fixation in 14 (93.3%). No intraoperative radial neck fracture or clinically relevant varus/valgus stem malalignment occurred. Mean MEPS increased from 58.7 ± 8.6 at 6 weeks to 92.7 ± 5.1 at 12 months; 14 patients (93.3%) had good or excellent final MEPS. Mean VAS pain decreased from 6.9 ± 1.1 preoperatively to 1.2 ± 0.8 at 12 months. At final follow-up, radiocapitellar congruity and acceptable stem alignment were maintained in all patients; no radiographic overstuffing, progressive loosening, implant migration, or revision was observed. Heterotopic ossification occurred in 2 patients (13.3%) and postoperative stiffness in 1 (6.7%).
Conclusion: In this small single-centre series, an anatomically contoured, pre-bent radial head prosthesis was associated with favorable early technical, functional, and radiological outcomes. The study supports the feasibility of the evaluated design. Larger comparative studies with standardized radiographic measurements and longer follow-up are required.

KEYWORDS: Mason type III; radial head arthroplasty; anatomically contoured stem; pre-bent stem; implant alignment; press-fit fixation; functional outcome.

INTRODUCTION
Radial head fractures are common elbow injuries, and the radial head contributes to elbow stability and load transmission. [1-3] Mason type III fractures are comminuted and may not permit stable reconstruction. When reconstruction is not feasible, RHA is used to restore radiocapitellar articulation and contribute to elbow and forearm stability, particularly when associated ligamentous injury is present. [1,2,4]
RHA implants differ in geometry, polarity, and stem fixation. Systematic reviews have demonstrated meaningful variability among fixed-stem devices in revision, instability, osteolysis, capitellar erosion, and functional outcomes, while broader reviews have not established a single implant design as universally superior. [5,6] A 2022 meta-analysis likewise found that fixation strategy is associated with different long-term reoperation and complication patterns, although the underlying studies were heterogeneous. [7]
Recent evidence has further emphasized the importance of stem fixation and study follow-up. A 2026 systematic review and meta-analysis of 46 studies including 4,467 elbows found a lower unadjusted revision rate for intentionally loose-fit stems than press-fit stems; however, the apparent difference was no longer statistically significant after adjustment for exposure time, underscoring the potential influence of surveillance

duration. [8] These findings support evaluation of the individual implant rather than assuming that all stem designs with a similar fixation philosophy behave equivalently.
Stem position is another clinically relevant technical variable. Cherches et al. found that greater radial stem angle in anatomic RHA was associated with failure and reoperation. [9] Overlengthening of the radial column can increase radiocapitellar contact forces and has been associated with capitellar erosion and other adverse radiographic findings. [10] These considerations make accurate canal preparation, implant sizing, stem alignment, and restoration of radial head height central elements of RHA technique.
Outcomes in younger adults are generally satisfactory, but evidence specifically addressing this population remains limited. A systematic review comparing patients younger than and older than 50 years found no significant difference in overall MEPS or implant revision/removal between age groups; within the younger cohort, primary RHA was associated with better MEPS than secondary arthroplasty. [11] Comparative evidence in Mason type III fractures also suggests favorable early functional recovery after RHA, whereas long-term studies demonstrate that satisfactory function may coexist with later radiographic changes such as capitellar wear. [12-14]
The present study therefore evaluates the insertion characteristics, initial stability, radiological behavior, and functional outcomes of an anatomically contoured, pre-bent radial head prosthesis in young adults with unreconstructible Mason type III fractures. The primary contribution is systematic description of predefined stem-specific intraoperative events and early radiological behavior.

Aim
To evaluate the impact of an anatomically contoured stem radial head prosthesis on intraoperative implant insertion, prosthesis stability, radiological alignment, and functional outcomes in patients with unreconstructible Mason type III radial head fractures.

Objectives
- To assess ease of implantation and initial press-fit stability.
- To assess MEPS, VAS pain, and elbow range of motion during 12-month follow-up.
- To evaluate stem alignment, radiocapitellar congruity, and implant-related radiographic findings.
- To document predefined stem-specific intraoperative and postoperative complications.

MATERIALS AND METHODS
Study Design and Setting
A prospective observational case series was conducted in the Department of Orthopaedics, Sree Balaji Medical College and Hospital, Chennai, India, over a 12-month study period. Fifteen consecutive eligible patients were included. The study was designed as a single-arm descriptive series without a comparator cohort.

Ethics and Consent
Institutional Ethics Committee approval was obtained before study initiation. Written informed consent for surgery, study participation, use of anonymized clinical and radiological data, and publication of anonymized images was obtained from all participants.

Eligibility Criteria
Patients aged 18–45 years with an unreconstructible Mason type III radial head fracture who underwent primary radial head arthroplasty using the specified anatomically contoured stem prosthesis and had a planned minimum follow-up of 12 months were included. Patients with Mason type I or II fractures, previous surgery involving the affected elbow, pathological fractures, chronic or neglected injuries, severe open fractures or contamination precluding the planned procedure, or those unavailable for follow-up were excluded.

Preoperative Evaluation
Clinical assessment included mechanism of injury, dominant limb, elbow stability, neurovascular status, range of motion, and associated injuries. Standard anteroposterior and lateral radiographs were obtained. Computed tomography was performed when required to characterize fracture comminution and associated osseous injuries.

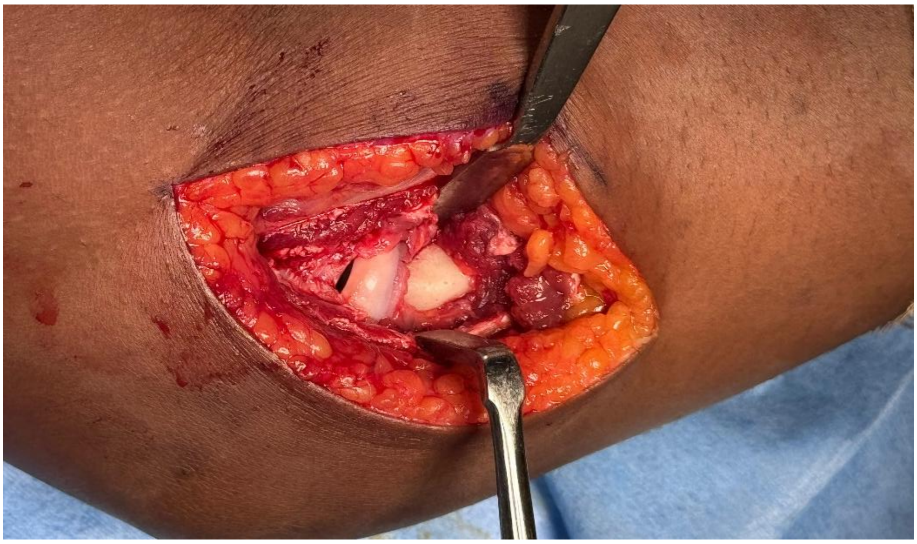
Preoperative AP/lateral radiographs and CT demonstrating unreconstructible Mason type III radial head fracture.

Surgical Technique

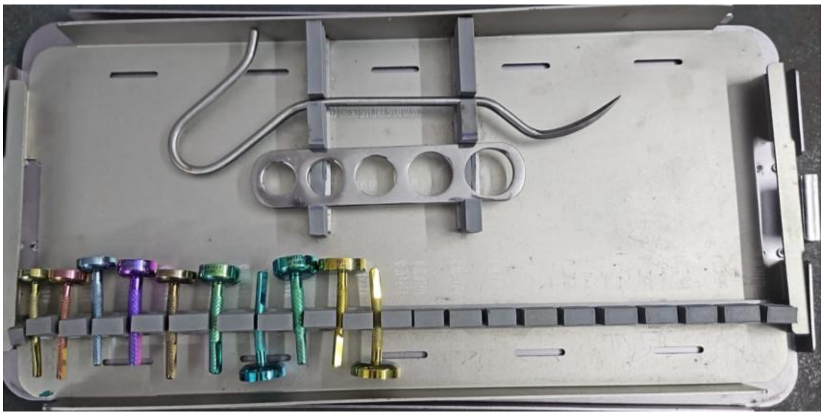
Under regional or general anaesthesia, the patient was positioned supine with the affected upper limb supported on a radiolucent arm board. A standard posterolateral (Kocher) approach was used with the forearm in pronation. The lateral collateral ligament complex was preserved when intact, and associated LUCL injury was documented.

The unreconstructible radial head fragments were excised and retained for sizing reference. Radial neck preparation was performed according to the implant system, followed by sequential canal broaching/rasping. Trial components were used to assess stem seating, initial press-fit stability, radial head diameter and height, radial length, radiocapitellar congruity, and forearm rotation. Fluoroscopy was used to assess implant height and alignment and to identify obvious overstuffing or maltracking.

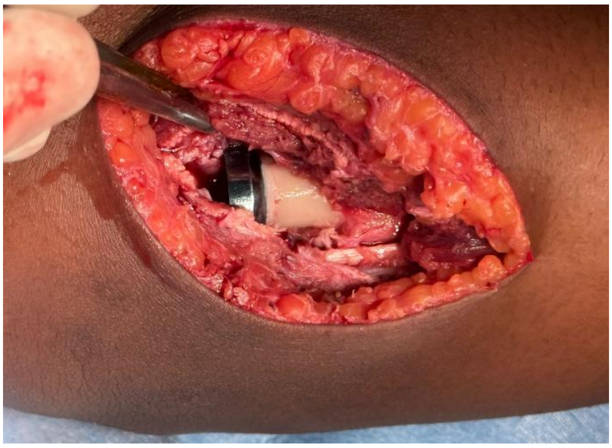
The definitive anatomically contoured stem prosthesis was inserted after satisfactory trial assessment. LUCL tears were repaired anatomically with non-absorbable sutures and/or suture anchors when instability or avulsion was identified. After implantation and soft-tissue repair, the elbow was taken through a controlled range of motion to assess stability and prosthetic tracking. The wound was irrigated and closed in layers. Postoperative immobilization and rehabilitation were individualized according to ligamentous and bony stability.



Intraoperative photograph showing the Kocher approach for Right radial head/neck exposure.



Photograph of the anatomically contoured stem and radial head components.



Intraoperative image demonstrating final stem seating and implant position.

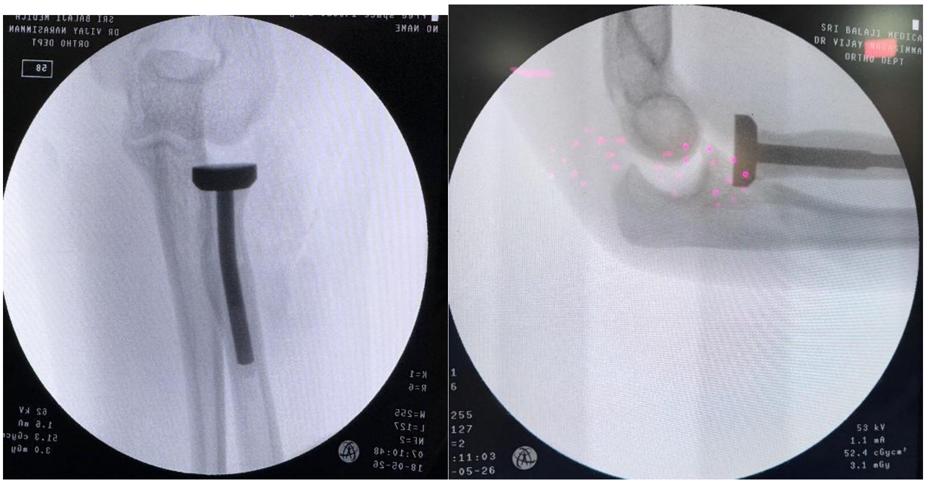
Stem-Specific Intraoperative Outcomes
The following prespecified stem-specific parameters were prospectively recorded because they were considered directly relevant to the proposed stem design:

- Difficulty in implant insertion.
- Cortical impingement during insertion.
- Need for additional canal preparation or reaming beyond the standard sequence.
- Intraoperative radial neck fracture.
- Stem malalignment in varus/valgus.
- Failure to achieve adequate press-fit stability.
- Implant sizing mismatch.
- Need for implant exchange.
- Operative time and fluoroscopy time.

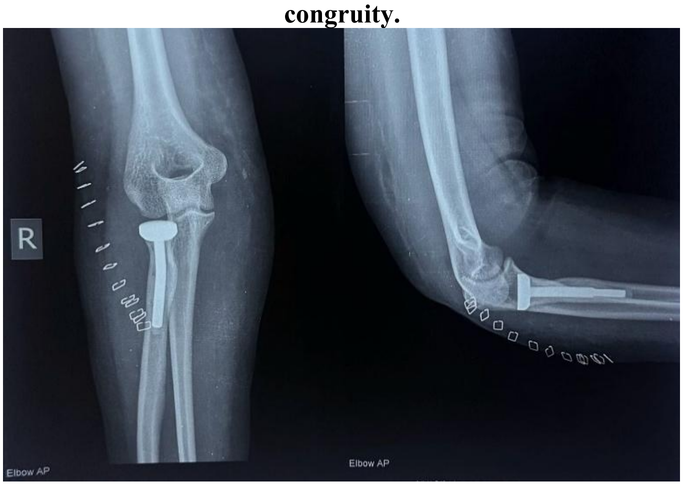
Stem-related variable	**Operational definition**
Insertion difficulty	None / mild resistance / significant difficulty / implant exchange
Cortical impingement	Present/absent; location documented if present
Additional canal preparation	Any additional reaming/broaching beyond standard sequence
Radial neck fracture	Intraoperative fracture and treatment
Stem malalignment	Neutral / varus / valgus on fluoroscopy
Press-fit stability	Adequate / inadequate
Sizing mismatch	Diameter/height mismatch or trial exchange

Functional and Radiological Outcomes

- Mayo Elbow Performance Score (MEPS).
- Visual Analogue Scale (VAS) for pain.
- Flexion, extension, pronation, and supination.
- Return to occupation or regular activity.
- Stem alignment and position within the radial canal.
- Periprosthetic radiolucency/loosening.
- Stress shielding or proximal bone resorption.
- Stem subsidence or migration on serial radiographs.
- Overstuffing/understuffing and restoration of radial head height.
- Radiocapitellar congruity.
- Capitellar wear/arthrosis.
- Heterotopic ossification (Brooker classification where applicable).
- Ulnohumeral osteoarthritic changes.



AP and lateral radiographs demonstrating stem alignment, radial head height, and radio-capitellar congruity.



Follow-up radiograph assessing stem position, lucency, subsidence, capitellar wear.

Clinical photographs at final follow-up showing flexion-extension and pronation-supination.

Follow-up
Patients were assessed at 6 weeks, 3 months, 6 months, and 12 months.

Statistical Analysis
This was a single-arm case series with a small sample size (n = 15). Continuous variables were reported as mean ± standard deviation and categorical variables as number and percentage. No formal between-group analysis was possible because there was no comparator cohort. Longitudinal outcomes were summarized descriptively. Valid paired analyses of changes in MEPS, VAS, and range of motion requiring individual patient-level observations at each time point were done.

RESULTS
Fifteen patients were included. The mean age was 31.9 ± 6.8 years (range, 21-44 years). Ten patients were male (66.7%) and five were female (33.3%). The dominant limb was involved in 9 patients (60.0%). Six patients (40.0%) required LUCL repair. The mean interval from injury to surgery was 4.2 ± 2.1 days.

Table 1. Demographic and injury characteristics

Variable	Value
Sample size, n	15
Age, mean ± SD, years	31.9 ± 6.8
Age range, years	21-44
Male sex, n (%)	10 (66.7)
Female sex, n (%)	5 (33.3)
Dominant limb involved, n (%)	9 (60.0)
LUCL repair required, n (%)	6 (40.0)
Time from injury to surgery, mean ± SD, days	4.2 ± 2.1

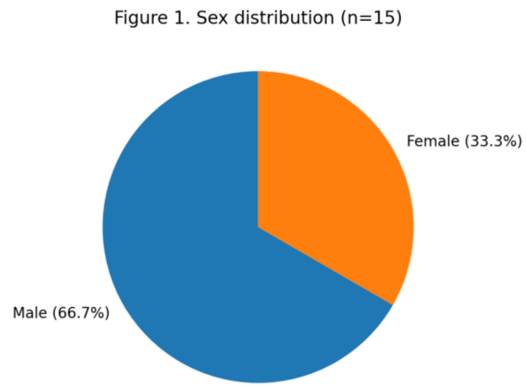


Figure 1. Sex distribution in the study cohort.

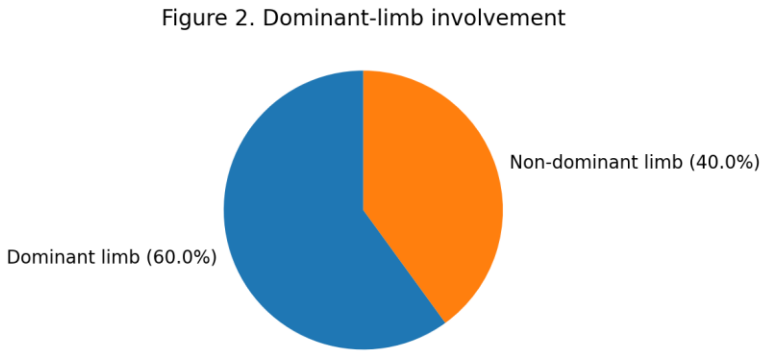


Figure 2. Dominant-limb involvement in the study cohort.

Stem-Specific Intraoperative Findings
Smooth stem insertion was achieved in 11 patients (73.3%); mild resistance was encountered in 3 (20.0%), and significant resistance requiring additional canal preparation occurred in 1 (6.7%). Cortical impingement was identified in 1 patient (6.7%), and additional broaching or reaming was required in 2 (13.3%). Adequate initial press-fit stability was achieved in 14 patients (93.3%). One patient (6.7%) required a change in stem size

because of inadequate initial stability. Trial exchange for sizing mismatch occurred in 2 patients (13.3%). No intraoperative radial neck fracture, clinically relevant varus/valgus stem malalignment, or conversion to a different prosthetic system occurred.

Table 2. Stem-specific intraoperative findings

Parameter	n (%)
Smooth stem insertion	11 (73.3)
Mild insertion resistance	3 (20.0)
Significant insertion resistance	1 (6.7)
Cortical impingement	1 (6.7)
Additional broaching/reaming	2 (13.3)
Intraoperative radial neck fracture	0 (0)
Adequate initial press-fit stability	14 (93.3)
Initial inadequate press-fit stability	1 (6.7)
Stem-size change required	1 (6.7)
Clinically relevant varus/valgus malalignment	0 (0)
Trial exchange for sizing mismatch	2 (13.3)
Alternative prosthetic system required	0 (0)

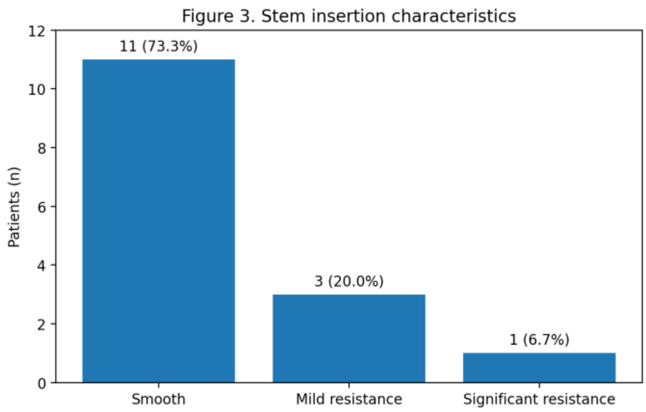


Figure 3. Stem insertion characteristics.

Functional Outcomes

Functional outcomes improved progressively. Mean MEPS increased from 58.7 ± 8.6 at 6 weeks to 78.4 ± 7.9 at 3 months, 88.9 ± 6.4 at 6 months, and 92.7 ± 5.1 at 12 months. At 12 months, 10 patients (66.7%) had excellent outcomes, 4 (26.7%) had good outcomes, and 1 (6.7%) had a fair outcome; no patient had a poor outcome.

Mean VAS pain decreased from 6.9 ± 1.1 preoperatively to 4.0 ± 1.2 at 6 weeks, 2.3 ± 0.9 at 3 months, 1.6 ± 0.8 at 6 months, and 1.2 ± 0.8 at 12 months.

Mean elbow flexion improved from 89° ± 18° at 6 weeks to 112° ± 13° at 3 months, 121° ± 11° at 6 months, and 126° ± 10° at 12 months. Mean extension deficit decreased from 26° ± 9° to 13° ± 7°, 9° ± 6°, and 7° ± 5° at the same intervals. Pronation improved from 62° ± 10° to 72° ± 9°, 76° ± 8°, and 78° ± 8°, while supination improved from 59° ± 12° to 70° ± 10°, 74° ± 9°, and 77° ± 9°, respectively.

Table 3. Functional outcomes during follow-up

Outcome	Preoperative	6 weeks	3 months	6 months	12 months
MEPS, mean ± SD	-	58.7 ± 8.6	78.4 ± 7.9	88.9 ± 6.4	92.7 ± 5.1
VAS pain, mean ± SD	6.9 ± 1.1	4.0 ± 1.2	2.3 ± 0.9	1.6 ± 0.8	1.2 ± 0.8
Flexion, °, mean ± SD	-	89 ± 18	112 ± 13	121 ± 11	126 ± 10
Extension deficit, °, mean ± SD	-	26 ± 9	13 ± 7	9 ± 6	7 ± 5
Pronation, °, mean ± SD	-	62 ± 10	72 ± 9	76 ± 8	78 ± 8
Supination, °, mean ± SD	-	59 ± 12	70 ± 10	74 ± 9	77 ± 9

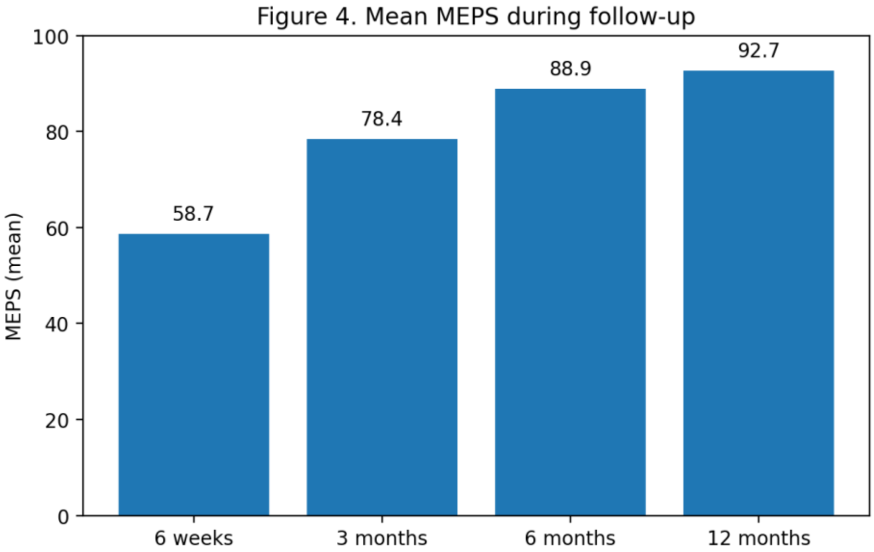


Figure 4. Mean MEPS during follow-up.

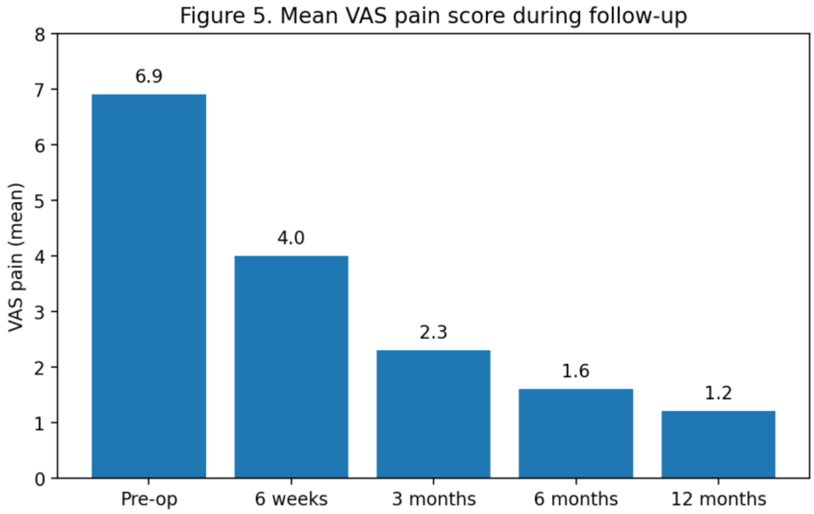


Figure 5. Mean VAS pain score during follow-up.

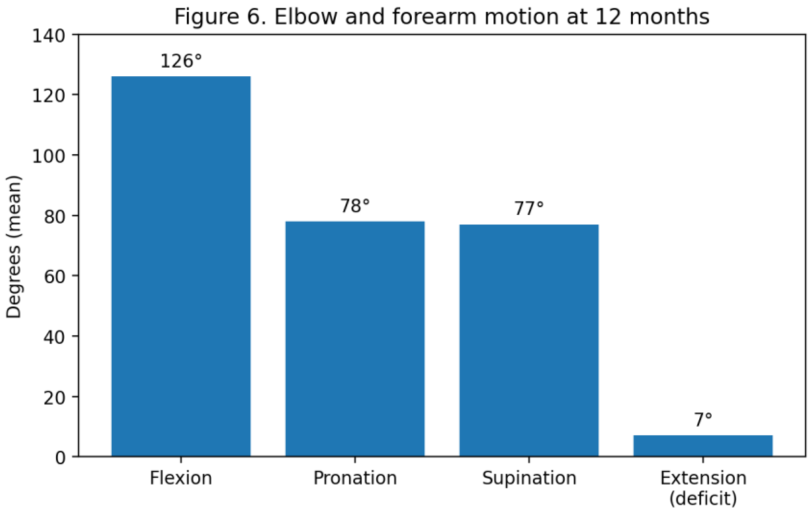


Figure 6. Elbow and forearm motion at 12 months.

Radiological Outcomes and Complications

At final follow-up, satisfactory radiocapitellar congruity and acceptable stem alignment were maintained in all 15 patients (100%). No progressive stem subsidence, progressive periprosthetic radiolucency, radiographic overstuffing, implant migration, capitellar erosion, or early prosthetic loosening was observed. Mild proximal stress shielding was identified in 2 patients (13.3%) without associated symptoms. Heterotopic ossification was observed in 2 patients (13.3%) without clinically significant motion restriction.

One patient (6.7%) developed postoperative elbow stiffness and was managed with supervised physiotherapy and progressive mobilization. No deep infection, nerve injury, recurrent instability, implant dissociation, revision surgery, or early implant removal occurred.

Table 4. Radiological findings and postoperative complications

Finding	n (%)
Satisfactory radiocapitellar congruity	15 (100)
Acceptable stem alignment	15 (100)
Progressive stem subsidence	0 (0)
Progressive radiolucency/loosening	0 (0)
Mild proximal stress shielding	2 (13.3)
Radiographic overstuffing	0 (0)
Heterotopic ossification	2 (13.3)
Capitellar erosion	0 (0)
Implant migration	0 (0)
Recurrent instability	0 (0)
Deep infection	0 (0)
Nerve injury	0 (0)
Postoperative elbow stiffness	1 (6.7)
Implant dissociation	0 (0)
Revision surgery	0 (0)
Early implant removal	0 (0)

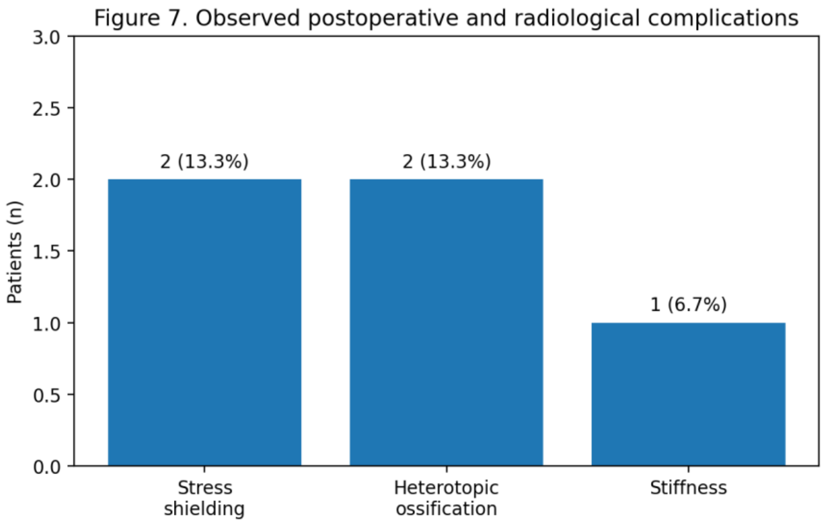


Figure 7. Observed postoperative and radiological complications.

DISCUSSION

The principal findings of this prospective case series were a high rate of successful initial press-fit fixation, a limited need for additional canal preparation, maintenance of acceptable stem alignment and radiocapitellar congruity, and progressive improvement in pain and elbow function during 12 months of follow-up. These findings are consistent with contemporary literature showing favorable early outcomes after RHA for unreconstructible Mason type III fractures. [8,11-14] The observations should be interpreted as implant-specific descriptive data rather than evidence of comparative effectiveness.

Contemporary comparative literature supports the use of RHA in appropriately selected Mason type III fractures when stable fixation cannot be achieved. De Mauro et al. reported fewer complications and better functional recovery with RHA than ORIF in a meta-analysis of prospective studies. [12] The present study similarly observed favorable final MEPS, with 14 of 15 patients (93.3%) achieving good or excellent scores. However, the single-arm design and small sample prevent any conclusion that the present implant is superior to ORIF or another RHA system.

Long-term comparative evidence provides an important counterbalance to early functional results. In isolated Mason type III fractures, Ly et al. reported broadly comparable long-term clinical outcomes after RHA and ORIF, with better pronation after RHA but a higher frequency of capitellar wear in the RHA group. [13] Accordingly, the favorable 12-month results in the present series should not be interpreted as evidence of long-term implant durability.

The focus on stem-specific performance is supported by systematic evidence that different fixed-stem RHA devices do not necessarily have equivalent clinical behaviour. Vannabouathong et al. reported variability among individual fixed-stem implants in revision, arthritis, capitellar erosion, instability, osteolysis, and functional outcomes. [5] The more recent 2026 meta-analysis found that the apparent revision advantage of intentionally loose-fit stems over press-fit stems was attenuated after adjustment for follow-up duration. [8] The 93.3% rate of initial press-fit success in this series therefore demonstrates technical feasibility of the evaluated stem, but it does not establish that press-fit fixation is superior to other fixation strategies.
Stem alignment is clinically relevant. Cherches et al. reported an association between increased radial stem angle and failure/reoperation in anatomic RHA. [9] In the present series, no clinically relevant varus or valgus malalignment was identified intraoperatively, and acceptable alignment was maintained at final follow-up in all patients. This observation is compatible with the broader principle that accurate stem positioning matters, but the absence of a control group means that any advantage attributable specifically to contouring cannot be determined.
The intraoperative findings provide practical information about implantation. Smooth insertion occurred in 73.3% of patients, additional broaching or reaming was required in 13.3%, and cortical impingement occurred in one patient. No intraoperative radial neck fracture occurred, and only one patient required a change in stem size because of inadequate initial stability. These data suggest that the evaluated design can be implanted reproducibly in this cohort, while also underscoring the continued importance of careful canal preparation, trialing, and sizing.
Avoidance of overstuffing remains important because excessive radial column length may increase radiocapitellar loading and contribute to capitellar wear. [10] No radiographic overstuffing was identified in the present series. Future comparative studies should use standardized quantitative measurements of radial head height and radial length to distinguish true design effects from differences in surgical technique and implant sizing.
The mean age of the present cohort was 31.9 years, making this study particularly relevant to younger adults. Heifner et al. found satisfactory outcomes in patients younger than 50 years and reported better MEPS when RHA was performed as a primary rather than secondary procedure in the younger subgroup. [11] The present results extend the descriptive literature by providing implant-specific early outcomes in a younger cohort, although they do not permit age-specific comparative inference.
Recent clinical studies also demonstrate substantial early improvement after RHA for complex radial head fractures. Singh et al. reported favorable short-term functional and radiological outcomes in a prospective cohort, and Bindal et al. reported improvement in MEPS and motion after RHA in Mason type III and IV fractures. [14,15] The magnitude of improvement in the present series is broadly comparable in direction, but differences in patient selection, fracture patterns, implant design, and follow-up preclude direct numerical comparison.
The observed short-term complication profile was favorable, with one case of postoperative stiffness and two cases of radiographic heterotopic ossification. Long-term studies indicate that radiographic abnormalities can become more evident with time, including capitellar wear after RHA. [13] The present 12-month follow-up therefore supports early clinical and radiological behavior only and should not be used to infer implant survivorship.
Overall, this study supports the use of RHA as a treatment option when Mason type III fractures are unreconstructible and adds implant-specific information on insertion resistance, cortical impingement, additional canal preparation, press-fit stability, sizing mismatch, and stem alignment. [1,5,8,11-15]

LIMITATIONS

The sample size was small, the study was conducted at a single centre, and there was no comparator group, limiting statistical power and generalizability. Six patients underwent LUCL repair; associated ligament injury and rehabilitation may therefore have influenced functional recovery. Some intraoperative and radiographic assessments were not reported as having undergone formal interobserver or intraobserver reliability testing. Follow-up was limited to 12 months and is insufficient to evaluate late capitellar wear, progressive stress shielding, radiolucency, loosening, or revision.

CONCLUSION

In this prospective single-centre case series of young adults with unreconstructible Mason type III radial head fractures, primary RHA using an anatomically contoured, pre-bent stem was associated with favorable early functional and radiological outcomes. Adequate initial press-fit fixation was achieved in 14 of 15 patients (93.3%), no intraoperative radial neck fracture or clinically relevant stem malalignment occurred, mean MEPS increased to 92.7 ± 5.1 at 12 months, and 14 patients (93.3%) achieved good or excellent final MEPS. No early radiographic overstuffing, progressive loosening, implant migration, or revision surgery was observed.
These findings are consistent with the broader literature supporting RHA for appropriately selected unreconstructible Mason type III fractures and with evidence emphasizing implant-specific fixation and alignment. [5,8,11-15] The present study does not establish superiority of the anatomically contoured stem over conventional or alternative designs. Larger comparative studies with standardized radiographic measurements

and long-term follow-up are required to determine whether anatomical contouring confers a clinically meaningful advantage.

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