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# Elbow hemiarthroplasty for intra-articular distal humerus fractures: results and technique

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A R T I C L E I N F O

*Keywords:*
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*Level of evidence:* Level IV; Case Series; Treatment Study

**Purpose:** The purpose of this study was to report results of elbow hemiarthroplasty for comminuted, intra-articular distal humerus fractures in low-demand elderly female patients.

**Methods:** This is a retrospective case series of eight patients who underwent elbow hemiarthroplasty for comminuted, intra-articular distal humerus fractures between 2015 and 2019. Patients were considered for the procedure if the humeral fractures were deemed nonreconstructable by open reduction internal fixation. Patients were excluded if the extensor mechanism was not intact, evidence of significant ulnohumeral osteoarthritis, or a fracture to the proximal radius or ulna. A "triceps-on" approach was used in all cases. Appropriate sizing of the spool and length of the implant were determined by intraoperative fluoroscopy. Both ulnar collateral ligament and the lateral ulnar collateral ligaments were repaired through the central spool after final placement of the implant. Postoperative radiographs, clinical data, and the Mayo Elbow Performance Score were used to assess elbow pain and function.

**Results:** Seven patients were included in final analysis. One patient was excluded from final analysis after sustaining a ground-level elbow dislocation at 13 weeks postoperatively, which subsequently revised to total elbow arthroplasty. The average age at the final follow-up was 72.1 years and duration of follow-up was 29.9 months (range 11.4-58.8 months). Average elbow range of motion was 21° ± 15° extension, 135° ± 9° flexion, 87° ± 5° pronation and 84° ± 8° supination. The average Mayo Elbow Performance Score was 88.3 (range 85-95; or "good" to "excellent") at the final follow-up. Postoperative ulnar neuropathy was reported by one patient at the first postoperative visit. This was followed up clinically and evaluation at 24 months revealed mild residual sensory deficits and adequate strength and motor function.

**Conclusion:** Elbow hemiarthroplasty using the humeral component of the total elbow arthroplasty is an option for treatment of isolated, comminuted distal humerus fractures in select patient populations. The ideal candidates are elderly, low-demand, and able to adhere to postoperative activity and weight-bearing restrictions. Overall patient satisfaction with off-label use of humeral component of commercially available total elbow implants in the United States is promising, yet development of a more anatomic spool is warranted to further optimize outcomes intraoperatively. Some advantages of elbow hemiarthroplasty are a less-demanding operation and avoids complications associated with linked design including polyethylene wear, periprosthetic fracture, or implant loosening. Limitations of this study include small sample size and retrospective nature of the study.



Distal humerus fractures remain one of the more challenging fractures to treat. Outcomes even with the best internal fixation techniques are fraught with elbow stiffness, pain, and decreased function. Fractures of the distal humerus make up approximately 30% of all elbow fractures.[3] Roughly half of these fractures occur in elderly female patients with osteoporotic bone.[10] Treatment in this demographic of the patient population poses a particularly difficult challenge, especially when dealing with comminuted, articular fractures in the elderly population. Total elbow arthroplasty (TEA) has been demonstrated as a reasonable treatment option in this situation.[4,9,11] Recent data comparing open reduction internal fixation and TEA with short-term follow-up demonstrate TEA as a viable alternative to open reduction internal fixation.[7,8] Unfortunately, limitations associated with TEA include stringent

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**Table I**
Demographics and operative extremity, hand dominance, and implants.

| Patient ID | Age at surgery (yr) | Sex (M or F) | BMI (kg/m^2) | Operative extremityLaterality lL or R) | Hand dominance (L or R) | Implant (Tornier latitude EV elbow humeral component) | |
|---|---|---|---|---|---|---|---|
| | | | | | | Spool size (small, medium, or large) | Humeral stem (small, medium, or large) |
| 1 | 68 | F | 23.8 | R | R | Medium | Medium |
| 2 | 83 | F | 27.3 | R | R | Medium | Medium |
| 3 | 61 | F | 44.3 | L | R | Medium | Medium |
| 4 | 82 | F | 32 | L | R | Medium | Medium |
| 5 | 64 | F | 28.9 | R | R | Medium | Medium |
| 6 | 79 | F | 20.7 | R | L | Medium | Medium |
| 7 | 63 | F | 42.97 | L | R | Small | Small |
| 8 | 77 | F | 27.3 | L | L | Medium | Medium |

postoperative weight-bearing restrictions, risk of periprosthetic fracture, implant loosening, and component failure, creating long-term outcome concerns when using this technique.

Hemiarthroplasty of the distal humerus is a less commonly used technique for treatment of nonreconstructable distal humeral fractures in the elderly population. There is limited supporting literature regarding this technique to-date, with small series and primarily short-term outcome data.[1,2,5,6,13] Avoiding use of a TEA can decrease some of the known complications associated with this procedure such as osteolysis resulting from wear of the polyethylene liner and component loosening due to increased stresses created by a constrained implant. Without these risks, patients are advanced through rehabilitation of the elbow at an accelerated rate compared to postoperative restrictions associated with a TEA.

In this article, we present the clinical results of a series of patients who underwent elbow hemiarthroplasty (EHA) in the United States using standard total elbow humeral components for treatment of intra-articular distal humerus fractures.

## Materials and methods

### *Patient selection*

Eight patients who underwent distal humeral hemiarthroplasty for intra-articular distal humerus fractures were identified from a consecutive series of patients. Procedures were performed at a single institution between 2015 and 2019 by senior authors (MAS) or (JDK), both fellowship-trained shoulder and elbow surgeons. Institutional review board approval and waiver of informed consent were obtained before the start of the study. Demographics of the patient population and operative extremity, hand dominance, and implants used for each patient are presented in Table I. Preoperative AP and lateral view radiographs and computed tomography scans were obtained to determine the extent of the articular fractures to the distal humerus (Fig. 1, *A*–*C*). Inclusion criteria consisted of patients who sustained a closed, comminuted, intra-articular distal humerus fracture with absence of fracture to proximal radius or ulna, were over 60 years of age, low demand, and had full motor and neurological function of the involved extremity preoperatively. Exclusion criteria consisted of evidence significant ulnohumeral arthritis or if the triceps attachment was not intact.

### *Surgical technique*

Informed consent is again obtained in preoperative waiting area. A patient is brought to operating room, positioned in the supine position where vitals are monitored. This is followed by administration of regional and general anesthesia. The patient is then positioned in the lateral decubitis position with the operative arm positioned across the chest. The patient is then prepped and draped in the usual sterile fashion, and operative site is confirmed. Preoperative antibiotics are given before initiation of the procedure. A direct posterior approach is made down through skin and soft tissue at the level of fascia. A “triceps-on” approach was used in all cases. Skin flaps are raised both medially and laterally. The ulnar nerve is identified and mobilized from the intermuscular septum down to the level of the first motor branch to the flexor carpi ulnaris. A Penrose drain is placed around the ulnar nerve for protection, to help prevent inadvertent stretch injury, and this prepares the nerve for transposition if necessary. The triceps is then mobilized off the humerus on both the medial and lateral sides, taking care to preserve the tendinous insertion on the olecranon. Once the triceps is fully and completely mobile, the origins of the medial and lateral collateral ligaments are then released. These are both tagged with #2 permanent suture for repair at the conclusion of the case. Once the collateral ligaments are released, the joint space is opened and then copiously irrigated and evacuated of hematoma and bone debris (Fig. 2*A*). The elbow is preferentially dislocated to the radial side, keeping the triceps mechanism intact (Fig. 2*B*). The distal humerus is then prepared with the oscillating saw and the humeral canal is opened with a burr and sequentially reamed to the appropriate diameter. The size of the humeral prosthesis is chosen assessing the articulation of the native radius and ulna with the humeral implant. This articulation is directly visualized and confirmed radiographically. Next, the distal humerus is sequentially broached to the selected size. Fine tuning of the metaphyseal portion of the humerus is achieved using the bur until the prosthesis is fully seated to the level of the native joint line. Trial reduction is attempted at this time, and implant fit is again confirmed with fluoroscopy to ensure appropriate position of the implant, as well as implant rotation and reduction. The height of the humeral implant dictates the flexion extension arc and triceps tension. Lengthening the construct limits flexion by effectively increasing triceps tension. Adjustment and confirmation of the implant height is completed prior to removal of the trials. Trial implants are then removed, and the canal is prepared for cementation and placement of the final implant. Commercial Cement restrictor is placed to the appropriate depth, and the stem is placed under standard pressurization technique. Once the cement has cured, the forearm is reduced onto the humeral prosthesis. The elbow is again tested though a full range of motion, ensuring adequate length, alignment, stability, and rotation.

When possible the epicondyles are reduced to the humeral shaft. However, with severe comminution this is not possible, so collateral ligaments are brought back and secured to the prosthesis and then repaired through the spool of the prosthesis. A #2 nonabsorbable suture is run through the medial and lateral

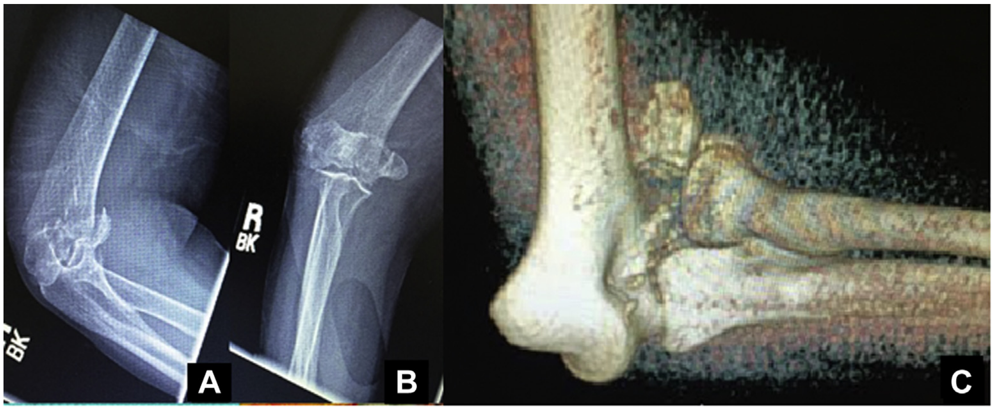

**Figure 1** Preoperative isolated distal humerus fracture radiograph AP (**A**) and lateral view (**B**), computed tomography lateral view (**C**).

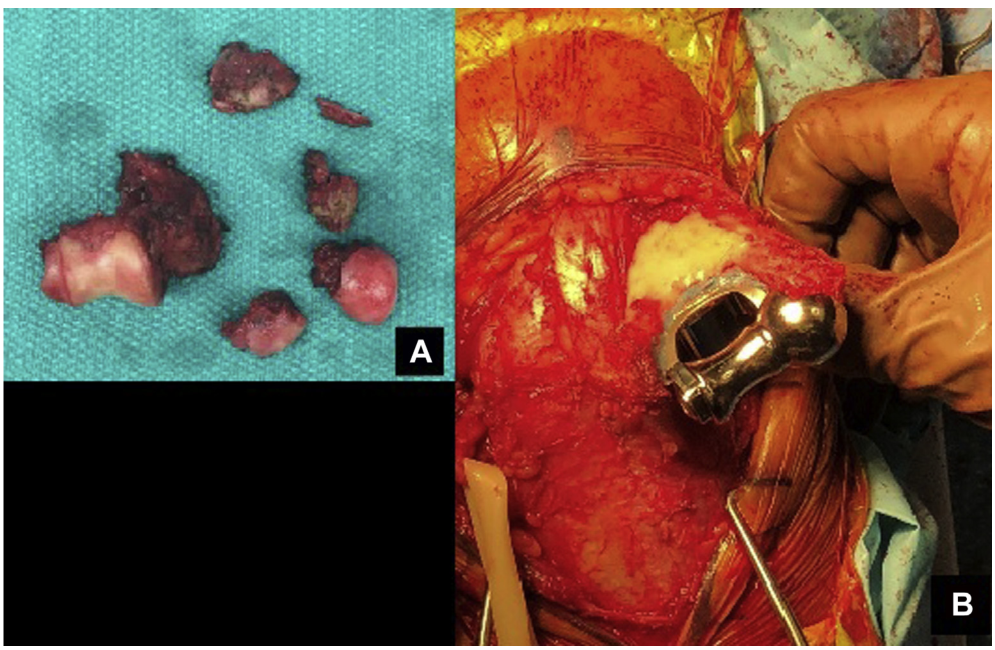

**Figure 2** Intraoperative articular bone fragments and debri illustrating degree of comminution (**A**). Intraoperative photo demonstrating "triceps-on" approach and preferential elbow dislocation to laterally (**B**).

collateral ligaments using a Krackow technique and the suture ends are passed through the spool using a suture passer. The free suture ends are then passed through the contralateral collateral ligament using a free needle and tied. Modified Mason-Allen sutures were used on each side and then tied over a mattress on the far side. The collateral ligaments should be well approximated to the humeral implant at this point and the elbow should be stable through range of motion. Once this is completed, the wound is again copiously irrigated. The split between the brachialis and the triceps on the radial side is then approximated using #2 permanent suture. The wound is copiously irrigated with a dilute betadine solution, followed by normal saline.

The position of the ulnar nerve is observed with full range of motion of the elbow and if stable without restriction, in situ stabilization is sufficient. If the nerve demonstrates subluxation out of the groove, a fat flap is raised in the medial soft tissue and gently used to secure and protect the nerve from any additional adhesions as well as scarring. The wound is again copiously irrigated, vancomycin powder is placed within the wound as per established protocol for acute trauma and joint replacements at operative facility. A layered closure is then performed, followed by placement of a posterior slab, long arm splint, immobilized in 90 degrees of flexion.

*Postoperative follow-up and rehabilitation*

Routine postoperative clinical follow-up with clinical examination and radiographs were obtained at 2 weeks, 6 weeks, 3 months, 6 months, and one year. Patients were encouraged to return for annual follow-up thereafter. Patient-reported satisfaction and functional outcomes were determined using Mayo Elbow Performance Score, obtained at most recent follow-up, where a score of 100 represents a normal elbow. The electronic medical records were retrospectively reviewed to obtain pertinent data.

*Rehabilitation*

Patients remain immobilized at 90 degrees of flexion in the long arm splint for 7-10 days postoperatively for soft-tissue rest and

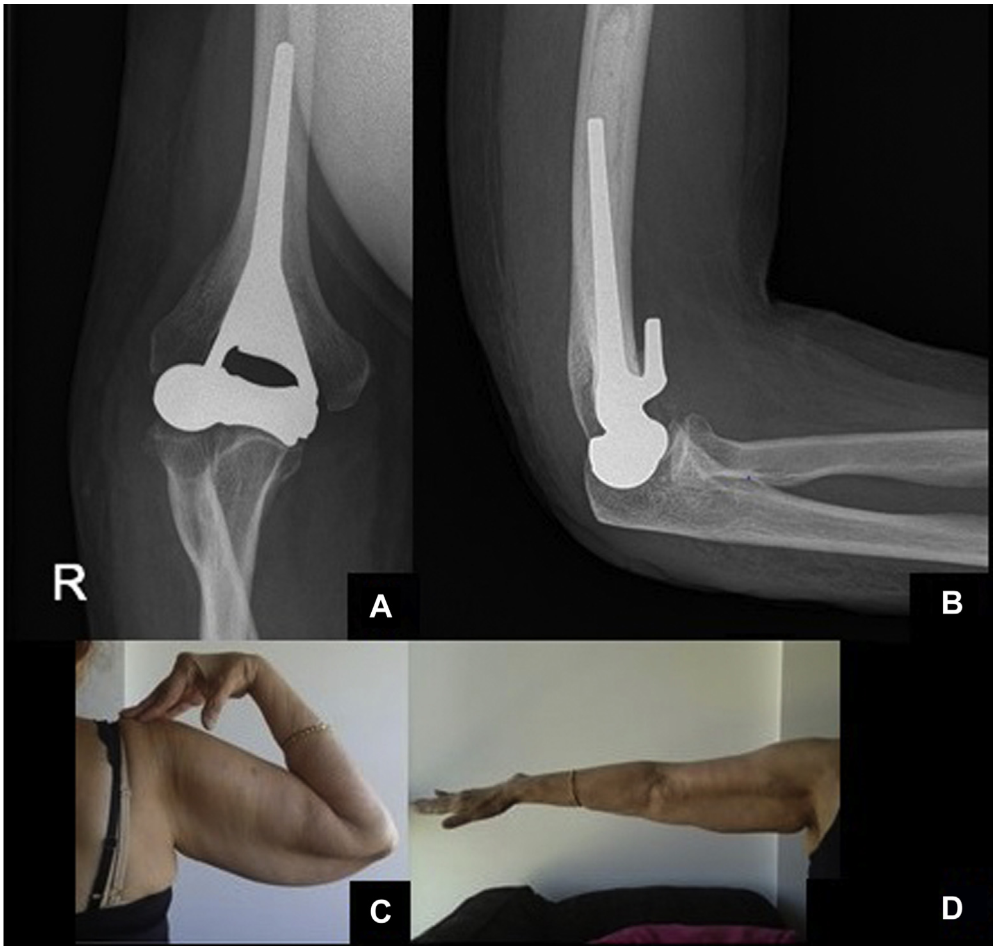


**Figure 3** Postoperative radiograph of elbow hemiarthroplasty AP (**A**) and lateral view (**B**). Patient range of motion 4.5 years out from surgery; extension (**C**) and flexion (**D**).

wound healing. The splint is removed at the first postoperative visit and sutures are removed. Gentle active elbow range-of-motion exercises are initiated at that time using the overhead motion protocol described by Schreiber et al.[12] The patient is placed in a hinged brace while they are not participating in exercises. At 4 weeks postoperatively, progressive gravity-assisted elbow extension exercises are initiated to assist with regaining full extension. At 6 weeks, the hinged brace is removed and range of motion including passive motion is initiated under the direction of a physical therapist. At this point, the patient returns to most of their regular daily activities. At 12 weeks, the patients begin strengthening with the therapist, and they are given instructions to avoid sports with high varus/valgus stresses (eg, tennis, throwing, golf) indefinitely.

## Results

Eight patients underwent humeral hemiarthroplasty for distal humerus fracture between 2015 and 2019 by the senior authors, both fellowship-trained surgeons, at a single institution. One patient sustained a mechanical fall at 13 weeks postoperatively resulting in an elbow dislocation. She was revised to a TEA without subsequent complications. The 7 patients with retained hemiarthroplasty are included in our final analysis. Results for the patient converted to TEA are reported separately.

All 8 patients were female with an average age of 72.1 $\pm$ 9.1 years. Half the patients underwent a left EHA and the other half the patients underwent right EHA. Half the patients underwent EHA of their dominant extremity and the other half of the non-dominant extremity. Amongst the seven patients who were included in final analysis, no patients were lost to follow-up with average follow-up time of 29.9 months.

All 7 patients reported “good” or “excellent” as response to satisfaction with the outcome of the elbow at the final follow-up. Average range of motion at themost recent follow-up showed elbow extension $21^\circ \pm 15^\circ$, elbow flexion of $135^\circ \pm 9^\circ$, pronation 87 $\pm$ 5, and supination $84^\circ \pm 8^\circ$. Average Mayo score obtained at the most recent follow-up was 88.3 $\pm$ 5.8 (range 85-95; good to excellent).

There were no reported intraoperative complications at time of surgery. One patient reported an ulnar neuropathy in the 4th and 5th digits with radicular pain at first postoperative visit. At 6 months postoperatively, neurologic assessment by EMG study confirmed ulnar neuropathy of the elbow, with acute denervation of left ulnar sensory nerve to stimulation and acute denervation with reduced response of distal voluntary motor units in left flexor carpi ulnaris and left first dorsal interosseous muscles. However, at 24 months after surgery, hand function and strength was documented as significantly improved. There was no interosseous muscle wasting noted, near symmetric strength to adduction between the index and long finger and very strong adduction of the thumb against the index finger, and strong grip strength. Sensation had significantly improved with only minor residual sensory deficit in 5th digit.

Additional complications unrelated to primary procedure occurred in 2 patients. At 13 weeks postoperatively, one patient suffered a ground-level fall onto her operative extremity resulting in a traumatic dislocation of the EHA. This was treated with conversion to a TEA without further complications. At most recent follow-up, this patient's radiographs showed total elbow components well-positioned with no evidence of malrotation or periprosthetic fracture, and flexion/extension arc was 0-135° and pronation-supination arc was 80°. Another patient sustained an ipsilateral proximal humerus fracture after mechanical fall, treated nonoperatively with no complications to implant. In remaining cohort of patients to date, there have been no cases of subsidence, hardware loosening, or periprosthetic fracture on postoperative radiographs, no wound complications, instability events, or infection (Fig. 3, *A–D*).

## Discussion

Preliminary findings of this study demonstrate promising functional outcomes with distal humeral hemiarthroplasty for treatment of comminuted, intra-articular distal humerus fractures in the elderly, female population. Preoperative radiographs and computed tomography scans are important to determine the extent of the articular fractures to the distal humerus. Patients were considered for hemiarthroplasty because of significant articular comminution or poor bone quality which was deemed not to be amenable to operative fixation. Patients were excluded from consideration not considered if they had fractures of the proximal radius or ulna or the extensor mechanism was not intact. A "triceps-on" approach was used in all cases. Both ulnar collateral ligament and the lateral ulnar collateral ligaments are repaired through the central spool of the distal humeral component after final placement of the implant, which in our opinion is a key step in success of reestablishing stability of the elbow. The combination of maintaining epicondyles, if possible, and reapproximating collaterals appears to be critical for long-term stability. This assertion cannot be directly validated by our study, but the observation of "no instability" at the final follow-up suggests that this technique may be helpful in maintaining long-term stability.

The patient with a dislocation after a fall at 13 weeks postoperatively yields interesting insights into the failure mechanisms of this construct. While this patient did suffer a dislocation and the need for a subsequent revision, they did not sustain a periprosthetic fracture. It is possible the patient would have suffered such a fracture had a total elbow been chosen for her initial treatment. In addition, the revision was fairly straightforward by converting her to a linked total elbow using the existing humeral component. This illustrates one of the potential advantages of an EHA in that the implant can be converted to a total elbow with retention of the humeral component.

Additional theoretical advantages of a hemiarthroplasty construct over a linked total elbow are the avoidance of a polyethylene bushing which can be a source of wear debris resulting in osteolysis as well as a shorter, less technically demanding procedure that does not require placement of an ulnar component. Finally, as this is an unlinked construct, we allow our patients to weight bear without a formal weight restriction.

In a recent series of 21 EHAs from Denmark, Al-Hamdani et al[2] reported "good to excellent results" in 21 patients, "fair" in 2 patients, and "poor" in 1 patient. The median Mayo Elbow Performance Score was 85 points. The median flexion/extension and supination/pronation arcs were 110° (range, 60°-140°) and 160° (range, 115°-180°). Complications in their series were recorded in 7 patients, and 3 of them underwent reoperation because of stiffness, which was treated with open release, with a median follow-up time of 20 months. Although our results are congruent with Al-Hamdani et al with respect to primarily good to excellent results, average Mayo Elbow Performance Score score of 85 in the study by Al-Hamdani et al compared with 88 in our case series. However, the demographics and indications of our study more closely resemble those reported by Burkhart et al and are worthy of comparison. Similar to our study, Burkhart et al[5] included all female patients with an average age of 75.2 years. The reported average Mayo Elbow Performance Score score was "good" to "excellent" and range of motion reported was similar to our results. However, our study contributes longer follow-up results at an average of 29.9 months, and the average follow-up for Burkhart et al[5] was 12.1 months. Both of these studies were completed outside of the United States, whereas our case series builds on existing knowledge and contributes additional outcome data with off-label use of commercially available total elbow implants in the United States.

Although to date the literature on EHA is limited, recent renewed interest has demonstrated encouraging results. Currently, this technique is off-label in the United States. Accurate sizing of the native width of the distal humerus is difficult in setting of severe articular fracture comminution. Development of a more anatomic spool to better replicate the distal humeral articular surface, with multiple size options independent of the stem width is warranted. The limited sample size and relatively short-term follow-up are obvious limitations to this study. Further follow-up of this patient population with an increased sample size over time will help delineate more reliable long-term results.

## Conclusion

EHA is an alternative approach to the treatment of isolated, comminuted distal humerus fractures. With a triceps-on approach, early active range of motion allowed for a rapid recovery. A hemiarthroplasty construct avoided any risks associated with placement of an ulnar component, intraoperative time spent placing the ulnar component and risks of loosening associated with a linked design. The ideal candidates are elderly, low demand, with capacity to adhere to postoperative activity. Intermediate outcomes are encouraging with respect to function, pain, range of motion, and overall patient satisfaction.

## Disclaimers

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Conflicts of interest: James D. Kelly II is a board or committee member of American Shoulder and Elbow Surgeons, owns stock in Consortium of Focused Orthopaedists, LLC. He receives IP royalties, other financial and material support, and research support from Wright Medical Technology, Inc. which is not related to the subject of this work. Mark A. Schrumpf receives financial payments from Shoulder Innovations which is not related to the subject of this work.

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