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# How age and gender influence proximal humerus fracture management in patients older than fifty years

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**Background:** As the aging population expands, proximal humerus fractures have become more prevalent. This study aimed to evaluate acute management of proximal humerus fractures in women and men older than the age of 50 years to determine how gender and age have affected definitive treatment selection over the last decade.

**Methods:** Patient records were retrospectively reviewed from a commercially available database, PearlDiver, to identify treatments for proximal humerus fractures between 2010 and 2019. Data were separated by age into two cohorts, patients aged 50-64 years and those aged 65 years and older before stratification by gender. Within each cohort, groups were matched with respect to age, region, and Elixhauser comorbidity index. Logistic regression analyses were performed to determine which gender was associated with a higher risk of undergoing operative treatment, which gender was associated with a higher risk of receiving arthroplasty, and which of the individual surgical operations were more likely given the patient's gender and age.

**Results:** In the 50- to 64-year-old cohort, men were less likely to be treated operatively than women (odds ratio [OR]: 0.90). However, men in this cohort had a 31% higher likelihood of receiving an arthroplasty procedure than women when given operative treatment. Specifically, men aged 50 to 64 years were more likely to receive hemiarthroplasty (OR: 1.48) and intramedullary nailing (OR: 1.19) and were less likely to have open reduction internal fixation (ORIF) (OR: 0.71). In the 65 years and older cohort, there was no relationship between gender and the likelihood of operative treatment for a proximal humerus fracture. Men older than 65 years had a 29% lower likelihood of receiving an arthroplasty type procedure than women older than 65 years. In addition, men older than 65 years were more likely to receive ORIF (OR: 1.14) and intramedullary nailing (OR: 1.43) and less likely to receive hemiarthroplasty (OR: 0.86) and reverse total shoulder arthroplasty (OR: 0.66) than similarly aged women.

**Conclusion:** Both age and gender have an association with the definitive treatment patients received for proximal humerus fractures over the last decade. Women younger than 65 years of age were more likely to undergo operative treatment, although once older than 65 years, there was no influence of gender on operative treatment. Men younger than 65 years were more likely to receive arthroplasty and women, more likely to undergo ORIF; however, as patients reached the age of 65 years and older, this finding was reversed such that women were more likely to receive arthroplasty and men, ORIF. Further exploration into these differences could improve decision-making between surgeons and patients.



As the third most common fracture type in the elderly after hip fractures and distal radius fractures, proximal humerus fractures account for 5%-6% of all adult fractures and occur annually at an incidence of 60 cases per 100,000 people in the United States.[3,9,22] These fractures have a bimodal distribution, presenting in young patients with high-energy trauma such as motor vehicle accidents and in older patients experiencing low-energy falls. With

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continued improvements in health care and subsequent growth of the elderly population, the overall cases of proximal humerus fractures are expected to increase exponentially.[21]

Early diagnosis of proximal humerus fractures is critical to guide acute management and reduce the risk of injury sequelae such as malunion, nonunion, infection, and avascular necrosis.[6] Treatment selection for proximal humerus fractures is affected by a myriad of factors, including fracture displacement, fracture type, concomitant injuries, activity level, age, and bone quality.[45] Although proximal humerus fragility fracture management remains controversial, the majority have historically been treated nonoperatively.[26,28] When indicated, operative treatment options include open reduction internal fixation (ORIF), closed reduction percutaneous pinning, intramedullary nailing (IMN), hemiarthroplasty (HA), total shoulder arthroplasty (TSA), and reverse TSA (RSA).[15]

In comparison with men, women have been noted to sustain proximal humerus fractures more frequently at a 2:1 ratio.[9] Elderly female patients may have underlying bone density deficits before sustaining a fragility fracture that may be undiagnosed before injury.[27,48] With the gaining popularity of RSA for the treatment of the aging population and increasing prevalence of proximal humeral fragility fractures, this study aimed to evaluate how gender and age have affected definitive treatment selection over the last decade.

## Materials and methods

### *Data source*

A large nationwide commercially available administrative claims database, PearlDiver (PearlDiver Technologies, Colorado Springs, CO, USA), containing 144 million patients was used to retrospectively review deidentified patient records. This study used the "MUExtr" data set within PearlDiver, which consists of records pertaining to procedures or diagnoses of the upper extremity across multiple insurance provider groups in U.S. territories and states, including commercial insurance groups, Medicare, and Medicaid from 2010 to Q1 of 2020. Patient claim codes used from this data set included Current Procedural Technology (CPT) and International Classification of Diseases (ICD), Ninth Revision and Tenth Revision (ICD-9/ICD 10). Institutional review board exemption was granted through our institution as the provided data were deidentified and compliant with the Health Insurance Portability and Accountability Act.

### *Patient selection*

Data were queried over a decade, from 2010 to 2019, to identify patients with a diagnosis of a proximal humerus fracture, and further stratified into either operative or nonoperative treatment within 1 month of initial fracture to define acute management. Identified patients were then separated by age into two cohorts, patients aged 50-64 years and those aged 65 years and older. The two cohorts were further subdivided by gender. The designated groups were men and women aged 50-64 years and men and women aged 65 years and older who received either operative or nonoperative treatment. Within each cohort, men and women were matched with respect to age, region, and Elixhauser comorbidity index (ECI) to create evenly numbered groups of men and women. The ECI was specifically chosen to stratify all cohorts due to its propensity to match patients with similar morbidity and mortality risks.[25,32]

Patients with a prior history of malignancy or infection were excluded as well as those with fractures of the isolated greater tuberosity, shaft, or distal humerus. In addition, patients who died during the period of study were not included. Similar to prior studies on proximal humerus fractures, this study used only ICD-9 and ICD-10 procedural codes to specifically identify RSA and TSA procedures, given the typical CPT code (CPT-23472) includes both RSA and TSA.[16,39,42] A comprehensive list of all ICD and CPT codes used in this study is included in Supplementary Tables S1.

**Table I**
Breakdown of proximal humerus treatments by gender for matched cohorts from 2010 to 2019.

| Age 50-64 yr (n = 44,168) | Males, n (%) | Females, n (%) |
|---|---|---|
| Operative treatment | 4637 (21.00) | 4897 (22.17) |
| CRPP | 176 (3.79) | 159 (3.24) |
| Hemiarthroplasty | 409 (8.82) | 305 (6.23) |
| Intramedullary nailing | 927 (19.99) | 860 (17.56) |
| ORIF | 2957 (63.77) | 3392 (69.27) |
| Total shoulder arthroplasty | 23 (0.50) | 14 (0.29) |
| Reverse shoulder arthroplasty | 145 (3.13) | 167 (3.41) |
| Nonoperative treatment | 17,447 (79.00) | 17,187 (77.83) |
| Total | 22,084 | 22,084 |
| **Age 65 yr and older (n = 73,468)** | **Males, n (%)** | **Females, n (%)** |
| Operative treatment | 6259 (17.04) | 6169 (16.79) |
| CRPP | 328 (5.24) | 369 (5.98) |
| Hemiarthroplasty | 498 (7.96) | 572 (9.27) |
| Intramedullary nailing | 1340 (21.41) | 1020 (16.53) |
| ORIF | 3556 (56.81) | 3428 (55.57) |
| Total shoulder arthroplasty | 35 (0.56) | 48 (0.78) |
| Reverse shoulder arthroplasty | 502 (8.02) | 732 (11.87) |
| Nonoperative treatment | 30,475 (82.96) | 30,565 (83.21) |
| Total | 36,734 | 36,734 |

*CRPP*, closed reduction percutaneous pinning; *ORIF*, open reduction internal fixation.

### *Outcomes*

The rates of treatment for proximal humerus fractures were queried for both men and women from 2010 to 2019. The different operations analyzed included closed reduction percutaneous pinning, HA, ORIF, IMN, TSA, and RSA. One month was chosen to capture acute treatment for the operative cohort as fractures operated on after this time period would likely be due to failure of nonoperative management.[35] Nonoperative treatment was identified if patients did not receive any surgical procedures requiring anesthesia for their proximal humerus fracture within 1 month of the initial injury. The number of patients undergoing surgery or nonoperative treatment for each matched group of men and women within each age cohort was totaled and compared using logistic regression to identify if gender was associated with a higher risk of undergoing operative treatment, having an arthroplasty operation (HA, TSA, RSA), and which of the individual surgical operations were more likely given the patient's gender and age.

### *Statistical analysis*

All data analyses were performed using the R statistical software (R Project for Statistical Computing, Vienna, Austria) integrated within PearlDiver with a significance level set to 0.05. Logistic regression analyses were performed to calculate adjusted odds ratios (ORs) with corresponding 95% confidence intervals (CIs) to determine if gender affected treatment (operative vs. nonoperative) and which of the individual surgical operations were more likely given a patient's gender and age.

## Results

After matching men and women for age, region, and ECI, the total number of patients evaluated in the 50- to 64-year-old cohort was 44,168 (22,084 men and 22,084 women) as seen in Table I.

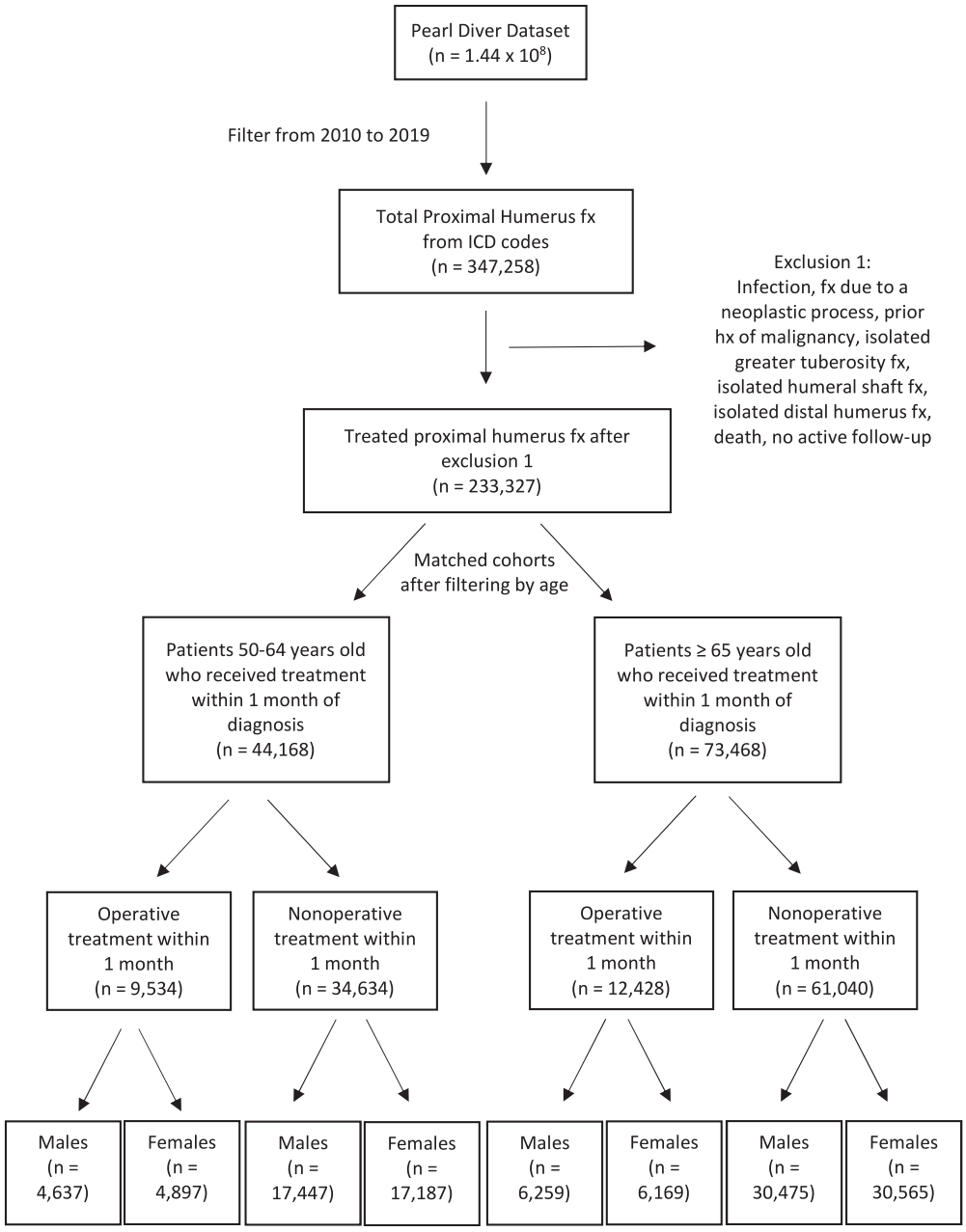


**Figure 1** Flow diagram of patients included in study. *ICD*, International Classification of Diseases; *Fx*, fracture; *Hx*, history.

Within this cohort, there were 4637 operations for men and 4897 operations for women (Fig. 1). Men aged 50-64 years were less likely to receive operative treatment for a proximal humerus fracture within the study period (OR: 0.91; 95% CI: 0.87-0.96) than women (Table II). Furthermore, men had a 31% higher likelihood (OR: 1.31; 95% CI 1.15-1.49) of receiving an arthroplasty procedure than similarly aged women and were more likely to receive HA (OR: 1.48; 95% CI: 1.27-1.73) and IMN (OR: 1.19; 95% CI: 1.07-1.33). However, men were less likely to receive ORIF (OR: 0.71; 95% CI: 0.64-0.79) than women.

In the 65 years and older cohort, after matching patients for the similar indications mentioned previously, there were a total number of 73,468 patients (36,734 men and 36,734 women). Within this cohort, there were 6259 operations for men and 6169 operations for women. There was no significant difference in the 65 years and older cohort with regard to which gender was more likely to receive an operation for a proximal humerus fracture (OR: 0.98; 95% CI: 0.94-1.02). Men had a 29% lower likelihood (OR 0.71; 95% CI: 0.65-0.79) of receiving an arthroplasty procedure (Table III). In terms of individual operations, men were significantly less likely to receive HA (OR: 0.86; 95% CI: 0.76-0.98) and RSA (OR: 0.66; 95% CI: 0.58-0.74), whereas they were more likely to receive IMN (OR: 1.43; 95% CI: 1.31-1.58) and ORIF (OR: 1.14; 95% CI: 1.05-1.24) than

**Table II**
Odds ratio of the male gender on the likelihood of receiving surgical treatment in comparison with females from 2010 to 2019.

| Likelihood of operation (males vs. females) | OR (95% CI) |
|---|---|
| Age 50-64 yr | 0.91 (0.87-0.96) |
| Age 65 yr and older | 0.98 (0.94-1.02) |

*CI*, confidence interval; *OR*, odds ratio.

**Table III**
Odds ratio of the male gender on the likelihood of getting arthroplasty vs. other operations when compared with females from 2010 to 2019.

| Likelihood of arthroplasty (males vs. females) | OR (95% CI) |
|---|---|
| Age 50-64 yr | 1.31 (1.15-1.49) |
| Age 65 yr and older | 0.71 (0.65-0.79) |

*CI*, confidence interval; *OR*, odds ratio.

**Table IV**
Odds ratio of the male gender on likelihood of receiving individual operative treatments in comparison with females from 2010 to 2019.

| Likelihood of individual operation (males vs. females) | OR (95% CI) |
|---|---|
| Age 50-64 yr | |
| CRPP | 1.19 (0.96-1.49) |
| Hemiarthroplasty | 1.48 (1.27-1.73) |
| Intramedullary nailing | 1.19 (1.07-1.33) |
| ORIF | 0.71 (0.64-0.79) |
| Total shoulder arthroplasty | 1.75 (0.91-3.51) |
| Reverse shoulder arthroplasty | 0.92 (0.74-1.16) |
| Age 65 yr and older | |
| CRPP | 0.75 (0.76-1.04) |
| Hemiarthroplasty | 0.86 (0.76-0.98) |
| Intramedullary nailing | 1.43 (1.31-1.58) |
| ORIF | 1.14 (1.05-1.24) |
| Total shoulder arthroplasty | 0.73 (0.47-1.14) |
| Reverse shoulder arthroplasty | 0.66 (0.58-0.74) |

*CI*, confidence interval; *OR*, odds ratio; *CRPP*, closed reduction percutaneous pinning; *ORIF*, open reduction internal fixation.

women (Table IV). There were no differences in the other individual procedures performed with respect to gender.

When evaluating the different operative treatments with respect to age, RSA was performed in men and women aged 50-64 years at 3.13% and 3.41%, respectively, and this rate increased to 8.02% and 11.87% in men and women older than 65 years of age, respectively. In addition, ORIF was performed in men and women aged 50-64 years at 63.77% and 69.27%, respectively, and this rate decreased to 56.81% and 55.57% in men and women older than 65 years of age, respectively.

## Discussion

In the aging population, postmenopausal women often have decreased estrogen production.[24,37] Due to a positive correlation between estrogen deficiency and vitamin D deficiency, older women have been reported to be at a higher risk of not only developing osteoporosis but also having fragility fractures.[5,18] Although fragility fractures are more common in women, they also manifest in men and are associated with higher mortality rates.[7] Women within the 3 years after their final menstrual periods were documented to have a rapid decline in bone mineral density, cortical thickness, trabecular connectivity, and composite indices of bone strength.[13,14,37] In addition, a cadaveric study of proximal humerus histomorphology by Barvencik et al demonstrated age and sex to be critical determinants of microarchitectural changes such that women older than 60 years had significant age-related decrease in bone mass with the greater tuberosity as the most affected location.[4] Alterations in the microarchitecture of the proximal humerus from osteoporosis may account for surgeons offering more RSA and HA to women in the 65 years and older cohort of our study due to concerns of poor bone healing. Moreover, Rajaee et al documented RSA was replacing HA as the most common arthroplasty procedure performed for proximal humerus fractures in patients 65 years and older, a finding similar to our study.[36] Although screening patients at risk for osteoporosis and giving pharmacological treatment when indicated decreases the risk of proximal humerus fractures by 45%, Ross et al reported these strategies have been initiated in less than 20% of patients after fragility fractures.[41,44]

The first instance of a proximal humerus fragility fracture in patients older than the age of 50 years is often an indication of osteoporosis and may be a sign of future impending fractures in other locations.[8,23,40] Women demonstrate the effects of decreased bone mineral density due to type I osteoporosis typically within the first 15 years of menopause, which manifest in the setting of estrogen deficiency.[10] This decrease in bone mineral density is further exacerbated as patients age due to type II osteoporosis, which may result in more severe fractures warranting initial joint arthroplasty instead of other operative management. In a 2020 study, Yahuaca et al reported age to be associated with surgical treatment selection for proximal humerus fractures such that patients older than 65 years had significantly more arthroplasty procedures, whereas those aged 65 years and younger had significantly more ORIF procedures.[52] Although this particular finding differed from our study, the trend was similar such that as patients aged, the rate of RSA procedures increased, whereas the rate of ORIF procedures decreased for both genders.

Although physiological differences may account for some of the proximal humerus fracture treatment selection, there may also be cultural and societal aspects, which could influence the shared decision-making of the surgeon and the patient. Despite modernization of attitudes toward social roles, the U.S. Department of Labor reported women spending a disproportionate amount of time compared with men taking care of children and the elderly while also serving as primary medical decision makers in the family.[29,46] Due to having greater household responsibilities, younger women may require operative treatments, which have been associated with better range of motion and reduced pain in the early postoperative period.[17] This finding may account for the higher likelihood of women in the 50- to 64-year-old cohort of our study receiving operative treatment.

With different attitudes, responsibilities, and activity level, treatment selection may be influenced by changing socioeconomic factors related to aging. Munnell et al reported U.S. men retire on average at the age of 64 years, which is 2 years later than women.[33] As nonoperative management is certainly the most common treatment option for proximal humerus fractures with a simple pattern, minimal displacement, and less comminution, younger men who have yet to retire may be more amenable to this treatment option due to the inability to take time off from work and concern for the need for secondary procedures if a primary operation fails.[19,20] In the present study, men in the 50- to 64-year-old cohort were demonstrated to have a significantly lower likelihood of receiving surgical treatment; however, if an operation was performed, they were more likely to receive HA as this may allow less pain and adequate range of motion if tuberosity healing is achieved.[1] As per a recent Centers for Disease Control and Prevention (CDC) report, although the peak life expectancy decreased for both genders from 2019 to 2020 due to increased mortality from COVID-19, U.S. women compared with men still continued to have a greater average life expectancy, 80.2 years vs. 74.5 years, respectively.[2] Although women tend to live longer than men, our study found no difference in the 65 years and older cohort with respect to gender in who received operative treatment for a proximal humerus fracture.

RSA has become increasingly popular as an acute treatment option for severe proximal humerus fractures in older patients.[38] This has been largely attributed to the excellent functional outcomes and low revision rates reported as well as a decline in HA utilization.[30] In a 2018 meta-analysis, Gallinet et al demonstrated

RSA, regardless of tuberosity healing, to be a more reproducible procedure with improvement in active forward flexion and abduction compared with HA, which relies on tuberosity healing to achieve good functional outcomes.[12,43,51] In addition, primary RSA after complex proximal humerus fractures in the elderly was documented to restore quality of life with 84% of patients returning back to their level of independency at 6 months and 91% at 1 year.[50] Moreover, in the same study, 97% of elderly patients at 1 year had improved pain control after RSA by returning to their preinjury level of analgesia intake. In our study, as patients aged, RSA utilization increased from 3.13% to 8.02% in men and from 3.41% to 11.87% in women, suggesting RSA may be better suited in patients 65 years and older than in the younger cohort. Previous literature has further reported a variable rate of complications after RSA for proximal humerus fractures, ranging between 10% and 75%.[31,47,49] In older patients with an American Society of Anesthesiologists (ASA) score of at least 3, Noguera et al reported a significant increase in major complications at the 90-day postoperative mark after RSA for a proximal humerus fracture.[34] In addition, Ezuma et al documented men were 2.38 times more likely to have perioperative and postoperative RSA complications and 10.59 times more likely to return to the operating room for an unplanned reoperation than women even though significantly more women compared with men older than 65 years underwent RSA for proximal humerus fractures.[11] Male patients and patients with multiple comorbidities in the setting of a complex proximal humerus fracture may be at a higher risk of complications with RSA. In concert with previous literature, the present study reported men in the 65 years and older cohort to be significantly less likely to receive RSA for a proximal humerus fracture than similarly aged women.

This study has several limitations. Using a large database, there is a possibility of coding discrepancies, which can occur through ICD-9 and ICD-10 codes being manually examined and queried for this study. In addition, coding descriptions may differ for any given ICD-9 and ICD-10 code. Therefore, a code translator was used to reduce this potential limitation to ensure the used ICD-9 codes corresponded with ICD-10 codes for a given diagnosis/procedure. Human error created from inputting medical billing codes is an inherent limitation of this administrative claims study. However, this would have minimal impact on the results obtained as it has been documented from a 2019 Centers for Medicare and Medicaid Services report such instances make up only 1.0% of overall payments.[53] Identifying TSA and RSA procedures with ICD procedural codes creates a possibility that the total number of procedures was undercounted. However, given that the main code used for TSA and RSA (CPT-23472) includes both procedures, this decision was necessary to maintain specificity. Similarly, code CPT-23616 is commonly used when coding for HA, TSA, and RSA for proximal humerus fracture; however, these three procedures are aggregated together under this one code. Thus, for this study, it was excluded to maintain specificity when identifying patients for these procedures. This was unlikely to have a large effect on the study numbers as the number of patients with CPT 23616 was compared with the total patients using ICD procedural codes, and they were found to be comparable. Outcome and complication data were not collected in this query and therefore cannot be evaluated. Although this study was inclusive of most proximal humerus fractures by including diverse fracture patterns ranging from nondisplaced to 4-part fractures, treatments for specific diagnosis codes were not examined.

## Conclusion

Both age and gender have an association with the definitive treatment patients received for proximal humerus fractures over the last decade. Women younger than 65 years of age were more likely to undergo operative treatment, although once older than 65 years, there was no influence of gender on operative treatment. Men younger than 65 years were more likely to receive arthroplasty and women, more likely to undergo ORIF; however, as patients reached the age of 65 years and older, this finding was reversed such that women were more likely to receive arthroplasty and men, ORIF. Further exploration into these differences could improve decision-making between surgeons and patients.

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Conflicts of interest: Dr Savoie has AAOS affiliations as the first Vice President and has received royalties from Exactech, Conmed, Zimmer Biomet, and Smith & Nephew. However, these affiliations and royalties are not related to the subject of this article. The other authors, their immediate families, and any research foundation with which they are affiliated did not receive any financial payments or other benefits from any commercial entity related to the subject of this article.

## Supplementary Data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jseint.2021.11.007.

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