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# Mid- to long-term follow-up of shoulder arthroplasty for primary glenohumeral osteoarthritis in patients aged 60 or under

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**Background:** Shoulder arthroplasty in young patients with primary glenohumeral osteoarthritis is an area of continued controversy.

**Methods:** A retrospective multicenter study was performed for all patients aged 60 years or less undergoing either hemiarthroplasty (HA) or total shoulder arthroplasty (TSA) for primary glenohumeral osteoarthritis with a minimum of 24-month follow-up. Clinical and functional outcomes, complications, and need for revision surgery were analyzed. Survivorship analysis using revision arthroplasty as an endpoint was determined.

**Results:** A total of 202 patients with a mean age of 55.3 years (range, 36–60 years) underwent TSA with a mean follow-up of 9 years (range, 2–24.7 years). Revision arthroplasty was performed in 33 (16.3%) shoulders, with glenoid failure associated with the revision in 29 shoulders (88%). TSA survivorship analysis demonstrated 95% free of revision at 5 years, 83% at 10 years, and 60% at 20-year follow-up. A total of 31 patients with a mean age of 52.5 years (range, 38–60 years) underwent HA with a mean follow-up of 8.7 years (range, 2–21.4 years). Revision arthroplasty was performed in 5 (16.1%) shoulders, with glenoid erosion as the cause for revision in 4 shoulders (80%). HA survivorship analysis demonstrated 84% free from revision at 5 years and 79% at the final follow-up. TSA resulted in a significantly better range of motion, pain, subjective shoulder value, and Constant score compared with HA.

**Conclusion:** In young patients with primary glenohumeral osteoarthritis, TSA resulted in significantly better functional and subjective outcomes with no significant difference in longitudinal survivorship compared with patients treated with HA.

**Level of evidence:** Level III; Retrospective Cohort Comparison; Treatment Study

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**Keywords:** Shoulder arthroplasty; glenohumeral arthritis; primary arthritis; total shoulder arthroplasty; hemiarthroplasty

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Management of glenohumeral osteoarthritis in young patients is challenging and represents an area of continued controversy. Numerous treatment strategies have been proposed including arthroscopic management,<sup>17,24,38</sup> hemiarthroplasty (HA),<sup>10,20,41,42,48</sup> humeral head resurfacing,<sup>2,27</sup> HA with glenoid resurfacing,<sup>18,43,47</sup> total shoulder arthroplasty (TSA),<sup>3,8,13,19,33,34</sup> and reverse TSA.<sup>12,36</sup> Despite the reliable benefits of shoulder arthroplasty on pain and functional improvement,<sup>10,14,22,26,28,49,50</sup> concerns pertaining to implant longevity and the need for revision surgery in a population that often desires to return to an active lifestyle remain at the core of the treatment dilemma.<sup>3,8-11,19,20,34,41,42</sup>

The role of shoulder arthroplasty in young patients with primary glenohumeral osteoarthritis is not clearly defined. These patients represent only approximately 5% to 10% of the shoulder arthroplasty population.<sup>3,33,39</sup> Younger patients considering shoulder arthroplasty have higher preoperative expectations regarding their postoperative function, including the ability to return to sports and exercise.<sup>16</sup> Recent evidence suggests a high proportion of patients can return to demanding recreational activity or sports after shoulder arthroplasty.<sup>23,35,50</sup> However, outcomes for younger patients undergoing shoulder arthroplasty have not been as reliable.<sup>3,8,34,41,42</sup> In addition, most of the literature in young patients consists of smaller single-center studies with heterogeneous patient populations.<sup>6,20,21,29,34,41,42</sup>

The purpose of this multicenter study was to longitudinally evaluate young patients ( $\leq 60$  years old) undergoing primary shoulder arthroplasty for primary glenohumeral osteoarthritis. We sought to evaluate functional and subjective outcomes and implant survivorship in patients undergoing HA compared with TSA. Our hypothesis was that patients treated with TSA would have better functional and subjective outcomes, but would have worse survivorship due to glenoid component loosening compared with HA.

## Materials and method

A retrospective review from 1992 to 2016 was performed for all patients undergoing primary shoulder arthroplasty for symptomatic primary glenohumeral osteoarthritis across 9 centers. Inclusion criteria included age equal to or less than 60 years at the time of surgery, underlying diagnosis of primary glenohumeral osteoarthritis, primary shoulder arthroplasty with either a stemmed metallic HA or TSA, use of an all-polyethylene glenoid component for TSA, and a minimum follow-up of 2 years. Exclusion criteria consisted of diagnoses other than primary osteoarthritis, patients treated with revision arthroplasty, resurfacing arthroplasty, stemless arthroplasty, interposition arthroplasty (snooker ball) or reverse shoulder arthroplasty, TSA with a metal backed glenoid, and incomplete radiographic and clinical information at the final follow-up. Any surgical procedure after the initial arthroplasty where the components were retained was considered a reoperation, whereas if the components were removed or exchanged, it was considered a revision.

During the study period, we identified 233 shoulders with a diagnosis of primary glenohumeral osteoarthritis, which were

**Table I** Baseline demographic information for the entire cohort of patients undergoing either hemiarthroplasty (HA) or total shoulder arthroplasty (TSA) for primary glenohumeral arthritis

	HA (n = 31)	TSA (n = 202)	P value
Age at surgery (yr)	52.5 (38-60)	55.3 (36-60)	.003
Age at the last follow-up (yr)	61.2 (49-80)	64.3 (47-78)	.016
Sex (male) (%)	48.4	49.5	.9
Duration of follow-up (yr)	8.7 (2-22.4)	9 (2-24.7)	.76

Baseline demographics for all patients undergoing primary shoulder arthroplasty. Data are expressed as means with range in parentheses.

treated with a primary HA or TSA. Of this cohort, 202 patients with a mean age of 55.3 years (range, 36-60 years) underwent TSA and 31 patients with a mean age of 52.5 years (range, 38-60 years) underwent HA (Table I). Of the patients treated with TSA, 10 (5%) required a reoperation and 33 (16.3%) required a revision shoulder arthroplasty. Of the patients treated with HA, 4 (12.9%) required a reoperation and 5 (16.1%) required revision shoulder arthroplasty.

Complete preoperative and postoperative clinical and radiographic data were available for 155 patients who underwent TSA and were free from revision arthroplasty at a mean final follow-up of 8.3 years (range, 2-24.7 years). Similar data were available for 21 patients treated with HA at a mean final follow-up of 9.9 years (range, 2-22.4 years) (Table II).

## Clinical analysis

Preoperative and postoperative clinical and demographic data were assessed and recorded independently at each institution. Range of motion (ROM) was assessed using a goniometer and consisted of active forward flexion in the scapular plane and

**Table II** Demographic information for patients undergoing either hemiarthroplasty or total shoulder arthroplasty who were free from revision

	Preoperative	Postoperative	P value
Active forward elevation ( $^{\circ}$ )	109 (80-170)	136 (90-180)	<.05
External rotation with arm at side ( $^{\circ}$ )	24 (-10 to 60)	27 (0-70)	>.05
Internal rotation (points)	4.6 (2-10)	5.6 (2-10)	>.05
Pain (points, 0-15)	5.8 (0-10)	10.3 (1-15)	<.01
Total Constant score (points)	44.3 (29-61)	59.8 (29.5-90)	<.01

Baseline demographics for all patients free from revision shoulder arthroplasty at follow-up. Data are expressed as means with range in parentheses.

external rotation with the arm at the side and at 90° of abduction. Internal rotation was measured based on a 10-point scale designed to limited measurement bias when assessing internal rotation after shoulder arthroplasty.<sup>44</sup> Additional outcome measures such as the Constant score<sup>32</sup> and the subjective shoulder value (SSV)<sup>15</sup> were assessed. Pain was evaluated based on the 15-point scale from the Constant score where a score of 0 represents the maximum pain and a score of 15 represents no pain.

## Radiographic analysis

Standardized plain radiographs as well as advanced imaging were obtained to evaluate the status of the rotator cuff and to better characterize glenoid morphology. Computed tomography or magnetic resonance imaging was available in 175 patients undergoing TSA and all 31 patients undergoing HA and was used to classify the glenoid type according to Walch's classification.<sup>4,46</sup> Among patients undergoing TSA, there were 48 (27.4%) A1, 33 (19%) A2, 39 (22.3%) B1, 44 (25.1%) B2, 4 (2.3%) B3, 6 (3.4%) C, and 1 (0.6%) D glenoids. Among patients undergoing HA, there were 7 (26%) A1, 5 (18.5%) A2, 2 (7.4%) B1, 7 (26%) B2, and 6 (22.2%) C glenoids. Postoperative radiographs were evaluated for signs of humeral and glenoid component failure, per-implant radiolucent lines, and progressive glenoid erosion in patients treated with HA. For patients treated with TSA, radiolucent lines (RLL) were assessed at 6 different locations around the glenoid and given a score of 0 to 3 at each location for a total score of 0 to 18.<sup>25</sup> Similar to Denard et al,<sup>8</sup> an RLL score of  $\geq 12$  was considered to signify radiographic loosening and when glenoid component migration was evident, a maximum score of 18 was assigned.

## Surgical technique

Various types of implants were used at the surgeon's discretion for both HA and TSA; however, all included patients had stemmed humeral implants with metallic heads. A total of 190 standard length stems and 43 short stem humeral components were used, of which 223 of 233 (96%) were Tornier Aequalis or Ascend Flex stems. Only cemented all-polyethylene glenoid components were included for patients undergoing TSA. The deltopectoral approach was used in 100% of patients. Management of the subscapularis also varied. The subscapularis was tenotomized in 64%, a subscapularis peel was used in 24%, and a lesser tuberosity osteotomy technique was used in 12%. The long head of the biceps was tenotomized or underwent tenodesis in 88.5% of patients.

## Statistical analysis

Descriptive statistics were determined and expressed as means, ranges, and percentages. Preoperative and postoperative clinical outcome scores were compared using the Wilcoxon signed-rank test. Subgroup analysis was performed with the Mann-Whitney *U* test. A 2-tailed Student's *t*-test was used for unpaired data. Implant survivorship was assessed by the Kaplan-Meier method to estimate survival probabilities with 95% confidence intervals, and the Logrank nonparametric test for comparison of survival distributions was used to compare the survival differences between TSA

and HA. The alpha risk was set to 0.05 for all tests to estimate statistical significance.

## Results

### Clinical results

At the final follow-up, 21 shoulders treated with HA and 155 shoulders treated with TSA were free of revision and had complete clinical data for assessment (Fig. 1). Comparison between patients undergoing HA and TSA who were free from revision demonstrated similar baseline demographics (Table II). Patients undergoing HA demonstrated significant improvement in ROM, pain, and Constant score (Table III). At the final follow-up, the mean subjective shoulder value was 69.9% (range, 30%-99%). For patients undergoing TSA, significant improvement was observed in ROM, pain, and Constant score (Table IV). At the final follow-up, the mean subjective shoulder value was 79.6% (range, 15%-100%).

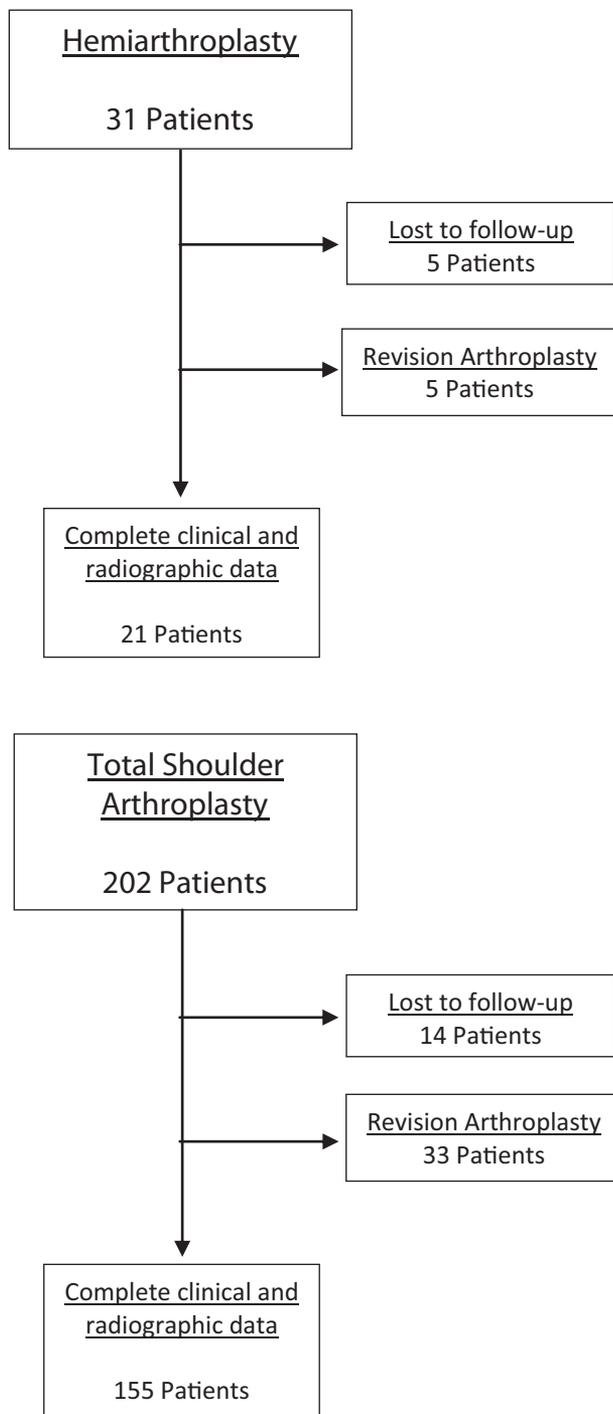
### Radiographic results

Postoperative radiographs of the 21 patients treated with HA who were free of revision surgery demonstrated glenoid erosion in 16 (76%) shoulders at the final follow-up. The extent of radiographic glenoid erosion appeared to progress over time. Patients without evidence of glenoid erosion had a mean follow-up of 4.9 years compared with a mean follow-up of 11.5 years in those patients with glenoid erosion. The small sample size limited meaningful analysis between shoulders with and without erosion; however, there was a trend toward worse functional outcome scores in those shoulders with glenoid erosion.

Postoperative radiographs of the 155 patients treated with TSA who were free of revision demonstrated a mean RLL score of 5.4 (range, 0-18). At a mean of follow-up 8.4 years, 23.8% (37) of TSAs had radiographic glenoid component loosening as denoted by an RLL score of  $\geq 12$ . Patients with an RLL of  $\geq 12$  had significantly worse ROM in all planes, pain, SSV, and Constant score compared with those with an RLL  $< 12$  (Table V). Patients without radiographic evidence of glenoid loosening had a mean follow-up of 6.6 years compared with those with radiographic evidence of loosening who had a mean follow-up of 12.8 years.

### Complications and survivorship

Postoperative complications occurred in 29% of shoulders treated with HA. The most common complications were progressive glenoid wear, followed by stiffness and pain. A total of 4 (12.9%) shoulders required reoperation and 5 (16.1%) shoulders required revision shoulder arthroplasty.



**Figure 1** Flow chart depicting cohort selection.

Glenoid wear was the cause for revision arthroplasty in 4 of 5 (80%) shoulders. Survivorship analysis of HA with “revision” as the endpoint demonstrated successive drops over time with 89% of the cases free of revision at 3 years, 84% at 5 years, and 79% after 8 years of follow-up. No further drop was observed after 8 years of follow-up (Fig. 2).

**Table III** Comparison of preoperative and postoperative range of motion and functional outcome scores of patients undergoing hemiarthroplasty (HA) who were free from revision

	HA (n = 21)	TSA (n = 155)	P value
Age at surgery (yr)	52.5 (38-60)	55.7 (36-60)	.065
Age at the last follow-up (yr)	62.4 (52-80)	64 (47-77)	.19
Sex (male) (%)	57.1	50.3	.56
Duration of follow-up (yr)	9.9 (2-22.4)	8.3 (2-24.7)	.25

TSA, Total shoulder arthroplasty.

Data are expressed as means with range in parentheses.

Postoperative complications occurred in 26.7% shoulders treated with TSA. The most common complication was glenoid loosening, which occurred in 39 (19.3%) shoulders. Overall, 10 (5%) reoperations and 33 (16.3%) revision arthroplasties were performed. Glenoid issues were associated with revision in 29 (88%) shoulders. The revision rates were not different between preoperative type A glenoids (A1 and A2) and type B glenoids (B1, B2, and B3) (14.1% vs. 20.5%, respectively;  $P = .28$ ). Survivorship analysis of TSA with “revision” as the endpoint demonstrated successive drops over time with 95% free of revision at 5 years, 83% at 10 years, 68% at 15 years, and 60% at 20 years of follow-up (Fig. 2).

### Hemiarthroplasty vs. total shoulder arthroplasty

#### Motion and function

At the final follow-up, patients free of revision who underwent TSA had significantly better ROM (except similar internal rotation), pain scores, and Constant score compared with those who underwent HA. Of note, the final SSV approached but did not reach statistical significance when comparing HA and TSA (69.9% vs. 79.6%, respectively;  $P = .07$ ) (Table VI).

**Table IV** Comparison of preoperative and postoperative range of motion and functional outcome scores of patients undergoing total shoulder arthroplasty who were free from revision

	Preoperative	Postoperative	P value
Active forward elevation (°)	104 (30-170)	150 (30-180)	.0001
External rotation with arm at side (°)	13 (-40 to 70)	37 (0-60)	.0001
Internal rotation (points)	3.4 (0-8)	6.8 (2-10)	.0001
Pain (points, 0-15)	5.1 (0-13.5)	12.5 (0-15)	.0001
Total Constant score (points)	37.5 (8-71)	73.3 (27-95)	.0001

Data are expressed as means with range in parentheses.

**Table V** Range of motion, functional, and subjective outcomes in patients treated with total shoulder arthroplasty (TSA) at the final follow-up comparing radiolucent line (RLL) scores

	HA (n = 21)	TSA (n = 155)	P value
Active forward elevation (°)	136 (90-180)	149 (30-180)	.023
External rotation with arm at side (°)	27 (0-70)	37 (0-60)	.021
External rotation with arm abducted (°)	45 (10-90)	63 (0-110)	.046
Internal rotation (points)	5.6 (2-10)	6.7 (2-10)	.071
Pain (points, 0-15)	10.2 (1-15)	12.5 (0-15)	.034
Total Constant score (points)	59.8 (29.5-90)	72.6 (27-95)	.003
Subjective shoulder value (%)	69.9 (30-99)	79.6 (15-100)	.070

HA, Hemiarthroplasty.

An RLL  $\geq 12$  signifies the radiographic appearance of a loose glenoid component. Data are expressed as means with range in parentheses.

**Table VI** Postoperative range of motion, functional, and subjective outcome scores of patients undergoing hemiarthroplasty and total shoulder arthroplasty who were free from revision

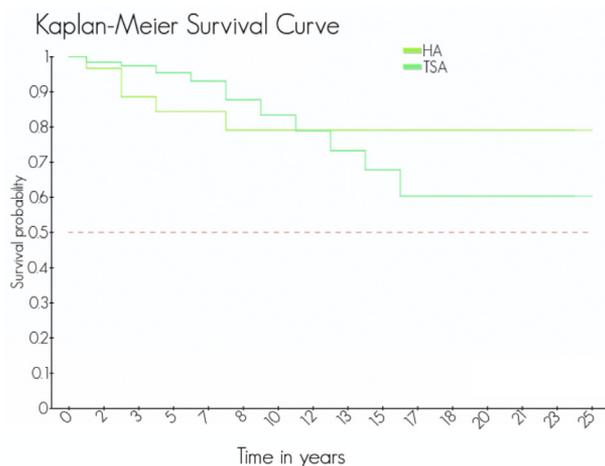
	RLL < 12	RLL $\geq 12$	P value
Active forward elevation (°)	153 (90-180)	140 (30-180)	.005
External rotation at side (°)	39 (0-60)	30 (0-70)	.028
External rotation at 90° abduction (°)	66 (0-110)	56 (0-80)	.027
Internal rotation (points, 0-10)	6.9 (2-10)	6 (2-10)	.032
Pain (points, 0-15)	12.8 (5-15)	11.5 (0-15)	.033
Total Constant score (points)	74.4 (28-95)	67.7 (27-91)	.011
Subjective shoulder value (%)	82.8 (40-100)	72.6 (15-100)	.005

RLL, Radiolucent line.

Data are expressed as means with range in parentheses.

### Complications and survivorship

Patients requiring revision arthroplasty after HA tended to do so earlier relative to those patients who underwent TSA. The majority of revision arthroplasty occurred by 5 years in the HA group compared with 15 years in the TSA group. Despite the differences in survival probability at the final follow-up, comparative analysis demonstrated no significant difference between the survival distribution when comparing TSA with HA ( $P = .91$ ). There was no significant difference in overall complications (29% vs. 26.7%;  $P = .73$ ) or revision rate (16.1% vs. 16.3%;  $P = .91$ ) when comparing HA with TSA.

**Figure 2** Kaplan-Meier survival curve for patients treated with hemiarthroplasty (HA; light green) and total shoulder arthroplasty (TSA; dark green) with revision arthroplasty as the endpoint.

### Discussion

At mid-term to long-term follow-up, the results of this multicenter study demonstrate favorable functional and subjective outcomes for young patients undergoing HA or TSA for primary glenohumeral osteoarthritis. Comparative functional analysis demonstrated statistically significant differences between these cohorts favoring TSA. Despite survivorship analysis demonstrating earlier revision with HA and a more precipitous decline in the TSA group particularly after 10 years, there was no statistical difference in the rate of revision or the survival distribution when comparing TSA with HA in young patients with primary osteoarthritis.

The current literature pertaining to glenohumeral arthritis in young patients is limited by heterogeneity within the study population and a lack of generalizability based on single-center or single-surgeon studies. Patient demographics and underlying disease etiology can impact prognosis after shoulder arthroplasty.<sup>9,30,33,39,42</sup> Saltzman et al<sup>33</sup> evaluated more than 1000 TSAs and found that younger patients (<50 years) undergoing shoulder arthroplasty had more complex pathology compared with an older group of patients. These authors suggested that preoperative diagnosis may be a more important factor for postoperative outcomes than simply age alone.<sup>33</sup> Satisfaction and pain relief after shoulder arthroplasty have also been significantly associated with underlying disease etiology.<sup>39</sup>

Current data evaluating shoulder arthroplasty in young patients contain relatively few patients with primary osteoarthritis.<sup>3,20,34,41,42</sup> Sperling et al<sup>41,42</sup> reported on mostly patients with post-traumatic and rheumatoid arthritis, with only 8 patients in their series treated for primary

osteoarthritis available for 20-year follow-up.<sup>34</sup> Levine et al<sup>20</sup> reported the results of 27 patients with long-term follow-up after HA; however, only 9 patients in this cohort were treated for primary osteoarthritis. Studies consisting of largely heterogeneous cohorts,<sup>6,9,11,19,21,23,35,39,48</sup> coupled with predominantly single-center or single-surgeon data, limit the generalizability of the current literature.<sup>3,11,20,29,30,34,39,41,42</sup>

The role of shoulder arthroplasty for primary osteoarthritis in young patients is often reported in an older patient population than described in this study.<sup>10,23,26,48</sup> Edwards et al<sup>10</sup> reported results of a large group of patients treated with shoulder arthroplasty for primary osteoarthritis; however, the mean age was 67.2 years with a range of 42-90 years. Studies by Rispoli et al<sup>30</sup> and Wirth et al<sup>48</sup> also have similar patient demographics. Unlike the aforementioned studies, our study consists of only young patients (below 60 years of age) treated for primary osteoarthritis with shoulder arthroplasty.

Patients in our study demonstrated significant improvement in pain and functional outcome scores at mid-term to long-term follow-up. Both the HA and TSA groups had significantly improved ROM across nearly all parameters, which is consistent with previously reported literature.<sup>10,19,20,26,31</sup> Both HA and TSA also resulted in significant improvements in pain and Constant score.<sup>37</sup> Similar to other authors,<sup>5,14,28,39</sup> our study indicates significant differences in ROM, Constant score, and pain favoring TSA. Moreover, although the mean SSV at the final follow-up favored TSA, this was not significantly different compared with HA.

Rates of complications after shoulder arthroplasty in the young patient have raised notable concerns and have been reported to be as high as 46.2%.<sup>3,8,10,19,31,41,42,45</sup> In our study, 26.7% of shoulders treated with TSA had at least 1 complication, with the majority of the complications relating to the glenoid. Similarly, 29% of shoulders undergoing HA had at least 1 complication, with progressive glenoid wear being the most common complication.

The most significant concern regarding shoulder arthroplasty in young patients pertains to implant longevity and subsequent need for revision surgery. Younger patients are likely to have increased life expectancy and higher demands on the prosthesis secondary to increased activity level after shoulder arthroplasty.<sup>23,35,50</sup> Underlying etiology<sup>42</sup> and younger patient age<sup>9,30,45</sup> have been associated with higher revision rates in this population. Our study demonstrated that the vast majority of revision arthroplasty was performed for glenoid-related issues. Of the shoulders that underwent TSA and ultimately required revision surgery, 88% were attributed to glenoid failure. We also found that 80% of the patients with HA who ultimately required revision were revised for progressive glenoid erosion.

Revision arthroplasty secondary to glenoid wear or glenoid component failure is common and results in inferior outcomes compared with primary arthroplasty.<sup>1,7,40</sup> Dillon et al<sup>9</sup> demonstrated that 70% of revision arthroplasty in younger patients was due to glenoid failure; however, contrary to our findings, they reported a higher risk of revision with HA compared with TSA. Levine et al<sup>20</sup> reported that 29% of patients treated with HA required revision arthroplasty at long-term follow-up, compared with our HA revision rate of 16.1%. Denard et al<sup>8</sup> reported on a series of young patients treated with TSA for primary osteoarthritis and noted that 24% required revision for glenoid failure, which is similar to our rate of revision in this population.

In our series, earlier revision arthroplasty was observed among the HA group, whereas a more precipitous decline was observed later on among the TSA population. The majority of revision arthroplasty occurred by 5 years in the HA group compared with 15 years in the TSA group. The predominance of early revision in the HA group likely reflects the cohort of patients not satisfied with their early pain relief or clinical outcome after HA. Conversely, survivorship of TSA dropped fairly precipitously after 10 years of follow-up, likely reflecting symptomatic glenoid component loosening and failure. Overall, there was no significant difference in revision rate or survivorship between HA and TSA. Our survivorship data for TSA are similar to what is reported by Denard et al,<sup>8</sup> who reported 62.5% revision free survivorship in patients with TSA who were younger than 55 years with primary osteoarthritis. The results of this study are different than what has been reported by other studies consisting of heterogeneous patient cohorts with long-term follow-up.<sup>3,34,41,42</sup>

This study has several limitations. The retrospective nature of this study subjects it to possible bias. The information for this study was analyzed through a collective database, which relies on individual upkeep and data input. In addition, this study was a multicenter study, and therefore, it is possible that variations in operative techniques, implants, and postoperative protocols could have influenced the results. However, we feel that this lends insight to more generalizable results because it avoids the implicit bias that is inherent to studies performed by a single surgeon or single institution.

This study has numerous strengths. To the best of our knowledge, this series represents the largest cohort of entirely young patients undergoing shoulder arthroplasty for primary osteoarthritis. This study also benefits from having mid-term to long-term follow-up with a large number of patients, which adds strength to our survivorship analysis. In addition, our comparative analysis between patients undergoing HA and TSA provides a unique insight into a controversial and challenging topic. Furthermore, the multicenter nature of this study

provides results that are more generalizable in comparison with series published by single surgeons or single institutions.

## Conclusion

For young patients with primary glenohumeral osteoarthritis, both primary HA and TSA provide pain relief as well as significant subjective and clinical improvement at mid-term to long-term follow-up. TSA results in superior objective and patient-reported outcomes compared with HA. Patients undergoing HA tended to require earlier revision arthroplasty, whereas those undergoing TSA demonstrated a more precipitous decline in survivorship particularly after 10 years. Ultimately, we demonstrated no statistical difference in the rate of revision or the overall survivorship free from revision when comparing TSA with HA. The results of this study allow surgeons to best counsel young patients with primary glenohumeral osteoarthritis considering shoulder arthroplasty regarding the potential benefits and risk of requiring revision arthroplasty with either HA or TSA.

## Disclaimer

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