

# Short to mid-term functional outcomes of stemless anatomical total shoulder arthroplasty in patients over 70 years of age

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## Abstract

**Introduction:** Anatomical total shoulder arthroplasty (ATSA) is the gold standard for treating primary glenohumeral osteoarthritis (GHOA) in patients with an intact rotator cuff. Recently, reverse total shoulder arthroplasty (RTSA) is increasingly used in patients over 70. Stemless ATSA designs aim to reduce stem-related complications and simplify revisions. This study evaluates functional outcomes and complication rates of stemless ATSA in patients aged 70+ with an intact rotator cuff and at least two years of follow-up.

**Methods:** Forty-three patients met the inclusion criteria. Outcomes were assessed using the Oxford shoulder score (OSS), subjective shoulder value (SSV), and numeric rating scale (NRS) for pain at rest and during activity. Postoperative complications were documented.

**Results:** Thirty-three patients completed follow-up (mean 49.2 months). OSS improved by a mean of 21.7 points (median 48, IQR 42.5–48). SSV increased by 49.5%, NRS pain decreased by 5.7 (rest) and 6.8 (activity), all statistically significant ( $P<0.001$ ). Complications included one revision for rotator cuff failure (3%) and one asymptomatic biceps tenodesis failure. No outcome differences were found between age groups 70–79 and 80+.

**Conclusion:** Stemless ATSA in patients aged 70+ with an intact rotator cuff yields significant functional improvement and low complication rates at short- to mid-term follow-up.

## Keywords

shoulder arthroplasty, glenohumeral osteoarthritis, stemless, anatomical total shoulder arthroplasty, elderly

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## Introduction

The prevalence of symptomatic glenohumeral osteoarthritis (GHOA) is significantly increasing due to a persistently aging population.<sup>1</sup> Initial management usually involves conservative treatment; however, for patients experiencing persistent GHOA-related pain with an intact rotator cuff, anatomical total shoulder arthroplasty (ATSA) is recommended. In elderly patients with primary GHOA and an intact rotator cuff, reverse total shoulder arthroplasty (RTSA) is often preferred. This preference is due to the increased likelihood of progressive rotator cuff degeneration associated with aging, which negatively impacts joint stability and shoulder biomechanics,<sup>2</sup> potentially contributing to the higher revision rates reported in ATSA compared to RTSA.<sup>3,4</sup> Generally, the age of 70 years is considered a threshold for recommending primary RTSA.<sup>5,6</sup> The utilization of stemless total shoulder arthroplasty designs has increased significantly since their first introduction in

2004, offering numerous advantages over stemmed designs, including avoidance of stem-related complications, reduced postoperative pain, reduced operation time, decreased blood

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loss, preservation of native humeral anatomy and relative ease of revision.<sup>7–10</sup> In particular, the SMR stemless design from Lima Corporate (Lima Corporate, S.p.A, Udine, Italy), introduced in 2014, is currently one of the only two convertible platform stemless systems available, along with the stemless design of FX Solutions (Easytech® Anatomical, FX Solutions, Viriat, France), allowing an easy revision from ATSA to RTSA with humeral core retention.<sup>11</sup>

Recent studies indicate that stemless designs provide similar long-term clinical outcomes, complication rates, and revision rates when compared to stemmed ATSA.<sup>10,12,13</sup> As people age, bone quality decreases, and the risk of developing osteoporosis increases.<sup>14</sup> This can impact the fixation of prostheses. This situation leads to the question whether a stemless design, which depends only on metaphyseal fixation, provides adequate stability for long-term durability and functionality in elderly patients. Alternatively, it may be worth considering whether a stemmed design or a reversed design would be more appropriate for this specific group of patients. To the authors' best knowledge, two studies have investigated stemless ATSA in elderly patients.<sup>15,16</sup> Singh et al. included elderly patients in their study, but most participants were under 70 years old. Only Baumgarten et al. specifically assessed the functional outcomes of stemless ATSA in patients aged 70 and older, and their study had a maximum follow-up period of just two years. This highlights a significant research gap and underscores the need for long-term studies on stemless ATSA in individuals over 70. Therefore, this study aims to evaluate the functional outcomes and complication rates of primary ATSA in patients aged 70 and older, with a minimum follow-up period of two years.

## Materials and method

### Design

The current study has a retrospective design and utilizes cross-sectional data collected during the follow-up period. After obtaining approval from the institutional review board (nr. 2023.0067), participants were identified using the anonymized data collection tool CTcue®. Patients were approached via mail, which included a patient information file and written informed consent and were contacted by telephone to address any questions and provide additional information as needed. Patients who provided written informed consent received patient-reported outcome measures (PROMs) questionnaires by mail, or, if they were not residing at their home address, PROMs were administered over the phone.

### Patient inclusion

From January 2016 to December 2022, all patients aged 70 years and older who received stemless anatomical total shoulder arthroplasty (ATSA) for primary glenohumeral osteoarthritis (GHOA) with an intact rotator cuff were

**Table 1.** In- and exclusion criteria.

Inclusion criteria	Exclusion criteria
<b>Age ≥ 70 years.</b>	Secondary glenohumeral degeneration (e.g., post-traumatic arthritis, inflammatory or infectious arthritis, metabolic disorders).
<b>Primary glenohumeral osteoarthritis (GHOA) with intact rotator cuff.</b>	Avascular necrosis (>20% of humeral head).
<b>Underwent stemless anatomical total shoulder arthroplasty (ATSA).</b>	Non-traumatic fractures due to osteoporosis or systemic bone diseases.
<b>Adequate bone quality (assessed pre- and intraoperatively).</b>	Steroid injections in the last 3 months.
<b>Provided written informed consent.</b>	Previous or revision shoulder arthroplasty.
	Post-traumatic tuberosity nonunion.
	Active infection in the shoulder or septicemia.
	Neuromuscular shoulder dysfunction (e.g., deltoid impairment).
	Systemic autoimmune diseases or recent malignancy treatment (<2 years).
	Alcohol or drug abuse.

included in the study. Cases involving revision shoulder arthroplasty, as well as patients with secondary GHOA, avascular necrosis, or systemic diseases causing secondary glenohumeral degeneration, were excluded (Table 1). All surgeries were performed at—by the two senior authors (— and —), and data was prospectively collected in a computerized shoulder arthroplasty database.

Eligibility for stemless anatomical total shoulder arthroplasty was determined using standard anteroposterior and axillary radiographs, a comprehensive clinical evaluation, and, in cases without clinically evident rotator cuff impairment, imaging such as MRI or ultrasound combined with computed tomography to assess rotator cuff integrity and glenoid morphology. The glenoid shape was evaluated using the modified Walch classification, which defines morphology in types A (1 or 2), B (1, 2, or 3), C (1 or 2),

and D.<sup>17–19</sup> In this study, Walch types A1, A2, B1, and B2 were considered suitable for stemless ATSA.

### Surgical approach and postoperative protocol

All stemless ATSA procedures were performed in the beach-chair position using the standard deltopectoral approach. A subscapularis tenotomy was performed in each case. During surgery, the quality of the rotator cuff and metaphyseal bone was assessed and documented.

To assess metaphyseal bone quality, the ‘thumb test’ was performed, which involves applying minimal force with the thumb to evaluate the compressibility of the metaphyseal bone. A negative result, indicating that the bone cannot be compressed, suggests sufficient metaphyseal bone quality to support the press fitted stemless total shoulder arthroplasty. The SMR stemless system (Lima Corp., Udine, Italy) was used in all cases. Different types of glenoid components were used, including metal-backed, hybrid and the all-polyethylene cemented components.

After surgery, patients wore a shoulder immobilizer for the first six weeks to promote healing following reattachment of the subscapularis tendon. During this period, they also engaged in a progressive program of both passive and active mobilization exercises. Standard follow-up evaluations took place at six weeks, three months, one year, and five years after the procedure, or more frequently if needed. A final clinical and radiographic assessment was scheduled at ten years post-surgery, assuming there were no complications and the patient outcomes were satisfactory. However, this study did not extend beyond the ten-year follow-up period.

### Patient reported outcome measures

The functionality of the affected shoulder was assessed using the Oxford shoulder score (OSS), the subjective shoulder value (SSV) and the numeric rating scale (NRS) for pain, both before surgery and at the final follow-up. The OSS provides a total score that ranges from 0 to 48, with higher scores indicating greater shoulder functionality.<sup>20</sup> The SSV is a single question score, where patients rate their shoulder function as a percentage of a completely normal shoulder.<sup>21</sup> The NRS for pain experienced is a score that aims to quantify pain at rest and during activity on a scale from zero (no pain) to ten (maximal pain).<sup>22</sup>

### Complications

All complications and revision procedures were identified by reviewing the patient’s files, including cases where patients revisited the surgeon outside of standard follow-up terms, as well as the reasons for revision. These complications were categorized into perioperative and postoperative events.

### Analysis

All outcome measures were collected and managed electronically using Research Manager (Research Manager, Deventer, Netherlands) and were further analyzed using SPSS statistics version 29.0 (IBM Corp. Released 2023. IBM SPSS Statistics for Windows, Version 29.0. Armonk, NY: IBM Corp.).

Continuous data is presented as mean and standard deviation (SD) in case of normality, otherwise medians and interquartile ranges (IQR) are used. Categorical variables are presented as percentages with accompanying proportions. As PROMs did not meet normality criteria due to ceiling effect at follow-up, they are presented as medians accompanied by IQRs. PROMs are reported as change from baseline (CFB) for the outcomes OSS, SSV, NRS rest and NRS activity, all of which were normally distributed. A One-sample T-test was conducted to evaluate the CFB using 0 as reference value and is presented as mean values with 95% confidence intervals (CI), with statistical significance set at  $P < 0.05$ . An age sub-analysis was performed to assess differences in mean CFB PROMs using an independent T-test reporting mean values with 95% confidence intervals and corresponding p values. A significance threshold of  $P < 0.05$  was considered indicative of statistical significance (for all analysis).

## Results

### Patient demographics

A total of 126 patients received stemless ATSA between January 2016 and December 2022. A total of 43 patients were aged 70 years and older and received a stemless ATSA for primary GHOA. In one case, an intraoperative fracture during stemless implant placement required conversion to a stemmed TSA which led to the patient’s exclusion from this study. At follow-up, three patients were unresponsive, and six had passed away, resulting in a final cohort of 34 invited patients. Of which 33 patients provided informed consent, all these patients completed the PROM’s and were included for final analysis (Table 2). At the time of the stemless total shoulder procedure, the mean age of the cohort was  $75.5 \pm 4.6$  years (range 70–87), with 63.6% of patients being women (21 vs 12). The mean time to follow-up was  $49.2 \pm 3.3$  months (range 24–104).

There was no significant association between the side of the affected shoulder and hand dominance ( $P = 0.70$ ).

### Patient reported outcomes

The final follow-up PROMs were completed and available from all patients. In three cases (10%), pre-operative OSS values were missing, resulting in 30 cases being analyzed for OSS-CFB.

**Table 2.** Patient demographics.

Total number of patients	33 (100%)
Age at surgery (years)	75.5 ± 4.6 (70–87)
Sex	
Male	12 (36%)
Female	21 (64%)
Affected shoulder	
Left	11 (33%)
Right	22 (67%)
Dominant hand	
Left	4 (12%)
Right	26 (79%)
Missing	3 (9%)
Weight (kg)	78.7 ± 14.62 (50–120)
Height (cm)	169.7 ± 9.52 (152–198)
Body mass index (kg/m <sup>2</sup> )	27.4 ± 4.91 (19.8–44.1)
ASA score	
I	3 (9%)
II	20 (61%)
III	10 (30%)
Smoking	
Yes	2 (6%)
No	30 (91%)
Missing	1 (3%)

Continuous variables are summarized as mean ± standard deviation | (range).

Categorical variables are summarized as number of patients in each category (percentage).

**Primary outcome measure.** The OSS-CFB had significantly increased with a mean value of 21.7 (95% CI: 18.9–24.5, P < 0.001) (Table 3).

**Secondary outcome measures.** The median SSV at follow-up was 98.0% (IQR 90–100). The SSV-CFB had significantly increased with a mean value of 49.5% (95% CI: 41.3–57.7, P < 0.001). Moreover, the median NRS at rest and activity at follow-up were both 0 (IQR 0–0) and 0 (IQR 0–1.5) (Appendix 1). The NRS rest CFB and NRS activity CFB were both significant, with a mean of 5.7 (95% CI: 4.9–6.4, p < 0.001) and 6.8 (95% CI: 5.9–7.6, p < 0.001), respectively.

**Table 3.** Change from baseline for patient reported outcomes measures.

CFB PROMs	Mean, 95% CI	P value
CFB-OSS	21.7 (18.9–24.5)	P < 0.001
CFB-SSV	49.5 (41.3–57.7)	P < 0.001
CFB-NRS at rest	-5.7 (4.9–6.4)	P < 0.001
CFB-NRS during activity	-6.8 (5.9–7.6)	P < 0.001

CFB: Change from Baseline; PROMs: Patient Reported Outcome Measures; OSS: Oxford shoulder score; SSV: Subjective shoulder value; NRS Numeric rating scale for pain.

An age sub-analysis compared mean PROMs-CFB between patients aged 70–79 (n = 27) and those aged 80 and above (n = 6). No significant differences were found in OSS-CFB (p = 0.24), SSV-CFB (p = 0.46), NRS-rest CFB (p = 0.99), or NRS-activity CFB (p = 0.32) between the two age groups.

### Intraoperative findings

According to the Walch classification, glenoid morphology was distributed as follows: A1 (n = 5, 11.4%), A2 (n = 17, 38.6%), B1 (n = 9, 20.5%), and B2 (n = 2, 4.5%) (Table 3). The median glenoid retroversion observed was 6 degrees (IQR 0–11). Glenoid components included hybrid (n = 20, 45.5%), cemented three-peg (n = 7, 15.9%) and metal-backed (n = 6, 13.6%) designs. The mean surgical time, addressing the time from incision to full skin closure was 104 ± 12 min.

### Complications

Perioperatively, one patient (3%) initially planned for a stemless TSA required conversion to a stemmed TSA due to a fracture of the greater tubercle of the humerus, which, though excluded from this study, should be noted as a complication. No other perioperative complications occurred in this study's cohort.

Postoperatively, three complications (9%) were observed. One patient required revision surgery at 41 months following the primary procedure due to a dysfunctional rotator cuff. Radiographs showed a persistent upward migration of the humeral head, similar to the early postoperative images. Upon reevaluation, this suggested a rupture of either the supraspinatus or the cranial infraspinatus. A revision to a stemless Reverse Total Shoulder Arthroplasty (RTSA) was performed with relative ease, aided by the modular design of the system. One year after the initial procedure, a second case presented an asymptomatic failure of a biceps tenodesis, indicated by the “popeye sign” during clinical assessment, while the rotator cuff remained asymptomatic.

Thirdly, a patient revisited the surgeon 29.5 months after the primary procedure because of symptomatic AC arthritis, which has since been effectively treated with corticosteroid injections.

## Discussion

The current study aimed to evaluate the functional outcomes of primary stemless ATSA in patients aged 70 years and older who have primary GHOA and an intact rotator cuff, with a minimum follow-up of two years. This is the first study to present short to mid-term functional outcomes of stemless ATSA specifically in this age group.

At a mean follow-up of 49.2 months, the results indicated both statistically significant and clinically meaningful improvements in patient-reported outcome measures (PROMs), including the Oxford shoulder score (OSS), subjective shoulder value (SSV), numerical rating scale (NRS) for pain at rest, and NRS during activity. These findings support previous studies that highlight the effectiveness of stemless designs in managing primary GHOA.<sup>23,24</sup> The OSS-CFB observed in this cohort (mean 21.7,  $P < 0.001$ ) surpasses the minimal clinical important difference (MCID) of 6 points<sup>25</sup> indicating an evident and significant improvement in shoulder functionality. Similarly, the SSV-CFB (mean 49.5), NRS for pain at rest (mean -5.7) and during activity (mean -6.8) exceeded the threshold for substantial clinical benefit (SCB) where applicable or showed evident improvement, confirming effective symptom relief.<sup>26</sup>

Research on the outcomes of stemless ATSA in elderly patients is limited. To the best of the authors' knowledge, only two studies specifically address this topic. One of these studies, conducted by Baumgarten et al., evaluated functional outcomes and complication rates over a two-year follow-up period in 108 cases of stemless ATSA. This study compared the results of 64 patients under the age of 70 with those of 44 patients aged 70 years and older.<sup>16</sup> Similarly, Singh et al. reported outcomes for 30 cases of stemless ATSA in elderly patients, with a minimum follow-up of 33 months, although they did not define elderly, their cohort had a mean age of 68.6 years (range 56–78) with over half of their patients aged below 70.<sup>15</sup> While these two studies report good results, all exceeding MCID and substantial clinical benefit thresholds, similar to the current study and provide points of reference, differences in functional outcome measures complicate direct comparisons with our results.

To compare our results with studies using the same outcome measures, it is necessary to include studies involving patients from different age groups and different follow-up.

Smith et al.<sup>27</sup> observed 129 cases with a mean age of 66.6 years and reported functional outcomes of stemless ATSA (Global ICON, DePuy Synthes, Warsaw, IN, USA) at 12 months follow-up. They reported an OSS improvement of 21.6 points from baseline to 12 months

follow-up which is in line with the reported CFB for OSS of our study (mean 21.7). Moreover, Batten et al.<sup>28</sup> examined 99 shoulders with primary GHOA who received stemless ATSA (Arthrex Eclipse, Naples FL, USA). They reported a mean OSS of 40.2 (95% CI: 38.8–42.2) at a mean follow-up of 6.7 years. Our findings reported a median OSS of 48.0 (IQR: 42.5–48.0) at follow-up. Discrepancies in scoring methods, follow-up duration and cohort size may explain these differences. Notably, Batten et al. found no significant decline in OSS between 2 and 5 years post-surgery after conducting a time-dependent deterioration analysis. This suggests that functional outcomes are not influenced by a decrease in prosthesis durability over time and are not suggestive of the differences found in OSS scores at follow-up. Despite our evidently older cohort, functional outcomes reported appear similar or even slightly superior compared to previous stemless ATSA studies.

We described a low revision rate, with one case requiring a revision (3%) to a stemless RTSA due to rotator cuff failure. Although the increasing preference for RTSA is based on the assumption that elderly patients are at higher risk for rotator cuff dysfunction, leading to more frequent ATSA failures compared to RTSA, the low revision rates observed in our study, consistent with Baumgarten et al.<sup>16</sup> and findings from multiple studies on stemmed ATSA, do not support this hypothesis.<sup>29,30</sup>

In fact, elderly patients, who often have lower activity levels, may even experience a protective effect against secondary rotator cuff tears. Some studies suggest that this decrease in physical activity could reduce their risk of requiring revision surgery, when compared to younger, more active individuals who are at a higher risk.<sup>31,32</sup>

Also, our findings, along with Baumgarten et al.<sup>16</sup> support the viability of stemless designs, even in older patients with reduced bone quality, as no conversions to stemmed implants were required due to instability.

Moreover, recent studies reported that while both ATSA and RTSA generally lead to similar functional outcomes, ATSA provides better external rotation or in some studies general greater range of motion compared to RTSA.<sup>3,29,33</sup>

Based on our findings, and in line with previous studies, solely age should not be considered as a contradiction when choosing stemless ATSA.<sup>3,4,34</sup> Age may be considered as a covariate alongside other relevant variables. For example, studies examine the classification of fatty infiltration, muscle atrophy, and glenoid morphology using the Walch classification to more accurately predict the risk of revision.<sup>35–37</sup> Although these studies represent significant progress, they have not yet yielded universally applicable results to help determine the best choice between an ATSA and a RTSA for elderly patients. Future larger, multicenter studies are necessary to identify variables that could enhance decision-making between ATSA and RTSA and to clarify the suitability of stemless versus stemmed designs.

This study has several limitations that must be acknowledged. First, the relatively small sample size ( $n=34$ ) and single-center design limit the generalizability of the findings. Additionally, functional range of motion assessments could not be collected due to the design of this study. Moreover, this study only shows the short to mid-term results, making it difficult to draw conclusions about long-term outcomes. Finally, this study lacks a control group for direct comparison between subgroups or different surgical approaches which also reduces generalizability of the findings. Given the aging population, these gaps should be further explored through larger controlled studies with long-term follow-up.

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### Contributorship

AvN, TDWA and JIPW researched literature and conceived the study. FJKJ, MW IS, and JIPW were involved in protocol development, gaining ethical approval, patient recruitment and data analysis. JIPW and FJKJ wrote the first draft of the manuscript. All authors reviewed and edited the manuscript and approved the final version of the manuscript.

### Declaration of conflicting interests

The authors declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: AvN has a consultant agreement with Lima Corp., Udine, Italy.

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Written informed consent was obtained from the patient(s) for their anonymized information to be published in this article.

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