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Subscapularis management in stemmed and stemless total shoulder arthroplasty: a surgeon decision-making analysis study

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Background: Stemless total shoulder arthroplasty (TSA) continues to grow in popularity as an evolution of stemmed humeral implants. Proposed advantages include bone preservation and ease of potential revision. However, absence of a stem may necessitate a change in subscapularis takedown approach. Specifically, there is theoretical concern about violation of supportive bone with lesser tuberosity osteotomy when using a stemless device. Therefore, the goal of this study was to identify if surgeons change their subscapularis takedown preference when performing stemless vs. stemmed TSA.
Methods and materials: Data from a consecutive series of patients who underwent stemmed and stemless TSA at an academic institution were collected. The subscapularis management technique was documented. Subscapularis takedown techniques were divided into 2 groups: soft-tissue approach (subscapularis tenotomy or peel) and bony approach (lesser tuberosity osteotomy). Historical preference for each surgeon was determined by evaluating techniques employed using stemmed TSA. A Cramers V analysis was run to determine the strength of association between this historical preference and subscapularis management technique used for stemless TSA.
Results: One hundred and fifty-four patients were included in this analysis. There were 72 and 82 stemmed and stemless arthroplasty cases performed, respectively. Of the 154 patients, 50.6% were women. The average age of patients was 64.2 years. Four surgeons were included in this study. In all, there were 79 and 75 bony and soft-tissue subscapularis techniques, respectively. The historical preference for 3 of the surgeons was a subscapularis bony approach, and the historical preference for one of the surgeons was a soft-tissue approach. A Cramer's V analysis was used to measure the relative strength of association between patient factors, historical subscapularis management preference, and subscapularis takedown approach in stemless TSA. Our analysis yielded a value of 0.65 ($P < .01$), indicating a redundant association between subscapularis management approach used between stemmed and stemless implant per surgeon.
Conclusion: In determining subscapularis tendon management strategy, in surgeons who performed stemmed TSA before stemless TSA, the subscapularis takedown approach used for stemless TSA is strongly associated with surgeon's historical preference for stemmed TSA. Future research will be needed to determine the clinical ramifications of this finding.

Total shoulder arthroplasty (TSA) continues to be the gold standard for surgical management of end-stage glenohumeral degenerative joint disease.[6,9,10,14-17,20,21,23] As a result, the incidence of TSA continues to climb.[22] Despite high rates of satisfaction, there continues to be concern regarding long humeral stems.[14] Some concerns include intraoperative fracture, challenging revision procedures, difficulty in the setting of abnormal proximal humeral anatomy, and a variety of other issues.[14] As a result, humeral stem length has progressively decreased.[30]

The advent of stemless TSA has been met with excitement as it obviates some of the potential complications associated with stemmed TSA.[30] However, there are concerns regarding this new technology including nonanatomic humeral head cut angles and aseptic loosening.[5,33,37] Another concern involves appropriate management of the subscapularis tendon when using this new technology.[3] It is unclear how surgeons may modify their techniques to accommodate a stemless TSA. For example, whether a

Duke Health Institutional Review Board approved this study.
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Table I
Descriptive statistics stratified by repair technique (N = 154).

Rotator cuff repair technique	Bony repair (N = 79)	Soft-tissue repair (N = 75)	P value
Age	67.9 (±10.7)	60.5 (±10.4)	.84
Sex	34 = male 45 = female	42 = male 33 = female	.11
Body mass index	30.4 (±6.6)	31.2 (±7.0)	.9
ASA score	2 = 1 41 = 2 35 = 3 1 = 4	3 = 1 35 = 2 35 = 3 2 = 4	.83

ASA, American Society of Anesthesiologists.

Table II
Descriptive statistics (N = 154).

Demographics	Stem (N = 71)	Stemless (N = 83)	P value
Age	68.90 (±9.74)	60.31 (±10.74)	**<.01**
Sex	30 = male 41 = female	46 = male 37 = female	.10
Body mass index	30.68 (±6.64)	30.90 (±6.99)	.84
ASA score	2 = 1 38 = 2 30 = 3 1 = 4	3 = 1 38 = 2 40 = 3 2 = 4	.79

ASA, American Society of Anesthesiologists.
$P < .01$ indicates a significant difference between the average age of patients who underwent a stemmed TSA and those who underwent a TSA.

surgeon who traditionally performs a lesser tuberosity osteotomy when using a stemmed implant would have concerns about violating the proximal humeral bone when using a stemless implant and, therefore, chose to switch to soft-tissue management techniques including tenotomy and peel for the stemless technique.

The purpose of the study was to evaluate how a group of surgeons' subscapularis takedown techniques may change when moving from performing stemmed to stemless TSA. Our hypothesis was that surgeon's historical subscapularis management preferences in stemmed TSA would be most predictive of subscapularis management in the setting of stemless TSA.

Methods

Study design

This was a retrospective observational study of the upper extremity shoulder surgeons at a single academic institution. We used the Reporting of studies Conducted using Observational Routinely-collected health Data (RECORD) Statement (which is an extension of STROBE) when working with and reporting data.[4] Institutional review board exemption was obtained for this study.

Participants

Participants were identified for inclusion in the study using a systematic sampling method that sampled every third patient who had a hospital stay (either in the outpatient or inpatient setting) for the current procedure terminology code for TSA (current procedure terminology 23472). A sample of 154 consecutive patients who underwent stemmed and stemless TSA at our academic orthopedic institution from 2016 to 2020 were aggregated from an electronic health record database. Surgical techniques were performed according to the manufacturing technique guides and surgeon preferences. Simpliciti stemless implants (Wright Medical, Memphis, TN) were used in all stemless cases. Stemmed implants consisted of Ascend Flex (Wright Medical, Memphis, TN) and Titan (Integra Lifesciences, Plainsboro Township, NJ).

Variables

Demographic information including patient age, sex, Body Mass Index, American Society of Anesthesiologists score, and subscapularis management technique were recorded.[1] Subscapularis takedown techniques were grouped into two cohorts: a soft-tissue approach (subscapularis tenotomy or peel) and a bony approach (osteotomy). Historical preferences for each surgeon were determined by evaluating techniques employed using traditional, stemmed TSA. A technique was considered a surgeon historical preference if used in one-third or more of the stemmed TSA cases.

Statistical analysis

All statistical analyses were performed using Statistical Package for the Social Sciences (SPSS) version 26.0 (IBM, Armonk, NY, USA). Descriptive statistics were obtained using t-tests for continuous variables and chi-squared tests for categorical variables comparing the boney and soft-tissue cohorts. A Cramers V analysis was run to determine the strength of association between this historical preference and subscapularis technique used for stemless TSA. The Cramer's V allows a measurement of correlation of two discrete variables and may be used with variables having two or more levels.[11] The Cramers V coefficient ranges from 0 to 1 (perfect association). Strength of association is categorized as moderately strong, 0.20 to 0.25; moderate, 0.25 to 0.30; and redundant, 0.45 to 0.99.

Results

One hundred fifty-four patients were included in this analysis. The demographic data for the included patients can be found in Table I. There were 71 and 83 stemmed and stemless TSA cases performed, respectively (Table II); 50.6% of the patients were women. The average age of patients was 64.2 years. Four surgeons were included in this study. In all, 79 and 75 bony and soft subscapularis techniques were used. The age, sex, Body Mass Index, and American Society of Anesthesiologists score did not differ significantly between the soft-tissue repair cohort and the bony repair cohort. The historical preference (indicated by usage on greater than one-third or more of all TSA procedures performed) for 3 of the surgeons was a subscapularis bony approach, and the historical preference for one of the surgeons was a soft-tissue approach. Each surgeon had a clear historical preference for either soft-tissue subscapularis management or osteotomy technique (Table III).

A Cramer's V analysis was used to measure the relative strength of association between the historical subscapularis management preference in stemmed and stemless TSAs. Our analysis yielded a value of 0.65 ($P < .01$), indicating a redundant (very strong) association of subscapularis management approach between stemmed and stemless implants per surgeon (Table IV). For surgeons who preferred a bony repair technique for subscapularis management, there was no increase in utilization of a soft-tissue release technique when making the transition from stemmed to stemless prosthesis for TSA.

Discussion

Stemless TSA continues to rise in popularity given a variety of factors which may yield superiority of these implants to their stemmed counterparts.[26,30,31,35,36,39,42] Decreased operative time, preservation of proximal humeral bone stock, elimination of a

Table III
Historical preference of either soft-tissue peel subscapularis management technique or osteotomy subscapularis management technique for each surgeon.

Subscapularis repair technique	Anakwenze	Lassiter	Klifto	Garrigues	Totals
Stem					
Osteotomy	14	3	6	31	54
Soft-tissue peel technique	3	12	2	0	17
Repaired primarily	0	0	0	0	0
Other/unkown	0	0	0	0	0
Stemless					
Osteotomy	9	0	5	12	26
Soft-tissue peel technique	16	41	0	0	57
Repaired primarily	0	0	0	0	0
Other/unkown	0	0	0	0	0
Totals	42	56	13	43	154

Table IV
Cramer's V analysis of the relative strength of association between the historical subscapularis management preference in stemmed and stemless TSAs.

Statistical analysis	Association score between historical subscapularis management preference (bony vs. soft-tissue repair) in stemmed TSA and subsequent approach choice in stemless TSA	*P* value
Cramer's V association score	0.65	.01

The coefficient ranges from 0 to 1 (perfect association). Strength of association was categorized as moderately strong, 0.20 to 0.25; moderate, 0.25 to 0.30; redundant, 0.45 to 0.99.
A value of 0.65 ($P < .01$) indicates a redundant association between subscapularis management approach chosen for stemless TSA and historical preference based on stemmed TSA.
TSA, total shoulder arthroplasty.

potential diaphyseal stress riser, possibility of less intraoperative blood loss, and easier revision surgery are all cited as potential advantages of stemless TSA.[5] Despite these advantages, surgeons' historical preference and familiarity of one implant or surgical technique can alter outcomes substantially.[32] To our knowledge, a study comparing choice of subscapularis management technique in stemless TSA to surgeon historical preference when performing stemmed TSA has not yet been undertaken. This study aimed to assess if choice of subscapularis tendon repair strategy (bony vs. soft tissue repair) in surgeons performing stemless TSA would be based on prior preference of repair technique by the surgeon when performing stemmed TSA. As hypothesized, we found a Cramer's V association score of 0.65, indicating a redundant association between subscapularis management approach chosen for stemless TSA and historical preference based on traditional stemmed TSA.

A robust literature exists exploring differences in outcomes of subscapularis repair strategy in stemmed TSA.[2,7,8,12,13,18,19,24,27,29,38,40,41,43] While some biomechanical studies have suggested a higher strength and greater yield stress to failure with the osteotomy technique, clinical studies have generally demonstrated no difference in repair failure rates.[7,28] Lapner et al published a randomized controlled trial in 2012, which reported no difference with regard to the primary outcome of subscapularis muscle strength at 24 months between the lesser tuberosity osteotomy group and the subscapularis peel group.[25] Furthermore, there was no difference identified across secondary clinical outcome scores (Western Ontario Osteoarthritis of the Shoulder Index and American Shoulder and Elbow Surgeons score).[25] Similarly, in 2019, Levine et al published a randomized controlled trial comparing lesser tuberosity osteotomy and subscapularis tenotomy, which, while demonstrating longer operative time among the osteotomy cohort, showed similar clinical outcomes as well as high rates of healing between both cohorts.[28] More recently, in 2020, O'Brien et al found no statistical difference between subscapularis tenotomy and lesser tuberosity osteotomy across a variety of outcome metrics including the American Shoulder and Elbow Surgeons score, subscapularis strength testing, rate of radiographic union, and postoperative shoulder range of motion.[34] Taken in summation, the existing literature in stemmed TSA yields no significant clinical difference with regard to functional outcome or repair strength between osteotomy and soft-tissue peel subscapularis tendon management techniques in stemmed TSA.

While there is seemingly little difference between osteotomy and soft-tissue peel in outcomes after stemmed TSA, the growing popularity of stemless TSA poses the following question once again: Does the difficulty in achieving robust bony fixation in stemless TSA warrant additional consideration of subscapularis management? Preserving bone stock for adequate fixation is imperative in stemless TSA. Lesser tuberosity osteotomy, especially when large lesser tuberosity bone bed is desired, may extend to the metaphyseal-calcar region or disrupt proximal humeral bone being relied upon for fixation of the stemless implant. To date, studies evaluating outcomes of different subscapularis management techniques in stemless TSA are rare. To our knowledge, only one study has formally evaluated subscapularis repair techniques in stemless TSA. Aibinder et al compared 2-year outcomes of lesser tuberosity osteotomy, subscapularis tenotomy, and peel repair, which found greater active external rotation in the peel group than the tenotomy, but this difference was not found with regard to the osteotomy group.[3] Furthermore, there was no statistically significant difference in clinical outcomes or subscapularis failures between groups.[3] The authors conclude that all 3 subscapularis management techniques are effective and safe at the 2-year mark. This may indicate that it is safe for shoulder surgeons to carry out whichever subscapularis management technique they are comfortable with when performing stemless TSA. The consistency in subscapularis management choice between stemmed and stemless TSA demonstrated by the present study may suggest surgeons' opinion of consistent clinical outcomes with the same subscapularis management technique between stemmed and stemless TSA. In addition, surgeons' comfort with one technique over the other may hold more significance for subsequent outcome than subscapularis repair choice itself.

Our study has several limitations. Primarily, the study includes only the stemmed and stemless TSAs from a single, high-volume academic university hospital. This may limit the generalizability of our results across other practice settings. In addition, this was a retrospective analysis, and further prospective studies may be indicated to substantiate our work. Finally, only one of the four surgeons included in our analysis had a historical preference for soft-tissue subscapularis repair over osteotomy. Future work should include larger samplings of surgeons with preference for one technique over the other.

Conclusion

The surgeon-specific subscapularis management approach used for stemmed TSA is strongly predictive of the approach used for stemless TSA. This consistency in approach may in part explain why stemless TSA appears to have similar outcomes to stemmed TSA and may explain the continued rise in popularity of stemless TSA. The results of this study can inform health-care and device manufacturers about the potential learning curve associated with stemless shoulder arthroplasty; the inability to carry over known uncomfortable techniques when adopting new technology can be presumed to be associated with a steeper learning curve.

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