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Stemless anatomic total shoulder arthroplasty is associated with less early postoperative pain

Brian C. Werner, MD[a,*], M. Tyrrell Burrus, MD[b], Patrick J. Denard, MD[c], Anthony A. Romeo, MD[d], Evan Lederman, MD[e], Justin W. Griffin, MD[f], Benjamin Sears, MD[g], Shoulder Arthroplasty Research Committee (ShARC)[1]

[a]*Department of Orthopaedic Surgery, University of Virginia, Charlottesville, VA, USA*
[b]*Ascension Medical Group Seton Orthopedics, Austin, TX, USA*
[c]*Oregon Shoulder Institute, Medford, OR, USA*
[d]*Duly Healthcare, Chicago, IL, USA*
[e]*Department of Orthopaedic Surgery, Banner Health, Phoenix, AZ, USA*
[f]*Jordan-Young Institute, Virginia Beach, VA, USA*
[g]*Western Orthopaedics, Denver, CO, USA*

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Background: Improvements in pain control after shoulder arthroplasty with a reduction in narcotic use continues to be an important postoperative goal. With the increased utilization of stemless anatomic total shoulder arthroplasty (aTSA), it is relevant to compare between stemmed and stemless arthroplasty to assess if there is any association between this implant design change and early postoperative pain.
Methods: Patients from a multicenter, prospectively-maintained database who had undergone a stemless aTSA with a minimum of two year clinical follow-up were retrospectively identified. Patients who underwent aTSA with a short stem were identified in the same registry, and matched to the stemless aTSA patients by age, sex and preoperative pain score. The primary study outcome was the Visual Analog Scale pain score. Secondary pain outcomes were the American Shoulder and Elbow Surgeons shoulder pain subscore, Western Ontario Osteoarthritis of the Shoulder physical symptoms subscore, and the Single Assessment Numeric Evaluation score. Finally, the percentage of patients who could sleep on the affected shoulder was assessed for each group. These pain-related clinical outcomes were assessed and compared preoperatively, and postoperatively at 9 weeks, 26 weeks, one year and two years. For all statistical comparisons, $P > .05$ was considered significant.
Results: 124 patients were included in the study; 62 in each group. At 9 weeks after surgery, statistically significantly improved pain control was reported by patients undergoing stemless aTSA, as assessed by the Visual Analog Scale (stemless: 1.5, stemmed: 2.5, $P = .001$), American Shoulder and Elbow Surgeons pain subscore (stemless: 42.4, stemmed: 37.3, $P < .001$), Western Ontario Osteoarthritis of the Shoulder Physical Symptoms (stemless: 80.3, stemmed: 73.1, $P = .006$) and Single Assessment Numeric Evaluation (stemless: 58.1, stemmed: 47.4, $P = .011$). Patients who underwent a stemless aTSA were significantly more likely to be able to sleep on the affected shoulder at 9 weeks (29% vs. 11%, odds ratio 3.2, 95% confidence interval 1.2-8.4, $P = .014$). By 26 weeks postoperatively, there were no differences in all pain-specific outcomes. At two years postoperatively, patient-reported outcomes, range of motion, and strength measures were all similar between the two cohorts.
Conclusion: Stemless aTSA provides earlier improvement in postoperative shoulder pain compared to matched patients undergoing short-stem aTSA. Additionally, earlier return to sleeping on the affected

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*Corresponding author: Brian C. Werner, MD, University of Virginia, 2280 Ivy Road, Charlottesville, VA 22903, USA.
E-mail address: bcw4x@uvahealth.org (B.C. Werner).
[1] Shoulder Arthroplasty Research Committee (ShARC) authorship: Anup Shah: anupshah78@gmail.com, Asheesh Bedi: asheesh.bedi@gmail.com, Benjamin Sears: bwsears@gmail.com, Bradford Parsons: bradford.parsons@mountsinai.org, Brandon Erickson: berickso.24@gmail.com, Brian C. Werner: bcw4x@uvahealth.org, Bruce Miller: bsmiller@umich.edu, Christopher O'Grady: ogradymd@yahoo.com, Daniel Davis: daniel.davis@rothmanortho.com, David Lutton: dmlutton@gmail.com, Evan Lederman: Elederman1@icloud.com, Joern Steinbeck: j.steinbeck@oppk.de, John Tokish: tokish.john@mayo.edu, Julia Lee: lee.julia@gmail.com, Kevin Farmer: farmekw@ortho.ufl.edu, Mariano Menendez: marianofurrer@gmail.com, Matthew Provencher: mmpro@mac.com, Michael Bercik: michael.bercik@gmail.com, Michael Kissenberth: michael.kissenberth@prismahealth.org, Patric Raiss: patric.raiss@gmail.com, Patrick J. Denard: pjdenard@gmail.com, Peter Habermeyer: peter.habermeyer@atos.de, Philipp Moroder: philipp.moroder@icloud.com, Russell Huffman: grussellhuffman@outlook.com, Samuel Harmsen: gwsharmsen@gmail.com, Timothy Lenters: lenters@mac.com, Tyrrell Burrus: tyrrellburrus@gmail.com, Tyler Brolin: tbrolin@campbellclinic.com, Anthony Romeo: anthony.romeo@duly.com, R. Alexander Creighton: alex_creighton@med.unc.edu, Justin W. Griffin: justinwilliamgriffin@gmail.com.

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shoulder was reported in the stemless aTSA group. The majority of these differences dissipate by 26 weeks postoperatively and there were no differences in pain, patient-reported outcomes, range of motion or strength measures between stemless and short-stem aTSA at 2 years postoperatively.

As the number of total shoulder arthroplasties (TSA) continues to increase in the United States,[27] surgeons are tasked with the goal of improving postoperative outcomes and the patient experience as well as minimize the rate of complications and preventable revisions. At the same time, there is a significant national campaign to minimize narcotic consumption following orthopedic procedures due to medication-related complications and addiction potential.[18]

With newer implants and surgical techniques becoming available, it is important to compare these implant and practice modifications to the traditional options to ensure that surgeons are accomplishing the above objectives. One such focus, postoperative pain control, continues to be a very important patient outcome measure that can increase patient satisfaction while at the same time reduce narcotic consumption.[7] Risk factors for poor TSA postoperative pain control have been studied before and include patients younger than 65 year old,[10] unemployment,[10] preoperative opioid use,[10] depression,[23] and tobacco use.[23]

Improving postoperative shoulder arthroplasty pain has been the subject of past research with most of the focus being on multimodal medication regimens,[6] regional nerve blocks,[12] postoperative interventional sleep pathways,[2] and preoperative patient education.[20] Modifications in implant designs have not been studied nearly as thoroughly, likely because most alterations do not significantly affect the overall surgical technique, and thus would be expected to have a negligible effect on postoperative pain.

Stemless humeral implants for anatomic total shoulder arthroplasty (aTSA) are seeing increased utilization in the United States and have been compared to the more traditional stemmed implants with radiographic and patient reported outcomes (PRO) based research studies. Compared to stemmed implants, stemless anatomic implants have similar implant longevity and PRO's.[1,14,15,22,24,26] However, stemless implants have been shown to result in less intraoperative blood loss,[4] reduced surgical time,[4,5] a lower rate of intraoperative fractures,[28] and improved center of rotation restoration.[21]

The aim of the current study is to compare postoperative pain measures between two matched cohorts of patients who underwent aTSA with either a short stemmed or compression screw fixation stemless implant. Secondary outcomes were ability to sleep on the affected shoulder, and other PROs, range of motion (ROM) and strength measures. The null hypothesis was that both cohorts would have similar improvements in pain control at all assessed times points in the first two years after undergoing aTSA.

Materials and methods

Database and study patients

A multicenter, prospectively-collected database of patients undergoing shoulder arthroplasty was utilized to retrospectively identify study patients. A total of 11 sites contributed patients to the database for this study. Institutional Review Board approval was attained. Inclusion criteria were: 1) aTSA with either a stemless (Eclipse; Arthrex Inc., Naples, FL, USA) or short stem humeral implant (Univers Apex; Arthrex Inc., Naples, FL, USA) and 2) minimum two year clinical follow-up. Exclusion criteria were: 1) revision arthroplasty, 2) standard length stem humeral implant, 3) any augmented or convertible glenoid implant, and 4) worker's compensation. Two cohorts were then created based on the type of humeral implant. Patients with a short stem were matched to stemless patients by age (±1 year), sex, and preoperative Visual Analog Scale (VAS) pain score (±1 point).

Baseline data

Baseline patient demographics were extracted from the registry for comparison. For each included patient, the preoperative glenoid morphology was classified on plain radiographs and recorded for comparison. Preoperative PROs assessed were: VAS, Western Ontario Osteoarthritis of the Shoulder (WOOS) index score, Single Assessment Numeric Evaluation (SANE) score, Veterans RAND 12 (VR-12) mental score, American Shoulder and Elbow Surgeons (ASES) score, and Constant-Murley score. ROM and strength measures were also recorded.

Surgical technique

A deltopectoral approach was utilized with subscapularis management varying by surgeon preference. An anatomic head cut with or without a guide was performed, and then the same, cemented all-polyethylene glenoid was implanted for patients in both cohorts (Univers VaultLock Glenoid; Arthrex Inc., Naples, FL, USA). The choice of humeral implant was based on surgeon preference, but most of the surgeons converted to stemless arthroplasty as the implant became more readily available.

For the press-fit short humeral stem (Univers Apex; Arthrex Inc., Naples FL, USA), humeral hand reaming followed by broaching was carried out until adequate cortical chatter was achieved. After trialing, the final implant was impacted into place with the humeral head secured on the trunnion. Stemless fixation utilized a device based on cortical rim support and compression (Eclipse; Arthrex, Inc., Naples, FL, USA). This device uses a titanium circular trunnion that was sized matched to the outer cortical rim of the humeral head cut and then compressed to the metaphysis with a hollow cage screw. Thus, no metaphyseal broaching or bone removal was required. Following trialing, an appropriate thickness and diameter concentric humeral head component was impacted. Although postoperative rehabilitation and pain management were not standardized, both cohorts underwent the same protocol based on surgeon preference regardless of which implant was utilized.

Outcomes

The primary study outcome was the VAS pain score. Secondary pain outcomes were the ASES shoulder pain subscore (which encompasses 4 different questions: overall pain overall, night pain, over-the-counter medication usage for pain, and narcotics usage for pain), WOOS physical symptoms subscore, and the SANE score. The percentage of patients who could sleep on the affected shoulder, a question within the ASES shoulder score, was also assessed for each group. These pain-related and sleep clinical outcomes were assessed and compared preoperatively, and postoperatively at 9 weeks, 26 weeks, one year and two years. Additional comparisons

Table I
Demographic comparison of short stem and stemless TSA.

Patient Characteristics	Short Stem (N = 62)		Stemless (N = 62)		*P*
Demographics					
Age: y (mean, s.d.)	66.0	7.3	65.9	7.3	.939
Sex: female (n, %)	32	51.6%	32	51.6%	1.000
BMI: kg/m^2 (mean, s.d.)	29.9	5.7	32.0	9.1	.126
Dominant arm: yes (n, %)	26	41.9%	29	46.8%	.588
Tobacco use: yes (n, %)	5	8.1%	4	6.5%	.729
Diabetes mellitus: yes (n, %)	9	14.5%	9	14.5%	1.000
Walch classification					
A1 (n, %)	22	35.5%	20	32.3%	.704
A2 (n, %)	9	14.5%	10	16.1%	.803
B1 (n, %)	11	17.7%	10	16.1%	.811
B2 (n, %)	19	30.6%	22	35.5%	.567

s.d., standard deviation; *BMI*, body mass index.

of all baseline and 2 year patient-reported outcomes (PROs) and ROM were also performed.

Statistical analysis

All statistical comparisons were performed in SPSS version 29 (IBM, Armonk, NY, USA). Comparisons of continuous variables were performed using Student's tests. Comparisons of categorical variables were performed using chi-squared tests or Fisher's exact tests where appropriate. For all statistical comparisons, $P < .05$ was considered significant.

Results

Baseline data

124 patients were included in the study; 62 in each group. The was no statistically significant differences between the stemless and short-stem TSA patients for demographics, glenoid morphology, baseline PROs and baseline strength (Tables I and II). The subscapularis takedown method was lesser tuberosity osteotomy in 41 (66%) of short-stem patients and 46 (74%) of stemless patients ($P = .326$). Baseline ROM was similar between groups for all measures with the exception of external rotation at the side, which was higher for the stemless patients (mean difference = 7 degrees, $P = .038$) (Table II).

Clinical outcomes

The VAS pain score was lower (short stem: 2.5 ± 1.6, stemless: 1.5 ± 1.5, $P < .001$) and the ASES pain subscore (short stem: 37.3 ± 8.1, stemless: 42.4 ± 7.6, $P < .001$), WOOS Physical Symptoms (short stem: 73.1 ± 15.2, stemless: 80.3 ± 13.0, $P = .006$) and SANE score (short stem: 47.4 ± 23.3, stemless: 58.1 ± 22.4, $P = .011$) were all significantly higher (less pain) at 9 weeks postoperatively in the stemless cohort compared to the short stem patients (Fig. 1). The SANE was also significantly higher at 1 year postoperatively in the stemless group ($P = .008$). At two years postoperatively, all PROs, ROM, and strength measures were statistically similar between both cohorts (Table III).

The percentage of patients that replied "not difficult" for sleeping on their affected shoulder was statistically higher at the 9-week time point in the stemless group compared to short-stem (29% vs. 11%, odds ratio of 3.2 [95% confidence interval 1.2-8.4], $P = .014$) (Fig. 2). There were no statistically significant differences in the percentage of patients who could sleep on their affected shoulder at any other assessed time point.

Table II
Comparison of baseline PROs and ROM.

	Short stem (N = 62)		Stemless (N = 62)		*P*
	Mean	Std. Dev.	Mean	Std. Dev.	
Baseline PROs					
VAS Pain	5.6	2.3	5.9	2.1	.449
ASES	42.4	18.1	41.9	16.3	.872
SANE	32.5	22.9	34.6	21.4	.599
WOOS	40.4	21.6	42.9	19.7	.502
Constant-Murley	42.8	15.5	42.3	15.9	.860
VR-12 Mental	47.0	12.5	47.6	11.4	.781
Baseline ROM					
Active FF (degrees)	105	29	113	32	.147
Active ER at Side (degrees)	29	17	36	20	.038
Active ER at 90 (degrees)	34	27	27	32	.191
Active IR (spinal level)	L5	3	L5	3	1.000
Active IR at 90 (degrees)	19	18	14	23	.180
Baseline Strength					
Constant-Murley	7.2	4.2	5.9	6.4	.183
ER in neutral	8.0	3.8	7.4	5.2	.465
Belly Press	9.6	4.4	9.4	7.4	.855

PROs, patient reported outcomes; *VAS*, visual analog scale; *SANE*, single assessment numeric evaluation; *WOOS*, Western Ontario Osteoarthritis of the Shoulder, *VR-12*, veterans RAND 12; *ROM*, range of motion; *FF*, forward flexion; *ER*, external rotation; IR, internal rotation.

Discussion

The current study demonstrates that patients undergoing aTSA with the studied stemless prosthesis report improved early postoperative pain compared to age, sex, and preoperative pain score-matched patients undergoing aTSA with short stemmed implants. Additionally, stemless aTSA patients reported a quicker recovery in the ability to sleep on their affected shoulder compared to short-stem aTSA patients. For all outcomes evaluated, there were no significant differences at 2 years postoperatively.

There are obvious potential benefits to this potential early reduction in pain, particularly with the increased shift toward outpatient TSA. However, there is conflicting existing literature regarding differences in early pain after stemless vs. stemmed anatomic TSA. Gruson et al showed reduced pain at the time of discharge after stemless with a VAS of 0 in 83 patients compared to 4 in the short stem cohort of 47 patient which was associated with a reduced length of stay in the hospital.[4] In a study of 203 stemless aTSAs, 354 short stem aTSAs and 1159 traditional length stem aTSAs, Labrum et al stratified postoperative pain scores by stem type.[11] The authors found no differences in postoperative pain between any cohort across all pain metrics recorded during the first 3 months postoperatively. Additionally, the stemless aTSA cohort did not show any significantly greater improvement in pain metrics at any time point postoperatively when compared to SS and TL cohorts.[11] There are two potential explanations for the difference in findings between our data and that of Gruson et al and this study. First, the authors utilized a registry which only included follow-up data recorded at the 3 month postoperative time point. Based on our analysis and that of Gruson et al, the pain relief afforded by a stemless design may be in the early recovery period and dissipates by 3 months postoperatively. While we noted a significant difference in pain at 9 weeks, this difference was no longer present by 26 weeks postoperatively. Second, the type of stemless design may have an impact on pain recovery. The stemless design evaluated by Labrum et al requires metaphyseal preparation and impaction of a central nucleus. Conversely, the design in the current study relies on cortical rim support and compression and does not require metaphyseal compaction or bone removal for implantation.

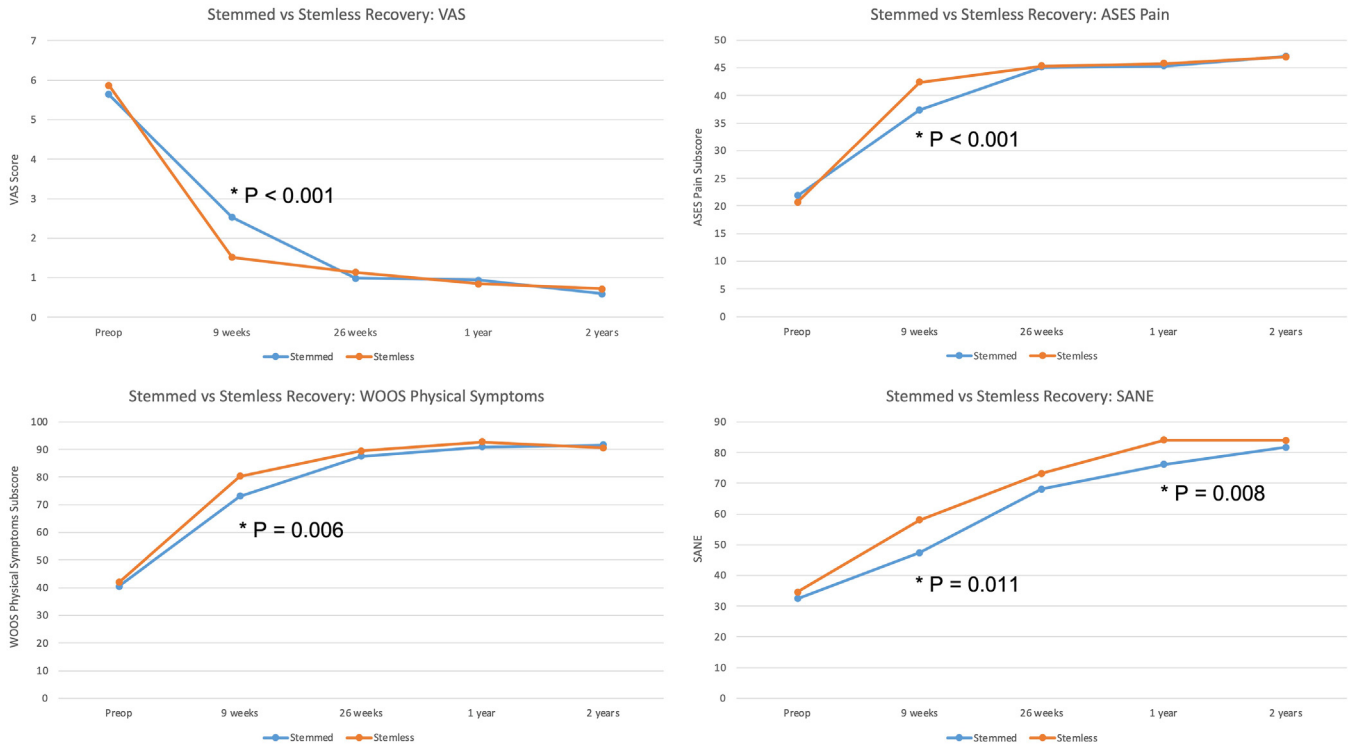

Figure 1 Comparison of recovery between stemless and short-stem aTSA. There were statistically significantly improved scores at 9 weeks postoperatively in the stemless aTSA group for all four pain-related metrics studied. *aTSA*, anatomic shoulder arthroplasty.

Table III
Comparison of two-year outcomes.

	Short stem (N = 62)		Stemless (N = 62)		*P*
	Mean	Std. Dev.	Mean	Std. Dev.	
2-y PROs					
VAS Pain	0.6	1.0	0.7	1.3	.632
ASES	89.4	9.4	88.3	16.4	.648
SANE	81.7	21.2	83.0	24.7	.754
WOOS	91.6	10.6	90.5	15.2	.641
Constant-Murley	79.8	14.5	80.4	18.4	.841
VR-12 Mental	53.0	9.5	54.4	9.5	.414
2-y ROM					
Active FF (degrees)	150	15	150	21	1.000
Active ER at Side (degrees)	57	21	61	14	.215
Active ER at 90 (degrees)	69	24	72	26	.506
Active IR (spinal level)	L2	3	L1	3	.066
Active IR at 90 (degrees)	36	20	34	29	.656
2-y Strength					
Constant-Murley	9.2	4.6	8.8	6.4	.690
ER in neutral	10.9	4.4	11.9	6.2	.302
Belly Press	11.7	5.1	11.8	6.4	.924

PROs, patient reported outcomes; *VAS*, visual analog scale; *SANE*, single assessment numeric evaluation; *WOOS*, Western Ontario Osteoarthritis of the Shoulder, *VR-12*, veterans *RAND 12*; *ROM*, range of motion; *FF*, forward flexion; *ER*, external rotation; *IR*, internal rotation.

Further comparative studies would be necessary to determine if stemless prosthetic design contributes to early pain postoperative pain relief.

The reasons behind the improved pain control cannot be fully elucidated from a retrospective clinical study but certainly warrant discussion. Hypothesis regarding this from past studies and from the authors of the current study include 1) decreased surgical time resulting in less soft tissue retraction, damage, and swelling, 2) a smaller local and systemic inflammatory response as a result of the decreased trauma to the bone by avoiding reaming and broaching, 3) less blood loss, and 4) less time under anesthesia which also affects the overall systemic inflammatory response.[19] From the lower extremity trauma literature, reaming the femoral intramedullary canal results in a significant release of IL-6, a pro-inflammatory cytokine, and this effect may be similar in the humerus.[16] The relationship between inflammation and pain has been extensively studied with inflammation appearing to be the nidus of pain.[17] However, as discussed previously, it is also possible that the technique of stemless implantation and implant design may also affect the early pain reduction benefit.[11]

Although pain outcome measures in the two cohorts eventually became similar, early pain control is of significant importance and may even affect long-term outcomes. In a retrospective case series of 314 shoulders with either a reverse TSA or aTSA, a multivariate analysis reported that increased pain in the first 24 postoperatively hours was independently associated with multiple worse PROs at 2 years postoperatively.[8] Additionally, as there continues to be an increase in more efficient, cost-effective, and safe outpatient shoulder arthroplasty, research such as this helps to reduce patients' primary concern regarding early postoperative pain control in the outpatient setting.[9] Furthermore, Magone et al showed that inadequate pain control is one of the primary barriers to discharge after shoulder arthroplasty.[13]

A unique finding of the current study is that patients undergoing stemless aTSA are significantly more likely to be able to sleep on the surgical shoulder in the early postoperative period compared to those in the short stem cohort (29% vs. 11%, respectively). In addition to the commonsense notion that improved sleep increases patient satisfaction, sleep disturbances after surgery are common and result in researched postoperative harmful effects such as an increased sensitivity to pain, a higher rate of delirium, more cardiovascular complications, and an overall poorer recovery.[25] Additionally, narcotic use results in poorer quality of sleep by

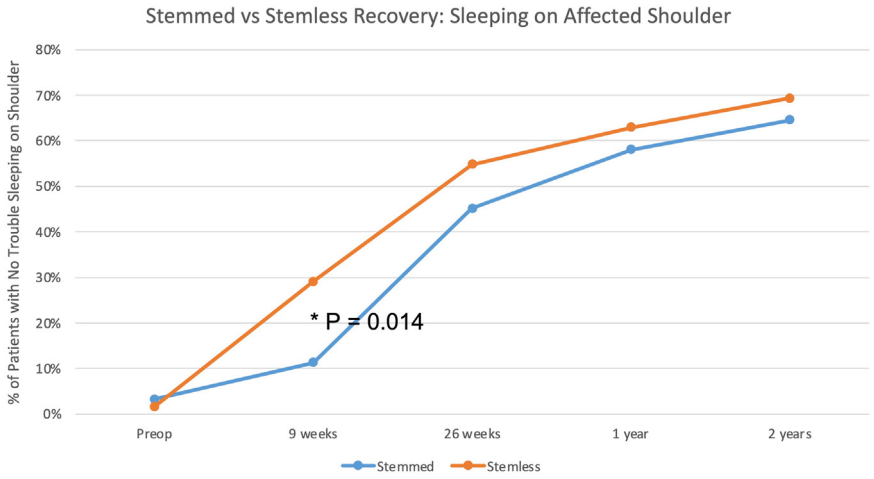

Figure 2 Comparison of percentage of patients who could sleep on the affected shoulder between stemless and short-stem aTSA. Significantly more patients (29% vs. 11%) were able to sleep on their shoulder in the stemless group at 9 weeks postoperatively. *aTSA*, anatomic total shoulder arthroplasty.

decreasing REM sleep so controlling early postoperative pain may work in synergy with less narcotic use and improved sleep.[3]

There are several limitations of the current study that warrant discussion. First, while we controlled for sex, age and baseline pain scores, there are numerous other confounding factors that could not be controlled for in this study, such as duration of pain preoperatively, chronic pain, preoperative opioid use, mental health, depression history, socioeconomic factors and education level, among others. These factors could influence the findings of the study. As was mentioned previously, perioperative pain management strategies, including medications and regional anesthesia, postoperative pain control regimen and postoperative rehabilitation were not able to be standardized across the various registry sites. However, each surgeon was consistent with these treatments regardless of what implant was placed so this would not affect the outcomes. Another limitation is that the chosen implant was based on surgeon preference and not due to any controlled or randomized process. This limitation reflects the trend in stemless utilization in each surgeon's practice and is not due to any purposeful selection bias or meaningful change in experience level when the stemless implants were placed. This is evident that after matching, there were very similar baseline characteristics between the cohorts and by the fact that these contributing surgeons were already high-volume surgeons (>100 shoulder arthroplasty procedures per year) before the stemless implants were in greater use. Despite the findings of this study, generalizing the early improved pain control outcome to all stemless implants may not prove true due to the unique implantation technique utilized. The findings of this study, while statistically significant, are not clearly clinically significant, thus larger studies would be necessary to establish firm clinical significance. Lastly, we did not evaluate narcotic usage. Further study could compare early narcotic usage between stemmed and stemless components.

Conclusions

The studied stemless aTSA provides earlier improvement in postoperative shoulder pain compared to age, sex and baseline pain-score matched patients undergoing short-stem aTSA. Additionally, earlier return to sleeping on the affected shoulder was reported in the stemless aTSA group. The majority of these differences dissipate by 26 weeks postoperatively and there were no differences in pain, PROs, ROM or strength measures between stemless and short-stem aTSA at 2 years postoperatively.

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