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Peer reviewed
Stemless shoulder arthroplasty: review of short and medium-term results

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Level of evidence: Level IV, Systematic Review

Background: The number of anatomic total shoulder (TSA), hemiarthroplasty (HA), and reverse total shoulder arthroplasties (RTSA) is rapidly increasing in the United States. Stemless shoulder arthroplasty has numerous theoretical advantages, including preserved bone stock, decreased operating time, reduced rate of intraoperative humerus fracture, and flexibility of anatomic reconstruction. Only recently studies with more than 5 years of mean follow-up have become available.

Methods: The MEDLINE database was systematically queried to identify all studies reporting outcomes regarding anatomic or reverse stemless shoulder arthroplasty. Studies were categorized according to mean reported follow-up. Outcome scores and range of motion measurements were compiled. Complication and revision rates due to failure of the humeral or glenoid components were summarized.

Results: Nineteen TSA and HA studies with a total of 1115 patients were identified, with 4 studies and 162 patients with a mean follow-up between 60 and 120 months. Six RTSA studies with a total of 346 patients were identified, all with a mean follow-up between 18 and 60 months. There was a reliable improvement in outcomes compared with preoperative scores across studies. A cumulative 0.7% (8 of 1115) humeral component complication rate was found for TSA and HA components. There was a cumulative 1.7% (6 of 346) humeral complication rate for RTSA prostheses.

Conclusions: In the studies reporting similar outcome measures, there were reliable improvements on par with stemmed counterparts. Aggregate complication rates appear similar to those published in the literature for stemmed components. Evidence supporting the utility and safety of stemless designs would be strengthened by longer-term follow-up and additional prospective comparative studies.

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published studies of patients undergoing stemless TSA, HA, and RTSA. Attention is focused on functional outcomes as well as reported complication and revision rates. We hypothesized that functional outcomes would be similar for stemless versus stemmed implants, and that humeral complications would not differ substantially from previously published rates for stemmed components.

**Methods**

A broad search of English-language literature was conducted beginning from January 1, 2000, through August 1, 2018. Investigators searched both MEDLINE through PubMed and Google Scholar using MeSH search terms including “stemless,” “canal-sparing,” “reverse,” “shoulder replacement,” or “shoulder arthroplasty.” A manual reference check of previous reviews and published studies was conducted to identify any additional relevant studies.

To meet inclusion criteria, studies needed to include more than 5 patients undergoing TSA, HA, or RTSA report functional outcomes measured using either standardized metrics or range of motion (ROM) measurement, and explicitly comment on complications. No threshold was set for minimum FU time. Studies were classified according to the mean length of FU into 3 groups: very short term (mean FU <18 months), short term (FU 18-60 months), and medium term (60-120 months).

Outcome measures reported by the authors varied substantially. Most included Constant-Murley scores (CMS), with other common metrics including the Disabilities of the Arm, Shoulder, and Hand score and the American Shoulder and Elbow Surgeons score. Most authors also reported explicit measures of ROM, such as external rotation (ER), abduction, and flexion.

All complications were examined in each study, with attention focused on humeral component-related complications and revisions. Revision rates due to failure of the humeral or glenoid component were also summarized. Study, patient, and treatment characteristics were summarized with the use of basic descriptive statistics.

**Results**

A total of 19 studies of anatomic stemless TSA and HA were included in the analysis, with a mean FU between 6 and 108 months. Across the 19 included studies, a total of 1115 patients who underwent stemless TSA (n = 814) or HA (n = 301) were identified: 212 in very short-term FU studies, 741 in short-term FU studies, and 162 in medium-term FU studies (Table I). A total of 6 studies involving stemless RTSA were identified involving 346 patients, all with a mean FU in the short-term category between 18 and 60 months (Table IV).

A total of 5 stemless TSA/HA implants from 6 different prosthesis companies were identified. These included the Total Evolutive Shoulder System (TESS; Biomet, Warsaw, IN, USA), the Eclipse stemless shoulder prosthesis (Arthrex, Freiham, Germany) (Fig. 1, A, B), the Affinis (Mathys AG, Bettlach, Switzerland), the Sidus Stem-Free Shoulder System (Zimmer Biomet, Warsaw, IN, USA), and the Simpliciti total shoulder system (Wright Medical, Memphis, TN, USA) (Fig. 1, C, D). The Simpliciti by Wright Medical and the Sidus system by Zimmer Biomet are the only devices currently Food and Drug Administration approved for use in the United States.

A total of 2 stemless RTSA implants were identified including the TESS short reverse corolla (Biomet) and the Verso stemless reverse metaphyseal TSA prosthesis (Innovative Design Orthopedics, London, UK). Neither stemless RTSA device is currently approved by the Food and Drug Administration.

**Table 1** Summary of stemless anatomical TSA and HA studies identified, grouped by average length of follow-up

| Study | Device/TESS | Type | Patients | Reported indications | Mean FU (mo) | Reported outcomes |
|-------|-------------|------|----------|----------------------|-------------|------------------|
| Medium term | Arthrex/Eclipse | Case series | 29 39 | Primary OA, post-trauma OA, postinfectious OA, instability, CTA, GD | 72 | CMS, ER, Flex, Abd |
| Hawi et al 2017 | Arthrex/Eclipse | Case series | 17 32 | Post-trauma OA, primary OA, instability, CTA, postinfectious OA | 108 | CMS, ER, Flex, Abd |
| Uschok et al 2017 | Arthrex/Eclipse | Randomized | 14 | Primary OA | 68 | CMS, ER, Flex, Abd |
| Beck et al 2018 | Biomet/TESS | Case series | 31 | Primary OA, RA, post-traumatic and HH necrosis | 95 | CMS, QuickDASH, VAS, Abd, Flex |
| Very short term | Biomet/TESS | Case series | 19 44 | Primary OA, post-trauma OA, osteonecrosis, AVN, RA, instability, CTA | 45 | CMS, ER, Flex |
| Brunner et al 2018 | Arthrex/Eclipse | Case series | 119 114 | Primary OA, post-trauma OA, postinfectious OA, AVN, RA, instability, CTA | 23 | CMS, ER, Flex, Abd |
| Berth and Pap 2012 | Biomet/TESS | Randomized | 41 | Primary OA | 31 | CMS, DASH, ER, Abd, Flex |
| Razmjou et al 2013 | Biomet/TESS | Comparative | 17 | Primary OA | >24 | RCMS, ASES, QuickDASH, WOOS |
| Bell and Coghlan 2014 | Mathys/Affinis | Case series | 12 | Primary OA | >24 | CMS, ASES, DASH, SPADI, Abd |
| Mariotti et al 2014 | Wright Med/ | Comparative | 9 | Primary OA | 24 | CMS, SST, ER, IR, Abd, Flex |
| Ballas et al 2016 | Biomet/TESS | Case series | 27 | Malunion | 44 | CMS, ASES, SST, VAS, ER, Abd, IR |
| Churchill et al 2016 | Wright Med/ | Case series | 149 | Primary OA, post-trauma OA | >24 | CMS, ASES, SST, VAS, ER, Abd, IR |
| Spranz et al 2017 | Biomet/TESS | Comparative | 12 | Primary OA | 52 | CMS, ER, Flex, Ext, Abd |
| Krukenberg et al 2018 | Zimmer/Sidus | Case series | 73 32 | Primary OA, post-trauma OA, AVN, instability, RA | >24 | CMS, ASES, SSV, ER, Flex |
| Heuberer et al 2018 | Arthrex/Eclipse | Case series | 33 40 | Primary OA, post-trauma OA | 58 | CMS |

TSA, total shoulder arthroplasty; HA, hemiarthroplasty; FU, follow-up; OA, osteoarthritis; CTA, cuff tear arthropathy; GD, glenoid dysplasia; CMS, Constant-Murley score; ER, external rotation; Flex, flexion; Abd, Abduction; TESS, Total Evolutive Shoulder System; RA, rheumatoid arthritis; HH, humeral head; DASH, Disabilities of the Arm, Shoulder, and Hand score; VAS, visual analog scale for pain; AVN, avascular necrosis; RCMS, relative Constant-Murley score; ASES, American Shoulder and Elbow Surgeons score; WOOS, Western Ontario Osteoarthritis Shoulder score; SPADI, Shoulder Pain and Disability Index; SST, Simple Shoulder Test; IR, internal rotation; SSV, Subjective Shoulder Value.
Primary osteoarthritis was the most common indication reported for stemless TSA, though studies varied in the indications included in analysis. There was considerable variability in reported outcome measures; the most commonly reported is the CMS with 84% (n = 16) of studies reporting preoperative and postoperative values (Table I). A total of 73% (n = 14) of studies were case series, 15% (n = 3) of studies were nonrandomized comparisons of stemmed and stemless humeral components, and 10% (n = 2) were randomized studies of stemmed versus stemless components.

Looking specifically at the randomized trials, the study by Berth and Pap analyzed 82 patients evenly randomized to stemless (TESS; Biomet) or cemented stem components. They found no difference in functional outcomes at more than 24 months of FU; however, there was significantly increased operating room (OR) time (106 vs. 92 minutes) and estimated blood loss (593 vs. 496 mL) reported in the stemmed group compared with the stemless group. The second study by Uschok et al analyzed 40 patients randomized to stemless (Eclipse; Arthrex) or press-fit stem components, with 29 patients available for analysis at more than 60 months of FU. The authors found no difference in functional outcomes between either group postoperatively.

A graphical representation of 2 commonly reported outcomes, ER and CMS, is displayed in Figure 2. Across studies, there was a reliable improvement in both CMS and ER postoperatively compared with preoperatively, with a roughly 30-point improvement in CMS and a 20% increase in ER.

Table II
Summary of humeral component complications in stemless anatomical TSA and HA

| Study                        | Patients | Complications | Radiologic changes | Related revisions |
|------------------------------|----------|---------------|--------------------|-------------------|
| Habermeyer et al 2015        | 78       | 1 incomplete RLL, 3 partial osteolysis under HH, 34% with decreased BD of GT | None              |
| Hawai et al 2017             | 43       | 1 asymptomatic radiological loosening | 1 incomplete RLL on HH, 29% decrease BD over GT | None |
| Uschok et al 2017            | 14       | 1 asymptomatic radiological loosening | Reduced BD in GT in 29% | None |
| Beck et al 2018              | 31       | None          | None               | None |
| Short term                   |          |               |                    |                   |
| Huguet et al 2010            | 63       | 5 intraoperative fracture of metaphysis | None              |
| Brunner et al 2012           | 233      | 1 asymptomatic radiological loosening | 9 incomplete RLL < 2 mm, 5 incomplete RLL > 2 mm, 2 RLL > 2 mm | None |
| Berth and Pap 2012           | 41       | None          | None               | None |
| Razmjou et al 2013           | 17       | None          | None               | None |
| Bell and Coghlan 2014        | 12       | None          | None               | None |
| Mariotti et al 2014          | 9        | None          | None               | None |
| Ballas et al 2016            | 27       | None          | None               | None |
| Churchill et al 2016         | 149      | None          | None               | None |
| Spranz et al 2017            | 12       | None          | None               | None |
| Krukenberg et al 2018        | 105      | 1 intraoperative fracture greater tuberosity | 1 incomplete RLL HH | None |
| Heuberer et al 2018          | 73       | None          | 8 with signs osteolysis, decreased BD over GT in 43% | None |
| Very short term              |          |               |                    |                   |
| Sayed-Noor et al 2018        | 63       | None          | None               | None |
| Maier 2015                   | 12       | None          | None               | None |
| Schoch et al 2011            | 115      | None          | None               | None |
| Kadum et al 2011             | 22       | None          | None               | None |

TSA, total shoulder arthroplasty; HA, hemiarthroplasty; RLL, radiolucent lines; HH, humeral head; BD, bone density; GT, greater tuberosity.

Table III
Summary of glenoid component complications in stemless anatomical TSA and HA

| Study                        | Patients | Complications | Radiologic changes | Related revisions |
|------------------------------|----------|---------------|--------------------|-------------------|
| Habermeyer et al 2015        | 78       | 2 loosening   | Incomplete RLL in 8.3% of MBC and 53% of cemented | 2 |
| Hawai et al 2017             | 43       | 2 loosening   | 5 with RLL, 27% with incomplete RLL        | None |
| Uschok et al 2017            | 14       | 1 loosening, 1 failure MBC | 2 incomplete RLL | 0 |
| Beck et al 2018              | 31       | None          | 20 of 22 with RL | 1 |
| Short term                   |          |               |                    |                   |
| Huguet et al 2010            | 63       | None          | None               | None |
| Brunner et al 2012           | 233      | 1 loosening   | None               | 1 |
| Berth and Pap 2012           | 41       | 1 intraoperative fracture | 9 with RL | None |
| Razmjou et al 2013           | 17       | 6 intraoperative perforation | 1 subsidence | None |
| Bell and Coghlan 2014        | 12       | None          | None               | None |
| Mariotti et al 2014          | 9        | None          | None               | None |
| Ballas et al 2016            | 27       | None          | None               | None |
| Churchill et al 2016         | 149      | None          | None               | None |
| Spranz et al 2017            | 12       | None          | None               | None |
| Krukenberg et al 2018        | 105      | 6 complete RLL, 10 incomplete RLL | None | None |
| Heuberer et al 2018          | 73       | None          | None               | None |
| Very short term              |          |               |                    |                   |
| Sayed-Noor et al 2018        | 63       | NR            | None               | None |
| Maier 2015                   | 12       | NR            | None               | None |
| Schoch et al 2011            | 115      | 2 loosening   | NR                 | None |
| Kadum et al 2011             | 22       | NR            | NR                 | None |

TSA, total shoulder arthroplasty; HA, hemiarthroplasty; RLL, radiolucent lines; MBC, metal-backed component; RL, radiolucent; NR, not reported.
The most common indications were cuff tear arthropathy and rotator cuff tear (Table IV). Four studies were case series reporting a variety of outcomes. Two studies were nonrandomized comparisons between stemmed and stemless RTSA components, neither finding any significant difference in functional outcomes. Reported outcomes varied substantially between studies, with 50% (n = 3) of the studies reporting CMS preoperatively and postoperatively, 1 reporting only postoperative values, and the

### Table IV

| Study                        | Device          | Type         | Patients | Reported indications                  | Mean FU (mo) | Reported outcomes                  |
|------------------------------|-----------------|--------------|----------|---------------------------------------|--------------|------------------------------------|
| Ballas and Béguin 2013       | Biomet/TESS     | Case series  | 56       | RCT, CTA, primary OA                  | 59           | CMS, OSS, ER, Abd                  |
| Kadum et al 2014             | Biomet/TESS     | Comparative  | 16       | CTA, primary OA with RCD, post-trauma sequelea, RA | 39           | QuickDASH, EQ-5D, VAS, IR, Abd, Flex |
| Teissier et al 2015          | Biomet/TESS     | Case series  | 87       | RCT, CTA                              | 41           | CMS, QuickDASH, ASES, ER, Abd, Flex |
| von Engelhardt et al 2015    | Biomet/TESS     | Case series  | 65       | CTA, revision arthroplasty            | 18           | RCMS, DASH                         |
| Levy et al 2016              | IDO/Verso       | Case series  | 98       | CTA, post-trauma sequelea, RA, RCT, RCD| 18           | RCS, DASH                          |
| Moroder et al 2016           | Biomet/TESS     | Comparative  | 24       | CTA                                   | 34           | CMS, ASES, SSV, VAS                 |

RTSA, reverse total shoulder arthroplasty; FU, follow-up; TESS, Total Evolutive Shoulder System; RCT, rotator cuff tear; CTA, cuff tear arthropathy; OA, osteoarthritis; CMS, Constant-Murley score; OSS, Oxford Shoulder Score; ER, external rotation; Abd, abduction; RCD, rotator cuff deficiency; RA, rheumatoid arthritis; DASH, Disabilities of the Arm, Shoulder, and Hand score; VAS, visual analog scale; IR, internal rotation; Flex, flexion; ASES, American Shoulder and Elbow Surgeons score; RCMS, relative Constant-Murley score; SSV, Subjective Shoulder Value.

* Only postoperative values reported for these scores.

**Stemless RTSA outcomes**

The most common indications were cuff tear arthropathy and rotator cuff tear (Table IV). Four studies were case series reporting a variety of outcomes. Two studies were nonrandomized comparisons between stemmed and stemless RTSA components, neither finding any significant difference in functional outcomes. Reported outcomes varied substantially between studies, with 50% (n = 3) of the studies reporting CMS preoperatively and postoperatively, 1 reporting only postoperative values, and the

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**Figure 1** Humeral components from 2 stemless total shoulder arthroplasty systems most commonly found in literature. (A) Picture of the Eclipse (Arthrex, Naples, FL, USA) from Habermeyer et al. with (B) the representative AP radiograph from Brunner et al. (C) Picture of Simpliciti (Wright Medical, Memphis, TN, USA) and (D) the representative anteroposterior radiography both from Churchill et al.
remaining 2 studies using other outcome measures including the Disabilities of the Arm, Shoulder, and Hand score.

CMS and ER and abduction measurements preoperatively and postoperatively are summarized in Figure 3 for those studies with the available information. There was an approximately 30-point improvement in CMS, a 20° increase in ER, and a 60° increase in abduction (Figure 3).

Complications

Of the 1115 stemless TSA and HA patients included, 0.7% (n = 8) of complications were related to the humeral component (Table II). Six were intraoperative fracture,19,22 5 of which were reported in the first published study on stemless components, and all healed with nonoperative management. Two complications were asymptomatic loosening confirmed by radiology.8,17 There were no revisions related to the humeral component. Four studies also reported changes in bone density over the greater tuberosity, with higher percentages indicating greater internal stress shielding, present in 29%,29 29%,17 34%,15 and 43%18 of patients undergoing stemless TSA. The one comparative study reporting changes in greater tuberosity bone density found a higher rate of reduced bone density in stemmed (47%) compared with stemless TSA components (29%), though this difference was not significant and the clinical relevance is not clear (P = .4).37 When comparing bone density at the humeral calcar however, a significant increase in the rate of reduced bone density was found in the stemmed group (41%) compared with the stemless group (0%).37

Of the 346 stemless RTSA patients included, 1.7% (n = 6) experienced complications related to the humeral component (Table V). Two of 6 were instances of symptomatic loosening,2,38 of which all were revised to a stemmed humeral component (one after 3 days,

Figure 2  Reported outcomes before and after anatomical stemless total shoulder arthroplasty and hemiarthroplasty for Constant-Murray score (A) and external rotation (B). Colors represent each study, with warm colors corresponding to medium-term follow-up studies and cool colors corresponding to short-term follow-up studies. Very short-term studies (average follow-up <18 months) were excluded.

Figure 3  Reported outcomes before and after stemless reverse total shoulder arthroplasty for Constant-Murray score (A), external rotation (B), and abduction (C). Colors represent each study. The size of the point represents the number of patients in each study.
the other not reported). Three complications were intraoperative fracture of the metaphysis, all managed conservatively.225 One case involved malpositioning of the humeral component, which required revision to a stemmed humeral component in the immediate postop period.38 Radiographical changes were sparingly reported with only 3 reports of incomplete radiolucent lines surrounding the humeral component.26

There were substantially more complications related to the glenoid component in patients undergoing TSA and RTSA. Of the 814 anatomic TSA patients, 2.1% (n = 17) experienced complications involving the glenoid component: 9 patients with loosening, 7 with intraoperative fracture or perforation, and 1 failure of the metal-backed component (Table III). A total of 29% (n = 5) of these patients required revision of the glenoid component. Of the 346 RTSA stemless RTSA patients, 3.2% (n = 11) experienced complications involving the glenoid component: 9 patients with loosening and 2 with malpositioning (Table VI). A total of 90% (n = 10) of these patients required revision of the glenoid component.

### Discussion

The body of literature regarding stemless anatomic and RTSA continues to grow with the available prospective and randomized studies showing outcomes similar to traditional stemmed counterparts. Across retrospective case series, there were consistent improvements in commonly reported outcomes including functional scores and ROM measurements. In the available comparative studies, there was also no difference in functional outcomes between stemmed and stemless components. These outcomes are maintained in the medium-term studies identified for anatomic TSA, with a mean FU more than 60 months. Standardization across reported outcomes, including both preoperative and postoperative values, would enable more robust meta-analyses in the future.

Data from 2 studies supported claims that stemless shoulder replacement results in shorter operative time compared with stemmed components. The aforementioned randomized study by Berth and Pap found a decreased OR time of roughly 15 minutes and a decreased estimated blood loss of roughly 100 mL in the stemless group compared with the stemmed group. Heuberer et al found operative time to be more than 20 minutes shorter in both stemless TSA and HA compared with stemmed alternatives (P < .001). This is an important benefit as shorter OR times have been shown to result in fewer postoperative infections, reduced complications, and decreased cost.9,13,30

Regarding other advantages and disadvantages, previous literature has highlighted the concern for increased loosening of stemless components, while citing decreased intraoperative fracture as a theoretical benefit. This review found a 0.2% rate of asymptomatic humeral loosening (none of which required revision) and a 0.5% rate of intraoperative humeral fracture in patients undergoing stemless TSA or HA. The most recent systematic review of complication rates in anatomic and reverse stemmed shoulder arthroplasty found a 0.1% rate of humeral loosening and a 0.6% rate of intraoperative humeral fracture,2 with an intraoperative fracture rate as high as 1.5% in other studies.1 Thus, in studies we identified, outcomes for anatomic stemless designs were found to have a comparable rate of humeral component loosening and similar if not slightly less rate of intraoperative fracture compared with stemmed components.

In cases of stemmed RTSA, reported rates of humeral loosening are 0.7%, and although isolated humeral fracture rates are not clearly available, 2.3% of RTSA were complicated by either a glenoid or humerus intraoperative fracture.2 In this review, the 6 studies available for stemless RTSA demonstrated a 0.6% rate of humeral component loosening and a 0.9% rate of humeral intraoperative fracture with no instances of glenoid fracture. Although our identified rate of humeral loosening for stemless RTSA was slightly higher than the rate identified in a recent systemic review of stemmed components,2 we cannot comment on the significance of this difference given the small number of stemless RTSA patients available in the literature.

In the studies identified, we found reliable improvements in functional outcomes and largely equivocal complication rates for stemless anatomic TSA, HA, and RTSA compared with those published for stemmed components. However, there are multiple limitations to the current body of literature. First, there is an absence of long-term FU studies with an average FU of 10 years or more for stemless implants. For stemmed TSA and HA components, multiple studies have examined patients at 15 and 20 years of FU, finding survival rates of 87% to 88% at 15 years and 84% to 85% at 20 years.14,15,16,35 Survival is substantially lower for stemmed anatomic HA averaging 75% to 76% at 20 years.11,32 Second, there is a relative lack of randomized studies comparing stemmed and stemless components. Although these studies may be expensive,

| Study | Patients | Complications | Radiologic changes | Scapular notching (%) | Related revisions |
|-------|----------|---------------|--------------------|-----------------------|------------------|
| Ballas and Béguin 2013 | 56 | 1 intraoperative fracture of metaphysis, 1 loosening (3 d) | None | 5 (9) | 3 |
| Kadum et al 2014 | 16 | None | None | 4 (25) | 2 |
| Teissier et al 2015 | 67 | None | None | 17 (9) | None |
| von Engelhardt et al 2015 | 98 | None | None | 21 (22) | 1 |
| Levy et al 2016 | 24 | None | None | 2 (8) | None |

RTSA, reverse total shoulder arthroplasty; NR, not reported.
reliance on data from case reports introduces the possibility of selection bias, which may result in underestimates of complication and revision rates associated with these new prostheses. Finally, one of the main theoretical advantages of stemless components is the preservation of bone stock and subsequently less complicated secondary or revision surgery. Although there is little data on the available literature on revisions of stemless humeral components (possibly because of their current lack of long-term FU), a study comparing outcomes in revision of stemless versus stemmed implants could shed new light on this possible advantage.

Conclusion

In our review of all the current available literature, we identified a total of 25 studies with 1461 patients who underwent stemless TSA, HA, or RTSA. Two randomized studies were available that showed no difference in functional outcomes between patients who received stemless or stemmed components. In the studies that reported similar outcome measures, there were reliable improvements in CMS and ROM including ER and abduction. Aggregate complication rates appear similar to those reported in the literature for stemmed implants. Overall, the current data on stemless implants are promising; however, evidence supporting the utility and safety of these relatively new designs would be strengthened by longer-term FU and additional randomized studies.

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References

1. Athwal GS, Sperling JW, Rispoli DM, Cofield RH. Periprosthetic humeral fractures during shoulder arthroplasty. J Bone Joint Surg Am 2009;91:594–603. https://doi.org/10.2106/JBJS.H.00439.

2. BALLAS R, BEGUIN L. Results of a stemless reverse shoulder prosthesis at more than 58 months mean without loosening. J Shoulder Elbow Surg 2013;22:e1–6. https://doi.org/10.1016/j.jse.2012.12.005.

3. BALLAS R, TEISSIER P, TEISSIER J. Stemless shoulder prosthesis for treatment of proximal humeral malunion does not require tuberosity osteotomy. Int Orthop 2016;40:1–7. https://doi.org/10.1007/s00264-016-3138-y.

4. Beck S, Beck V, WEGNER A, DUDDA M, PATSALIS T, JAGGER M. Minimum of 20-year follow-up of덤시술 and muscle atrophy of the rotator cuff in stemless total shoulder arthroplasty: a prospec-tive cohort study. J Shoulder Elbow Surg 2017;26:1609–15. https://doi.org/10.1016/j.jse.2017.02.009.

5. Habermeyer P, Lichtenberg S, TAUBER M, MAGOSCH P. Midterm results of stemless shoulder arthroplasty: a prospective study. J Shoulder Elbow Surg 2015;24:1461–72. https://doi.org/10.1016/j.jse.2015.02.012 and a randomised study. BMC Musculoskelet Disord 2015;16:1–7. https://doi.org/10.1186/s12891-015-0479-9.

6. https://doi.org/10.1016/j.jse.2014.04.005.

7. https://doi.org/10.1007/s00264-013-2277-7.

8. CRONE CR, GERBER C, EMERY RJH, SAJJBERG JO, GOHLE F, BOILEAU P. A review of the Constant score: Modifications and guidelines for its use. J Shoulder Elbow Surg 2008;17:355–61. https://doi.org/10.1016/j.jse.2007.06.022.

9. DAELEY BJ, CELIC W, CLARKE PC, COFER JB, GUILLAMONDEGUAI OD. How slow is too slow? Correlation of operative time to complications: an analysis from the Tennessee surgical quality collaborative. J Am Coll Surg 2015;220:350–8. https://doi.org/10.1016/j.jamcollsurg.2014.12.040.

10. DISHUKH AV, KORIS M, ZURAKOWSKI D, THORNHILL TS. Total shoulder arthroplasty: long-term survivorship, functional outcome, and quality of life. J Shoulder Elbow Surg 2015;24:471–9. https://doi.org/10.1016/j.jse.2015.02.009.

11. https://doi.org/10.1016/j.jse.2015.12.021.

12. TEISSIER P, TEISSIER J, KOUSYMAILOU P, ASCENGIO G. The TESS reverse shoulder prosthesis without a stem: clinical and radiologic outcome in 50 patients younger than 50 years: minimum 20-year follow-up. J Shoulder Elbow Surg 2015;24:705–10. https://doi.org/10.1016/j.jse.2014.07.016.

13. SPERLING JW, COFER JB, GOLDBERG MM, LEONARD T, BOILEAU P. A review of the Constant score: Modifications and guidelines for its use. J Shoulder Elbow Surg 2008;17:355–61. https://doi.org/10.1016/j.jse.2007.06.022.

14. https://doi.org/10.1016/j.jse.2014.04.005.

15. TORCHIA ME, COFER RH, SETTIGER CR. Total shoulder arthroplasty with the Neer prosthesis: long-term results. J Shoulder Elbow Surg 1997;6:495–506.
36. Trofa D, Rajaee SS, Smith EL. Nationwide trends in total shoulder arthroplasty and hemiarthroplasty for osteoarthritis. Am J Orthop (Belle Mead NJ) 2014;43:166–72.
37. Uschok S, Magosch P, Moe M, Lichtenberg S, Habermeyer P. Is the stemless humeral head replacement clinically and radiographically a secure equivalent to standard stem humeral head replacement in the long-term follow-up? A prospective randomized trial. J Shoulder Elbow Surg 2017;26:225–32. https://doi.org/10.1016/j.jse.2016.09.001.
38. von Engelhardt LV, Manzke M, Filler TJ, Jerosch J. Short-term results of the reverse Total Evolutive Shoulder System (TESS) in cuff tear arthropathy and revision arthroplasty cases. Arch Orthop Trauma Surg 2015;135:1–8. https://doi.org/10.1007/s00402-015-2218-6.
39. Willis-Owen CA, Konyves A, Martin DK. Factors affecting the incidence of infection in hip and knee replacement. J Bone Joint Surg Br 2010;92:1128–33. https://doi.org/10.1302/0301-620X.92B8.