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The TESS reverse shoulder arthroplasty without a stem in the treatment of cuff-deficient shoulder conditions: clinical and radiographic results

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Background: Reverse total shoulder arthroplasty (RSA) is a recent concept that enables good functional outcomes in cases of massive rotator cuff tear and cuff tear arthropathy. Design parameters influence the functional results and complications. The purpose of this study is to present the results of a novel RSA, the Total Evolutive Shoulder System (TESS; Biomet, Warsaw, IN, USA), based on a reverse corolla without a stem.
Methods: We enrolled 101 patients with 105 RSAs in a prospective study, with a minimum follow-up period of 24 months. The analysis concerned 91 RSAs in 87 patients (61 men and 26 women), with a mean age of 73 years, at a mean follow-up of 41 months (range, 24-69 months).
Results: Ninety-six percent of patients rated their satisfaction as good or excellent. Mean flexion was 143° (range, 90°-170°), and mean external rotation was 39° (range, 20°-70°). The Constant score improved from 40 points preoperatively to 68 points at last follow-up ($P < .001$). The mean American Shoulder and Elbow Surgeons score was 24 points. The mean neck-shaft angle was 154° (range, 142°-165°). Inferior scapular notching occurred in 17 cases (19%). The notching rate was higher when the glenometaphyseal angle increased ($P < .001$), when the inferior tilt decreased ($P = .003$), and when the neck-shaft angle increased. There was no evidence of component loosening.
Conclusion: TESS RSA provided encouraging midterm results with favorable outcomes and a low rate of complications. The stemless TESS with a reverse corolla is a reliable, less invasive system.
Level of evidence: Level IV, Case Series, Treatment Study.
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Keywords: Reverse shoulder arthroplasty; stemless prosthesis; scapular notching; humeral fixation; shoulder arthroplasty; rotator cuff arthropathy; shoulder

The concept of reverse total shoulder arthroplasty (RSA) was developed by Grammont[12] almost 30 years ago. This concept was based on inversion of the anatomy, enhancing the role of the deltoid muscle in cases of massive rotator cuff tear (MRCT) and cuff tear arthropathy (CTA).[19] Published series have reported an improvement in the range of motion and pain relief.[2,13,29,33] However, high complication
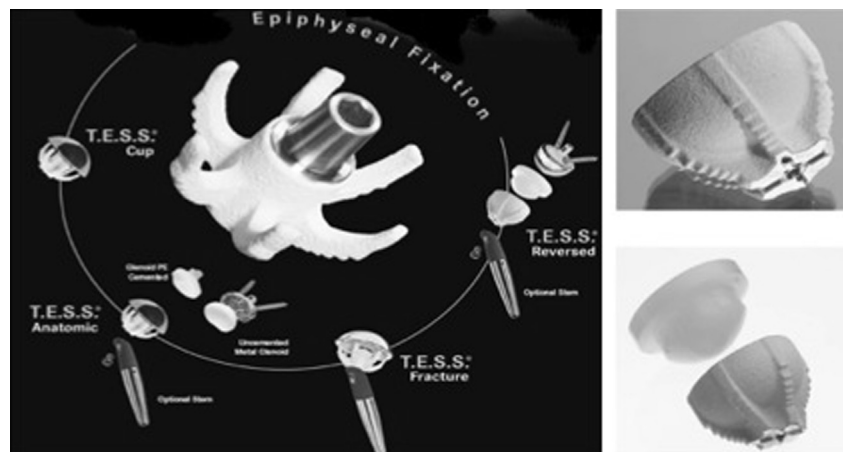
Figure 1   Total Evolutive Shoulder System.

rates remain a concern, principally for the glenoid.[34] The humeral implant, with the use of a stem, may also cause complications. The Total Evolutive Shoulder System (TESS; Biomet, Warsaw, IN, USA) allows all shoulder arthroplasties to be performed using the same humeral component. In RSA or anatomic prostheses (total shoulder arthroplasty), humeral fixation can be achieved either with a short reverse corolla (RCo) or with a classical stem. In the current climate of de-escalation of total shoulder arthroplasty, we report on a series using this previously unreported prosthesis, the stemless TESS RSA, with an RCo, at a minimum follow-up of 24 months.

Materials and methods

This prospective study included 105 stemless RSAs in 101 patients, performed by the same surgeon between January 2006 and March 2010. At a minimum follow-up period of 24 months, 6 patients had died of unrelated causes and 8 had moved overseas. Therefore, this study ultimately included 91 arthroplasties in 87 patients. There were 61 men and 26 women, with a mean age of 73 years (range, 55-89 years) at the time of surgery. The patients provided informed consent for their data to be included in the study.

The indications were MRCT and CTA, quantified using the classification of Hamada et al.[15] Other indications (trauma, tumor, revisions) were not included. Thirteen percent of patients had undergone previous failed rotator cuff surgical treatment (repairs).

TESS RSA design

The design of the TESS prosthesis was based on Grammont's concept (Fig. 1).[12] The glenoid baseplate is uncemented and is secured by a full hydroxyapatite central peg with titanium plasma spray, as well as 2 superior and inferior 4.5-mm locked screws. The glenosphere (sized 36 or 41 mm in diameter) is eccentric, with a 3-mm lateralization, and is placed inferiorly. The humeral implant is based on the RCo, which was developed from the anatomic corolla. The RCo is an uncemented metaphyseal-epiphyseal implant, made of chrome cobalt, with a titanium plasma spray and full hydroxyapatite coating, available in 4 sizes. Six wings on the surface of the RCo optimize the rotational stability. The stem is an option, with an angulation of 150°. The polyethylene component, available in 4 thicknesses, is prevented from dislocating by a ring-lock system.

Operative technique

The procedure was usually performed by a superolateral approach. A deltopectoral approach was chosen for concomitant latissimus dorsi transfer in 4 cases of negative and deficient preoperative active external rotation.

For the glenoid, an asymmetric reamer increased the height of the central portion to improve osteointegration and preserved the peripheral rim to optimize the stability of the baseplate. The humerus was cut with a 150° centromedullary guide. The RCo was retroverted by 20° and was uncemented and without a stem.

The limb was immobilized on a 45° abduction splint for 3 weeks. Passive range of motion started on day 1 postoperatively, and active range of motion started at 3 weeks postoperatively.

Assessment

Clinical assessment including visual analog pain scores; range of motion; strength in flexion; and a functional assessment with the Constant score (CS), American Shoulder and Elbow Surgeons score, and QuickDASH (short version of Disabilities of the Arm, Shoulder and Hand questionnaire) score was performed preoperatively and at follow-up. The adjusted CS was calculated as a percentage of normal values relative to gender and age.[13] A determination of patient satisfaction completed the clinical analysis.

The radiographic protocol at the last follow-up visit included standardized, fluoroscopically controlled, anteroposterior radiographs in neutral rotation and adduction views, 1 tangential to the baseplate and 1 tangential to the RCo, as well as a lateral view. We measured glenoid inclination, the neck-shaft angle (NSA), glenometaphyseal (GM) angulation, lateralization, and lowering using Osirix software (UCLA, Geneva, Switzerland) (Fig. 2). Scapular inferior notching was recorded according to the
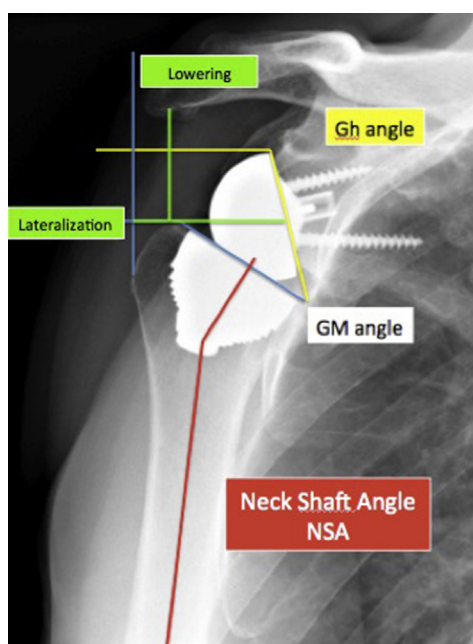
Figure 2 Radiographic assessments. *Gh*, Glenoid inclination.

classification of Sirveaux et al.[29] Radiolucent lines were assessed in 5 glenoid areas (Fig. 3).

Statistical analysis

Analysis of variance with a multivariate analysis plus the Wilcoxon signed rank test (for comparison of specific values obtained postoperatively and at last follow-up), the Mann-Whitney *U* test (for analysis of differences between 2 subgroups), and the Kruskal-Wallis test (for analysis among several subgroups) was used to analyze the data. $P < .05$ was considered significant.

Results

The mean follow-up period was 41 months (range, 24-69 months). In this series, 45% of patients were stage 3 and 46% of patients were stage 4 according to the Hamada and Fukuda classification. The teres minor was intact in 86% of cases. The mean body mass index (BMI) was 26 kg/m^2.

Clinical results

Ninety-six percent of patients were satisfied or very satisfied. Mean maximal pain was rated as 2 of 15, and 86% of patients had no pain (Table I). The final ranges of motion were as follows: flexion, 143° (47% in the glenohumeral joint and 53% in the scapulothoracic joint); abduction, 138°; external rotation in adduction, 39°; external rotation in abduction, 68°; and 4 points on the CS scale in internal rotation. Strength in flexion was 6 kg (106% of contralateral side and 70% gain compared with preoperative values).

The mean CS was 68 points, and the mean adjusted CS was 90 of 100 points. This was not affected by gender, operative side, or time after surgery. It was correlated with age ($P = .039$) and BMI ($P < .0001$). The mean American Shoulder and Elbow Surgeons
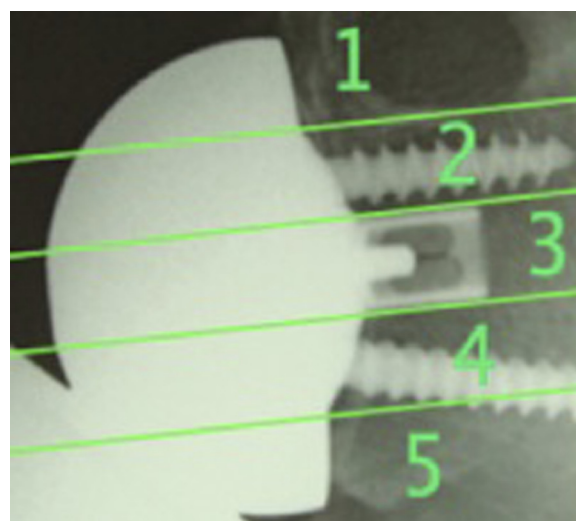
Figure 3 Bone modifications in 5 zones.

score was 24 points, and the mean QuickDASH score was 20 of 30 points. Outcomes did not differ significantly between patients with previous rotator cuff repair and those without it (CS of 70 points with previous rotator cuff tear vs CS of 68 points).

Complications occurred in 3 patients. One patient who presented with recurrent dislocations was reoperated on successfully with the addition of a 6-mm polyethylene spacer. A stress fracture of the spine of the scapula occurred in 1 patient and a traumatic clavicle fracture occurred in another patient after a fall (without repercussions for the final result).

Radiographic results

No radiographic evidence of glenoid or humeral component loosening was observed (Table II and Fig. 4). The mean glenoid inclination angle was 96° (range, 80°-108°), corresponding to a 6° inferior glenoid tilt. The mean NSA was 154° (range, 142°-165°). The mean GM angle was 49° (range, 25°-72°). Lateralization and lowering measured 42 mm and 27 mm, respectively.

Inferior scapular notching occurred in 17 cases (19%), with 16 cases at stage 1 and 1 case at stage 2. Scapular notching did not affect the CS (66 points vs 69 points). The incidence of scapular notching increased as the GM angle increased ($P < .001$) and as the glenoid inclination angle or inferior tilt decreased ($P = .03$).

Discussion

RSA is a relatively recent solution for treating MRCT and CTA. Many published results on Grammont's prosthesis, as well as subsequent RSAs, have shown improvements in pain relief, range of motion, and function in patients with these indications, but the rate of complications requires vigilance and limits their use in young patients. This suggests that changes are required to reduce these complications.[11]

This is the second published series concerning TESS RSA[1] and describes more cases than the previous study. The results of a few series regarding other RSAs have been published (Table III).[1,4,14,24,29,33] Our series is

Table I Clinical outcomes

Clinical results	Preoperative	Last follow-up	Change	P value
Maximal pain score	8 (1 to 15; ±3)	2 (0 to 8; ±1.4)	−6	<.001*
Flexion (°)	96 (0 to 160; ±0)	143 (90 to 170; ±42)	+47	<.001*
Abduction (°)	89 (0 to 160; ±28)	138 (80 to 160; ±49)	+49	<.001*
External rotation in adduction (°)	26 (−60 to 70; ±25)	39 (20 to 70; ±3)	+13	<.001*
External rotation in abduction (°)	47 (−25 to 90; ±21)	68 (20 to 100; ±7)	+21	<.001*
Internal rotation	5 (2 to 10; ±1.4)	4 (2 to 8; ±3)	−1	<.001*
Strength (kg)	2 (0 to 7; ±2)	6 (2 to 12; ±1)	+4	<.001*
CS (points)	40 (12 to 76; ±24)	68 (42 to 100; ±12)	+28	<.001*

Data are presented as mean (range; SD).
  * Statistically significant.

Table II Radiographic results

	All patients	Patients without notching (74 cases)	Patients with notching (17 cases [18.7%])	P value
Glenoid inclination angle (°)	96 (80-108; ±5)	97 (84-108; ±5)	91 (80-105; ±11)	.03*
NSA (°)	154 (142-165; ±3)	154 (142-165; ±0)	155 (150-162; ±5)	.18
GM angle (°)	49 (25-72; ±11)	47 (25-64; ±7)	58 (38-72; ±15)	<.001*
Lateralization (mm)	42 (28-54; ±1)	42 (28-52; ±2)	41 (32-54; ±9)	.53
Lowering (mm)	27 (13-39; ±5)	26 (16-39; ±4)	29 (13-37; ±2)	.10
Radiolucent lines in zones 1 and 2 (%)	60.5	44	84	—

Data are presented as mean (range; SD).
  * Statistically significant.
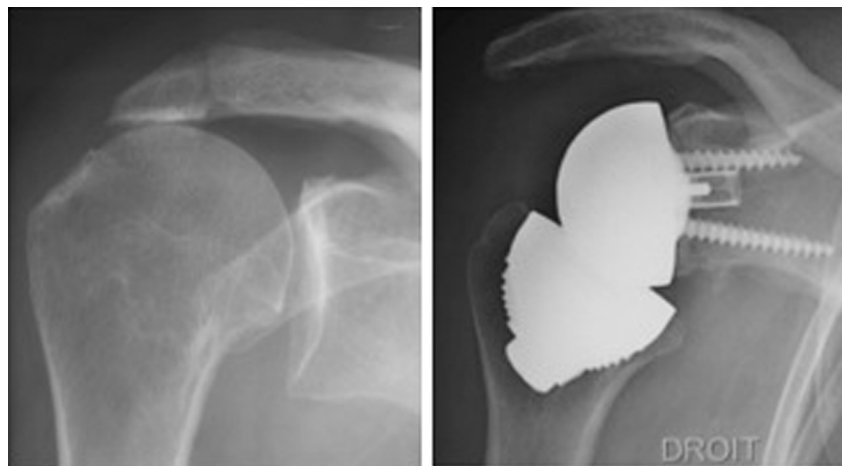
Figure 4 Radiographs obtained preoperatively (*left*) and at 2 years' follow-up (*right*).

homogeneous regarding the population and the indications. The case number and timing of follow-up are comparable. Our findings for the aforementioned indications are similar to or better than those in other series. We found a significant improvement in pain relief, flexion, abduction, and external rotation. These good results are probably at least partially because of the indications, which excluded revisions and acute fractures.[31] Previous rotator cuff repairs did not affect the clinical outcome, as was reported by Boileau et al[3] and Sadoghi et al.[28]

We found that an intact teres minor was statistically correlated with greater external rotation (+11° in external rotation in adduction and +15° in external rotation in abduction).[27] Similarly, in 4 cases with deficits in external rotation, Favre et al[10] found that a latissimus dorsi tendon transfer restored functional external rotation (gain of 29° in RE1 and 36° in RE2). Internal rotation is usually the most affected range of motion. In our series, internal rotation decreased by 1 point on the CS scale.[22] Sixty-five percent of patients had internal rotation that exceeded the buttock with

Table III Published series on RSA

Series	Prosthesis	No. of patients	Follow-up (mo)	Painless patients (%)	Flexion (°)	External rotation (°)	Strength (kg)	CS/ASES score (points)	Scapular notching (%)	Satisfaction (%)
Sirveaux et al,[29] 2004	Delta III	77	44	96	138	32	7.4	65.6 (CS)	63.6	92
Molé and Favard,[24] 2007	Delta III Aequalis	484	52	—	130	12	7.5	62 (CS)	68	—
Young et al,[33] 2009	SMR	49	38	92	122	15	—	70.1 (ASES score)	24	89
Gravier et al,[14] 2010	Scultra (135°)	45	10	95	—	—	6	56 (CS)	0	59
Boileau et al,[4] 2011	Aequalis + Bio-RSA	42	38	—	146	17	7	66.6 (CS)	19	93
Ballas and Beguin,[1] 2013	TESS	56	58	95	140	45	6	62 (CS)	9	—
Our series	TESS	91	41	96	143	39	6	68 (CS)	19	96

ASES, American Shoulder and Elbow Surgeons.

the hand, but 86% reported discomfort performing perineal hygiene. Retroversion influences the rotation.[24] We used 20° of retroversion to improve external rotation. In all cases, the subscapularis is essential for rotation and stability.[5,7] The superolateral approach spares the subscapularis.[25]

The low rate of complications (3%)[9,34] was related to experienced surgeons[17] and MRCT indications.[8] In our series, a case of instability occurred as a result of inadequate soft-tissue tensioning, which was resolved with a thicker spacer. The fracture of the spine of the scapula was a stress fracture of porous bone, type 3 in the classification of Crosby et al,[6] and orthopaedic treatment (use of a splint in abduction for 2 months) led to a good functional result. There were no infections or neurologic lesions.

We observed no humeral loosening of the corolla despite the lack of a stem, as well as no component dissociation. We found no evidence of glenoid loosening related to inferior tilt[18] or poor bone stock.[16] These types of failure usually occur early because of insufficient initial fixation. The glenoid baseplate presents a central convex surface that increases bone contact, a central peg coated with hydroxyapatite for good bone integration without radiolucent lines in front of the central peg, and peripheral flat edges that increase stability.

The rate of scapular notching observed in our medium-term follow-up study was about 19%, but the incidence varies widely in the literature. The first series of TESS RSA reported a rate of 9% (all stage 1) at 59 months' follow-up.[1] Members of a French orthopaedic society reported a rate of 62% at 47 months.[23] This rate is consistent with findings in recently published series. Further study with a longer follow-up will be necessary, despite the fact that Wermer et al[32] stated that scapular notching occurs early (68% of cases of scapular notching seen at 5 years' follow-up existed after 1 year). This could in part be attributed to the surgical technique, with the baseplate positioned as

inferiorly as possible in the margin of the glenoid.[26] Lateralization decreases notching.[20,30] Boileau et al[4] recommended biological lateralization to minimize torque on the glenoid component and reported notching in 19% of cases at 38 months' follow-up. We chose mechanical lateralization using a 3-mm eccentric glenosphere, without glenoid loosening. Similar to Kempton et al,[21] we observed that an inferior glenoid tilt protects against scapular notching.

Falaise et al[8] introduced the GM angle, which is the relation between the humerus and glenoid in adduction in the resting position. The GM angle was significantly larger in the group with scapular notching (46.9° in the group without notching vs 57.8° in the group with notching). Our results are consistent in terms of the GM angle, which is a predictive factor for the occurrence of scapular notching. However, the GM angle changes with the position of the glenoid and resting adduction, which vary with BMI.[8] For stemless RSA, a third factor affects the GM angle, that is, the RCo position in the frontal plane: the GM angle decreases when the NSA decreases. This highlights the importance of placing the humeral implant in a more varus position in patients with a risk of scapular notching. Three-dimensional analysis would bring precision, especially in the horizontal plane.

Our study has some limitations. The 41-month follow-up is comparable with that of previously published series, but a longer follow-up study will be necessary for optimal analysis of complications, scapular notching, and survival rate. There is also selection bias: whether to use the stem was determined by the surgeon, perioperatively, depending on bone quality and the primary stability of the humeral implant. A second study will report on the use of the stemless RCo. A randomized comparison with and without a stem, as well as a comparison of variations of the NSA, will subsequently be performed.

Conclusion

The new designs of the TESS RSA yield favorable outcomes and a low rate of complications in MRCT and CTA patients. Provided that the bone stock is sufficient, a stemless prosthesis is reliable and less invasive.

Disclaimer

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