**ORTHOPAEDIC SURGERY**

# Long-term results of the reverse Total Evolutive Shoulder System (TESS)

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**Abstract**

**Introduction** Latest trends in shoulder replacement aim at bone stock preservation. Long-term results of stemless anatomical total shoulder implants compare favourably with stemmed designs in terms of function and survivorship. The Total Evolutive Shoulder System (TESS) has been one of the first designs offering a stemless implant not only for anatomical but also for reverse total shoulder arthroplasty with optional short stem attachment in cases with poor bone quality. The aim of the present study was to evaluate long-term results of the reverse Total Evolutive Shoulder System (TESS).

**Materials and methods** Between 2006 and 2009, 49 shoulders in 47 patients were replaced using the Biomet reverse Total Evolutive Shoulder System (TESS). 29 shoulders in 27 patients who were aged $72.4 \pm 6.7$ (53–88) years were available for review at a mean follow-up of $101.6 \pm 24.6$ (75–142) months.

**Results** The implant survival rate was 93.1% at 101 months (8.4 years). The overall revision rate of the TESS implant was 17.2%. No implant associated complications to the reverse corolla implant could be observed. All reverse corolla implants showed solid fixation at follow-up. Scapular notching was found in 72.3% of the shoulders. Clinical scores significantly improved at long-term follow-up (VAS from $7.5 \pm 1.2$ to $1.4 \pm 1.5$, $p < 0.001$; quick-DASH from $70.9 \pm 12.0$ to $28.9 \pm 22.9$, $p < 0.001$ and Constant score from $13.0 \pm 3.7$ to $60.5 \pm 16.8$, $p < 0.001$).

**Conclusions** In terms of clinical scores, radiographic loosening, complication rates and implant survivorship the reverse Total Evolutive Shoulder System provides results comparable to those of conventional stemmed reverse shoulder arthroplasty.

**Keywords** TESS · Stemless · Reverse shoulder arthroplasty · Long-term follow-up · Survivorship

## Introduction

Bone stock preservation currently represents a trend in arthroplasty implant design for almost all joints. Especially in shoulder replacement a vast evolution has been observed in the last decade. In the meantime most companies provide stemless designs for anatomic shoulder arthroplasty and few manufacturers offer stemless implants for reverse shoulder arthroplasty (RSA) as well.

Stemless humeral components can be implanted independently from humeral shaft axis, and therefore, enable bone preservation of the proximal humerus. This can be of benefit in posttraumatic situations with humeral head and metaphyseal deformity. In addition, preserving humeral bone stock facilitates revision surgery [1, 2].

The Biomet Total Evolutive Shoulder System (TESS, Biomet, Warsaw, IN, USA) has been available in Europe for more than 10 years now. The stemless TESS implant is designed for anatomic and reverse shoulder replacement. Depending on bone stock, a stem can be attached to the humeral metaphyseal implant (corolla) to aid in stability. Stemless designs in anatomical shoulder replacement have proven to be comparable with stemmed arthroplasty at 8–9 year follow-up [2, 3]. In short- to mid-term follow-up several studies focusing on stemless RSA have shown promising results [4, 5]. This study presents our 10-year experience using the stemless reverse TESS design.

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## Materials and methods

Between November 2006 and October 2009, 49 shoulders in 47 patients were treated with a reverse shoulder replacement using the Biomet Total Evolutive Shoulder System (TESS, Biomet, Warsaw, IN, USA). Informed consent was obtained from all patients.

Preoperative radiological assessment was made by anteroposterior, axillary and lateral radiographs of the affected shoulder. Rotator cuff deficiency was confirmed with MRI when necessary. CT scans were used to assess glenoid bone stock. Shoulder function, VAS-, Constant score and quick-DASH questionnaire were recorded in all patients prior to surgery. All patients were operated by the same orthopaedic surgeon with a special interest in shoulder surgery. Surgery was performed in a beach-chair position under general anaesthesia and an interscalene block. The deltopectoral approach was used in all cases with tenotomy and transosseous refixation of the subscapularis whenever possible with the arm held in 40° of external rotation. Otherwise the subscapularis tendon was left unattached. Resection of the humeral head was performed with the aid of a cutting guide in 10 degrees of retroversion. After a 360° capsular release the glenoid was reamed with a power instrument and press-fit fixation of the peg-metal back was obtained. It was secured with two locking screws, one directed into the scapular neck and the second into the base of the coracoid process. Depending on glenoid size, a 36 or 41 mm glenosphere was attached. Using the instruments provided, the reverse humeral corolla implant was positioned press fit in the centre of the metaphysis. A short stem was attached in cases with poor bone quality or metaphyseal defects to aid in primary stability.

For rehabilitation a shoulder immobilizer was applied allowing the patients to exercise from day one under physiotherapist supervision limiting external rotation to 10°, elevation and flexion to 90° and avoiding retroversion for 6 weeks.

Outcome and patient satisfaction were evaluated using the VAS-, quick-DASH and Constant shoulder score as well as anteroposterior, axillary and lateral radiographs of the affected shoulder.

## Statistics

Summary statistics of the data were expressed as mean ± SD. The Shapiro–Wilk test was used to test for normal distribution. The paired Student's $t$ test was used for comparison of the normal distribution of pre- and postoperative means and the Wilcoxon signed-rank test for non-normal distribution. The comparisons with $p$ values < 0.05 were considered to be significant. The software SPSS 19 (SPSS Inc. Headquarters, Chicago, IL, USA) was used to carry out the statistical computations.

## Results

During the course of the study eight patients were lost for follow-up and 11 patients died of unrelated causes. Therefore, 29 shoulders in 27 patients (22 female, 5 male) with ages at operation ranging from 53 to 88 years (mean $72.4 \pm 6.7$ years) were available for follow-up. Two patients underwent bilateral RSA. The indication for reverse shoulder arthroplasty was cuff tear arthropathy (CTA) in 19 cases, fracture sequelae in 7 cases and revision arthroplasty in 3 cases. The dominant arm was involved in 22 of the cases.

At a mean follow-up of $101.6 \pm 24.6$ (75 to 142) months the VAS-score changed from $7.5 \pm 1.2$ to $1.4 \pm 1.6$ ($p < 0.001$). The quick-DASH score significantly improved from $70.9 \pm 12.0$ to $28.9 \pm 22.9$ ($p < 0.001$) and the Constant score increased from $13.0 \pm 3.7$ to $60.5 \pm 16.8$ ($p < 0.001$) at follow-up (Table 1).

Stemless implants were applied in 12 shoulders (11 patients) all suffering from CTA. A short stem was attached to the corolla implant in 17 shoulders (16 patients) with 7 cases suffering from CTA, fracture sequelae in 7 cases and arthroplasty revision in 3 cases.

Four early complications have been observed: A 74-years-old patient with rheumatoid arthritis and CTA developed a hematoma that had to be surgically revised and also suffered a dislocation of the prosthesis treated initially by closed reduction. Because of ongoing instability the stemless reversed corolla implant had to be revised to a stemmed component 4 weeks after the index surgery. The corolla had to be revised as there was a lack in offset that could not be managed by increasing height of the polyethylene inlay. The stemless corolla showed solid fixation at the time of revision. In a 72-years-old female patient revision of a hemiarthroplasty to RSA was performed due to rotator cuff failure. There was a significant bone defect of the superior glenoid.

**Table 1** Preoperative and postoperative results (mean FU 101 months)

|  | Preoperative | At follow-up | Gain | $p$ value |
|---|---|---|---|---|
| Flexion | $51.9 \pm 14.0$ | $135.5 \pm 26.6$ | 83.6 | < 0.001 |
| Abduction | $38.3 \pm 9.8$ | $116.1 \pm 25.7$ | 77.8 | < 0.001 |
| Constant score | $13.0 \pm 3.7$ | $60.5 \pm 16.8$ | 47.5 | < 0.001 |
| Quick-DASH | $70.9 \pm 12.0$ | $28.9 \pm 22.9$ | 42.0 | < 0.001 |
| VAS | $7.5 \pm 1.2$ | $1.4 \pm 1.5$ | 6.1 | < 0.001 |

3 months after revision surgery to RSA a dislocation of the glenoid base plate occurred. The shoulder was revised to a hemiarthroplasty.

Another implant was lost due to a low-grade infection. A two-stage revision procedure was performed 109 months after the index operation with cement spacer implantation and final revision to a stemmed revision prosthesis (Delta Xtend, Depuy Synthes, Warsaw, IN, USA) with bony augmentation of the glenoid.

In the shoulders available for radiographic follow-up no radiolucent lines were found neither on the humeral side with stemless (Fig. 1) or short-stemmed implants (Fig. 2) nor on the glenoid side. Radiographic signs for scapular notching were present in 72.3% of the reverse TESS arthroplasties. We found scapular notching grade 0 in 27.8% of the cases, grade 1 in 33.3%, grade 2 in 22.2%, grade 3 in 16.7% and 0% grade 4 according to the classification of Sirveaux

[6]. The humeral neck shaft angle (humeral inclination) measured $150.5 \pm 6.3$ (range 133.5–159.1) degrees.

## Discussion

Stemmed fixation of the humeral component has been regarded as the gold standard in shoulder replacement for many decades. The stemless concept "Total Evolutive Shoulder System" (TESS, Biomet, Warsaw, IN, USA) has been available in Europe for more than 10 years now. Studies with short- and mid-term follow-up of this implant show promising results regarding patient satisfaction and revision rates [4, 7]. In a matched pair analysis stemless implants have been found equal to stemmed RSA in terms of clinical or radiographic outcomes at short- to mid-term follow-up



Fig. 1 Anteroposterior and axillary radiographic views of a reverse stemless TESS showing solid fixation of the glenoid and humeral components, inferior scapular notching grade 3 at 91 months follow-up
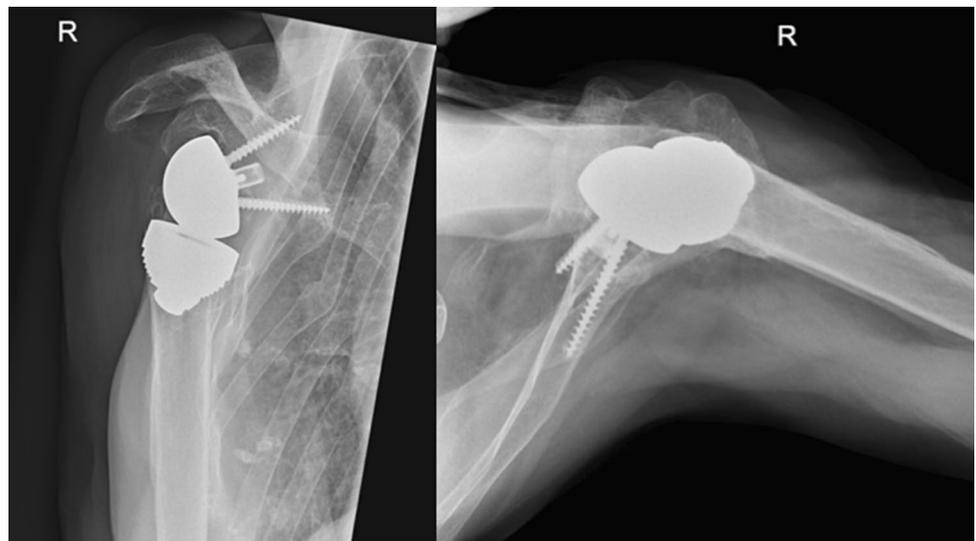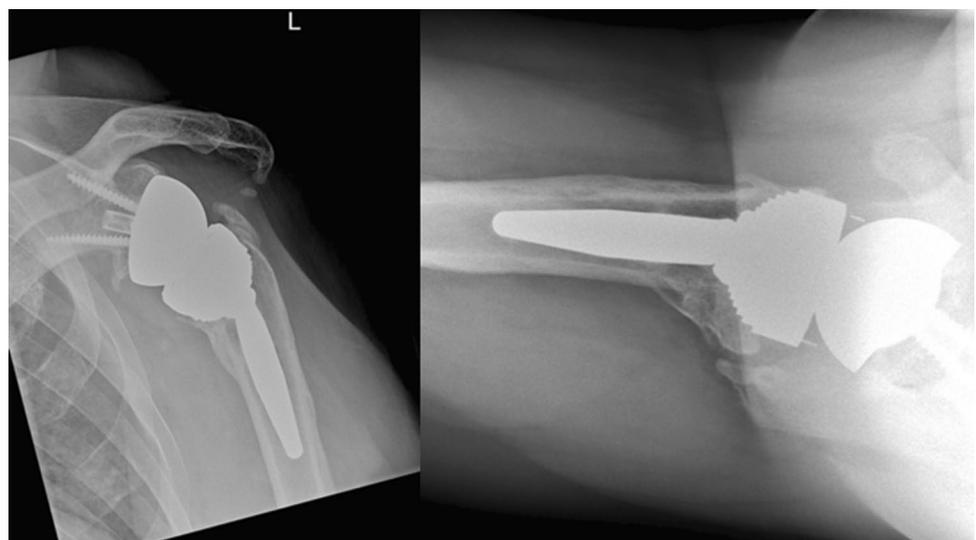


Fig. 2 Anteroposterior and axillary radiographic views of a reverse TESS with a $12 \times 100$ mm stem demonstrating solid fixation of the glenoid and humeral components, no inferior scapular notching at 108 months follow-up

[8]. However, long-term outcome and survivorship of the reverse TESS implant needs to be investigated.

The reverse TESS corolla implant offers a stemless option but a short stem can also be attached depending on bone quality and metaphysical bone stock to aid in primary stability. The authors recommend stemless implantation only in cases with good bone quality and adequate metaphyseal bone support following reaming. In our case series a stemless implant was only used in shoulders with cuff tear arthropathy. In these cases the reverse corolla showed good primary stability after press-fit fixation of the implant. One stemless implant had to be revised 4 weeks after the index surgery due to recurrent dislocations of the reverse prosthesis. In revision surgery the corolla implant proved to be solidly fixed. However, to an increase in offset, the stemless corolla had to be replaced by a short-stemmed implant since no higher polyethylene inlay was available at that time.

We used the reverse TESS as a revision implant in three cases. All of these showed enough metaphyseal bone stock after implant removal to support the corolla implant. In the revision cases available for follow-up no implant associated complications were observed. Nevertheless, the authors feel that the reverse TESS is not a revision implant and can only be recommended for revision surgery if there is no metaphyseal defect after explantation of the failed humeral prosthesis.

Since the short cementless stems attached to the reverse corolla only aid in primary stability and do not fill the humeral canal or provide fixation within the shaft, the term "stemless" may also apply for these cases. The manufacturer does not recommend using the TESS prosthesis in cases with complete metaphyseal defects and lack of bony support of the corolla due to the risk of a breakage or disassembly (manufacturer´s manual). Having failed to appreciate this in one patient we observed an implant failure with disassembly of the stem and the corolla implant. This case was not included in our study since the patient died from a disease not related to the shoulder arthroplasty prior to follow-up.

Ascione et al. reported 3.3% of humeral complications after stemmed RSA [9]. Apart from the reported disassembly of the stem and the corolla, no implant associated complications were found on the humeral side. In all shoulders solid fixation of the reverse corolla implant could be observed in radiographic review.

On the glenoid side scapular notching was present in 72.3% of the reverse TESS implants. Minor notching, that is grades 1 and 2 according to the Sirveaux classification [6], was found in 55.6% of the cases, whereas a higher degree of notching was only present 16.7% of the shoulders. Teissier et al. observed scapular notching in only 30% of the reverse TESS implants at a mean follow-up of 39 months. But, the extent of notching is known to increase with time [10, 11]. With regard to the follow-up of more than 8 years in our patient cohort the observed scapular notching preferably corresponds to the rates reported in literature for long-term follow-up of stemmed RSA ranging from 57 to 73% [10–12]. Despite the high amount of notching no correlation to the clinical outcome could be observed ($p = 0.324$). This concurs with the findings of other researchers [10–14].

In a systematic review Erickson et al. found that the rate of scapular notching was significantly higher with a 155° prosthesis than with a 135° humeral implant [15]. Werner et al. identified a lower humeral neck shaft angle to be effective for an improvement in range of motion [16]. Radiographic analysis of the humeral neck shaft angle (humeral inclination) in our patient cohort revealed a range of 133.5–159.1 degrees. No association between humeral inclination and scapular notching ($p = 0.450$) or range of motion ($p = 0.105$) could be observed. This might be due to the relatively small number of patients available for follow-up.

Ballas et al. reported good clinical and radiographic results using the reverse TESS implant with a mean Constant score of 62 at 58 months follow-up [17]. In the current study with a follow-up twice as long the absolute Constant score was $60.5 \pm 16.8$ ($p < 0.001$). Thus, at a mean follow-up of $101.6 \pm 24.6$ months the results of the reverse TESS prosthesis seem to be comparable to the results of other authors reporting on long-term results of conventional stemmed RSA [10, 12, 18].

Using the reverse TESS prosthesis, the complication rate at a mean follow-up of $101.6 \pm 24.6$ months was 17.2% (5 revisions in 29 shoulders) with 4 revisions in the early period (< 6 months after the index surgery) including evacuation of hematoma, closed reduction and revision surgery of the humeral implant as well as a dislocation of the glenoid base plate in one case needing revision to a hemiarthroplasty. No case of revision was related to the corolla implant. One implant was lost due to a low-grade infection with the need for a two-stage revision surgery 109 months after the index surgery. Thus, in the course of our study two implants were lost indicating an implant survival rate of 93.1% (Fig. 3). These findings correspond to the results of stemmed RSAs with survival rates between 89 and 93% at 10 years follow-up [12, 19, 20].

## Limitations

Our study has some limitations: our investigation is a single centre retrospective study. It has to be mentioned that 6 patients could only be assessed by telephone interview as they were unable to attend. We are reporting on long-term results, nevertheless, the reverse TESS implant needs to be the subject of further investigation since the conventional stemmed implants still represent the ´gold standard' with regard to implant survival rates over 10 years of time.
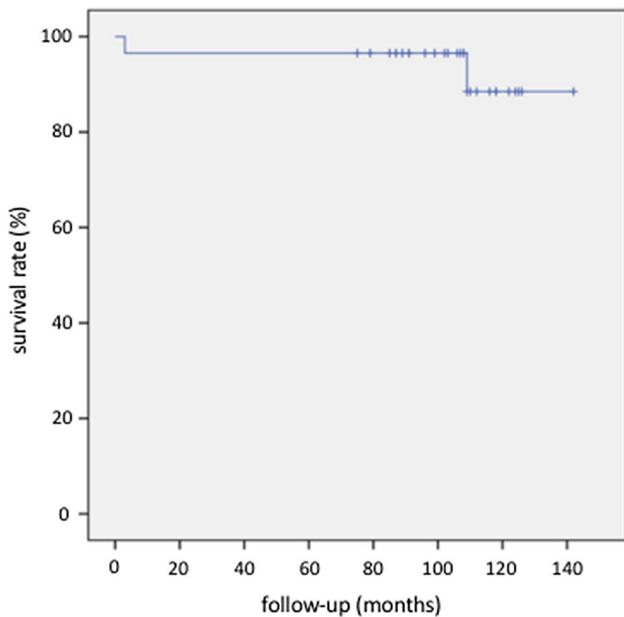
**Fig. 3** Kaplan–Meyer curve demonstrating the survival rate of the reverse TESS prosthesis

## Conclusion

With the numbers given and in regard of the follow-up described hereby, the results of the reverse TESS arthroplasty match those of conventional stemmed implants. However, comparative studies with a longer follow-up are required to reach a scientific final conclusion. This is of special interest since the results of conventional stemmed RSA deteriorate over time [19].

## Compliance with ethical standards

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