



# Trends in 3D planning and navigation in shoulder arthroplasty: Analysis of 70,137 cases over 8 years

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## Abstract

This study aims to retrospectively evaluate TSA planning patterns over an 8-year period, examining nearly 70,000 cases. For both aTSA and rTSA, over half of the planned cases are navigated, with most adhering to the planned procedure. Practitioners who plan both procedures are more likely to navigate the case, particularly in aTSA.

For aTSA, neutral inclination and slight retroversion are consistent targets. In rTSA, 0° inclination is the aim, with significant inferior corrections and greater version adjustments using posterior augments. Augmented implants help maintain planned residual angles while addressing severe deformities. No notable differences were observed between low- and high-volume surgeons.

## 1 Introduction

Launched some ten years ago, 3D pre-operative planning is now widely utilized in total shoulder arthroplasty (TSA)[5], whether navigation is used or not[3]. They allow accurate measurements of glenoid version and inclination [9] and deviation from the preoperative plan seems low[4, 2]. It has been proven to predict glenoid and humeral component size[1, 7], thus potentially to reduce costs[8].

However, it remains largely unclear what the optimal plan for any given case would be relative to procedure type, anatomic (aTSA) or reversed (rTSA), implant placement, and correction of deformity[6]. This study evaluated planning trends over an 8-year period to try to determine whether the types of planned procedures (aTSA or rTSA) are being implemented using navigation, what factors are likely to influence this decision, what the targets are for implant positioning, and whether these elements have changed over this period.

## 2 Material and Methods

A retrospective review of a multicenter prospectively collected de-identified data from a single TSA planning and navigation system (Equinox, Exactech GPS, Blue-Ortho) was carried out between 2017 and 2024. All planning cases were included (navigated or not).

Were assessed the following trends:

- Planning aTSA only, rTSA only or both aTSA and rTSA;
- Whether or not the planned case has been navigated;
- In cases where both procedures were planned, look for criteria explaining procedure choice for navigation. Available information for this exploration were patient’s age and native glenoid measurements;
- Over the years, what target values were chosen for the implant version and inclination, stratified by procedure (aTSA or rTSA) and implant type (augmented or not).

### 3 Results

Enrolled cases are those planned using the Exactech Equinox Planning application (Blue-Ortho, France) and uploaded to a dedicated server from January 1st, 2017 to November 15th, 2024.

This represents 68,151 planned cases, performed by 1864 surgeons, in 18 countries, including 5769 aTSA plan (8.5%), 50,373 rTSA plans (73.9%), and 12,009 with both aTSA and rTSA plans (17.6%). Among these plans, 40,672 were navigated (59.7%).

52.3% of the aTSA planned were navigated, including 97.5% with an aTSA and 2.5% rTSA. 58.1% of the rTSA plans were navigated, mostly using the same procedure type (99.7%). When a case was planned for both procedures, the navigation rate rose to 69.8%, with a slight preponderance for aTSA (53.4%). See Table 1.

	<b>aTSA</b>	<b>rTSA</b>	<b>aTSA and rTSA</b>
Planned	5769	50373	12009
Navigated	3020 (52.3%)	29272 (58.1%)	8380 (69.8%)
Procedure (%)	aTSA: 97.5, rTSA: 2.5	aTSA: 0.3, rTSA: 99.7	aTSA: 53.7, rTSA: 46.3

Table 1: Occurrence of planned procedures, navigated procedures, and percentage of those performed as planned (stratified by procedure type, aTSA or rTSA).

When both aTSA and rTSA were planned and the procedure navigated (8380 cases), the aTSA procedures presented younger patients ( $64.7 \pm 8.5$  versus  $69.9 \pm 8.2$  years old,  $p < 0.001$ ), slightly more retroverted glenoids ( $12.1 \pm 8.0^\circ$  versus  $11.9 \pm 9.5^\circ$ ,  $p < 0.001$ ) and more inferior native inclination ( $-0.8 \pm 6.0$  versus  $0.1 \pm 6.7$ ,  $p < 0.001$ ).

With regard to target values and planned corrections, along the 8 year, Table 2 displays the results.

### 4 Discussion and conclusion

For both aTSA and rTSA, just over half of planned cases are navigated, with the vast majority following the planned procedure. When the practitioner has planned both aTSA and rTSA procedures, she/he is more likely to navigate the case and rather in aTSA. In this case, if the first criteria to choose aTSA or rTSA is obviously driven by diagnosis and the condition of the rotator cuff, information to which we did not have access in this study, but patient’s age seems playing a role in this choice, moving to aTSA for younger patients.

	aTSA	rTSA
<b>Planned inclination</b>		
Non Augmented Glenoids	1.3±3.6°	0.0±2.7°
Posteriorly Augmented Glenoids	0.9±3.5°	-0.2±2.5°
<b>Planned inclination correction</b> (planned - native)		
Non Augmented Glenoids	0.1±4.7°	5.3±8.7°
Posteriorly Augmented Glenoids	3.1±5.3°	11.4±9.9°
<b>Planned retroversion</b>		
Non Augmented Glenoids	3.2±3.7°	2.4±3.5°
Posteriorly Augmented Glenoids	4.6±4.1°	3.2±4.0°
<b>Planned retroversion correction</b> (planned - native)		
Non Augmented Glenoids	2.7±4.6°	2.8±7.6°
Posteriorly Augmented Glenoids	11.0±5.5°	8.3±8.1°

Table 2: Mean target values and planned corrections, among the 8 years, for the implant version and inclination, stratified by procedure (aTSA or rTSA) and implant type (augmented or not).

As far as target values are concerned, neutral inclination and slight retroversion remain the objective over the period studied, for the aTSA. For rTSA, 0° inclination is the target, with significant inferior corrections and greater version correction which are observed with posterior augments.

The use of augmented implants allow surgeons to remain stable in planned residual angles while correcting high deformities. No major differences were observed between low-volume and higher-volume surgeons.

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