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# Clinical Use of a Computer Assisted Anatomic Total Shoulder Arthroplasty System: An Analysis of 574 Cases

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**Abstract**

Accurate reproduction of glenohumeral anatomy during anatomic total shoulder arthroplasty (aTSA) has been shown to correlate with positive clinical outcomes. Preoperative planning and computer assisted surgery (CAS) can improve upon glenoid placement, but such systems for aTSA have experienced limited commercial success. Postoperative surgical reports from the first 574 clinical cases of a commercially available CAS aTSA system were collected and analyzed for implant selection, implant placement, and incision start to incision close operative time, and compared to similar date cohorts for non-navigated cases. Navigated aTSA cases had a significantly longer incision time than non-navigated cases. Augmented glenoid components were used in a much higher percentage of navigated cases than non-navigated cases, suggesting that augmented glenoid components provide utility for correcting pathologic glenoid wear. The average resultant version of the implanted component increased with the size of augment used, suggesting there may not be a clear consensus on optimal retroversion. term clinical follow up will need to be collected to determine if preoperative planning combined with more precise and accurate glenoid component positioning leads to improved clinical outcomes and implant longevity.

## 1 Introduction

Anatomic total shoulder arthroplasty (aTSA) can be a challenging procedure. With limited access to bony landmarks of the scapula and no clear indicators of the mechanical axes for alignment, precise determination of glenoid version and inclination can be very difficult[1]. Accurate reproduction of glenohumeral anatomy during aTSA has been shown to correlate with positive clinical outcomes[2].

Numerous studies have demonstrated that malposition of the glenoid component leads to increased stresses in the glenoid bone as well as increased micromotion in the implant which may contribute to early glenoid loosening[3]. Using conventional free hand instrumentation, Iannotti et al. demonstrated that when surgeons believe they are aiming for neutral version/inclination pin placement in the glenoid, the angular accuracy in fact exceeds ± 10° in both planes[1].

With the advent of 3D preoperative planning software, surgeons now have the ability to visualize a patient's anatomy before the surgery and template the exact implant and placement by weighing a variety of factors, which alone has been shown to improve accuracy of glenoid implant placement[1]. To execute such a preoperative plan, patient specific instrumentation may improve accuracy, but the degree of improvement has recently come into question[4]. Computer assisted surgery (CAS) can improve upon glenoid placement, but such systems for aTSA have experienced limited commercial success. The purpose of this study is to examine the utility of a commercially available CAS aTSA system in 574 clinical cases.

# 2 Methods

A CT based preoperative planning software and intraoperative total shoulder arthroplasty navigation system was developed and launched in September of 2016. For the procedure, the patient's indicated shoulder is CT scanned to capture the entirety of the scapula in 1mm slice spacing increments. The scapula is segmented and loaded into the preoperative planning software. The surgeon then templates the case by selecting and adjusting the glenoid component with respect to the scapula in 1mm/1° increments and optimizing for factors such as implant coverage, vault penetration, and residual version/inclination correction (Figure 1). For aTSA, this system offers a standard non-augmented component, an 8° posterior augmented wedge component, and a 16° posterior augmented wedge component. Once satisfied with the plan, the surgeon transfers the plan to the navigation unit.

The surgical workflow is identical to a standard aTSA, with the exception that additional exposure must be made to expose the coracoid, a tracker fixation device is pinned to the tip of the bone, and acquisition points are then taken with an infrared LED probe to map the bone to the CT scan. After acquisitions, preparation of the glenoid bone for implantation of the glenoid implant including drilling and reaming are all guided by the navigation system. A floating target and axis for the instrument is displayed and overlaid with the target for the preoperative plan on a 3D rendering of the scapula (Figure 2).

Since the launch of the system, over 4200 cases have been performed in 9 countries worldwide. Previous reported accuracy of the system allowed surgeons to place a glenoid component within 1.9° of version, 2.4° of inclination, .7mm of anterior-posterior (AP) placement, 1.1mm of superior-inferior (SI) placement, and 1.1mm of reaming depth with respect to their preoperative plans. Intraoperatively, the navigation system captures data on instrument position, implant selection, and implant placement. Postoperative surgical reports from the first 574 aTSA clinical cases were collected and analyzed for implant selection, implant placement, and incision start to incision close operative time, and compared to similar date cohorts for non-navigated cases.

# 3 Results

For operative time, navigated aTSA cases lasted significantly longer than non-navigated cases ($p < .05$), when compared to a similar date range cohort (Nav: 104 ± 27 minutes; Non-nav: 84 ± 29 minutes).

For implant usage, standard non-augmented glenoid components were used 34.5% of the time, compared to total sales data for the same date range of 80.2%. 8° augmented glenoid components were used 61.0% of the time, compared to total sales data for the same date range of 19.0%. Lastly, 16° augmented glenoid components were used 4.5% of the time, compared to total sales data for the same date range of 0.8%.

For resulting version and inclination, non-augmented glenoid components were implanted in 3.1 ± 3.2° of retroversion and 1.9 ± 3.2° of inclination, 8° augmented glenoid components were implanted in 4.1 ± 4.1° of retroversion and 1.5 ± 3.1° of inclination, and 16° augmented glenoid components were implanted in 5.8 ± 4.6° of retroversion and 2.0 ± 4.2° of inclination.

# 4 Discussion

Navigated cases took significantly longer than non-navigated cases. Anecdotal individual surgeon time data suggests a learning curve, where the surgeon takes longer at first to get used to the system before reducing his or her total incision time after a number of cases. This observation is also seen in navigated arthroplasty procedures in other joints[5].

A usage rate of 65.5% augmented glenoid components in the navigated cohort suggests the utility of augmented components in correcting pathologic retroversion. The observation of a much higher percentage of augmented glenoid components in the navigated cohort vs. the non-navigated cohort may be the result of the surgeon being able to more accurately visualize pathologic wear patterns on 3D models vs. 2D CT or plain films, which lends surgeons to use augmented components more frequently to correct this wear[6]. This high frequency of augmented glenoid component use and inconsistent degree of version correction in each implant category paired with high standard deviations raises questions about how much retroversion for an aTSA is optimal. This trend was not observed for inclination.

# 5 Significance/Clinical Relevance

Given the potential consequences of malpositioned glenoid components with conventional freehand instrumentation, this navigation system may represent an improvement in implant placement and potentially implant longevity. Further study is required to see if these improvements in preoperative planning and more accurate and precise glenoid component positioning are associated with better clinical outcomes in the short and long term. Long term clinical follow up is being collected on both navigated and non-navigated patient cohorts and will be reported at a future date.

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# Figures

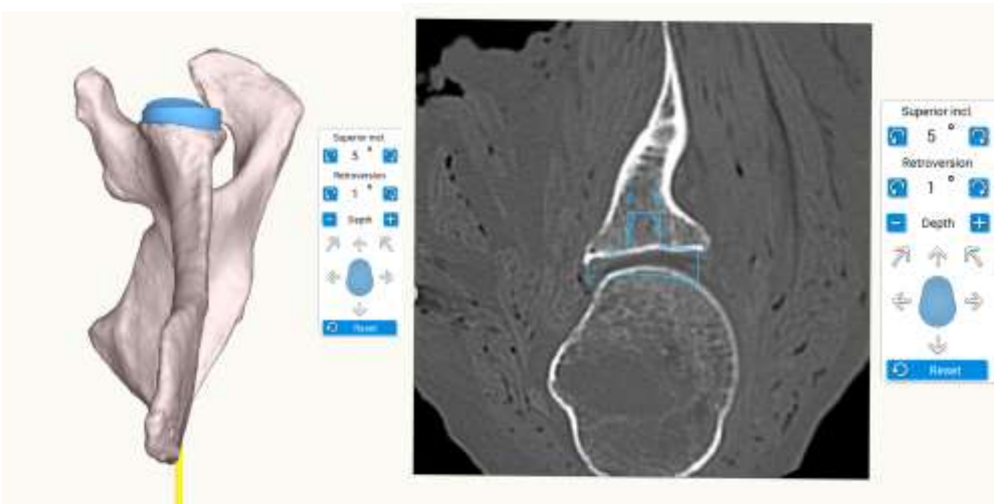

**Figure 1: Preoperative Planning Software User Interface**

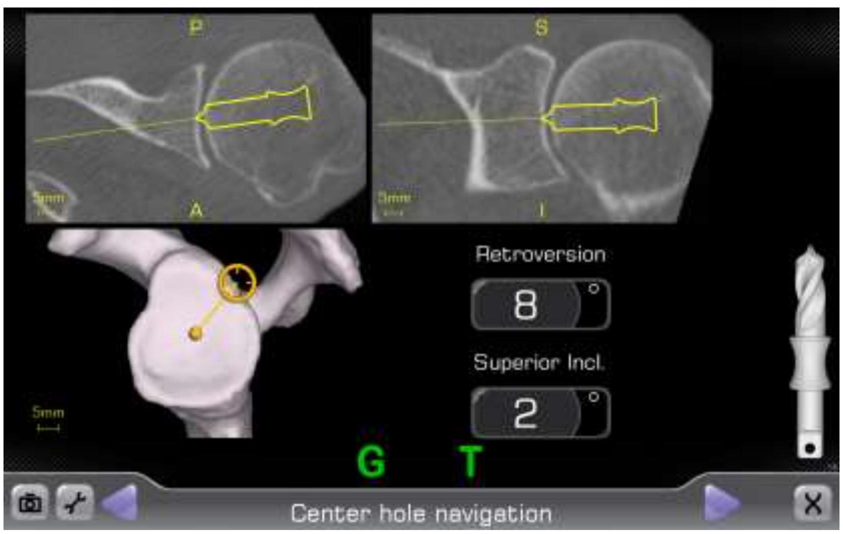

**Figure 2: Navigation Software User Interface**