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Two-year clinical outcomes of total shoulder arthroplasty performed with a computer navigated surgery system

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Abstract

Two-year minimum clinical outcomes were collected on anatomic and reverse total shoulder arthroplasty patients enrolled in a single implant global registry that were performed using an intraoperative computer navigated surgery system. Age, gender, and follow-up matched cohorts were created from the same registry for comparison purposes for both anatomic and reverse total shoulder arthroplasty. The navigated cohorts exhibited as good or better clinical outcomes compared to the non-navigated cohorts as well as reductions in postoperative complications, revision rates, and adverse events.

1 Introduction

The introduction of new surgical technologies to the market is often exciting and has many immediate intangible benefits to the user. Intraoperative computer assistance from both robotics and navigation systems has become commonplace in knee and hip total joint arthroplasty procedures with a slower adoption in total shoulder arthroplasty (TSA). Although the lower annual procedural volume in TSA combined with a later evolution in design and procedural approach than what occurred in hip and knee arthroplasty likely contributes to this trend, the utility of such computer assisted systems is nonetheless equally beneficial.

Previous studies have reported on both the accuracy[1,2] and clinical application of such systems[3]. Although there are many time-zero benefits to intraoperative computer assisted systems, the rising cost pressures in the modern health system and the push for value-based healthcare has made it increasingly challenging to lobby for the use of such technologies until clinical follow up is reported that demonstrates improvement with use.

The purpose of this study is to report on the two-year clinical outcomes of a single TSA implant system used in conjunction with a computer navigated surgery system.

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2 Material and methods

2.1 Data collection

Clinical follow up was collected on TSA patients enrolled in a multi-center global registry where a single implant system was used (Exactech Equinoxe, Gainesville, FL). Inclusion criteria was all patients that received a TSA utilizing the same intraoperative navigation system (ExactechGPS, Gainesville, FL) with a minimum follow up of two years. The navigation system consisted of a computed tomography based preoperative planning software and an intraoperative computer and active tracking system to help guide the user on instrument and implant placement. Exclusion criteria included revision arthroplasty, and diagnoses of infection, osteonecrosis, rheumatoid arthritis, ankylosing spondylitis, and fractures. 148 anatomic total shoulder arthroplasty (ATSA) and 386 reverse total shoulder arthroplasty (RTSA) patients met these criteria. A 2:1 age, gender, and follow-up matched cohort was created for both navigated ATSA and RTSA patients for comparison purposes. Intraoperative and postoperative complications, adverse events, revisions, functional outcomes, patient reported outcome metrics, and functional shoulder scores were compared between the two cohorts using two-tailed unpaired t-tests in Excel (Microsoft, Redmond, WA).

3 Results

3.1 ATSA Outcomes

Two-year minimum follow up results for ATSA patients are presented below in Table 1. Average follow up for the navigated and non-navigated cohorts was 29.1 and 32.5 months, respectively. Navigated ATSA patients reported a significantly better internal rotation score and external rotation, as well as a significantly higher amount of augmented glenoid components used compared to the non-navigated cohort. No difference was reported in intraoperative or postoperative complications between the two cohorts. Although non-statistically significant, both a lower revision and adverse event rate was reported in the navigated cohort.

ASTA	Internal rotation	External rotation (°)	Max wieght (lbs)	Pain daily basis	Shoulder function	Patient satisfaction	SST	Constant	ASES	UCLA	SPADI	SAS	Augment usage (%)	Intra op complications (%)	Post op complications (%)	Revision Rate (%)	Adverse events (%)
Navigated cohort (N=148)																	
AVG	5.3	58.9	9.4	1.1	8.8	1.8	10.9	75.2	87.5	31.8	14.5	83.6	60.1	0.0	4.1	1.4	2.0
STDEV	1.3	17.2	5.6	1.8	1.6	0.6	1.8	11.9	15.6	4.5	19.7	10.7	49.1	0.0	19.9	11.6	14.1
Non-Navigated 2:1 Age, Gender, Follow-up Matched cohort (N=296)																	
AVG	4.8	53.8	9.9	1.0	8.8	1.8	11.0	76.0	88.5	31.7	13.2	81.9	11.8	0.0	3.2	4.7	6.1
STDEV	1.4	17.4	5.8	1.9	1.9	0.6	2.0	13.6	16.1	4.8	18.9	10.5	32.3	0.0	17.6	21.3	23.9
Diff	0.5	5.1	-0.5	0.1	0	0	-0.1	-0.8	-1	0.1	1.3	1.7	48.3	0	0.9	-3.3	-4.1
P-Value	0.00	0.00	0.41	0.70	1.00	0.25	0.92	0.56	0.52	0.86	0.52	0.10	0.00	1.00	0.62	0.07	0.06

Table 1: ATSA clinical outcomes for navigated (blue) vs. non-navigated (green) cohorts. Significant differences are highlighted in yellow.

3.2 RTSA Outcomes

Two-year minimum follow up results for RTSA patients are presented below in Table 2. Average follow up for the navigated and non-navigated cohorts was 29.1 and 31.2 months, respectively. Navigated RTSA patients reported a significantly better internal rotation score, external rotation, amount of maximum weight able to be lifted, and improvements in the SST, Constant, ASES, and Shoulder Arthroplasty Smart Score (SAS) compared to the non-navigated cohort. As well, the navigated cohort utilized a significantly higher number of augmented glenoid components as well as a significantly lower number of screws average compared to the non-navigated cohort. Postoperative complications, revision rates, and adverse events were all significantly lower in the navigated cohort. The navigated cohort reported a significantly higher number of intraoperative complications (2.3%, N=6 vs. .3%, N=2), with the specific complications being navigation system malfunction in four cases and proximal humerus fractures in two cases in the navigated cohort and proximal humerus fractures for the two cases in the non-navigated cohort.

ASTA	Internal rotation	External rotation (°)	Max wieght (lbs)	Pain daily basis	Shoulder function	Patient satisfaction	SST	Constant	ASES	UCLA	SPADI	SAS	Augment usage (%)	# of baseplate screws	Intra op complications (%	Post op complications (%)	Revision Rate (%)	Adverse events (%)
Navigated cohort (N=386)																		
AVG	4.5	43.3	9.1	1.1	8.3	1.7	10.4	71.8	84.4	30.8	21.2	77.2	72.5	3.5	2.3	1.0	0.5	1.0
STD	1.8	18.4	5.1	1.9	1.9	0.6	2.2	13.3	17.3	4.8	22.3	11.3	44.7	1.7	15.1	10.2	7.2	10.1
Non-Navigated 2:1 Age, Gender, Follow-up Matched cohort (N=774)																		
AVG	4.1	38.0	7.8	1.3	8.1	1.7	9.9	68.7	82.0	30.2	23.2	75.0	24.3	3.7	0.3	4.2	2.1	3.9
STD	1.7	17.1	5.0	2.1	2.0	0.7	2.7	14.0	19.0	5.2	25.3	12.0	42.9	0.8	5.2	20.1	14.3	19.3
Diff	0.4	5.3	1.3	-0.2	0.2	0	0.5	3.1	2.4	0.6	-2	2.2	48.2	-0.2	2	-3.2	-1.6	-2.9
P-Val	0.00	0.00	0.00	0.27	0.13	0.10	0.00	0.00	0.04	0.08	0.19	0.00	0.00	0.00	0.00	0.00	0.04	0.01

Table 2: RTSA clinical outcomes for navigated (blue) vs. non-navigated (green) cohorts. Significant differences are highlighted in yellow.

4 Discussion

Two-year minimum follow-up outcomes for patients that received a TSA performed with an intraoperative computer navigated surgery system demonstrated excellent results compared to non-navigated patients of a similar age, gender, and follow-up matched cohort. A non-significant reduction in postoperative complications, revision rate, and adverse events was observed in the navigated ATSA patients compared to their non-navigated counterparts, and a statistically significant reduction in postoperative complications, revision rate, and adverse events was observed in the navigated RTSA patients compared to their non-navigated counterparts.

In terms of interoperative complications, the reported complication of navigation system malfunction was unique to the navigation cohorts. This complication occurred in 0/148 navigated ATSA cases for a rate of 0% and in 4/386 navigated RTSA cases for a rate of 1%.

Other findings include an increased number of augmented glenoid implants in both ATSA and RTSA navigated cohorts and a decreased number of baseplate screws in the RTSA navigated cohort when intraoperative navigation was used, which has also been observed in other studies[4,5].

Although not measured in this study, navigation systems offer many intangible benefits to the surgeon user such as reproducibility and consistency in the OR as well increased confidence and decreased anxiety about the case. These “soft” benefits can have a positive effect the procedure as they enhance the surgeon’s ability to confidently and correctly execute surgical steps in a prompt and methodical fashion.

Future work includes continued follow-up on these patient cohorts for medium and long-term clinical outcomes which will be reported at a future date.

5 Significance/Clinical Relevance

This is the first study to report on short-term clinical outcomes of shoulder arthroplasty performed with intraoperative computer assisted navigation.

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