PEER-REVIEWED PUBLISHED DATA ON GPS SHOULDER

Scientific & Clinical Evidence

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CLINICAL DATA

Does Commercially Available Shoulder Arthroplasty Preoperative Planning Software Agree with Surgeon Measurements of Version, Inclination, and Subluxation?

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Journal of Shoulder and Elbow Surgery (2021) 30, 413–420

KEY TAKEAWAYS

- Significant differences were found between surgeon and commercial software measurements in version, inclination, and subluxation.
- Software measurements tended to be more superiorly inclined (average -2° to 2° greater), more retroverted (average 2°-5° greater), and more posteriorly subluxed (average 7°-10° greater) than surgeon measurements.
- Blueprint was the only planning software that had significantly different software measurements than surgeon measurements.

BACKGROUND

Preoperative planning with commercially available imaging software in shoulder arthroplasty may allow for improved decision-making and more accurate placement of the glenoid component.

METHODS

A total of 81 consecutive shoulder computed tomography scans obtained for preoperative planning purposes for shoulder arthroplasty were analyzed by commercially available software from 4 companies (Blueprint: Wright Medical, Memphis, TN, USA; GPS: Exactech, Gainesville, FL, USA; Materialise: DJO, Vista, CA, USA; and VIP: Arthrex, Naples, FL, USA) and by 5 fellowship-trained sports medicine/shoulder surgeons. Inclination, version, and subluxation of the humerus were measured in a blinded fashion on axial and coronal sequences at the midglenoid. Surgeon measurements were analyzed for agreement and were compared with the 4 commercial programs.

RESULTS

Surgeon reliability was acceptable for version (intraclass correlation coefficient [ICC]: 0.876), inclination (ICC: 0.84), and subluxation (ICC: 0.523). Significant differences were found between surgeon and commercial software measurements in version ($P = .03$), inclination ($P = .023$), and subluxation ($P < .001$). Software measurements tended to be more superiorly inclined (average -2° to 2° greater), more retroverted (average 2°-5° greater), and more posteriorly subluxed (average 7°-10° greater) than surgeon measurements. In comparing imaging software measurements, only Blueprint was found to produce significantly different version measurements than surgeon measurements ($P = .02$).

CONCLUSION

Preoperative planning software for shoulder arthroplasty has limited agreement in measures of version, inclination, and subluxation measurements, whereas surgeons have high inter-reliability. Surgeons should be cautious when using commercial software planning systems and when comparing publications that use different planning systems to determine preoperative glenoid deformity measurements.

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Two-Year Clinical Outcomes And Complication Rates in Anatomic And Reverse Shoulder Arthroplasty Implanted With Exactech GPS Intraoperative Navigation

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Journal of Shoulder and Elbow Surgery (2023) 32, 2519–2532

KEY TAKEAWAYS

- Retrospective 35 different surgeons at 30 institutions (N=534) and 2:1 matched cohorts for age, gender and follow-up
- Navigated patients presented:
  - Lower postoperative complications (2.3% vs. 3.9%)
  - Lower revisions (0.9% vs. 1.8%)
  - Lower dislocations (0.0% vs. 0.7%)
  - Lower acromial stress fractures (0.2% vs. 0.7%)
- Navigated patients demonstrated significant improvement over non-navigated patients in internal rotation, external rotation, maximum lifting weight, the Simple Shoulder Test (SST), Constant, and Shoulder Arthroplasty Smart (SAS) scores.

INTRODUCTION

We compared the 2-year clinical outcomes of both anatomic and reverse total shoulder arthroplasty (ATSA and RTSA) using intraoperative navigation compared to traditional positioning techniques. We also examined the effect of glenoid implant retroversion on clinical outcomes.

HYPOTHESIS

In both ATSA and RTSA, computer navigation would be associated with equal or better outcomes with fewer complications. Final glenoid version and degree of correction would not show outcome differences.

METHODS

A total of 216 ATSAs and 533 RTSAs were performed using preoperative planning and intraoperative navigation with a minimum of 2-year follow-up. Matched cohorts (2:1) for age, gender, and follow-up for cases without intraoperative navigation were compared using all standard shoulder arthroplasty clinical outcome metrics. Two subanalyses were performed on navigated cases comparing glenoids positioned greater or less than 10 degrees of retroversion and glenoids corrected more or less than 15 degrees.

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RESULTS

For ASTA, no statistical differences were found between the navigated and non-navigated cohorts for postoperative complications, glenoid implant loosening, or revision rate. No significant differences were seen in any of the ATSA outcome metrics besides higher internal and external rotation in the navigated cohort. For RTSA, the navigated cohort showed an ARR of 1.7% (95% CI 0%, 3.4%) for postoperative complications and 0.7% (95% CI 0.1%, 1.2%) for dislocations. No difference was found in the revision rate, glenoid implant loosening, acromial stress fracture rates, or scapular notching. Navigated RTSA patients demonstrated significant improvements over non-navigated patients in internal rotation, external rotation, maximum lifting weight, the Simple Shoulder Test (SST), Constant, and Shoulder Arthroplasty Smart (SAS) scores. For the navigated subcohorts, ATSA cases with a higher degree of final retroversion showed significant improvement in pain, Constant, American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form (ASES), SST, University of California–Los Angeles shoulder score (UCLA), and Shoulder Pain and Disability Index (SPADI) scores. No significant differences were found in the RTSA subcohort. Higher degrees of version correction showed improvement in external rotation, SST, and Constant scores for ATSA and forward elevation, internal rotation, pain, SST, Constant, ASES, UCLA, SPADI, and SAS scores for RTSA.

CONCLUSION

The use of intraoperative navigation shoulder arthroplasty is safe, produces at least equally good outcomes at 2 years as standard instrumentation does without any increased risk of complications. The effect of final implant position above or below 10 degrees of glenoid retroversion and correction more or less than 15 degrees does not negatively impact outcomes.

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CLINICAL DATA

Early Clinical Outcomes Following Navigation-Assisted Baseplate Fixation in Reverse Total Shoulder Arthroplasty: A Matched Cohort Study

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Journal of Shoulder and Elbow Surgery. 2023 Feb;32(2):302-309

KEY TAKEAWAYS

- The navigated group had better post-operative results for the following:
  - Active forward elevation (135o vs 129o, 16 p=0.023)
  - Active external rotation (39o vs 32o, p=0.003)
  - Constant scores (71.1 vs 65.5, 17 p=0.003)

BACKGROUND

Accurate placement of the glenoid baseplate is an important technical goal of reverse total shoulder arthroplasty (RSA). The use of computer navigated instrumentation has been shown to improve the accuracy and precision of intraoperative execution of preoperative planning. The purpose of this study was to compare early clinical outcomes of patients undergoing navigated reverse total shoulder arthroplasty versus a non-navigated matched cohort.

METHODS

A retrospective review of a prospectively-collected shoulder arthroplasty database was used to identify 113 patients from a single institution who underwent navigated primary RSA with a minimum 2-year follow-up. A matched cohort of 113 non-navigated RSA was created based on gender, age, follow-up, and preoperative diagnosis. Preoperative and postoperative range of motion, functional outcome scores, and complications were reported.

RESULTS

226 shoulders with mean age of 71 years were evaluated after navigated (113) or non navigated (113) RSA. Mean follow-up was 32.8 months (range 21-54 months). At the final postoperative follow-up the navigated group had better active forward elevation (135º vs 129º, p=0.023), active external rotation (39º vs 32º, p=0.003), and Constant scores (71.1 vs 65.5, p=0.003). However, when comparing improvements from the preoperative state, there were no statistically significant differences in range of motion or functional outcome scores between groups.

Complications occurred in 1.8% (2) of patients undergoing navigated RSA compared to 5.3% (6) in the non-navigated group (p=0.28). Scapular notching (3.1% vs 8.0%, p=0.21) and revision surgery (0.9% vs 3.5%, p=0.37) was more common in non-navigated shoulders.

CONCLUSION

At early follow-up, navigated and non-navigated RSA yielded similar rates of improvement in range of motion and functional outcome scores. Notching and reoperation was more common in non-navigated shoulders, but did not reach statistical significance. Longer follow-up and larger cohort size is needed to determine if intraoperative navigation lengthens the durability of RSA results and reduces the incidence of postoperative complications.

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CLINICAL DATA

Two-Year Clinical Outcomes of Total Shoulder Arthroplasty Performed with a Computer Navigated Surgery System

Alexander T. Greene, Clément Daviller, Sandrine V. Polakovic, Noah Davis, and Chris Roche, MS, MBA

Presented at International Society for Computer Assisted Orthopaedic Surgery - CAOS 2022

KEY TAKEAWAYS

- 2-year minimum follow up outcomes for patients receiving a navigated tSA demonstrated excellent clinical results compared to non-navigated patients of similar age, gender and follow-up match
- A non-significant reduction in post operative complications, revision rate, and adverse events was observed in the navigated aTSA patients compared to non-navigated counterparts.
- A statistically significant reduction in post operative complications, revision rate and adverse events was observed in the navigated rTSA patients compared to non-navigated
- Improved IR and ER for aTSA
- Improved IR, ER, and SST, Constant, ASES and SAS scores for rTSA
- Reduced complication rate (intra and postop), revision rate, and rate of adverse events intra-operative navigation complication occurred 0% in aTSA and 1% for rTSA cohort (just 4/386)
- Reduction in rTSA screws for navigated rTSA baseplates (found in other studies)

BACKGROUND

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.

METHODS

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

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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).

RESULTS

Two-year minimum follow up results for aTSA patients are presented below in Table 1, see below. 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.

CONCLUSION

Two-year minimum follow up results for rTSA patients are presented below in Table 2, see next page. 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.

ATSA	Internal Rotation Score	External Rotation (°)	Max weight (lbs)	Pain Daily Basis	Shoulder Function	Patient Satisfaction	SST	Constant	ASES	UCLA	SPADI	SAS	Augment Usage	Intraop Complications	Postop 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%
P Value	0.000	0.004	0.410	0.696	1.000	0.247	0.917	0.557	0.520	0.855	0.517	0.103	0.000	1.000	0.620	0.072	0.058

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

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RTSA	Internal Rotation Score	External Rotation (°)	Max weight (lbs)	Pain Daily Basis	Shoulder Function	Patient Satisfaction	SST	Constant	ASES	UCLA	SPADI	SAS	Augment Usage	# of Baseplate Screws	Intraop Complications	Postop 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%
STDEV	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%
STDEV	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%
P Value	0.000	0.000	0.000	0.266	0.133	0.103	0.001	0.003	0.043	0.076	0.193	0.003	0.000	0.003	0.001	0.004	0.044	0.007

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

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.

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CLINICAL DATA

Computer Navigation Leads to More Accurate Glenoid Targeting During Total Shoulder Arthroplasty Compared With 3D Preoperative Planning Alone

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Journal of Shoulder and Elbow Surgery. 2020 Nov;29(11):2257-2263

KEY TAKEAWAYS

- 48% of the time, surgeon-modifiable, clinically relevant errors were observed
- GPS feedback provides a significant advantage over pre-planning only; even in experienced hands.
- Malposition at 58% despite surgeon years of experience
- Surgeons years of experiences did not correlate to better execution of their preoperative plan (30 years vs. 4 years).
- NOT A CADAVERIC STUDY; no control. Same patient with different surgeons provides more control.

BACKGROUND

Commercially available preoperative planning software is now widely available for shoulder arthroplasty. However, without the use of patient-specific guides or intraoperative visual guidance, surgeons have little *in vivo* feedback to ensure proper execution of the preoperative plan. The purpose of this study was to assess surgeons' ability to implement a preoperative plan *in vivo* during shoulder arthroplasty.

METHODS

Fifty primary shoulder arthroplasties from a single institution were retrospectively reviewed. All surgical procedures were planned using a commercially available software package with both multiplanar 2-dimensional computed tomography and a 3-dimensional implant overlay. Following registration of intraoperative visual navigation trackers, the surgeons (1 attending and 1 fellow) were blinded to the computer navigation screen and attempted to implement the plan by simulating placement of a central axis guide pin. Malposition was assessed (>4 mm of displacement or >10 error in version or inclination). Data were then blinded, measured, and evaluated.

RESULTS

Mean displacement from the planned starting point was 3.2 ± 2.0 mm. The mean error in version was 6.4 ± 5.6, and the mean error in inclination was 6.6 ± 4.9. Malposition was observed in 48% of cases after preoperative planning. Malposition errors were more commonly made by fellow trainees vs. attending surgeons (58% vs. 38%, P = .047).

CONCLUSION

Despite preoperative planning, surgeons of various training levels were unable to reproducibly replicate the planned component position consistently. Following completion of fellowship training, significantly less malposition resulted. Even in expert hands, the orientation of the glenoid component would have been malpositioned in 38% of cases. This study further supports the benefit of guided surgery for accurate placement of glenoid components, regardless of fellowship training.

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CLINICAL DATA

Accuracy and Precision of Placement of the Glenoid Baseplate in Reverse Total Shoulder Arthroplasty Using a Novel Computer Assisted Navigation System Combined with Preoperative Planning: A Controlled Cadaveric Study

Richard B. Jones, Alexander T. Greene, Sandrine V. Polakovic, Matthew A. Hamilton, Nicole J. Mohajer, Ari R. Youderian, MD, Ira M. Parsons, MD, Paul D. Saadi, MD, Emilie V. Cheung, MD

Journal of Shoulder and Elbow Surgery Seminars in Arthroplasty. May 2020; 30(1): 73-82.

KEY TAKEAWAYS

- Glenoid baseplates placed using the navigation system demonstrated significantly improved accuracy and precision of positioning, based on the preoperative plan, than those placed using conventional freehand
- instrumentation without navigation for:
  - Version (1.9 ± 1.9°) vs (5.9 ± 3.5°; P = 0.004)
  - Inclination (2.4 ± 2.4°) vs (6.3 ± 6.2°; P = 0.026),
  - Post hoc power > 95% (α = 0.05).
  - Insignificant difference was noted for anterior/posterior (AP) positioning, superior/inferior (SI) positioning, and reaming depth.
- A lower standard deviation was observed for AP positioning in the navigated cohort (0.6 mm vs 1.3 mm; P = 0.017).

BACKGROUND

Variability in placement of total shoulder arthroplasty (TSA) glenoid implants has led to the increased use of 3D CT preoperative planning software. Computer assisted surgery (CAS) offers the potential of improved accuracy in TSA while following a preoperative plan, as well as the flexibility for intraoperative adjustment during the procedure. This study compares the accuracy of implantation of reverse total shoulder arthroplasty (rTSA) glenoid implants using a CAS TSA system versus traditional non-navigated techniques in 30 cadaveric shoulders relative to a preoperative plan from 3D CT software.

METHODS

Five fellowship trained surgeons preoperatively planned 30 cadaveric scapulae (15 side matched pairs) for an rTSA baseplate using preoperative CT scans and a custom 3D templating software. The specimens were randomized with respect to side and were split into two equal cohorts. One cohort used preoperative planning and conventional freehand instrumentation to implant the baseplate, and the other cohort used preoperative planning and a CT based navigation system to implant the baseplate. Postoperative CT scans were taken, and accuracy and precision for baseplate position and angulation with respect to the preoperative plan was compared for both groups.

RESULTS

Glenoid baseplates placed using the navigation system demonstrated significantly improved accuracy and precision of positioning, based on the preoperative plan, than those placed using conventional freehand instrumentation without navigation for version (1.9 ± 1.9° vs 5.9 ± 3.5°; P = 0.004) and inclination (2.4 ± 2.4° vs 6.3 ± 6.2°; P = 0.026), with a post hoc power > 95% (α = 0.05). No significant difference was noted for anterior/posterior (AP) positioning, superior/inferior (SI) positioning, and reaming depth. A lower standard deviation was observed for AP positioning in the navigated cohort (0.6 mm vs 1.3 mm; P = 0.017).

CONCLUSION

Preoperative planning combined with the navigation system used in this side matched pair cadaveric study is more accurate and precise in achieving the desired version and inclination of the glenoid baseplate in rTSA compared to preoperative planning combined with conventional freehand instrumentation alone. The system may offer less benefit in improving AP or SI placement as well as reaming depth.

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CLINICAL DATA

Computer Navigation Recreates Planned Glenoid Placement And Reduces Correction Variability in Total Shoulder Arthroplasty: An *In Vivo* Case-Control Study

Piyush S. Nashikkar, Corey J. Scholes, Mark D. Haber

Journal of Shoulder and Elbow Surgery. 2019 Dec;28(12):e398-e409

KEY TAKEAWAYS

- GPS group = twice as many augmented glenoids were used while navigating
- GPS group = greater proportion of components in "neutral" alignment for inclination and version
- Glenoid within 5 degrees of plan in more than 70% of cases and no detectable difference from plan in 40% of cases
- Posterior and anterior screw length were significantly longer and better purchase quality (>22mm); GPS group had significantly less unplanned central cage perforation

BACKGROUND

Accurate glenoid component placement is important to prevent glenoid component failure in total shoulder arthroplasty (TSA). Navigation may reduce the variability of glenoid component version and inclination; therefore, the aims of this study were to determine, in patients undergoing TSA, whether computer navigation improved the ability to achieve neutral postoperative version and inclination, as well as achieve the individualized preoperative plan.

METHODS

Patients undergoing TSA using navigation (computer-assisted surgery [CAS], n = 33) or the conventional technique (n = 27) from January 2014 to July 2017 were recruited and compared. Preoperative and postoperative version and inclination, as well as postoperative inferior overhang, were measured using computed tomography scans.

RESULTS

The CAS group had more than twice as many augmented glenoid components as the conventional group (45.5% vs. 19.2%). CAS significantly reduced the between-patient variability in the postoperative version and led to a greater proportion of components positioned in "neutral" alignment for both inclination and version ($P < .015$). The incidence of neutral inclination or version postoperatively was significantly higher in the CAS group, and the glenoid was implanted within 5° of the surgical plan in more than 70% of cases, with more than 40% displaying no detectable difference.

CONCLUSION

An integrated system of 3-dimensional surgical planning, augmented glenoid components, and intraoperative navigation may reduce the risk of glenoid placement outside of a neutral position in patients undergoing TSA compared with conventional methods. This study demonstrated the capacity for CAS to replicate the surgical plan in a majority of cases.

**In vitro (bench) test results may not necessarily be indicative of clinical performance.*

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CLINICAL DATA

Intraoperative Navigation and Preoperative Templating Software Are Associated with Increased Glenoid Baseplate Screw Length and Use of Augmented Baseplates in Reverse Total Shoulder Arthroplasty

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Journal of Shoulder and Elbow Surgery International. 2020 Oct 31;5(1):102-108

KEY TAKEAWAYS

- Navigation resulted in use of significantly longer individual screws (36.7 mm vs. 30 mm, $p < 0.0001$), greater composite screw length (84 mm vs 76 mm, $p = 0.048$)
- Navigation resulted in fewer screws (2.5 ± .7 vs. 2.8 ± 1, $p = 0.047$)
- Navigation resulted in increased frequency of using two screws total with a standard baseplate (35/51 (68.6%) vs. 32/63 (50.8%), $p = 0.047$)
- Preoperative templating resulted in more frequent augmented baseplate utilization (76.5% vs. 19.1%, $p < 0.0001$)

BACKGROUND

Preoperative templating software and intraoperative navigation have the potential to impact baseplate augmentation utilization and increase screw length for baseplate fixation in rTSA. We aimed to assess their impact on (1) baseplate screw length, (2) number of screws used, and (3) frequency of augmented baseplate use in navigated rTSA.

METHODS

Fifty-one patients who underwent navigated rTSA were compared against 63 controls who underwent conventional rTSA at a single institution. Primary outcomes included screw length, composite screw length, number of screws used, percentage of patients in which two total screws were used, and use of augmented baseplates.

RESULTS

Navigation resulted in use of significantly longer individual screws (36.7 mm vs. 30 mm, $p < 0.0001$), greater composite screw length (84 mm vs 76 mm, $p = 0.048$), fewer screws (2.5 ± .7 vs. 2.8 ± 1, $p = 0.047$), and increased frequency of using two screws total 35/51 (68.6%) vs. 32/63 (50.8%), $p = 0.047$). Preoperative templating resulted in more frequent augmented baseplate utilization (76.5% vs. 19.1%, $p < 0.0001$).

CONCLUSION

The difference in screw length, number of screws used, and augmented baseplate use demonstrates the evolving role that computer navigation and preoperative templating play in surgical planning and intraoperative technique for rTSA.

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CLINICAL DATA

Role of Intraoperative Navigation in the Fixation of the Glenoid Component in Reverse Total Shoulder Arthroplasty: A Clinical Case-Control Study

Piyush S. Nashikkar, MS, DNB, Corey J. Scholes, PhD, Mark D. Haber, FRACS

Journal of Shoulder and Elbow Surgery. 2019 Sep;28(9):1685-1691

KEY TAKEAWAYS

- Posterior and anterior screw purchase length was longer in the GPS group and purchase quality was better (>22mm)
- GPS group had significantly less central cage perforation

BACKGROUND

Fixation of the glenoid baseplate in reverse total shoulder arthroplasty (rTSA) is an important factor in the success of the procedure. There is limited information available regarding the effect of navigation on fixation characteristics. Therefore, the aims of this study were to determine whether computed tomography-based computer navigation improved the glenoid base plate fixation by (1) increasing the length of screw purchase, (2) altering screw angulation, and (3) decreasing central cage perforation in patients undergoing rTSA.

METHODS

Patients undergoing rTSAs using navigation (NAV, N = 27) and manual technique (MAN, N = 23) from January 2014 to July 2017 were analyzed in a case-control design. Screw purchase length and central cage perforation were assessed using multiplanar computed tomography.

RESULTS

Median screw purchase length was significantly longer in the NAV group for both anterior (20 mm vs. 15 mm, P < .01) and posterior screws (20 mm vs. 13 mm, P < .01). In addition, the NAV group displayed significantly lower incidences of inadequate screw purchase (<22 mm) for the anterior (64.7% vs. 95.2%, P = .03) and posterior (70.6% vs. 100%, P = .01) screws. Significant differences in axial and coronal screw angulation were observed between groups. Similarly, the NAV group displayed significantly reduced incidence of central cage perforation (17.7% vs. 52.4%, P = .04).

CONCLUSION

The use of computer-assisted navigated rTSA contributes to significant alterations in screw purchase length, screw angulation, and central cage perforation of the glenoid baseplate compared with non-navigated methods.

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CLINICAL DATA

Computer Navigation of the Glenoid Component in Reverse Total Shoulder Arthroplasty: A Clinical Trial to Evaluate the Learning Curve

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Journal of Shoulder and Elbow Surgery. 2020 Mar;29(3):617-623

KEY TAKEAWAYS

- GPS surgical time: 77.3 ± 11.8 minutes
- Conventional instrumentation surgical time: 78.5 ± 18.1 minutes
- The learning curve in this study was 8 cases to time neutrality
- Implant placement was equally accurate throughout the learning curve

BACKGROUND

Intraoperative computer navigation has been introduced recently to assist with placement of the glenoid component. The aim of this study was to evaluate the learning curve of a single surgeon performing computer navigation of glenoid implant placement in primary reverse total shoulder arthroplasty (rTSA).

METHODS

Following training with the intraoperative computer navigation system, we conducted a prospective case-series study of the first 24 consecutive patients undergoing a primary rTSA with navigation performed by a single surgeon. Surgical times, complications, and accuracy of glenoid positioning compared with the preoperative plan were evaluated. Surgical times were compared with the preceding non-navigated series of 24 consecutive primary rTSA cases. Postoperative 3-dimensional computed tomography scans were performed to evaluate glenoid component version and inclination compared with the preoperative plan.

RESULTS

The total surgical time was 77.3 minutes (standard deviation [SD], 11.8 minutes) in the navigated rTSA cohort and 78.5 minutes (SD, 18.1 minutes) in the non-navigated series. A significant downward trend in the total surgical time was observed in the navigated cohort (P = .038), which flattened after 8 cases. No learning curve was observed in deviation of glenoid version or inclination from the preoperative plan. The mean deviation of achieved version from planned version was 3° (SD, 2°), and the mean deviation of achieved inclination from planned inclination was 5° (SD, 3°).

CONCLUSION

Findings from this study suggest that intraoperative computer navigation will not require substantially increased operating times compared with standard surgical techniques. With prior surgeon training, approximately 8 operative cases are required to achieve proficiency in intraoperative computer navigation of the glenoid component.

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CLINICAL DATA

Impact of Preoperative 3D Planning and Intra-operative Navigation of Shoulder Arthroplasty on Implant Selection and Operative Time: A Single Surgeon's Experience

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KEY TAKEAWAYS

- Usage of the Equinoxe Planning App enhances surgeons' understanding of the patient's glenoid anatomy
- 54% of the time surgeons chose an augmented glenoid component when using 3D pre-op planning vs. 15% without using pre-op planning software
- Insignificant increase in the length of surgery after the learning curve

BACKGROUND

Preoperative 3D planning and intraoperative navigation for shoulder arthroplasty has recently gained interest because of the potential to enhance the surgeon's understanding of glenoid anatomy and improve the accuracy of glenoid component positioning. The purpose of our study was to assess the impact of preoperative 3D planning on the surgeon's selection of the glenoid component (standard vs. augmented) and compare duration of surgery with and without intraoperative navigation.

METHODS

We retrospectively analyzed 200 consecutive patients who underwent shoulder arthroplasty. The first group of 100 patients underwent shoulder arthroplasty using standard 2D preoperative planning based on standard radiographs and computed tomographic scans. The second group of 100 patients underwent shoulder arthroplasty using 3D preoperative planning and intraoperative navigation. The type of glenoid component and operative time were recorded in each case.

RESULTS

For the group of patients with standard preoperative planning, only 15 augmented glenoid components were used, whereas, in the group of patients with 3D preoperative planning and navigation, 54 augments were used ($P < .001$). The operative time was 11 minutes longer for the procedures that used intraoperative navigation, compared with those that did not ($P < .001$). This difference diminished as the surgeon became more proficient with the navigation technique.

CONCLUSION

The use of preoperative 3D planning changes the surgeon's understanding of the patient's glenoid anatomy. In our study, using 3D planning increased the likelihood that the surgeon selected an augmented glenoid component compared with 2D planning. Intraoperative navigation slightly lengthened the duration of surgery, but this became insignificant as part of a learning curve within 6 months.

**In vitro (bench) test results may not necessarily be indicative of clinical performance.*

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