Virtual Implant Positioning™ (VIP™) Preoperative Planning Scientific Update

A Review of Modern Technologies

Launched in 2016, based on the foundational work of Joseph Iannotti and built from the clinically proven Custom Orthopedic Solutions software, the VIP system offers surgeons an intuitive, comprehensive preoperative planning experience coupled with the only reusable, sterilizable patient-specific instrumentation available on the market. The VIP system software has been continually enhanced, and additional preoperative planning features have been added over time to support surgeons in optimizing patient care.

VIP System-Specific

Iannotti J, Baker J, Rodriguez E, Brems J, Ricchetti E, Mesiha M, Bryan J

Three-dimensional preoperative planning software and a novel information transfer technology improve glenoid component positioning. *J Bone Joint Surg Am.* 2014;96(9):e71. doi:10.2106/JBJS.L.01346

- The use of 3D planning increased the accuracy of the glenoid guide pin placement by 4.5° in version, 3.3° in inclination, and 0.4 mm in location vs 2D planning and standard instrumentation.
- The use of patient-specific instrumentation combined with 3D planning further increased the accuracy of the glenoid guide pin placement by 3.7° in version, 8.1° in inclination, and 1.2 mm in location vs 3D planning alone.
- Overall, glenoid guide pin placement improved by 8.2° in version, 11.4° in inclination, and 1.7 mm in location when using 3D planning and patient-specific instrumentation vs 2D planning and standard instrumentation.

Takeaway

The use of 3D preoperative planning software demonstrates a statistically significant improvement in the version angle of the central guide pin compared to 2D planning and standard instrumentation alone. Further, the use of an adjustable targeter statistically improved the version, inclination, and placement (deviation in millimeters) of the central pin compared to 2D planning and standard instrumentation alone.

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Hartzler RU, Denard PJ, Griffin JW, Werner BC, Romeo AA

ShARC Study:

Surgeon acceptance of an initial 3D glenoid preoperative plan: rates and risk factors. *J Shoulder Elbow Surg.* 2021;30(4):787-794. doi:10.1016/j.jse.2020.06.032

- Surgeons accepted the VIP™ system-placed implant version 66% of the time, inclination 72% of the time, and both version and inclination 55% of the time. Surgeons accepted neither parameter only 18% of the time.
- Agreement was slightly lower among the high-volume surgeon group, but the difference was no more than 5% in any one category.
- Acceptance increased significantly as retroversion and inclination decreased among both high- and lower-volume groups. Lower acceptance rates with increased retroversion and inclination could be linked to the FDA-regulated limits on component positioning imposed on the planners.

Takeaway

Acceptance rates of VIP preoperative plans are relatively high in TSA with respect to the version and inclination of the technician-generated plan. As native retroversion increased, the agreement on proposed version decreased; the statistical significance with the acceptance rate of proposed inclination remained relatively constant.

Werner BC, Lin A, Lenters TR, Lutton D, Creighton RA, Port J, Doody S, Metcalfe N, Knopf D

ShARC Study:

Influence of backside seating parameters and augmented baseplate components in virtual planning for reverse shoulder arthroplasty. *J Shoulder Elbow Surg.* 2024;33(6):1352-1359. doi:10.1016/j.jse.2023.10.024.

- Nine surgeons virtually planned 30 reverse shoulder replacement cases using the VIP system.
- The study consisted of 3 phases, during which surgeons planned cases with: (1) backside seating percentage blinded and without the option to use augmented components; (2) backside seating unblinded; (3) augmented baseplate options available in pre-op planning.
- Mean implant version and inclination were lowest in phase 3 ($P < .001$). Phase 3 also had lower cancellous invasion and volume of total reamed bone ($P < .001$) and larger backside seating contact ($P < .001$).
- Phase 3 had statistically significantly greater glenoid lateralization (mean = 10.5 mm) compared with phase 1 (mean = 7.8 mm; $P < .001$) and phase 2 (mean = 7.9 mm; $P < .001$).

Takeaway

The option of a full-wedge augmented baseplate when 3D planning with the VIP system resulted in statistically significantly greater correction of glenoid deformity, improved total and cortical baseplate contact area, less cancellous bone reaming, and greater glenoid-sided implant lateralization.

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Galasso L,
Ladermann A,
Werner BC,
Greiner S,
Denard PJ,
ShARC

ShARC Study:

Virtual assessment of internal rotation in reverse shoulder arthroplasty based on statistical shape models of scapular size. *JSES Int.* 2024;8(6)1248-1258. doi:10.1016/j.jseint.2024.07.014

- In smaller scapulae, maximum IR0 was reached with a combination of 2.5 mm inferior offset and 0-4 mm of lateralization.
- In larger scapulae, maximum IRABD was achieved with 2.5 mm of inferior offset and 4 mm of lateralization.
- Maximum IRABD was reached in smaller scapulae with 4-6 mm of lateralization and in larger scapulae with at least 12 mm of lateralization.

Takeaway

Statistical shape models of 5 scapula sizes were each fitted with various configurations of glenosphere position, size, eccentricity, and lateralization. Glenosphere position and the amount of lateralization required to maximize internal rotation varied by scapula size. This study supports previous research demonstrating that up to 8 mm of glenoid-sized lateralization can improve some range of motion metrics, particularly as scapulae grow in size.

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Werner BC,
Parsons B,
Johnson J,
Denard PJ

ShARC Study:

Correlation of preoperatively planned humeral component size and actual implanted size: a retrospective and prospective evaluation of anatomic and reverse shoulder arthroplasty.
JSES Int. 2025;9(2):411-414. doi:10.1016/j.jseint.2024.09.020

- A total of 98 reverse total shoulder arthroplasties (rTSAs) (50 retrospective, 48 prospective) and 77 total shoulder arthroplasties (TSAs) (33 retrospective, 44 prospective) were performed by the four surgeon coauthors.
- Across all rTSAs:
  - Retrospectively, stem diameter was within two sizes of the planned measurement in 84% of cases.
  - Prospectively, stem diameter was within one size of the planned measurement in 73% of cases and within two sizes in 90%.
  - Cup diameter was always within one size; it matched in 84% of the retrospective cases and 90% of the prospective cases ($P > .05$).
- Across all TSAs:
  - Retrospectively, prosthetic head diameter was an exact match in 52% of cases, within one size in 85%, and within two sizes in 100%.
  - Prospectively, head diameter was an exact match in 57% of cases, within one size in 86%, and within two sizes in 100% ($P > .05$).
  - Thickness of the implant was a match to the plan in 88% of retrospective cases and 86% of prospective cases ($P > .05$).

Takeaway

Humeral planning for rTSA affords some predictability for stem size and humeral cup diameter, whether assessed retrospectively or prospectively. For stemless TSA, humeral component diameter was an exact match to the plan in slightly over half of all cases, and within one size in 85%-86% of cases. There were no statistically significant differences between retrospective and prospective planning results.

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VIP™ Preoperative Planning vs Other Systems

Erickson BJ, Chalmers PN, Denard P, Lederman E, Horneff G, Werner BC, Provencher MT, Romeo AA

ShARC Study:

Does commercially available shoulder arthroplasty preoperative planning software agree with surgeon measurements of version, inclination, and subluxation? *J Shoulder Elbow Surg.* 2021;30(2):413-420. doi:10.1016/j.jse.2020.05.027

- Of the four programs tested (VIP system, Blueprint, Materialise, and ExactechGPS), only Blueprint displayed significantly different version measurements compared to surgeon measurements and had the widest range of version measurements.
- Although none of the mean inclination measurements calculated with each of the four programs were significantly different from surgeon measurements, Blueprint had both the fewest number of measurements within 5° and the most measurements greater than 10° of difference from surgeon measurements.
- Blueprint and Materialise were compared to surgeon measurements for humeral head subluxation and were both found to have statistically significant differences from surgeon measurements.

Takeaway

3D planning software produces values for version, inclination, and subluxation that differ from those of a group of five surgeons, with acceptable intraobserver reliability scores. All four systems (the VIP system, Blueprint, Materialise, and ExactechGPS) provided different inclination, retroversion, and subluxation values from those of the surgeon group. Blueprint was the only program of the four to provide significantly different values (P = .02) for version.

Denard PJ, Provencher MT, Lädermann A, Romeo AA, Parsons BO, Dines JS

ShARC Study: Blueprint vs VIP™ Preoperative Planning

Version and inclination obtained with 3-dimensional planning in total shoulder arthroplasty: do different programs produce the same results? *JSES Open Access.* 2018;2(4):200-204. doi:10.1016/j.jses.2018.06.003

- Automated separation of the glenohumeral joint either left extra humeral head fragments on the glenoid or over-removed portions of the glenoid in 30.6% of cases, which could have contributed to the 45.5% of cases with version measurements differing by at least 5° between the two systems.
- In more than 50% of cases, inclination or version varied by at least 5° between the systems, with variances of at least 10° in nearly 25% of cases.
- Although the mean version and inclination measurements were similar between the two systems, Blueprint had a wider distribution of values in both measurements, particularly in inclination.

Takeaway

The values for version and inclination vary between VIP planning and Blueprint, with Blueprint having a wider range than the VIP system, but none of the differences are statistically significant.

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Shah SS, Sahota S, Denard PJ, Provencher MT, Parsons BO, Hartzler RU, Dines JS

ShARC Study: Blueprint vs VIP Preoperative Planning

Variability in total shoulder arthroplasty planning software compared to a control CT-derived 3D printed scapula. *Shoulder Elbow.* 2021;13(3):268-275. doi:10.1177/1758573219888821

- Landmarking and automated techniques both demonstrated variability in version and inclination calculations compared to 3D-printed representative anatomy.
- The automated technique had a wider range of calculations for both version and inclination angles than the landmark technique, with statistically significant differences in average calculated version compared to those for the representative model in the automated technique.
- The automated technique was twice as likely to have greater than 10° of variance from representative anatomy in inclination calculations (20% vs 10%) and had greater than 10° of variance in version in 10% of calculations vs none in the landmark technique.

Takeaway

Both Blueprint and VIP preoperative planning demonstrated variability in inclination and version measures, particularly in version measurements, with differences in average calculated version being statistically significant in Blueprint compared to the VIP system.

Waltz RA, Peebles AM, Ernat JJ, Eble SK, Denard PJ, Romeo AA, Golijanin P, Liegel SM, Provencher MT

Commercial 3-dimensional imaging programs are not created equal: version and inclination measurement positions vary among preoperative planning software. *JSES Int.* 2022;6(3):413-420. doi:10.1016/j.jseint.2022.01.006

- VIP preoperative planning most frequently aligned with the inferior quadrant of the glenoid for version measurements, whereas Blueprint most often aligned with the superior quadrant when calculating version, leading to overestimated version measurements compared to the average manual measurements.
- Both systems most frequently aligned with the posterior quadrant when calculating version, with both systems overestimating inclination compared to the average manual measurements.

Takeaway

When compared to manual measurements, VIP and Blueprint preoperative planning differ in both retroversion and inclination measurements, with Blueprint overcalculating both retroversion and inclination compared to manual measurements. Overall, VIP preoperative planning undercalculated retroversion and overcalculated inclination (by a larger margin than Blueprint) compared to manual measurements. VIP preoperative planning aligned most often with the inferior quadrant of the glenoid for retroversion, while Blueprint most frequently aligned with the superior quadrant. For inclination, both systems most frequently aligned with the posterior quadrant.

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Werner BC, Thakur S, Metcalfe N, Poltaretskyi S

Glenoid version and inclination can be accurately predicted for shoulder arthroplasty from preoperative computed tomography scans utilizing Virtual Implant Positioning™ despite missing angulus inferior data using statistical shape modeling. *J Shoulder Elbow Surg.* 2025;S1058-2746(25)00185-5. doi:10.1016/j.jse.2025.01.041

- When comparing a "best-fit scapular plane" using a least-squares approach to modeling an incomplete scapula to an approach using a statistical shape model (SSM), there were no significant mean differences in the calculated glenoid version and inclination values compared to their native values when 10 or 20 mm of the inferior scapula was removed.
- When 30 mm of the inferior scapula was removed, the best-fit scapular plane method demonstrated statistically significant mean differences in both calculated glenoid version and inclination compared to native values. The mean differences in the calculated glenoid version and inclination from native values did not approach statistical significance in the SSM method.
- The SSM method significantly outperformed the best-fit scapular plane method across all levels of cropping, and the mean differences in the calculated values vs the native values across all levels of cropping were more than doubled in the best-fit scapular plane method compared to the SSM method.

Takeaway

CT imaging with an incomplete scapula is frequently a cause for rejection in preoperative planning softwares. Commonly, the angulus inferior, a necessary anatomical landmark for systems using manual landmarking to generate the scapular plane, is omitted in these scans. The SSM method is more accurate in the reconstruction of missing distal scapular anatomy than the best-fit scapular plane method, particularly in cases where 30 mm of inferior scapula is cropped.

3D Planning and Patient-Specific Instrumentation (PSI)

Hendel MD, Bryan JA, Barsoum WK, Rodriguez EJ, Brems JJ, Evans PJ, Iannotti JP

Comparison of patient-specific instruments with standard surgical instruments in determining glenoid component position: a randomized prospective clinical trial. *J Bone Joint Surg Am.* 2012;94(23):2167-2175. doi:10.2106/JBJS.K.01209

- The use of 3D planning and PSI significantly increased the accuracy of the inclination of the glenoid component in TSA compared to 3D planning with standard instrumentation (2.9° vs 11.6° of deviation from the planned trajectory, respectively).
- Although the use of 3D planning with PSI was more accurate than 3D planning and standard instrumentation in correcting version, PSI was far more accurate in severely retroverted glenoids (>16° of retroversion) with an average of 1.6° of deviation vs 10° from the planned trajectory.

Takeaway

The use of 3D planning with PSI improves the accuracy of glenoid pin placement compared to 2D CT planning and standard instrumentation. Although version, inclination, and medial-lateral offset were all improved in the 3D PSI group, the only statistically significant improvement was in version among patients who had more than 16° of retroversion.

Burrus MT, Denard PJ, Lederman E, Gobezie R, Werner BC

ShARC Study:

The influence of computed tomography preoperative planning on clinical outcomes after anatomic total shoulder arthroplasty: a matched cohort analysis. *Semin Arthroplasty.* 2022;32(4):856-862. doi:10.1053/j.sart.2022.04.011

- Patients receiving TSAs with preoperative planning both with and without the use of PSI had a significantly larger improvement in baseline ASES scores at 2-year follow-up than those that were not planned preoperatively (45.4 vs 39, respectively).
- Patients receiving TSAs that were preoperatively planned also achieved greater external rotation at 90° than those that were not planned (42° vs 29°, respectively).
- Patients receiving TSAs that were preoperatively planned attained a significantly greater patient acceptable symptomatic state than those that were not planned (89% vs 75%, respectively).

Takeaway

Planning has a positive (though not clinically significant) effect on clinical outcomes compared to nonplanned surgeries. The use of PSI has no effect on clinical outcomes when compared to planned surgeries not using PSI.

Hao KA, Sutton CD, Wright TW, Schoch BS, Wright JO, Struk AM, Haupt ET, Leonor T, King JJ

Influence of glenoid wear pattern on glenoid component placement accuracy in shoulder arthroplasty. *JSES Int.* 2022;6(2):200-208. doi:10.1016/j.jseint.2021.11.021

- 3D planning alone is not enough to overcome errors greater than 10° in version when placing glenoid guide pins, particularly in B2 and B3 glenoids in the setting of rTSA, where standard instrumentation alone resulted in a nearly 4-fold increase in errors greater than 10° in version.
- 53% of components placed without intraoperative guidance would have been malpositioned, with either greater than 10° of version or 4 mm of displacement error.
- 63% of components were placed with at least 5° of inclination error across both TSA and rTSA groups with the use of standard instrumentation, with no significant differences among various glenoid wear patterns or Walch classifications.

Takeaway

Surgeons using preoperative 3D planning without PSI had statistically significant differences in version measurements of their glenoid pin (>10°) using standard instrumentation in B2 and B3 glenoids compared to their planned trajectories.

Jacquot A, Gauci MO, Chaoui J, Baba M, Deransart P, Boileau P, Mole D, Walch G

Proper benefit of a three dimensional pre-operative planning software for glenoid component positioning in total shoulder arthroplasty. *Int Orthop.* 2018;42(12):2897-2906. doi:10.1007/s00264-018-4037-1

- The use of PSI in TSA led to more accurate positioning of the glenoid guide pin than standard instrumentation.
- The accuracy of PSI over standard instrumentation is more pronounced in retroverted glenoids, especially in those with more than 10° of retroversion.

Takeaway

PSI and 3D planning without PSI are comparable in version and inclination values, while pin positioning is more accurate with PSI vs 3D planning alone, particularly in glenoids with greater than 10° of retroversion.

Throckmorton TW, Gulotta LV, Bonnarens FO, Wright SA, Hartzell JL, Rozzi WB, Hurst JM, Frostick SP, Sperling JW

Patient-specific targeting guides compared with traditional instrumentation for glenoid component placement in shoulder arthroplasty: a multi-surgeon study in 70 arthritic cadaver specimens. *J Shoulder Elbow Surg.* 2015;24(6):965-971. doi:10.1016/j.jse.2014.10.013

- In the combined TSA/rTSA groups, components positioned using standard instrumentation were nearly 4 times more likely to be malpositioned than those using PSI.
- The use of PSI provided statistically significant differences in the accuracy of component positioning in both version and inclination measures vs the use of standard instrumentation in TSA.
- Statistically significant differences were found in inclination measures between the PSI and standard instrumentation groups in the combined TSA/rTSA group.

Takeaway

The use of PSI in arthritic shoulders is more accurate than standard instrumentation in both inclination and version measurements across both TSA and rTSA procedures.

Raiss P, Walch G, Wittmann T, Athwal GS

Is preoperative planning effective for intraoperative glenoid implant size and type selection during anatomic and reverse shoulder arthroplasty? *J Shoulder Elbow Surg.* 2020;29(10):2123-2127. doi:10.1016/j.jse.2020.01.098

- Preoperative planning has a high concordance rate of planned implants in both TSA and rTSA, with 85% and 90% complete concordance in each category. More importantly, there was a complete mismatch in concordance in only 2% of TSA cases and 3% of rTSA cases.
- There were no cases where a TSA was planned and an rTSA performed and vice versa, indicating not only a high concordance in implant selection but also a complete concordance of procedures performed in the planned groups.
- High concordance rates between planned implants and selected implants in surgery may lead to decreased available inventory necessary for procedures and a streamlined back table in the OR.

Takeaway

The use of preoperative planning software with component selection has a high concordance with intraoperative implant selection (85% in TSA; 90% in rTSA), increasing operative efficiency and potentially optimizing implant availability for future procedures.

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Freehill M, Weick J, Ponce B, Bedi A, Haass D, Ruffino B, Robbins C, Prete A, Costouros J, Warner J

Anatomic total shoulder arthroplasty: component size prediction with 3-dimensional pre-operative digital planning. *J Shoulder Elb Arthroplast.* 2022 May 6;6:24715492221098818. doi:10.1177/24715492221098818

- Chosen anatomic glenoid components matched the planned component size 89% of the time and were within one size of the planned component 99% of the time.
- Stemmed humeral components matched the planned component size 83% of the time and were within one size of the planned component 88% of the time, while stemless components matched 79% of the time and were within one size 98% of the time.
- Humeral head diameters on stemmed components matched the planned size 71% of the time and were within one size of the planned component 84% of the time, while stemless heads matched the planned size 71% of the time and were within one size 99% of the time in non–soft-tissue balancing heads.

Takeaway

Preoperative planning in anatomic shoulder arthroplasty is a reliable predictor of the implants selected during surgery, particularly for glenoid components, stemless humeral components, and standard head diameters. Planning may help to decrease the number of instruments and implants that need to be available for a given case, making it an important part of patient care in facilities with limited space or capacity to process trays.

Werner BC, Lenters TR, Thakur S, Knopf D, Metcalfe N, Tokish JM

The impact of 3-dimensional humeral planning and standard transfer instrumentation on reconstruction of native humeral anatomy for anatomic total shoulder arthroplasty. *J Shoulder Elbow Surg.* 2025;34(1):147-153. doi:10.1016/j.jse.2024.04.011.

- This prospective study used 3D-printed humeri (3D Anatomy models) of -3, -1, 0, 1, and 3 SD of normal anatomy.
- The study design included the following 3 tests: (1) humeral head cuts were performed without any preoperative humeral planning; (2) humeral head cuts were performed on the same anatomies with VIP™ preoperative planning; (3) a neck-shaft angle (NSA) guide and digital calipers were used to measure humeral osteotomy thickness to aid in the desired humeral head cut.
- For both 3D change in center of rotation (COR) and medial-to-lateral change in COR, use of preoperative planning with standard transfer instrumentation resulted in a statistically significantly greater anatomic restoration of ideal COR compared to cases using CT imaging alone.
- Deviations from planned cut thickness decreased from phase to phase: 2.6 mm ± 1.9 mm mm in phase 1; 2.0 mm ± 1.3 mm in phase 2; 1.4 mm ± 0.9 mm in phase 3 (P = .041 for phase 3 vs phase 1). For NSA, in phase 1, 47% of cases were in varus; in phase 2, 33% were in varus; and in phase 3, 7% were in varus (P = .013 for phase 3 vs phase 1).

Takeaway

The use of VIP preoperative humeral planning for stemless TSA improved prosthetic humeral COR regardless of whether it was performed with or without transfer instrumentation. The use of a humeral head cut guide (NSA cut guide) and calipers to measure cut thickness significantly reduced the percentage of varus humeral cuts and deviation from the planned cut thickness.

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Werner BC, Denard PJ, Tokish JM, Bedi A, Donegan RP, Metcalfe N, Dines JS

ShARC Study:

The addition of preoperative three-dimensional analysis alters implant choice in shoulder arthroplasty. *Shoulder Elbow.* 2022;14(4):378-384. doi:10.1177/1758573221989306

- Although the five surgeons had very good interobserver reliability in the measurements for version, inclination, and humeral head subluxation across both 2D and 3D measurements, surgeons disagreed on implant selection in nearly a third of cases based on 2D radiographic measurements.
- Among the 3D CT images, surgeons agreed on implant selection in 80% of cases, indicating that 3D CT imaging not only increases surgeon agreement on implant selection but also exerts a greater effect on implant selection than 2D imaging alone.

Takeaway

The use of preoperative 3D planning changes implant choice in nearly a third of cases compared to plain radiographs and improves surgeon agreement on implant choice compared to x-ray and 2D CT.

Lilley BM, Lachance A, Peebles AM, Powell SN, Romeo AA, Denard PJ, Provencher CM, CPT

What is the deviation in 3D preoperative planning software? A systematic review of concordance between plan and actual implant in reverse total shoulder arthroplasty. *J Shoulder Elbow Surg.* 2022;31(5):1073-1082. doi:10.1016/j.jse.2021.12.006

- In four studies where version and inclination measures were examined, version and inclination implant measurements were found to deviate 4.4° and 5° from their respective preoperatively planned measurements when 3D preoperative planning was used.
- 3D preoperative planning led to 88% concordance in glenoid component selection with the preoperative plan in one study and baseplate central screw length was found to have 100% and 81% concordance with the preoperative plan in two separate studies, indicating a reliable replication of the preoperative plan when 3D planning is used.
- The use of PSI with 3D preoperative planning led to the use of fewer screws, longer screws, and screws placed with minimal deviation (2.8°-5.1°) from their planned trajectories.
- The use of PSI with 3D preoperative planning also increased the use of augmented baseplate usage in two studies, reducing the need for eccentric reaming. Augmented baseplates also reduced the depth of reaming and the volume of bone removed when reaming, and increased the backside contact of the implant to cortical bone.

Takeaway

3D preoperative planning for rTSA not only results in accurate placement of glenoid components but also demonstrates a high concordance with planned procedure type, implant selection, and screw length in this retrospective study looking at nine different studies across 415 patients.

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Gauci MO, Glevarec L, Bronsard N, Cointat C, Pelletier Y, Boileau P, Gonzalez JF

Is preoperative 3D planning reliable for predicting postoperative clinical differences in range of motion between two stem designs in reverse shoulder arthroplasty. *J Shoulder Elbow Surg.* 2024;33(8):1771-1780. doi:10.1016/j.jse.2023.11.031

- Simulated abduction was significantly higher in a 155° inlay construct than in a 145° onlay construct, whereas simulated external rotation was significantly lower in the 155° inlay compared to the 145° onlay. Both trends were observed clinically in patients with these humeral constructs at a minimum follow-up of 2 years.
- Movements involving scapular motion were significantly underestimated in the software, while external rotation were significantly overestimated:
  - Forward elevation was predicted at 126° ± 16° and observed at 150° ± 24°
  - Abduction was predicted at 95° ± 13° and observed at 114° ± 13°
  - External rotation was predicted at 50° ± 19° and observed at 36° ± 19°

Takeaway

Although the values given in a simulated range of motion have little bearing on clinical ranges of motion at a minimum follow-up of 2 years, there are still merits in simulated range of motion with respect to comparison of expected ranges of motion with different humeral implants and consideration of the limitations of the software with respect to movements involving scapular motion and external rotation.

Sheth B, Lavin AC, Martinez C, Sabesan VJ

The use of preoperative planning to decrease costs and increase efficiency in the OR. *JSES Int.* 2022;6(3)454-458. doi:10.1016/j.jseint.2022.02.004

- There were no significant differences in surgical time, pain, outcome, or return-to-function scores between a group where a preoperative plan was created, but not referenced intraoperatively and a group where the preoperative plan was referenced intraoperatively to guide implant selection and decision-making.
- There were significant differences in the number of trays opened and the per-procedure sterilization costs, where the planned and referenced group opened 3.5 fewer trays on average and saved $350 per procedure in sterilization costs at a calculated cost of $100 per tray.

Takeaway

In a single-surgeon study, referencing the preoperative plan intraoperatively for implant selection and placement did not contribute to improved patient outcomes, but did achieve significant sterilization cost savings and resulted in fewer trays opened per procedure than in cases where a preoperative plan was created but not referenced intraoperatively. Importantly, none of the patients in either group had PSI used in their surgeries, which may have contributed to the lack to significant differences in pain, function, and satisfaction scores between groups.

The Future of Preoperative Planning Technologies

Moroder P, Poltaretskyi S, Raiss P, Denard PJ, Werner BC, Erickson BJ, Griffin JW, Metcalfe N, Siegert P

ShARC Study:

SECEC Grammont Award 2024: The critical role of posture adjustment for range of motion simulation in reverse total shoulder arthroplasty preoperative planning. *Bone Joint J.* 2024;106-B:1284-1292. doi:10.1302/0301-620X.106B11.BJJ-2024-0110.R1.

- Three posture types have been theorized off of previously established values for scapulothoracic orientation (types A, B, and C).
- All movement planes showed significant differences when evaluated with and without adjusting for posture ($P < .001$).
- Accounting for scapulothoracic orientation had a significant impact on simulated range of motion for rTSA across all motion planes, particularly resulting in lower values for external rotation and extension, and high internal rotation.

Takeaway

This study argues for the critical reevaluation of previous published research that examined implant selection and placement for optimized range of motion in rTSA using preoperative planning.

Abdic S, Van Osch NJ, Langohr DG, Johnson JA, Athwal GS

Mixed reality visualization in shoulder arthroplasty: is it better than traditional preoperative planning software? *Clin Shoulder Elb.* 2023;26(2):117-125. doi:10.5397/cise.2022.01326.

- Variances in guide pin position, inclination, and version were not significantly different between placing the pin freehand referencing the preoperatively planned pin position on a screen or using a mixed-reality headset for reference among any of the four groups of participants.
- Times for definitive pin placement were not significantly different between the two modalities among any of the four groups of participants.

Takeaway

The use of mixed reality did not offer any clear benefits over a freehand method of inserting a guide pin into a 3D-printed glenoid in a soft-tissue model among junior residents, senior residents, fellows, or senior surgeons with respect to the time for pin placement or the accuracy of guide pin placement with respect to the preoperative plan. Although the visualization of and the ability to manipulate the preoperative plan are thought to be helpful, the data do not support any significant benefits to the use of the technology in glenoid guide pin placement.