



VIP™ Preoperative Planning Scientific Update

A Review of Modern Technologies

Launched in 2016 and based on the foundational work of Joseph Iannotti and built from the clinically proven Custom Orthopedic Solutions software, the Virtual Implant Positioning™ system offers an intuitive, comprehensive preoperative planning experience for surgeons, coupled with the only reusable, sterilizable patient-specific instrumentation available on the market.

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

VIP System-Specific

[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.

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-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.



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

VIP Preoperative Planning vs Other Systems

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, Blueprint, Materialise, and ExactechGPS), only Blueprint displayed significantly different version measurements than surgeon measurements and had the widest range of version measurements among the four programs tested
- 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° of and the largest number of measurements greater than 10° of difference from surgeon measurements
- Blueprint and Materialise were both 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 different values for version, inclination, and subluxation than a group of five surgeons, with acceptable intraobserver reliability scores. All four systems (VIP, Excatech GPS, Materialise, and Blueprint) provided different inclination, retroversion, and subluxation values than the surgeon group. Blueprint was the only program of the four to provide significantly different values ($P = .02$) in version.

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 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.

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



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 demonstrate variability in version and inclination calculations compared to 3D-printed representative anatomy
- The automated technique has a wider range of calculations for both version and inclination angles than the landmark technique, with statistically significant differences in average version calculated compared to those for the representative model in the automated technique
- The automated technique was twice as likely to have a >10° variance from representative anatomy in inclination calculations (20% vs 10%) and had a >10° 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.

[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 aligns with the inferior quadrant of the glenoid for version measurements, whereas Blueprint most often aligns with the superior quadrant when calculating version, leading to overestimated version measurements compared to manual averaged measurements
- Both systems most frequently align with the posterior quadrant when calculating version, with both systems overestimating inclination compared to manually averaged 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.

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



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

3D Planning and Patient-Specific Instrumentation (PSI)

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.

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.

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



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 $>10^\circ$ errors 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 $>10^\circ$ version errors
- 53% of components placed without intraoperative guidance would have been malpositioned with either $>10^\circ$ 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 ($>10^\circ$) 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 leads 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 $>10^\circ$ 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/RSA 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/RSA 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 RSA procedures.



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 RSA, 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 RSA cases
- There were no cases where a TSA was planned and an RSA 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 RSA), increasing operative efficiency and potentially optimizing implant availability for future procedures.

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 it has 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.

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

- Version and inclination measures were examined in four studies and found that version and inclination implant measurements deviated 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 reduce the depth of reaming and the volume of bone removed when reaming, and increase 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.