# The Influence of Computed Tomography-Based Preoperative Planning on Clinical Outcomes after Reverse Total Shoulder Arthroplasty: A Matched Cohort Analysis

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INTRODUCTION:
There has been a significant increase in the use of computed tomography (CT)-based preoperative planning and transfer technology for shoulder arthroplasty in the past decade. While numerous studies have demonstrated improved positioning of components, there is little evidence to support any impact that the use of such technology has on clinical outcomes after shoulder arthroplasty. The goal of this study was to investigate the impact of CT-based preoperative planning on clinical outcomes, including patient reported outcome measures (PROs) and active range of motion (ROM) after reverse total shoulder arthroplasty (RSA).

METHODS:
A multicenter shoulder arthroplasty registry was retrospectively queried to identify all patients who underwent RSA with minimum 2-year clinical follow-up. Patients with preoperative three-dimensional CT-based planning were identified and separated into two study groups: 1) use of CT-based planning software without transfer instrumentation and 2) use of CT-based planning software with transfer instrumentation. Control patients without any CT-based planning were then identified and matched 1:1 to the each study group based on age (±3 years), sex and baseline ASES score (±10 points). Additional demographic and baseline characteristics were compared between groups to assure similar distribution of comorbidities, glenoid morphology, and baseline impairment and function. The primary outcome measure was the 2 year ASES score. Additional outcomes were the following PROs: VAS pain, WOOS, Constant-Murley and VR-12 mental score as well as the following active ROM measurements: FF, ER at side (ER0), ER at 90 (ER90), IR measured by spinal level (IRspine) and IR at 90 (IR90). For all comparisons, $p < 0.05$ was considered statistically significant.

RESULTS:
56 patients were identified that underwent RSA with 3D CT-based preoperative planning without transfer instrumentation and were matched to 56 controls; 122 patients were identified that underwent RSA with 3D CT-based preoperative planning and utilized transfer technology, these were matched to 122 controls. Overall, there were minimal additional differences in demographics, glenoid morphology, glenoid metallic lateralization or baseline PROs between the groups. The final outcomes at 2 years between the study groups and matched controls were not significantly different (Tables 1 and 2) The change in PROs, ROM and strength from baseline for both of the study groups compared to controls were also not overall significantly different. Although several very minor statistically significant differences were noted, no clinically significant differences were noted between the study groups with CT-based planning and controls without planning.

DISCUSSION AND CONCLUSION:
Patients undergoing RSA with three dimensional CT-based preoperative planning with or without transfer instrumentation had no clinical differences at early follow up compared to matched controls without CT-based planning. Additional longer-term follow up studies are necessary to confirm these findings and assess any long-term impact of CT-based planning and transfer technology on outcomes, longevity and complications after RSA.

**Table 1.** 2 Year Outcomes: CT-Based Planning without Transfer

| Variable | *CT-Based Planning (n = 56)* | | *Matched Controls (n = 56)* | | *p* |
|---|---|---|---|---|---|
| *Clinical Outcome Measures* | *Mean* | *Std. Dev.* | *Mean* | *Std. Dev.* | |
| VAS Pain | 1.1 | 2.0 | 1.2 | 1.8 | 0.781 |
| ASES | 83.8 | 16.4 | 81.6 | 17.8 | 0.498 |
| WOOS | 86.4 | 18.1 | 83.3 | 19.2 | 0.381 |
| SANE | 76.1 | 26.8 | 74.3 | 25.1 | 0.714 |
| VR-12 Mental | 52.5 | 9.4 | 52.2 | 9.9 | 0.870 |
| Constant | 69.6 | 7.1 | 63.2 | 15.8 | 0.007 |
| *Range of Motion* | *Mean* | *Std. Dev.* | *Mean* | *Std. Dev.* | |
| Active FF (degrees) | 149 | 15 | 133 | 30 | 0.007 |
| Active ER at Side (degrees) | 48 | 12 | 53 | 27 | 0.208 |
| Active ER at 90 (degrees) | 70 | 25 | 64 | 21 | 0.172 |
| Active IR (spinal level) | L1 | 3 | L3 | 3 | < 0.001 |
| Active IR at 90 (degrees) | 32 | 12 | 35 | 15 | 0.245 |
| Total ROM | 244 | 54 | 233 | 52 | 0.275 |
| *Strength* | *Mean* | *Std. Dev.* | *Mean* | *Std. Dev.* | |
| Constant-Murley (lbs) | 7.9 | 1.9 | 8.2 | 3.9 | 0.606 |
| External Rotation Strength (lbs) | 10.1 | 2.7 | 10.0 | 4.7 | 0.890 |
| Belly Press Strength (lbs) | 11.3 | 3.0 | 9.9 | 4.4 | 0.052 |
| *Satisfaction/Expectations* | *n* | *%* | *n* | *%* | |
| Pain level (met/exceeded) | 49 | 87.5% | 48 | 85.7% | 0.781 |
| Motion/strength (met/exceeded) | 46 | 82.1% | 45 | 80.4% | 0.809 |
| ADLs (met/exceeded) | 47 | 83.9% | 48 | 85.7% | 0.792 |
| Sport (met/exceeded of applicable) | 29 | 74.4% | 26 | 72.2% | 0.834 |
| *Clinically Significant Milestones* | *n* | *%* | *n* | *%* | |
| MCID | 52 | 92.9% | 53 | 94.6% | 0.696 |
| SCB | 42 | 75.0% | 37 | 66.1% | 0.300 |
| PASS | 43 | 76.8% | 40 | 71.4% | 0.518 |

**Table 2.** 2 Year Outcomes: CT-Based Planning with Transfer

| Variable | *CT-Based Planning with Transfer (n = 122)* | | *Matched Controls (n = 122)* | | *p* |
|---|---|---|---|---|---|
| *Clinical Outcome Measures* | *Mean* | *Std. Dev.* | *Mean* | *Std. Dev.* | |
| VAS Pain | 0.9 | 1.6 | 1.2 | 2.1 | 0.211 |
| ASES | 82.9 | 16.3 | 81.4 | 18.9 | 0.507 |
| WOOS | 85.2 | 19.1 | 83.5 | 19.7 | 0.494 |
| SANE | 73.9 | 25.1 | 76.9 | 22.4 | 0.326 |
| VR-12 Mental | 53.0 | 9.3 | 53.3 | 8.9 | 0.797 |
| Constant | 61.9 | 14.7 | 66.4 | 12.3 | 0.010 |
| *Range of Motion* | *Mean* | *Std. Dev.* | *Mean* | *Std. Dev.* | |
| Active FF (degrees) | 130 | 29 | 138 | 22 | 0.016 |
| Active ER at Side (degrees) | 43 | 20 | 46 | 14 | 0.176 |
| Active ER at 90 (degrees) | 49 | 28 | 63 | 23 | < 0.001 |
| Active IR (spinal level) | L4 | 3 | L4 | 3 | 1.000 |
| Active IR at 90 (degrees) | 28 | 20 | 40 | 21 | < 0.001 |
| Total ROM | 207 | 57 | 236 | 48 | < 0.001 |
| *Strength* | *Mean* | *Std. Dev.* | *Mean* | *Std. Dev.* | |
| Constant-Murley (lbs) | 9.3 | 7.1 | 8.8 | 4.0 | 0.499 |
| External Rotation Strength (lbs) | 9.2 | 5.6 | 10.4 | 4.0 | 0.055 |
| Belly Press Strength (lbs) | 8.9 | 5.8 | 10.1 | 3.8 | 0.057 |
| *Satisfaction/Expectations* | *n* | *%* | *n* | *%* | |
| Pain level (met/exceeded) | 117 | 95.9% | 112 | 91.8% | 0.183 |
| Motion/strength (met/exceeded) | 109 | 89.3% | 102 | 83.6% | 0.190 |
| ADLs (met/exceeded) | 110 | 90.2% | 105 | 86.1% | 0.323 |
| Sport (met/exceeded of applicable) | 60 | 82.2% | 55 | 79.7% | 0.706 |
| *Clinically Significant Milestones* | *n* | *%* | *n* | *%* | |
| MCID | 113 | 92.6% | 116 | 95.1% | 0.424 |
| SCB | 88 | 72.1% | 89 | 73.0% | 0.886 |
| PASS | 92 | 75.4% | 91 | 74.6% | 0.882 |