

Clinical accuracy of the HipSextant™ navigation system: multiuser experience

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Introduction: More than half of all conventionally placed acetabular components placed during hip arthroplasty are malpositioned [2] and cup malpositioning is directly associated with accelerated wear and instability, the two most common reasons for revision hip arthroplasty [1]. The HipSextant™ Navigation System is a patient-specific mechanical navigation instrument that was designed to address this problem. The system has been shown to be reliable when adjusted based on CT-imaging in a single-surgeon series [4]. The current study assesses component accuracy when used by multiple surgeons.

Patients & Methods: The local institutional review board (IRB) approved this study. In the study group, we prospectively assessed postoperative cup orientation in a consecutive series of 44 patients (45 hips) who underwent THA performed using the mechanical navigation device (HipSextant™ Navigation System, Surgical Planning Associates, Boston, Massachusetts). The instrument is adjusted on a patient-specific basis using CT imaging. On a 3D model, the AP plane coordinate system is defined and then the instrument coordinate system is determined by three points: one just behind the posterior wall of the acetabulum, a second on the lateral aspect of the anterior superior iliac spine, and a third which is on the surface of the ilium, and equally distance between the other two points. Two protractors on the instrument are then adjusted to point the direction indicator in the direction of desired cup orientation.

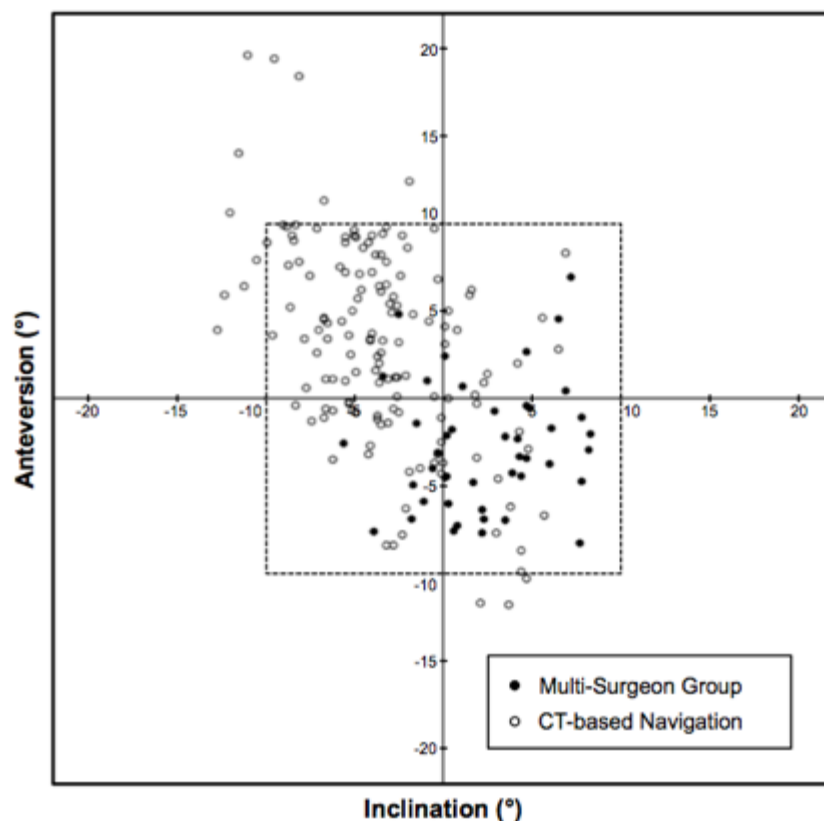
The HipSextant was applied and the cup aligned by seven different surgeons who had not previously used the instrument. None of these surgeons had any prior experience with any type of surgical navigation of cup orientation. These surgeons contributed a minimum of one to a maximum of 10 procedures to the study. Instruction in the use of the instrument consisted of demonstration either on a sawbones or in surgery together with demonstration of the HipSextant planning software application. The current study group included 27 hips in women and 18 hips in men with 20 right hips and 25 left hips.

Post-operative component orientation was measured using HipMatch, a noncommercial two-dimensional/three-dimensional matching application (HipMatch, Institut for Surgical Technology and Biomechanics, Bern, Switzerland) [3, 5]. This software application uses a fully automated registration procedure that can match the three-dimensional model of the preoperative CT with the projected pelvis on a postoperative radiograph. This allows for the calculation of cup inclination and anteversion relative to the anterior pelvic plane, corrected for pelvic malposition on the radiograph. This method has been validated and showed a mean accuracy of $1.7^\circ \pm 1.7^\circ$ (-4.6° to 5.5°) for inclination and $0.9^\circ \pm 2.8^\circ$ (-5.2° to 5.7°) for anteversion compared to postoperative CT measurements. Software consistency, reproducibility and reliability was graded very good and no systematical error of the algorithm was found.

These orientation results were compared to two prior series. Group 2 is a series of 70 cups placed using the HipSextant by a single surgeon, and Group 1 is a series of 146 cups placed using the CT-based Vector Vision system from BrainLab (BrainLAB AG, Feldkirchen, Germany), [4].

Results: Cup orientation measurements of the series of 45 THA's performed in the current study (Group 3) using the mechanical navigation instrument showed an error of inclination of $2.3^\circ \pm 3.6^\circ$ [range, -5.6° to 8.3°] and an error of anteversion of $-2.8^\circ \pm 3.6^\circ$ [range, -8.3° to 6.9°]. As reported

previously, the cup orientation measurements of the series of 70 THA's (Group 2) performed using the mechanical navigation instrument showed an error of inclination of $1.3^\circ \pm 3.4^\circ$ [range, -6.6° to 8.2°] and an error of anteversion of $1.0^\circ \pm 4.1^\circ$ [-8.8° to 9.5°]. The cup orientation measurements of the series of 146 THA's (Group 1) performed using CT-based optical navigation show an error of inclination of $3.5^\circ \pm 4.2^\circ$ [range, -12.7° to 6.9°] and an error of anteversion of $3.0^\circ \pm 5.8^\circ$ [range, -11.8° to 19.6°]. The current study group (Group 3) showed significantly better accuracy in both inclination ($p=0.014$) and anteversion ($p=0.003$) compared to Group 1. The current study group (Group 3)



showed no statistically significant difference in either inclination ($p=0.203$) or anteversion ($p<0.276$) compared to the single-surgeon series (Group 2). There were no outliers in Group 3 or Group 2. In Group 1, 9.6% of the hips were outliers in inclination, anteversion, or both. Comparison of cup orientations in Group 3 vs Group 1 is depicted in Figure 1.

Discussion: The mechanical navigation instrument has shown great promise in reducing the number of cup orientation outliers resulting from hip arthroplasty. Yet, our initial experience reported data from a single surgeon who developed the instrument and who had significant experience with navigation and with prior prototypes of the instrument. The current study demonstrates that the mechanical instrument may be used effectively by surgeons who have had no prior experience with either navigation of cup orientation or with the HipSextant.

References

1. Bozic KJ, Kurtz SM, Lau E, Ong K, Vail TP, Berry DJ. The epidemiology of revision total hip arthroplasty in the United States. *J Bone Joint Surg Am.* 2009;91:128-133.
2. Callanan MC, Jarrett B, Bragdon CR, Zurakowski D, Rubash HE, Freiberg AA, Rubash HE, Malchau H. Risk factors for cup malpositioning. Quality improvement through a joint registry at a tertiary hospital. *Clin Orthop Relat Res* (2011) 469:319-329.
3. Callanan MC, Jarrett B, Bragdon CR, Zurakowski D, Rubash HE, Freiberg AA, Malchau H. The John Charley Award: Risk Factors for Cup Malpositioning: Quality Improvement Through a Joint Registry at a Tertiary Hospital. *Clin Orthop Relat Res.* 2010; Aug 18.
4. Steppacher SD, Tannast M, Zheng G, Zhang X, Kowal J, Anderson SE, Siebenrock KA, Murphy SB. Validation of a new method for determination of cup orientation in THA. *J Orthop Res.* 2009;27:1583-1588.
5. Steppacher SD, Kowal JH, Murphy SB. Improving cup positioning using a mechanical navigation instrument. *Clin Orthop Relat Res.* 2011;469:423-8.
6. Zheng G, Zhang X, Steppacher SD, Murphy SB, Siebenrock KA, Tannast M. HipMatch: an object-oriented cross-platform program for accurate determination of cup orientation using 2D-3D registration of single standard X-ray radiograph and a CT volume. *Comput Methods Programs Biomed.* 2009;95:236-248.