Registration and tracking accuracy of the HipSextant™ navigation system in patients suffering from developing dysplasia of hip joint with Crowe III and IV deformities

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Introduction: We often lose orientation when we try to place acetabular cups in total hip arthroplasty (THA) for patients with severe developing dysplasia of hip joint (DDH) because secondary acetabulums are very shallow with abnormal version. In such cases, we prefer to use CT-based navigation systems, however, time and cost to use such systems are very high and the procedures are still not simple. The HipSextant™ Navigation System (Surgical Planning Associates, Boston, MA) has been shown to produce accurate cup orientation with simple and quick procedures in 70 hips treated by THA¹. We introduced novel bioskills pelvic models, which were created based on the Japanese pelvis with DDH, to analyze the accuracy of navigation tools for acetabular cups at the previous CAOS International meeting. The aim of our current study is to analyze the accuracy of acetabular cup placement according to the HipSextant navigation system specifically in severe DDH hips with Crowe III and IV deformities by using of our bioskills pelvic models.

Methods: Bioskills models of 6 patients with DDH were manufactured using a 3D printer. The models were based on high-resolution CT imaging. Each model had a direction rod placed to designate the desired direction of cup orientation. The direction rod to placed in 20 degrees of operative anteversion and 45 degrees of operative inclination. The bioskills models were of 3 Crowe III and three Crowe IV deformities. The original CT data were then used to plan the surgery using the HipSextant™ Navigation System. Using this system, a 3D model is created from CT data and the anterior pelvic plane is defined. Next, the patient-specific ipsilateral hemi-pelvic docking coordinate system is determined by 3 points. The first point is located behind the posterior wall of the acetabulum, 20mm above the infracotyloid notch. The second point is located on the lateral aspect of the anterior superior iliac spine. The third point is located equally distance from the first two and on the surface of the bone. Calculations between the instrument coordinate system and the anterior pelvic plane coordinate system are performed to allow the adjustment of two protractors on the top of the instrument to be adjusted such that a direction indicator points in the direction of desired cup orientation.

Using the bioskills model, the surgeon then docked the instrument according to the plan and then adjusted the two protractors so that the direction indicator was parallel with the direction rod on the model. The angles chosen were recorded. The error in anteversion and inclination between the recommended plan and the actual angles chosen were calculated. Each of the 6 bioskills models was test 3 times.

Results: The results of the 9 tests for Crowe III hips showed an average of 1.1 (+/−1.5) degrees with a range of -2.4 to 3.3 degrees for operative inclination and 0.5 (+/−1.8) degrees with a range of -2.3 to 2.8 degrees for operative anteversion. The results of the 9 tests for Crowe IV hips showed an average of 0.2 (+/−2.4) degrees with a range of -2.2 to 3.7 degrees for operative inclination and 0.1 (+/−2.8) degrees with a range of -3.2 to 3.8 degrees for operative anteversion.

Discussion: The current study demonstrated that accuracy for acetabular cup placement using the HipSextant was clinically acceptable in severe DDH pelvis with Crowe III and IV deformities. However, the amounts of errors were slightly greater than those in the pelvis with Crowe I and II deformities.
demonstrated in our previous study\(^2\). At the time of the study, we were not able to remove the femur during the planning process which impeded precise planning of the basepoint docking location in these severely deformed hips with severe subluxation or dislocation. Current planning software now enables removal of the femur in the planning process which may improve the accuracy in these complex hips even further.

References