Registration and tracking accuracy of the HipSextant™ navigation system in patients with DDH

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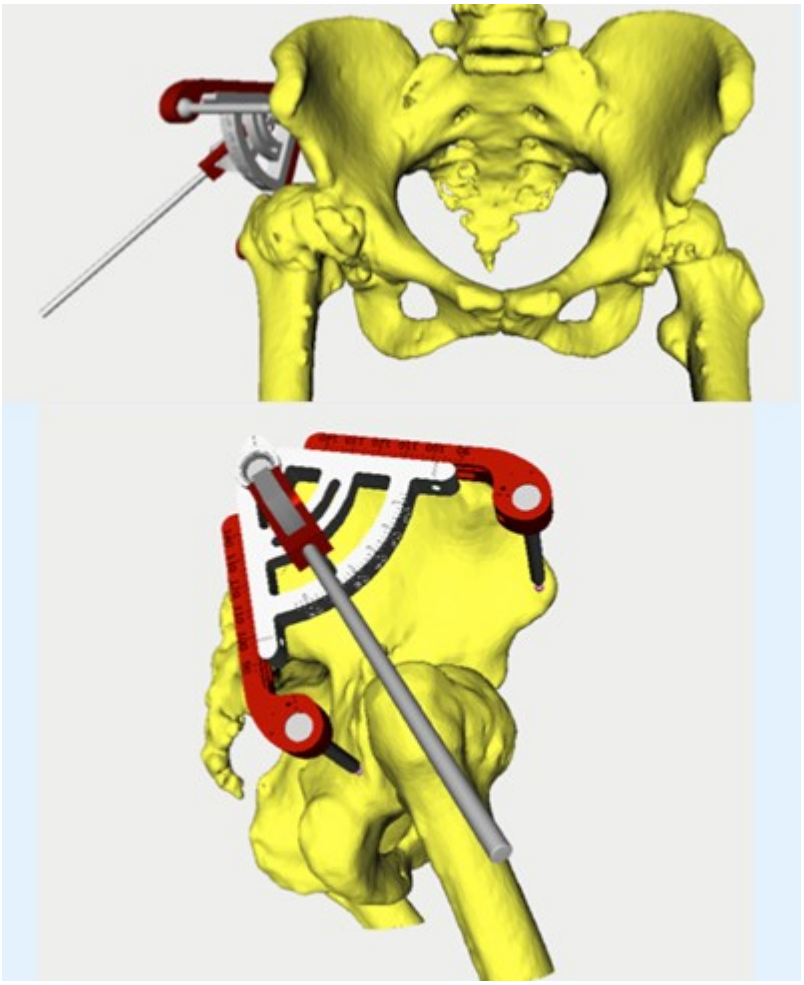
Introduction: Cup malposition is a common problem affecting hip arthroplasty in general and patients with hip dysplasia in particular. Patients with hip dysplasia are particularly susceptible to problems associated with cup malposition since smaller components with thinner bearings can have accelerated wear in association with cup malposition, potentially doubling the rate of osteolysis1. HipSextant™ Navigation System (Surgical Planning Associates, Boston, MA) has been shown to produce accurate cup orientation in a clinical study of 70 hips treated by total hip arthroplasty2. The current study assesses the surgeon's ability to register and track the pelvis and align the acetabular component using this navigation system specifically in hips with DDH.

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 I and three Crowe II 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 protroctors on the top of the instrument to be adjusted such that a direction indicator points in the direction of desired cup orientation.



Patient-specific HipSextant plan for a patient with DDH

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 1 hips showed an average of -0.44 degrees (+/-1.13) with a range of 0 to -3 degrees for operative inclination and -1.1 (+/-1.76) with a range of 0 to -3 degrees. The results of the 9 test for Crowe 2 hips showed an average of 0.55 degrees (+/-1.13) with a range of 1 to -2 degrees for operative inclination and 0.6 degrees (+/-1.87) with a range of 3 to -2 degrees.

Conclusion: The current study demonstrates the potential for accurate cup placement using a mechanical instrument in hips with Crowe 1 and Crowe 2 dysplasia. While the errors in this study are small and clinically acceptable, they include not only the equivalent of registration and tracking accuracy, but also any differences between the AP plane points chosen during model generation and instrument planning. Future experiments will assess accuracy for more severe deformities and also synchronize the coordinate systems used for model generation and planning.

References

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