Accuracy of cup position and leg lengthening in THA for dysplastic hip using imageless navigation system

OHASHI H, INORI F, YO H, OKAJIMA Y, MATSUI Y, SHINTANI K

Department of Orthopaedic Surgery, Saiseikai Nakatsu Hospital, Osaka, Japan

LU7H-OOHS@asahi-net.or.jp

Introduction: Osteoarthritis of the hip secondary to developmental dysplasia represents acetabular hypoplasia, femoral deformity, supero-lateral subluxation, and leg-length discrepancies. These anatomic abnormalities increase the risk of improper position of the cup and inaccurate leg-length adjustment. We have developed an imageless navigation system in THA focusing on dysplastic hips. The cup position and the leg lengthening are planned based on the radiological templating. The navigation system provides cup orientation in reference to the anterior pelvic plane and cup position in reference to the landmarks in acetabulum. The leg lengthening is also provided without femoral reference tracker. The aim of this study was to investigate the following questions: (1) how accurate are the values of cup position, cup orientation and leg lengthening? (2) is there a learning curve by comparing the initial 20 cases to the last 20 cases? (3) what are the factors that influence the accuracy?

Materials & Methods: Patients Eighty THA of 71 patients were performed for dysplastic hips using an imageless navigation system (OrthoPilot THA plus Dysplasia 3.1, B. Braun Aesculap, Tuttlingen, Germany). According to Crowe classification, 58 hips were categorized in type I, 18 hips were in type II, and 4 hips were in type III. The sample consisted of 10 men and 61 women with a mean age of 59.9 years. The mean weight was 58.6 kg, the mean height was 156 cm, and the mean BMI was 24.0 kg/m2. Preoperative planning Preoperative planning was done on the antero-posterior radiograph. The vertical distance from the inter-teardrop line to the planned cup center was measured, and this distance was defined as planned cup height. The leg lengthening was intended to minimize the leg-length discrepancy. Operative procedure Surgeries were performed by 4 expert surgeons, while all operations were supervised by one chief surgeon. We used two approaches, direct anterior approach in supine position (34 hips), and direct lateral approach in lateral position (46 hips). Before capsulectomy, the pelvic reference tracker was fixed on the iliac crest. The anterior pelvic plane was determined by palpating both anterior superior iliac spines and pubic symphysis. Two pointing pins were inserted at the greater trochanter, and at the lateral or medial epicondyle of distal femur. The position of the femur was recognized by registering two points on the femur and the pelvic reference tracker at the same time. After exposure of the acetabulum, the teardrop was registered as cranio-caudal reference point for the cup center, the posterior rim of acetabulum was registered as antero-posterior reference point, and the medial wall of acetabulum was registered as medio-lateral reference point.

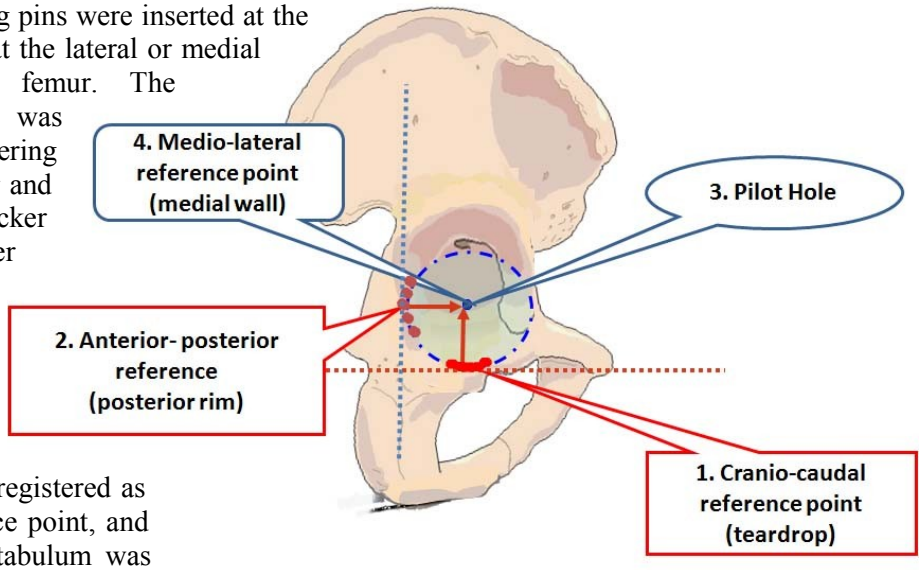

Figure Registration of acetabulum

Then, the cup center was navigated

and the acetabular reaming was performed in reference to the navigated cup center. Plasma cup (B. Braun Aesculap, Tuttlingen, Germany) was used in all cases. The cup height (the distance between teardrop and final cup center), cup medialization (the distance between medial wall of acetabulum and cup surface), the cup inclination, and anteversion were recorded. The leg lengthening (the longitudinal transfer of the distal femoral pointing pin from initial registration to final reduction) was navigated. Assessment The cup height, cup medialization and the leg lengthening were measured on AP radiographs. The perpendicular distance from the inter-teardrop line to the cup center was defined as cup height and the distance between medial wall of acetabulum and cup surface was defined as cup medialization to compare with the navigated values. The perpendicular distance from the inter-teardrop line to the tip of lesser trochanter was measured on radiographs before and after operation. The leg lengthening was defined as the difference between these distances before and after operation. The cup inclination and anteversion were measured on CT images.

Firstly, the accuracy was defined as the absolute difference between the navigated value and the measured value. Secondly, we compared initial 20 cases and last 20 cases to investigate the existence of learning curve as for the accuracy. Thirdly, we examined whether the accuracy was influenced by the Crowe classification, the surgeons, and the surgical positions. The Mann-Whitney U-test was applied for the statistical analysis.

Results: The absolute difference between the navigated value and the measured value was 4.5±4.0 mm in cup height, 3.0±2.5 mm in cup medialization, 3.7±3.0 mm in leg lengthening, 4.3±3.1 degrees in cup inclination, and 5.5±3.8 degrees in cup anteversion. Comparing the initial 20 cases with last 20 cases, the accuracy of cup medialization was significantly improved. While the cup height was significantly high and the leg lengthening was significantly great in Crowe type II and III in comparison with Crowe type I, the accuracy was not influenced by the Crowe classification. The accuracy was not also influenced by the surgeons and the surgical positions.

Discussion: Our imageless navigation system is unique since it realizes to navigate cup position, cup orientation, and leg lengthening according to the 2D radiographic templating. While radiographs provide limited information for antero-posterior direction, 2D radiographic templating is simple and familiar to reconstructive hip surgeons. In dysplastic hips, the cup cannot always be fixed at the anatomical position due to acetabular hypoplasia. The accuracy of the cup height depends on the registration point of the tear drop, and the accuracy of cup medialization depends on the registration point of medial wall of acetabulum. When the teardrop and the medial wall of acetabular was covered by osteophyte or proliferated synovial tissue, the registration of the exact point tended to be difficult. In this study, the learning curve was observed for the accuracy of the cup medialization. We have developed an imageless navigation system in THA focusing on dysplastic hips. We found that the accuracy of these measurements was acceptable for clinical use, and was not influenced by the Crowe classification, the surgeons, and the surgical positions. We found no learning curve except for the accuracy of cup medialization. These results indicated this navigation system is simple to use and can be applied for THA for dysplastic hips.