A HIGH HIP CENTER LIMITS STABLE JOINT MOTION FOLLOWING THR

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Introduction: When Total Hip Replacement (THR) is performed in advanced hip dysplasia with severe subluxation, the morphologic abnormalities presented by the dysplastic joint often complicate the restoration of enduring joint function. One approach is to restore the subluxed femur to its original position with respect to the pelvis and fix the acetabular cup within the original acetabulum. However, the magnitude of leg-lengthening associated with this approach carries a high risk of permanent neurovascular injury, especially in cases of extreme subluxation. In light of these risks, some surgeons accept the existing shortening of the extremity and prepare the neo-acetabulum to accept an acetabular cup by reaming and bone grafting. Although this approach has fewer complications, function of the hip is not restored well and the stable range of motion of the hip may be compromised. This study was performed to quantify the range of motion of the dysplastic hip after THR using three alternative positions of the head center: the original acetabulum, the neo-acetabulum, and an intermediate position.

Materials and Methods: Patient-specific computer models of the femur and pelvis were prepared from helical CT scans of 6 patients with Crowe Class II or III hip dysplasia. All patients were female with an average age of 55.3 years (range: 49 to 65 years). CAD models of hemispherical acetabular cups and modular femoral prostheses were generated using CAD software (Unigraphics). Surgical reconstruction of each dysplastic joint was simulated by an experienced hip surgeon who performed 3 sequential procedures on each computer model, according to the position of the joint center (Fig. 1):

1. Original Acetabulum: An acetabular cup was implanted in the original acetabulum with sufficient depth to allow coverage of a cup oriented in 45° of abduction and 20° of anteverision. A modular femoral prosthesis with a 135 degree neck/shaft angle and 26mm diameter head was implanted in the femur. The optimal depth of the femoral component and position of the femur were determined by pre-operative X-rays and CAD models.

2. Neo-acetabulum. An acetabular cup of same size as used in the original acetabulum was implanted at 20mm higher than the original acetabulum.

3. Mid-position. An acetabular cup of the same size was implanted at 10 mm higher than original acetabulum. The acetabular cups in the neo-acetabulum and mid-position were implanted by the same conditions of inclination and anteverision as set in the original acetabulum.

After reduction of the prosthetic components, the shift in position of the head center was measured from the computer models. The range of motion of the hip joint was measured by placing the femur in the principal positions of joint instability (Fig. 2), namely:

1. Flexion beyond 90 degrees with 0-30 degrees of adduction and 0-50 degrees of internal rotation.

2. Extension from 0-30 degrees, with 0-40 degrees abduction and 0-50 degrees of external rotation.

Using customized collision detection routines, positions of bony and prosthetic impingement were identified. The procedure was repeated for each position of the head center with the corresponding implant selections.

Results: There was no correlation between cup position and the range of motion in the simple motions (flexion, extension, abduction, adduction, external rotation and internal rotation). When the hip joint was placed in 90° and 100° of flexion with combinations of 0° and 10° of abduction, the range of internal rotation that occurred before anterior impingement in the high hip center group was significantly less than that of the original acetabulum group (p<0.005) (Fig. 3). The average range of flexion that occurred before anterior impingement was 89.3±6.5°, significantly limited in the high hip center group (89.3±6.5°, p=0.009).

Conclusions: This study demonstrates that the cup position in THR significantly influences the range of motion that occurs before anterior impingement which leads to dislocation. Implantation in the high hip center position increased the risk of the anterior impingement compared to the normal cup center. In cases of severe subluxation of the femoral head, even when the high hip position is accepted, surgeons should evaluate the intraoperative range of motion carefully. Nonetheless, in cases where joint motion in flexed and internal position is limited, more motion may be restored by resection from of the acetabulum and around the femur. However, in order to restore the range of motion to a safe limit which prevents dislocation and factoring the limitations in resection from the anterior aspect of the pelvis, the position for implantation of the cup is recommended near the position of the original acetabulum to ensure the best range of motion.

Figure 1: Three alternative positions of the cup center: (i) original acetabulum (ii) med-position (iii) neo-acetabulum

Figure 2: The range of motion was measured by placing the femur in principle positions of joint instability.

Figure 3: Positions of anterior impingement related to different cup locations.

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