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Does registration with distal points increase accuracy and precision for femoral stem placement in CT-based navigation assisted THA?

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Abstract

Most CAOS for THA is used only for cup placement. Only Stryker Navigation provides real time navigation for stem insertion, however, few surgeons use this system during stem insertion because its accuracy is believed to be low. We analyzed whether the additional reference points on distal femur improve the accuracy of stem placement. Sixty-three hips of 57 cases (13 males, 44 females, average age: 65.9 y.o.) were analyzed in the study. Proximal registration group (36 hips) were registered with 30 arbitrary points on proximal femur and distal registration group (27 hips) were registered with additional 4-8 points on the distal femoral condyle in addition to 30 arbitrary points on proximal femur. The differences (average ± standard deviation of absolute values) between the pre- and post-operative angles of stem anteversion were 3.7 ± 3.5°in the only proximal registration group, and 3.8 ± 3.1° in the distal addition group. The differences (average ± standard deviation of absolute values) between the pre- and intra-operative angles of stem anteversion were 3.6 ± 2.2° in the proximal registration group and 1.6 ± 1.7° in the distal registration group. Registration with additional distal reference points on femur did not improve accuracy and precision for stem placement. However, addition distal reference points provided intraoperative replication of preoperative planning. Future modifications are needed to improve accurately for stem insertion.

1 Introduction

Current CAOS, such as navigations and robotic surgeries have provided accurate implant placement in THA. However, these CAOS are used only for cup placement and are not commonly used for stem placement because of low accuracy and precision of femoral registration in comparison to those of cup registration[1-2]. So far, few studies were reported to improve the accuracy of stem

placement in CAOS in THA. We have clinically used Stryker CT-based navigation for both cup and stem in THA. Surface matching registration is used in this system for both cup and stem placement. The surface matching registration of Stryker's system requires at least 30 reference points on boney surface of proximal femur in the operative field[3]. Although this method provides acceptable mean errors after registration, we often find inaccuracy of registration and misalignment at the distal femur. To improve these accuracy and precision, we have taken reference points on distal femur in addition to 30 points on proximal femur. The purpose of this study is to determine whether the registration with additional distal reference points improve accuracy and precision for stem placement.

2 Methods

Sixty-three hips of 57 cases (13 males, 44 females, average age: 65.9 years old) were included in the study. All procedures were performed by two surgeons (TH, KT) through modified Watson-Jones approach in lateral decubitus position. Cementless acetabular cups; Trident cups (Stryker) or G7 cups (Zimmer-Biomet), and cementless femoral stems; Accolade II stem (Stryker) were used with a CT-based navigation system, Stryker Hip Navigation ver. 1.2 and 1.3. Thirty-six hips were registered with 30 arbitrary points on the proximal femur for stem placement (the proximal registration group). These 30 registration points on the proximal femur were taken in the operative field. The remaining 27 hips were registered with additional 4 to 8 registration points on the distal femoral condyle in addition to 30 points on the proximal femur (the distal registration group). Points on distal femoral condyle were taken percutaneously through the needle holes using a 18G injection needle to palpate the distal femoral bone surface. Several registration points were added to the distal femoral condyle using this method. In all cases, preoperative planning was performed using 3D image analysis software Zed Hip (LEXI, Japan) based on preoperative CT images, and surgical planning and actual surgery were performed with Stryker Hip Navigation. 3D-3D registration was used to match the pre- and post-operative CT images to measure the post-operative stem angles in the same femoral coordinate system. We used table top plane as the femoral coordinate, which was created at the most posterior point of the proximal femur and the bilateral posterior epicondyles. The Z axis was the projection of the line connecting the trochanteric fossa and the knee joint center onto the tabletop plane. The stem flexion angle was defined as the angle between the Z-axis of the table top plane and the stem center axis on the YZ plane of the table top plane. The stem varus angle was the angle between the Z-axis of the table top plane and the stem center axis on the XZ plane of the table top plane. The stem anteversion angle was the angle between the X-axis of the table top plane and the stem neck center axis on the XY plane of the table top plane. Statistical analyses were performed using Welch t-test for accuracy and F test for precision. P-values less than 0.05 were defined as statistically significance.

3 Results

The differences (average ± standard deviation of absolute values) between the pre- and post-operative angles of stem flexion angle, abduction angle, and anteversion angles were 2.2 ± 1.6°, 0.9 ± 0.9°, 3.7 ± 3.5° in the proximal registration group, and 2.7 ± 1.3°, 1.0 ± 0.7°, and 3.8 ± 3.1° in the distal registration group, respectively. There was no significant difference between two groups. The differences (average ± standard deviation of absolute values) between the pre- and intra-operative angles of stem anteversion were 3.6 ± 2.2° in the proximal registration group, and 1.6 ± 1.7° in the distal registration group, respectively. There was significantly different between two groups.

In the proximal registration group, there were 18 hips out of 36 hips (50%) whose stem sizes were different from the preoperative plannings. In the distal registration group, there were 13 hips out of 27 hips (48%) whose stem sizes were different from the preoperative plannings.

4 Discussion

Surface matching registration of proximal femur was accurate in both two groups, and the anteversion accuracy in this study was comparable to the previous studies[4,5]. However, the distal registration group could not improve accuracy and precision for stem placement in this study. On the other hand, there was a significant difference in accuracy and precision between the pre- and intra-operative angles of anteversion. There are several factors, other than registration procedure, which determine accuracy and precision for stem placement. Stem designs have large effects of degrees of freedom for stem insertion[5]. Fixation stability of stem holders and initial fixation of stem itself are also effect on accuracy and precision for stem placement. The limitation of this study is the small number of subjects. Also, the study was conducted on a single stem model, and different results may be obtained with large number cases and different stem designs.

5 Conclusion

Surface matching registration of the femur with additional distal reference points did not provide better accuracy when we used taper-wedge stem in CT-based navigation assisted THA. However, the additional distal reference points did provide intraoperative replication of preoperative planning. Future studies are needed to determine how to place the stem more accurately and precisely.

References

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