Augmented Reality with CT-based Navigation in Total Hip Arthroplasty

Masahiro Hasegawa[1], Shine Tone[1], YOHEI NAITO, Akihiro Sudo[2]
[1]Mie University Graduate School of Medicine, [2]Mie University

INTRODUCTION:

Augmented reality (AR) is a natural extension of computer assisted surgery, and enables surgeon direct visualization of radiological images by overlaying them on the patient. Computer tomography (CT)-based navigation with AR technology has been developed. During total hip arthroplasty (THA), surgeons can find not only three-dimensional (3D) pelvis model but also vessels and muscles on the monitor (Fig. 1). The purpose of this study is evaluating accuracy of this novel AR navigation system.

METHODS:

A total of 50 prospectively enrolled patients underwent primary cementless THA in a supine position using this novel AR navigation system. Twenty-eight hips were treated using a direct anterior approach, with the remaining 22 hips treated using an anterolateral supine approach. There were 8 men and 42 women. Mean age was 64.8 ± 9.4 years and mean body mass index (BMI) was 23.9 ±4.4 kg/m^2. Preoperative diagnosis was osteoarthritis in all hips. CT from the pelvis to the knee joint was taken before surgery, and preoperative plan was performed using a 3D digital templating system. Cup orientation was planned to be radiographic inclination (RI) of 40° and radiographic anteversion (RA) of 15° relative to the functional pelvic plane (FPP). Changes in pelvic tilt were evaluated using this AR navigation system. Intraoperative RI and RA were recorded. Navigation error was defined and was calculated by subtracting angles of the intraoperative navigation record from the angles of postoperative CT measurement.

Factors that affected the absolute value of navigation error in cup alignment were determined. The Mann-Whitney U-test was used to determine differences in terms of sex and approach. Correlation analyses were performed using Spearman's rank correlation test. In these analyses, dependent variables included age, BMI, pelvic tilt at the time of registration, change of pelvic tilt between registration and cup insertion (cup insertion – registration), and change of pelvic tilt between registration and reduction (reduction – registration). Values of $p < 0.05$ were considered significant.

RESULTS:

The mean preoperative pelvic tilt was 3.9° ± 5.9° (range, -17–14°). The mean change of pelvic tilt between registration and cup insertion was 1.8° ± 2.9° (range, -9–6°). The mean change of pelvic tilt between registration and reduction was 1.0° ± 2.3° (range, -5–5°). The mean absolute value between registration and cup insertion was 2.7° ± 2.1°. The mean absolute value between registration and reduction was 2.1° ± 1.4°.

Mean postoperative RI and RA relative to the FPP were 38.0° ± 2.7°and 16.4° ± 3.5°, respectively. Mean absolute values for navigation error (postoperative CT-navigation record) were 2.4° ± 1.6°in inclination and 2.6° ± 2.3°in anteversion (Fig. 2).

No factors significantly affecting absolute value of navigation error were found for RI. However, change of pelvic tilt between registration and reduction significantly correlated with absolute values of RA error (r=0.401, p=0.004). Other factors did not affect RA errors.

DISCUSSION AND CONCLUSION:

Clinical use of AR navigation system was easy, and the accuracy was comparable of previously reported that in navigation. AR can overlay 3D images of not only bone but also important soft tissue including vessels and muscles to provide guidance for arthroplasty procedures. Visually induced motion sickness has been reported with the use of AR headset. The strong point of this AR navigation included easy use without AR headset.

In conclusion, navigation errors were 2.4°in RI and 2.6°in RA, and change of pelvic tilt affected RA error.

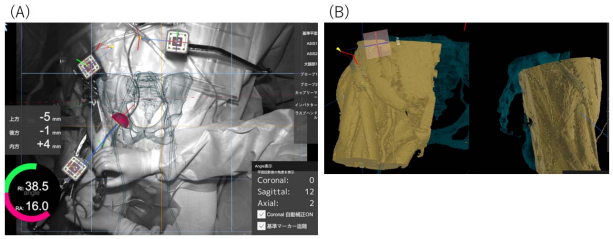

Fig. 1. Vessels (A) and muscles (B) were demonstrated with pelvis on the monitor.

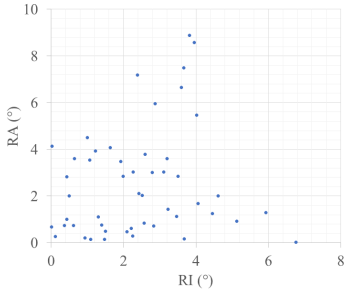

Fig. 2. Scatter plot of absolute value of navigation error in RI and RA.