Effects of incorrect acquisition of anatomical landmarks on image-free navigation-assisted total knee arthroplasty

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ABSTRACT

Background

The study was designed to assess whether, and to what extent, incorrect acquisition of anatomical landmarks during navigated total knee arthroplasty affects the accuracy of implant positioning.

Methods

An artificial model of the lower limb was used to simulate a navigated total knee arthroplasty. The anatomical landmarks necessary for navigation were identified and the procedure performed as usual. Navigation was then repeated after having collected the anatomical landmarks with an error of 10 mm from the reference points. The spatial orientation of resulting bone cuts was registered with the navigation system and compared with that of bone cuts performed with correct anatomical landmarks.

Results

Compared with the reference cuts, the incorrect collection of anatomical landmarks led to changes in the coronal alignment of tibial and femoral cuts within 1° and 2.2°, respectively, and in sagittal alignment within 1.5° and 2.1°, respectively. Incorrect landmarks of the medial and lateral epicondyles led to errors in the rotation of the epicondylar axis of 10–17°.

Conclusions

When computer-navigation is used, the coronal and sagittal alignment of total knee arthroplasty may be improved by an accurate collection of anatomical landmarks. Axial rotation of the femoral component should be assessed using other techniques in addition to the palpation of femoral epicondyles.

Keywords

bony landmarks, computer navigation, total knee arthroplasty

INTRODUCTION

Several studies have shown that the correct positioning of a total knee arthroplasty (TKA) improves the clinical outcome and decreases the risks of implants, wear and loosening.[1–5] Computer navigation systems have been introduced to achieve this goal, and promising results have been reported in comparative studies showing more accurate positioning of prostheses with navigation compared with the standard procedure.[6–16] However, a limited number of patients operated on by experienced surgeons were analyzed;[7–12,15,16] therefore, caution should be taken in generalizing the results of this new technique. Moreover, most previous studies analyzed sagittal and coronal alignment of the implants, while little is known of the possible benefits of the computer to rotational alignment.

In recent years image-free navigation systems have gained greater popularity than have image-based systems. However, a possible limitation of image-free navigation is that its accuracy relies on the accuracy of the operating surgeon in collecting the bony landmarks necessary to the software for surgical navigation. Because this potential limitation has been scarcely investigated so far,[17] in the present study we assess whether, and to what extent, the accuracy of bone cuts performed during a navigated TKA is influenced by an incorrect collection of the bony landmarks required for navigation.

MATERIALS AND METHODS

A plastic anatomical model of the right lower limb (Aesculap, Germany) was used to simulate a total knee procedure with computer navigation. The anatomical model included a hip, a knee and an ankle joint. Medial and lateral cords, providing some varus-valgus stability were present at the knee joint. To avoid inaccurate bone cuts, which may occur when using the power saw on plastic models,[18,19] the navigated procedures were performed on a single artificial limb including (1) preformed femoral and tibial cuts resembling the bone cuts usually performed during TKA and (2) femoral and tibial ''ephiphyses'' easily disconnected from the preformed cuts (Figure 1A). During each test, the anatomical landmarks were initially collected on both the femoral and tibial sides to start navigation. The femoral and tibial ''ephiphyses'' were then removed, and the spatial orientations of the preformed bone cuts were evaluated with the computer (Figure 1B). The reliability of the experimental model was tested in a preliminary investigation, including the simulation of 50 surgical procedures with computer navigation.

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