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Original Article

Efficacy of the Anatomical-Pelvic-Plane Positioner in Total Hip Arthroplasty in the Lateral Decubitus Position

Kentaro Iwakiri, MD, PhD [a, *], Akio Kobayashi, MD, PhD [a], Yoichi Ohta, MD, PhD [b], Kunio Takaoka, MD, PhD [a]

[a] Department of Orthopaedic Surgery, Shiraniwa Hospital, Ikoma City, Nara, Japan
[b] Department of Orthopaedic Surgery, Osaka City University Graduate School of Medicine, Osaka City, Osaka, Japan

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ABSTRACT

Background: Total hip arthroplasty in the lateral position involves particularly large variance in the sagittal tilt of pelvis fixation, which affects the imprecision of the cup anteversion leading to poor outcomes. We have added an additional compression pad to an existing device, also to be used in the lateral position, but theoretically enabling fixation on the anatomical pelvic plane (APP) serving as the reference plane. The present study aims to evaluate the usefulness of this device in comparison with the conventional device.

Methods: We have studied 141 patients who underwent total hip arthroplasty at our hospital. Two frontal plain x-rays of the pelvis were obtained preoperatively for each patient after pelvis fixation; one with the conventional lateral fixation device and the other with an APP lateral fixation device. The sagittal tilt of the pelvis in each position was measured with 3D templating software, and variance in the sagittal tilt was compared between the 2 devices.

Results: The mean bias in sagittal tilt relative to the functional pelvic plane (FPP) in the conventional device was −5.0° ± 4.8° (minus mean backward tilt) and was within 5° relative to the functional pelvic plane in 43%. The mean bias in the sagittal tilt relative to the APP in the APP lateral position device was 1.7° ± 3.1° (forward tilt) and was within 5° relative to the APP in 89%. The APP lateral device significantly reduced the variance in the sagittal tilt.

Conclusion: This device holds promise as a means of reducing the sagittal tilt in a simple, minimally invasive, and highly cost-effective manner.

Total hip arthroplasty (THA) has been widely used as a very effective surgical procedure capable of eliminating pain due to hip joint disease (eg, osteoarthritis [OA] of the hip), and markedly improving quality of life for patients. Patients are generally placed in supine or lateral positions for THA. In recent years, THA in the supine position has been increasing. According to the Japanese Orthopaedic Association registry data in 2014, however, THA was performed in the lateral position in more than half of all patients undergoing the primary operation and more than 60% of those receiving revision THA [1]. The lateral position is also anticipated to be the principal position for THA in the foreseeable future, taking into account the educational requirements, intraoperative troubleshooting, and an expected increase in the number of patients receiving revision THA. Having said that, pelvis fixation in the lateral position reportedly shows greater variance among facilities and even among individual patients than pelvis fixation in the supine position [2,3]. The types of variance in pelvis fixation include sagittal, coronal, and axial tilts. Of these, sagittal tilt has been reported to be associated with particularly large variances [4,5]. Variance in the sagittal tilt of the pelvis during lateral position THA is known to affect the precision of the anteversion for cup placement. Biases in cup placement can lead to a higher incidence of dislocation, increased polyethylene wear, restriction of range of motion, and poor THA outcomes in general [6-10]. Regarding the angle of cup anteversion, it has been reported that the standard anteversion is 15° ± 10° relative to the anatomical pelvic plane (APP) [4] or that the true safe anteversion without dislocation or

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* Reprint requests: Kentaro Iwakiri, MD, PhD, Department of Orthopaedic Surgery, Shiraniwa Hospital Joint Arthroplasty Center, 6-10-1 Shiraniwadai, Ikoma City, Nara, Japan, 630-0136.

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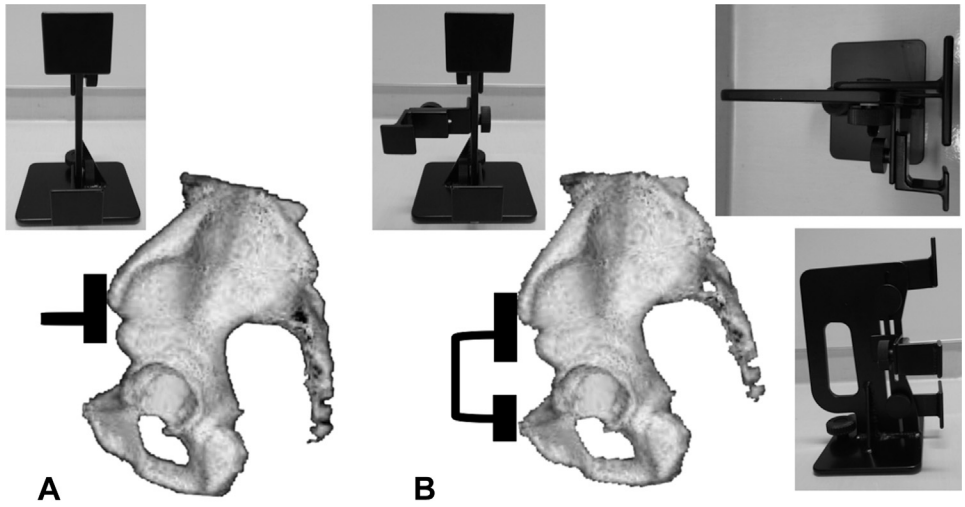

Fig. 1. (A) Conventional lateral fixation device and (B) anatomical pelvic plane (APP) lateral position fixation device capable of fixing the anterior pelvis on the same plane by applying compression to 3 points (2 anterior superior iliac spine [ASIS] and pubic symphysis) from anteroposterior (AP), lateral, and aerial views.

mechanical complications seems to be 10°-24° [11]. Meanwhile, there are also reports describing intraoperative pelvis movement in addition to variance in pelvis fixation in the lateral position [3,4]. If the plane serving as the goal for cup placement is uncertain; therefore, it is not possible to elevate the precision of cup placement.

In May 2013, we have added an additional compression pad for pubis to an existing lateral position fixation device capable of fixing the anterior pelvis on the same plane by applying compression to 3 points (pubic symphysis in addition to the right and left anterior superior iliac spines) and, at least theoretically, thereby enabling fixation on the APP to be achieved. Since then, this device has been used at our facility. We assume that with the application of this device, it will be possible to reduce sagittal tilt that has been considered to show the particularly large variance in pelvis fixation. The present study aims to evaluate the usefulness of this modified fixation device as a means of achieving precise pelvis fixation in comparison with that of the device conventionally used for this purpose.

Materials and Methods

Subjects

We examined consecutive 148 hips of 148 patients (126 women and 22 men) who underwent primary THA with an APP lateral position fixation device at our hospital between July 2013 and December 2015. This study has been approved by the institutional review board at our hospital. The mean age of the patients at the time of surgery was 68.7 years (range 51-91 years) and mean body mass index (BMI) was 24.1 kg/m^2 (range 16.9-34.3 kg/m^2). The primary diagnosis was OA in 139 hips and osteonecrosis of the femoral head in 2 hips.

Images and Measurements

In all cases, we obtained computed tomography (CT) images (from the pelvis to the femur) in the supine position before surgery. Before THA, fixation of the pelvis was performed with a conventional fixation device under general anesthesia (compressive fixation of the bilateral anterior superior iliac spines in the anterior part of the pelvis and compressive fixation of the sacrum in the posterior part of the pelvis). Then, a frontal plain x-ray of the pelvis was taken (Fig. 1A). The film was held vertically and positioned at the back of the pelvis parallel to the trunk. The x-ray beam was centered at the superior margin of the pubic symphysis. Next, the fixation device in the anterior part of the pelvis was replaced with an APP lateral position fixation device, without changing the x-ray tube or the film position, and another frontal plain x-ray of the pelvis was taken (Fig. 1B). The arm for pubic symphysis fixation of this device can easily be mounted on the conventional commercially available anterior pelvis fixation device and is designed to enable compression of the bilateral anterior superior iliac spines and pubic symphysis on the same plane (the so-called “APP”). The pad of the pubis symphysis is equipped with a sliding mechanism against head-to-caudal and lateral side of the pelvis on the positioner. To exclude the variances of axial tilt, the pubic symphysis and coccyx were captured to be on the same line in the center of the pelvic cavity.

All CT and x-ray image data were downloaded onto Digital Imaging and Communications in Medicine format and uploaded onto a computer for measurement. The 2- and 3-dimensional templating software (ZedHip; LEXI, Tokyo, Japan) was used for measurements [12]. The APP or functional pelvic plane (FPP) as the standard plane could easily be changed by the software. Three-dimensional pelvic tilts were quantified by superimposing the images reconstructed from the CT data onto the radiographs taken at the positions fixed with each of the 2 devices in the lateral position as follows: 3D templating software was used to rotate the reconstructed image in 3 planes in 1° increments, and the image was approximated to the radiographs; approximation was confirmed by making the width ratio of the longitudinal dimension and/or transverse dimension ratio of the pelvic cavity to the same value in both images. In this study, we have only analyzed the sagittal tilt particularly affecting the precision of the anteversion for cup placement. The cases that the pubic symphysis and coccyx were not captured to be on the same line in the center of the pelvic cavity on frontal x-rays were excluded. From the 2 frontal x-ray images of the pelvis thus obtained, the sagittal tilt of the pelvis was calculated on each x-ray [13]. Anterior sagittal tilt was defined as positive. After the sagittal tilt in each patient has been determined using this approach, the following 3 measurements were performed: (1) the extent to which the sagittal tilt after fixation with the conventional lateral position fixation device varies (a) from the FPP serving as an indicator for