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ORIGINAL STUDY

Improving tibial component coronal alignment using clearly defined anatomical structures in total knee arthroplasty

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Several authors recently proposed to use clearly defined anatomical structures for extramedullary tibial alignment in total knee replacement, instead of using the intermalleolar center. The purpose of this study was to evaluate the benefits of using the dorsalis pedis artery and the anterior tibial crest as distal landmarks. Postoperative radiographs in 195 knees (98 in the control and 97 in the landmark group) were evaluated. The mean coronal alignment of the tibial component was 89.7° ± 2.1° in the control group and 90.0° ± 1.3° in the landmark group. Although there was no significant difference, the proportion of radiological outliers was significantly reduced in the landmark group compared to the control group (6.2% vs 27.6% in > 2° outliers ; p < 0.0001, 1.0% vs 10.2% in > 3° outliers ; p = 0.01). In order to achieve accurate coronal alignment of the tibial component, it appears better to use multiple clear anatomical landmarks such as the dorsal pedis artery and the anterior tibial crest rather than using only the intermalleolar center.

Keywords : knee, arthroplasty, landmark, coronal alignment.

INTRODUCTION

Proper alignment of the lower extremity is essential for the long-term success of total knee arthroplasty (TKA). Negative effects of component malalignment include poor clinical outcomes, excessive polyethylene wear, implant loosening, and early revision arthroplasty (*18,6,20*). It is commonly accepted that the position of 90° ± 3° to the long axis of the tibia in the coronal plane is ideal (*3,14,11,20*). Conventional techniques in cutting the proximal tibia are fairly effective for achieving proper coronal alignment of the tibial component. However, there are considerable outliers representing more than 3° of varus or valgus alignment even with computed navigation assistance (*9*). An extramedullary cutting guide is preferred rather than an intramedullary guide when determining tibial alignment (*15*). It is essential to accurately locate the ankle center for extramedullary tibial alignment. Although the traditional landmark for the ankle center is a point slightly medial to the intermalleolar center (*7*), it seems inappropriate to use this point as the sole landmark for determining the alignment (*16,22*). Recently, several authors proposed using more clearly defined anatomical structures for extramedullary tibial alignment, such as the extensor hallucis longus tendon (*17*), the anterior tibial

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crest (*10,23*), and the dorsalis pedis artery (*21*). In actual practice, it is easy to locate these new landmarks except the extensor hallucis longus tendon during surgery. Because it is better to use multiple anatomical landmarks to reduce errors in component alignment, we recently started to use two of these new landmarks, i.e. the dorsalis pedis artery and the anterior tibial crest.

The purpose of this retrospective study was to evaluate the benefits of using these new landmarks for extramedullay tibial alignment in TKA by comparing the accuracy of tibial component coronal alignment between the traditional technique and the new one.

PATIENTS AND METHODS

Between September 2009 and August 2012, primary TKAs were consecutively performed on 164 patients (200 knees) at our institution. There were 33 men and 131 women. The average age was 73 years (range : 52-89). The diagnosis was osteoarthritis in 166 knees, rheumatoid arthritis in 27 knees, osteonecrosis in 7 knees. Patients with osteoarthritis following high tibial osteotomy or fractures were excluded from this study. From September 2009 to March 2011 the intermalleolar center was used as a distal landmark in 100 knees (control group), and from April 2011 to August 2012 the dorsalis pedis artery and the anterior tibial crest were used in 100 knees (landmark group). Postoperative long-leg anteroposterior standing radiographs taken at 3 months were analyzed. Five radiographs were rejected because the ankle was not clearly visualized. A total of 98 radiographs in the control group and a total of 97 radiographs in the landmark group were analyzed. The measurement on the radiograph was made using image analysis software (CIS-Image/Viewer for Windows, version 2.11.04, IBM, Tokyo, Japan). For assessment of the coronal alignment of the tibial component, two lines were drawn on the computer monitor. The first line was the mechanical axis of the tibia ; a line connecting the center of the proximal tibia and the midpoint of the dome of the talus. The second line was drawn parallel to the undersurface of the tibial component. The medial angle formed between these two lines was measured semi-automatically as the coronal alignment of the tibial component. An angle less than 90° was classified as varus alignment, while an angle greater than 90° was classified as valgus alignment. Surgical outliers were graded as deviation greater than 2° or 3° from ideal alignment. All measured values were displayed to one decimal place (degree) on the computer monitor. The measurements were performed twice by two observers (MI and MI) with an interval of at least a week. Intraclass correlation coefficients were calculated for the inter- and intra-observer reliability of measurements.

Surgical Procedures

All surgeries were performed by or under supervision of the senior author (MI) through a medial parapatellar approach. An intramedullary jig was used for the femur while an extramedullary jig was used for the tibia. In order to clearly identify anatomical landmarks during surgery, the leg was wrapped with an adhesive transparent drape. Anatomical landmarks used in the landmark group (Fig. 1) were marked with surgical skin marker at the beginning of the surgery. The dorsalis pedis artery was carefully located approximately 1cm lateral to the tibialis anterior tendon at the level of the ankle joint (*21*). Prostheses used in this study were the Vanguard PS (Biomet, Warsaw, USA) in 148 knees and the Nexgen LPS (Zimmer, Warsaw, USA) in 47 knees. A measured resection technique was used to determine femoral component rotation (*8*). The posterior slope of the tibial cutting guide was 3 degrees for the Vanguard PS and 7 degrees for the Nexgen LPS. Identical tibial cutting jigs with 2 spikes and the ankle clamp were used in all patients. First, the proximal end of the jig was provisionally secured by impacting the longer spike of the cutting jig into a point where the postoperative mechanical axis intersected the tibial articular surface, which was determined at preoperative planning (*13*). At the same time, rotational orientation of the cutting jig was carefully assessed so that it aligned over the Akagi's line connecting the middle of the posterior cruciate ligament and the medial border of the patella tendon attachment (*1*). Its orientation in the coronal and sagittal planes was then determined by placing the arms of the alignment clamp around the ankle. In the control group, a point slightly medial to the intermalleolar center was used as a distal landmark for the extramedullary cutting jig. In the landmark group, the cutting jig was roughly aligned over the anterior tibial crest, specifically a line connecting the medial border of the patellar tendon attachment and the distal one-fourth of the anterior border (*10*), and then the coronal orientation was determined so that the distal end of the cutting jig pointed to the dorsal pedis artery at the level of the ankle joint. If the dorsalis pedis artery could not be located, the coronal orientation of the extramedullary jig was aligned over the anterior tibial crest. After reassessing the align-

Fig. 1. — Anatomical landmarks for extramedullary tibial alignment in the landmark group. Line A represents the anterior tibial crest ; a line connecting the medial border of the patellar attachment and the distal one-fourth of the anterior border. Point B represents the dorsal pedis artery at the level of the ankle joint.

ment of the cutting jig, the shorter spike was impacted into the proximal tibia to finally secure the assembly. A tibial stylus was used to determine the exact bone resection thickness and the cutting block was secured with 3 pins. The proximal tibia was cut with a bone saw through the slit opening of the cutting block. After preparation for the tibial stem and fin, all prostheses were implanted with cement.

Statistical analysis

Categorical data including coronal alignment of the tibia were compared between two groups using Fisher's exact test, while continuous variables were compared

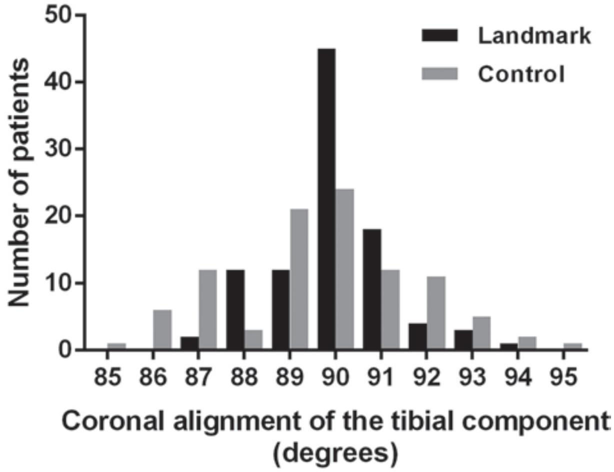

Fig. 2. — Histogram illustrating the distribution of coronal alignment of the tibial component in the landmark and control group.

using the Mann-Whitney U test. $P < 0.05$ was considered significant. All analyses were performed using SPSS ver. 16.0 (SPSS Inc, Chicago, IL).

RESULTS

Patients' demographic data are shown in Table I. No significant differences were found between the two groups regarding gender, age, body mass index (BMI), preoperative diagnosis, range of motion (ROM), or femorotibial angle (FTA) on the anteroposterior radiographs.

Figure 2 shows the distribution of the coronal alignment of the tibial component for the landmark group and the control group. The mean coronal alignment of the tibial component was 89.7° (SD : 2.1°) in the control group and 90.0° (SD : 1.3°) in

Table I. — Demographic data of the two groups

	Landmark	Control	*p* value
Female (%)	79	82	n.s.
Age (years)	75 (5)	73 (8)	n.s.
BMI (kg/m^2)	28 (4)	26 (8)	n.s.
Osteoarthritis (%)	90	83	n.s.
ROM (degrees)	111 (13)	109 (16)	n.s.
FTA (degrees)	186 (9)	184 (12)	n.s.

Values are means (SD).
BMI = body mass index, *ROM* = range of motion, *FTA* = femorotibial angle.

Table II. — The number of surgical outliers in the landmark and control group

	Landmark	Control	*p* value
> 2° outliers	6 (6.2%)	27 (27.6%)	< 0.0001
> 3° outliers	1 (1.0%)	10 (10.2%)	0.01

the landmark group. There was no significant difference in the mean coronal alignment between the two groups ($p = 0.29$). However, the proportion of outliers in the landmark group was significantly smaller than in the control group ($p < 0.0001$ for > 2° outliers and $p = 0.01$ for > 3° outliers) (Table II). Intraclass correlation coefficient was 0.86 for the inter-observer reliability and 0.90 for the intra-observer reliability of measurements, giving good agreement.

DISCUSSION

The main finding of this study was that patients in the landmark group showed better coronal alignment of the tibial component compared to the control group. The only difference between the two groups was the use of anatomical landmarks for extramedullary tibial alignment. Although there was no significant difference in the mean coronal alignment, the proportion of radiological outliers (both > 2° and > 3° outliers) was significantly reduced in the landmark group. Because good placement within 3° of ideal alignment has been shown to reduce the risk of implants failure (*3,14,11,20*), the results obtained in the present study provide clinically important information on the anatomical landmarks for extramedullary alignment in TKA. Based on our results, it is better to use the dorsalis pedis artery and the anterior tibial crest rather than using only the intermalleolar center to achieve accurate coronal alignment of the tibial component.

There are several possible reasons for improved accuracy of component alignment in the landmark group. One is that the dorsalis pedis artery and the anterior tibial crest are clear anatomical structures which can be easily located during surgery. On the other hand, the intermalleolar center is not an anatomical structure which can be determined by palpating the prominences of medial and lateral malleoli. In addition, although the ankle center is located at a point slightly medial to the intermalleolar center (*8*), it is unclear how much medial adjustment of the extramedullary guide should be done in each patient. These factors can negatively affect the accuracy in the control group. Another reason is that two landmarks were used in the landmark group, while the intermalleolar center was used as the sole landmark in the control group. Errors in landmark identification commonly occur during surgery. In addition, recently reported landmarks also have drawbacks similar to the intermalleolar center. Previous studies showed congenital absence (*24*) or absent pulse (*12*) of the dorsalis pedis artery, and wide variations among individuals (*10*) and gender differences (*23*) of the anterior tibial crest. Therefore, it is safer to use multiple landmarks to reduce errors in component alignment.

Computer navigation is a recent advancement in joint replacement surgery. Computer assistance achieves more accurate postoperative alignment in TKA (*2,4,5,9,19*). A recent meta-analysis concluded that the proportion of > 2° outliers for coronal alignment of the tibial component was 6.0% in navigated TKAs and 19.7% in conventional TKAs, and the proportion of > 3° outliers was 2.8% and 9.9% respectively (*9*). Several studies have shown no significant difference between navigated and conventional TKAs.

Our findings are comparable to the results reported with navigated TKA. If computed navigation is not available, it is thus possible to improve the accuracy of the tibial component coronal alignment similar to navigated TKA.

We think that it is essential to use multiple clear anatomical structures for anatomical landmarks such as the dorsalis pedis artery and the anterior tibial crest.

This study has some limitations. First, it was a retrospective case-control study. The results might have been confounded by other factors related to the study design, such as the different periods involved and different prostheses used. Second, only radiological alignment of the tibial component was evaluated in this study. It is unclear whether good placement of the tibial component improves the clinical outcomes. Third, although we noted that arterial pulse of the dorsalis pedis artery was not palpable in a few patients, the exact number of such patients is unknown. Only the anterior tibial crest was used in these patients. Despite these limitations, this study provides important information on the value of using anatomical landmarks for extramedullary alignment in TKA.

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