Inter- and intra-observer errors in identifying the transepicondylar axis and Whiteside’s line

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ABSTRACT

Purpose. To assess inter- and intra-observer errors in identifying the transepicondylar axis and Whiteside’s line in a cadaveric model mimicking total knee arthroplasty.

Methods. Four cadaveric knees with intact soft tissues were used. The knees were exposed anteriorly using the Insall approach, with the patella everted laterally. Three observers (2 surgeons and one trainee) took turns to identify the anatomic landmarks of the transepicondylar axis and Whiteside’s line. Each observer repeated the process 20 times. Each identification was photographed and referenced with the true values obtained from the knees after they were stripped of all soft tissue. Inter- and intra-observer errors in the anatomic landmarks were compared.

Results. Inter-observer error was significant with both the transepicondylar axis and Whiteside’s line (p<0.001, one-way ANOVA). The intra-observer variation was greater for Whiteside’s line than the transepicondylar axis (standard deviation, 4.2º vs 2.5º). The maximum potential errors in the transepicondylar axis and Whiteside’s line were 13º and 24º, respectively.

Conclusion. The accuracy of rotational alignment of the transepicondylar axis and Whiteside’s line were operator-dependent, and their intra-operative reproducibility was low.

Key words: arthroplasty, replacement, knee; observer variation

INTRODUCTION

Total knee arthroplasty (TKA) is the standard treatment for end-stage arthritis of the knee joints. Correct rotational alignment of the femoral component enables optimal patellar tracking and balance of the flexion gap.1-4 Mal-alignment increases the risk of anterior knee pain, patellar subluxation, notching of the anterior femoral cortex, and even periprosthetic...
fractures, TKAs with an imbalanced flexion gap may decrease the flexion range, patellofemoral joint stability, and prosthesis survival.

The transepicondylar axis, Whiteside’s line, and posterior condylar axis are anatomic landmarks for rotational alignment of the femoral component, which are usually identified intra-operatively by palpation and visualisation. We assessed inter- and intra-observer errors in identifying the transepicondylar axis and Whiteside’s line in a cadaveric model mimicking TKA.

MATERIALS AND METHODS

Four fresh frozen cadaveric knees with intact soft tissue were used. The knees were exposed anteriorly using the Insall approach with the patella everted laterally, as in conventional TKAs. The transepicondylar axis was defined as a line joining the medial and lateral femoral epicondyles (Fig. 1a), forming an approximately 90° angle to the mechanical axis of the leg. It is the rotational axis of the knee joint during flexion and extension. The Whiteside’s line was defined as a line joining the deepest point of the femoral trochlea and the centre of the intercondylar notch (Fig. 1b). It is the anteroposterior axis of the distal femur, perpendicular to the transepicondylar axis.

A piece of Velcro tape with the surface of tiny hooks was attached to a Schanz screw. Three other pieces of Velcro tape with the surface of uncut pile were pinned to the medial and lateral distal femoral condyles and the intercondylar region (Fig. 1). Three observers (2 surgeons and one trainee) took turns to identify the transepicondylar axis and Whiteside’s line by positioning the Schanz screw. Each observer repeated the process 20 times. Each identification was photographed with the camera placed approximately 1 m away to give an end-on view. The positions of the camera and the knee remained unchanged throughout the experiment. The angle between the Schanz screw (transepicondylar axis) and the posterior condylar axis was then measured by 2 independent observers using the OSIRIS image analysis software.

After the experiment, the knees were stripped of all soft tissue to expose the medial and lateral femoral epicondyles indicated by 2 Kirschner wires (Fig. 2). The medial femoral epicondyde was defined as the origin of the deep part of the medial collateral ligament and was usually a central sulcus surrounded by a bony ridge. The lateral femoral epicondyde was defined as the origin of the lateral collateral ligament and was usually the most prominent point in that area. The angles between the posterior condylar axis and transepicondylar axis/Whiteside’s line in the stripped knees were considered as true values. Inter-observer errors were compared using the one-way ANOVA test. A p value of <0.05 was considered significant.
RESULTS

The mean inter-observer errors for the transepicondylar axis and Whiteside’s line were 2º (standard deviation [SD], 2.5º) external rotation and 2º (SD, 4.2º) internal rotation, respectively (p<0.001, one-way ANOVA, Table 1). The intra-observer variation was greater for Whiteside’s line than the transepicondylar axis (SD, 4.2º vs 2.5º). The maximum potential errors in the transepicondylar axis and Whiteside’s line were 13º (3º internal rotation to 10º external rotation) and 24º (16º internal rotation to 8º external rotation), respectively. The ranges of error for all 3 observers were comparable for the transepicondylar axis, but for Whiteside’s line they were greater in the trainee (Table 2).

DISCUSSION

The most commonly used rotational alignments for the femoral component are the ones parallel to the transepicondylar axis, perpendicular to the anteroposterior axis, and at 3º external rotation from the posterior condylar axis. The accuracy of the latter is questionable in cases with severe wear in the posterior condyles (e.g. valgus deformity) or with marked anatomic variation between the posterior condylar axis and transepicondylar axis. The accuracy of the former 2 alignments are operator-dependent. The intra-operative reproducibility of the alignment of the transepicondylar axis is low, with a maximum inter-observer error of up to 15º. The inter-observer error has reportedly ranged from 7º to 32º. In a study involving 10 cadavers and 11 observers, the ranges of error for rotational alignments of the transepicondylar axis and Whiteside’s line were 24º and 28º, respectively.

In our study, 3% and 40% of alignments of the transepicondylar axis and Whiteside’s line were in the outlier zone (defined as >5º of mal-alignment), respectively (Fig. 3). The significantly higher percentage of outliers in the alignment of Whiteside’s line may be due to inexperience in using the anteroposterior axis to align the femoral prosthesis.

Identifying the transepicondylar axis intra-operatively by palpation is difficult, because of thick soft tissue and anatomic variations in the femoral epicondyles. Excessive osteophytes in the intercondylar notch and severe trochlear wear affect the accuracy of alignment using Whiteside’s line. The alignment accuracy can be improved by dissecting superficial soft tissue obscuring the medial femoral epicondyle, using a hypodermic needle to locate the femoral epicondyles, and removal of all obscuring osteophytes in the intercondylar notch.

The limitation of our study was the small number of specimens and observers. Its validity is therefore weak, especially in consideration of anatomic

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**Table 1**

<table>
<thead>
<tr>
<th>Observer</th>
<th>Mean±SD (range) of inter-observer error*</th>
<th>Transepicondylar axis</th>
<th>Whiteside’s Line</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Trainee)</td>
<td>1.9º ER±2.1º (2.9º IR to 6.2º ER)</td>
<td>1.6º IR±4.3º (16.2º IR to 8.4º ER)</td>
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<tr>
<td>2 (Surgeon)</td>
<td>3.3º ER±1.6º (0.8º IR to 8.1º ER)</td>
<td>0.2º IR±3.8º (7.2º IR to 7.4º ER)</td>
<td></td>
</tr>
<tr>
<td>3 (Surgeon)</td>
<td>2.3º ER±3.2º (3.2º IR to 10.2º ER)</td>
<td>2.7º IR±4º (8.6º IR to 6.4º ER)</td>
<td></td>
</tr>
<tr>
<td>ANOVA</td>
<td>p&lt;0.001</td>
<td>p&lt;0.001</td>
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* ER denotes external rotation, and IR internal rotation.

**Table 2**

<table>
<thead>
<tr>
<th>Observer</th>
<th>Range of intra-observer variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transepicondylar axis</td>
<td>Whiteside’s line</td>
</tr>
<tr>
<td>1 (Trainee)</td>
<td>9º</td>
</tr>
<tr>
<td>2 (Surgeon)</td>
<td>9º</td>
</tr>
<tr>
<td>3 (Surgeon)</td>
<td>13º</td>
</tr>
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</table>
variation. Marked anatomic variation has been reported in the medial femoral epicondyle.\(^\text{31}\) The level of arthritis, in terms of excessive osteophytes in the intercondylar notch and severe trochlear wear, may increase inter- and intra-observer errors, especially for identification of Whiteside's line. The range of error of the trainee may not be representative and comparable to that of experienced surgeons.

**REFERENCES**


