Comparison of total knee arthroplasty using computer-assisted navigation versus conventional guiding systems: a prospective study

CH Pang, WL Chan, CH Yen, SC Cheng, SB Woo, ST Choi, WK Hui, KH Mak
Department of Orthopaedics and Traumatology, Kwong Wah Hospital, Hong Kong

ABSTRACT

Purpose. To compare knee alignments in total knee arthroplasty (TKA) using computer-assisted navigation versus conventional guiding systems.

Methods. Five men and 49 women aged 49 to 79 years underwent TKA for primary osteoarthritis of the knee with varus deformity. All valgus knees were associated with inflammatory arthritis and thus excluded. Computer-assisted navigation was used for the first 35 TKAs, whereas conventional extramedullary tibial and intramedullary femoral guiding systems were used for the next 35 TKAs. The mechanical axis, coronal tibial and femoral angles, sagittal tibial and femoral angles in the 2 groups were compared.

Results. Sagittal tibial and femoral angles aligned more optimally in TKAs using computer-assisted navigation. In the respective computer-assisted navigation and conventional guiding systems, 33 (94%) and 26 (74%) of the TKAs attained a postoperative mechanical axis of <3° varus/valgus.

Conclusion. Computer-assisted navigation gives a more consistent alignment correction and reduces outliers during implant positioning.

Key words: arthroplasty, replacement, knee; surgery, computer-assisted

INTRODUCTION

The 10-year survival rate of total knee arthroplasty (TKA) has improved to approximately 95%.1-3 TKAs with a postoperative mechanical axis of <3° varus or valgus have better long-term survival.4-9 The prosthetic loosening rate is 24% when the deviation is >3° but only 3% when less.8 The 10-year survival rate is 90% when the deviation is <4° and decreases to 71 to 73% when the deviation is >4°.7 Malposition may cause pain,10 limited range of movement,11 joint instability,12 early polyethylene wear and implant loosening.13 The accuracy of the conventional extra- and intra-medullary guiding systems may decrease
in patients with obesity, a wide medullary canal or severe extra-articular deformity.\textsuperscript{14} Results of computer-assisted navigation are diverse.\textsuperscript{15–19} We compared knee alignments in TKAs using computer-assisted navigation or conventional guiding systems.

MATERIALS AND METHODS

From January 2005 to May 2006, 5 men and 49 women aged 49 to 79 years underwent TKA for primary osteoarthritis of the knee with varus deformity. All valgus knees were associated with inflammatory arthritis and thus excluded. Computer-assisted navigation (VectorVision CT-free; BrainLab, Munich, Germany) was used for the first 35 TKAs, whereas conventional extramedullary tibial and intramedullary femoral guiding systems were used for the next 35 TKAs. Operations were performed or supervised by the same surgeon using either a fixed bearing posterior stabilised prosthesis or rotating platform knee prosthesis (PFC Sigma or PFC Sigma RP; DePuy, Warsaw [IN], USA) via a medial parapatellar approach. Slopes of proximal tibial cuts were set at 0º in both groups; valgus angles of the distal femur cut were determined based on preoperative radiographs in the conventional group. Patient characteristics were comparable in both groups (Table 1).

The mechanical axis, coronal tibial (β) and femoral (α) angles were measured on standing long radiographs (Fig. a), whereas sagittal tibial (δ) and femoral (γ) angles were measured on lateral knee radiographs (Fig. b) with the patient lying and the knee at 30º flexion. Two independent observers carried out these measurements at 2 time-points. The inter- and intra-observer correlations were assessed using the Pearson correlation coefficient. Measurements in both groups were compared using independent sample \textit{t}-tests. The proportions of TKAs with a postoperative mechanical axis of <3º varus/valgus were compared using Pearson’s Chi squared test. A p value of <0.05 was considered statistically significant.

RESULTS

With reference to the optimal angle of 90º, the postoperative coronal tibial and femoral angles of the 2 groups were not significantly different. Nonetheless, sagittal tibial and femoral angles aligned more optimally in TKAs based on computer-assisted navigation (p<0.001, Table 1). In the respective computer-assisted navigation and conventional guiding systems, 33 (94%) and 26 (74%) of the TKAs attained a postoperative mechanical axis of <3º varus/valgus (p=0.022, Pearson’s Chi squared test, Table 2), which was comparable to other studies.\textsuperscript{20,21} The inter- and intra-observer correlations were significant (r>0.90). There were no major complications, except in one patient in whom the intramedullary femoral guide rod was accidentally broken during the procedure.\textsuperscript{22}

DISCUSSION

Outliers arise not only from the alignment system, but also from factors related to patients and surgeons.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Computer-assisted navigation</th>
<th>Conventional guiding systems</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>66±8 (49–79)</td>
<td>66±7 (54–78)</td>
<td>0.98</td>
</tr>
<tr>
<td>No. of cases (male/female)</td>
<td>2/33</td>
<td>5/30</td>
<td>-</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>153±9 (144–167)</td>
<td>155±9 (147–165)</td>
<td>0.62</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>69±14 (49–73)</td>
<td>66±13 (52–78)</td>
<td>0.77</td>
</tr>
<tr>
<td>No. of left/right knees</td>
<td>17/18</td>
<td>13/22</td>
<td>-</td>
</tr>
<tr>
<td>Preoperative mechanical axis</td>
<td>17.1º±6.7º (6º–28º)</td>
<td>13.8º±7.1º (0º–23º)</td>
<td>0.11</td>
</tr>
<tr>
<td>Preoperative knee score</td>
<td>32.9±16.7 (2–80)</td>
<td>29.7±24 (2–66)</td>
<td>0.49</td>
</tr>
<tr>
<td>Preoperative function score</td>
<td>39.1±14.2 (10–60)</td>
<td>40.9±25.7 (20–80)</td>
<td>0.71</td>
</tr>
<tr>
<td>Tourniquet time (minutes)</td>
<td>134±18 (93–168)</td>
<td>116±20 (80–150)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Blood loss (ml)</td>
<td>266±107 (100–600)</td>
<td>284±110 (100–500)</td>
<td>0.47</td>
</tr>
<tr>
<td>Postoperative coronal tibial angle</td>
<td>89.5º±1.8º (86º–93º)</td>
<td>88.3º±2.3º (84º–94º)</td>
<td>0.36</td>
</tr>
<tr>
<td>Postoperative coronal femoral angle</td>
<td>89.9º±2.6º (86º–93º)</td>
<td>90.1º±1.8º (87º–93º)</td>
<td>0.81</td>
</tr>
<tr>
<td>Postoperative sagittal tibial angle</td>
<td>88.3º±1.9º (84º–90º)</td>
<td>85.7º±2.4º (82º–90º)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Postoperative sagittal femoral angle</td>
<td>89.2º±2.4º (84º–94º)</td>
<td>86.8º±2.5º (81º–94º)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Postoperative mechanical axis</td>
<td>-0.4º±1.7º (-4º–5º)</td>
<td>1.0º±2.8º (-3º–6º)</td>
<td>0.16</td>
</tr>
</tbody>
</table>

* Data presented as mean±SD (range) unless otherwise stated
Coronal bowing of the femur and tibia is common in the Chinese population. This anatomic variation, together with errors arising from registration, movement of cutting blocks, precision of bone cuts, and implantation may attribute to suboptimal alignment.

No significant difference in the sagittal tibial alignment was reported in other studies. In our study, sagittal tibial and femoral angles aligned more optimally in TKAs using computer-assisted navigation. This may be due to inaccuracy of the tibial slope cut according to the extramedullary guide based on the experience of the surgeon. In addition, anterior femoral bowing may also affect the accuracy of the intramedullary guiding system. Computer-assisted navigation may enhance the accuracy of the sagittal femoral component placement. The registration process may accurately define the femoral head centre and mechanical axis of the femur, and surface mapping for the anterior aspect of the distal femur.

TKA using computer-assisted navigation avoids instrumentation of the intramedullary canal which may cause fat embolism and death, and achieves better alignment in difficult cases with extra-articular deformity or femoral/tibial bowing. However, the operating and tourniquet times were longer, owing to the insertion of process trackers and registration.

Our study has limitations. The sample size was small. There may be variability during radiography, as it was difficult to control the rotation of the lower limb. Computer-assisted navigation gives a more consistent alignment corrections and reduces outliers during implant positioning. Nonetheless, its effect on long-term survival still requires longer follow-up.

### REFERENCES