The amount of tibial slope does not affect the level of maximum flexion: a review of 123 navigated total knee arthroplasties

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Introduction: The navigated Columbus® total knee replacement is a modern total knee system that has enlarged femoral-tibial contact zones to produce optimal stability whilst reducing the maximum stress in the polyethylene. The Columbus® knee system was designed as a standard knee implant that allows high flexion without the need for additional bone resection. The aim of this retrospective study was to investigate the correlation between the maximum flexion achieved at five years and the slope of the tibial component. The hypothesis was that increased slope would give increased flexion.

Patients and Methods: The study design was a retrospective cohort study at a single centre. The inclusion criterion was having had a navigated cemented Columbus primary TKA implanted between March 2005 and December 2006 using the image free OrthoPilot® navigation system (Aesculap, Tuttlingen, Germany) in our institution. All the patients had undergone the standard of care that was in place in our institution in 2005 and 2006. The follow-up had been carried out at review clinics by an independent arthroplasty team. Patient-related data had been recorded either in case notes, the departmental proprietary database or as radiographic images. In addition to demographic and operative details, five-year follow-up range of motion (ROM) was collected. All radiographs available on the national Picture Archiving and Communication System (Eastman Kodak Company, 10.1_SP1, 2006), whether taken at our institution or at the patient’s local hospital, were analysed by a trainee orthopaedic surgeon (NCS) who was independent of the patients’ care. Component position according to the Knee Society TKA scoring system was determined from the five-year review lateral X-ray. The tibial slope was calculated as 90° minus the angle of the tibial component so giving a posterior slope as a positive number and an anterior slope as a negative number. The correlation between maximum flexion angle and tibial slope was calculated. Further to this a subgroup of only CR prostheses and patients with BMI<35 were analysed for a relationship. The tibial slope of the group of patients having 90° or less of flexion (poor flexion) was compared to those having 110° or more (good flexion) using a t-test, as was the flexion of the those with BMI <30 to those with BMI > 35.

Results: A total of 219 knees in 205 patients were identified. 123 had five-year radiograph and maximum flexion measurement available. Cohort demographics are given in Table 1.

<table>
<thead>
<tr>
<th>Age at operation</th>
<th>BMI at operation</th>
<th>Max flexion at 5 years</th>
<th>Tibial slope at 5 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>68.2 (8.6) [50 to 86]</td>
<td>32.0 (5.9) [22.0 to 51.5]</td>
<td>101 (11) [60 to 120]</td>
<td>2 (2.8) [-6 to 10]</td>
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</table>

Table 1: Demographics of patients followed up at five years, mean (SD) [range]

The tibial slope angle showed variation around the mean of 2° (Table 1, Figure 1a). There was no correlation between tibial slope and maximum flexion for either that whole cohort (r=-0.051, p=0.572, Figure 1b) or the subgroup of CR and BMI<35 patients (n=78, r=-0.089, p=0.438). The mean tibial slope of those patients having poor flexion was 2° (SD2.6°) and this was not significantly different to the mean for those with good flexion, 3° (SD3.1°) p=0.614. The mean flexion of those with BMI<30 was 100° (SD8.7°) and this was not significantly different to those with BMI>35, mean 101° (SD11.4°).
**Discussion:** High knee flexion is a goal that surgeons and patients are both keen to reach after total knee arthroplasty. It has been reported that increasing tibial slope increases knee flexion in opening more the flexion gap of replaced knees. On the other hand too much posterior tibial slope increases the strain on the posterior cruciate ligament kept in CR knee implants which is not suitable for long term implant survivorship. Therefore fine tuning of tibial slope is important for knee flexion. Our review study could not identify any relationship between tibial slope and maximum knee flexion.

There are a few limitations in our study. Measurement of the tibial slope was done on short X-ray which is known for inaccuracy and lack of reproducibility. Another limitation in the study is the number of high patient’s BMI which obviously represents a limiting factor for knee flexion.

Bellemans et al. looked at 20 cadavers where they varied the tibial slope from 0° to 4° to 7° and found a relationship of 1.7° increased maximum flexion per degree of tibial slope [1]. We did not find this relationship in the clinical setting at five years post-operation. This is because not only the tibial slope but several other factors, such as the patient, surgical technique, complications, perioperative physiotherapy and implant design, affect the knee flexion after TKA. Therefore flexion after TKA is obviously more complex to assess in patients than in cadavers. Furthermore there is a difference between passive knee flexion in cadavers and active knee flexion in patients.

As stated above the patient is a major factor in the knee flexion outcome after TKA and Van der Linden et al. found that in general people do not need more than 105° to carry out daily activity [2]. Bellemans gives 104° flexion with 0° tibial slope [1] so our patients might not require more flexion than this and so do not try and bend their knee any further. Also Bellemans measured maximum flexion as the point at which the insert touched the posterior femur, which is different to a clinical assessment with high BMI patients (mean 32), as already mentioned above, where knee soft tissue impedes range of movement. So even with ideal knee design and controlled surgical technique more tibial slope does not necessarily translate into higher flexion in clinical practice.

This study did not find any correlation between the tibial slope and maximum flexion angle in 123 TKAs at five year follow up. Further studies with a more accurate measurement of tibial slope should be carried out to confirm whether a relationship exists in the clinical setting.

**References**