Effect of medial–lateral malpositioning of the femoral component in total knee arthroplasty on anterior knee pain at greater than 8 years of follow-up

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1. Introduction

The incidence of anterior knee pain (AKP) after total knee arthroplasty (TKA) can be disturbingly high, with a reported incidence between one and 49% [1–5]. The aetiology is poorly understood and several factors have been postulated: trochlear design, resurfacing of the patella, circumferential denervation, joint line alterations, femoral and/or tibial malrotation, wear, referred pain, soft tissue imbalance and specific patient characteristics [2,6–8]. Numerous cadaveric studies and computer experiments have shown that slight alterations of the shape and position/rotation of the femoral component in TKA result in significant changes in patellar tracking and patellar contact forces [9–15]. While all of these studies thoroughly investigate the patellar tracking patterns and patellar position, the correlation between difference in pre- and postoperative patellar tracking and clinical results remains unknown. Meijerink et al. [16] reported on the position of the most distal point of the patellar groove of the femoral component in relation to the position of the most distal point of the trochlea in the natural knee. These positions were assessed intra-operatively in 61 patients. Overall, they concluded that standard TKA leads to a medialization of the trochlea of about 2.5 mm (range from −4 to +9 mm). This medialization is in concordance with patellar tracking studies [10,15]. Since it has been hypothesised that medialization is suggested to lead to higher pressure on the lateral facet of the patella, it might lead to more anterior knee pain [17].

In the current midterm follow-up study, with the same patient population as the study of Meijerink et al. [16], we assessed whether patients with more medialization of the trochlear groove have more anterior knee pain. More specifically, the tested hypothesis was that more medialization of the trochlea results in a higher VAS pain score and lower Kujala anterior knee pain score at midterm follow-up.
or rheumatoid arthritis. Three surgeons measured the mediolateral displacement during surgery. All were experienced knee surgeons with more than four years of experience with the implant. None of the patellae were resurfaced. One surgeon routinely placed the LCS rotating platform prosthesis (DePuy, Warsaw, IN) and determined the mediolateral displacement in 21 patients. Two other surgeons placed the PFC prosthesis (DePuy, Warsaw, IN) and both measured the mediolateral displacement in 20 patients. The mediolateral displacement was defined as positive when a medialization was measured and negative in cases of a lateralisation. The precise method of measurement is published by Meijerink et al. [16]. In that study the authors used a special instrument to intraoperatively measure the mediolateral position of the trochlea. After preparing the knee for primary TKA, just before any bone resection took place, this instrument was placed on the distal femur. Three hollow cylinders with a diameter of 2.7 mm were positioned in the epicondyles as reference points and the three fixing pins of the instrument were slid into those cylinders. At the most distal point of the trochlea, a probe was used to measure the anatomical mediolateral position of the trochlea. After preparing the distal femur and placing the trial component of a TKA, the three pins of the instrument were slid into the three hollow cylinders in the epicondyles again and the mediolateral position of the most distal point of the prosthetic groove was determined, see Fig. 3. The difference between both positions was defined as the mediolateral error of the prosthetic groove relative to the anatomical position of the trochlea.

The most distal point of the trochlea represents about 90–120° of flexion. Most activities during normal daily living only require 0–70° of flexion. At 30° of flexion the patella enters the trochlea in the natural knee. Since the patella is guided by the trochlear groove, it seems logical that the position of the patella at the most proximal point of the trochlea should be equal before and after TKA. Earlier evaluation of the trochlea in the natural knee and patellar groove after TKA showed a difference of 5 mm at the most proximal point of the trochlea, see also Fig. 2. So, when the femoral component is placed 5 mm more medial, the patella is on average at the perfect mediolateral position. So, the hypothesis of more medial tracking giving overload of the lateral patella facet, equals a different threshold at the proximal and distal point of the

### 2.2. Data collection

For this study, all patients of the same cohort as published by Meijerink et al. [16] were contacted by telephone. Both general health status and knee specific patient reported outcome measures were noted. A Numeric Rating Scale (NRS) score was recorded for pain at rest, while getting out of a low chair and for satisfaction. The patients were asked to grade their pain and satisfaction from 0 (no pain/very dissatisfied) to 10 (intolerable pain/very satisfied) by 1 point increments [18]. To determine knee function, two questionnaires were used. First the KOOS-PS was used [19]. The KOOS-PS is a 7-item measure of physical function derived from the items of the function, daily living and function, sports and recreational activity subscales of the KOOS. Similar to the KOOS, it is intended to elicit people’s opinions about the difficulties they experience with activity due to problems with their knee. The measure is scored by summing the responses to the seven items of the KOOS-PS. The interval score from 0 to 100, with zero representing no difficulty, is obtained by using the published conversion chart [19]. Second, to address anterior knee pain, the Kujala score [20,21] was used. This score ranges from 0 to 100, with a best score of 100.

### 2.3. Analysis

The most distal point of the trochlea represents about 90–120° of flexion. Most activities during normal daily living only require 0–70° of flexion. At 30° of flexion the patella enters the trochlea in the natural knee. Since the patella is guided by the trochlear groove, it seems logical that the position of the patella at the most proximal point of the trochlea should be equal before and after TKA. Earlier evaluation of the trochlea in the natural knee and patellar groove after TKA showed a difference of 5 mm at the most proximal point of the trochlea, see also Fig. 2. So, when the femoral component is placed 5 mm more medial, the patella is on average at the perfect mediolateral position. So, the hypothesis of more medial tracking giving overload of the lateral patella facet, equals a different threshold at the proximal and distal point of the

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**Fig. 1.** Flow diagram showing the enrolment of the patients.
patella. We therefore performed two analyses, first at the most distal point of the trochlea, by comparing medialization with lateralization of the femoral component. The second analysis resembled the proximal point of the patella, by comparing a medialization of $\geq 5\,\text{mm}$ with $<5\,\text{mm}$.

### 2.4. Statistics

All data were analyzed using SPSS 17.0. Appropriate measurements of location and spread were calculated for every variable. Differences between the groups were calculated using the unpaired T-test, since a normal distribution of the variables was assumed. Variance was assessed using the Levene’s Test for Equality of Variances. Differences were considered significant at the $p < 0.05$ level. Correlations were determined by the Pearson correlation coefficient.

### 3. Results

Of the 61 patients included in the study by Meijerink et al. [16], 10 patients had died (Fig. 1). Due to their age and co-morbidity, four patients were not capable of answering the questionnaires. Three patients were not traceable due to missing addresses. One patient refused to participate and one patient did not speak Dutch. So, a total of nine patients were lost to follow-up. Finally, 42 patients completed the questionnaires with a mean follow-up of 8.8 (SD 0.5) years. Of this group, two patients were not included for final analysis. One patient had a cerebrovascular incident three months after the operation, which lead to a right sided hemiparesis with altered sensibility. Since she also was operated on the right knee, the questionnaires could not be reliably recorded in relation to the mediolateral displacement. The other patient received a revision total knee arthroplasty at the beginning of 2013 for a suspected low grade infection at 9 years follow-up. One of the patients had a new operation of the included knee 14 months after the total knee replacement. The reason was a spin out of the insert of the rotating platform LCS. The insert was replaced by a thicker one. No secondary patella resurfacing procedure was performed. Since the femoral component was left untouched, this patient remained included in the study.

A total of 40 completed questionnaires were used in this evaluation (Fig. 1). The average age of this group was 75.7 (standard deviation, SD 7.4) years. The average body mass index, BMI was 31.0 (SD 8.4) kg/m$^2$.

In Table 1 the results of the different questionnaires are given. The influence of medialization or medialization is represented in Table 2. Three patients had no displacement, they were left out of this evaluation since we wanted to detect differences between a
medialization and lateralization. In total 30 patients had a medialization of the trochlea and seven patients a lateralization.

Subanalysis of the type of prosthesis, LCS (16 patients) or PFC (24 patients), did not reveal any significant differences, as shown in Table 3.

In total 10 patients had a medialization of ≥5 mm. The patients with a medialization of ≥5 mm showed a significant lower NRS-rest (0.2 [SD 0.42] versus 1.4 [SD 2.08]; p = 0.004) and higher NRS-satisfaction (9.6 [SD 0.70] versus 8.2 [SD 2.14]; p = 0.045) than patients with a medialization of <5 mm. All other results did not differ significantly, see Table 4.

4. Discussion

The present study showed no significant differences when comparing a medialization of the femoral component with a lateralization. This comparison resembles the position of the patella around 90° of flexion. Since most patients use up to 80° of flexion in normal daily living [22,23], this analysis might not be useful. A more relevant analysis is probably performed for the most proximal part of the trochlea. This is performed by comparing patients with a medialization of ≥5 mm to patients with a medialization of <5 mm. The first group shows less pain at rest (0.2 vs. 1.4; p = 0.004) and higher satisfaction (9.6 vs. 8.2; p = 0.045). However, the groups are small and no large conclusions should be drawn. Despite this, it is important to debate these results since they are contrary to what one would expect. One would expect that more medialization of the trochlea, and therefore alteration of the patellar tracking and higher patellofemoral forces, would result in more anterior knee pain. A medialization of the trochlea in relation to the tibial tuberosity is suggested to result in higher pressures at the lateral facet and this may lead to more patellofemoral pain [17]. The present data shows the opposite: a more medial position resulted in less postoperative pain. The reason for this unexpected finding is probably the anatomical difference between the normal trochlea and the TKA trochlea.

As studied by Barkin et al. [24], the natural sulcus guides the patella from 30° to 120° of flexion. The sulcus of most femoral components in TKA guide the undersurfaced patella from 0° to 120° of flexion. In Fig. 2, the rollout of the patellar groove (dashed lines) and natural knee (continues line) are drawn. This rollout is also confirmed by patellar tracking studies [15,25]. It can be clearly seen that there is a major difference in orientation between both. Especially when the position of the most distal point of the trochlea is recreated after TKA, the entrance of the trochlea from extension to flexion is quite far apart (small dashed lines and continues line). When the femoral component is medialized, the entrance of the trochlea is more normally situated (large dashed lines and blue line). This phenomenon could explain why medialized components result in less anterior knee pain. However, this is only the case in the average natural trochlea. This contradicts what one would expect, since in theory more medialization leads to higher patellofemoral forces. It therefore seems that a patella position with the lowest stresses in the soft tissues around the knee is best. The difference in patellar tracking in the individual patient was not measured and therefore the influence of the difference in shape of the natural trochlea between patients is not known and might also be of importance. Therefore, the previous explanation is only a suggestion to give a new insight in the understanding of anterior knee pain.

Obviously mediolateral positioning of the component is not the only factor influencing these results. It is clear that component malrotation is associated with patellofemoral complaints [26,27]. Several studies suggest that internal rotation of the femoral component of more than 3°–6° may lead to chronic symptoms [28,29]. We do not think that the rotation of the femoral component influences the mediolateral position of the most distal point of the trochlea, since it lies very close to the axis of the femur. The rotation and mediolateral position of the femoral component are determined during different steps of preparing the femur. So, it is unlikely that the group with higher values of medialization have higher values of internal rotation.

Our overall results in NRS satisfaction (8.5, SD 2.0), KOOS-PS (34, SD 13.2) and Kujala knee score (72.1, SD 11.4) are comparable to previously published results [6,30]. Therefore, the patient group seems to be a reliable reflection of the general population. The overall survival of the included TKAs is good. Only one patient was revised for a low grade infection and no patients were revised for malposition or aseptic loosening.

As far as we are aware of, this is the first study which directly compares patients’ outcome and mediolateral displacement of the trochlea in total knee arthroplasty. Previous CT based studies did not take the mediolateral displacement into account, probably because it can only be measured reliably intraoperatively. The mean follow-up of 8.8 years should be enough for a reliable mid-to-long term follow-up. The patient population is relatively small, with 40 patients included for evaluation. This results in small groups when subanalysis is performed. However, the population is unique, since these are the only patients in which the medialization of the trochlea was actually measured during surgery. Therefore, this data offers a unique possibility to for a better understanding of different factors influencing total knee arthroplasty outcome and indicating trends. Another limitation is that two different implants were used. The present study showed no difference between these two implants. This is in concordance with other studies [31,32]. A final limitation is that no objective results were

<table>
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<th>Table 2</th>
<th>Influence of medialization compared to lateralization. In total three patients had an exact reconstruction of the notch position after total knee replacement.</th>
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<tbody>
<tr>
<td></td>
<td>Medial (SD) (n = 30)</td>
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<td>Displacement (mm)</td>
<td>3.7 (2.4)</td>
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<td>NRS-rest</td>
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<tr>
<td>NRS-raising</td>
<td>1.3 (2.1)</td>
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<tr>
<td>NRS-satisfaction</td>
<td>8.6 (2.1)</td>
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<tr>
<td>KOOS-PS</td>
<td>34.9 (13.4)</td>
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<tr>
<td>Kujala knee score</td>
<td>72.1 (11.2)</td>
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<td></td>
<td>LCS (SD) (n = 16)</td>
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<tr>
<td>Displacement (mm)</td>
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</tr>
<tr>
<td>NRS-rest</td>
<td>1.1 (2.2)</td>
</tr>
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<td>NRS-raising</td>
<td>1.8 (2.6)</td>
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<tr>
<td>NRS-satisfaction</td>
<td>8.2 (2.5)</td>
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<td>KOOS-PS</td>
<td>32.6 (8.1)</td>
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<td>Kujala knee score</td>
<td>71.8 (14.7)</td>
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<th>Influence of ≥5 mm medialization compared to &lt;5 mm medialization. The NRS-rest and NRS-satisfaction scores are significantly different.</th>
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<tbody>
<tr>
<td></td>
<td>≥5 mm medialization (SD) (n = 10)</td>
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<td>Displacement (mm)</td>
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<tr>
<td>NRS-rest</td>
<td>0.2 (0.4)</td>
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<tr>
<td>NRS-raising</td>
<td>0.3 (1.3)</td>
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<td>NRS-satisfaction</td>
<td>9.6 (0.7)</td>
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<td>KOOS-PS</td>
<td>38.5 (20.0)</td>
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<tr>
<td>Kujala knee score</td>
<td>72.1 (6.9)</td>
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compared, like flexion/extension measurements. We had specifically chosen a telephone survey with patient reported outcome measures (PROMs) to increase participation of the patients.

In conclusion, a more medial position may result in better postoperative outcome, which can probably be explained by the lateral orientation of the trochlear groove in TKA designs.

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References