

# Medial parapatellar approach leads to internal rotation of tibial component in total knee arthroplasty

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## Abstract

**Purpose** The purpose of this study was to investigate if the type of approach [medial parapatellar approach (MPA) versus lateral parapatellar approach with tibial tubercle osteotomy (LPA)] influences rotation of femoral and/or tibial component and leg axis in total knee arthroplasty (TKA). It was the hypothesis that MPA leads to an internally rotated tibial TKA component.

**Methods** This study included 200 consecutive patients in whom TKA was performed using either a parapatellar medial ( $n = 162$ , MPA) or parapatellar lateral approach with tibial tubercle osteotomy ( $n = 38$ , LPA). All patients underwent clinical follow-up, standardized radiographs and computed radiography (CT). TKA components' position and the whole leg axis were assessed on 3D reconstructed CT scans (sagittal, coronal and rotational). Mean values of TKA component position and the whole leg alignment of both groups were compared using a  $t$  test. The tibial component was graded as internally rotated ( $<3^\circ$  of external rotation (ER)), neutral rotation (equal or between  $3^\circ$  and  $6^\circ$  of ER) and externally rotated ( $>6^\circ$  ER). The femoral component was graded as internally rotated [ $>3^\circ$  of internal rotation (IR)], neutral rotation (equal or between  $-3^\circ$  IR and  $3^\circ$  of ER) and externally rotated ( $>3^\circ$  ER).

**Results** There was no significant difference in terms of whole leg axis after TKA between both groups (MPA:  $0.2^\circ$  valgus  $\pm 3.4$ ; LPA:  $0.0^\circ$  valgus  $\pm 3.5$ ). Means of tibial component rotation were  $2.7^\circ$  ER  $\pm 6.1$  (MPA) and  $7.6^\circ$  ER  $\pm 5.4$  (LPA). Patients of group LPA presented a significantly less internally rotated (LPA: 18.4%; MPA: 48.8%) and more externally rotated (LPA: 52.6%; MPA: 22.8%) tibial component ( $p < 0.001$ ). No significant differences were seen for the femoral component position, tibial valgus/varus and tibial slope.

**Conclusion** The type of approach (medial versus lateral) significantly influenced tibial TKA component rotation. It appears that a MPA tends to internally rotate the tibial TKA component and a LPA tends to externally rotate the tibial TKA. The anterior cortex should not be used as landmark for tibial TKA component placement when using the lateral approach with tibial tubercle osteotomy.

**Level of Evidence** Retrospective comparative study, Level III.

**Keywords** CT · Total knee arthroplasty · Tibial component rotation · Femoral component rotation · Tibial tubercle osteotomy · Parapatellar medial approach · Parapatellar lateral approach

## Abbreviations

TKA	Total knee arthroplasty
LPA	Lateral parapatellar subvastus approach with tibial tubercle osteotomy
MPA	Medial parapatellar approach
CT	Computed tomography
ER	External rotation
IR	Internal rotation
EKNZ	Ethikkommission Nordwest- und Zentralschweiz
VAS	Visual analogue scale
KSS	Knee society score

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## Introduction

Tibial and femoral component rotations are considered as a key factor for successful outcomes after total knee arthroplasty (TKA) [11, 39]. Suboptimal rotational TKA position severely alters knee kinematics leading to patellar maltracking and overloading [1, 2, 26], flexion instability [2], synovial and soft tissue impingement [2], accelerated inlay wear [26, 40] or stiffness [36]. Typically, internal rotation of the femoral TKA component results in an increased lateral flexion gap and causes overloading on the lateral patellar facet [5, 23]. An externally rotated femoral component leads to a medial lift-off in flexion [13]. An internally rotated tibial component is associated with medial compartment pain and limited knee flexion [5, 23]. Combined internal rotation of the femoral and tibial component is reported to increase the risk of patellar dislocation and anterior knee pain [4, 6, 8].

There is a variety of different TKA approaches the surgeon can choose from. Among those, the medial parapatellar approach (MPA) and the lateral parapatellar approach with tibial tubercle osteotomy (LPA) are commonly used for varus or valgus knees. The MPA is most frequently used, in both varus and valgus knees as it is less demanding [20, 31]. However, it violates the vascular supply of the patella and some authors suggest using a lateral subvastus approach combined with a tibial tubercle osteotomy particularly in valgus-deformed knees [3, 19]. The main risk associated with MPA in valgus knees is an excessive release of medial collateral ligament and other medial structures. Furthermore, it provides a poorer access to the posterolateral corner, limiting the release of lateral soft tissues under direct view. On the other side, a LPA allows a better visualization of lateral soft tissue structures. The lateral release, which is a necessary part in most valgus knees, is already included into the approach [10, 34, 35]. Following LPA, a better patellar vascularization, improved quadriceps strength and a better patellar tracking have been reported [12, 24]. However, this approach is more technical demanding, less familiar to most of the surgeons and causes a higher rate of complications [16, 22, 41]. In addition, the surgery time is longer than with MPA [16].

The purpose of this study was to investigate whether and how the choice of the approach (MPA or LPA) in primary TKA affects the rotation of the femoral and tibial TKA components and the entire leg axis. The hypothesis was that there is a tendency to internally rotate the tibial component in MPA and to externally rotate the tibial component in LPA.

## Materials and methods

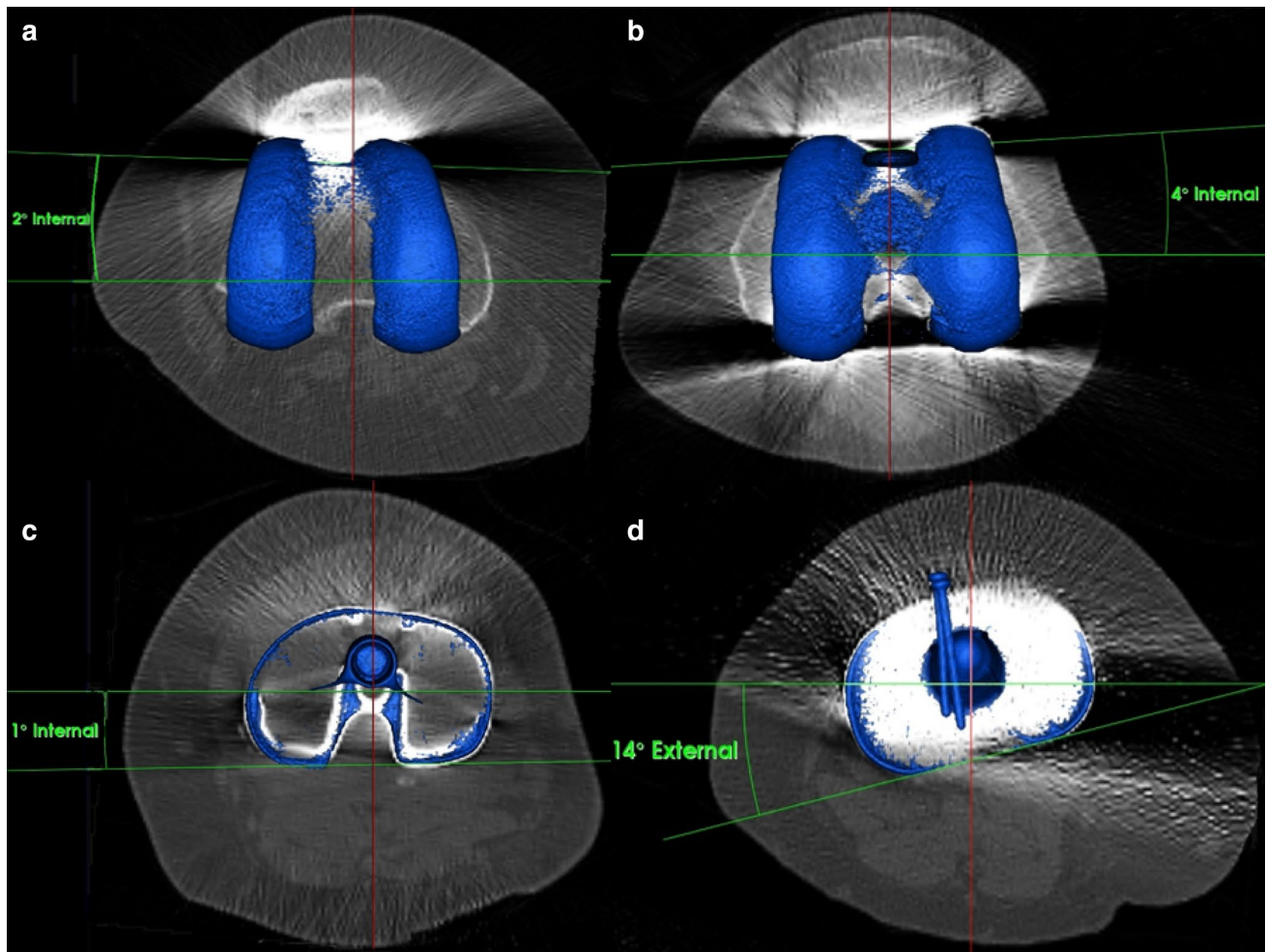
A consecutive series of 200 patients who underwent a computed tomography (CT) after primary TKA from 2013 to 2016 as clinical routine follow-up or because of knee pain in a university-affiliated hospital were prospectively collected and retrospectively analysed. Indication for TKA was end-stage osteoarthritis. A team of two senior surgeons performed the surgeries using either cruciate retaining or posterior stabilized TKA. The decision to perform a CR or PS TKA was based on the integrity of the posterior cruciate ligament and was done independently from alignment (varus versus valgus knees). The tibial TKA components were all of symmetrical shape.

The landmarks used for femoral and tibial TKA rotation were surgical transepicondylar axis, anteroposterior trochlear line, posterior femoral condyle line and medial third of the tibial tubercle, second metatarsal, Akagi's line, anterior tibial marginal line, respectively. Femoral rotation for each TKA was based on a 3° external rotation with regard to the posterior condylar line and parallel to the anatomical transepicondylar axis.

Patients were divided into two groups with regard to the used surgical approach. Group LPA included thirty-eight patients (male/female = 14:24;  $67.5 \pm 10.4$  years), who underwent TKA using a lateral parapatellar approach combined with tibial tubercle osteotomy. The lateral parapatellar approach with tibial tubercle was done in standardized Bruderholz technique. A lateral curved skin incision from the distal lateral thigh to the lateral tibia was performed towards the tibial tubercle. The subcutaneous layer was bluntly prepared, and the iliotibial tract as well as the anterior tibial muscle fascia was incised. Then, a lateral subvastus approach to the knee joint and a tibial tubercle osteotomy was performed.

Group MPA included one-hundred sixty-two patients (male/female = 56:106;  $67.2 \pm 9.8$  years) who underwent TKA using a medial parapatellar approach.

All patients underwent standardized clinical and radiological examination including radiographs and CT scans according to a previously published protocol [32]. Data were processed by interactive reconstruction, and images were displayed in axial, coronal and sagittal planes. Femoral and tibial TKA position was assessed on 3D reconstructed CT as previously published [32]. Measurements were taken by a musculoskeletal radiologist with more than ten-year experience using a customized analysis software (OrthoExpert©, London, UK) (Fig. 1). A good-to-excellent inter- and intra-observer reliability for the measurements of TKA position on 3D reconstructed CT was shown [15].



**Fig. 1** Measurements of femoral (*a, b*) and tibial (*c, d*) TKA component rotation using a customized software. (OrthoExpert©, London, UK)

For the femoral component, the external (+) and internal (–) rotation on the transversal plane was measured as an angle between the surgical femoral transepicondylar axis and a tangent line of the femoral component surface at the internal part of the anterior flange. Varus (+) and valgus (–) inclination on the coronal plane was measured as an angle between the perpendicular line to the femoral mechanical axis and a distal tangent line on the distal femoral condyles. Flexion (+) and extension (–) on the sagittal plane was measured as an angle between the femoral mechanical axis and a tangent line to the internal flat side of the anterior flange.

For the tibial component, external (+) and internal (–) component rotation on the transversal plane was measured as an angle between the tangent line to the posterior tibial component and the tibial posterior condylar axis. Varus (+) and valgus (–) inclination on the coronal plane was measured as an angle between a perpendicular line to the tibial mechanical axis and a line parallel to the tibial TKA component. Posterior (+) and anterior (–) slope on the sagittal

plane was measured as an angle between a perpendicular line to the tibial mechanical axis and a tangent line put on the tibial TKA component. Varus (+) and valgus (–) alignment of the whole leg on the coronal plane was measured as the hip-knee-ankle angle.

Femoral TKA component rotation was graded as internally rotated for measured angles lower than  $-3^\circ$ , neutrally rotated for angles between  $-3^\circ$  and  $+3^\circ$  and externally rotated for angles greater than  $+3^\circ$ . Tibial TKA component rotation was graded as internally rotated for measured angles lower than  $+3^\circ$ , neutrally rotated for angles between  $+3$  and  $+6^\circ$  and externally rotated for angles greater than  $+6^\circ$ . This grading is based on our previous experience with those landmarks and measurement protocol.

Ethical approval was obtained from the Ethikkommission Nordwest- und Zentralschweiz (EKNZ, Basel). All procedures performed were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

**Table 1** Demographics of patients represented as mean values, incidences and standard deviations

	Group MPA	Group LPA	<i>p</i>
Number of patients	162 (81%)	38 (19%)	
Age (mean ± SD)	67.2 ± 9.8	67.5 ± 10.4	n.s.
Gender ( <i>N</i> , %)	F: 106 (65%) M: 56 (35%)	F: 24 (63%) M: 14 (37%)	n.s.
Side ( <i>N</i> , %)	Right: 81 (50%) Left: 81 (50%)	Right: 13 (34%) Left: 25 (66%)	n.s.

*t* test and Chi-square tests were performed in order to test the comparability of the groups

**Table 2** Total knee arthroplasty component position on the three spatial planes and leg axis measurement

	Group MPA (mean ± SD)	Group LPA (mean ± SD)	<i>p</i>
<b>Femur</b>			
Varus (+) Valgus (–)	–0.01° ± 2.5	0.2° ± 2.7	n.s.
Flexion (+) Extension (–)	7.9° ± 4.1	6.9° ± 3.8	n.s.
External (+) Internal (–)	–3.0° ± 2.9	–2.6° ± 2.6	n.s.
<b>Tibia</b>			
Varus (+) Valgus (–)	1.1° ± 1.7	0.6° ± 1.6	n.s.
Posterior (+) Anterior (–) Slope	3.7° ± 3.6	4.1° ± 4.1	n.s.
External (+) Internal (–)	2.7° ± 6.1	7.6° ± 5.4	<0.001
<b>Leg axis</b>			
Femorotibial angle	–0.2° ± 3.4	–0.04° ± 3.5	n.s.
Varus (+) Valgus (–)			

Results are presented with mean values; standard deviation and corresponding measurements have been compared between the two groups with the *t* test

**Table 3** Clinical grading of femoral TKA component rotation and Chi-square tests, overall significance *p* = 0.130

Femoral component	Group MPA	Group LPA	Total	<i>p</i>
Internal rotation <–3°	71 (43.8%)	11 (28.9%)	82 (41.0%)	n.s.
Neutral orientation –3° ≤ ±3°	90 (55.6%)	27 (71.1%)	117 (58.5%)	n.s.
External rotation >3°	1 (0.6%)	0 (0.0%)	1 (0.5%)	n.s.

classified rotations between the groups was tested with Chi-square tests (Table 1). A two-tailed *p* < 0.05 was considered statistical significant. Post hoc power analysis was performed with G\*Power version 3.1.9 (University of Düsseldorf, Germany). A post hoc power analysis of the main result (external vs. internal rotation in the tibia) showed a large effect size of 0.84 which corresponds to a power (1-beta) of 99.6%.

**Results**

The two groups did not differ with regard to the age (n.s.), gender (n.s.) and knee side (n.s.). Means, standard deviations and *p* values of TKA component position of both groups are presented in Table 2. A significant difference between the two groups was seen for the rotation of the tibial component on the transversal plane (*p* < 0.001) (Table 2). No significant differences were seen for the position of the tibial and femoral component on others planes (n.s.) (Table 2). The graded measurements of femoral and tibial TKA component are presented in Tables 3 and 4.

The femorotibial axis was almost neutral in both groups (group MPA: –0.16 ± 3.368; group LPA: 0.04 ± 3.458) without a significant difference (n.s.) (Table 2).

The percentages of neutrally orientated tibial TKA components were similar in both groups (LPA: 28.9%; MPA:

Informed consent was obtained from all individual participants included in the study.

**Statistical analysis**

All data were analysed by an independent professional statistician using IBM SPSS version 22.0 (Armonk, NY: IBM Corp.). Continuous data were described as mean and standard deviation (SD) while categorical data were presented as frequencies and proportions. For basic comparison of groups in terms of age a *t* test and of gender and side a Chi-square test were used. For comparison between groups in terms of TKA component orientation and whole leg axis a *t* test was used. The difference of



**Table 4** Clinical grading of tibial TKA component rotation and Chi-square tests, overall significance  $p < 0.001$ 

Tibial component	Group MPA	Group LPA	Total	<i>p</i>
Internal rotation <3°	79 (48.8%)	7 (18.4%)	86 (43.0%)	0.001
Neutral orientation 3° ≥ ≤6°	46 (28.4%)	11 (28.9%)	57 (28.5%)	n.s
External rotation >6°	37 (22.8%)	20 (52.6%)	57 (28.5%)	<0.001

28.4%). In group LPA, more than twofold externally ( $p < 0.001$ ) and less than half internally ( $p < 0.001$ ) rotated tibial TKA components were found. In group LPA, almost 15% more neutrally orientated femoral components (LPA: 71.1%; MPA: 55.6%) (n.s.) and almost 15% less internally rotated tibial femoral components (LPA: 28.9%; MPA: 43.8%) were seen when compared to group MPA (n.s.) (Table 3).

## Discussion

The most important result of the present study was that the type of approach significantly affected the resulting tibial component rotation after TKA. The tibial component was more externally rotated in group LPA and more internally rotated in group MPA; hence, the starting hypothesis of the authors was confirmed.

The findings are in agreement with Passeron et al. who, using the self-adjustment method for the tibial component positioning, reported similar results in a small-sized prospective study using measurement on transverse CT slices (2D). They found that LPA led to significantly more external rotation in tibial TKA components [28]. However, in here the Berger method was used, which is considered as less reliable than measurements on 3D reconstructed CT [18, 32].

MPA and LPA provide the surgeon with less or more access to the lateral corner structures. Within the LPA, a lateral release is done leading to an internal rotation of the tibia during TKA surgery. In contrast, MPA includes a medial approach and medial release, which comes along with an externally rotated tibia. However, this tibial position during TKA surgery has a significant influence on the surgeon's perspective and explains finding of the present study. In addition, with a tibial tubercle osteotomy done in LPA, also the local bony anatomy of the proximal tibia changes, which might be another reason for a tendency to externally rotate the tibial TKA component. In contrast, the lateral eversion/subluxation of the patella performed in MPA limits the direct view on the lateral corner structures

[21, 29, 30, 33, 34]. The present study did not take into account the postoperative clinical outcomes. While an internally rotated tibial component is known to be a major cause of pain, reduced knee flexion and higher rates of revision TKA [4, 5, 23, 25, 27], an externally rotated tibial component seems to improve the patellofemoral tracking [28]. Hirschmann et al. compared the clinical outcomes at a two-year follow-up of 143 patients who undergone TKA with LPA ( $n = 76$ ) and MPA ( $n = 67$ ). The LPA group presented higher scores at the visual analogue scale (VAS) and at knee society score (KSS), more patients' satisfaction and increased pain-free walking distance [16]. However, in this group of patients, a higher TKA revision rate, due to a secondary proximal migration of the tibial tubercle was seen (LPA: 4%; MPA: 1.5%) [16]. Teng et al. in a meta-analysis collected 940 primary TKAs (LPA: 482; MPA: 458) and found better KSS scores in the LPA group at 4-, 6-week and 1-year follow-up [37]. The ROM at 1-year follow-up was similar in both groups [37]. Matsueda et al. found no differences between LPA and MPA at 6-month follow-up with regard to the KSS and ROM; however, a better patellar tracking in the LPA group was reported [24].

Terashima et al. [38] showed that externally rotated femoral components lead to better patellofemoral tracking which might be explained by lower patellofemoral contact stress. This present study showed a higher rate of neutrally orientated and a smaller rate of internally rotated femoral components in the LPA group. However, the finding was not significantly different to the MPA group.

Another finding of the present study was that there was no other significant difference in terms of TKA component position, except tibial component rotation. Also, there was no significant difference in terms of mechanical leg axis, which was almost neutral in all patients. Restoration of a neutral leg axis is one of the most important factors for a successful TKA [9, 11]. Medial collapse and ligament instability have been reported to be cause of TKA failure, respectively, in valgus and varus malaligned legs [7, 14]. In accordance with the present study, other also did not find any significant difference between patients who underwent TKA using LPA or MPA [16, 22].

The study bears a considerable number of limitations. This is a retrospective analysis of prospectively collected data. The retrospective nature bears a selection bias, which is, however, limited due the prospective data collection. The sample size is well balanced for the question to be answered.

The postoperative functional scores have not been considered. The choice of only one observer to assess the TKA component position and leg axis on CT images could be criticized; however, Figueroa et al. [15] reported a good inter- and intra-observer reliability for the CT on this type of measurements. Furthermore, 3D-CT reconstructed images have been used for the present study and these have

been assessed as more reliable than 2D-CT images for TKA component measurements [17, 18, 32].

Clinically, all orthopaedic surgeons should be aware of the fact that MPA has the tendency to result in internally rotated tibial TKA components. This can only be avoided if a combination of landmarks is used for determination of TKA position.

## Conclusion

The different knee exposure in MPA or LPA affects tibial TKA component rotation differently; MPA led to internal rotation and LPA external rotation. A meticulous selection and combination of tibial landmarks are recommended to overcome these tendencies.

**Author contributions** FFS collected and analysed the data and prepared the manuscript. FA carried out the statistical analysis and helped drafting the manuscript. MTH designed the study, helped with the analysis of data and prepared and revised the manuscript. All authors read and approved the final manuscript.

## Compliance with ethical standards

**Conflict of interest** All authors declare that they have no conflict of interest.

**Funding** There was no financial conflict of interest with regards to this study.

**Ethical approval** Ethical approval was obtained from the Ethikkommission Nordwest- und Zentralschweiz (EKNZ, Basel). All procedures performed were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

**Informed consent** Informed consent was obtained from all individual participants included in the study.

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