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Case Study

Can the Medial Proximal Tibial Angle (mPTA) be a Reliable Predictor for the Femoral Rotation in Total Knee Arthroplasty for Varus Osteoarthritis? - A Pilot Study. In Conclusion, there is a Strong Correlation Between the Femoral External Rotation and the Proximal Tibia Varus

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Abstract

Background: In this retrospective study the authors determine if there is a correlation between a preoperative x-ray measurement and intra-operative femoral rotation.

Methods: 20 consecutive patients with varus osteoarthritis of the knee underwent total knee arthroplasty using a modified flexion gap technique. The predicted degree (pDER) was calculated by subtracting the medial Proximal Tibial Angle (mPTA) from 90°. The intraoperative degree of external rotation given to the femur was recorded (iDER). The error of deviation (ED) of the tibial cut was calculated by subtracting the postoperative mPTA from 90°. The corrected iDER (ciDER) was calculated as ciDER = iDER + ED. The correlation between pDER and ciDER was statistically analysed.

Results: The pDER correlated significantly with the ciDER with a p value of <0.00001, weighted Kappa value of 0.868 and Pearson`s Coefficient R of 0.88.

Conclusions: A strong correlation exist between the preoperative mPTA and the femoral implant rotation. The level of evidence is III.

What are the new findings?

- This is a case-cohort study (observational retrospective).
- Shows a strong correlation between the tibia varus angle and the degree of femoral rotation.
- Can derive a reasonably accurate estimate from a simple preoperative radiograph.

Keywords: Knee Arthroplasty; Varus Osteoarthritis; Femoral Rotation; Preoperative Radiographic Measurements

Abbreviations

AP: Antero-posterior; ciDER: Corrected Intraoperative Degree of External Femoral Rotation; ED: Error of Deviation; EFR: External Femoral Rotation; iDER: Intraoperative Degree of External Femoral Rotation; mPTA: Medial Proximal Tibial Angle; pDER: Predicted Degree of External Femoral Rotation; TKA: Total Knee Arthroplasty

Introduction

Preoperative planning is recognized as a fundamental aspect of orthopaedic practice and an indispensable part of any successful surgical procedure. Benjamin Franklin stated that “By failing to prepare, you are preparing to fail [1].

External Femoral rotation (EFR) of the total knee prosthesis is linked to a good or excellent outcome. Proper EFR imparts good

patellar tracking, equal flexion gap between the medial and lateral sides, and improved tibio-femoral kinematics. Internal rotation of the femur, on the contrary, is associated with stiffness, pain, and a less than satisfactory result after total knee arthroplasty (TKA) [2]. However, accurate EFR is difficult to achieve in TKA [3] and varies among surgeons. The degree of EFR to be given to the prosthesis is not defined precisely and only one method, which uses a preoperative CT scan, exists to determine this [4]. A Japanese paper suggested a special axial Xray of the femur to determine the EFR preoperatively [5]. The Xray involves a special wooden table and training of the radiographic technician for reliable results. However, no study exists for measuring the EFR based on a standard preoperative antero-posterior (AP) Xray to the best of our knowledge. The intraoperative methods for EFR described are the posterior condylar angle (PCA), the surgical trans-epicondylar axis(sTEA), the anatomical trans-epicondylar axis (aTEA) and the trochlear antero-posterior axis (TRAx). However, these intraoperative measurements are generally prone to errors in judgement [4] affecting techniques like the measured resection technique.

An additional intraoperative method which does not depend on above mentioned measurements is that of the "balanced flexion gap" technique originally described by Insall which requires dependent bone cutting based on the first tibial master cut [6,7]. This gives superior early functional results after TKA [8]. We use a modification of this technique, as described by Castelli, where there are two independent master cuts (distal femoral and tibial) and the following cuts are dependent on these ones [9].

As described originally by Insall [6], when the tibia is cut perpendicularly, there is a 3 degree of correction of the 'natural' tibia varus. To compensate for this, he suggested externally rotating the femur by 3 degrees to make the flexion gap rectangular. In this study the authors aim to find out if this holds true for larger degrees of varus of the tibia preoperatively.

Methods

20 consecutive patients with varus osteoarthritis of the knee who underwent a cruciate substituting TKA were included in this retrospective study period from January 2019 to December 2019. Preoperative antero-posterior (AP) standing, lateral and skyline view Xray were performed. A hip-knee-ankle Xray with the patella pointing forward in the standing position was also taken. The medial proximal tibial angle (mPTA) was defined as the angle between a line along the flat portion of the subchondral bone of the tibia plateau (Figure 1A, line cd) and the proximal tibial anatomic axis (Figure 1A, line ef) on AP Xray [10]. A software (PACS, MEDSYNAPSE, Chennai, India) system was used to measure the mPTA and recorded. As the proximal tibial cut is made at 90^0 to its anatomic axis, the pDER was calculated as pDER = 90° - Preoperative mPTA.

The iDER given at the time of surgery was retrieved from surgical notes. It was observed that when the tibial plateau resection plane was obtained perfectly at 90^o the pDER and iDER matched accurately. However, when the resection plane erred with a deviation of a few degrees positive or negative from 90^o, the pDER matched with a corrected iDER (ciDER). For this the postoperative mPTA was measured as the angle between the line along the tibial base plate (Figure 1B, line cd) and the proximal tibial anatomic axis (Figure 1B, line ef) on the postoperative AP Xray from PACS [11]. The error of deviation (ED) of the tibial cut was calculated by subtracting the postop mPTA from 90^o. A negative value indicates residual tibia valgus and a positive value of tibia varus. The ciDER was calculated as ciDER = iDER + ED. To decrease bias and to reduce inter and intra-observer variation two sets of readings were taken from the preoperative and postoperative radiographs by each author and the mean of the values (4 readings) were taken for final calculation.

Selection criteria

Only cases of osteoarthritis with varus deformities were included. Cases with severe varus associated with subluxation, Xray which show overlapping of the medial tibial and femoral condyles, previous fracture or osteotomy, and extra-articular tibial and femoral deformities were excluded as the mPTA cannot be accurately measured for these. Also, all valgus knees and all knees with inflammatory pathologies were excluded as the degree of bone loss from the posterior femoral condyles can confound the calculation of the intraoperative EFR.

Surgical technique

A standard medial para-patellar approach was taken for all the patients. An antero-medial release of the proximal tibia and release of the deep medial collateral ligament was done till the mid-coronal line and the tibia was subluxated anteriorly. A proximal tibial cut perpendicular to the mechanical axis of the tibia was done with an extra-medullary guiding system (Attune, Depuy-Synthes, USA). The distal femur was then cut at 9 mm depth (11 mm, if there was a preoperative flexion contracture more than 15 degrees) and at an angle determined from the preoperative measurement on the weight bearing long leg Xray (Valgus Correction Angle VCA) [11]. All osteophytes from the femur, tibia and patella were removed. Further medial release, whenever necessary, was done till equal gaps medially and laterally were achieved in the extension space. The gap was measured with a spacer block and its size noted. The knee was flexed to 90 degrees and the femoral sizer (Attune, Depuy- Synthes) was fixed temporarily. The rotation of the sizer is at increments 0, 3, 5 and 7 degrees (Figure 2 arrow). A simple lamina spreader is then placed in the centre of the knee between the posterior femur and tibial cut surface and carefully distracted to increase the volume in the flexion space. At this time rotation of the femur is determined by keeping the pins parallel to the proximal tibial cut surface and the degree recorded (iDER). No further ligament releases were done in flexion. The 4-in-1 block is fixed, and the flexion gap checked with the same spacer block used to check the extension gap. The femur is then finalised with the box cut. The patella is resurfaced in all cases and after checking with trials, the final prosthesis is implanted with bone cement (Attune, Depuy-Synthes, Warsaw, IN, USA).

Statistics

The statistical analysis was performed for correlation between the pDER and ciDER using weighted Kappa value of agreement, Pearson`s coefficient correlation and its derived p value.

Results

The age, sex and side involved, and the preoperative mPTA, pDER, postoperative mPTA, ED, iDER and the ciDER measured are recorded in table 1.

Patient	Side	Preoperative mPTA on X-ray	Based on preoperative X-ray calculated external rotation (x=90-E)	Actual proximal tibial cut by author	Difference from 90 degrees (90-G=y)	Actual expected prediction for femoral rotation on the table (x-y)	Intra-operative femoral rotation degree given
Adult female	Right	81.3	8.7	89	1	7.9	7
Adult female	Right	83.3	6.7	87.7	2.7	4	5
Adult female	Left	84.6	5.4	89.2	0.8	4.6	5

Adult female	Right	83.9	6.1	89.6	0.4	5.7	5
Adult female	Left	84.3	5.7	87.1	2.9	2.8	5
Adult male	Right	82	8	91	-1	9	7
Adult female	Right	85.3	4.7	90.2	-0.2	4.9	5
Adult female	Right	81.2	8.8	89.6	0.4	8.4	7
Adult male	Right	84	6	89.1	0.9	5.1	5
Adult female	Right	86.8	3.2	90	0	3.2	3
Adult female	Right	83.9	6.1	88.1	1.9	4.2	4
Adult female	Right	87.3	2.7	90.4	-0.4	3.1	5
Adult male	Left	79.8	10.2	85.2	4.8	5.4	5
Adult female	Left	81.1	8.9	87.3	2.7	6.2	5
Adult male	Right	82.4	7.6	88.1	1.9	5.7	5
Adult male	Left	83.1	6.9	89	1	5.9	5
Adult female	Left	87.3	2.7	90.1	-0.1	2.8	3
Adult female	Right	84.7	5.3	89.4	0.6	4.7	5
Adult female	Left	86.6	3.4	89.9	0.1	3.5	3
Adult female	Left	83.2	6.8	88.3	1.7	5.1	5

Table 1

Column E: 90-preoperative mPTA on X-ray.

In our study 35% (7/20) of patients had an accurate tibial cut of 90° (+/- 0.5°). In these, the pDER matched the iDER and ciDER in 70%. In two patients where the iDER and ciDER did not match the pDER, one (patient 8 in table 1) had a pDER of more than 7° which was not possible with the jig. The other patient (patient 12 in table 1) needed less medial capsule release. Hence a larger angle was kept.

Only one patient (patient 6 in Table 1) had a tibial cut of more than 90°. Here the pDER matched the iDER. The intraoperative visual measurement was closer to 9°. However, the jig allowed only till 7°. Hence the mismatch was noted in the ciDER.

In 12 patients the tibia was cut in varus with mPTA being less than 89.5°. Of these, in 2 patients pDER matched the iDER and ciDER (patients 3 and 18 in Table 1) as these were within less than 1° from 90° at 89.4° and 89.2°. The remaining 10 required correction of the iDER by the ED following which they matched the ciDER.

The weighted Kappa value between the pDER and ciDER is 0.868 which denotes almost perfect agreement. The Pearson`s coefficient correlation value of R is 0.88 which shows a strong positive correlation between the pDER and the ciDER with a highly significant derived p value of < 0.00001.

Discussion

One of the goals of TKA is to achieve a mechanical axis perpendicular to the ground as this is associated with long term survivorship of the joint [12]. The proximal tibial cut is made at 90^0 to its anatomic/mechanical axis and the distal femoral cut angle is required to be made as per preoperative hip-knee-ankle Xray calculations [11]. However, the normal tibia is in 3 degrees of varus. To compensate this, an over-resection of the lateral tibial plateau is recommended. This balances the extension gap but has the drawback of making the flexion gap wide on the lateral side. Insall suggested to externally rotate the femur to close the lateral flexion gap without affecting the extension gap balance [6] (Figure 3).

The iDER can be determined by using intra-operative landmarks and angles like the trans-epicondylar axis (surgical and anatomical), the trochlear antero-posterior axis, and the posterior condylar angle.

Using computer navigation on the reproducibility of the trans-epicondylar axis, authors Jenny and Boeri found that it would have a low and unacceptable reproducibility in the hands of less experienced surgeons [13].

In a cadaveric study, even under perfect conditions in an anatomical laboratory, the reproducibility of the epicondyles was found to have a high degree of variance among the participating surgeons [14].

The posterior condylar angle is not reliable at the time of surgery and is prone to variability among patients [15].

The trochlear antero-posterior axis (Whiteside`s line) is prone to error of parallax and hence has a lower rate of reproducibility [16].

In the modified flexion gap technique that we use, the amount of medial and postero-medial release is less which avoids the problems with the classic flexion gap technique such as joint line elevation and mid-flexion instability while achieving a balanced flexion-extension gap. Here the EFR is determined as per the ligament balance achieved with the lamina spreader device.

The iDER value increased proportionately to increasing preoperative varus deformity of the tibia. i.e. the larger the preoperative varus, the greater was the value of the EFR at surgery. Pagnano and Hansen found in their study of 60 patients a similar finding. As the tibial varus joint line obliquity increased, there was a distinct tendency for the trans-epicondylar axis to be rotated more externally relative to the posterior condylar axis [17].

Western literature says that the average iDER is 3^{o} [18]. However, it has been reported that in the Indian population [19] with varus osteoarthritis TKA only 27.7% require 3^{o} whereas 48.2% require more than 3^{o} iDER. Our data suggests that majority (85%) of patients required an iDER of more than 3^{o}.

A highly accurate preoperative predictive EFR on an AP Xray of the knee joint helps the surgeon execute the iDER with confidence. We managed to obtain an accurate 90^{o} (2^{o} standard deviation) tibial cut in 85% of our patients which compares with previous reports [20]. In those patients where the tibial cut was at a perfect 90^{o} the pDER matched the iDER (Figure 4). However, for those patients where our cut was less (Figure 1) or more than 90^{o}, the pDER correlated with the ciDER. This experience suggests that during surgery if the iDER does not match the pDER, then the surgeon should be alerted to the fact that the tibia may not have been cut at 90^{0}. Reorienting the tibial cut at this time can be considered.

The limitation of our study is that the study population is small. Future larger studies to determine the accuracy of the pDER would be worthwhile.

Conclusions

The authors have shown that when using the modified gap balancing technique the preoperative mPTA (pDER) correlates closely with the femoral rotation at surgery(iDER). Further we conclude that, if the iDER does not match the pDER, the tibia may not have been cut precisely at 90^{o}. This can be an added tool in

the surgeon`s armamentarium to achieve correct rotation and correct tibial cut during surgery. In the Indian population, a 5° EFR is appropriate for most patents.

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Bibliography

1. Atesok Kivanc., *et al*. "Preoperative planning in orthopaedic surgery: current practice and evolving applications". *The Free Library* (2015).

2. Berger RA., *et al*. "Determining the rotational alignment of the femoral component in total knee arthroplasty using the epicondylar axis". *Clinical Orthopaedics and Related Research* 286 (1993): 40-47.

3. Katz MA., *et al*. "Determining femoral rotational alignment in total knee arthroplasty: reliability of techniques". *The Journal of Arthroplasty* 16.3 (2001): 301-305.

4. Luyckx T., *et al*. "Is adapted measured resection superior to gap-balancing in determining femoral component rotation in total knee replacement?" *The Journal of Bone and Joint Surgery. British Volume,* 94-B.9 (2012): 1271-1276.

5. Kanekasu K., *et al*. "Axial radiography of the distal femur to assess rotational alignment in total knee arthroplasty". *Clinical Orthopaedics and Related Research* 434 (2005): 193-197.

6. Insall JN. "Surgery of the knee". ed 2. Churchill Livingstone, New York (1993).

7. Moreland JR. "Mechanisms of failure in total knee arthroplasty". *Clinical Orthopaedics* 226 (1988): 49.

8. He Q., *et al*. "Is gap balancing superior to measured resection technique in total knee arthroplasty? A meta-analysis". *Arthroplasty* 2.1 (2020): 3.

9. Castelli CC., *et al*. "Rotational alignment of the femoral component in total knee arthroplasty". *Annals of Translational Medicine's* 4.1 (2016): 4.

10. Wang JH., *et al*. "Medial open wedge high tibial osteotomy: the effect of the cortical hinge on posterior tibial slope". *The American Journal of Sports Medicine* 37.12 (2009): 2411-2418.

11. Mullaji AB., *et al*. "The influence of preoperative deformity on valgus correction angle: an analysis of 503 total knee arthroplasties". *The Journal of Arthroplasty* 28.1 (2013): 20-27.

12. Kim YH., *et al*. "The relationship between the survival of total knee arthroplasty and postoperative coronal, sagittal and rotational alignment of knee prosthesis". *International Orthopaedics* 38.2 (2014): 379-385.

13. Jenny JY and Boeri C. "Low reproducibility of the intra-operative measurement of the transepicondylar axis during total knee replacement". *Acta Orthopaedica Scandinavica* 75.1 (2004): 74-77.

14. Stoeckl B., *et al*. "Reliability of the transepicondylar axis as an anatomical landmark in total knee arthroplasty". *The Journal of Arthroplasty* 21.6 (2006): 878-882.

15. Cieliński Ł., *et al*. "Variation in the Posterior Condylar Angle". *Ortopedia, Traumatologia, Rehabilitacja* 18.6 (2016): 549-561.

16. Talbot S., *et al*. "The sulcus line of the trochlear groove is more accurate than Whiteside's Line in determining femoral component rotation". *Knee Surgery, Sports Traumatology, Arthroscopy* 23.11 (2015): 3306-3316.

17. Pagnano MW., *et al*. "Varus tibial joint line obliquity: a potential cause of femoral component malrotation". *Clinical Orthopaedics and Related Research* 392 (2001): 68-74.

18. Boldt JG., *et al*. "Femoral component rotation in mobile-bearing total knee arthroplasty". *Knee* 13.4 (2006): 284-289.

19. Gurava Reddy AV., *et al*. "Reference axes for optimal femoral rotational alignment in varus osteoarthritic Indian knees - A CT based study". *Journal of Clinical Orthopaedics and Trauma* 7 (2016): 215-219.

20. Chiu KY., *et al*. "The accuracy of extramedullary guides for tibial component placement in total knee arthroplasty". *International Orthopaedics* 32.4 (2008): 467-471.