Painful knee prosthesis: CT scan to assess patellar angle and implant malrotation

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Summary

Background: **According to literature, the incidence of pain in knee prostheses is on the increase.**
In the last decade Authors have focused attention on rotational alignment of the prosthetic components. The aim of this study is to evaluate the efficiency of a new angle, which we define as patellar angle, in order to achieve early diagnosis of malrotation.
Methods: **We set up a retrospective observational study recruiting 100 subjects who had undergone total knee prosthesis. 50 subjects suffered from knee anterior pain and 50 without any symptoms. Through CAT scan and VITREA software®, we were able to study the rotation of prosthetic components. We defined a new angle, which links the tibial component and the patella margins. The angles were measured by two different orthopaedic surgeons blinded to the study.**
Results: **The patella angle ranged from 10 to 28°, with an average value of 23.2° in the control group; in the study group the angle ranged from 26 to 34°, with an average value of 29.9°.**
Conclusion: **Our data supported the reproducibility and efficacy of new angular value. It would represent a new method to detect tibial rotational malalignment.**
Level of evidence: IV.

KEY WORDS: axial view, tibial apophysis, tibial plate.

Introduction

Total knee arthroplasty is the best surgical approach to treat severe knee arthritis[1,2].
From data analysis on the European Prosthetic Register it emerged that the survival rate of an implant in 85 to 95% of patients is 15 years[3-7].
We also found that the rate of revision at a 10 year follow up is 15% and the most common causes are aseptic loosening and instability[8].
The first symptom of a failing prosthesis is pain; the Australian Prosthetic Register revealed that aseptic loosening accounts for 35% of the pain, septic 17% and femur patellar 20%[8].
19% of patients reported pain one year after surgery[9].
According to literature, anterior knee pain in total knee prosthesis is predictable in relation to preoperative anatomic conditions such as *genu valgum*, external tibial torsion, fixed or reducible patello-femoral and femoro-tibial deformities and the state of the ligaments[10].
In recently years, orthopaedic literature has paid more attention to this problem explaining that this is associated with the malalignment of the prosthesis. In those patients who reported pain, when infection was excluded through various tests, the Orthopaedics turned their attention to the possibility of malalignment of femoral or tibial or both components.
The bad positioning of these was recognized as the main cause of pain in the knee prosthesis[11,12].
Indeed, the correct mechanical axes and varus/valgus position relate directly to a good functional recovery[12,13].
The request made by patient to be able to recommence not only normal every day activities but also to have a more active life style induced industries to design and develop new devices and biomaterials as well as surgical instruments to improve precision and surgical performance. Nevertheless, despite the introduction of intra and extramedullary systems for femoral and tibial alignment in order to improve surgical accurancy and placement accuracy, the literature reports many errors linked to anatomical bone profiles or related to the surgeon[14].

In 1998 Richard[15] demonstrated femoral and tibial malalignment using CAT scan. As far as the femoral component is concerned, he defined a new angle between the tangent of the posterior condyles and parallel to the clinical epicondylar axis (Fig. 1).
A 5° angle revealed a 5° femoral intrarotation compared to the epicondylar axis. In women the condylar axis is usually 0.3±1.2° and so the femoral component in this case is a 4.7° angle which is too steep; in men this angle ranges from 3.5±1.2°.
In 1998 Richard[15] defined also the centre of the prosthetic tibial component, sketched the line through this centre and calculated the angle between this line and the axis that goes between the middle and tibial tuberosity; the physiologic value was 18° of intrarotation compared to tibial tuberosity. The increase of post-operative pain after knee prosthesis, the dissatisfaction of the patient at the one year follow up and the trend of many Authors to conduct new studies to define ever more precise anatomic referents induced us to start a study to establish a new method to detect post-surgery tibial component rotation. The aim of our study is to validate a new parameter in order to monitor prosthesis malalignment.

Materials e methods

We enrolled 100 patients with total knee prosthesis. Sample sizes were in line with those in previously published works regarding painful total knee arthroplasty. According to literature the numbers were sufficient to reach statistical efficiency[16,17].
The implants were Genesis II C.R. (Cruciate Retaning) and TC Plus (Smith-Nephew Inc, Memphis, TN, USA), Nexgen® C.R. (Zimmer, Warsaw, IN, USA), Vanguard P.S. (posterior-cruciate sacrificing design) (Biomet Inc, Warsaw, US) and Columbus (B. Braun Aesculap, Tuttlingen, Germany). We carried out a retrospective study according to international ethical standards[18] (Tab. I).

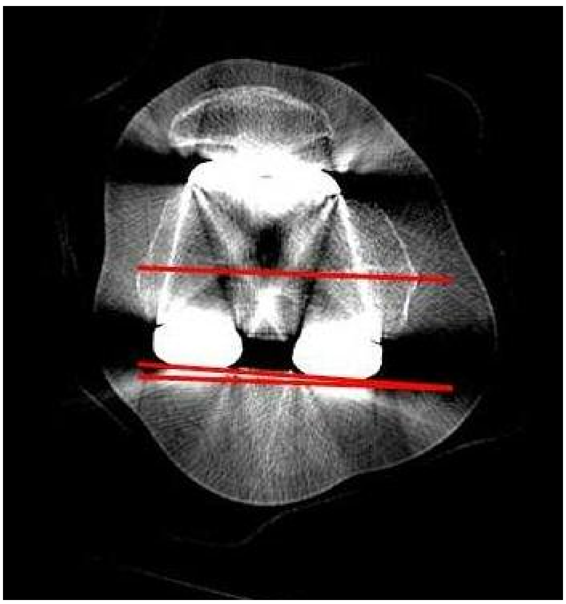

Figure 1. CAT scan view shows the angle subtended between the tangent to posterior condyles and parallel to clinical epicondylar axis.

Each patient, recruited from the Orthopedic Unit at the General Hospital of Bari (Italy), was affected with knee arthritis and underwent knee replacement surgery in various regional Hospitals. We divided the 100 patients into two groups. The study group was composed of 50 painful knee prostheses (some from our hospital and others from various regional hospitals) and the control group of 50 patients (all from our hospital) completely satisfied with their implants and with no complications. Painful knee prosthesis can be diagnosed only after the exclusion of all other possible causes reported in literature, such as septic or aseptic loosening, lack of balance of soft tissues, instability and prosthesis impingement[19,20].
The inclusion criteria for the enrollment of patients were:

- Patients with knee prosthesis
- Early anterior pain in the first year.

The exclusion criteria were:

- Malalignment in AP and LL view of femoral and tibial component
- Septic or aseptic loosening
- Soft tissue instability
- Metal hypersensibility
- Algodistrophic syndrome
- Extensor system insufficiency (patella and femur hypoplasia and congenital deformation of the patella).

We studied the patients' knees through X-rays taken from two different views and CAT scan according to Jazrawi protocol[13].
Through high definition CAT scan (64 slices) and using VITREA software® (Vital Images Minnetonka USA), we were able to study the rotation of the prosthetic components at the femoral condyle, patella, tibial plate and apophisis.
As far as the femoral component is concerned, we measured the angle between the parallel of the epycondilic axis and the tangent of posterior prosthesis condyles, as Richard defined in his work in 1998[15].

Table I. A demographic data of the patients enrolled in this study.

Number of patients	100
Age	Average value : 57.5 (range): 45-70
Gender	□=78 □=22
Weight	Average value: 67.5 (range): 60-75
BMI (kg/m²)	Average value: 27.4 (range): 25-30

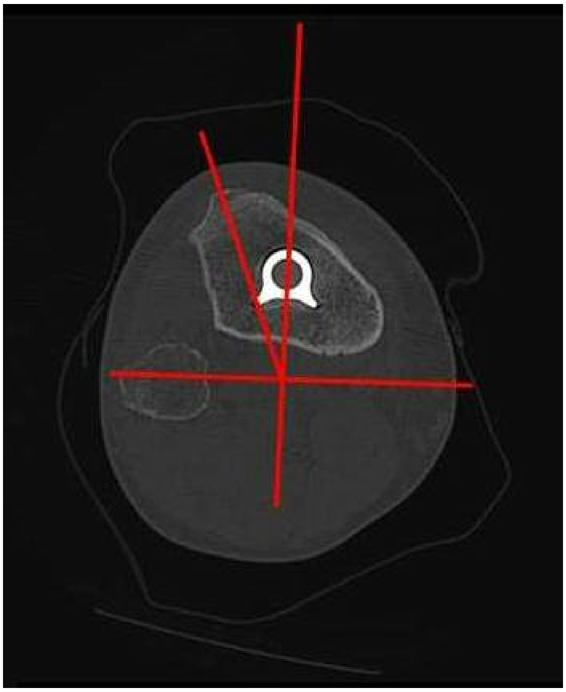

Figure 2. CAT scan view shows the angle described by Berger and linked to tibial apophysis.

As for the tibial component, we evaluated two angles. The first was already described by Berger in 1993[21], and correlated the tibial component with the apophysis through CAT scan. This angle can be defined calculating the centre of the tibial plate, measuring the angle subtended between the line for apophysis, and the centre of the component passing through the prostetic center and at the same time perpendicular to the posterior tangent of implant (Fig. 2).

Finally, we defined a new angle, not yet reported in literature, which links the tibial component and the patella margins through CAT scan; this angle is subtended between the tangent of the lateral part of the patella and the cartesian system, which is represented by the posterior tangent of the tibial plate, and the line, perpendicular to this tangent, which passes through the centre of the prosthetic component.

We reported the axes system at patella level through VITREA software® and using CAT scan and we sketched a tangent of the lateral margin of patella defining the patellar angle (α) (Fig. 3a, b).

The angles were measured by two different orthopaedic surgeons not involved in the study, in order to check the accurancy of the data and the possibility of applying this method.

Statistical analysis

In our work we used a method to verify this hypothesis in the average differences between two groups of patients in order to establish the angle range significance in the study group. To confirm the hypothesis between the averages, we measured the average value both in the study group and in the control group, deviations and variance S^2.

We verified the hypotheses at 5% of significativity level (0.05) and confidence range of 95%. The data were inserted into a database. We were able to compare the averages through the t-student test for independent samples.

Results

In our study, we enrolled 100 subjects who we divided into two groups; 50 in the control group (knee

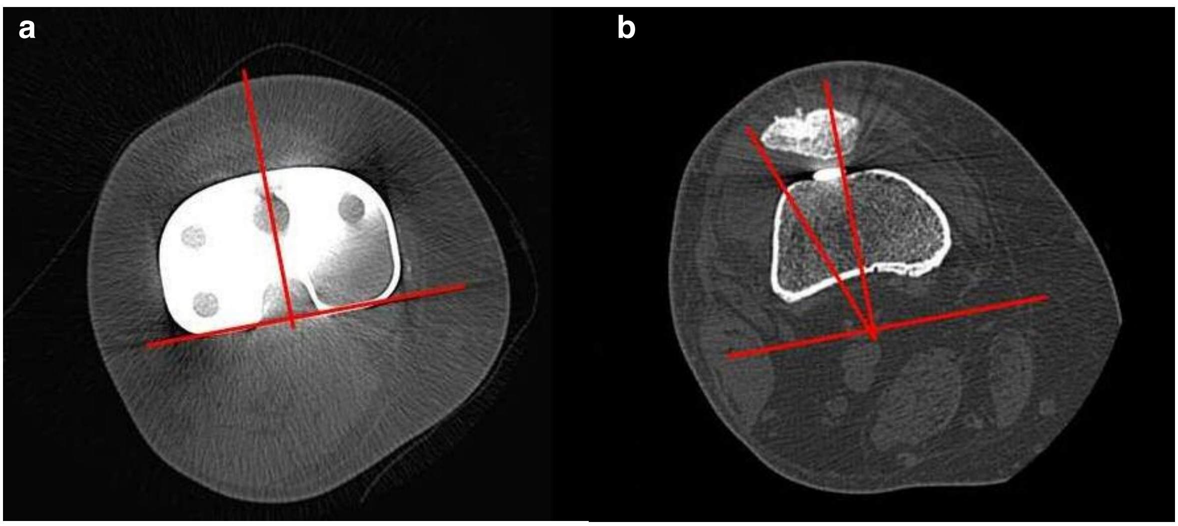

Figure 3 a, b. CAT scan views show the angle linked to patella margins.

Table II. the average value of α, β, γ in the control and study group.

Average Values	Control Group	Study Group
Posterior condylic angle (γ)	3.2°	2.8°
Tibial angle (β)	17.8°	14.6°
Patella angle (α)	23.2°	29.9°

arthroplasties with good clinical-functional results) and 50 in the study group (painful anterior knee arthroplasties without clinical-instrumental symptoms of septic or aseptic loosening).
The value of condylic posterior angle ranged from 1 to 5° with an average value of 3.2° in the control group; the same angle in the study group ranged from 1 to 4°, with an average value of 2.8°.
The value of the tibial angle in the control group ranged from 15 to 21°, with an average value of 17.8° whilst, in the study group, it ranged from 3 to 27°, with an average of 14.6°.
The patella angle ranged from 10 to 28° with an average value of 23.2° in the control group; in the study group it ranged from 26 to 34°, with an average value of 29.9° (Tab. II).

Discussion

The first aim of knee arthroplasty surgery is to re-establish the mechanical axis in frontal and sagittal planes with respect to the other limb; the varus-valgus malalignment of the prosthetic components have already been described whilst in the last 10 years there has been a growing interest in the study of rotational defects[22-26].
An increase in the intrarotation of the femoral/tibial component is responsible for patella maltracking because there is an asymmetric contact of the femur-patella joint.
At the same time, excessive extrarotation of the tibial component might be responsible for a development of impingement between its posterior-lateral part and soft tissues[27].
In our study, we aimed to validate a new angle which could be helpful for the early diagnosis of rotational defects of the tibial component in patients with painful arthroplasty without clinical-instrumental symptoms of septic or aseptic loosening. The aspects to take into consideration were:

1) each patient in the study group presented rotational defects of one or both prosthetic components
2) each patient in the control group showed rotational defects.

The posterior condylic angle both in the control group and study group allowed us to exclude femoral rotational defects in the study group. In fact, the average of posterior condylic angle (γ) is 3.2° in the control group and 2.8° in the study group; the differences in the average values and the ranges were not statistically significant ($p > 0.05$)[28,29].
Afterwards, we hypothesised the rotational defects of the tibial component and we measured the tibial angle (β) of which the value was 17.8° in the control group and 14.6° in the study group.
In accordance with the physiological value, reported in literature as being 18° (standard value), we were able to define intra or extrarotational tibial defects. Applying the same statistical method to compare the range of values and the averages, we did not find any statistically significant differences ($p > 0.05$).
As far as the patella angle is concerned, we defined the average value as 23.2° in the control group and 29.9° in the study group; this difference in average is statistically significant ($p < 0.05$ e $t = 2.021$).
As well as evaluating the confidence range between the averages, it also allowed us to find a physiological range of this value (23.2 ± 4.02).
In our study, the statistical analysis gave us the possibility to suspect significant differences for the patella angle, unlike for the tibial angle. Through the observation of our results, we were therefore able to confirm that every subject (100%) of the study group presented malrotation of one prosthetic component (in our limited group).
In the same way, it emerged from the analysis of the data that 2 patients out of 50 (10%) in the control group presented excessive intrarotation of the tibial component; in fact, β angle was greater than the 18° described in literature and also α angle was not included in the defined physiological range.
We therefore achieved our aim of considering a new angle value and, at the same time, the possibility of using a new value to make a correct diagnosis.
In fact, we did not find any statistically significant differences related to the tibial angle, due to the fact that the number of the sample is too limited and to the difficulty in objectively defining the top of tibial apophysis.
Moreover, we enrolled patients who had a well represented lateral margin of the patella, thanks to surgical toilette of the osteophytes and this allowed us easier measurement.
The critical points of this study are:

- limited study sample
- anatomical and morphological variables that could affect the measurement of the patellar angle
- mobility of the patella and the extensor apparatus in reference to the tension of the alar ligaments and trasverse axis of cross system both in pre and post operative condition. As far as the patellar angle is concerned, we defined a wide value

through statistical analysis: ± 4.02.
This is particularly significant when compared to condylic and tibial angle defined in literature.

Conclusion

The role of rotational malalignment of TKA components assumes a central position in modern literature, especially when related to the wearing down of the polyethylene and to the index of the survival of implants. For this reason, it is very important to have different anatomical parameters such as the condylic angle, the tibial angle and the patellar angle that we validated in our study, in order to perform a complete and early diagnosis. Finally, as supported by our data and notwithstanding a limited sample, the measurements of angle maybe reproducible and objective. Our next study will aim to overcome the critical points encountered in the present work in order to better define this angular value and reduce the range of the angle.

Conflicts of interest

The Authors declare no conflicts of interest concerning this article.

References

1. Laskin RS. The Genesis total knee prosthesis: a ten-year follow-up study. Clin Orthop and related research. 2001;388:95-102.
2. Rodriguez JA, Bhende H, Ranawat CS. Total condylar knee replacement: a 20-year follow-up study. Clin Orthop and related research. 2001;388:10-17.
3. Koskinen E, Eskelinen A, Paavolainen P, Pulkkinen P, Remes V. Comparison of survival and cost-effectiveness between unicondylar arthroplasty and total knee arthroplasty in patients with primary osteoarthritis: A follow-up study of 50,493 knee replacements from the Finnish Arthroplasty Register. Acta orthopaedica. 2008;79(4):499-507.
4. Paavolainen P, Hämäläinen M, Mustonen H, Slätis P. Registration of arthroplasties in Finland. Acta Orthopaedica Scandinavica. 1991;62(sup241):27-30.
5. Bäthis H, Perlick L, Tingart M, Lüring C, Zurakowski D, Grifka J. Alignment in total knee arthroplasty. Bone & Joint Journal. 2004;86(5):682-687.
6. Graves S, Davidson D and Tomkins A. Australian Orthopaedic Association National Joint Replacement Registry Annual Report 2010. Adelaide, Australia 2009.
7. Mortazavi SJ, Molligan J, Austin MS, Purtill JJ, Hozack WJ, Parvizi J. Failure following revision total knee arthroplasty: infection is the major cause. International orthopaedics. 2011;35 (8):1157-1164.
8. Robertsson O, Dunbar M, Pehrsson T, Knutson K, Lidgren L. Patient satisfaction after knee arthroplasty: a report on 27,372 knees operated on between 1981 and 1995 in Sweden. Acta Orthopaedica Scandinavica. 2000;71(3):262-267.
9. Bourne RB, Chesworth BM, Davis AM, Mahomed NN, Charron KD. Patient satisfaction after total knee arthroplasty: who is satisfied and who is not? Clinical Orthopaedics and Related Research®. 2010;468(1):57-63.
10. Baldini A, Castellani l, Traverso F, Balatri A, Balato G, Franceschini V. The difficult primary total knee arthroplasty: a review. The Bone and Joint Journal. 2015;97(10)-B(10 Suppl A):30-39.
11. Berger RA, Crossett LS, Jacobs JJ, Rubash HE. Malrotation causing patellofemoral complications after total knee arthroplasty. Clinical orthopaedics and related research. 1998;356: 144-153.
12. Lakstein D, Zarrabian M, Kosashvili Y, Safir O, Gross AE, Backstein D. Revision total knee arthroplasty for component malrotation is highly beneficial: a case control study. J Arthroplasty. 2010;25(7):1047-1052.
13. Jazrawi LM, Birdzell L, Kummer FJ, Di Cesare PE. The accuracy of computed tomography for determining femoral and tibial total knee arthroplasty component rotation. J Arthroplasty. 2000;15(6):761-766.
14. Vanbiervliet J, Bellemans J, Verlinden C, Vandenneucker H, Luyckx JP, Labey L, Innocenti B. The influence of malrotation and femoral component material on patella femoral wear during gait. J Bone Joint Surg Br. 2011;93(10):1348-1354.
15. Berger RA, Crossett LS. Determining the rotation of the femoral and tibial components in total knee arthroplasty: A computer tomography technique. Operative Techniques in Orthopaedics. 1998;8(3):128-133.
16. Huang YM, Wang CM, Wang CT, Lin WP, Horng LC, Jiang CC. Perioperative celecoxib administration for pain management after total knee arthroplasty - a randomized, controlled study. BMC Musculoskelet Disord. 2008;9(1):1.
17. Mammoto T, Fujie K, Mamizuka N, Taguchi N, Hirano A, Yamazaki M, Hashimoto K. Effects of postoperative administration of celecoxib on pain management in patients after total knee arthroplasty: study protocol for an open-label randomized controlled trial. Trials. 2016;17(1):1.
18. Padulo J, Oliva F, Frizziero A, Maffulli N. Muscles, Ligaments and Tendons Journal - Basic principles and recommendations in clinical and field Science Research: 2016 Update. MLTJ. 2016;6(1):1-5.
19. Mandalia V, Eyres K, Schranz P, Toms AD. Evaluation of patients with a painful total knee replacement. Bone & Joint Journal. 2008;90(3),265-271.
20. Maloney WJ. The stiff total knee arthroplasty: evaluation and management. The Journal of arthroplasty. 2002;17(4):71-73.
21. Berger RA, Seel MJ, Schleiden M. Computerized tomographic determination of the normal tibiofemoral rotational angle: A guide to tibial component rotational alignment in TKA. Orthop Trans. 1993(17):1174.
22. Scuderi GR, Komistek RD, Dennis DA, Insall JN. The impact of femoral component rotational alignment on condylar lift-off. Clin Orthop and Relat Res. 2003;410:148-154.
23. Colwell CW, Chen PC, D'Lima D. Extensor malalignment arising from femoral component malrotation in knee arthroplasty: Effect of rotating-bearing. Clinical biomechanics. 2011;26 (1):52-57.
24. Nagamine R, Whiteside LA, Otani T, White SE, McCarthy DS. Effect of medial displacement of the tibial tubercle on patellar position after rotational malposition of the femoral component in total knee arthroplasty. The Journal of arthroplasty. 1996;11 (1):104-110.
25. Tashiro Y, Uemura M, Matsuda S, et al. Articular cartilage of the posterior condyle can affect rotational alignment in total knee arthroplasty. Knee Surgery, Sports Traumatology, Arthroscopy. 2012;20(8):1463-1469.
26. Harman MK, Banks SA, Kirschner S, Lützner J. Prosthesis alignment affects axial rotation motion after total knee replacement: a prospective in vivo study combining computed tomography and fluoroscopic evaluations. BMC musculoskeletal disorders. 2012;13(1): 206.
27. Uehara K, Kadoya Y, Kobayashi A, Ohashi H, Yamano Y.

Bone anatomy and rotational alignment in total knee arthroplasty. Clin Orthop Relat Res. 2002;402:196-201.
28. Berger RA, Rubash HE, Seel MJ, Thompson WH, Crossett LS. Determining the rotational alignment of the femoral component in total knee arthroplasty using the epicondylar axis. Clinical orthopaedics and related research. 1993;286:40-47.
29. Berger RA, Seel MJ, Schleiden M, Britton CA, Crossett LS, Rubash HE. Determination of femoral component rotation in total knee arthroplasty using computer tomography. Orthop Trans. 1993;17(3):1174.