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Research Article

INTRA- AND INTER-OBSERVER VARIATION AND RELIABILITY OF KNEE PANGONOMETRIC PREOPERATIVE PLANNING IN TOTAL KNEE ARTHROPLASTY: ABOUT 21 CASES COLLECTED IN THE ORTHOPEDICS-TRAUMATOLOGY DEPARTMENT OF THE SINT-PIETER TEACHING UNIVERSITY MEDICAL CENTER IN BRUSSELS

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Abstract

Knee arthritis is a frequent disease. Genu varum and genu valgum are the most important etiologic factors. Total Knee Arthroplasty (TKA) is indicated for patients above 70 years old, with symptomatic arthritis, especially if the conservative treatment fails. During total knee replacement (TKR), the initial deformity of the affected lower leg can be corrected by bone resection and soft tissue release. It is possible to plan the bone resections from the pre-operative long leg radiographs using the QT 3000 AGFA Orthopedic tools. Some surgeons plan for it whereas others do not. This is why we studied pre and post-operative X rays and measured bone resections of patients with TKR. Because this intervention is not a common practice in Cameroon, we also attempted to study its indications, technique and results. We found that arthritis is the most common indication. It is mostly caused by a genu varum (71,43%). The TKR by internal para-patellar approach, use of cement, mobile bearing, and cruciate ligament sacrifice is widely used. Complications are rare and patients are very satisfied. The X rays quality is not excellent because 38,10% of them have problems. Angle measurements using computer are reliable. There is a moderate correlation between the bone cuts and angle measurements. We were able to predict the bone cuts of more than 80% of patients. We recommend the respect of the technique of long leg standing radiographs, the use of TKR as a means of treatment of arthritis in Cameroon and the use of computer aided pre-operative planning. This will serve as a guide in order to avoid big errors.

Keywords: Total knee arthroplasty – Preoperative planning - Pangonometry.

INTRODUCTION

Invaliditing knee disease affects more than one third of the population above 65 years [1, 2]. Frontal deformations in genu varum and genu valgum are sources of secondary osteoarthritis and these deformations must be corrected by planned bone resections in order to avoid asymmetric stresses that are sources of loosening of the total knee replacement (TKR) prosthesis. It is an intervention that must be rigorous, hence the interest here more than elsewhere of preoperative planning [3], among other things for corrective bone resections, sizes and orientation of the implants. It is increasingly robotic and scanographic (computer-assisted surgery or CAS) [4] in developed countries, but these instruments are expensive for countries with limited resources. We therefore propose a simpler radiographic method, presenting its limits and requirements for 21 planned and then operated knees. Bone cutting errors are very common [3-5]. In the care taken to improve this rigor in terms of surgical technique, we proposed to review the pre, per and postoperative data of patients in whom a total knee prosthesis had been installed.

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Do the data from the preoperative planning correspond to the intraoperative data? In other words, do the bone resections correspond to the planned quantities? Are the radiological measurements reliable? Should we give reason to the authors [4, 6-8], who consider radiography of mechanical axes of the lower limbs unnecessary? Are we right to plan on x-rays? These were the research questions. The objective pursued by this work carried out in the Orthopedic-Traumatology Department of the the University Medical Center (UMC) Sint-Pieterin Brussels was to be able to answer as much as possible to these questions raised by this controversy.

METHODOLOGY

We carried out an analytical and prospective study on a cohort of patients operated at the University Medical Center (UMC) Sint-Pieterin Brussels, between January 1, 2002 and December 31st, 2005, by the same surgeon. Were included, all the patients who had a total knee arthroplasty (TKA) during the period of study and presenting a file comprising two X-rays of mechanical axes of the lower limbs, one of which was preoperative and the other made approximately one year after the procedure. Measurements of bone resections were performed intraoperatively The following were excluded:

patients who had a unicompartmental prosthesis, cases of revision, patients who did not have a pre-operative or post-operative digitalised mechanical axis radiograph, and those in whom the measurements of bone resections were not specified. Twenty-one knees were analyzed. The variables were based on pre, per, and postoperative data from the medical record. We compared the bone resections planned by the preoperative planning with those actually performed by the surgeon during TKR and studied several angles. The frontal angular deviation or HKA angle (H= Hip, K= Knee, A= Ankle) is the angle formed by the mechanical axis of the femur and the mechanical axis of the tibia. This angle was measured medially. The angle of the condylar component or alpha angle or mechanical femoral angle is the angle between the mechanical axis of the femur and the distal bicondylar axis: it was measured medially. The angle of the tibial component or beta angle or tibial mechanical angle (TMA), is the angle between the mechanical axis of the tibia and the tangent to the tibial plateaus; it was measured medially. The HKS angle (H= Hip, K= Knee, S= Shaft) is the angle between the anatomical axis and the mechanical axis of the femur.

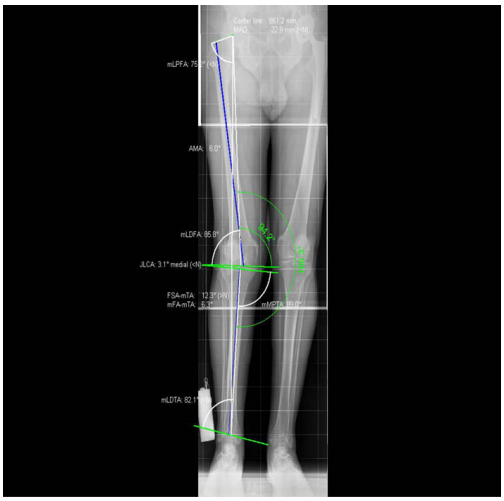

Figure 1. Angular measurements on a preoperative pangonogram

The centering of the prosthesis was determined by measuring the distance between the center of the prosthesis and that of the condyles (femoral implant) or the plateau (tibial implant). Tibial slope was also assessed. The measurement of the patellar height was obtained by calculating the Caton index. It consists [9] in relating the distance from the lower edge of the articular surface of the patella-antero-superior angle of the tibia (TA) to the purely articular length of the patella (PA). This TA/PA ratio is equal on average to 0.96 ± 0.134 in men and 0.99 ± 0.129 in women, i.e. not very different from 1. We considered that a patella was low when this ratio was between 0.6 and 0.8 and we considered that the patella was high when this ratio was greater than or equal to 1.2. For each case retained, the data of the medical file were recorded. The pre- and post-operative radiographs were analyzed with the QT3000 software (see Figures 1 to 5). The analysis of digital images assisted by software being more reproducible and more reliable than that of analog images [10-12]. All pre, per and post-operative data were recorded in an Excel spreadsheet. We used as specific material: digitized radiographs, the QT3000 software (AGFA Orthopedic tools), the medical records of the degenerative pathology of the knee from the UMC Sint-Pieter, the clinical follow-up sheets and the EPI info version 3.3 software.

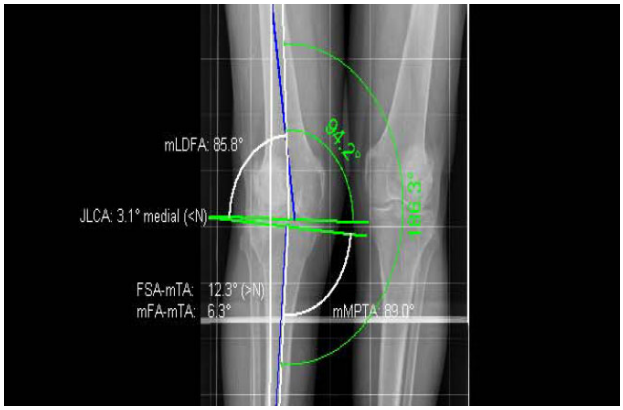

Figure 2. Knee angular measurements

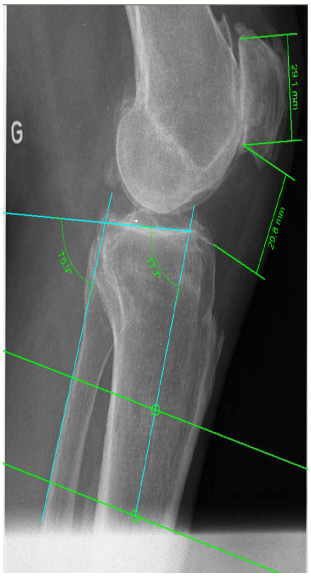

Figure 3. Measurement of the patellar height and the tibial slope on a profile knee X-ray

Figure 4. Post-operative pangonogram radiography

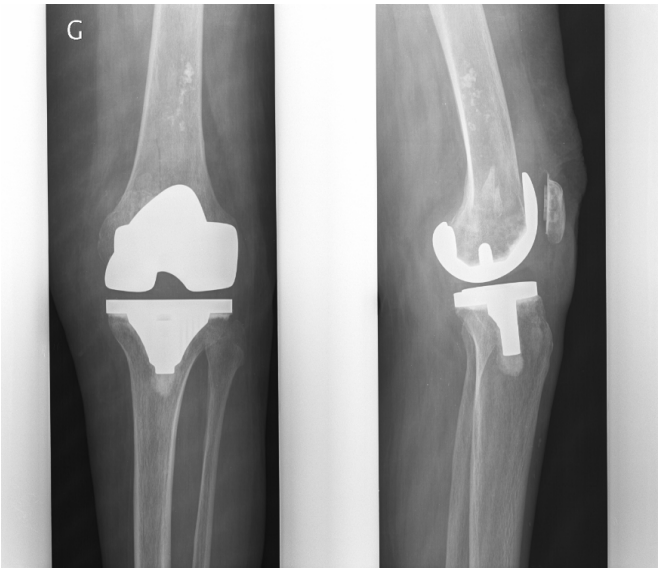

Figure 5. X-ray of an operated knee (front and leftviews)

RESULTS

Twenty-one knees operated between 2002 and 2005 for total arthroplasty at University Medical Center (UMC) Sint-Pieterin Brusselswere analyzed (pre, per, and post-operative data). Only 61.90% (respectively 47.62%) of the radiographs of mechanical axes showed no quality abnormality preoperatively (respectively postoperatively). The most common anomaly (44.44%) was the external rotation of the knee during the realisation of the preoperative X-ray. The intra-observer variation of the preoperative HKA angle ranged from 0° (minimum) to 1.7° (maximum) with an average of 0.38°. The mean inter-observer variation was 0.81° with extremes ranging from 0 to 3.9°. In the case where it was 3.9°, the hips were not clear. All other inter-observer variations were less than 2°. The mean change in the HKA angle after surgery was 7.36° [0.8°-16.7°]. No knees were aggravated. By comparing the postoperative HKA angles to normal, we find that 42.86% were normal, that is corrected at 180°±2° and 85.71% at 180°±3°. We had greater hypocorrections in major varus knees (3 cases). There was a strong correlation between the thickness of the distal femoral resection and the variation of the Alpha angle (correlation coefficient R = 0.85) and a medium correlation between the thickness of the proximal Tibial resection (in the center) and the variation of the Beta angle (correlation coefficient R = 0.70). In 100% of cases, we were able to predict distal femoral resections to $\pm$ 3 millimeters and in 17 cases (80% of cases), we were able to predict tibial resections to $\pm$ 3 millimeters. The average thickness of the patella before resection was 22.46 mm [20-26 mm]. The patellar resection was 10.69 mm with extremes ranging from 8 to 14 mm. The average thickness of the patella after cutting was 11.77 mm [10-14 mm]. The femoral implant was 0.98 mm [0-3.1 mm] outside of the center of the femur. The tibial implant was 1.01 mm [0-4.1 mm] out from the center of the tibia. The implants were therefore centered to the nearest millimetre. In 5 cases, the postoperative A and B tibial slopes were normal. In 13 cases at least one was normal. The mean preoperative A tibial slope was 81.97° [69.7-58.5°]. The mean preoperative B tibial slope was 82.23° [75.3-95.3°]. The mean postoperative A tibial slope was 82.36° [75.8-88.8°]. The mean postoperative B tibial slope was 84.47° [77.7-92.0°]. Caton's index preoperatively ranged from 0.66 to 1.23 with an average of 0.90. Postoperatively, it ranged from 0.52 to 1.91 with an average of 1.05. We had 6 patellar heights above 1.2 (high patellas) and 5 below 0.8 (low patellas).

DISCUSSION

Reliability of measurements

It seems very important to correctly perform digitalised radiographs of the mechanical axes of the lower limbs. Indeed, preoperative planning depends on strict adherence to a rigorous technique [13,14]. The measurement of the femoro-tibial angular deviation in the frontal plane requires taking the same X-ray image of the entire lower limb, hips and ankles included. The examination is most often performed standing in bipodal support. Positioning the knees strictly in front is not always easy, but is essential, because a rotation of the knees completely distorts the HKA measurement [3,16] even if the alpha angle is less so [16]. It is necessary to proceed by determining the bicondylar profile plane under televised fluoroscopy, make a tracing of the position of the feet in this profile, rotate the tracing by 90°, and place the patient on the tracing thus turned for the realization of the goniometry shot. . The standardization of this technique and of the femoro-tibial measurements was proposed by Duparc and Massare in 1967. The goniometry is based on a radiograph 120cm by 30 or 40cm long, making it possible to assess the entire lower limb: feet to the femoral heads. There are thus a very large number of variants in the literature in the definition of these anatomical points of reference:

- The upper femoral point remains, however, the easiest to determine: it is the center of the femoral head (see Figure 5);

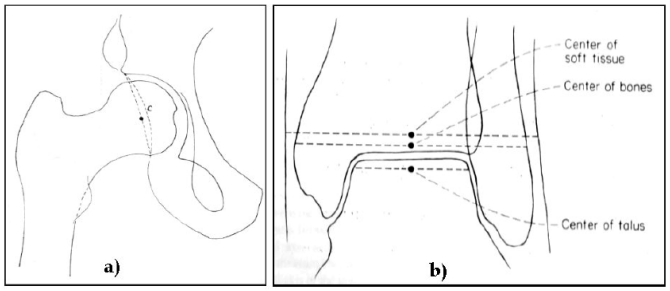

Figure 5. Center of Femoral Head and Ankle (Front Views)

- The center of the knee (see Figure 6), is the theoretical point of convergence between the tibial and femoral mechanical axes. This point is subject to many controversies [6]. We have opted for the middle of the thorns in our series.

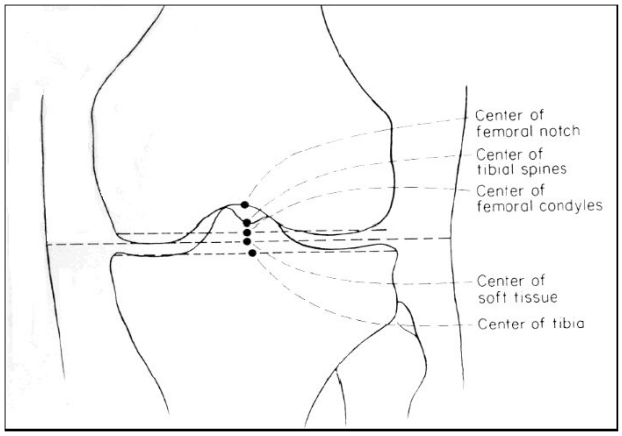

Figure 6. Center of Knee (Front View)

In the case of a translation of the tibia under the femur in the frontal plane, it is necessary to change the convention (see Figure 7). A single anatomical reference (knee center) is no longer sufficient, so two points are chosen: one on the distal femur, the other on the proximal tibia.

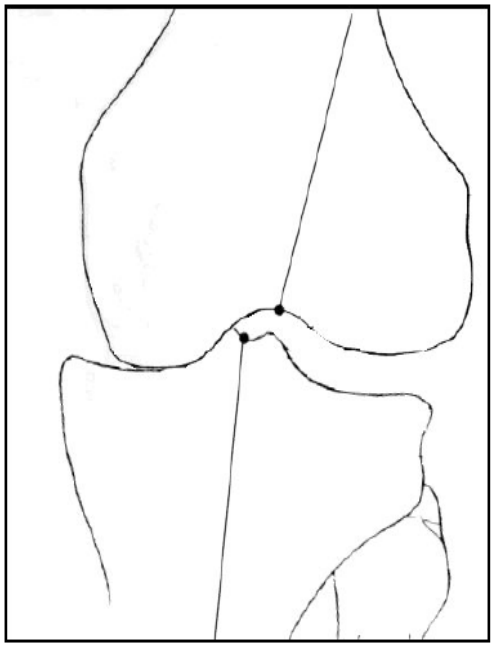

Figure 7. Center of the knee in case of translation of the tibia

In general, the highest point of the inter-condylar notch corresponds to the lower femoral point of the femoral mechanical axis and the middle of the tibial spines is the upper point of the tibial mechanical axis. Manual measurements are less reliable than digital measurements [3]. Semi-automatic measurement by software on digital radiographs is reliable, as Lonner [16] had already noticed in 1996 and Desmé [17] in 2002 : this is the one we used in our study. Like Howcroft [18], we reported lower intra-observer variation than inter-observer variation. These 2 variations remain small for the HKA angle which is the angle for which the number of gestures before the actual measurement is the greatest.

Angles study

We noted 2 residual deviations of more than 6° in our series. But, in both cases, they were large varum knees. Letenneur [15] observed more than 10% of them in his series and explained them by errors in bone cutting; the latter were more femoral in valgus knees (22%) and tibial in varus knees (23%). They were for this author, either isolated on one bone, or associated and then objectified on the 2 bones, being able to cancel each other out or add up. Concerning the 2 cases in our series, the preoperative radiography was of poor quality in one of the cases and in the other, there was simply an alpha angle undercorrection. In total, our series showed that 42.86% of knees operated by TKA are normal-corrected at 180°±2° and 85.71% at 180°±3°, whereas for Letenneur (34), 69% of his knees operated (208 cases) were realigned at 180°±3°.

Correlations

The quality of the correlation can be measured by a correlation coefficient r. It was calculated automatically by the analysis programs. The correlation coefficient is between -1 and +1. The further from zero, the better the correlation.

r = +1	positive perfectcorrelation
r = -1	negativeperfectcorrelation
r = 0	No correlation

a> 0	positive correlation
a< 0	negative correlation
a = 0	No correlation

The sign (a) of the slope of the correlation line gives the direction of the correlation, but not its quality. At the level of the distal condyle, it is logical to have a strong correlation between bone resections and variations in the alpha angle. Preoperative tibial plateau data appear more predictable centrally, with the correlation between bone resections and beta angle being stronger centrally than anteriorly and posteriorly. This would be due to the fact that cartilage wear at this level brings preoperative measurements closer to intraoperative measurements.

PREDICTIONS OF RESECTIONS

We were able to predict, to within 3 mm, the bone resections and therefore the angular corrections in more than 80% of the cases in our series. There is a moderate to strong correlation between bone resections and angular variations, but it is not perfect. The results of preoperative planning should therefore simply be guides, as Aslam [19] demonstrated so well in 2004, working on operated knees, in order to anticipate any gross errors. Also, preoperative planning appears interesting to prepare and facilitate total knee arthroplasty in elderly patients suffering from chronic and disabling knee osteoarthritis associated with mechanical axis deviation of the lower limbs.

Conclusion

The quality of preoperative radiographs is important in preoperative planning. She would rarely be perfect. The inter- and intra-observer variations are low for the HKA angle. Semi-automatic measurement by software on digital radiographs is therefore reliable. The HKA correction depends on the "release" and the alpha and beta angles. There is a moderate to strong correlation between bone resections and angular variations. We were able to predict to within 3 millimeters, on average, the bone resections and therefore the angular corrections.

Recommendations

At the end of this work, we recommend that radiologists always respect stricto sensu the technique of goniometry on which the pre-operative planning of TKA depends and that orthopedic surgeons include in Cameroon (and in countries with a similar level), TKA in the therapeutic arsenal for chronic and disabling knee osteoarthritis in the elderly and to ensure that preoperative planning is always carried out.

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