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BRIEF ARTICLE

Reliability of preoperative measurement with standardized templating in Total Knee Arthroplasty

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Abstract

AIM: To investigate the correlation between preoperative measurement in total knee arthroplasty and the prosthetic size implanted.

METHODS: A prospective double-blind study of 50 arthroplasties was performed. Firstly, the reliability and correspondence between the size of said measurement and the actual implant utilized was determined. Secondly, the existing correlation between the intra- and interobserver determinations with the intraclass correlation coefficient was analyzed.

RESULTS: An overall correspondence of 54%, improving up to 92% when the measured size admitted a difference of one size, was found. Good intra- and interobserver reliability with an intraclass correlation coefficient greater than 0.90 ($P < 0.001$) was also discovered.

CONCLUSION: Agreement between the preoperative measurement with standardized acetate templates and the prosthetic size implanted can be considered satisfactory. We thus conclude it is a reproducible technique.

Key words: Total knee arthroplasty; Templating; Preoperative measurement; Prosthetic size; Correlation coefficient

Core tip: Choosing the correct size in total knee arthroplasty is one of the factors known to the good evolution of this procedure. Preoperative evaluation using templates is a recommended step in achieving this goal. There are controversies in the literature on the correlation between this measurement and the size of the prosthesis finally implanted.

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INTRODUCTION

Preoperative planning in total knee replacement helps in making decisions and anticipating potentially severe problems that may arise during surgery[1,2]. X-rays in two projections that include the hip and ankle allow for the localization of the mechanical axis and the appropriate planning of the femoral angulation, the thickness of the polyethylene, the height of the joint line, and the ideal size of the prosthetic components.

Oversized components may cause tissue irritation or affect the lower extremity joints during articular stress. On the other hand, undersized components may lead to the exposure of the damaged bone, a greater peri-prosthetic osteolysis, and the overload of the articular contact zone with accentuated wearing down of the polyethylene insert[3].

Measurement with standardized templates on the preoperative X-ray is a commonly used practice in this type of surgery and some authors have proclaimed its advantages[4-9]. However, authors like Knight *et al*[10] or Heal *et al*[11] have pointed out its limitations. Schiffers *et al*[12] have even suggested using differing diagnostic methods such as computerized axial tomography.

The aim of this investigation was to ascertain the suitability of preoperative measurement of a prosthetic knee implant. Our hypothesis was that preoperative measurement would be reproducible, and thus help the surgeon in choosing the most suitable implant.

MATERIALS AND METHODS

A prospective double-blind study to assess the suitability of preoperative measurement of a prosthetic implant by evaluating 50 primary TKA's consecutively implanted was carried out. The first diagnosis was primary osteoarthritis in all cases.

The series was made up of 37 females (74%) and 13 males (26%). The average age and weight were 73.40 years (ranging from 57 to 84) and 76.45 kg (55 to 95) in the female subgroup. In the male subgroup, the average age was 73.38 years (63 to 88), and the average weight was 81.92 kg (68 to 98). The right side was involved in 30 cases and the left in twenty. There were no bilateral cases. Minimally invasive surgery (MIS), *via* mid-vastus approach, was carried out in 9 cases (18%).

Preoperative anteroposterior and lateral weight-bearing X-rays and a 30º patellar axial view were taken; a long standing radiograph that included the hip and the ankle was also done according to the specific protocol for this work. In order to make all the measurements reproducible, a constant and uniform distance between the X-ray tube and the knee was maintained.

The measuring was done by superimposing the acetate templates on the X-ray images. Two observer groups were formed (observer 1 and 2), as well as the implanting surgeon (neither of them knew the measurement of the other). The size implanted by the surgeon, who did not have knowledge of the measurement carried out previously, was considered the standard with which to compare. The TKA implanted was always the Triathlo® Knee System (Stryker, Mahwah, New Jersey, United States) with tibial, femoral, and patellar components cemented. The thickness of the polyethylene was decided by the surgeon during surgery according to the final mobility and stability obtained with the trial implants.

All data were analyzed with the statistical SPSS (V 15.9) software package. A tool for assessing reliability (Cronbach's Alpha > 0.95) was used throughout the process. All the variables were described by inputting the percentage and the number of cases as categorical variables. The quantitative variables were described as an average and a standard deviation. The suitability study was done by calculating the intraclass correlation coefficient (ICC), also denominated the "internal correlation coefficient" or "reliability coefficient", with a confidence interval of 95%. The relationship between the variables was described with contingency tables for the study of two categorical variables. The inference was studied with the χ^2 test or Fisher's exact test, as required. The inference was carried out with the *t* test. Finally, by applying logistic regression, a multivariant approximation was obtained by selecting the variables that previously showed a slight slide towards significance ($P < 0.20$). The level of significance was set at $P < 0.05$.

Table 1 Suitability of the implant size

		Frequency	Percentage
Femur	Yes	29	58%
	No	21	42%
Tibia	Yes	25	50%
	No	25	50%

Yes: Same exact size; No: Size different than the measured one.

Table 2 Differences between the measured size and the size implanted in the femur and tibia

	Frequency	Percentage
Femur		
-2 (2 sizes smaller)	2	4%
-1 (1 size smaller)	11	22%
0 (same size)	27	54%
1 (1 size larger)	8	16%
2 (2 sizes larger)	2	4%
Tibia		
-2 (2 sizes smaller)	0	0%
-1 (1 size smaller)	11	22%
0 (same size)	24	48%
1 (1 size larger)	13	26%
2 (2 sizes larger)	2	4%

RESULTS

The correlation between the femoral component measured and the one implanted was 55%, and 50% for the tibial component (Table 1). The overall value was 54%. In light of a variability of more or less a correlative size, the percentage increases up to 90% for the femur and 94% for the tibia (Table 2). There was a tendency to underestimate the size of the tibia for which the cause was unknown. The measured size was right for 58.2% of the women and 42.4% of the men. With reference to the side operated on, there seems to be a greater percentage adequate for the right-side at 60% while for the right-side it was 45%. When the MIS technique was used, the suitability percentage was 66.7% with a clear decrease of effectiveness in the measurement of the tibial component.

Intraobserver reliability was clearly correct in all cases; the lower limit of the CI was 95% of the ICC, which was greater than 0.90. It was statistically significant in all of them ($P < 0.001$). There was a tendency towards a slightly lower ICC in the case of the tibia compared to the femur, and the same tendency relative to the second observer in comparison to the first (Table 3). The study of the intraobserver results was carried out by comparing the measurements of observer 1 before and after the

Table 3 Intraclass correlation coefficient inter- and intraobserver values

	Femur	Tibia
Observer 1	0.989	0.974
Observer 2	0.960	0.944
Before operation	0.994	0.942
After operation	0.943	0.863
ICC	0.735	0.806

Intraclass correlation coefficient (ICC) for intraobserver study. $P < 0.001$ (before *vs* after, observer 1 *vs* observer 2, measured *vs* implanted).

operation with those of observer 2. Thus, it was possible to confirm the reproducibility of the measuring process on the same person by taking the readings at different times. The ICC was > 0.9 for observer 1, the same as for observer 2, and the same was true for both the femur and the tibia. That being the case, the measurement was considered valid and reproducible. The reading of the femur turned out to be slightly more reliable and reproducible than that of the tibial plate.

The interobserver study makes it possible to know whether different people can carry out the preoperative measurements and obtain the same or similar results. The first readings by observer 1 were compared with those of observer 2 and subsequently the second readings of those very same observers were also compared. Intra- and interobserver reliability was high in all of the cases (both groups of observers for both bones); the lower limit of the IC was 95% of the ICC, which was greater than 0.77. It was statistically significant in all of them ($P < 0.001$). Therefore, it can be said that the study with standardized templates can be reproduced with different observers. The reading of the femoral component is still better than the reading of the tibia, just like in the intraobserver study.

DISCUSSION

The measurement with templates should be a part of the systematic preoperative evaluation in TKA. It allows for finding the most adequate size of the implant (as exactly as possible) and the prevention of possible errors or technical difficulties at the time of surgery[13]. However, the aforementioned opinion is not uniform. Some studies[14] suggest that preoperative measuring is not currently substantially beneficial for the surgeon, since the correlation percentage stands at around 50%. Our study obtained a 54% reliability percentage for the measurement of the implanted prostheses. Although this figure is not very high, the percentage increases to 92% if one larger or smaller size is added. There are few works that assess intra- and interobserver reliability in the preoperative measuring of implants. Bothra *et al*[15] observed greater intraobserver than interobserver agreement. However, the differences between both readings were insignificant in terms of clinical practice. Good inter- and intraobserver agreement was demonstrated for both femoral and tibial templating in a recent work. The correct size of the implant was predicted in only 48% of the femoral and 55% of the tibial components[16]. Those figures are very similar to the results in the current study.

Preoperative measuring, if accompanied by checking/verification of the results after the operation also initiates a dynamic learning process as useful for the expert surgeon as for the resident in training. Therefore, this planning makes for a reduction in the learning curve of the surgeon[17]. It also shortens surgery duration, and facilitates the job of the surgical nurse and the adequate programming of the surgical theatre.

Howcroft *et al*[14] found greater agreement in the measurements of the tibia in comparison to the femur. The measurement was very similar for both components in this study when the average of the measurements was taken. It was slightly greater for the tibia, but the difference was not statistically significant. The slight difference seen might be influenced by the different anatomical characteristics of the tibia and the femur[18] as well as the projection of the bone segment in the radiography.

The measurement with standardized templates might not end up being very exact for different reasons, such as the incorrect superimposition of the templates on the part of the observer. The collaboration of the Radiology department is essential, as defects in the positioning of the member upon doing the X-rays or a deficient quality of the same can make the measure useless, or even lead to errors in the surgical procedure[19-21]. The acceptance of a uniform protocol agreed between surgeons and radiologists should avoid these errors.

As diverse authors indicate[22,23], the acquisition of digitalized X-rays may permit greater ease in the preoperative measuring of orthopedic implants. With this method, it is possible to select the magnification, and the superimposition of the digital templates is more exact and less subject to personal variables. Trickett *et al*[16] studied the correlation of measurements with digitalized templates from 40 TKA patients. The results were similar to those obtained with standardized acetate templates. The same findings were published by The *et al*[24] upon comparing analogical and digital templates in hip arthroplasties. Other authors[25,26] even find a greater frequency of errors with the latter compared to the acetate templates. Manual measurement may disappear with time, especially in certain countries, but measurement with standardized templates will still be the rule for many years to come. The profound change in hospital equipment required and the cost-benefit it yields will not be feasible in underdeveloped healthcare systems.

The utility of this preoperative practice can be confirmed with the results obtained herein. Measurement with standardized templates allows for finding the closest suitable implant size, facilitates the surgical technique, is a reproducible technique and can presumably improve the clinical outcomes of knee arthroplasties.

COMMENTS

Background

The measurement with templates should be a part of the systematic preoperative evaluation in total knee arthroplasty. It allows for finding the most adequate

size of the implant (as exactly as possible) and the prevention of possible errors or technical difficulties at the time of surgery.

Research frontiers

Measurement with standardized templates on the preoperative X-ray is a commonly used practice in this type of surgery and some authors have proclaimed its advantages. However, other authors have pointed out its limitations.

Innovations and breakthroughs

The study obtained a 54% reliability percentage for the measurement of the implanted prostheses. Although this figure is not very high, the percentage increases to 92% if one larger or smaller size is added. Good inter- and intraobserver agreement was demonstrated for both femoral and tibial templating.

Applications

Preoperative measuring, if accompanied by checking/verification of the results after the operation also initiates a dynamic learning process as useful for the expert surgeon as for the resident in training. Therefore, this planning makes for a reduction in the learning curve of the surgeon. It also shortens surgery duration, and facilitates the job of the surgical nurse and the adequate programming of the surgical theatre.

Terminology

Preoperative measuring (templating) was done by superimposing the acetate templates on the X-ray images of the knee.

Peer review

The utility of this preoperative practice can be confirmed with the results obtained herein. Measurement with standardized templates allows for finding the closest suitable implant size, facilitates the surgical technique, is a reproducible technique and can presumably improve the clinical outcomes of knee arthroplasties. Manual measurement may disappear with time, especially in certain countries, but measurement with standardized templates will still be the rule for many years to come.

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