Accuracy of Preoperative Templating in EM Computer Assisted Total Knee Arthroplasty

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Abstract

Introduction
In joint replacement surgery, meticulous preoperative planning allows the surgeon to perform the procedure precisely, avoid potential intra operative complications, and achieve good surgical results.
Patients and Methods
A retrospective review of the preoperative radiographs, templates, plans and operative reports of 30 consecutive primary total knee replacements using Nexgen EM computer assisted navigation was performed. There were 13 males and 17 females. The average age was 70 years. Four measurements were taken: femoral anteroposterior and lateral views, tibial anteroposterior and lateral views. Correlation between preoperatively templated size findings and intraoperative computer assisted size findings was performed.
Results
For the femoral component size, the templated size measuring from lateral view had the highest accuracy of 83.3 % (25/30 knees) and for the femoral AP view was 70 % (21/30 knees). For the tibial components, the highest prediction of the final component size was measured from tibia AP view with the accuracy of 80 % (24/30) and for the lateral tibial view; it was 56.6 % (17/30).
Conclusion
The lateral view of femur and AP view of the tibia gave the best agreement for the femoral component (83.3%) and tibial component (80%) respectively. Both values indicate high levels of agreement above chance. Preoperative templating may optimize surgical time and facilitate the identification of specific cases that require special implants.

Keywords
Templating; Preoperative; Total; Knee; Arthroplasty.

Introduction

Pre-operative planning is an essential step towards a successful total knee replacement [1, 2]. Unlike total hip arthroplasty, pre-operative templating in total knee arthroplasty (TKA) is not routinely used in all institutes[3]. Perhaps the conflicting reports regarding the accuracy of templating in TKA is one of the main reasons that drove many surgeons away from relying on templating for appropriate selection of implant size. To the extent that some studies have gone to recommend against preoperative templating as a reliable method to choose proper implant size[4–6], while others found it to be a reliable and effective method[7–9].

The aim of pre-operative templating is the selection of the proper size and orientation of both the tibial and femoral components, thus avoiding complications related to malalignment, over and under sizing of the components[2].

Although digital templating is becoming widely available, yet there has been no difference between the accuracy of digital and analogue templating as long as both are used correctly[4]. Perhaps many centers worldwide still find it difficult to implement a digital templating system due to cost related problems.

The objective of this study was the evaluation of the accuracy and reliability of pre-operative analogue templating in TKA, using the Electromagnetic (EM) navigation system.

Patients and Methods

A retrospective review of the preoperative radiographs, templates, plans and operative reports of 30 consecutive primary total knee replacements using

Nexgen EM computer assisted navigation system, that were conducted between the periods of March 2008 till October 2008 in Derriford hospital, Plymouth NHS Trust, United Kingdom. A single surgeon, who was a joint arthroplasty fellow during that period (primary author), conducted all surgeries.

The sample included 13 males (43 %) and 17 females (57 %), with a mean age of 70 years old. (Range 50-87 years).

Preoperative radiographs consisted of an anteroposterior (AP) and lateral view of the knee, and a long leg film. The AP and lateral view radiographs were magnified to 120 % and magnification was checked in all radiographs using a radiological marker (reference ball placed at the level of the joint). Standard templating using a transparency provided by the implant manufacturer was then conducted. Four measurements were obtained and recorded, including: femoral anteroposterior and lateral view, tibial anteroposterior and lateral view. Templating was done by a trainee who had received appropriate training in TKA templating, and the surgeon was blinded to the size chosen by the trainee.

For the femoral component; in the AP view, the predicted component was positioned perpendicular to the mechanical axis and covered both the medial and lateral condyles as much as possible, taking care not to overhang on each side. For the lateral view, the template was positioned to achieve maximal coverage of the distal femoral bone, while the anterior flange of the femoral component was flush with the anterior femoral cortex. The center of the prosthesis pointed along the longitudinal axis of the femoral shaft, avoiding flexion or extension of the femoral component.

For the AP view of the tibia; the template was placed on the tibial plateau with the tibial stem parallel to the mechanical axis. The largest size, which covered the greatest amount of host bone without overhanging, was selected. For the lateral view of the tibia, the template was placed with the tibial stem parallel to the anterior tibial cortex and adjusted so that the posterior slope best matched patient's own anatomy.

Intra operative sizing was done by two methods simultaneously, first was using the EM navigation system, the second method was manual selection by the surgeon. In this series there was 100 % agreement between the two methods.

The postoperative radiographs were then assessed to check the component size.

The preoperative radiographic template size and the final prosthesis size were recorded for each patient (table 1). The accuracy of the preoperative templating technique on each view was reported as a percentage.

This percentage was used to provide the degree of agreement between the preoperative template values and the actual components used.

Table 1: Different sizes of tibial and femoral sized recorded after preoperative templating

Femoral component	Number	Tibial component	Number
E	12	4	10
F	9	5	9
G	6	6	6
D	2	3	2
C	1	7	1

Results

For the femoral component size, the accuracy of the lateral femoral view in predicting the actual size was 83.3 % (25/30 knees), and for the femoral AP view it was 70 % (21/30 knees). The accuracy was 100% when we considered a margin of error of one size above or one size below between the implanted prosthesis and the template measurement as an agreement.

For the tibial components, the AP view showed the highest degree of agreement between the implanted prosthesis size and templated size at 80 % (24/30), and for the lateral tibial view; it was 56.6 % (17/30). This accuracy increased to 93.3% of templated sizes within one size above or below those actually used.

Consequently, the lateral view of femur and AP view of the tibia gave the highest accuracy for the femoral component (83.3%) and tibial component (80%) respectively.

Post-operative assessment of the component size revealed that all components were of appropriate size.

Discussion

Proper component sizing is mandatory for a successful TKA; an oversized component would lead to overhanging, soft tissue irritation and affect the balancing efforts. An undersized component would leave

uncovered cancellous bone, which would increase the post-operative blood loss, and increase incidence of wear. Additionally over sizing or under sizing would alter the tissue tension and cause patellofemoral maltracking.[10]

This study showed that standard analogue preoperative templating is a reliable method for predicting the actual component size. Preoperative templating would aid the surgeon in selecting the appropriate component size; the surgeon would select the component size intra-operatively during the procedure, and compare it to the planned size, thus monitoring the accuracy of his measurements. Additionally, preoperative templating would save the operative time, as the implants will be available in the operative room during surgery. In total hip arthroplasty, Della Valle et al found that in their institute, without preoperative preparation, there was a 2 min delay in bringing each of the 2 components from the implant room to the operating room. Thus, by having both components available in the operating room, up to 6.6 hours could be saved for every 100 surgeries.[11]

Furthermore, Hsu et al who used template directed instrumentation (TDI), which is a technique that involves limiting the number of instrumentation in the operative theater according to the outcomes of the pre-operative templating, found that TDI saved 9621 USD over their 1 year study period [9].

Recent studies have focused on digital templating using computer-assisted software. Although there is an increasing trend for digital templating, the costs related with these systems cannot be easily fulfilled in all hospitals. Additionally, Jain et al found no statistical difference between digital and analogue methods of TKA templating[4].

Whether analogue or digital templating, recent studies have shown contradicting results regarding the accuracy of pre-operative templating n TKA (Table 2).

Table 2: Comparison of the different results of preoperative templating in TKA

Authors	Number of knees	Method of templating	Exact Femoral Match	Exact Tibial Match	Femoral +/-1 Match	Tibial +/- 1 Match
Unnanuntana et al[12]	113	Analogue	50.4 %	55.8 %	97.3	97 %
Del Gaizo et al [13]	200	Analogue	82 %	79.5 %	97 %	92 %
Trickett et al[6]	40	Digital	48 %	55 %	98 %	100 %
Miller at al [14]	25 with marker 25 without marker	Digital Digital	52 % 64 %	48 % 60 %	100 % 100 %	96 % 100 %
Hsu et al	82	Digital	83 %	90 %	100 %	100 %
Herandez-Vaquero et al[7]	50	Digital	55 %	50 %	90 %	94 %
Kniesel et al[15]	46 with marker 48 without marker	Digital Digital	52 % 33 %	72 % 46 %	98 % 94 %	100 % 88 %

Herandez-Vaquero et al [7] and Unnanuntana et al[12] reported lower accuracy, however both studies did not use a radiological marker to calibrate the magnification of their radiographs. The same can be said about the 48 cases that were templated by Kniesel et al[15] without a radiological marker. On the other hand, the results of Hsu et al[9], who used a radiological marker, were consistent with our findings. Although Trickett et al[6] used a radiological marker, they reported low accuracy, they attributed their findings to the design of the system they used; which had 9 sizes for both the femoral and the tibial components and a 4-5 mm size difference between each component.

In this study the lateral view of the femur and the AP view of the tibia were the most accurate in predicting the final component size (83.3 % and 80 % respectively). These results were also consistent with the findings of Unnanuntana et al[12]. However other studies did not comment separately about the AP and lateral views of the femur and tibia[6, 7, 9, 14].

Perhaps the reasons for the discrepancy of the readings between the pre-operative measurements and the actual measurements can fall into three major categories. First are factors related to the radiographs obtained, which include faulty magnification, improper positioning and rotation. The second are patient related factors; which may include malalignment or flexion contracture, Heal and Blewitt[16] found that when the degree of knee flexion contracture increased, the distance between the knee and x-ray plate increased as well, which in turn resulted in a greater degree of magnification on the radiographs. Lastly are technique related factors, which aim to balance the extension and flexion gaps to achieve the desired range of motion.

We believe that the usage of the EM navigation sys-

tem added to the strength of this study, as it added an objective measurement to the final implant size. Another strength is the usage of a radiological marker to confirm the appropriate magnification of the radiographs, and the fact that the surgeon was blinded to the template size. Potential weaknesses include the sample size, the retrospective design, and that preoperative templating was done by a single assessor, consequently inter and intra observer reliability were not measured.

We believe that more studies are warranted to further validate the effectiveness of pre operative templating in TKA, and more data is needed to reach a gold standard regarding the optimal templating technique.

Conclusion

Although pre-operative templating in total knee arthroplasty is not 100 % accurate, yet it is a good indicator of the final component size. The lateral view of the femur and the AP view of the tibia gave the best predictors of the final component size.

The Authors Declare that there are no conflict of interests related to this study.

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