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Original Article

The accuracy and reliability of pre-operative templating in revision total knee arthroplasty. A comparison of analogue and digital methods

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ABSTRACT

Aims: To determine whether the size of the prostheses used in revision knee arthroplasty may be accurately and reproducibly predicted using analogue or digital pre-operative templating techniques.
Methods: Pre-operative radiographs were templated using analogue radiographs and acetate templates, digital radiographs and acetate templates and digital radiographs and digital templating software.
Results: Overall accuracy of predicting the size of implant used at surgery was 44%. There was no significant difference in the accuracy of the various templating techniques ($p = 0.098$).
Conclusions: Templating in revision knee arthroplasty is neither of suitable accuracy nor reliability enough to safely recommend its use for implant size prediction.

1. Introduction

Pre-operative planning is recommended for all surgery. Pre-operative templating has become very popular when planning orthopaedic surgical procedures and is extensively used in arthroplasty surgery. It is suggested that templating is a useful tool in aiding the surgeon to determine both the size and orientation of the prosthesis that is to be inserted.[1–4]

Many studies have reviewed the accuracy of templating in both primary knee and primary hip arthroplasty.[5,6] The consensus is that it should not be used as an absolute guide but merely as a general guide as to the size of the prosthesis to be inserted. This is due to most studies demonstrating

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discrepancies in the predicted prosthesis size and the actual prosthesis size used.[1–6]

It has also been proposed that templating may have a role in revision arthroplasty.[2] It was suggested that templating is excellent at predicting the size of a primary prosthesis to within one size, either larger or smaller. The suggestion being that such templating may identify the required revision prosthesis to within one size. This would decrease the need for a wide range of extensive and less used stock being kept on site and permit the ordering in of the necessary sizes on demand. As a result, this may be more cost effective.[2]

With most orthopaedic departments now utilising digital rather than analogue radiographs, the templating techniques have changed to involve computer aided design (CAD) software rather than the use of acetate templates for either analogue or digital radiographs.

The aim of this study was to determine if the size of the prostheses used in revision knee surgery could be accurately and reproducibly predicted by pre-operative templating. We also aimed to assess whether analogue or digital radiographs, and manual acetate or computer-aided templating had an effect on the accuracy of the templating.

2. Patients and methods

Ten patients underwent revision knee arthroplasty at our unit. Each patient had both digital and analogue pre-operative antero–posterior (AP) and lateral radiographs. All received the Nexgen LCCK prosthesis (Zimmer, Warsaw, Indiana, USA).

The pre-operative radiographs were retrospectively templated for revision total knee replacement by two consultants with a specialist interest in revision lower limb arthroplasty (JP & JK). Each radiograph was templated using three different techniques; analogue radiograph and manual acetate template (Analogue & Acetate – AA), digital radiograph and manual acetate template (Digital & Acetate – DA) and digital radiograph and Orthoview computer aided design template (Digital & Orthoview – DO).

This process was repeated following a four-month period with an alteration in the sequence of the radiographs displayed. The findings were then compared to the actual size of the implant used at the time of surgery as documented in the operation note. With these findings we were able to analyse the accuracy and reproducibility of templating and determine which was the superior technique for templating (AA, DA or DO).

All pre-operative radiographs that were templated had been taken within a close time period to surgery thereby negating any possibility of a change in the bone stock of the patient, which may influence the templated prosthesis sizes.

The AA group was the use of an analogue radiograph and the standard acetate template. The DA group involved the use of a digital radiograph and an acetate template. This was possible as there was a calibration ball (measuring 2.54 cm in diameter) on the digital radiograph. The radiograph size was altered until this ball measured the actual size of 2.54 cm on the acetate. The DO group used digital radiographs and a computer software programme that was able to calibrate appropriate sizes of the prosthesis templates from the calibration ball mentioned previously.

Accuracy was determined by comparing the templated size of the implant to the actual implant size used. We then assessed the accuracy to within one size of the size of implant used at the time of surgery, either one size too big or one size too small. Comparing the kappa scores for intra-observer and inter-observer errors and determining the Pearson coefficient determined reproducibility, and therefore reliability. The accuracy and reproducibility of each of the different modes of templating was observed to determine which was the most accurate and which the most reproducible.

3. Results

3.1. Accuracy

The overall accuracy of predicting the correct size of implant used in the surgery was 44%. The accuracy of the different templating techniques is summarised in Fig. 1.

The accuracy of predicting the femoral component to within one size of that used at the time of surgery was 91%. The accuracy of predicting the tibial component to within one size was 85% overall.

3.2. Reproducibility

The overall intra-observer error demonstrated a kappa value of 0.52 that is described as moderate agreement. The overall inter-observer error resulted in a kappa score of 0.467 that is also described as moderate agreement.

The overall Pearson coefficient was 0.711 suggesting strong correlation between the templated sizes suggested by the surgeons templating the radiographs.

3.3. Templating technique

The AA group had the highest overall exact accuracy of 54% and the DO group was the lowest at 37.5%. Accuracy improved when measuring accuracy within one size with each of the templating techniques. There was no statistically significant difference between the three groups in terms of accuracy,

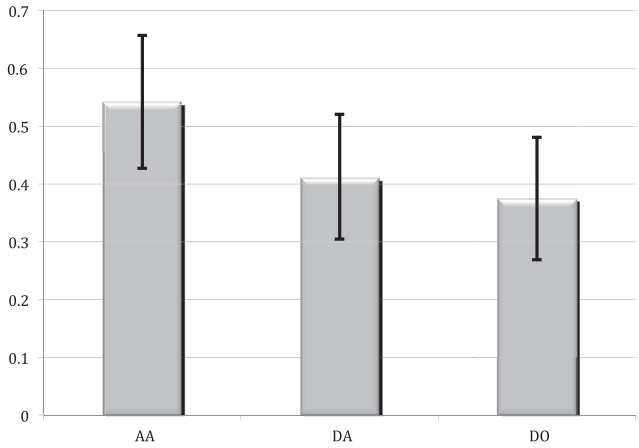

Fig. 1 – Accuracy of different templating techniques with 95% confidence interval.

$p = 0.098$ (Chi^2 test). The exact accuracy and accuracy to within one size for the different types of templating is summarised in Table 1.

The AA group demonstrated the highest kappa value, describing substantial agreement with both intra-observer and inter-observer errors. It also had the highest Pearson coefficient suggesting the best correlation between the templated sizes of all the different templating techniques. The lowest kappa value observed (fair agreement) was with the DO group as was the lowest Pearson coefficient. Table 2 shows the kappa values for each of the templating techniques. Pearson coefficient values for each of the templating techniques are shown in Table 3.

Of the cases that were not predicted to be the correct size, there was variation among the 3 templating techniques as to whether the trend was to undersize rather than oversize both components. These trends are summarised in Fig. 2.

4. Discussion

Templating for primary total knee replacement (TKR) is a well-recognised part of pre-operative planning and is recommended by many. Manufacturers provide similar templates for use in revision total knee replacement (R-TKR) as those for TKR. Surgeons use these templates to help plan surgery.

While many studies have investigated both the accuracy and reliability of templating in TKR, we did not find any in the literature that investigated the accuracy and reliability of templating in R-TKR. There is literature to aid pre-operative planning in R-TKR; however no comment is made regarding formal templating.[3,7–9]

4.1. Accuracy

We demonstrated an overall accuracy in R-TKR of 44% which is comparable to that for TKR[1,2,6,10,11] although is less than some in the literature.[5,12] When assessing accuracy to within one size of the actual size of implant used we demonstrated 91% accuracy for the femur and 85% accuracy for the tibia. This is lower than the majority of findings in the literature for TKR.[1,2,11,13,14] A comparison of the findings in the literature is shown in Table 4.

We feel the suggestion that templating for revision surgery would be beneficial as it would improve the cost-effectiveness of R-TKR[2] does not stand true as our findings suggest that templating for R-TKR is not accurate enough to confidently state that the templated size will be within one size of that used at surgery.

Table 1 – Accuracy of variable templating techniques overall and to within one size.

	Accuracy %		Accuracy (+/− 1 size) %	
	Femur	Tibia	Femur	Tibia
Analogue Acetate (AA)	52.8	55.6	100	85
Digital Acetate (DA)	50	32.5	85	82.5
Digital Orthoview (DO)	37.5	37.5	87.5	87.5

Table 2 – Kappa scores of reliability for variable templating techniques.

	Analogue Acetate (AA)	Digital Acetate (DA)	Digital Orthoview (DO)
Intra-observer error	0.73 (Substantial)	0.50 (Moderate)	0.33 (Fair)
Inter-observer error	0.63 (Substantial)	0.40 (Fair)	0.33 (Fair)

4.2. Reproducibility

The overall intra-observer error for our study was 0.52, which is in keeping with some of the literature for TKR templating[2,4] although not as reproducible as other studies have found.[1,6,14] The inter-observer error for our study was 0.467 which is again similar with the two studies that had a similar intra-observer error[2,4] but lower than other studies in the literature.[1,6] Such intra-observer and inter-observer errors as those found in our study would suggest only moderate agreement overall which we feel is not of a suitable enough level of reproducibility or reliability to support the use of templating in R-TKR. Interestingly the Pearson coefficient suggested strong agreement between the templated sizes proposed by the two surgeons thereby suggesting that the inadequate accuracy of templating is reproducibly inadequate.

4.3. Templating technique

Previous studies have investigated the differences between analogue and digital templating for TKR.[6,13,14] Some have suggested that digital templating was more accurate,[6] whereas some have suggested that there was no significant advantage with digital templating[14] or that digital was at least as accurate as acetate templating.[13]

We analysed the differences for three different techniques for templating. With regards to accuracy we found that templating analogue radiographs with an acetate template (AA) was the most accurate and the Orthoview templating with digital radiographs (DO) was the least accurate. When extended to accuracy within one size the results were more similar between the three groups. The only group to have 100% accuracy was the femoral implant for the AA group. All the other subgroups were near 85% accuracy.

The AA group also had the highest intra-observer and inter-observer values suggesting that this was the most reproducible and reliable technique. Again the lowest values were in the DO group suggesting that the digital style of templating is less reproducible and reliable.

Table 3 – Pearson coefficient of variable templating techniques.

	Analogue Acetate (AA)		Digital Acetate (DA)		Digital Orthoview (DO)	
	Femur	Tibia	Femur	Tibia	Femur	Tibia
Pearson coefficient	0.951	0.852	0.828	0.867	0.333	0.432

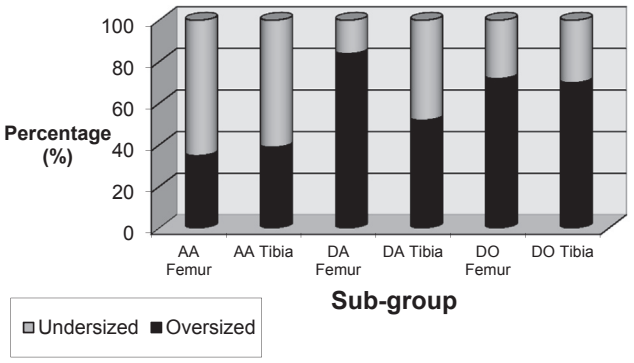

Fig. 2 – Trends in over-sizing and under-sizing in cases that did not predict the correct size of implant.

Interestingly the trends in AA group was to undersize both components whereas the trend for the DO group was to oversize both components. Other studies have suggested that under-sizing is a problem for both forms of templating.[6]

Our third group which involved the use of digital radiographs and acetate templates (DA) produced findings that were less accurate and reliable than the AA group but more accurate and reliable than the DO group.

4.4. *Alternatives*

There may be a number of reasons for the poor accuracy and reliability of templating in R-TKR, including the difficulty in predicting the potentially large amount of loss of bone stock from a plain radiograph pre-operatively, partially because of the presence of an existing prosthesis.

Other methods of pre-operative planning for R-TKR have been described in the literature and may be more accurate and reliable. Rather than limit the planning to purely radiographic templating, it is recommended that the pre-operative examination of the collateral ligaments combined with radiographs to determine bone stock and the joint line can result in 99% of R-TKR procedures being stable for the patient.[9] A similar step wise approach is also advocated elsewhere,[7] whereas others have suggested 4 other predictors of bone loss.[8] It may be that more extensive imaging is more reliable in assessing the amount of bone stock in R-TKR surgery.[15]

Table 4 – Comparison of our findings with those described for primary TKR.

Study	Accuracy %		Accuracy (+/– 1 size) %	
	Femur	Tibia	Femur	Tibia
Primary TKR				
Trickett et al[1]	48	55	–	–
Del Gaizo et al[12]	82.5	79.5	–	–
Lewis et al (digital)[14]	80	40	100	100
Lewis et al (analogue)[14]	55	50	100	100
Aslam et al[11]	49	67	89	92
The et al (analogue)[6]	8	14	64	69
The et al (digital)[6]	55	52	92	94
Howcroft et al[2]	38–62	53–75	100	100
Revision TKR				
Jain et al	46.8	41.9	91	85

4.5. *Overall*

We acknowledge that we had small numbers for this study. This was due to the small number of patients that had both analogue and digital pre-operative radiographs, which was required in order to provide the comparison. This was only possible because of a transition period at our hospital where the analogue system was being phased out in favour of a modern digital system. As a result some patients had duplicated radiographs in both analogue and digital forms and it was this cohort that we were able to use for this study.

Our overall findings are such that we would not recommend templating as being accurate or reliable enough with analogue or digital radiographs and various templating techniques to be used confidently and safely in R-TKR to predict the size of prosthesis required, even to within one size.

Conflicts of interest

All authors have none to declare.

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