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ORIGINAL STUDY

Reliability of preoperative templating in total knee arthroplasty

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The purpose of this study was to determine the reliability of preoperative templating in primary total knee arthroplasty and the influence of the seniority of the surgeon on templating. A retrospective study of 25 randomly selected total knee replacements was undertaken, with templating of preoperative radiographs by four surgical staff members. These included a consultant, a specialist registrar and two senior house officers. Reliability for an exact match between template size and implant actually used was 49% for the femoral component and 67% for the tibial component. The statistical agreement between templated size and actual implant size was classed as only fair to moderate. There was no statistical difference in templating reliability between junior and senior surgical staff. These results indicate that the current system of templating for total knee arthoplasties is prone to error and can only be used as an approximate guide.

INTRODUCTION

Preoperative templating is considered important in orthopaedic surgery. We are provided with templates for multiple prosthetic designs and use them as a basis for deciding on the implant size inserted into our patients. Knowledge of implant design and appropriate interpretation of radiographs plays an important role to achieve the best functional results for our patients. The survival of an implant is critically dependant on understanding the normal mechanical axis and ensuring the correct alignment of the prosthesis. However this system of preoperative planning is not without its faults which have been highlighted by recent publications (*1*). The use of 'micro' digitalised radiographs and use of non standardised views provide an additional margin for error. We set out to determine whether templating was reliable using a weighted kappa coefficient and whether the seniority of the surgeon made a difference to the accuracy of templating.

We report the preliminary results of our recent audit and evaluation of templating in total knee arthroplasty, with a series of 25 patients evaluated by a consultant, a specialist registrar and two senior house officers . The overall reliability of templating size versus actual size used was examined for all four investigators.

METHOD

Twenty four patients who had undergone total knee arthroplasty were randomly selected from a surgical database. There were 25 total knee arthroplasties in this group. All patients underwent anteroposterior and later-

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al knee radiographs prior to surgery. Radiographs were taken with a standardised method to minimise magnification errors. All patients underwent total knee arthroplasty using a cemented bicondylar knee replacement (PFC, Johnson and Johnson).

All identifying markers or templating markers had been removed from the radiographs prior to assessment by surgical staff. Each radiograph was independently reviewed by a consultant, a specialist registrar and two senior house officers (SHO's).

No reviewer had been associated with the surgery or had prior knowledge of implants used.

RESULTS

Epidemiology

There were 10 male patients and 14 female patients. Twenty five total knee arthroplasties were carried out in total, with one case bilateral. Twenty three of the 25 knee replacements were right sided. The mean age of the patients was 73 years (range, 53 to 81 years). The indication for arthroplasty was osteoarthritis in all cases.

Templating size versus Actual Size

The overall reliability of templating size versus actual size used was examined for all four investigators (table I, II). For femoral components the templated size was the same as the actual size used in 49% of cases. This increased to 89% for templated sizes within one size above or below that used. Eleven percent had a discrepancy equal to or greater than two sizes. For the tibial components, the templated size was the same as the actual size in 67% of cases ; 92% were within one size, and only 8% were two sizes or more adrift.

Statistical analysis of templated size and actual size indicated only a fair to moderate agreement using the weighted kappa test.

Weighted kappa

Unweighted kappa coefficients take no account of the degree of disagreement – all are treated equally. The weighted kappa gives weights to disagreements according to the magnitude of the discrepancy. Disagreement near the main diagonal is treated as less significant than disagreement far from the main diagonal. If all responses are in agreement, kappa is 1. If there is no more agreement than that expected by chance kappa is 0. A kappa of less than 0 indicates less agreement than that expected by chance. Below is an indication of the strength of agreements for a range of kappa values (table III).

Table I. — Femoral component : Templated versus Size Used (All observers)

Templated Size	No. Knees	%
3 larger	1	1
2 larger	5	5
1 larger	20	20
Same	49	49
1 smaller	20	20
2 smaller	4	4
3 smaller	1	1

Table II. — Tibial Component. Templated versus Size Used (All observers)

Templated Size	No. Knees	%
3 larger	3	3
2 larger	4	4
1 larger	11	11
Same	67	67
1 smaller	14	14
2 smaller	1	1
3 smaller	0	0

Agreement between each surgeons' templated size and the actual size

The results in table IV show that the agreement between each surgeon's templated size and the actual size used are not very high (all are classed as either fair or moderate).

SHO 1 has the highest agreement for both femur and tibia. The agreement for the tibia is consistently higher than that of the femur for all surgeons (table IV).

Table III. — Weighted kappa

< 0.20	Poor
0.21-0.40	Fair
0.41-0.60	Moderate
0.61-0.80	Good
0.81-1.00	Very good

Table IV. — Agreement between each surgeons' templated size and the actual size

	Comparison to actual	Weighted		
		Agreement	Expected Agreement	Kappa
Femur	SHO 1	82.7	62.0	0.54
	SHO 2	73.3	66.2	0.21
	Registrar	82.7	66.2	0.49
	Consultant	77.3	68.0	0.29
Tibia	SHO 1	88.0	69.9	0.60
	SHO 2	83.0	74.0	0.35
	Registrar	90.0	76.7	0.57
	Consultant	88.0	75.8	0.51

Agreement between surgeons' templated sizes

The results in table V show the agreement in templated sizes between the surgeons. It can be seen that, with the exception of SHO 2 and consultant (femur) (which is a fair agreement), all agreements are rated as moderate or good (table V).

McNemar's test for difference in proportion of correct templated size

The results in table VI show whether the proportion of correctly templated knees differs between surgeons. It can be seen that for the majority of comparisons there is no evidence of a difference. The only consistent difference across both templates is between SHO 1 and SHO 2 (with SHO 1 correctly templating significantly more femurs and tibias than SHO 2). The results also show that the registrar has correctly templated significantly more tibias than SHO 2 (p value = 0.020). There are no other significant differences, indicating that there is no evidence that the seniority of the surgeon affects the results (table VI).

Table V. — Agreement between surgeons' templated sizes

Femur

Surgeon 1	Surgeon 2	Weighted		
		Agreement	Expected Agreement	Kappa
SHO 1	SHO 2	82.7	68.6	0.45
	Registrar	89.3	64.4	0.70
	Consultant	78.7	64.0	0.41
SHO 2	Registrar	74.0	54.8	0.42
	Consultant	66.0	51.0	0.31
Registrar	Consultant	84.0	55.5	0.64

Tibia

Surgeon 1	Surgeon 2	Weighted		
		Agreement	Expected Agreement	Kappa
SHO 1	SHO 2	86.7	68.1	0.58
	Registrar	88.0	69.0	0.61
	Consultant	90.7	69.7	0.69
SHO 2	Registrar	82.7	64.0	0.52
	Consultant	90.7	66.1	0.72
Registrar	Consultant	89.3	67.2	0.68

Table VI. — McNemar's test for difference in proportion of correct templated size

Femur

Surgeon 1	Surgeon 2	p value
SHO 1	SHO 2	0.034
	Registrar	0.71
	Consultant	0.32
SHO 2	Registrar	0.13
	Consultant	0.37
Registrar	Consultant	0.41

Tibia

Surgeon 1	Surgeon 2	p value
SHO 1	SHO 2	0.034
	Registrar	0.65
	Consultant	0.41
SHO 2	Registrar	0.020
	Consultant	0.10
Registrar	Consultant	0.18

Chi squared test for a trend

The chi-squared test for a trend was used to assess whether the seniority of the surgeon affected the results. The results are highly non-significant with p values of 0.72 and 0.93 for the femur and tibia respectively. This suggests that the seniority of the surgeon makes no significant difference to the accuracy of the template.

DISCUSSION

Preoperative templating in total knee arthroplasty is routinely performed by surgeons prior to surgery. The aims of templating are to determine the size of implant required and to anticipate any problems that may arise due to abnormalities of mechanical alignment and bone stock. This theoretically should allow a reduction in surgical time and reduce complications, by allowing the surgical team to have appropriate implant sizes and special equipment ready if needed (*2*).

Previous studies have been performed on uncemented hip and unicondylar knee arthoplasties (*1, 3*). Both found that the reliability for an exact match between template and actual implant size used was only approximately 50%.

It was felt important to understand more fully the errors in sizing, as undersized components may lead to iatrogenic fracturing, and oversized components may result in early loosening (*7*). Furthermore, magnification errors due to fixed flexion deformities are theoretically more likely to result in undersizing of components.

Overall reliability

The overall accuracy of templating by all four reviewers was poor, with an exact match of 49% for the femoral component and 67% for the tibial component. The overall accuracy of templating was higher for the tibial implant. This goes for an exact match and also for within 1 size discrepancy, with the reliability of templating tibial components 92% versus 89% in femoral components. The statistical agreement between templated size and actual implant size was only fair to moderate, using the weighted kappa test.

Technical experience

There were no significant interobserver differences, with agreement moderate to good, suggesting that errors were occurring as a group rather than individually. Furthermore, there was no relationship between surgical seniority and reliability of templating based on the proportion of correctly templated knees (McNemar's test and Chi squared). Previous studies have not found that seniority or experience increased the accuracy of templating (*1*).

Radiographic errors

Variability in sizing may be related to rotation of the radiograph (*5*). This is supported by the fact that the femoral component was more difficult to size accurately, and is more prone to rotation than the tibia on AP radiographs. This discrepancy may be the result of greater rotational differences in the femur during AP radiographs. On lateral views, differentiating between medial and lateral femoral condyles, especially in the presence of degenerative osteoarthritic changes, has been singled out as a point of error in unicondylar knee arthroplasty (*1*).

Fixed flexion deformity

Magnification errors caused by fixed flexion deformity have been identified as a possible source of error in knee templating (*5*). This may account for a sizing error of plus one size with a flexum deformity of 20°, and plus two sizes for a deformity of 30°. Similar problems have been noted in total hip arthroplasty, with patient weight or obesity accounting for magnification errors ranging from 14% to 26%. Methods for reducing magnification error include the use of a specified marker on radiographs, such as a coin. Use of a simple coin method increased sizing accuracy from 59% to 69% in the assessment of hip radiographs (*4*).

Flexion space balancing

The size of the femoral component has been shown to be related to the surgical technique used during knee arthroplasty. A technique based on lig-

ament balancing to determine the femoral size may lead to smaller sizes than those based on anatomical sizing alone (*6*). This may explain why the accuracy is lower for the femur than for the tibia.

CONCLUSION

This study confirms that there is a lack of reliability in the current system of knee arthroplasty assessment by preoperative templating and this is not related to the seniority of the surgeon. The exact size of the prosthesis has been predicted for 49% of femoral and 67% of tibial components. Furthermore, this study would strongly suggest that a minimum of 2 sizes larger and smaller should be available in the operating theatre.

A reappraisal of both the templating technique and radiographic assessment, including the use of simple methods to determine magnification, is indicated. Computer assisted navigation systems have been recently introduced in the United Kingdom and may play an important role in the future, in allowing preoperative and intraoperative assessment of implant size and position.

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