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Original Article

Accuracy of templating the acetabular cup size in Total Hip Replacement using conventional acetate templates on digital radiographs

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ABSTRACT

Objective: Templating of the acetabular cup size in Total Hip Replacement (THR) is normally done using conventional radiographs. As these are being replaced by digital radiographs, it has become essential to create a technique of templating using digital films. We describe a technique that involves templating the digital films using the universally available acetate templates for THR without the use of special software.

Materials and methods: Preoperative digital radiographs of the pelvis were taken with a 30 mm diameter spherical metal ball strapped over the greater trochanter. Using standard acetate templates provided by the implant company on magnified digital radiographs, the size of the metal ball (X mm) and acetabular cup (Y mm) were determined. The size of the acetabular cup to be implanted was estimated using the formula $30 \times Y/X$. The estimated size was compared with the actual size of the cup used at surgery.

Results: Using this technique, it was possible to accurately predict the acetabular cup size in 28/40 (70%) of the hips. When the accuracy to within one size was considered, templating was correct in 90% (36/40). When assessed by two independent observers, there was good intra-observer and inter-observer reliability with intra-class correlation coefficient values greater than 0.8.

Conclusion: It was possible to accurately and reliably predict the size of the acetabular cup, using acetate templates on digital films, without any digital templates.

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Key message:

Acetabular cup templating in Total Hip Replacement (THR) using digital radiographs is an easy and accurate method and can be done without the need of any special software.

1. Introduction

The purpose of Total Hip Replacement surgery (THR) is to provide pain relief, good range of hip movement and restoration of normal hip function. To restore the normal hip biomechanics, it is essential that the prosthetic cup used to fit the acetabulum is of the correct size and also placed in the correct position. During surgery, the acetabulum is reamed in 2 mm increments till a “good fit” is obtained. The reaming is done till the subchondral bone is just exposed. The uncemented cup, either of the same diameter or 1–2 mm bigger is then “jammed” as a “press fit” into the reamed acetabulum. If the fit is not exact, the cup would either be too loose or may not be seated adequately in the acetabulum. Templating helps us determine the size of the cup preoperatively.^{1–3}

Currently, pre-operative templating is done using “conventional X-rays”, which produce a magnification of 110–120%. To determine the size of the acetabular cup that is most likely to be used, implant companies have created templates drawn on acetate paper that can be used with these “conventional radiographic films.” These templates are designed to be of the same magnification as that produced by standard X-ray machines – 110–120%. However, there are several problems with these templates. There is no uniformity in the degree of magnification present in the templates provided by the companies. The scale of magnification present in the X-rays may not be consistent, and depends on the distance between the X-ray plate and the bony pelvis. It is not always possible to ensure the required 120% magnification. In addition, conventional radiographs are becoming difficult to obtain, and are being replaced by digital films. In future, conventional X-rays could become obsolete and it has therefore become essential to create a technique of templating using digital films.

To resolve this problem, several companies have produced software for digital templating.⁴ This software is however not universally available and each company requires specific software for their implant. It is also expensive and the use of the software requires special training.

Hence there was a need to develop an alternative method of templating. We describe a technique that involves templating the digital films using the universally available acetate templates for THR. Our aim was to see if this technique was reliable and accurate.

2. Materials and methods

All patients who underwent uncemented total hip replacement during the period January–April 2013 were enrolled in the

study. Patients with pelvic tilt or flexion deformity of the hip (as in ankylosing spondylitis) were excluded from the study. Institutional IRB clearance was sought for the study.

A digital antero-posterior X-ray of the pelvis of the patient, centered just below the symphysis pubis, was taken before surgery. A marker (a spherical metal ball of 3 cm diameter) was placed at the level of greater trochanter and held on to the skin with adhesive plaster. The radiographs were digitally magnified before printing/viewing on the flat screen computer monitor. The magnification of the digital radiograph was deemed optimal (Fig. 1), if the size of the metal ball, as measured by the scale on the acetate template was between 28 mm and 38 mm (93–126% magnification). Using the standard THR acetate templates, the size of the metal ball (X mm) (Fig. 1) and the acetabular cup (Y mm) (Fig. 2) were determined on the digital films.

The method of determining the acetabular cup size (Y) was standardized. Three radiographic landmarks in the acetabulum were marked: the base of the teardrop (A), the ilio-ischial line (B), and the superolateral margin of the acetabulum (C). A reference line was drawn through the base of the teardrops. The acetabular cup template was superimposed on the radiograph, with the appropriately sized cup placed at 40°–45° of inclination, with the inferior margin leveled at the inter-teardrop line and the medial border approximating the ilio-ischial line.² The size that provided the most congruent fit was noted (Y). The actual size of the prosthetic acetabular cup to be used was estimated using the formula $30 \times Y/X$.

3. Statistics

All preoperative X-rays were independently studied by 2 observers (primary surgeon and first assistant) on two occasions separated by a period of 3 weeks. Using the acetate templates provided by the implant companies on the digital films, the observers predicted the size of the prosthetic cup, using the technique described above. The investigators were blinded to the actual size of the acetabular prosthetic cup used, which was retrieved from the operation notes.

The reliability of this technique of digital templating was assessed using the intra-class correlation (ICC). An ICC value between 0.7 and 0.9 was considered good. To determine the accuracy of this method of digital templating, the size of the templated cup was compared to the actual size of the cup that was implanted in the patient. All statistical analyses were performed using SPSS version 12.

4. Results

40 hips of 32 patients who fulfilled the inclusion criteria were reviewed in the study. 38 hips had implants from DePuy used for the acetabulum. Ten had Duraloc cups and 28 had Pinnacle cups. Two hips had R3 cups from Smith & Nephew.

The intra-observer reliability of the acetabular templating for the 2 readers was calculated using ICC and was found to be 0.83 and 0.86 for the two readers. The inter-observer reliability was 0.85.

Fig. 1 – Antero-posterior digital radiograph of the pelvis taken with the metal ball at the level of the greater trochanter (Inset showing the method of assessment of the size of the metal ball (X) using the acetate overlay template on the digital radiograph viewed on a flat screen monitor).

In the case of the primary surgeon, the acetabular cup size was accurately predicted using this technique of templating in 70% (28/40) of the cases. When the accuracy to within one size was considered, templating was correct in 92% (37/40) of the cases. All 3 outliers were hips of patients with rheumatoid arthritis. The templating was off by a maximum of 3 mm. When evaluating the templating done by the first assistant, the acetabular cup size was accurately predicted in 75% (30/40) of the cases. When the accuracy to within one size was considered, templating was correct in 90% (36/40) of the cases.

5. Discussion

Restoration of normal hip biomechanics, leg lengths and offsets are important components of a successful total hip replacement (THR). Preoperative planning is integral to achieving this outcome. Templating also helps the surgeon minimize guesswork and plan for potential intra-operative problems. Templating using conventional hard copy radiographs and transparent acetate overlay templates has been

Fig. 2 – Acetabular cup templating. The landmarks are: A – base of the teardrop, B – ilio-ischial line, C – superolateral margin of the acetabulum. The acetabular cup size (Y) is assessed using the onlay template on the digital radiograph viewed on a flat screen monitor.

Table 1 – Accuracy of different templating methods.

Method of templating	Author	Accuracy - same size as acetabular CUP (%)	Accuracy -within ± 1 size (2MM) (%)
Conventional templating	1. Della Valle AG et al ² (2005)	83%	99%
	2. Unnanuntana A et al ¹⁸ (2009)	42%	90%
	3. Gamble P et al ³ (2010)	20%	60%
	4. Whiddon et al ⁹ (2011)	31%	67%
	5. Murzic WJ et al ¹⁰ (2006)	30%	95%
Digital templating	1. Shaarani SR et al ¹¹ (2013)	38%	80%
	2. Gamble P et al ³ (2010)	38%	80%
	3. Whiddon et al ⁹ (2011)	39%	78%
	4. Murzic WJ et al ¹⁰ (2006)	60%	95%
CMC templating* (hybrid)	* Christian Medical College	70%	90%

proven to be an accurate and effective method in predicting prostheses sizes.^{5,6}

Digital radiographs are replacing conventional radiographs in many hospitals. Many centres have withdrawn traditional radiography altogether. The accuracy of templating of digital radiographs in predicating the size of the implant has been assessed and found to be good. However, digital templating requires special software provided by the companies. As these digital templates are not commonly available, many centres have stopped templating prior to surgery. In a study of 28 NHS hospitals, Lakshmana et al found that although 50% of the NHS hospitals had digital templating available, none used them for preoperative templating, as most were unaware of how to use the system.⁷ 28% admitted to occasional templating with conventional films and 43% claimed that they had stopped templating because hard copies could not be obtained in their hospitals, as all radiographs were available only on the Picture Archiving and Communication Systems (PACS) system.⁷ In other studies, authors have attempted to recreate a digitally magnified hard copy radiograph (120%) for templating with the standard acetate templates – but the reproduction has not been consistent, and hence predication of implant sizes was not accurate.⁸ This highlights the fact that there is a need to find a more suitable option for templating – one that combines the use of digital radiographs and templating with universally available acetate templates.

This is the first paper that has looked at the accuracy of preoperative templating of digital radiographs, using standard onlay templates. The size of the acetabulum has been predicted using acetate onlay templates on digital radiographs. The simple technique described with the metal marker is reasonably accurate and reproducible. A comparison with other studies which have used the conventional templates or digital templates for determining the size of the acetabulum is given in Table 1. Surgeons who are unable to access special software for digital templating can therefore use the standard acetate templates on the digital radiographs. The digital radiographs can be read off the flat screen computer monitors or laptops, or can be read off a digitally magnified X-ray film. The 3 cm metal marker can be procured at most hardware shops and provided to the radiology department, with appropriate instructions on its placement. It is essential that the marker is placed at the level of the greater trochanter and not on the table/radiograph plate. Other authors have used a ball marker in the groin – at the level of the pubic symphysis. It is also essential that the marker is a metal ball of uniform

diameter. The use of a coin or scale is not acceptable, as the size of the image may be altered by the obliquity of the X-ray beam.

While this paper describes the steps to template the acetabular cup, it does not address the issue of femoral templating and offset. To ensure that there is no limb length discrepancy and that the femoral prosthesis is seated with the correct offset, it is essential that the femoral component is also accurately templated. The details of this process need to be addressed.

Templating can also be done on the PACS system by digitally magnifying the X-ray, such that the metal ball measures 3 cm on the scale provided on the acetate template. The acetabular cup size can be directly templated off the X-ray image on the computer screen using the acetate templates, to get the actual size of the cup to be implanted. It would then be possible to template the femur also with this method.

6. Conclusion

It has been established that preoperative templating is an essential part of the preoperative work up for a hip arthroplasty. Using the technique of templating described, the exact size of the acetabular component can be accurately predicted in about 70% of the cases; with the accuracy increasing to 90% if prostheses within 1 size (above or below) are included. Meticulous preoperative planning helps the surgeon anticipate potential intra-operative complications, as well as achieve the goals of restoring normal biomechanics by equalization of limb lengths and restoration of hip offset.

Conflicts of interest

All authors have none to declare.

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