Assessment of magnification of digital pelvic radiographs in total hip arthroplasty using templating software

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ABSTRACT

INTRODUCTION Templating of pelvic radiographs traditionally involved using implant-company provided acetates which assumed a magnification of 115–120%. With the introduction of digital imaging, many departments are becoming filmless. Templating software has been designed to allow on-screen templating of digital images. Knowledge of the true magnification of the image is required for accurate measurement.

PATIENTS AND METHODS Fifty consecutive postoperative pelvic radiographs were analysed using templating software. The implanted component was measured using an assumed magnification factor of 115%. The template image was then reset to the known component size, and the magnification factor was adjusted until the template covered the true component.

RESULTS An assumed magnification factor of 115% oversized the acetabular component by a mean of 6 mm (three component sizes) in all 50 components. The mean true magnification in our department was 127%.

CONCLUSIONS Validation of the true magnification produced by a radiology department using templating software is a simple and reproducible technique. It is recommended to all departments using digital images and templating software. Assumption of a magnification factor of 115% risks oversizing components by 6 mm.

KEYWORDS

Digital – Radiographs – Templating – Arthroplasty – Magnification

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Templating of pelvic radiographs is an integral step in pre-operative planning for total hip arthroplasty. Templating identifies factors that may need to be addressed to optimise the function and longevity of the arthroplasty such as femoral offset, leg-lengths, acetabular floor depth and inclination. It also identifies technical issues that may be encountered during surgery such as a narrow femoral canal, dysplastic acetabulum or poor bone stock. For cemented femoral components, it allows the surgeon to gauge the size of component that will allow an adequate cement mantle, and for cementless components it allows the surgeon to predict the size required for a suitable press-fit. Occasionally, cases will be identified where prostheses are required which are not routinely stocked in the department inventory, such as extra small femoral components, or high-offset or lateralised-offset stems. For cementless femoral components, there is a risk of intra-

operative fracture of between 3–24% if an oversized component is inserted.^{1,2} Accurate templating is useful to re-assure the surgeon that a satisfactory size of component has been selected for implantation.

Traditionally, templating involved the use of implant-company provided acetates which were laid over hard-copy pelvic radiographs. Most companies provide acetates with magnification factors of 115–120%. This assumed that the pelvic radiograph obtained had this degree of magnification. With the introduction of digital methods of radiographic acquisition and the provision of the Picture Archiving and Communication System (PACS) across many trusts in the UK, it is becoming common-place that hard copy radiographs are not printed and, therefore, templating must be performed from computerised digital images. Digital templating applications have been developed to allow on-screen templating of PACS images. These applications

Figure 1 Example of templating using Orthoview software. Selected template size is undersized (white rim of true component remaining).

Figure 2 Example of satisfactory size of acetabular component (template covers acetabular component with no white rim remaining).

require the user to state the magnification factor. Previous methods of determining the magnification factor have been described including the coin method,⁵ the use of a lead-shield with graduated pinholes,⁴ and calliper measurements of bony distances.⁵

We set out to determine the magnification factor of digital pelvic radiographs archived on PACS when using the digital templating software itself.

Patients and Methods

Fifty consecutive postoperative anteroposterior pelvic radiographs were analysed of patients who had undergone primary total hip arthroplasty using a hemispherical

cementless acetabular component. Radiographs were acquired using a Wolverson Arcoma system (Willenhall, UK), and converted to digital images using the Kodak Capture Link Server (Rochester, NY, USA). The gantry was positioned 1 m above the film plate in all patients. Images were archived to PACS. Radiographs were viewed and analysed using Orthoview software (Meridian Technique Limited, Southampton, UK). Only components that had templates provided on Orthoview were studied. The study was performed by two observers who were blinded to the component size initially, and blinded later when adjusting the magnification factor.

The size of acetabular component was first measured using the software at an assumed magnification factor of

Figure 3 Example of incremental adjustment of magnification factor.

115%. Starting with a template too small to cover the component (Fig. 1), the size of the template image was gradually increased until complete coverage of the true acetabular component was achieved (Fig. 2). This measurement represented the component size at 115% magnification. The known implanted size was obtained from operative records, and the on-screen template image was then reset to this size. In our study, this template image always appeared smaller than the true component. The magnification factor of the radiograph was then adjusted incrementally starting at 115% (Fig. 3), and increasing by 1% at a time until comparable complete coverage of the acetabular component by the template image was achieved.

Results were analysed using SPSS v.12.0 software. Statistical analysis was performed using Student's *t*-test.

Results

The mean acetabular component size implanted was 52.9 mm (range, 48–58 mm). The mean measured component size at 115% magnification was 58.9 mm (range, 52–64 mm). This represented a mean oversizing of acetabular component of 6 mm or three component sizes, assuming a magnification factor of 115% ($P < 0.0001$). All 50

components were oversized using this magnification factor of 115%. Forty-two components were oversized by 6 mm (3 cup sizes), and 4 components each by 4 mm and 8 mm (2–4 cup sizes).

The mean corrected magnification was 127.4% (range, 122–133%; SD 1.89). The range of magnifications are shown in Figure 4.

Discussion

Traditional radiographs are rapidly becoming obsolete in modern orthopaedic practice, yet the need for templating remains high because of increased use of cementless components and increased patient demands for restoration of as near-normal biomechanical function with leg-length equality. Digital templating software gives the user the opportunity to adjust the magnification factor, which is an advance from the implant-company provided acetates which were usually produced at factors of 115–120%. However, the need to know the magnification of the pelvic radiograph has, therefore, increased.

The importance of re-analysing the magnification factor produced by a radiology department following introduction of digital radiographic techniques has previously been

Figure 4 Range of true magnifications determined for series.

highlighted.⁶ In that study, it was found that the magnification of pelvic radiographs was 97% compared to 120% assumed by the implant companies. One study reported a risk of 11% inaccuracy when assuming a standard of 120% magnification.⁷ Methods of scaling the PACS radiograph have been described whereby known distances or sizes are scaled using the PACS measurement tools. It was found that the coin method which involves coins embedded in a plastic frame placed adjacent to the patient's leg, gave improved accuracy compared to calliper measurement of the distance between the anterior superior iliac spines.⁵ Templating can be performed using the implant-company provided acetates directly on the computer screen as long as the image is manipulated to match the acetate magnification factor. Digital line-measurements were found to be less accurate than a coin method when attempting to scale the magnification of the radiograph using that technique.⁸ Those methods do not take into account any in-built error or discrepancy that any templating software itself may introduce. Therefore, a method of validating the magnification of radiographs using the templating programme eliminates this problem. The coin method has a drawback by assuming that the coin position is in the same plane or the same distance from the radiographic plate as the area being templated. Therefore, when assuming the magnification of the acetabular component, the coin would need to be in the same plane as the acetabulum. It is recommended to place the coin at the greater trochanteric prominence on the lateral aspect of the thigh, but this assumes that the greater trochanter is in the same plane as the acetabulum. The

plane of the greater trochanter may change with the amount of rotation of the femur.

The accuracy of alternative digital templating software has been reported.⁹

Pre-operative templating of the predicted acetabular component size was compared to the actual component size implanted using Endomap software. The mean size was found to be within 1 mm of the component size implanted.

We have chosen not to evaluate the accuracy of pre-operative templating compared to the actual component implanted, as we feel that the methodology for this technique would allow the introduction of bias. The person performing the templating analysis would need to have the same criteria for satisfactory component size and position as the surgeon implanting the component. On the other hand, if the operating surgeon performed the pre-operative analysis, then that itself would introduce bias into the study, as a surgeon can alter the reaming technique to insert a component one size larger or smaller if necessary by removing more or less bone. Most surgeons would accept that pre-operative templating is only a guide to likely size required for implantation, but other factors determine true size of implant used such as integrity of the posterior acetabular wall which cannot be readily assessed on the anteroposterior radiograph.

We did not use the femoral component as this could change appearance depending on the amount of rotation of the femur, and is likely to be less accurate than a hemispherical component.

Although the range of magnification found in our department was 122–133%, the mean value of 127% would correctly identify the component size to within 1 cup size in all 50 patients.

The variation may reflect differing sizes of patient, as the gantry was set to 1 m above the plate in all cases. We did not specifically set-out to study the variation for differing patient habitus. The important point to highlight is that a value of 115% used pre-operatively would predict an oversized component by at least 2 cup sizes in all cases.

Our technique allows an institution using this software to determine the magnification that their radiology department produces quite simply, without the requirement for positioning of markers, or without extra work from the radiology department. We assume that other templating software will allow similar methodology to be used. We recommend that departments using templating software validate the magnification of radiographs produced by their department using this method. Ideally, accurate pre-operative templating would involve a combination of using scaling balls, and validation of templating software as described here.

References

1. Schwartz JT, Mayer JG, Engh CA. Femoral fracture during non-cemented total hip arthroplasty. *J Bone Joint Surg Am* 1989; **71**: 1135–42.
2. Carter LW, Stovall DO, Young TR. Determination of accuracy of preoperative templating of noncemented femoral prostheses. *J Arthroplasty* 1995; **10**: 507–13.
3. Conn KS, Clarke MT, Hallett JP. A simple guide to determine the magnification of radiographs and to improve the accuracy of preoperative templating. *J Bone Joint Surg Br* 2002; **84**: 269–72.
4. Gorski JM, Schwartz L. A device to measure magnification in preoperative planning for cementless arthroplasty. *Clin Orthop* 1986; **202**: 302–6.
5. Wimsey S, Pickard R, Shaw G. Accurate scaling of digital radiographs of the pelvis. *J Bone Joint Surg Br* 2006; **88**: 1508–12.
6. White SP, Shardlow DL. Effect of introduction of digital radiographic techniques on pre-operative templating in orthopaedic practice. *Ann R Coll Surg Engl* 2005; **87**: 53–4.
7. Pickard RJ, Higgs D, Ward N. The accuracy of the PACS for pre-operative templating. *J Bone Joint Surg Br* 2006; **88**(Suppl): 264.
8. Oddy MJ, Jones MJ, Pendegrass CJ, Pilling JR, Wimbhurst JA. Assessment of reproducibility and accuracy in templating hybrid total hip arthroplasty using digital radiographs. *J Bone Joint Surg Br* 2006; **88**: 581–5.
9. Davila JA, Kransdorf MJ, Duffy GP. Surgical planning of total hip arthroplasty: accuracy of computer-assisted EndoMap software in predicting component size. *Skelet Radiol* 2006; **35**: 390–3.