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Original Article

Pre-operative templating for trauma hemiarthroplasty (Thompson's)

Robert Nicholas Green ^{a,*}, Paul R.P. Rushton ^a, Derek Kramer ^b,
Dominic Inman ^b, Paul F. Partington ^c

^a Trauma and Orthopaedics, Northern Deanery, Newcastle upon Tyne, Tyne and Wear NE21HJ, UK

^b North Tyneside General Hospital, UK

^c Wansbeck General Hospital, UK

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ABSTRACT

Introduction: Surgical complications may be avoided by preoperative templating in trauma hemiarthroplasty.

Materials and methods: Digital templates for the Stryker™ range of Thompson's prostheses were created and fifty trauma patients that had undergone cemented hemiarthroplasty were retrospectively templated by 2 blinded surgeons.

Results: Templating for prosthesis size was highly accurate with excellent Inter and intra-observer reproducibility. Sensitivity for identifying femoral canals too narrow for a Thompsons was 100%.

Conclusions: Templating is a valuable tool and should be standard practice in trauma. We have demonstrated that it is possible to generate custom templates to allow accurate templating.

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1. Introduction

Hip hemi-arthroplasty is a key facet of elderly hip fracture care, with safe high quality surgery important in achieving good clinical outcomes. Whichever implant is used; the surgeon must try to achieve the same goals as elective total hip replacement; the abolition of pain, restoration of a stable and functional hip and avoidance of complications. These surgical goals can be achieved in the vast majority of cases using the Thompson's prosthesis but the surgeon must be wary of

situations where this might not be the case. Parker et al identified that the femoral canal was too small for a Thompson's in 2% of cases.¹ Patients with coxa vara or coxa valga often require different levels for neck osteotomy and in some cases may be unsuitable altogether. Pajarinen and Kwok both reported an association between Thompson's dislocation and leg length errors.^{2,3} Any measures that might reduce dislocation rates should be considered since the associated 6 month mortality is 30% after this complication.⁴ Furthermore occasionally patients may require head sizes that are not catered for by the range of implants stocked routinely. Unexpectedly

* Corresponding author. 8 Kimberley Gardens, Jesmond, Newcastle, Tyne and Wear NE21HJ, UK. Tel.: +44 7977008943 (mobile).

E-mail address: nicholasgreen@doctors.org.uk (R.N. Green).

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encountering these problems intra-operatively will result in prolonged operating times and serious complications. Time may be needed to locate specialist equipment, iatrogenic fracture can occur in patients with a narrow femoral canal and limb length inequality can be significant. Whatever the choice of stem, accurate templating will increase patient safety.

The potential for these problems to ambush the operating surgeon is increased since trauma hemiarthroplasty is commonly performed by trainees rather than consultants. However, technical errors may be avoided, irrespective of surgical experience, by pre-operative templating. This is where implant-specific templates are applied to the patient's radiographs to determine suitability, size and positioning. This process enables the surgeon to perform a “dry run” of the operation and anticipate problems pre-emptively. Most UK trusts currently use digital radiography and picture archiving and communications systems (PACS). Digital templating has become popular in elective hip arthroplasty and is well published. Implant manufacturers have been quick to respond in providing electronic templates to software companies to facilitate the use of their products. Templating for trauma hemiarthroplasty is not routinely performed, and unlike elective stems, Thompson's templates are not available from the implant manufacturers.

In this study we aim to develop a templating system for the Thompson's hemiarthroplasty and retrospectively validate its use using clinically important measures; the ability of templating software to identify femoral canals too narrow for a Thompson's hemiarthroplasty stem and predict the head size in a reproducible manner.

2. Materials and methods

A radiology protocol was introduced providing calibrated “low-slung” antero-posterior (AP) pelvis plain films as part of the initial imaging for hip fractures. Mdesk™ (RSA Biomedical, Umeå, Sweden) templating software was used and their recommendations for standard calibration were followed; a 30 mm sphere placed between the patient's legs at the height of the centre of the hip. The Mdesk™ digital templating system did not include Thompson's templates for any manufacturer. Several major implant manufacturers were approached, none possessed the necessary templates and nor were they prepared to dedicate resources to their research and development teams to produce them. Since the Stryker™ (Newbury, UK) Thompson implant was currently in use within our institution, custom-made templates for this manufacturer were developed with the aid of RSA Biomedical directly. A full range of digital templates were produced from AP profile PDF images of the smallest (38 mm) and largest (57 mm) implants, after confirming that stem geometry remained constant with increasing head size. This was accomplished using an Oasis® floral foam brick, a material normally used for flower arranging. (Fig. 1) The implants were pressed into the surface, producing imprints allowing comparison.

The prospectively gathered institutional trauma database was used to identify patients with hip fractures that had undergone cemented hemiarthroplasty. The Thompson's prosthesis is the first line prosthesis used in our trust and a

Fig. 1 – Left image depicts the 57 mm prosthesis embedded into the block. Right image demonstrates the 38 mm prosthesis placed into the imprint left by the largest prosthesis, confirming stem geometry remains consistent across the range of head sizes.

cemented Exeter Total Hip Replacement Stem (ETHRS) with a bipolar head is selected for patients with atypical anatomy or those whose canal is too narrow for a Thompson's. All cases with correctly calibrated “low-slung” AP pelvis admission plain films were included in this study. Cases without a native hip on the contralateral side and those where the un-injured could not be reliably templated were excluded.

Two surgeons (RNG & PRPR) blinded to the definitive implants used, retrospectively templated all included cases from October 2013 to May 2014 using the new custom-made Thompson's templates. Head size was determined first; a digital ruler was used to measure the widest diameter of the bony femoral head on the uninjured side. This distance in millimetres was combined with the widest diameter of the joint space in millimetres (This accounts for femoral head cartilage at each end of the measured bony diameter). The digital template matching this combined head diameter was then placed over the un-injured side to confirm an optimal concentric match, including a thin layer of cartilage (Fig. 2). If necessary a larger or smaller template was trialled to establish the best fit. Finally, the template was placed at the expected neck osteotomy site and orientated to optimally fit within the shaft, any cortical overlap onto the stem would classify the canal as too narrow (Fig. 3).

Validity for head size was determined through comparison of templated results against actual implants used. The findings of both surgeons were then compared to determine inter-observer reliability. Both surgeons re-templated the most recent 25 cases a week later to measure intra-observer reproducibility. Statistical analysis was performed using SPSS v22 (IBM-SPSS, Armonk, New York). The validity, interobserver reliability and intraobserver reproducibility of the novel

Fig. 2 – Templating example, the widest bony diameter measures 46 mm and the joint space is 3 mm. A 49 mm head template is applied and overlaps the native femoral head concentrically.

templates were evaluated by Cohen's Kappa. Interpretation of Cohen's Kappa followed the recommendations of Landis and Koch (0.00–0.20 slight agreement, 0.21–0.40 fair agreement, 0.41–0.60 moderate agreement, 0.61–0.80 substantial agreement and 0.81–1.00 excellent agreement).⁵ Sensitivity, specificity and positive predictive value for identifying a narrow femoral canal were calculated for both surgeons.

3. Results

Fifty consecutive cases that fulfilled the inclusion criteria were templated by both surgeons separately. Thirty four cases were excluded due to the absence of calibration or inadequate views obtained. Thompson's hemiarthroplasty was planned for all cases preoperatively following trauma meeting discussion. Forty four patients had a Thompson's cemented hemiarthroplasty implanted and two were documented as

Fig. 3 – To determine if the femoral canal is too narrow, the template is aligned with the shaft at the level of neck osteotomy where correct leg length is restored. Here there is ample space for the Thompson's.

being extremely narrow with the decision intra-operatively to leave the stem slightly proud rather than convert to another device or risk femoral fracture. Six cases underwent intra-operative conversion to the ETHRS with a bipolar head due to the presence of a small femoral canal. These eight cases were considered too narrow for a Thompson's stem.

3.1. Validity

Femoral Head size: Surgeon 1 templated within one size (1 mm) of the definitive implant in 80% of cases (Kappa 0.78) and within two sizes (2 mm) in 94% of cases (Kappa 0.93). Surgeon 2 templated within one size as that templated in 70% of cases (Kappa 0.64) and within two sizes in 94% of cases (Kappa 0.93).

3.2. Interobserver agreement

For exact agreement of head size, Kappa was 0.38. When a precision scale of 1 size (1 mm) was used, Kappa increased to 0.91 demonstrating excellent inter-observer agreement.

3.3. Intraobserver reproducibility

Using a precision scale of 1 size (1 mm), intra-observer agreement was excellent (Kappa 1.00 for both surgeons).

3.4. Tight femoral canal

Templating by both surgeons was 100% sensitive for identifying femoral canals too narrow for the Thompson's prosthesis. Surgeon 1 identified a further 4 cases as narrow where this was not the case intra-operatively (specificity 67%). Surgeon 2 identified a further 8 cases as narrow incorrectly (specificity 50%). These values correspond to a positive predictive value for a 'tight canal' of 67% and 50% for surgeons 1 and 2 respectively. This might represent 'false positives' where potential problems were identified. No canal that was intra-operatively too narrow for a Thompson's prosthesis was missed i.e. no 'false negatives'.

4. Discussion

Rising standards of hip fracture care across the UK are in part attributable to the National Hip Fracture Database.⁶ This is a clinically led system that audits all 186 eligible hospitals against standards defined by the British Orthopaedic Association (BOA) and British Geriatrics Society (BGS). The 6 critical standards are based on pre-operative and post-operative factors, but attention must also be given to intra-operative techniques. Level 1 evidence supports the use of cement, where hemiarthroplasty is chosen.⁷ NICE guidance recommends the use of an ODEP rated stem of at least 3B, equating to 97% survival at 3 years.⁸ The exclusion of non-ODEP rated stems is controversial and not based on strong evidence. An RCT by Parker et al found no difference in outcomes between patients randomised to a Thompson's prosthesis or an Exeter Trauma Stem (ETS)⁹ though it should be noted that the ETS does not have the same surface finish as the Exeter total hip stem, and is not directly comparable.¹⁰ An important UK

multicentre RCT is planned comparing the Thompson's prosthesis with the ODP 10A-rated Exeter stem with a Uni-trax™ monopolar head. Unless the findings of this study recommend otherwise, our trust and many others in the UK will continue to offer the Thompson's prosthesis as first line treatment for cemented hemiarthroplasty.

We have produced a valid preoperative templating system that reliably identified cases unsuitable for a Thompson's hemiarthroplasty and the head size required. Routine templating for trauma hemiarthroplasty is a means of improving care quality through predicting intraoperative difficulties, avoiding complications and identifying anatomical variation, yet it is not common practice. Most trauma hemiarthroplasties are being performed by a trainee without a consultant scrubbed. Whilst the vast majority of cases lend themselves to a standardised hemiarthroplasty technique, there are subtle variations in anatomy that can surprise an inexperienced surgeon, to the detriment of the patient. We strongly recommend the increased use of templating in this setting to improve patient care. Our study has demonstrated this process can be easily incorporated into routine hip fracture care. Introducing a radiology protocol for calibration is simple and can be made sufficiently accurate with a known diameter sphere placed roughly at the level of the hip joint. Both surgeons in this study accurately templated 94% of cases within 2 sizes/2 mm of the implants used. The excellent inter and intra-observer agreement confirms that inaccuracies of the templating process are more likely to have been due to variation in placement of the calibration sphere relative to the hip centre.

To our knowledge there are no previous studies of templating for hip hemiarthroplasty for trauma in the literature with which to compare our results. We consider 2 mm to be sufficiently accurate to identify cases at the edge of available implant sizes allowing preoperative contingency planning. In any case a major benefit of templating is that it encourages the surgeon to critically evaluate each patient's plain films in a methodical way which may improve recognition of important anatomical variations. This is illustrated in Fig. 4, a patient from the series undertaken by an experienced surgeon which demonstrates the need to recognise cases of coxa valga pre-operatively and leave more calcar in order to balance leg lengths. A surgeon failing to evaluate preoperative plain films thoroughly and using a 'standardised technique' may fail to accommodate for this leaving the patient with leg length discrepancy and an increased risk of dislocation.

Importantly the templating software was also able to identify all patients with a femoral canal too narrow for the Thompson's prosthesis. False positives can be explained by two factors; firstly the inaccurate placing of the sizing sphere and secondly the rotational profile of the patient's proximal femur. Due to femoral neck anteversion, a true AP profile of the hip and proximal femur can only be obtained with the leg in slightly internal rotation; this is impractical in trauma where injured patients cannot optimally position themselves due to pain or confusion. Specificity could be improved with more accurate placement of the calibration sphere and slight internal rotation of the uninjured leg but this is probably unnecessary as the surgeon only needs to be prepared for such an occurrence. Notwithstanding this PPV of 50–66% for a narrow canal are clinically useful; if the case templates as

Fig. 4 – Templated and post-operative plain films of same case demonstrating how neck cut should be adjusted in coxa valga otherwise limb length discrepancy can result.

'narrow' the surgeon can expect intraoperative difficulties in at least half of cases, and can thus plan accordingly.

Contemporary hemiarthroplasty systems may have templates available from their respective manufacturers, but none were available for the Thompson's prosthesis on Mdesk™. The process of creating custom-made templates directly was straightforward and can be recommended as long as the relevant templating software company is willing to help, as was the case with RSA Biomedical. We hope to have provided sufficient detail to allow other units to produce templates for their implants and operating system.

Whilst we have demonstrated a templating system for hip hemiarthroplasty is both valid, reproducible and can predict intraoperative difficulties we have done so retrospectively. Further work is necessary to identify if intraoperative difficulties and operating times are in fact reduced clinically as we hope.

5. Conclusions

Avoiding complications and prolonged operations in frail elderly hip fracture patients is vital. This may be aided by

preoperative templating for hip hemiarthroplasty. Accordingly we have introduced a calibration protocol, generated custom-made digital templates and validated the system. The system has sufficient precision to anticipate narrow femoral canals and identify uncommon head sizes. We feel the process of templating is useful to identify anatomical variations. It is hoped that other hospitals can replicate this for any hemiarthroplasty system and should consider this step as a means of further improving hip fracture care.

Conflicts of interest

All authors have none to declare.

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