Journal of Orthopaedics 15 (2018) 146–150

Contents lists available at ScienceDirect

Journal of Orthopaedics

journal homepage: www.elsevier.com/locate/jor

Original Article

Templating in uncemented THA. On accuracy and postoperative leg length discrepancy

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ARTICLE INFO

Keywords:
Arthroplasty
Uncemented
THA
Digital
Templating
Accuracy

ABSTRACT

Purpose: This study examines the accuracy of digital templating in uncemented total hip arthroplasty (THA), i.e., whether the templated components where actually inserted during surgery. The surgical outcome was evaluated on the basis of limb length equality.
Methods: We retrospectively examined digital x-rays of 41 patients scheduled for uncemented THA. These were templated using templating software. The template was compared to the surgical choice of implant registered in the patients' journal. Postoperative x-rays were evaluated for limb length equality. The data underwent statistical analysis to assess accuracy.
Results: The acetabular component was templated accurately in 7.3%, while 41% was within +/− 1 component size difference, and 73% was within +/−2 size differences. The femoral stem was templated accurately in 34%, while 76% was within +/− 1 component size difference, and 90% was within +/−2 size differences. The neck length was templated accurately in 29%, while 88% was within +/−1 component size difference, and 100% was within +/−2 size differences.

Fifty four percent of patients experienced radiologic equalization within +/− 5 mm, and 85% within 10 mm. Fifteen percent had leg length discrepancy of more than 10 mm postoperatively. There was no systematic tendency to overestimate or underestimate leg length peroperatively.
Conclusions: We find that the accuracy of digital templating in uncemented THA is acceptable for the femoral stem, but somewhat inferior for the acetabular shell and poor for neck length. Templating is a useful tool in preoperative planning, but cannot be regarded as a blueprint for the operative choice.

1. Introduction

Templating is an important aspect of preoperative planning for total hip arthroplasty (THA) and can help determine the size and positioning of the prosthesis.[1–4] Traditionally, templating has been performed by positioning acetate templates over printed radiographs. As a result of the increasing use of digital imaging, surgeons now either obtain additional printed radiographs solely for templating purposes or use specialized digital templating software, both of which carry additional cost. The rationale for doing this should be adequately documented.

Theoretically, preoperative planning can aid in obtaining optimal implant sizes and positioning.

One would expect improved biomechanics and, thereby, better function and longevity of the prosthesis. In a previous study, we found that the intra- and interobserver reliability of templating is good for uncemented acetabular and femoral components, but less precise for neck length.[5] We could not, however, conclude on whether this precision was correlated with accuracy, i.e. whether the components implanted during surgery was the same as templated preoperatively.

In most studies on how well preoperative templating correlates with the actual size implanted, it is reported moderate to high degrees of correlation.[6–11] However, most of these studies were not blinded; i.e. planning and surgery were done by the same person, or the result of the template was known to the surgeon. It may be argued, that each surgeon templates according to how he or she operates, and that templating therefore should be performed by the operating surgeon. It may also be argued, however, that surgeons are untowardly bound by the template during operation, hence a bias towards agreement between template and surgery. Therefore we have investigated how digital templating correlates with the size of actual implants when the procedures of surgery and templating were independent of each other.

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https://doi.org/10.1016/j.jor.2018.01.038
Received 10 August 2017; Accepted 14 January 2018
Available online 17 January 2018

2. Methods

This study was performed in accordance with the ethical standards of the 1975 Declaration of Helsinki and the 2008 revision. Data were anonymized and treated according to the ethical standards of our institution. As the study was not interventional, the patients followed ordinary routines and could not be identified, therefore specific ethics approval and patient consent were not required.

We retrospectively examined the x-rays of 41 patients who underwent primary uncemented THA at our institution before digital templating software was available. We identified 26 women (63%) and 15 men (37%), with an age range of 13 to 82 years, and a mean of 50 years. The indication for THA was primary osteoarthritis in 17 (41%), developmental dysplasia in 9 (22%), avascular necrosis of the femoral head in 6 (15%), Calve Legg Perthes disease in 4 (10%), and miscellaneous in 5 (12%).

All patients were scheduled for a total hip arthroplasty using Zimmer Trilogy uncemented shell, and DePuy Corail uncemented femoral stems. The available acetabular implants ranged from 40 mm to 68 mm in 2 mm increments, and the femoral implants ranged from 8 to 18 in 11 size units. The neck lengths on hand were short, medium and long. We routinely used a device to measure change in offset and leg length intraoperatively.

All the radiological examinations were performed digitally at the same radiological centre, using a standardized protocol. We used a calibration marker of 36 mm positioned between the patient's legs, as close to the focal point of the x-ray beam as practically possible. Templating was performed retrospectively, without prior knowledge of the surgical choice. We utilized a digital planning software (EndoMap, Siemens, Nuremberg, Germany), which is routinely used in our clinic. All surgeons are trained in using this software to position the templates within the accurate anatomical borders.

The templates were compared to the implants actually chosen during surgery, as documented in the digital patient journal. The biomechanical adequacy of this implant choice was estimated by measuring postoperative radiological leg length discrepancy. Measurements were performed on calibrated digital x-rays, to ensure comparable values. We used the bi-ischial line and the most medial point on the minor trochanter as reference points for measurements.

Discrepancy within the error of measurements, i.e. within +/−2 mm, were considered as equal leg length, and groups of < +/−5 mm and < +/−10 mm were established. Errors of measurement and identification of anatomical reference points do not allow for more precise groupings than this.

Two patients lacked sufficient anatomical reference points to allow adequate leg length measurements, and were excluded from this evaluation. In cases with obvious contralateral pathology, e.g. osteosynthesis due to proximal femoral fractures, the leg length was compared to the preoperative leg length.

A statistical analysis of our findings was performed, utilizing SPSS statistics. We used the Pearson Correlation Coefficient (PCC) to describe the relationship between the template and chosen implant. A value of 1 implies a linear relationship, while a value of 0 indicates no relationship at all.

3. Results

The results of the evaluation of accuracy are shown in Table 1. There was a tendency to underestimate both the femoral and acetabular components by templating, while there was no correlation in templating neck length as compared to inserted (Fig. 1–3).

The evaluation of leg length discrepancy is shown in Table 2. Three patients had elongation of more than 10 mm, with 27 mm being the highest value. Three had shortening of more than 10 mm, with 16 mm as the highest discrepancy. Two patients had too severe pathological changes to allow any credible leg length measurement postoperatively.

Table 1
Number of implants out of 41 coinciding with template. PCC is Pearson Correlation Coefficient.

	Accurately templated	+/−1 component size	+/−2 component sizes	PCC
Femoral component	14 (34%)	31 (76%)	37 (90%)	0.784
Acetabular component	3 (7.3%)	17 (41%)	30 (73%)	0.62
Neck component	12 (29%)	36 (88%)	41 (100%)	0.019

Fifteen patients had limb shortening, and 15 had limb elongation, so no tendency to under- or overestimation of leg length could be identified.

We also evaluated the potential leg length discrepancy that would have occurred, if the templated neck length had actually been implanted during the operation. There is a tendency for elongation (46%) over shortening (34%), with the largest elongation being 28 mm, and the largest shortening being 17 mm.

4. Discussion

In this study we found an acceptable accuracy for templating the femoral stem, with 76% being within +/−1 size compared to the template. A PCC of 0.784 is interpreted as a high correlation. We found lower accuracy for templating the acetabular shell, with 41% within +/−1 size, and a PCC of 0.62; a moderate correlation. Neck length was almost completely arbitrary, with 88% within +/−1 size, but a PCC of 0.019. We are not aware of any previous publications regrading accuracy of templating neck length.

An accuracy of up to 90–100% has been reported for both acetabular and femoral implants.[6–11] But many studies concerning accuracy and precision in templating THA are not blinded, at least not expressively so. One might argue, that each surgeon templates according to how he/she operates, so that in a clinical setting the surgeon must perform his own templates. In contrast, when an evaluation of a method is performed, one might argue, that a surgeon is biased by her templates, so a significant bias towards correlation exists. This alone might explain why our results are somewhat inferior to previous reports.

We have not, in line with most publications, assessed the postoperative x-rays with regard to whether the implanted components were "correctly" sized. There are no absolute criteria to evaluate this. But we did try to evaluate the biomechanical result of the operation by measuring leg length discrepancy, as leg length equalization usually is one of the most important goals of THA. We did not evaluate medial offset or anteversion and inclination of the acetabular shell. This could have further improved the biomechanical evaluation. However, due to stem design, offset and leg length is interdependent. Peroperatively, one must regularly prioritize one over the other, and leg length discrepancy is more often a patient complaint.[12] Also, femoral neck version is a confounder that cannot be determined by templating on frontal x-rays.[13]

When we compared the actual leg length discrepancy postoperatively (Table 2) with the potential leg length discrepancy (Table 3), we found a tendency towards elongation during templating. Conversely, the other components may not have been seated as deeply as planned. The main constraint on elongation during surgery is tissue tension, which is impossible to predict accurately while templating. The neck length may be manipulated during surgery to fine-tune tissue tension, which explains the arbitrary correlation between template and surgical choice. Altogether, this strengthens the argument that peroperative observations must override preoperative planning.

Radiological leg length discrepancy is not equal to clinical leg length discrepancy. Transient functional leg length discrepancy may also occur.[14] However, for the sake of evaluation of templating as a method, we focused on the more objective radiological measurements.

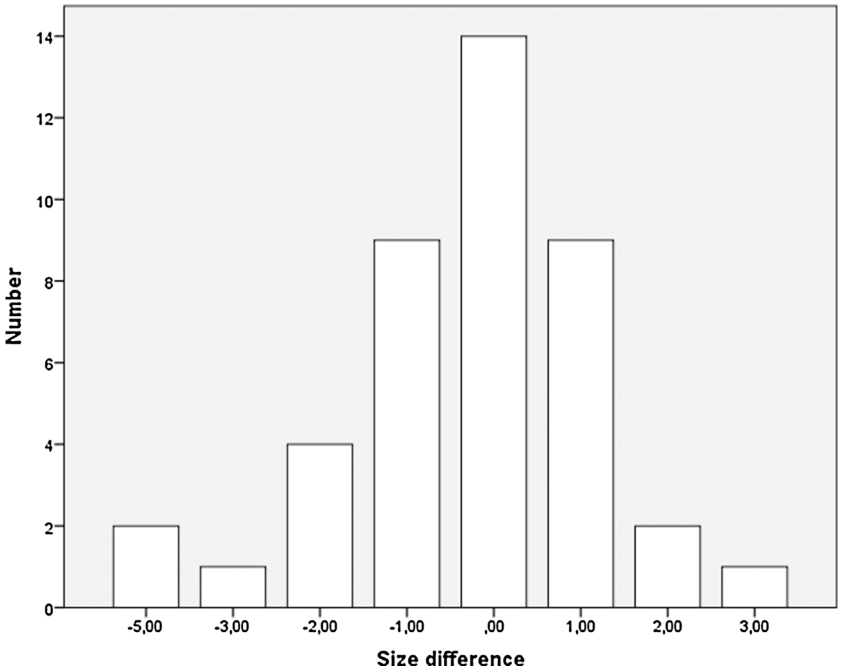

Fig. 1. Number of templated femoral implants as a function of size difference from actually implanted.

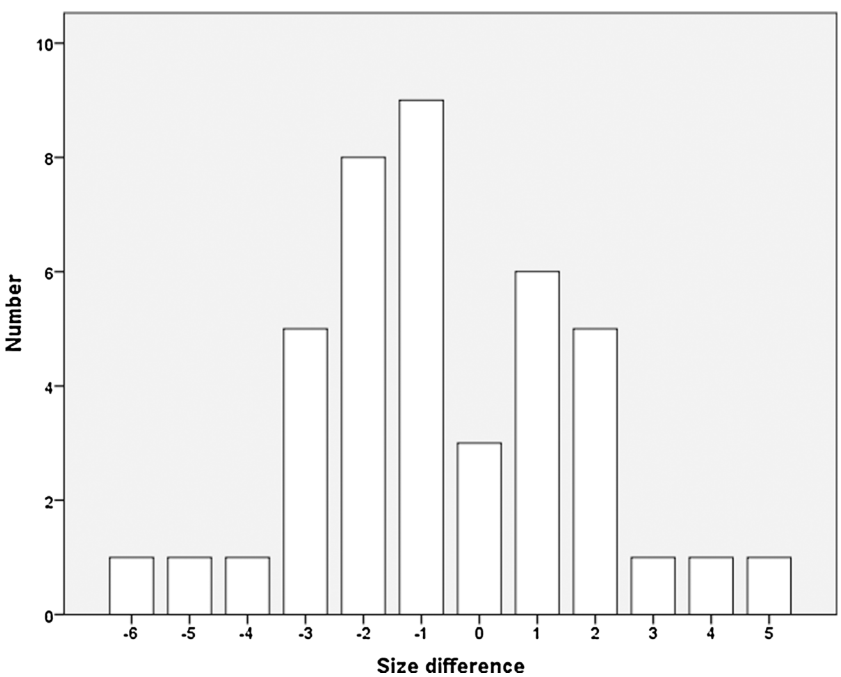

Fig. 2. Number of templated acetabular components as a function of size difference from actually implanted.

There is no consensus on what the threshold for clinically significant leg length inequality is.[15] We found that 85% had leg length equality within +/−10 mm, which in usually regarded as clinically insignificant.

There are a few limitations of our study. It was carried out in only one clinic, but it is unclear how a multicentre evaluation might enhance our findings. Also, as a tertiary referral centre, we may have seen more pronounced preoperative pathology than what is typical elsewhere, even in primary THA. Templating, as well as surgery, is more challenging in these situations. We did not investigate in a longitudinal fashion. However, all observers were experienced in using the software, so we do not expect any significant change in measurements over time. The number of observations is not very large, but our power analysis suggests that the number is sufficient to yield significant results. Also, our sample population had an adequate distribution of all values to make the analyses meaningful. There is no golden standard that we could compare our results with. But this is a general and main objection to preoperative templating of joint prostheses. We concede that radiographic interpretation relies on the clinician's experience with reading hip radiographs. Main sources of errors when measuring radiographs are errors in locating corresponding landmarks, and errors in calibration on digital radiographs. However, previous findings suggest that above a certain threshold of experience, this is mainly a methodological problem, and is not likely to infer further bias to our results.

In conclusion, we find that the accuracy of digital templating in uncemented THA is acceptable for the femoral stem, but somewhat inferior for the acetabular shell and poor for neck length. Templating is a useful tool in preoperative planning, but cannot be regarded as a

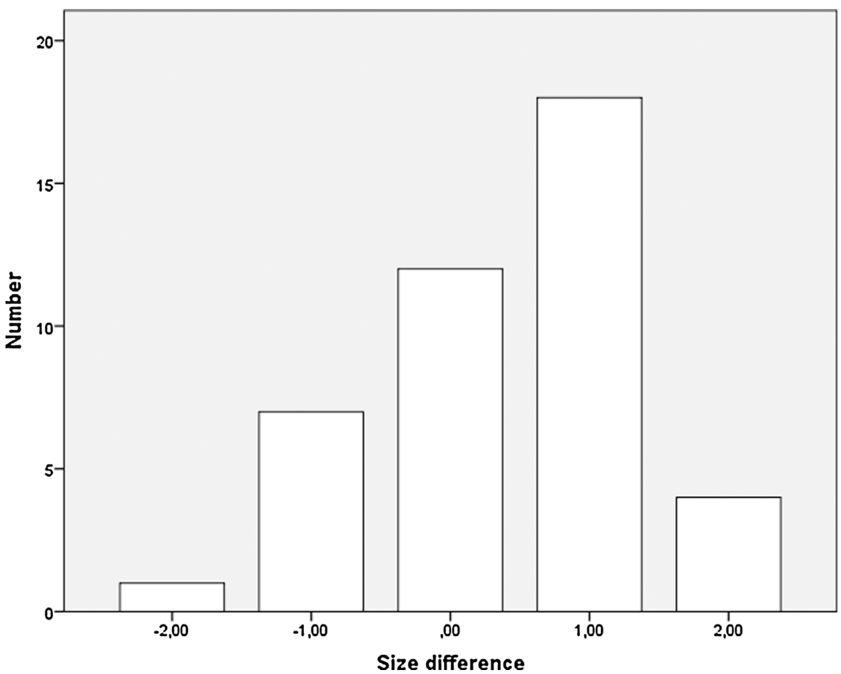

Fig. 3. Number of templated neck implants as a function of size difference from actually implanted.

Table 2
Number of patients with elongation or shortening of the operated leg.

	> −10 mm	−10 ≥ −5 mm	≤ −5 mm	equal	≤ +5 mm	+5 ≤ +10 mm	+10mm <
Number of patients	3 (7.7%)	8 (21%)	4 (10%)	9 (23%)	8 (21%)	4 (10%)	3 (7.7%)

Table 3
Potential number of patients with elongation or shortening of the operated leg.

	> −10 mm	−10 ≥ −5 mm	≤ −5 mm	equal	≤ +5 mm	+5 ≤ +10 mm	+10mm <
Number of patients	3 (7.7%)	5 (13%)	2 (5.1%)	11 (28%)	7 (18%)	6 (15%)	5 (13%)

blueprint for the operative choice.

Conflict of interest

None.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

Acknowledgements

We wish to thank John Magnar Slåstad and Anne Guro Vreim Holm for their help with the study.

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