A Comparison of Acetate and Digital Templating for Hip Resurfacing

Daniel N. Bracey, MD, Thorsten M. Seyler, MD, John S. Shields, MD, Xiaoyan Leng, PhD, Riyaz H. Jinnah, MD, FRCS, and Jason E. Lang, MD

Abstract

This study sought to determine whether templating for metal-on-metal hip resurfacing is more accurate with digital or acetate methodology.

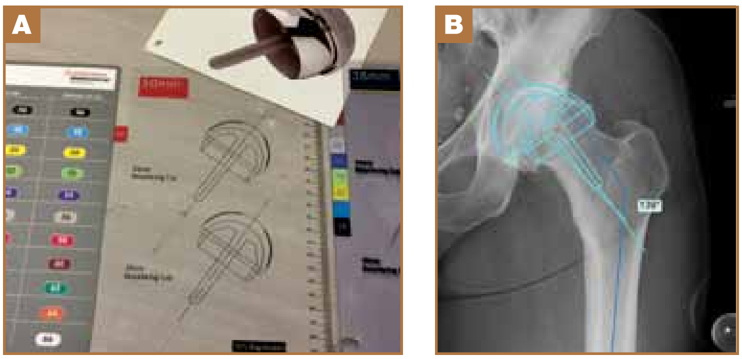
The medical records of 102 consecutive patients who underwent hip resurfacing at our institution were retrospectively reviewed. Records lacking preoperative radiographs that included a magnification-establishing marker were excluded, leaving 78 records for study. Two investigators independently prepared acetate and digital templates of the preoperative radiographs, which had been calibrated to 120% magnification, to predict femoral and acetabular component size. Accuracy was measured by comparing the predicted component sizes to the surgically implanted component sizes.

Digital templating was more accurate than acetate templating in predicting hip resurfacing component size when measuring accuracy of templates by the absolute error of predicted component sizes (femoral, $P < .001$; acetabular, $P = .002$), and by the prediction of components to +/-1 size difference (femoral, $P = .001$; acetabular, $P = .002$). Experience of the templating surgeon did not correlate with templating accuracy for acetate or digital templating. Although acetate templating is often regarded as the "gold standard" in preoperative planning, data from the current study shows that digital technology can be used for accurate preoperative templating prior to hip resurfacing procedures.

Metal-on-metal hip resurfacing offers a bone conserving alternative to total hip arthroplasty (THA) for young, active patients with osteoarthritis.[1,2] Both surgical treatments utilize a similar acetabular component, but unlike THA, hip resurfacing uses a short, stemmed femoral component that preserves the femoral neck.[3] The benefits of preserving the femoral neck are thought to include: easier revision surgery, lower dislocation rates, improved stress shielding to the proximal femur, increased range of motion, and limb length preservation.[4-7] However, placement of the femoral component presents challenges unique to hip resurfacing. Femoral neck fracture occurs in 0% to 4% of cases and is responsible for 30% of failed outcomes.[5,7-10] The incidence of femoral neck fractures has been found to be higher for inexperienced surgeons.[10-13] Risk factors known to provoke femoral neck fracture include: notching of the femoral neck during femoral head preparation, varus implant alignment, an undersized femoral component, and inadequate coverage of the reamed femoral head.[13] To avoid these risk factors, accurate sizing and placement of the components are critical.

Surgeons use templating before arthroplasty procedures to determine the appropriate size and placement of implanted components. Templating also benefits the operative team by allowing them to ensure availability of the anticipated component sizes for surgery and minimizing the risk of opening

Figure 1. (A) Acetate templates of femoral and acetabular component sizes provided by the manufacturer to overlay on printed radiographs; (B) Digital template of preoperative radiograph with TraumaCad software planning for 50 mm femoral and 58 mm acetabular components. Radiopaque marker used to calibrate radiograph magnification (*).



Authors' Disclosure Statement: The authors report no actual or potential conflict of interest in relation to this article.

Table I. Accuracy in Predicting Exact Size of Component

		Resident			Attending		
		Acetate	Digital		Acetate	Digital	
Femoral Component	Trial 1	19/78 (24%)	34/78 (44%)	P = 0.11	29/78 (37%)	23/78 (29%)	P = 0.73
	Trial 2	21/78 (27%)	21/78 (27%)		13/78 (17%)	20/78 (26%)	
	Trial 1&2	**11/78 (14%)**	**10/78 (13%)**		**8/78 (10%)**	**8/78 (10%)**	
Acetabular Component	Trial 1	19/78 (24%)	32/78 (41%)	P = 0.06	36/78 (46%)	29/78 (37%)	P = 0.85
	Trial 2	24/78 (31%)	27/78 (35%)		18/78 (23%)	25/78 (32%)	
	Trial 1&2	**12/78 (15%)**	**13/78 (17%)**		**11/78 (14%)**	**11/78 (14%)**	

the wrong components intraoperatively.[14] In the United States, wasted hip and knee implants alone cost hospitals an estimated $36 million each year.[15] Preoperative templating may represent a simple way to reduce this cost.

Conventional templating overlays acetate templates (**Figure 1A**) of different sizes on printed radiographs to predict component size, and has long been regarded as the "gold standard" in preoperative planning.[14,16] The push to adopt electronic medical records[17] has led many hospitals to replace printed radiographs with digital imaging systems, making acetate templating impractical, both financially and logistically.[18] Digital templating software (**Figure 1B**) is available, but its reliability in comparison to acetate templating has been questioned.[14,16,18-22] The accuracy of digital templating was compared with acetate templating in several studies for THA. The and colleagues[14] and Della Valle and colleagues[18] found acetate templating to be more accurate, but more recent studies by Iorio and colleagues,[20] Kosashvili and colleagues,[21] and Gamble and colleagues[22] found no difference between the templating methods, and concluded that digital templating was safe and reliable.

The literature regarding templating for hip resurfacing, however, is limited. Only 3 studies have tested the accuracy of acetate or digital templating, and no study has compared the 2 methods for hip resurfacing.[6,23,24] Because resurfacing is a technically difficult surgery that requires careful preoperative planning, it is imperative that we establish whether digital templating is a safe and reliable method. The purpose of the current study was to compare acetate to digital templating for hip resurfacing by addressing the following research questions: (a) is preoperative digital templating as accurate as acetate templating in predicting component size for hip resurfacing, and (b) does surgical experience of the templating surgeon correlate with templating accuracy?

Materials and Methods

Following Institutional Review Board approval, medical records of all patients who underwent hip resurfacing at our institution between January 2007 and December 2009 were reviewed. A total of 102 patients were identified. Twenty-four patients were excluded because they did not have preoperative radiographs with a magnification-establishing marker at the level of the greater trochanter, leaving 78 to be studied. The cohort included 53 men and 25 women, with a mean age of 48.8 years (range, 19 to 64), and mean body mass index of 29.4

Table II. Accuracy in Predicting Within One Component Size

		Resident			Attending		
		Acetate	Digital		Acetate	Digital	
Femoral Component	Trial 1	51/78 (65%)	65/78 (83%)	P = 0.008	60/78 (77%)	52/78 (67%)	P = 0.057
	Trial 2	55/78 (71%)	65/78 (83%)		41/78 (53%)	62/78 (79%)	
	Trial 1&2	**45/78 (58%)**	**55/78 (71%)**		**38/78 (49%)**	**48/78 (62%)**	
Acetabular Component	Trial 1	56/78 (72%)	69/78 (88%)	P = 0.01	63/78 (81%)	64/78 (82%)	P = 0.114
	Trial 2	56/78 (72%)	66/78 (85%)		58/78 (74%)	66/78 (85%)	
	Trial 1&2	**50/78 (64%)**	**58/78 (74%)**		**53/78 (68%)**	**56/78 (72%)**	

Table III. Intra and Inter-class Correlation Coefficient Analysis

Intraobserver Reliability				
	Acetate Templating		Digital Templating	
	Acetabular	Femoral	Acetabular	Femoral
Resident	0.84 (0.76-0.89)	0.87 (0.80-0.91)	0.76 (0.65-0.84)	0.76 (0.65-0.84)
Attending	0.85 (0.78-0.90)	0.76 (0.65-0.84)	0.87 (0.80-0.91)	0.82 (0.73-0.88)
Interobserver Reliability				
	Acetate Templating		Digital Templating	
	Acetabular	Femoral	Acetabular	Femoral
Trial 1	0.82 (0.73-0.88)	0.84 (0.76-0.89)	0.73 (0.61-0.82)	0.66 (0.52-0.77)
Trial 2	0.86 (0.79-0.91)	0.86 (0.79-0.91)	0.78 (0.68-0.85)	0.75 (0.64-0.83)

(range, 19.1 to 44.3) at the time of surgery. All patients received the Birmingham Hip Resurfacing (BHR) system (Smith and Nephew, Memphis, TN, USA).

Preoperative anteroposterior unilateral hip radiographs were taken in standard fashion with a 25.4 mm radiopaque sphere and stored in iSite v3.6 (Philips Healthcare, Andover, MA, USA) Picture Archiving and Communication System (PACS). Radiographs were calibrated to 120% and printed for acetate templating with standardized templates provided by the manufacturer. Digital templating was performed with TraumaCad v2.0 software (Voyant Health, Columbia, MD, USA) on digital PACS radiographs calibrated to 120%.

Two investigators, 1 fellowship-trained attending surgeon and 1 chief resident, independently prepared templates to predict the femoral and acetabular component sizes for each of the 78 preoperative radiographs. Both surgeons had experience with templating for hip resurfacing, but did not participate in the surgeries of enrolled patients. Acetate and digital templates were prepared on different occasions, separated by 2 months. Both surgeons repeated acetate and digital measures 4 months later to assess intra- and interobserver variability. When repeating measures, subject order was randomized and surgeons were blinded to their previous results in order to minimize recall bias.

Accuracy of the templating methods was measured by comparing the templated femoral and acetabular component sizes to the sizes of components actually implanted, which were retrieved from patients' medical records. To determine if a correlation existed between surgical experience and templating accuracy, results of the more-experienced attending surgeon were compared with the less-experienced chief resident.

Statistical analyses were performed with SAS 9.2 (Cary, NC, USA) and a p-value of 0.05 was considered statistically significant. Templating accuracy was calculated as the percentage of agreement between the templated and implanted components, either to within +/-1 size difference, or exact size. Frequencies of accuracy and component undersizing were calculated for each combination of method, surgeon, and location. Logistic regressions with repeated measures were used to compare templating accuracy and component undersizing of the 2 templating methods for each location, either for single surgeon or combined. A comparison of acetate and digital templating methods using absolute error values pooled from both surgeons was done using mixed effect models to account for within-subject-correlation for the repeated measures. To evaluate within-surgeon-reliability and between-surgeon-reliability, intraclass correlation coefficients (ICC) were calculated; ICC can be interpreted as follows for strength of agreement: 0.00 to 0.20 'poor', 0.21 to 0.40 'fair', 0.41 to 0.60 'moderate', 0.61 to 0.80 'substantial', and 0.80 to 1.00 'nearly perfect.'[25,26]

Results

Digital templating was more accurate than acetate templating in predicting femoral and acetabular component size. The absolute error (size increments away from actual implant size) of predicted femoral components was 1.13 sizes for acetate templates and 0.93 sizes for digital templates ($P < .001$). The absolute error of predicted acetabular components was 0.98 sizes for acetate templates and 0.81 sizes for digital templates ($P = .002$). Surgeons predicted the exact component size (**Table I**) in 29% of acetate templates and 34% of digital templates (femoral, $P = .101$; acetabular, $P = .202$). They predicted to +/-1 component size (**Table II**) in 71% of acetate templates and 82% of digital templates, (femoral, $P = .001$; acetabular, $P = .002$). Intraobserver reliability (**Table III**) was substantial to nearly perfect for both surgeons with both methods (ICC, 0.76 to 0.87). Interobserver reliability was also substantial to nearly perfect (ICC, 0.66 to 0.86). When surgeons did not predict exact size, they tended to underestimate component size (**Table IV, Figure 2**), which was done more often and to a larger degree with acetate templating.

The attending surgeon's templates were not more accurate than the chief resident's templates. The attending surgeon's absolute error for femoral components was 1.08 sizes and the resident's was 0.98 sizes ($P = .37$). The attending surgeon's absolute error for acetabular components was 0.86 sizes and the resident's was 0.92 sizes ($P = .53$).

Table IV. Component Undersizing

		Frequency					
		Resident			Attending		
		Acetate	Digital		Acetate	Digital	
Femoral Component	Trial 1	51/78 (65%)	20/78 (26%)	P < 0.001	39/78 (50%)	52/78 (67%)	P = 0.720
	Trial 2	54/78 (69%)	32/78 (41%)		62/78 (79%)	39/78 (50%)	
	Trial 1&2	**47/78 (60%)**	**13/78 (17%)**		**37/78 (47%)**	**35/78 (45%)**	
Acetabular Component	Trial 1	49/78 (63%)	19/78 (24%)	P < 0.001	32/78 (41%)	41/78 (53%	P = 0.344
	Trial 2	50/78 (64%)	30/78 (38%)		54/78 (69%)	30/78 (38%)	
	Trial 1&2	**42/78 (54%)**	**10/78 (13%)**		**30/78 (38%)**	**27/78 (35%)**	
		Mean & Standard Error of Undersizing (Component Size Increments)					
		Resident			Attending		
		Acetate	Digital		Acetate	Digital	
Femoral Component	Trial 1 (SEM)	1.61 (0.09)	1.25 (0.12)		1.51 (0.10)	1.56 (0.08)	
	Trial 2 (SEM)	1.52 (0.09)	1.31 (0.10)		1.71 (0.08)	1.26 (0.09)	
Acetabular Component	Trial 1 (SEM)	1.51 (0.09)	1.16(0.12)		1.44 (0.09)	1.34 (0.07)	
	Trial 2 (SEM)	1.56 (0.10)	1.27 (0.10)		1.41 (0.08)	1.20 (0.09)	

Discussion

The findings of the current study revealed that digital templating is more accurate than acetate templating in predicting component size when grading accuracy by absolute error and by prediction to +/-1 component size. The accuracy of digital templating for hip resurfacing was previously assessed by Olsen and colleagues.[24] In this study, surgeons predicted exact component size in 54% of femoral and 47% of acetabular templates. Digital trials in our study were less accurate (femoral, 31%; acetabular, 36%). Surgeons undersized components in roughly 35% of templates in Olsen and colleagues'[24] study, nearly as often as our surgeons did (42%). Konan and colleagues[6] found significant agreement between digital templates and actual implant size, but their study measured accuracy of

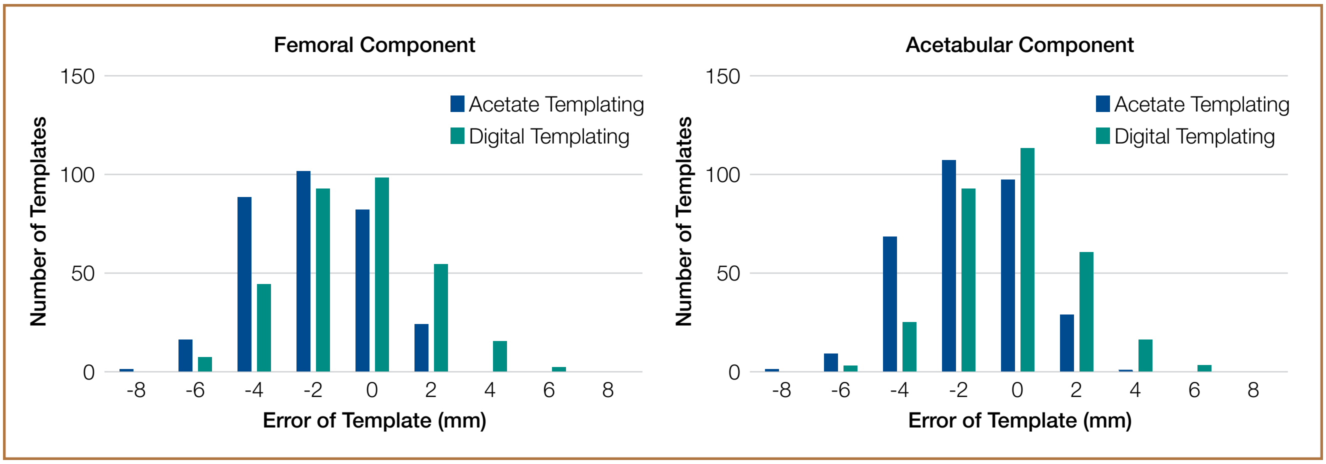


Figure 2. Distribution of the errors of acetate and digital templates. Acetate templating tended to undersize components as shown by the leftward shift of its distribution.

templates using ICC values, making comparison with our accuracy results difficult.[6] Most recently, Choi and colleagues[23] reported on acetate templating for hip resurfacing. In this study, surgeons predicted exact component size in 64% of femoral and 38% of acetabular templates, which was more accurate than our acetate trials (femoral, 26%; acetabular, 31%). Components were predicted to +/-1 size in 98.8% of femoral and 80.6% of acetabular templates, also more accurate than our acetate trials (femoral, 66%; acetabular, 75%).

While the results from our study were less accurate than those reported by Olsen and colleagues[23] and Choi and colleagues[24], one explanation for this finding is that additional sizes of the femoral component became available during our patient series. The majority of patients in our study received the BHR system with femoral components available in 4-mm-increments, but in early 2009 the manufacturer released femoral components in 2-mm-increments.[23] The acetate and digital templates used in our study already offered femoral components in 2-mm-increments. As a result, the surgeons in our study were templating with additional component sizes that were not available at the time of surgery, and accuracy was limited by this.[23] This discrepancy was accounted for by Choi and colleagues[23] and Olsen and colleagues,[24] and likely explains why templates were more accurate in these studies.

Surgical experience did not correlate with templating accuracy in our study. Templates prepared by the attending surgeon who completed an adult reconstruction fellowship were no more accurate than those performed by the resident. A relationship between surgical experience and templating accuracy has been suggested in the arthroplasty literature, but these studies were done for THA and total knee arthroplasty, not hip resurfacing.[27-29]

The tendency to undersize the femoral component in our study (**Figure 2**) is concerning, but consistent with results published in other acetate and digital templating studies.[6,14,16,23,24,30] Perhaps a more concerning finding in our study, however, was that surgeons were more likely to undersize the femoral component with acetate templating than with digital templating ($P < .001$). An undersized component is more likely to notch the femoral neck, which greatly increases the risk of fracture. It is also more difficult to seat in proper valgus orientation.[9] A biomechanical investigation in cadaveric femurs showed that components in valgus orientation had a significantly greater ultimate load to failure than components in varus orientation.[13]

The primary limitation to our study was the inconsistency of component size-increments, which limited the accuracy of predicted component sizes. However, both templating methods were equally affected by this, and in the setting of excellent intra- and interobserver reliability, comparative results remain valid. A second limitation was that implanted component sizes were assumed to be correct.[16] The purpose of our study was to compare the 2 templating methods, so clinical outcomes were not assessed. Our conclusions regarding surgical experience and templating accuracy are limited by the small number of templating surgeons. Additional limitations to our study include the retrospective single center design, the small sample size, and exclusive use of a single digital templating software system. The strengths of our study include subject randomization to minimize recall bias, and calibration of both acetate and digital radiographs to ensure that any difference in accuracy found between the templating methods cannot be attributed to incorrect image magnification.[18,30-32] Previous comparative studies have performed digital templating on calibrated radiographs but performed acetate templating on images that were printed at an assumed magnification based on patient distance from the radiograph cassette.[23,24] This assumed magnification is inaccurate because inconsistencies in patient position and body size alter distance from the cassette.[33] The difference in calibration would naturally make digital templating more accurate in these cases. In contrast to the previous studies, we eliminated this variable by including only radiographs with magnification establishing markers so that both acetate and digital images could be properly calibrated to 120% magnification before templating. This did limit our sample size, but the significance of proper image calibration is well documented in the templating literature and this was necessary to ensure a fair comparison of the templating methodologies without image calibration bias.[23,24]

The current study showed that digital templating is at least as accurate as acetate templating in predicting femoral and acetabular component sizes for hip resurfacing. Although the difference in accuracy was statistically significant, we are unable to comment on the clinical significance of this. These findings do suggest that, with appropriate calibration of the radiograph, surgeons can rely on digital templating for accurate preoperative planning and to ensure that anticipated component sizes are available in the operating room.

Dr. Bracey is Physician Scientist Resident, Dr. Seyler is Resident, Dr. Shields is Assistant Professor, Dr. Jinnah is Professor, and Dr. Lang is Associate Professor and Residency Program Director, Department of Orthopaedic Surgery, Wake Forest School of Medicine, Winston-Salem, North Carolina. Dr. Leng is Associate Professor, Department of Biostatics, Wake Forest School of Medicine, Winston-Salem, North Carolina.

Address correspondence to: Jason E. Lang, MD, Department of Orthopaedic Surgery, Wake Forest School of Medicine, Medical Center Boulevard, Winston-Salem, NC 27157 (tel, 336-716-9657; fax, 336-716-6286; e-mail, jlang@wakehealth.edu).

Am J Orthop. 2014;43(1):E19-E24.

References

1. Daniel J, Pynsent PB, McMinn DJ. Metal-on-metal resurfacing of the hip in patients under the age of 55 years with osteoarthritis. *J Bone Joint Surg Br.* 2004;86(2):177-184.
2. Amstutz HC, Ball ST, Le Duff MJ, Dorey FJ. Resurfacing THA for patients younger than 50 year: results of 2- to 9-year followup. *Clin Orthop Relat Res.* 2007;460:159-164.
3. Seyler TM, Marker DR, Boyd HS, Zywiel MG, McGrath MS, Mont MA. Preoperative evaluation to determine candidates for metal-on-metal hip resurfacing. *J Bone Joint Surg Am.* 2009;91 Suppl 6:32-41.
4. McMinn D, Treacy R, Lin K, Pynsent P. Metal on metal surface replacement of the hip. Experience of the McMinn prothesis. *Clin Orthop Relat Res.* 1996(329 Suppl):S89-S98.
5. Carrothers AD, Gilbert RE, Jaiswal A, Richardson JB. Birmingham

hip resurfacing: the prevalence of failure. *J Bone Joint Surg Br.* 2010;92(10):1344-1350.
6. Konan S, Rayan F, Meermans G, Geurts J, Haddad FS. Preoperative digital templating of Birmingham hip resurfacing. *Hip Int.* 2010;20(1):14-17.
7. Stulberg BN, Trier KK, Naughton M, Zadzilka JD. Results and lessons learned from a United States hip resurfacing investigational device exemption trial. *J Bone Joint Surg Am.* 2008;90 Suppl 3:21-26.
8. Khan M, Kuiper JH, Edwards D, Robinson E, Richardson JB. Birmingham hip arthroplasty: five to eight years of prospective multicenter results. *J Arthroplasty.* 2009;24(7):1044-1050.
9. McBryde CW, Theivendran K, Thomas AM, Treacy RB, Pynsent PB. The influence of head size and sex on the outcome of Birmingham hip resurfacing. *J Bone Joint Surg Am.* 2010;92(1):105-112.
10. Mont MA, Ragland PS, Etienne G, Seyler TM, Schmalzried TP. Hip resurfacing arthroplasty. *J Am Acad Orthop Surg.* 2006;14(8):454-463.
11. Davis ET, Olsen M, Zdero R, Waddell JP, Schemitsch EH. Femoral neck fracture following hip resurfacing: the effect of alignment of the femoral component. *J Bone Joint Surg Br.* 2008;90(11):1522-1527.
12. Marker DR, Seyler TM, Jinnah RH, Delanois RE, Ulrich SD, Mont MA. Femoral neck fractures after metal-on-metal total hip resurfacing: a prospective cohort study. *J Arthroplasty.* 2007;22(7 Suppl 3):66-71.
13. Richards CJ, Giannitsios D, Huk OL, Zukor DJ, Steffen T, Antoniou J. Risk of periprosthetic femoral neck fracture after hip resurfacing arthroplasty: valgus compared with anatomic alignment. A biochemical and clinical analysis. *J Bone Joint Surg Am.* 2008;90 Suppl 3:96-101.
14. The B, Diercks RL, van Ooijen PM, van Horn JR. Comparison of analog and digital preoperative planning in total hip and knee arthroplasties. A prospective study of 173 hips and 65 total knees. *Acta Orthop.* 2005;76(1):78-84.
15. Zywiel MG, Ulrich SD, Suda AJ, Duncan JL, McGrath MS, Mont MA. Incidence and cost of intraoperative waste of hip and knee arthroplasty implants. *J Arthroplasty.* 2010;25(4):558-562.
16. Specht LM, Levitz S, Iorio R, Healy WL, Tilzey JF. A comparison of acetate and digital templating for total knee arthroplasty. *Clin Orthop Relat Res.* 2007;464:179-183.
17. Bitton A, Flier LA, Jha AK. Health information technology in the era of care delivery reform: to what end? *JAMA.* 2012;307(24):2593-2594.
18. González Della Valle A, Comba F, Taveras N, Salvati EA. The utility and precision of analogue and digital preoperative planning for total hip arthroplasty. *Int Orthop.* 2008;32(3):289-294.
19. Hossain M, Lewis J, Sinha A. Digital pre-operative templating is more accurate in total hip replacement compared to analogue templating. *Eur J Orthop Surg Traumatol.* 2008;18(8):577-580.
20. Iorio R, Siegel J, Specht LM, Tilzey JF, Hartman A, Healy WL. A comparison of acetate vs digital templating for preoperative planning of total hip arthroplasty: is digital templating accurate and safe? *J Arthroplasty.* 2009;24(2):175-179.
21. Kosashvili Y, Shasha N, Olschewski E, et al. Digital versus conventional templating techniques in preoperative planning for total hip arthroplasty. *Can J Surg.* 2009;52(1):6-11.
22. Gamble P, de Beer J, Petruccelli D, Winemaker M. The accuracy of digital templating in uncemented total hip arthroplasty. *J Arthroplasty.* 2010;25(4):529-532.
23. Choi JK, Geller JA, Wang W, Nyce JD, Macaulay W. The accuracy and reliability of preoperative templating for metal-on-metal hip resurfacing. *J Arthroplasty.* 2011;26(5):765-770.
24. Olsen M, Gamble P, Chiu M, Tumia N, Boyle RA, Schemitsch EH. Assessment of accuracy and reliability in preoperative templating for hip resurfacing arthroplasty. *J Arthroplasty.* 2010;25(3):445-449.
25. Shrout PE, Fleiss JL. Intraclass correlations: uses in assessing rater reliability. *Psychol Bull.* 1979;86(2):420-428.
26. Naqvi GA, Walsh JC, Htein W, Curtin W. Accuracy of preoperative templating for total hip arthroplasty using the Picture Archiving and Communication System. *Eur J Orthop Surg Traumatol.* 2010;20(3):211-215.
27. Hsu AR, Kim JD, Bhatia S, Levine BR. Effect of training level on accuracy of digital templating in primary total hip and knee arthroplasty. *Orthopedics.* 2012;35(2):e179-e183.
28. Mittag F, Ipach I, Schaefer R, Meisner C, Leichtle U. Predictive value of preoperative digital templating in THA depends on the surgical experience of the performing physician. *Orthopedics.* 2012;35(2):e144-e147.
29. Efe T, El Zayat BF, Heyse TJ, Timmesfeld N, Fuchs-Winkelmann S, Schmitt J. Precision of preoperative digital templating in total hip arthroplasty. *Acta Orthop Belg.* 2011;77(5):616-621.
30. Oddy MJ, Jones MJ, Pendegrass CJ, Pilling JR, Wimhurst JA. Assessment of reproducibility and accuracy in templating hybrid total hip arthroplasty using digital radiographs. *J Bone Joint Surg Br.* 2006;88(5):581-585.
31. White SP, Bainbridge J, Smith EJ. Assessment of magnification of digital pelvic radiographs in total hip arthroplasty using templating software. *Ann R Coll Surg Engl.* 2008;90(7):592-596.
32. 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(1):53-54.
33. Bayne CO, Krosin M, Barber TC. Evaluation of the accuracy and use of x-ray markers in digital templating for total hip arthroplasty. *J Arthroplasty.* 2009;24(3):407-413.

This paper will be judged for the Resident Writer's Award.