The use of digital radiography and templating software continues to become more prevalent in orthopedics as the number of total hip arthroplasty (THA) and total knee arthroplasty (TKA) procedures increases every year. The purpose of this study was to evaluate the effect of training level on the accuracy of digital templating for primary THA and TKA. Digital radiographs of 97 patients undergoing primary THA (49 cases) and TKA (48 cases) were retrospectively templated using OrthoView digital planning software (OrthoView LLC, Jacksonville, Florida). Anteroposterior hip and lateral knee radiographs were digitally templated and compared with the actual size of the implants used intraoperatively. An implant sales representative, physician assistant, medical student (J.D.K.), resident (A.R.H.), and fellowship-trained arthroplasty surgeon (B.R.L.) templated all cases independently after a standardized orientation and were blinded to the actual component sizes used for surgery. The medical student, resident, and arthroplasty surgeon retemplated the same 97 cases 1 month later to determine intraobserver reliability. Digital templating was accurate in predicting the correct implant size in 33% of THAs and 54% of TKAs. In 73% of THAs and 92% of TKAs, digital templating was within 1 size of the actual implant used, and in 88% of THAs and 99% of TKAs, templating was within 2 sizes of the final components. In no cases did the templated implant size vary by >3 sizes from the final components. Interobserver reliability for templating THAs and TKAs showed good reliability as measured by intraclass correlation coefficient (ICC) (ICC\textsubscript{THA}=.70; ICC\textsubscript{TKA}=.86). Intraobserver reliability for templating THAs had excellent reliability for the resident and arthroplasty surgeon, with a kappa coefficient (κ) of 0.92, and good reliability for the medical student (κ=0.78). Intraobserver reliability for templating TKAs showed excellent reliability among all examiners (κ=0.90).
Preoperative planning is a critical component of total hip arthroplasty (THA) and total knee arthroplasty (TKA) to produce accurate and reproducible clinical outcomes and radiographic results. Templating also helps determine the need for nonstandard implant sizes, predict levels of bony resection, match normal anatomy, and anticipate the intraoperative plan.1 Traditionally, preoperative templating for THA and TKA were performed using flexible plastic templates on standard acetate radiographs with good success.2 However, variability in radiograph magnification, penetration, and image quality can significantly affect the accuracy and reproducibility of templating.1,3 Advances in technology combined with federal initiatives to reduce health care costs have led to the widespread use of digital radiography via picture archiving and communication systems (PACS). This trend is driving the progressive elimination of printed acetate radiographs and the increased use of digital radiography and templating software packages. The goals of digital templating are to improve preoperative planning by reducing the number of errors in component sizing, alignment, and fit, while also reducing radiograph printing costs and the need to prepare excess components for the operating room. Advantages of digital templating include quick and reproducible templating, the opportunity to minimize the number of the plan that is easily accessible, and anticipate the intraoperative plan.1,2,4 Several studies have compared with standard acetate templating and its efficacy as a means for predicting the size of THA and TKA components used intraoperatively.1,2,4,6 Although digital templating is often cited as easy to learn with reliable and reproducible results, this concept has not previously been tested or examined in the literature across different levels of training. The purpose of this study was to evaluate the effect of the level of orthopedic training on digital templating accuracy and reproducibility for primary THA and TKA. Training levels tested included an implant sales representative, physician assistant, medical student (J.D.K.), resident (A.R.H.), and fellowship-trained arthroplasty surgeon (B.R.L.).

**MATERIALS AND METHODS**

Ninety-seven patients with digital radiographs undergoing primary THA (49 cases) and TKA (48 cases) during a 1-year period were randomly chosen and analyzed for this study. Institutional Review Board approval was obtained for this retrospective study. All cases were templated using OrthoView digital planning software (OrthoView LLC, Jacksonville, Florida) after each examiner was given a standardized 10-minute orientation session to learn how to use the features of the software package. Of the 49 THAs templated, 27 were right-sided and 22 were left-sided. Of the 48 TKAs templated, 22 were right-sided and 26 were left-sided. All digital radiographs used for this study were obtained by the same radiology technologists at our institution using standardized protocols for the hip and knee. A 25-mm metallic ball was used in every radiograph as a standard calibrating marker to calculate the intraclass correlation coefficient (ICC) for interobserver reliability. An established scale was used to grade coefficient reliability.7

**RESULTS**

Digital templating was accurate in predicting the correct implant size in 33% of THAs and 54% of TKAs (Table 1). In 73% of THAs and 92% of TKAs, digital templating was within 1 size of the actual implant used, and in 88% of THAs and 99% of TKAs, templating was within 2 sizes of the final components. In no case did the templated implant size vary by >3 sizes from the final components. No trends of oversizing or undersizing components were observed by examiners for either THA or TKA cases. No observable trend of increased accuracy was found between cases that were templated in the...
Digital templating in THA and TKA | Hsu et al

beginning of the series and cases that were templated at the end (no learning curve).

Digital templating for THA predicted the correct acetabular cup size 36% of the time and correct femoral stem size 31% of the time. Templating was within 1 size of the implanted acetabular and femoral components 75% and 71% of the time, respectively. Increasing the range to within 2 sizes improved accuracy to 90% for the acetabular component and 85% for the femoral component. For TKA cases, the correct femoral component size was predicted 58% of the time and correct tibial tray size 50% of the time. Accuracy improved to 96% and 88% for the femoral and tibial components, respectively, when the range was increased to within 1 size of the implanted components. Increasing the range to within 2 sizes improved accuracy to 100% for the femoral component and 98% for the tibial component.

Interobserver reliability for templating THAs and TKAs showed good reliability as measured by the intraclass correlation coefficient (ICC) (ICC\(_{THA}=.70\); ICC\(_{TKA}=.86\)). Intraobserver reliability for templating THAs had excellent reliability for the resident and arthroplasty surgeon, with a kappa coefficient (κ) of 0.92, and good reliability with the medical student (κ=0.78). Intraobserver reliability for templating TKAs showed excellent reliability for the medical student, resident, and arthroplasty surgeon (κ=0.90).

**DISCUSSION**

Digital templating is an effective tool for preoperative planning in THA and TKA and can accurately predict the size of components to be used in the operating room.\(^1,2,4\) The main finding of the current study was that digital templating for THA and TKA was accurately and reproducibly performed by personnel with varying levels of orthopedic training. Although several studies have compared the accuracy of digital templating with that of standard acetate templating,\(^1,2,4,6\) the cases in these studies were all templated by arthroplasty-trained orthopedic surgeons, not personnel with varying levels of training, such as implant sales representatives, physician assistants, medical students, and residents.

Hossain et al\(^5\) found improved accuracy with digital templating in THA compared with standard acetate templating, and Specht et al\(^1\) also found greater accuracy of digital templating in TKA. Trickett et al\(^8\) demonstrated good inter- and intraobserver agreement for femoral and tibial component templating in a series of 40 consecutive TKA cases. The correct femoral implant was predicted 48% of the time and correct tibial implant 55% of the time.\(^8\) Kumar et al\(^9\) also demonstrated excellent intra- and interobserver reliability with good accuracy for 45 primary uncemented THA cases. Acetabular and femoral components were exactly correct 56% and 62% of the time, respectively. Increasing the range to within 1 size improved accuracy to 91% for the acetabular components and 78% for femoral components. Crooijmans et al\(^10\) developed a modified technique to magnify the calibrating marker that further improved the ease and accuracy of THA and TKA digital templating.

Preoperative digital templating has also been found to be accurate with good reliability (ICC >0.8 for acetabular and femoral components) for Birmingham hip resurfacing procedures.\(^11\) A recent study by Whidden et al\(^12\) comparing standard acetate vs digital templating in THA found an 11% improvement in predicted acetabular component size and 8% improvement in femoral stem size with digital templating. Zhao et al\(^13\) recently showed that digi-

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**Table**

<table>
<thead>
<tr>
<th>Overall Digital Templating Results for THA and TKA Cases</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>THA (n=49)</strong></td>
<td></td>
</tr>
<tr>
<td>Acetabulum</td>
<td></td>
</tr>
<tr>
<td>Correct size</td>
<td>58</td>
</tr>
<tr>
<td>Within 1 size</td>
<td>96</td>
</tr>
<tr>
<td>Within 2 sizes</td>
<td>100</td>
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<tr>
<td>Femur</td>
<td></td>
</tr>
<tr>
<td>Correct size</td>
<td>31</td>
</tr>
<tr>
<td>Within 1 size</td>
<td>71</td>
</tr>
<tr>
<td>Within 2 sizes</td>
<td>85</td>
</tr>
<tr>
<td>Tibia</td>
<td></td>
</tr>
<tr>
<td>Correct size</td>
<td>50</td>
</tr>
<tr>
<td>Within 1 size</td>
<td>88</td>
</tr>
<tr>
<td>Within 2 sizes</td>
<td>98</td>
</tr>
</tbody>
</table>

Abbreviations: THA, total hip arthroplasty; TKA, total knee arthroplasty.

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**Figure 1:** Digitally templated anteroposterior radiograph for right total hip arthroplasty using OrthoView software (OrthoView LLC, Jacksonville, Florida). Components shown are size 52 acetabular cup and size 12 femoral stem.

**Figure 2:** Digitally templated lateral radiograph for right total knee arthroplasty using OrthoView software (OrthoView LLC, Jacksonville, Florida). Components shown are size C femoral component and size 3 standard keel tibial component.
Digital templating could be effectively used to template THA for Crowe type II and III dysplastic hips that have increased disruption of normal radiographic landmarks compared with patients with primary osteoarthritis.

One of the limitations of the current study is the small number of examiners in each of the training levels who participated in the simulated THA and TKA templating. However, the purpose of this study was to first establish that digital templating could be easily learned with reproducible results across a wide spectrum of orthopedic training levels. Each examiner received the same orientation session prior to using the templating software and was blinded to the final component sizes used and their own previously templated sizes to reduce any unfair learning bias between training levels.

Another study limitation is that we were unable to account for the severity of preoperative disease in hips and knees that may have influenced the predicted and actual component sizes used. However, all cases were selected at random and templated in a standardized manner by each examiner. Although the accuracy of digital templating in predicting correct implant size in the current study was 33% for THAs and 54% for TKAs, these results are appropriate given the wide array of training levels tested and the fact that 1 of the 5 examiners was a fellowship-trained arthroplasty surgeon. A previous study from our group using a different digital templating software tested by a single arthroplasty surgeon. A previous study of the 5 examiners was a fellowship-trained training level tested and the fact that 1 of template sizes to reduce any unfair learning bias between training levels.

Plant size in the current study was 33% for THAs and 54% for TKAs, these results are replicated, worsened, or improved upon.

One of the long-term goals of disseminating digital templating education and use is to allow implant representatives to help template preoperative radiographs to efficiently use vendor and hospital inventory. Secure portals for transfer of de-identified patient radiographs can be established, allowing sales representatives, ancillary staff, students, residents, and surgeons the ability to template from home, office, or hospital over the Internet. Early awareness of implant needs may allow companies the ability to tightly control inventory and production with the possibility of increased savings for the hospital and health care system as a whole. The relative ease, accuracy, and reproducibility of digital templating across varying orthopedic training levels makes it an attractive option for arthroplasty surgeons, implant manufacturers, and hospitals alike. Further studies are needed to determine the efficacy and cost effectiveness of using digital templating for small and large institutions in which THAs and TKAs are performed, along with the potential effects on clinical outcomes. In addition, it would be advantageous to test larger groups of personnel in each training level ranging from sales representatives to senior arthroplasty surgeons at multiple institutions to see if our results are replicated, worsened, or improved upon.

**REFERENCES**


