Template-directed Instrumentation in Total Knee Arthroplasty: Cost Savings Analysis

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abstract

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The use of digital radiography and templating software in total knee arthroplasty (TKA) continues to become more prevalent as the number of procedures performed increases every year. Template-directed instrumentation (TDI) is a novel approach to surgical planning that combines digital templating with limited intraoperative instruments. The purpose of this study was to evaluate the financial implications and radiographic outcomes of using TDI to direct instrumentation during primary TKA.

Over a 1-year period, 82 consecutive TKAs using TDI were retrospectively reviewed. Patient demographics and preoperative templated sizes of predicted components were recorded, and OrthoView digital planning software (OrthoView LLC, Jacksonville, Florida) was used to determine the 2 most likely tibial and femoral component sizes for each case. This sizing information was used to direct component vendors to prepare 3 lightweight instrument trays based on these sizes. The sizes of implanted components and the number of total trays required were documented. A cost savings analysis was performed to compare TDI and non-TDI surgical expenses for TKA. In 80 (97%) of 82 cases, the prepared sizes determined by TDI using 3 instrument trays were sufficient. Preoperative templating correctly predicted the size of the tibial and femoral component sizes in 90% and 83% of cases, respectively. The average number of trays used with TDI was 3.0 (range, 3-5 trays) compared with 7.5 (range, 6-9 trays) used in 82 preceding non-TDI TKAs. Based on standard fees to sterilize and package implant trays (approximately $26 based on a survey of 10 orthopedic hospitals performing TKA), approximately $9612 was saved by using TDI over the 1-year study period.

Overall, digital templating and TDI were a simple and cost-effective approach when performing primary TKA.

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Preoperative planning is an essential component of total knee arthroplasty (TKA) to obtain accurate and reproducible clinical outcomes and radiographic results. Templating can help determine the need for nonstandard component sizes, predict amounts of bony resection, and anticipate surgical plans. Although acetate templating remains the gold standard with proven accuracy and reliability, digital radiographs and templating can help reduce errors associated with manipulating films and templates.

The use of digital templating has recently grown due to advances in picture archiving and communication system (PACS) technology and government initiatives to reduce health care costs. Digital templating can improve preoperative planning by reducing errors in component sizing and alignment while also decreasing costs associated with radiograph printing and bringing excess components into the operating room. Advantages of digital templating include quick and reproducible planning, remote access, and the ability to keep a permanent digital record of the surgical plan.

In addition, it is possible to minimize the number of surgical trays used based on this preoperative plan. Studies have confirmed the accuracy of digital templating compared with standard acetate templating and its ability to correctly predict the size of TKA components used intraoperatively. The current authors previously reported that digital templating is an effective means for predicting the size of TKA components and can be performed by personnel across different levels of orthopedic training with reliable and reproducible results.

The rising cost of health care in the United States is at the forefront of national debate and represents a serious threat to societal infrastructure. The number of TKA procedures is projected to increase each year to approximately 3.5 million by 2030, representing a significant overall cost to the national health care system. Improved hospital resource use to reduce costs and improve quality care is critical in combination with individual surgeon accountability to make use of effective, inexpensive solutions supported by clinical data. With the increased use of digital radiography and templating software in TKA, template-directed instrumentation (TDI) is a novel approach to surgical planning that combines digital templating with prepared instruments and components used intraoperatively. The purpose of this study was to evaluate the financial implications and radiographic outcomes of using TDI to direct instrumentation during primary TKA.

**Materials and Methods**

Eighty-two consecutive patients with digital radiographs undergoing primary TKA by a single surgeon (B.R.L.) at 1 hospital during a 1-year period were retrospectively analyzed for this study. Institutional review board approval was obtained prior to study initiation.

Inclusion criteria were patients undergoing primary TKA who had standard calibration markers on preoperative digital radiographs. All digital radiographs used for this study were obtained by the same group of radiology technologists at the authors’ institution using standardized knee protocols. Patient demographics, including age, sex, and body mass index (BMI), were recorded, as well as operative side and presence of varus or valgus alignment. All cases were preoperatively templated using OrthoView digital planning software (OrthoView LLC, Jacksonville, Florida) by the senior author (B.R.L.), who has extensive experience using digital templating software. Lateral knee radiographs were digitally templated for TKA planning using a standard 25-mm calibration marker placed at the midline of the anterior thigh at the level of the patella, with the best sizes of the femoral and tibial components recorded (Figure 1). Average time to complete preoperative templating was 55 seconds, with a maximum time of 90 seconds.

Two types of TKA implants were used for templating based on surgeon preference to reduce sizing errors stemming from multiple implant-specific design features. Ten cases of TKA were templated for the Vanguard TKA system (Biomet, Warsaw, Indiana), and 72 cases were templated for a NexGen CR Flex TKA (Zimmer, Warsaw, Indiana). Templated sizing information was used to direct component vendors to prepare 3 lightweight instrument trays based on these sizes. The sizes of implanted components and the number of total trays required were documented. Preoperative templating sizes were compared with implant sizes used intraoperatively, which were obtained from operative notes. The final number of trays used intraoperatively for TDI cases was recorded and compared with the number of trays used for 82 preceding TKA cases without TDI.
All TKAs were performed using a midvastus approach and standard surgical instruments. Postoperative radiographs were analyzed for mechanical axis and proper component positioning. A cost savings analysis was performed to compare TDI and non-TDI TKAs in regard to instrument tray costs. Costs per instrument tray were based on interview data from 10 orthopedic hospitals performing TKA to determine cleaning and sterilization costs per instrument tray and associated costs of labor, utilities, materials, waste, and machine depreciation.

RESULTS

Fifty-three patients were women and 29 were men. Average patient age was 63 years (range, 39-87 years). Average BMI was 33.9 kg/m² (range, 19-65 kg/m²). Of the 82 TDI TKAs, 49 were left- and 33 were right-sided. Varus and valgus preoperative limb alignment were present in 69 and 13 TKAs, respectively. Digital templating was accurate in predicting the correct tibial component size in 74 (90%) of 82 cases and the correct femoral component size in 68 (83%) of 82 cases (Table 1). All templated cases were within 1 size of the final components used intraoperatively.

In 80 (97%) of 82 cases, the prepared sizes determined by TDI and 3 component trays provided all of the instruments necessary for surgery. One case required conversion from a cruciate-retaining implant to a posterior-stabilized implant of the same size, requiring 1 additional tray. In another case, a tibia size 1 larger than prepared was needed, and an additional tray was opened. The average number of trays used with TDI was 3.0 (range, 3-5 trays) compared with 7.5 (range, 6-9 trays) for the 82 preceding non-TDI TKAs. Analysis of postoperative radiographs showed no significant outliers in regard to mechanical axis, with no components undersized by more than 2 mm and none with more than 1.5 mm of overhang.

A total cost of $26.05 for cleaning and sterilizing each instrument tray was determined based on interview data from 10 orthopedic hospitals, factoring in labor, utilities, materials, waste, and machine depreciation (Figure 2). The total cost of 82 TDI TKA cases was approximately $6408 compared with approximately $16,020 for the 82 preceding non-TDI TKAs. Analysis of postoperative radiographs showed no significant outliers in regard to mechanical axis, with no components undersized by more than 2 mm and none with more than 1.5 mm of overhang.

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DISCUSSION

The main finding of this study was that TDI for primary TKA cases accurately predicted intraoperative component sizes and saved approximately $9612 over a 1-year period for a single surgeon with no negative effects on radiographic outcomes. In no case did the templated implant size vary by more than 1 size from the final components used. Additional savings not directly analyzed by this study include reduced cost from faster operating room turnover times, shorter setup time, and the ability to template without printing hard copies of radiographs. With an estimated cost of $1 per radiograph sheet and approximately 3 to 5 radiograph sheets per case, this would create an ad-

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Overall Digital Templating Results for TKAs</th>
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<tr>
<td>Size</td>
<td>Tibia</td>
</tr>
<tr>
<td>Correct size</td>
<td>90</td>
</tr>
<tr>
<td>Within 1 size</td>
<td>100</td>
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Abbreviation: TKA, total knee arthroplasty.
ditional savings of $246 to $410 for the 82 TKA cases in the current study.

The current authors previously reported that digital templating is an effective means for predicting component sizes for primary TKA and can easily, accurately, and reproducibly be performed by a wide range of orthopedic training levels. Combined results from an implant sales representative, physician assistant, medical student, resident, and fellowship-trained arthroplasty surgeon after templating 97 TKA cases showed that in 92% of TKAs, digital templating was within 1 size of the actual implant used, and in 99% of TKAs, templating was within 2 sizes of final components. Intraobserver reliability for templating TKAs showed excellent reliability among all examiners (κ = 0.90). Specht et al reported greater accuracy of digital templating compared with acetate templating in TKA, and Trickett et al demonstrated good inter- and intraobserver agreement for both femoral and tibial component templating in a series of 40 consecutive TKAs. Crooijmans et al developed a modified technique to magnify the calibrating marker that further improved the ease and accuracy of TKA digital templating, which was used as a standard technique in the current study.

Kobayashi et al compared preoperative templating in 100 TKA cases using conventional 2-dimensional and computed tomography–based 3-dimensional techniques. No significant differences existed in accuracy between 2- and 3-dimensional templating in predicting implant sizes, suggesting that 3-dimensional templating may not have added usefulness for primary TKA cases. Peek et al analyzed the accuracy of digital templating by focusing on postoperative radiographs from a series of 90 consecutive TKAs; half were templated digitally with a calibration ball and half were not templated. Digital templating using a calibrating marker correctly predicted the exact size for 60% of tibial and 71% of femoral components. These results are comparable to previous findings by the current authors that digital templating accurately predicted tibial size in 63% and femoral size in 69% of 176 consecutive TKAs. Results from the current study showed a significant improvement in templating accuracy to 90% for tibial and 83% for femoral component sizes. Increased experience with digital templating by the senior author was likely the cause for the improved templating accuracy.

Routine primary TKA typically requires 5 to 10 instrument trays that are each prepared, sterilized, packaged, set up, and delivered to the operating room. The total cost and time required to provide and supply these instruments can be substantial for hospitals and vendors. Proposed solutions to decrease the amount of intraoperative instrumentation required include patient-specific cutting guides, intraoperative navigation, disposable guides, and TDI. Template-directed instrumentation has the potential to help surgeons forgo the need to print radiographs and transport templates to the operating room, thus saving expenses associated with materials, storage, and staff time. In addition, as TDI continues to be refined and integrated in hospital systems, less instrumentation could help improve tray and operating room turnover to allow for more cases to be completed, minimize surface area for contamination, and lower hospital costs per procedure. Inventory control by vendors using scheduling software to control inventory more tightly could improve operating room efficiency and reduce manufacturing costs.

One of the limitations of this study was the limited number of TKAs analyzed by a single surgeon at 1 hospital. However, the purpose of this study was to first establish that TDI could reduce costs associated with instrument tray preparation as a proof of principle. Larger-scale integration of TDI would need to incorporate multiple surgeons at several institutions to determine if the cost savings found in the current study are increased at scale and what pattern the cost savings curve follows. Another limitation was that the authors were unable to account for confounding factors such as severity of preoperative disease and quality of preoperative radiographs, which may have influenced templating accuracy.

As more hospitals incorporate digital radiography and templating due to cost and efficiency reasons, the demand for digital templating software is growing, as is the need for orthopedic surgeons to synthesize the benefits of digital templating into surgical plans. One of the long-term goals of

<table>
<thead>
<tr>
<th>Tray Processing Step</th>
<th>Category</th>
<th>Average Cost, $</th>
<th>Total Cost Per Tray, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical waste disposal</td>
<td>Waste volume</td>
<td>1.23</td>
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<td>Cleaning</td>
<td>Labor, detergent</td>
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<td>Labor, capital</td>
<td>2.13</td>
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<tr>
<td>Wrapping</td>
<td>Labor, materials</td>
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</tr>
<tr>
<td>Total</td>
<td></td>
<td>26.05</td>
<td>100</td>
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</tbody>
</table>

*Sterile processing and distribution processing steps categorized as waste, labor, detergent, capital, or materials.
disseminating digital templating education and use is to allow various members of the orthopedic team to help template preoperative radiographs to efficiently use vendor and hospital inventory. Awareness of implant needs can allow companies to tightly control inventory and production with the goal of increased savings for hospitals and health care systems. The relative ease, accuracy, and reproducibility of digital templating, as well as its reduction in instrument tray expenses, makes it an attractive cost savings strategy for arthroplasty surgeons, implant manufacturers, and hospitals. Wider acceptance of TDI in the future may also significantly decrease staff costs due to less man hours needed and improved sterile processing and distribution efficiency. Future prospective, multicenter studies are needed to determine the long-term efficacy and cost effectiveness of using digital templating for small and large institutions in which arthroplasty procedures are performed.

REFERENCES


