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Shifting to an app-based method of preoperative templating in orthopaedic surgery

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Abstract

Background: Preoperative templating plays an important part in attaining successful surgical outcomes after fracture fixation. Traditionally, surgeons have performed this task with printed radiographs, tracing paper, and colored markers. Now that digital radiography is ubiquitous, and digital templating platforms are needed but are expensive and may not be available to all surgeons, especially those in low-income and middle-income countries. In this study, we evaluate an innovative and user-friendly method using a mobile app that may facilitate the use of digital templating for all surgeons worldwide.

Methods: A study involving 2 groups of residents ($N = 12$) was conducted. Group A ($n = 6$) was assigned to do conventional templating; Group B ($n = 6$) was assigned to perform digital templating. Each group then switched to the other templating method and the process was repeated. Conventional templates were evaluated using the Arbeitsgemeinschaft für Osteosynthesefragen-Association for the Study of Internal Fixation (AO-ASIF) guidelines of template completeness. Digital templates were assessed using Image-Based Surgery Planning. Each subject in both groups completed templates for 3 injury patterns: AO 2R2A3/2U2C2, 32B2, and 43C2. Wilcoxon signed-rank and binomial tests (5% level of significance) were used for statistical analysis.

Results: Template processing, fracture classification, and plan elaboration were comparable between the traditional and digital template groups, with good interobserver and intraobserver reproducibility using the Wilcoxon signed-ranks test (*all |z values| below 1.96, all P-values* > 0.05). There was no significant difference in the evaluation scores for either exercise, whether doing a traditional standard template or the digital template (P value > 0.05).

Conclusions: This study shows that digital templating can achieve the same goals as conventional preoperative templating for fracture fixation. With the ubiquity of digital radiography, digital templating provides an opportunity to visualize fracture configurations and create an optimum preoperative plan for fracture reconstruction using an innovative and user-friendly platform.

Key Words: preoperative planning, preoperative template, fracture surgery

1. Introduction

Surgical training includes the development of hands-on skills through multiple modalities including cadaveric dissections, synthetic bone fixation, and software simulations. However, trainees can only perform such skills correctly after carefully planning and executing the steps mentally. "Failing to plan is planning to fail" has been a mantra for orthopaedic surgeons worldwide. This refers to performing the cerebral and practical exercise of preoperative templating before the actual surgery is performed. Performing such tasks plays an important part in achieving a successful outcome. Preoperative planning is beneficial for injuries ranging from simple diaphyseal to complex periarticular fractures where fracture patterns dictate reduction and fixation principles.

Fracture templating has been encouraged by the Arbeitsgemeinschaft für Osteosynthesefragen (AO) for decades and is emphasized in all AO basic courses. It includes a step-by-step assessment and reconstruction of the fracture fragments and a detailed plan of the internal fixation process.[1] Many orthopaedic implant companies supply acetate templates to allow for preoperative planning before surgery.[2,3] Traditionally, this is performed by hand with printed radiographs, tracing paper, and markers.

As many of our tasks have transitioned to digital platforms, more can now be achieved with the click of a button or the swipe

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TABLE 1

Descriptive Statistics of Residents Involved in the Study

	Group A	Group B
Age		
<30 y old	33.3%	16.7%
>30 y old	66.7%	83.3%
Sex		
Male	83.3%	83.3%
Female	16.7%	16.7%
Year level		
PGY 1	33.3%	50.0%
PGY 2	50.0%	16.7%
PGY 3	0%	33.3%
PGY 4	16.7%	0%
Time from start to finish		
<30 min	38.9%	77.8%
30–60 min	55.6%	22.2%
>60 min	5.5%	0%

of a finger. An abundance of digital tools are now available online; however, the cost can be substantial and digital templating platforms may not be universally available, especially to surgeons who work in low-income and middle-income countries that have less resources. In this study, we evaluate whether a mobile app-based platform which is innovative and user-friendly can successfully achieve the standard goals of preoperative templating. Our specific objectives are the following:

1. To describe the technique of digital templating using a commercially available app-based platform.
2. To compare digital and conventional preoperative templating techniques in achieving the standard goals of preoperative templating.

We hypothesize that there is no significant difference in using an app-based platform with the conventional preoperative templating technique.

2. Methodology

2.1. Study Design

Twelve residents affiliated with a single residency program (10 male [80%], 2 female [20%]; median age 31 years [28–34 years]) were divided into 2 equal, randomly assigned groups, A and B, using lottery method. 33.3% were below 30 years, and 66.7% were older than 30 years. There were 5 postgraduate year (PGY)-1 residents (41.7%), 4 PGY-2 residents (33.3%), 2 PGY-3 residents (16.7%), and 1 PGY-4 resident (8.3%) (Table 1). This was approved by the Research Ethics Review Committee (RERC).

Data collected including the general demographic data of the patients, laterality of the fracture, and AO/OTA classification of the injury. Group A (n = 6) was assigned to perform conventional templating first, and Group B (n = 6) was assigned to perform digital templating. Each resident was assigned a random number from 1 to 12. Each resident in both groups completed templates for 3 injury patterns: AO 2R2A3/2U2C2, 32B2, and 43C2 assigned with letters F × 1, F × 2, and F × 3, respectively. After completing their 3 templates with the designated modality, each group then repeated the templating process using the alternative modality.

The residents in the traditional templating group were asked to use markers and tracing paper which they placed over the radiographic images to create their templates. Each fragment was outlined then cut out with scissors. They were then glued together on a separate paper in a reduced, anatomic position. The type and location of the fracture was noted, as well as the severity based on the AO classification system. The goals of surgery were also documented (Fig. 1). The template was then used to select the proper implant for the fracture fixation, and this was added to the diagram as well as an alternative, back-up plan in case of complication. The lists of implants and equipment needed were recorded as well as the time required to complete the surgery reduction and fixation (Fig. 1).

The residents in the digital templating group imported the radiographs to the digital program (Procreate). The type and location of the fracture was noted, as well as the severity based on the AO classification. The goals of surgery were also documented (Fig. 2). They then used the digital templating program to use a pencil tool to digitally trace and select the fracture fragments and then click and drag them into a reduced, anatomic position using a "transform" tool (Fig. 2). So-called "E-templates" were then used to select the proper implant for fracture fixation. Once the implant was selected, it was then uploaded to the digital program. The size of implants was measured using the reference points on the uploaded radiograph and the e-template digital reference ruler (Fig. 3). An alternative, back-up plan was documented in case of complication. The lists of implants and equipment needed were recorded as well as the time required to complete the surgery reduction and fixation.

Digital templates were evaluated based on the image-based surgery planning (Table 2).[4] Traditional templates were

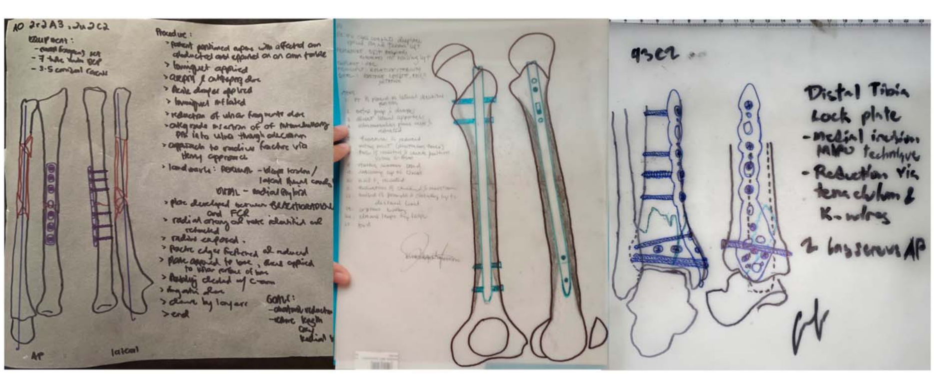

Figure 1. Preoperative templates for 2R2A3/2U2C2, 32B2, and 43C2 using the standard technique including the alternative plans, lists of implants, and equipment as roadmap to surgery.

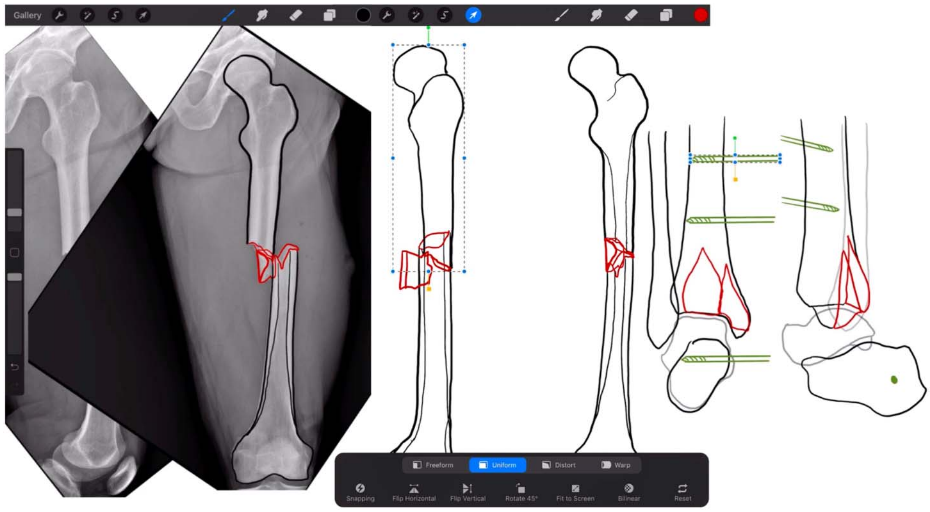

Figure 2. Preoperative templates for 2R2A3/2U2C2, 32B2, and 43C2 using the digital technique including the alternative plans, lists of implants, and equipment as roadmap to surgery.

evaluated based on the standard AO guidelines of template completeness (Table 3).[1] Both groups were evaluated using both scoring systems to eliminate bias. The templates were recorded and reviewed by the researchers.

2.2. Statistical Analysis

Wilcoxon signed-rank and binomial tests (5% level of significance) were used as statistical tools. The interobserver reliability was measured by comparing the templates of 2 surgeons with each other. The Wilcoxon signed-rank test was used to compare the distribution of scores of the residents doing the digital templating with the scores of the residents doing the standard technique (interobserver variability). The Wilcoxon signed-rank test was used to see whether there were differences in scoring between digital and conventional templating for a given resident (intraobserver variability). The level of significance was set at 0.05. All statistical computations were processed through the Statistical Package for Social Sciences (SPSS) software version 28.

3. Results

There was no significant difference in the evaluation scores used for either exercise, whether doing a traditional standard template (Table 4) or the digital template (Table 5) (P value $>$ 0.05). Template processing, fracture classification, and plan elaboration were comparable with good interobserver and intraobserver reproducibility using the Wilcoxon signed-ranks test *(all z values below 1.96, all P*-values $>$ 0.05) (Appendix, http://links.lww.com/OTAI/A94).

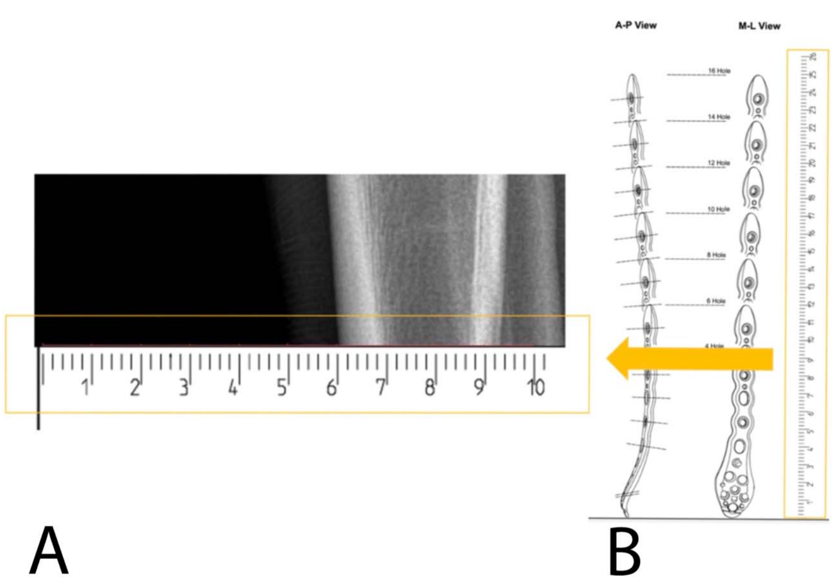

Figure 3. A, Measurement reference point with the radiograph in red juxtaposed with the reference ruler from an e-template to estimate the size of implant in proportion to the bone. B, E-template for a distal femoral locking plate.

TABLE 2
App-Based Templating Scoring System

	Present (1)	Incomplete (0.5)	Absent (0)	Total
Preoperative image processing				
Fracture classification				
Visual exploration of the anatomy				
Segmentation and model construction				
Fracture fragments recognition and reconstruction				
Steps in reduction				
Restoration of anatomy				
Plan elaboration				
Assessment of the selected plan				
Definition of task-specific goals				
Logistic requirements				
Alternative plan				
Time from start to finish				
<30 min				
31 min–60 min				
>60 min				
Total				

4. Discussion

As the field of orthopaedic surgery adopts more digital technology, computerized surgical tools and software simulations have been incorporated into orthopaedic training. Preoperative planning allows the trainee to perform all steps in a virtual environment without the fear of making mistakes before the actual surgery itself. Orthopaedic surgery requires knowledge and understanding of the fracture and its relation to the soft tissue and other anatomic structures around it.

Preoperative templating is an important skill for an orthopaedic surgeon to develop and a necessary step to have a successful surgery. Thoroughly undertaking a preoperative surgical plan allows the surgeon to optimize efficiency during surgery, anticipate possible difficulties and minimize preventable complications.[5] Traditionally, preoperative planning relied on printed radiographs and tracing paper.[6] The fracture is drawn then the fragments are cut out and reconstructed manually like the pieces of a jigsaw puzzle.[7] Although it is a valuable exercise, this can be time-consuming and requires additional materials such as printed radiographs, tracing papers, and colored pens. The use of a digital platform provides the convenience of bypassing the mentioned hard documents in lieu of digital content.[8] However, there may also be a learning curve brought about by the use of new technology.

We found that intraobserver and interobserver scores were almost the same in the standard and digital groups. Both junior and senior residents showed satisfactory results using the app-based and standard techniques. Both junior and senior residents regardless of group had incomplete alternative plans and most who accomplished their templates in a short span of time had incomplete details. Templates of the residents after cross-over did not show significant difference.

Using an app-based platform allows the surgeon to perform preoperative templating anywhere using their mobile device, and it is not excessively expensive.[9] In our setting, Procreate for iOS costs under 10$ from the App Store (Savage Interactive, Tasmania) and is made available to each trainee. Computer-based digital programs which can be integrated with PACS system such as TraumaCad are available.[10–12] However, they are more expensive, and it is important to emphasize that many surgeons who practice in low-income and middle-income nations do not have access to such digital templating options because they are not able to afford their cost and upkeep. This study demonstrates that preoperative templating can still be successfully achieved by using more affordable mobile apps. Other studies have shown comparable results in other areas of orthopaedics. Recently, Pongkunakorn et al[13] demonstrated the accuracy of hip replacement templating with a mobile device. Transitioning to digital radiographs has helped hospitals reduce the numbers of wasted substandard films.[14] Transitioning to a digital program may similarly reduce the materials needed to perform the function of templating.[15]

TABLE 3
Traditional Templating Scoring System

	Present (1)	Incomplete (0.5)	Absent (0)	Total
Fracture assessment				
Fracture classification				
Fracture fragments recognition				
Reconstruction				
Sequence of reduction				
Restoration of anatomy				
Decision making				
Goals and principles of surgery				
Surgical tactic (equipment required, preparation, and postoperative regimen)				
Alternative plan				
Annotated drawing				
Time from start to finish				
<30 min				
31 min–60 min				
>60 min				
Total				

5. Limitation of the Study

Although the length of time needed to complete the template was measured and had no significant difference, this study did not attempt to evaluate whether the level of surgeon experience contributed to the templating process. The study was not designed to compare the preoperative template with the postoperative outcome of the surgery. This is a direction for future study.

6. Conclusion

This study showed that digital templating is comparable with traditional templating and is a viable alternative. Digital templating gives trainees and orthopaedic surgeons an opportunity to visualize fracture reduction and fixation using an innovative, affordable, and user-friendly platform.[16,17] Programs such as Procreate and Adobe Photoshop can help lower-income countries keep up with the technological advancements in the field of medicine around the world. As technology in orthopaedics evolves, digital preoperative templating may soon become the gold standard.

TABLE 4

Summary of Standard Template Scores

Group A	Pattern Fx1 (AO 2R2A3/2U2C2)		Pattern Fx2 (AO 32B2)		Pattern Fx3 (AO 43C2)	
	z	Significance (2-Tailed)	z	Significance (2-Tailed)	z	Significance (2-Tailed)
Fracture assessment	−1.414*	0.157	−0.577*	0.564	−0.577*	0.564
	0.000†	1.000	0.000†	1.000	0.000†	1.000
Reconstruction	0.000†	1.000	0.000†	1.000	0.000†	1.000
	−1.000‡	0.317	0.000†	1.000	−1.000‡	0.317
	−1.000‡	0.317	0.000†	1.000	0.000†	1.000
Decision-making	0.000†	1.000	0.000†	1.000	0.000†	1.000
	0.000†	1.000	0.000†	1.000	0.000†	1.000
	−1.000*	0.317	0.000†	1.000	0.000†	1.000
	0.000†	1.000	0.000†	1.000	0.000†	1.000

* The sum of negative ranks equals the sum of positive ranks.
† Based on positive ranks.
‡ Based on negative ranks.

TABLE 5

Summary of Digital Template Scores

Group B	Pattern Fx1 (AO 2R2A3/2U2C2)		Pattern Fx2 (AO 32B2)		Pattern Fx3 (AO 43C2)	
	z	Significance (2-Tailed)	z	Significance (2-Tailed)	z	Significance (2-Tailed)
Preoperative image processing	0.000*	1.000	0.000*	1.000	−1.000*	0.317
	0.000*	1.000	0.000*	1.000	0.000†	1.000
Segmentation and model construction	0.000*	1.000	0.000*	1.000	0.000†	1.000
	−1.414†	0.157	−1.000†	0.317	−1.414‡	0.157
	−1.000†	0.317	−1.000†	0.317	0.000†	1.000
Plan elaboration	−1.000‡	0.317	0.000*	1.000	0.000†	1.000
	−0.577†	0.564	−1.000†	0.317	0.000†	1.000
	−1.000†	0.317	−1.000†	0.317	−1.000*	0.317
	0.000*	1.000	−1.000†	0.317	0.000†	1.000

* The sum of negative ranks equals the sum of positive ranks.
† Based on positive ranks.
‡ Based on negative ranks.

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