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# Operating Room Stencil: A Novel Mobile Application for Surgical Planning

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**Summary:** The techniques used to make preoperative markings before soft tissue reconstruction have remained relatively unchanged since the earliest years of plastic surgery. Using skin-marking pens, many surgeons continue to draw markings freehand as “best estimates” before their first incisions. Although efficient for the experienced surgeon, this strategy may prove challenging for residents and trainees striving to learn and maintain consistency while replicating the intricate geometries of flap markings. To address this need, Operating Room Stencil was developed as a novel tool for digitally planning flap markings that may then be projected onto contoured surfaces such as the human body. As a cost-free mobile application, Operating Room Stencil is widely accessible to the medical community and offers educational captions for a majority of the flaps featured in its database. Users can plot relaxed skin tension lines onto uploaded facial images, thus enabling surgeons to orient surgical markings in a way that optimizes scar formation and reduces wound contraction. Although originally intended to appeal to trainees as a reliable way to learn about flaps and practice their technique, Operating Room Stencil may prove useful even among more experienced surgeons striving to further perfect their visualization and execution of flap markings. (*Plast Reconstr Surg Glob Open* 2021;9:e3807; doi: [10.1097/GOX.0000000000003807](https://doi.org/10.1097/GOX.0000000000003807); Published online 17 September 2021.)

## INTRODUCTION

The techniques used to draw surgical markings before soft tissue reconstruction have remained relatively unchanged since the origins of plastic surgery. The earliest known examples are from the sixth century B.C., when the ancient Hindus hand-tailored leaves to serve as stencils for forehead flaps while performing reconstructive rhinoplasties.<sup>1,2</sup> Over one millennium later, surgeons continue to rely on hand-drawn markings while planning their operations. Even for experienced surgeons, the difficulty of consistently reproducing these markings intraoperatively cannot be understated. These challenges are

particularly pertinent to surgical trainees or individuals with limited access to technical guidance.

Several studies have begun to address the need for advancements in surgical markings to improve preoperative planning. Schreiber et al, for instance, described a novel approach to autologous fat grafting for facial asymmetry using projected three-dimensional holograms as topographical guides.<sup>3</sup> Similarly, Vyas et al developed an augmented reality system in which craniofacial surgeons stationed in the United States can overlay their hand movements onto a virtual visual field to assist international surgeons in making surgical markings and performing the surgery in real time.<sup>4</sup>

Inspired by these advances, this article presents the Operating Room (OR)-Stencil application, a novel tool for digitally planning flap markings that can be projected as stencils onto human skin and has previously been shown to increase accuracy and predictability in designing surgical markings.<sup>5</sup> OR-Stencil offers educational captions for the flaps featured in its database and enables users to

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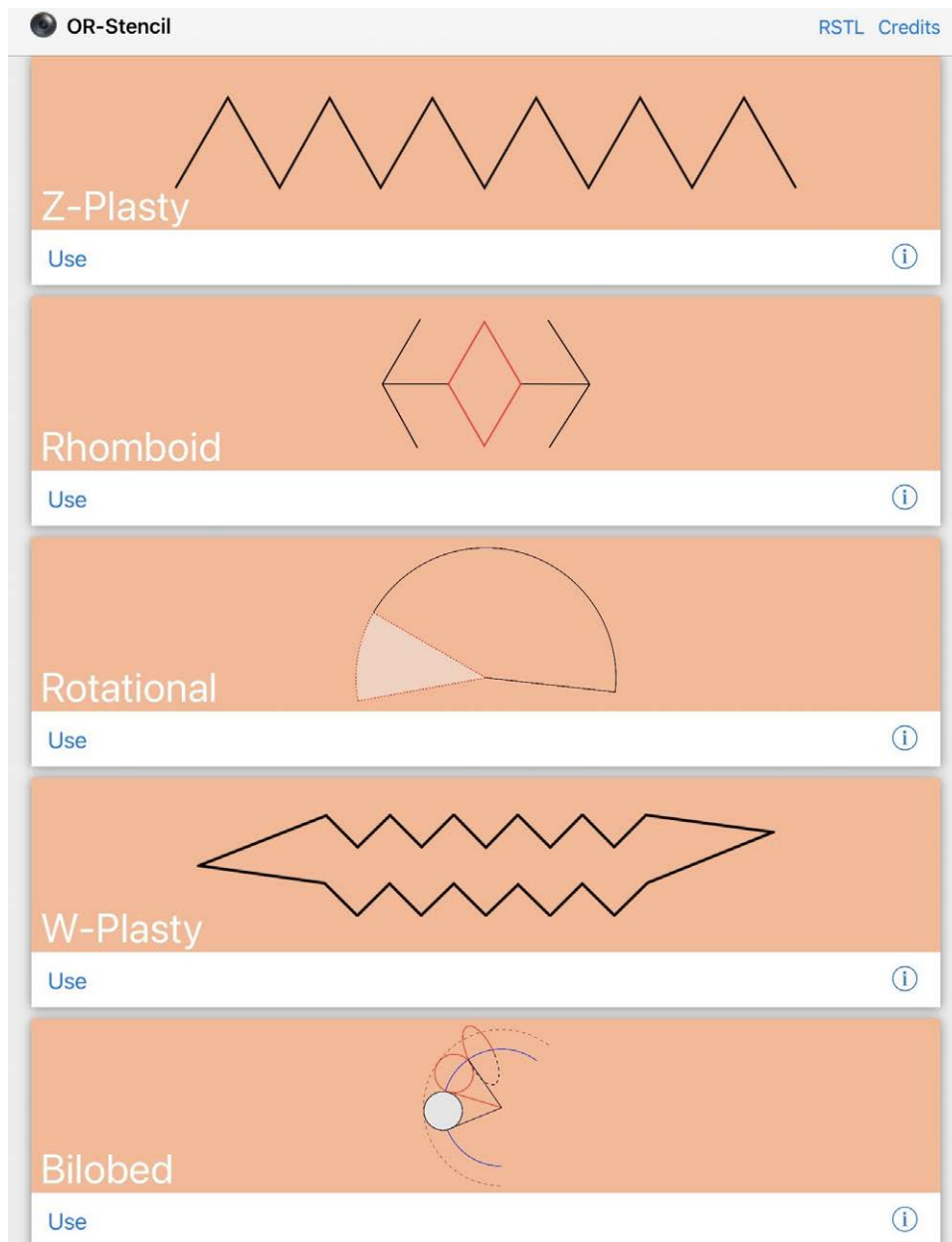
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**Fig. 1.** A scrolling menu of flap stencils available for use upon opening OR-Stencil.

plot relaxed skin tension lines (RSTLs) onto uploaded headshot images. Its availability as a free mobile application ensures its educational accessibility to surgeons of all levels in any setting.

### MATERIALS AND METHODS


OR-Stencil is written in Java for Android and Swift for its iOS counterpart. The stencil data are saved in a Scalable Vector Graphics format on the device to ensure the stencils can be freely manipulated and scaled using multi-touch without losing fidelity.

The RSTL model is accessed on an endpoint using the Amazon Web Services Application Programming Interface (AWS API) Gateway and Lambda. The user's image is

uploaded to AWS Lambda to be processed in the cloud. The results are then returned back to the app for viewing.



The algorithm for RSTL processing works in two main stages. Initially, a deep, pretrained convolutional neural network is used to detect the face and the individual facial landmarks. This neural network was accessed from the Python 2.7 face-recognition library, which is built on Dlib's machine learning library. After facial landmarks are acquired, a combination of interpolation and weighted averaging techniques are used to construct line-point representations of the skin tension lines. The weighted averaging helps find intermediate facial landmarks located in the cheekbones and forehead area. The quadratic interpolation maps permutations of points to RSTLs.

**USER EXPERIENCE**

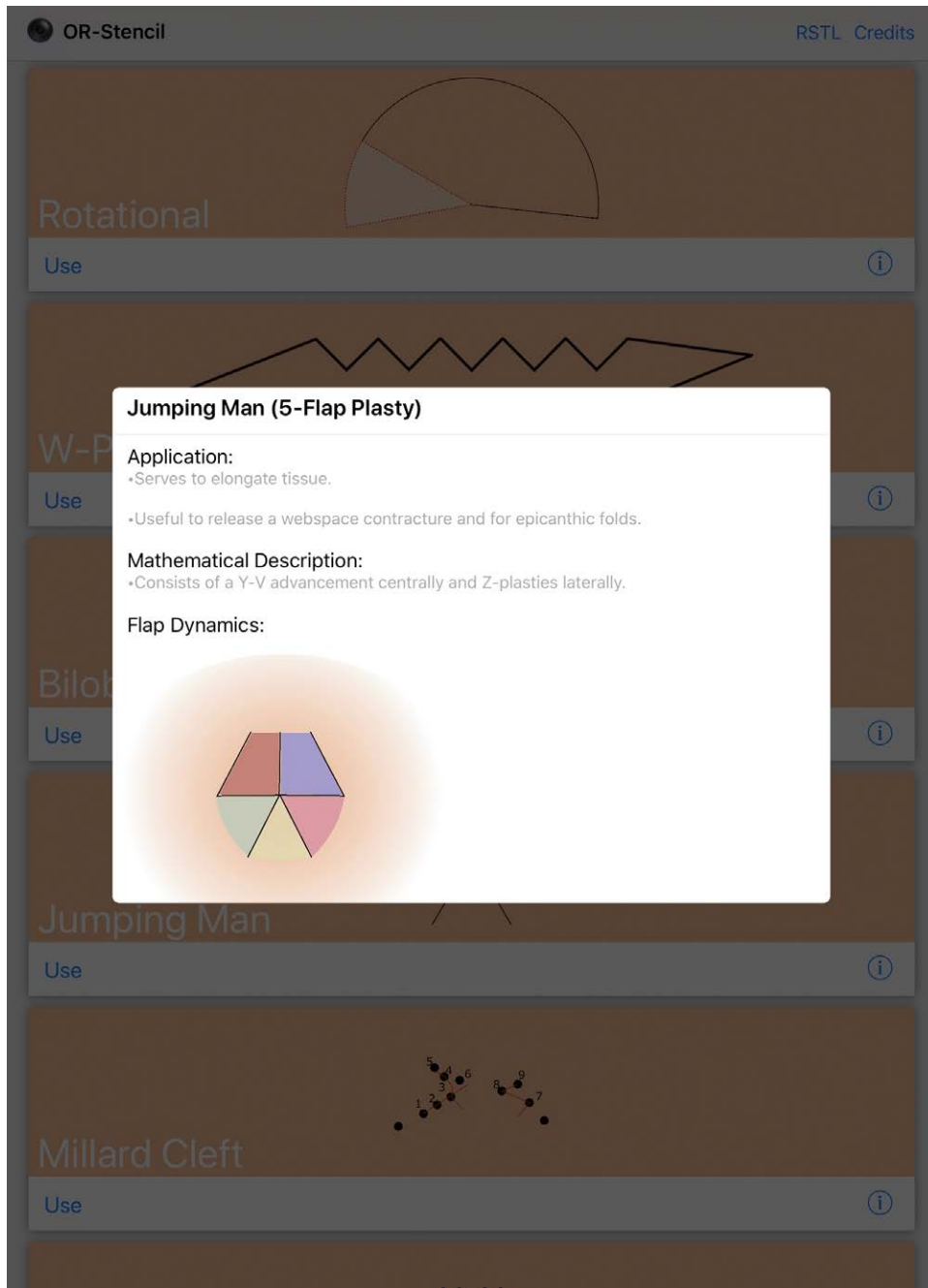
Upon opening OR-Stencil, the user is presented with the flap stencils available for use (Fig. 1). Clicking the  button details a flap’s history, surgical applications, and mathematical description. Additionally, the dynamics of the flaps (eg, incisions and rotations of soft tissue) are presented in a stepwise fashion (Fig. 2).

Pressing the *USE* button allows the user to proceed with one of the flap stencils, which include Z-plasty, rhomboid, rotational, W-plasty, jumping man, unilateral cleft, bilateral cleft, Wise pattern, skate, C-V, star,

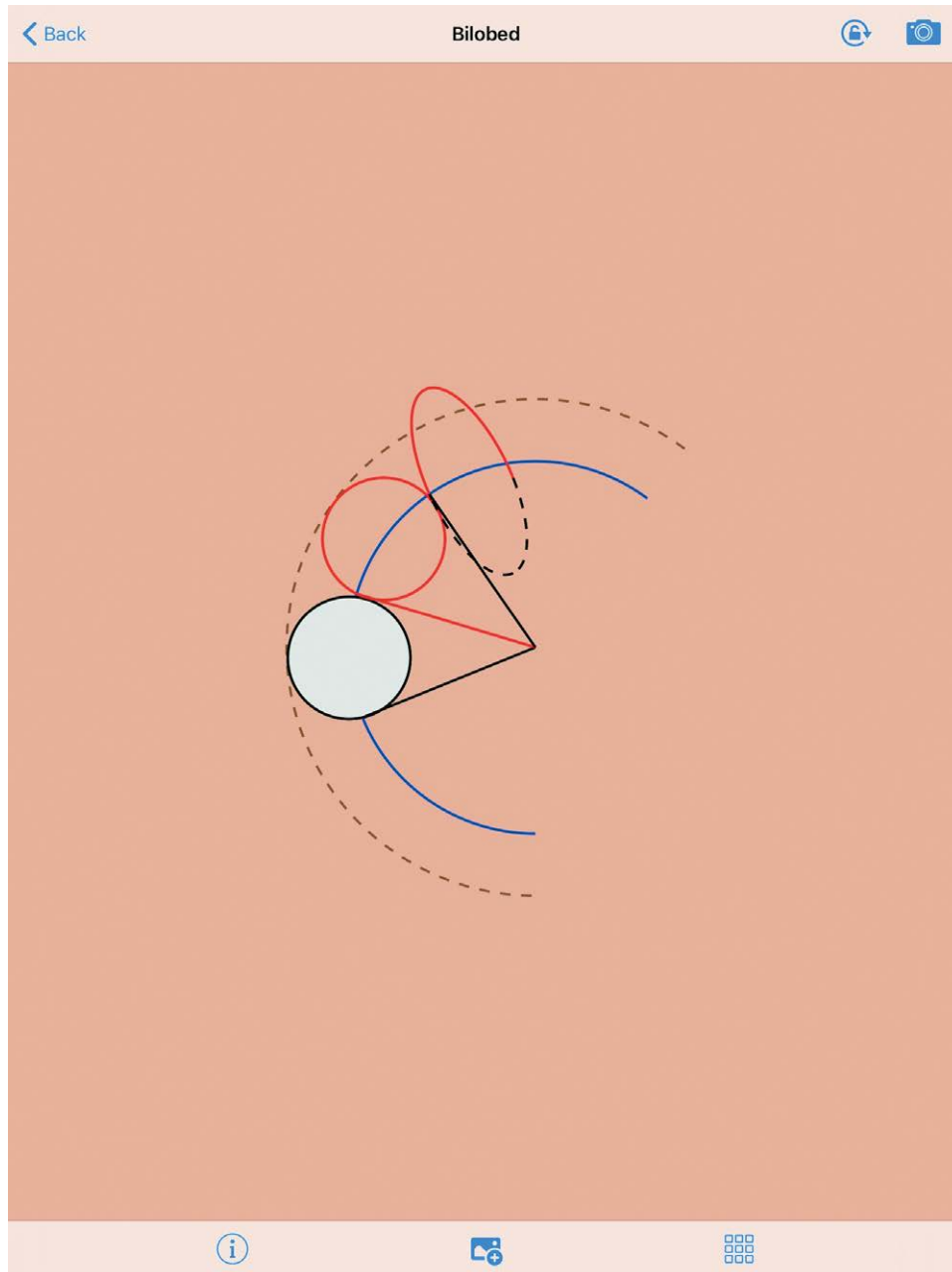
forehead, and bilobed flaps (Fig. 3). Common variations and/or angular alterations are chosen by selecting the

 or  icons located at the bottom right corner. The stencil can now be projected onto the soft tissue using a projector, such as the Insignia Portable Pico Projector Cube NS-PR166. While projecting, the user can manipulate the stencil’s size or rotate it in a 360-degree plane.


Surgical planning can be accomplished before the stencil is projected. (See **Video**, which displays a




**Fig. 2.** Surgical applications, mathematical description, and flap dynamics of the jumping man flap.



**Fig. 3.** The bilobed flap stencil has been selected. Its size and orientation can be altered with two fingers.

demonstration of surgical planning of a bilobed flap with the OR-Stencil application.) In the application's initial screen, selecting *RSTL* in the top right corner will present the user with instructions on plotting the RSTLs. Pressing *Select Image* will prompt the user to upload the patient's headshot from their device. Once completed, the algorithm will process the RSTLs. The processed image is saved. Continuing on, the user can then select the appropriate flap and press  located at the lower dock. The previously saved image with the RSTLs is uploaded and the flap stencil can be adjusted as described earlier. Once

done, the user can press the  at the top right corner

to screenshot the surgically planned image overlaid with the RSTLs and stencil (Fig. 4).

## CONCLUSIONS

OR-Stencil is a novel, educational surgical tool that (1) offers accuracy and predictability in generating surgical markings, and (2) is cost-free and widely accessible for plastic surgeons in all career stages. The application has been shown to have significant quantitative and qualitative results compared with freehand-drawn flaps when used by an experienced, board-certified plastic surgeon.<sup>5</sup>

The projected stencil meticulously defines the ratios and angles that are critical for soft tissue reconstruction.



**Fig. 4.** The rhomboid flap has been overlaid onto an intraoperative facial image. The stencil is now ready to be projected onto the patient.

This aspect is important for surgeons in training who may have trouble consistently achieving the desired surgical markings. In this case, OR-stencil can be used in simulations in the cadaver laboratory for students to perfect their technique. Additionally, surgeons in any career stage can utilize the RSTL algorithm to orient flaps parallel to tension lines, thus minimizing scar formation and wound tension.

OR-Stencil has a few existing limitations. The stencil is projected as a two-dimensional image; so variations in depth must be accounted for while making preoperative markings. Another limitation is the application's inability to automatically scale the stencil based on defect size. The application offers estimates of flap geometries (eg, arc length in a rotational flap =  $4 \times$  the arc length of defect), but the stencil must be manually manipulated based on the surgeon's measurements. However, the development of the mobile application and the RSTL algorithm foreshadow numerous advancements. For instance, our team is currently working on three-dimensional projection of these stencils onto the operative site in a contour-conforming fashion. Lastly, the integration of OR-Stencil with artificial intelligence technology can be used to collect information about the skin canvas (eg, perfusion, elasticity, collagen density) and further aid in surgical planning and soft tissue reconstruction.

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