A Novel Approach to Surgical Markings Based on a Topographic Map and a Projected Three-Dimensional Image

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Summary: Surgical markings play a crucial role in the planning of plastic surgery procedures.[1–4] However, despite their importance, they are often imprecise. For instance, when assessing patients in need of autologous fat grafting, surgeons often base markings on estimations of where volume deficiency exists and how much volume will correct the deficiency. In this article, the authors describe a novel approach to lipostructure, guided by a computer-based roadmap. A digital three-dimensional topographic surgical map is created using three-dimensional photography and analytic software and then projected as an image onto the patient in the operating room. This unique concept can be applied to most soft-tissue procedures in plastic surgery. (*Plast. Reconstr. Surg.* 137: 855e, 2016.)
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5 THERAPEUTIC

Surgical markings are used as an operative guide in most plastic surgery procedures.[1–4] Despite their importance, these diagrams are based largely on best estimation.[5] Preoperatively, a surgeon will mark planned incisions and/or highlight regions of soft-tissue deficiency.[6–9]

Autologous fat grafting relies heavily on surgical markings. At present, preoperative planning is limited to physical examination and two-dimensional photographs, followed by traditional markings.[10–12] In the age of three-dimensional photography and computer-aided design, this is antiquated.[13–19] We describe a concept for creating and transferring a surgical plan to the operation, which uses three-dimensional photography, computer analysis, and intraoperative projection to create a topographic surgical map. This technique yields a more accurate approach to fat grafting, and describes a methodology for preoperative planning that can be applied to other procedures.

CREATION OF A THREE-DIMENSIONAL TOPOGRAPHIC SURGICAL MAP

Four patients undergoing autologous fat grafting for facial asymmetry had preoperative three-dimensional photographs taken using a handheld camera (VECTRA H1; Canfield Scientific, Fairfield, N.J.). Facial asymmetry was analyzed by creating a midsagittal plane, which bisected the three-dimensional model into two hemifaces. [**See Video, Supplemental Digital Content 1**, which demonstrates the symmetry analysis and volumetric study to generate the three-dimensional topographic map of volume deficiency. The patient's three-dimensional model is bisected at the midsagittal plane, and the nondeficient hemiface is reflected to generate a simulation of an ideal symmetric model. The distance between the deficient and nondeficient surface is calculated and represented by a smooth color gradient, ranging in projection from a minimum of 1 mm (red) to a maximum of 10 mm (blue), available in the "Related Videos" section of the full-text article on PRSJournal.com or, for Ovid users, available at ***http://links.lww.com/PRS/B705***.] The reference hemiface was reflected onto the defect side,

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Video. Supplemental Digital Content 1 demonstrates the symmetry analysis and volumetric study to generate the three-dimensional topographic map of volume deficiency. The patient's three-dimensional model is bisected at the midsagittal plane, and the nondeficient hemiface is reflected to generate a simulation of an ideal symmetric model. The distance between the deficient and nondeficient surface is calculated and represented by a smooth color gradient, ranging in projection from a minimum of 1 mm (red) to a maximum of 10 mm (*blue*), available in the "Related Videos" section of the full-text article on PRSJournal.com or, for Ovid users, available at ***http://links.lww.com/PRS/B705***.

creating a new hemicomposite, which served as the reference three-dimensional model (Fig. 1). The reference model was then overlaid using Canfield VECTRA Analysis Module software on the patient image. A color map was generated, which outlined the differences between the two surfaces. The resulting map was a well-circumscribed region of volume deficiency colored according to the relative distances between the normal and abnormal hemiface. This difference in projection is represented by a smooth color gradient (Fig. 2, *left*).

To create a digital three-dimensional topographic surgical map, contour curves were generated on the three-dimensional color maps (Fig. 2, *second from left*). Analogous to topographic mapping of geographic landscapes, the contour curves at discrete projection values represent the three-dimensional surface. To generate the curves, the minimum sensitivity of the map was adjusted and traced at 1, 3, 5, and 7 mm, until the threshold exceeded the topographic change. A composite of the individual tracings generated the final topographic map. The map was enhanced with landmarks on facial structures to ensure proper scale and alignment when projected (Fig. 2, *right*).

VOLUME CALCULATION

To further guide injection, volume was calculated for each 2-mm interval segment in VECTRA Analysis Module software. To account for fat graft resorption, we added 30 percent to

Fig. 1. An 8-year-old boy with a history of retinoblastoma and irradiation who presented for facial asymmetry. (*Left*) Preoperative two-dimensional (*2D*) photograph. (*Right*) The three-dimensional (*3D*) model is bisected at the midline, and the reference nondeficient hemiface is reflected over the defect to create a symmetric hemicomposite model.

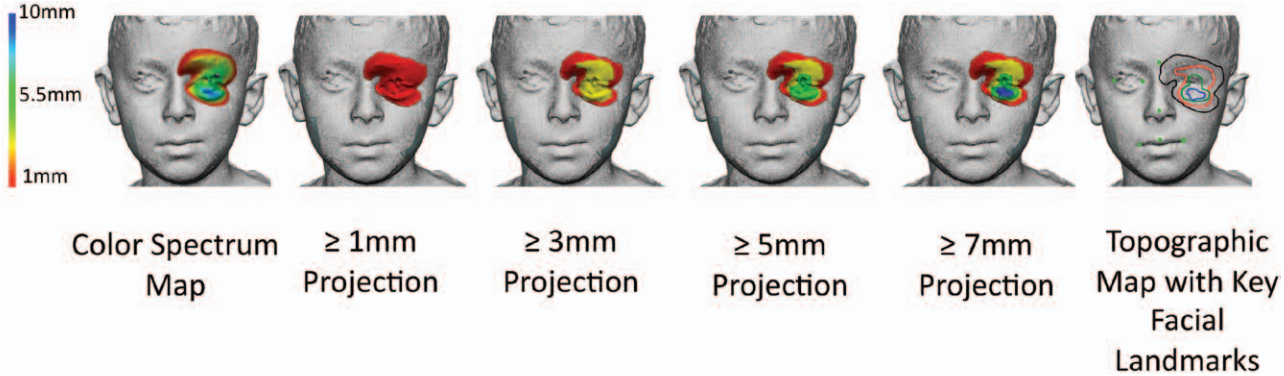

Fig. 2. Creation of a three-dimensional topographic surgical map. (*First five images*) overlay of hemicomposite and true patient model and creation of color gradient highlighting the distance between surfaces. Color gradient is outlined at discrete projection intervals of 1, 3, 5, and 7 mm (*second from left*, *third from left*, *third from right*, and *second from right*, respectively). (*Right*) Final topographic map with concentric curves representing progressive projection values.

calculated injection volumes, which guided clinical injection.[11,20–22]

Patient Image Projection

The maps were used as templates for preoperative markings, uploaded onto a mobile platform and projected using the hand-held, smart phone–compatible, LED Pocket Projector (AAXA Technologies, Inc., Tustin, Calif.). The construct was secured to an overhead operating room light for stable, hands-free projection. The platform was positioned such that key landmarks on the projected map aligned on the patient. By using this overlay as a guide, colored marking pens assigned to specific projection values were then used to trace the map (Fig. 3). Patients underwent autologous fat harvesting and transfer using standard techniques. Fat was injected according to the region and degree of deficiency as indicated by our topographic map, beginning centrally in the most deficient region (Fig. 4).

Intraoperative Assessment

Intraoperative analysis evaluated adherence to the surgical plan and guided surgical decision-making. An intraoperative three-dimensional photograph was overlaid with the surgical plan that highlighted regions in need of further augmentation.

Postoperative Assessment

Postoperative three-dimensional photographs, taken immediately postoperatively and at 3 months after surgery, were also overlaid with the surgical plan, and the difference was calculated.

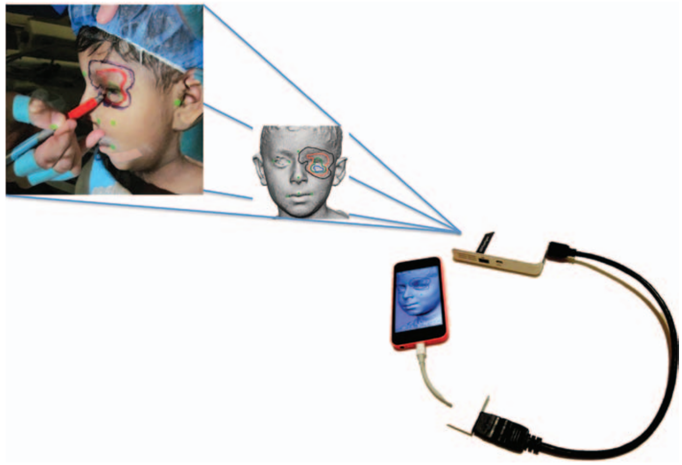

Fig. 3. Projection of topographic map as a three-dimensional image onto the patient.

Fig. 4. Photographs of the patient preoperatively (*left*) and 6 months postoperatively (*right*). This patient had an initial overcorrection of 2 to 4 mm immediately postoperatively, and repeated analysis at 3 months postoperatively demonstrated a loss of 1 mm of projection to the upper brow compared with immediately postoperatively, but a lower lid volume overcorrection between 2 and 4 mm remained.

Postoperative analysis demonstrated improvement in symmetry and highlighted regions that may benefit from additional volumization. Using 3-month time point regions, we were able to identify areas that may have lost some of the initial correction, giving insight into how different regions respond to autologous fat grafting.

DISCUSSION

This is the first description of soft-tissue computer surgical planning used to guide surgical marking. Rather than relying on surgeon assessment alone, we applied three-dimensional surface scanning technology to perform an objective symmetry analysis, which was translated into a virtual plan used in the operating room.

The use of virtual surgical planning for skeletal-based facial reconstruction has been well described.[13,15] However, the computer simulation transferred to the operating room is in the form of images, printed jigs, cutting guides, and prebent plates. Similar innovative technology can be used for soft-tissue reconstruction, where three-dimensional models are printed as guides for surgery.

This technology quantifies the contour difference between hemifaces, and topographic mapping provides an easy-to-follow roadmap for injection. We chose 2-mm projection intervals. However, the interval is chosen based on the defect size (i.e., smaller defects require tighter intervals for more precise intervention). By targeting all regions of asymmetry that are mapped on the initial assessment, in theory, we have decreased the need for repeated procedures and increased surgical efficiency.

Further study is indicated to incorporate factors such as graft survival into the volume calculation to predict injection volume and its correlation to topographic changes. Limitations of this approach include access to three-dimensional photography, a learning curve associated with generating the surgical plan, and an understanding of how fat grafting behaves following injection to superficial compartments.

Although this article focuses on autologous fat grafting, other areas could benefit from a similar soft-tissue surgical roadmap. The concept of topographic mapping is an ideal method of representing three-dimensional contours through two-dimensional markings. Projection offers a fast and reliable method of transferring a digital surgical plan that can be easily reproduced intraoperatively without breaking sterility. It is conceivable that a prefabricated roadmap developed on the computer can be projected and traced onto the skin surface, offering an increasingly precise and effective approach to surgical marking and placement of incisions.

CONCLUSIONS

This is the first report describing the use of preoperative markings projected as a three-dimensional image. By referencing markings generated by computer analysis, the surgeon has a topographic map that is a simplified translation of the complex three-dimensional contour. This provides an easy-to-follow guide tailored to the patient's unique volume needs. The value of this technology and its applications in other aspects of plastic surgery has yet to be explored but offers great potential.

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PATIENT CONSENT

Parents or guardians provided written consent for the use of patient's images.

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