Three-Dimensional Surface Imaging Is Not Enough for Surgical Simulation

Sir:

We read with great interest the article entitled "Three-Dimensional Surface Imaging in Plastic Surgery: Foundation, Practical Applications, and Beyond," by Chang et al.,[1] and we wish to discuss some limitations of what is indeed a very interesting tool. We contend that the method cannot be used for surgical simulation without a robust integument mechanical model.

We congratulate the authors for their fine overview; we are convinced that rapid technical progress will ensure that convenient and inexpensive devices will become commercialized in the near future. We strongly agree that three-dimensional surface imaging represents a revolution, providing objective information on changes in volume or shape before and after treatment, during growth. However, to simulate the outcomes of plastic surgery procedures, simulation software must combine three-dimensional surface imaging data with those of a reliable model of the complex mechanical behaviors of soft tissues (i.e., nonlinear and anisotropic) if they are to accurately predict how much fat must be injected to correct a facial deformity, or which breast implant is ideal in terms of volume or shape. Such models are not yet available; the available simulations feature isotropic unilamellar or bilamellar modeling, which assume that the internal anatomies can be represented by averaged data.

Recently, we postprocessed male and female whole-body 3-T magnetic resonance imaging acquisitions and built a generic geometrical architectural model of the anatomy of subcutaneous tissue, facilitating digital modeling and specialization during construction of simulation platforms.[2] The collagenic septa of each fat lobule were modeled by tessellating the volume. Superficial fascia and skin collagenic mean of union were modeled by a procedural method.[3] We were able to specialize this generic model to every part of the body by imputing some relevant parameters (i.e., superficial and deep adipose tissue thickness, average lobule diameter, and the positions of clusters of skin ligaments). This model is the first to consider subcutaneous anatomical complexity, and is able to be specialized everywhere in the body.

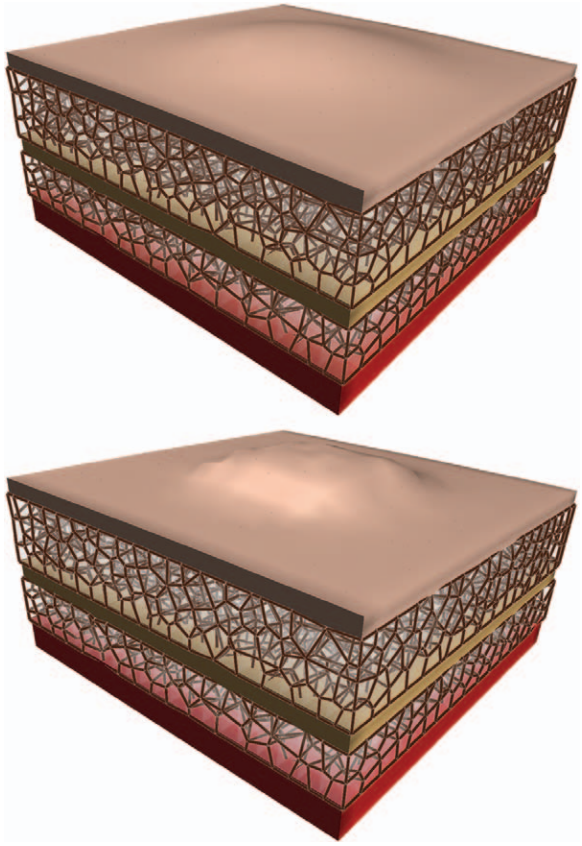

Fig. 1. Simulating fat injection (same volume) in a 5 × 5-cm square of cheek zone integument under the superficialis fascia plane (*above*) or above this plane (*below*).

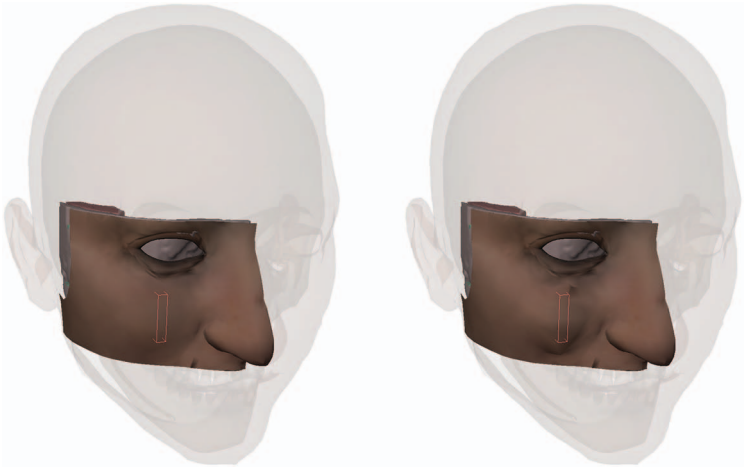

Fig. 2. Clinical application after elastic registration on a voluntary subject: simulating fat injection of 2 cm^3 under the superficialis fascia plane (*left*) or above this plane (*right*).

This modeling method can simulate the effects of fat injection into the face or breast, with very encouraging results.[3] For example, we can successfully simulate the different surface effects of superficial or deep fat injections (Figs. 1 and 2), and the orange peel effect, by changing the mechanical parameters of the means by which adipose tissue and collagen are joined. However, a validation step is still essential to study the effects of inflammation and/or scarring on the final result.

We expect to rapidly personalize our generic model with three-dimensional surface imaging and ultrasound or Cutometer data gathered rapidly during consultation.[4] It will thus soon be possible to offer personalized medicine to patients who require soft-tissue operations such as is already done in bone surgery, where mechanics are relatively well understood.[5]

We believe that three-dimensional surface imaging is indeed revolutionary, but practitioners must be aware that current commercial packages apply principally morphing, or error-generating approximations, creating disappointment in patients hoping for cosmetic corrections or a new appearance. A better understanding of the complex mechanics of soft tissue and the microarchitectural changes caused by plastic surgery procedures is essential when seeking validation of simulation software that claims to be of clinical utility.

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DISCLOSURE

The authors have no financial interest in any of the products or devices mentioned in this communication.

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Reply: Three-Dimensional Surface Imaging in Plastic Surgery: Foundation, Practical Applications, and Beyond

Sir:

I thank the authors for their letter in response to our article entitled "Three-Dimensional Surface Imaging in Plastic Surgery: Foundation, Practical Applications, and Beyond." I respectfully disagree with their assertion that three-dimensional surface imaging cannot be used for surgical simulation and must be combined with a reliable model of complex mechanical behaviors of soft tissues.

The reality is that three-dimensional surface technology is used daily to demonstrate to patients the expected change possible with a particular procedure (this is surgical simulation). This technology has