Three-dimensional Breast Imaging

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Abstract

Human anatomic structures are, of course, three-dimensional (3-D) objects. In plastic surgery, we try to capture a sense of this by taking two-dimensional photographs using multiple views from standardized points. The reliability of this approach is limited by variations in technique and the ability of the viewer to envision the 3-dimensional appearance based on a set of standard photographs. Technology is emerging that will make full 3-D imaging practical and perhaps standard practice for plastic surgery.

INSTRUCTIONS

This article contains a virtual reality 3 dimensional demonstration of a new 3D imaging technique in plastic surgery. In order to see the 3D demonstration you will have to download the 3D viewer and install it by double clicking the “3Dexploration.exe” file. This will load the viewer on your computer. You will also have to download the 2 3D objects discussed in this article. Remember where (folder) you save the 2 object files and open them after opening the 3Dexplorer on your computer. The 3Dexplorer program will give you the opportunity to open your folder on the left-hand side of your screen. Once you open the correct folder, you will see the 2 downloaded object files appear underneath the viewer window. Double-click on the object files and use your mouse to rotate the 3D object in the viewer widow. Have fun!

Use these files to download to your computer (You may have to right-click on the link and select "Save link as...".)

3Dexploration.exe (2,101 KB)

breast1.obj (710 KB)

breast2.obj (1,406 KB)

METHODS

We imaged a series of women who were candidates for breast reconstruction using a non-contact 3-D digital imaging system (Minolta Vivid 700, Minolta Corporation, Ramsey, NJ). The system operates on a laser light stripe triangulation range-finding principle. The patient’s breast is scanned from top to bottom with a projected laser light stripe. The reflected rays are focused onto a CCD and the distance to the breast is measured at 400 points across the skin surface. Simultaneously, a color image is obtained and both sets of data are combined to form a 3-D digital image. Two views are obtained of each breast along with a single frontal of the entire chest. The time required to obtain each image is 0.6 seconds. The set of 5 images is then registered manually using the utility software provided with the Vivid 700 system to yield a 3-D image of the chest and both breasts. The device was set up with a large screen monitor and a computer workstation in a separate room in the clinic dedicated to patient imaging. A physician assistant was trained in the use of the system and was responsible for obtaining the images.

RESULTS

The physician assistant easily learned how to use the system. Patients accepted the procedure well. Obtaining the images required less than 5 minutes per patient and the patient flow in the clinic was not disrupted. Generally 3-5 images were required to achieve a complete rendering of the patient. Registration and merging of separate images into a single image required additional technician time that varied according to the complexity of the different patients. Final composite images provided views from the clavicles to the costal margins and mid-axillary lines bilaterally (Fig. 1). It was difficult to image the inframammary fold in patients with ptotic breasts. It was possible in a single composite image to view the both breast from all vantage points and easily assess shape, projection, and symmetry.

DISCUSSION

Three-dimensional imaging is becoming more routine in a variety of medical and surgical specialties. Computed tomography, magnetic resonance imaging, and ultrasound are almost universally available at major medical centers, and software for 3-dimensional rendering and visualization is increasingly well developed [1] These modalities have been used for planning osseous reconstruction in orthopedics [2], craniofacial [3], and maxillofacial surgery [4] as well as soft tissue procedures involving the liver [5], uterus [6], colon [7]. Imaging devices that capture surface information are not as widely used in medicine but as technology becomes more widely available and less expensive it will become certainly be used more routinely for surgical planning, patient education, insurance documentation, and patient records. One way to create devices for 3-dimensional surface imaging is based on a triangulation range-finding principle in which the object is scanned with light projected from a laser [8]. The reflected light is collected, and the distance to each point on the reflective surface is calculated. This data is then recorded and each point is linked together as a mesh of polygons to recreate the entire surface.

Possible applications for this technology go beyond merely maintaining photographic records of patients. Once the computer can manipulate a full set of 3-dimensional data about an individual patient's surface contours, this can be used to create full simulations of the patient's breast to assist in surgical planning, prediction of outcomes, patient education and decision-making tools, and systems for resident training. Finally, a prerequisite for ultimate clinical application of tissue engineering techniques for breast replacement will depend on computer-assisted systems to translate detailed anatomic information into a recipe for a custom tissue fabrication. Specifications will involve identifying the exact types and amounts of synthetic materials used as tissue molds and scaffolds, number of cells for transplantation, and bioactive peptides that will lead to a custom tissue replacement. Development of these computational methods is fundamental to practical clinical application of any tissue engineering approach.

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