Comparison of 2 Methods of Making Surgical Models for Correction of Facial Asymmetry

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Purpose: Stereolithography is useful in reconstructive surgery in that the surgical template or customized implant can be prefabricated on the models. To correct facial asymmetry, prior reshaping of the replica of the original structures is frequently required before it can be used as a surgical model. This is traditionally accomplished by direct sculpturing. This method has its limitations in clinical use. Recently, we developed a method using computer techniques to reconstruct the required structures. We herein report several of its applications in a variety of clinical situations and compare this virtual method with the traditional method.

Patients and Methods: With the traditional method, reconstruction of the models was handmade on the replica of the original structures. In the virtual method, the anticipated reconstructions were completed on the computer using various image-processing tools and were verified by the surgeons before sending to stereolithography. Thirteen patients who had undergone surgical correction of facial asymmetry using models made by either method were retrospectively reviewed. The traditional method was used in 5 of them while the virtual method was applied in the other 8 patients. The surgical models and the patients following the reconstruction were evaluated for symmetry and esthetics.

Results: To construct implants or to precontour fixation plates, an average of 1.4 models was fabricated for each patient using the traditional method, whereas only 1.1 models were made for each patient in the virtual method group. Both methods worked satisfactorily in restoring symmetry of the bony structures on the models. However, the projection of the chin on the model created by the traditional method was inadequate, as showed postoperatively in 1 patient. There was surface roughness on the customized area of the models made by the virtual method. The surgical result was poor in symmetry in 1 case in the traditional method group. One patient in the virtual method group showed irregularities on the temporal region following augmentation with prefabricated bone cement implant.

Conclusions: Both methods of making models were useful and effective in surgical reconstruction for facial symmetry in selected cases. The virtual method was preferred in cases where midline structures had already been deformed, or when soft tissue was involved in reconstruction. From the technical standpoint, the virtual method was superior because of its versatility, predictability, precision, communicability, and the convenience of storage and documentation.

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Facial asymmetry, when obvious, has enormous sociopsychological impact on the affected individuals. It can occur as a consequence of developmental anomalies or disease or after trauma or surgery. Surgical reconstruction is usually indicated in most instances involving a noticeable facial asymmetry. This is usually accomplished by reconstructing the deformed portion with its normal counterpart working as a reference. Although the operation looks quite straightforward, difficulties are commonly encountered in establishing valid references for preoperative assessment and intraoperative navigation. The esthetic result is often unpredictable and may be less than optimal.

Stereolithography is a technology originally used in industry to fabricate prototype models. Three-dimensional digitized data are delivered to the stereolithographic apparatus where a laser beam is programmed to cure a photosensitive polymer layer-by-layer accordingly to form a 3-dimensional (3D) model. The technology allows production of highly accurate and realistic replicas of the body structures of an individual. Literature has shown some promising results using a stereolithographic model as a guide for reconstruction.[1-5] Implants can be customized and prefabricated, or fixation plates precontoured on the models. This method has been reported to reduce surgical trauma, ease the procedure, save operating time, and can increase accuracy and predictability of the reconstruction.[1-5]

Traditionally, clinical use of this technology refers to models that copy the original structures unaltered.[1-7] In situations where the models need to be changed for the purpose of reconstruction, these are done by direct sculpturing on the model. We have developed a different approach to these situations. We reconstruct the facial structure or design the master implant on the computer and then produce the stereolithographic model from these newly formed data. We herein report several of its applications in a variety of clinical situations and compare this new virtual method with the traditional handwork method.

Patients and Methods

ACQUISITION OF IMAGE AND CONVERSION OF DATA

Since 1998, the Virtual Reality Laboratory in National Cheng Kung University has been developing interactive 3D medical image software in collaboration with the Department of Oral and Maxillofacial Surgery to provide the tools for 3D visualization and manipulation of multiple objects on a personal computer.

The relevant region of the patient's head is scanned with a helical computed tomograph (Hispeed; GE Mediland Medical System, Ltd, Milwaukee, WI). Depending on the location of the deformity and the accuracy of the model one needed, the scanning is done with either a 1-mm table increment to form a 1-mm slice thickness or a 3-mm table increment and then interpolated to form a 1-mm slice thickness. Metallic objects such as arch bars should be removed before scanning to avoid degradation of the images. During scanning, disocclusion of the teeth by biting on a small piece of gauze is advocated if rearrangement of occlusion is required to correct the asymmetry. The computed tomography data are transferred to a workstation in the Virtual Reality Laboratory, where they were reprogrammed to a file that is readable by the stereolithography machine (STL format) with or without preceding modifications.

METHODS OF MAKING SURGICAL MODELS

Two methods were used to make the surgical models. In the traditional method, the model was manufactured and then modified to achieve symmetry, on which cutting or sculpturing was usually needed and was done by our staff. To improve the final result and ease the work, the method could be modified in which the normal counterpart of the structures was mirror-imaged, prototyped, and then welded to the border of the defect with wax or plaster. In either way, reconstruction was done after the models had been manufactured.

In recent years, we have developed a virtual method with which reconstruction is completed before stereolithography. This is attained by editing the images under the supervision of the surgeons. The processing tools commonly used include segmentation, regional growing, pasting, erasing, drawing, and mirroring. For immediate surgical reconstruction, the region of the deformity on the image was identified and erased. The counterpart structure on the normal side can be extracted, mirror-imaged, and superimposed on the defect. In a situation where the counterpart is also involved, the equivalent anatomic structure of proper size and shape can be selected from the data bank and used. A midsagittal plane is drawn using the internal as well as the external structures of the subject as references. The position and the contour of the overlay are checked and adjusted for symmetry. It is then joined with the adjacent structures. The final construct is highlighted by thresholding and saved in a new file. This maneuver is repeated through the slices that are involved in the virtual reconstruction. The new set of the data is saved and converted to an STL format, and a stereolithographic model is manufactured with the reconstruction already finished. For late surgical reconstruction, prior