

## **Increasing Efficiency, Repeatability, and Accuracy in Prosthetics and Orthotics Through the Use of CAD**

- **Jennifer Dowell, CPO**
- **Cheryl White, BSE**

Many functions in today's O&P office are performed by hand and are often tedious and susceptible to human error. In some cases, they are inconvenient and even uncomfortable for the patient. Most of these processes can be improved through the use of a computer-aided design (CAD) system, allowing the prosthetist to spend more time with the patient and less time on tedious tasks without sacrificing quality. Patients who have been asked to compare sockets produced conventionally versus those made with CAD have reported no significant difference between the two types<sup>1</sup>.

### **Documenting**

Many aspects of creating a prosthesis or orthosis involve recording data. In most offices, measurements are recorded on a paper form, and information about the patient's condition is jotted down in a paper folder. When information must be transferred from one person to another, the potential for miscommunication is always a possibility.

Some portions of the process are never recorded at all. Instructions given to a technician for modifying the model are likely relayed verbally or are written in a temporary format. The information is never permanently recorded in the patient's file, allowing for the possibility of misunderstanding. Complete and accurate information about a shape is rarely measured and recorded.

A complete CAD system will allow the clinician to enter the patient's information directly into user-friendly software to reduce the possibility of errors. The shape of the model and a list of its modifications are stored in the computer for easy reference at any time. Requests for data from third parties can easily be met with a few clicks of the mouse.

### **Measuring**

Typically, the lengths and circumferences of the applicable body part are measured with a measuring tape. Depending on whether the tape is held loosely or tightly against the body, or whether the tape is held at a slight angle, these measurements can differ significantly. Petrek *et al.*, states that measurements taken with a measuring tape "can vary according to the degree to which the tape itself constricts soft tissue."<sup>2</sup> Without a consistent measurement system, it is difficult to achieve consistent outcomes.

These human variables can be reduced by obtaining measurements electronically through the use of a digital, non-contact, three-dimensional shape-capture system. The measurements are entered directly into the patient's record in the software, eliminating the possibility of recording the wrong numbers.

Measurements acquired through such a precise electronic method are much more repeatable and reproducible than those collected by hand. (A result is *repeatable* when each time the clinician measures the same patient using the same equipment, the measurements are the same. A result is *reproducible* when the same measurements are obtained by different clinicians on the same patient using the same equipment.) Regardless of how many times a clinician measures the patient, or how many different clinicians measure the patient, the results are *accurate* every time. (*Accuracy* is how close the measured value is to the actual value.) Information on the accuracy of specific CAD systems is available from the manufacturers.

The importance of obtaining accurate measurements cannot be overstated. If the process begins with inaccurate data, then there is little chance that the final product will fit properly. Time and effort will be required to address a problem that could have been avoided if a more precise method had been used. As stated by Geil, "Without proper fitting, overall function of the prosthesis as well as quality of life for the patient is diminished.... Thus it is crucial that techniques used to produce limb sockets be accurate, repeatable, and cost effective<sup>3</sup>."

### **Casting**

The process of accurately capturing the patient's shape is crucial for providing a comfortable fit. Just as measurements can vary depending on technique, so can a cast. The plaster casting material can be stretched loosely or tightly, and the prosthetist's hands can apply varying levels of pressure.

Casting is a lengthy process, requiring the patient to remain in one position for several minutes. The nature of plaster also means that in addition to the time required for taking the cast itself, there is also time required for preparation and cleanup. Then, as the plaster for the positive model is mixed, poured, and allowed to dry, the total time is increased again.

With a successful CAD system, plaster is eliminated entirely. The time for the shape-capture process is reduced significantly—only a few minutes are required for the entire process. There is no preparation aside from perhaps applying a sock or other covering to the body, and there is no drying or cleanup required. There is no additional time required at this point for the creation of a positive model. The three-dimensional shape of the limb is created in the software almost immediately after it is captured. As with the measuring process, the shape-capture process becomes repeatable and reproducible through the use of CAD.

### **Modifying the Model**

The process of creating a prosthesis or orthosis always involves modifying the model to achieve the desired design. The typical method involves using an assortment of tools such as a file, a piece of sandpaper, and even a tongue depressor to remove, apply, or shape plaster in specific areas.

Applying/removing plaster by hand is extremely imprecise, messy, and tedious. If a clinician needs to reduce a positive model by 5 percent, he must attempt to shave plaster off of the model as symmetrically as possible. He must stop periodically and re-measure the model with a measuring tape and then repeat the process until the goal is achieved. An infinite number of reduction amounts in different areas can result in the desired 5 percent reduction, with some areas being reduced more than 5 percent and other areas less than 5 percent. Convery *et al.* reported inaccuracies of up to 2mm when a prosthetist followed a single list of instructions to modify multiple copies of the same transtibial model<sup>4</sup>. This process has so many variables that it cannot accurately be repeated or reproduced.

If, in the course of making a particularly extensive modification, a clinician makes a mistake that cannot be easily corrected, he must start over by making a new positive model from plaster.

A user-friendly CAD system replaces the plaster-related tools with electronic tools. The clinician is still able to use his skill in determining the location and extent of the modifications; however, he is able to obtain the result with just a few clicks of a mouse. The modifications are much more precise than they could ever be when performed by hand. A 5 percent volume reduction is accomplished in seconds and is exactly 5 percent over the entire model. Also, there is no chance of ruining a positive model with an inaccurately performed modification. With CAD, modifications can easily be undone. A thorough CAD system also maintains a list of the modifications that are made, providing a record of each step that was used to design the device.

### **Fabricating**

Once a plaster positive model has been modified, the fabrication of the final device can be done in-house, or the plaster model can be shipped to an outside fabricating facility.

A prosthetist with a complete CAD system can either fabricate the device in-house by taking a few minutes to carve a foam positive model on a carver and producing the socket or orthosis from there, or he can e-mail the CAD file to a fabricating facility within seconds and without shipping costs. Precise instructions for fabricating and shipping can be included along with the file.

If the clinician performs an initial fitting and finds that the fit is less than optimal, he can easily review the modification steps and fabrication instructions to determine where an error may have been made. Electronic modifications to improve the fit can be quickly made and recorded.

### **Building a Prosthesis**

Fabricating a socket isn't the only step in making a prosthesis. The prosthetist must also select all of the other required components. Normally, a prosthetist would search charts and catalogs to select appropriate weight and activity options and jot down item numbers for placement of orders by the office staff. This method requires an investment of time to research the options for each patient and allows for the possibility of human error.

A truly effective CAD system will improve the efficiency and accuracy of not just the socket fabrication process but of every step along the way, including component ordering. Because all the data required for selecting components is already entered into the software, it is a logical step to use that information to rule out unsuitable components and submit orders. These componentry orders can be reviewed at any time and thoroughly tracked.

### **Monitoring the Fit After Delivery**

Most patients experience a change in the shape and/or volume of the affected limb over time. Sometimes this change is minor enough to be addressed through a simple adjustment, but in some cases the change is drastic enough that a replacement is required. It is critical that clinicians be able to clearly justify a socket or brace replacement based on

exact patient information. Simple handwritten notes in a file do not accomplish this task, and certainly it is impractical to ship plaster models to prove a change in size or shape.

A well-designed CAD system allows the prosthetist to compare one file to another to show the change in the patient's shape over time. The required documentation can be easily printed out and submitted whenever justification is necessary. Although reimbursement is probably the most notable instance in which detailed documentation is required, most clinicians will find that this level of record keeping is invaluable in many aspects of their business.

## **References**

1. Oberg T, Lilja M, Johansson T, Karsznia A. Clinical evaluation of transtibial prosthesis sockets: a comparison between CAD CAM and conventionally produced sockets. *Prosth Orthot Int* 1993;17:164-171.
2. Petrek J, Pressman P, Smith R. Lymphedema: Current Issues in Research and Management. *CA Cancer J Clin* 2000; 50: 292-307.
3. Geil M. Consistency and accuracy of measurement of lower-limb amputee anthropometrics. *J Rehabil Res Dev* 2005;42(2):131-140.
4. Convery P, Buis AWP, Wilkie R, Sockalingham S, Blair A, McHugh B. Measurement of the consistency of patellar-tendon-bearing cast rectification. *Prosth Orthot Int* 2003;27:207-213.

*Jennifer Dowell, CPO, has more than 15 years of experience specializing in the research, development, and instruction of CAD/CAM technology in the field of prosthetics and orthotics. She is the Education Prosthetist for Ohio Willow Wood.*

*Cheryl White, BSE, is the Technical Specialist for Ohio Willow Wood.*