Journal of Rehabilitation Research and Development
Vol. 39, No. 3 (Supplement), May/June 2002
VA/NIH Prosthetics Roundtable
Pages 15–16

Presentation highlights: Computer-Aided Design and Manufacture (CAD-CAM)

Dudley S. Childress, PhD
VA Chicago Health Care System—Lakeside; Northwestern University

BIOGRAPHICAL INFORMATION

Dr. Dudley Childress is the Senior Rehabilitation Research Scientist at the VA Chicago Health Care System—Lakeside. At Northwestern University, he is Professor of Physical Medicine and Rehabilitation; Professor of Biomedical Engineering; Director, Prosthetics Research Laboratory; Director, Rehabilitation Engineering Research Program; and, Executive Director, Prosthetics and Orthotics Education Program. He received his PhD from Northwestern University, IL, in Electrical and Biomedical Engineering.

In addition to earlier career awards, he is the recipient of numerous honors and awards, including the Missouri Honor Award for Distinguished Service in Engineering, 1991; Founding Fellow, American Institute of Medical and Biological Engineering, 1992; Honorary Member, American Academy of Orthotists and Prosthetists (AAOP), 1993; Elected Member of the Institute of Medicine of the National Academy of Sciences, 1995; Elected Fellow, Institute of Medicine of Chicago, 1997; and the Magnuson Award (VA RR&D), 2002. He serves on the Editorial Board of the *Journal of Rehabilitation Research and Development*, and has been a member of the Advisory Board, National Center for Medical Rehabilitation Research of NIH (NICHD), and the National Research Advisory Council (NRAC), VA.

His present research and development activities are concentrated in the areas of:

- biomechanics,
- human walking,
- artificial limbs,
- ambulation aids, and
- rehabilitation engineering.

PRESENTATION

The evolution of Computer-Aided Design and Manufacture (CAD-CAM) as a method of producing prosthetic sockets can be seen in the transition from manual to computerized production. In the conventional or manual approach, plaster is used to create a negative mold of the residual limb. The mold is then filled with plaster to make a positive model, which is carefully hand-sculpted into final form. The socket is then laminated or vacuum-formed over the model.

With CAD-CAM, various technologies can be used, such as laser scanning or magnetic resonance imaging (MRI), to create a digital representation of the "topography" of the residual limb. This digital image can then be modified, on a computer screen, using special software. These data are then fed to an automated carving, or milling, apparatus that shapes the residual-limb model out of foam, or a mixture of plaster and corn starch. In one system, called "SQUIRT Shape," the data are used to form the socket directly, without a model. Finally, a socket is formed around the model with the use of a vacuum former and thermo-plastic.

Historically, the development of CAD-CAM stems from the initial conception and engineering work by James Foort, in the 1960s and 1970s. In the late 1980s, companies such as BioSculptor and Shape Products were founded. The 1990s saw the advent of more

sophisticated CAD-CAM systems, such as the VA-developed Seattle Limb system and the Otto Bock system. The first working model of a CAD-CAM prosthetics system was displayed at the 1983 World Congress of the International Society of Prosthetists and Orthotists in London.

Today, approximately eight different CAM-CAD systems are on the market, most of which are proprietary. From a positive viewpoint, these systems were all successful, and the diversity of CAD-CAM systems available today may simply reflect the natural process of product evolution. However, the drawback to so many companies and diverse methodologies is a lack of uniformity and standardization.

The SQUIRT Shape socket-fabrication method, just mentioned, was pioneered by the VA Chicago Health Care System—Lakeside. The system fabricates sockets by extruding a continuous bead of molten plastic and laying it down in the desired socket form. This method, which makes a socket in about 30 minutes, does away with intermediate steps, such as the fabrication of plaster blanks and the carving of positives, and enables the socket to be fabricated in a single operation. One day, entire prostheses will be produced with this technology.

From an economic perspective, computerized production is superior to manual. A study done in the laboratory of Finnieston Clinic, Inc., in which ten patients were fitted manually and then were fitted using CAD-CAM found that the CAD-CAM process was up to four times more efficient.

KEY POINTS

- CAD-CAM has become widely accepted as a timesaving, cost-effective means of producing prosthetic sockets.
- There are numerous digitizing devices, software packages, and milling (carving) machines on the market. Prosthetic labs can acquire complete systems or combine individual components.
- The SQUIRT Shape system may eventually be used to fabricate an entire prosthesis, along with the socket.

REFERENCE INFORMATION

1. Houston V, Burgess E, Childress D, Lehneis H, Mason C, Garbarini M, LaBlanc K, Boone D, Chan R, Harlan J, Brncick M. Automated fabrication of mobility aids (AFMA): Below-knee CASD/CAM testing and evaluation program results. J Rehabil Res Dev 1992;29(4):78–124.
2. Boone D, Harlan J, Burgess E. Automated fabrication of mobility aids: Review of the AFMA process and VA/Seattle ShapeMaker software design. J Rehabil Res Dev 1994; 31(1):42–49.
3. Boenick U, Näder EhM, Seitz M, editors. CAD/CAM Systems in pedorthics, prosthetics, and orthotics (Clinical perspectives and state of the art). Proceedings of an International Symposium on CAD/CAM; 1997 May 4–5; Nuremberg, Germany. Dortmund: Verlag Orthopäedie-Technik; 1998.