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# Presentation highlights: Tunnel cineplasty

**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

Tunnel cineplasty is a surgical technique for attaching muscle in the residual limb to the prosthesis. While no longer popular, newer cineplasty methods have the potential to provide excellent sensory feedback and control for the prosthesis wearer. Similar, in one sense, to osseointegrated fixtures, the body is working on direct attachments. The ability to connect a prosthesis with the body, allowing for a natural way of working, is thought to be a good concept for prosthetics design.

Tunnel cineplasty was developed initially by German surgeon Ernst Ferdinand Sauerbruch, before World War I, based on earlier work in Italy. With the use of a team approach to rehabilitation—surgeon, physiologist, and technician working together—tunnels were constructed in the muscles of the residual limb and lined with skin grafts. Connecting pins inserted into the skin-lined tunnels allowed the force of the muscles to travel directly to the prosthesis.

There were several stages in the evolution of this method, including the biceps tunnel cineplasty developed by surgeon M. Lebsche, a student of Sauerbruch. This procedure was performed on many veterans after World War II. With a biceps tunnel, when the muscle is relaxed, the hand is open. When the muscle is contracted, the hand is closed and the force in the fingers is proportional to the force in the muscle. This method allows for sensory feedback, a useful property.

Although tunnel cineplasty fell out of favor by the 1970s, partly because of several cases in which the procedure failed to transfer sufficient muscle power to the prosthesis, more recent versions of the procedure have addressed this issue. The technique developed by Dr. Robert Beasely, called “tendon exteriorization,” enables muscles and tendons to be hooked up to external controllers that basically multiply the power to the prosthesis, while still preserving the same degree of control. Today, development of high forces in the muscle and forearm is not necessary, since low forces can suffice; a control system can be used to transduce low forces into high forces.

Extended physiological proprioception refers to the capability of specially designed controlling devices to allow the input to "feel" the condition of the output. Sensory messages from the skin and muscle in the cineplasty are relayed to the user. The user can sense where the prosthesis is going and what kinds of forces are acting on it. This is an improvement over the more common myoelectrical control, which uses the electrical signal generated by the muscle but not the actual force of the muscle.

The use of external power sources for the prosthesis has enabled smaller cineplasties to be performed. This, in turn, creates the possibility of multiple cineplasties in a group of muscles, e.g., the forearm, to create a greater degree of control in the fingers of an artificial hand.

The successful development of these methods hinges on a true interdisciplinary effort, one in which the surgeon, the technologist, the prosthetist, and the engineer work together on these types of systems.

## KEY POINTS

- Tunnel cineplasty, which applies the force—not just the electrical impulse—of the muscle to the prosthesis, provides sensory feedback and better control to the user.
- Effective surgical techniques (whether old or new) should be combined with promising new technologies.
- Advancing the science of prosthetics will require cooperation between the surgeon, physiologist, technologist, and bioengineer.

## REFERENCE INFORMATION

Weir R, Heckathorne C, Childress D. Cineplasty as a control input for externally powered prosthetic components. J Rehabil Res Dev 2001;38(4):357–63.