NEW DESIGNS FOR PROSTHETIC PREHENSORS

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Abstract

At the present time, arm amputees have a basic choice of a hook or a hand for the prosthetic prehensor. There are compromises between these two options. The hook is more functional, and the hand is more cosmetic. Some amputees solve the dilemma by having one of each and interchanging them as work and social situations dictate. Arm amputees prefer to have one acceptable prehensor, and they want one which is functional, is attractive, and does not necessarily have to look like a hand. The challenge is to design a prehensor which is as functional as a hook and is acceptably esthetic in appearance. In this paper presentation, three new designs for prosthetic prehensors will be shown, including two incorporating different kinds of grasp and combining voluntary opening and closing features.

Introduction

About two thirds of the upper-limb amputees in the USA use hooks as the prosthetic prehensor. The Hosmer/Dorrance 5X Hook (1), stainless steel or aluminum, is the most common and is considered the "standard" for comparison with other prehensors. See Figure 1

While many upper-limb amputees get used to the appearance of the hook, it is not what most people would call an attractive looking device. For that reason, some amputees prefer the use of a prosthetic hand even though it may be less functional. Also, some amputees try to have the best of both by having a hook and a hand and interchanging their use. Even then, sometimes the hand is relegated to closet because of the inconvenience of switching prehensors and the superior function of the hook.

In querying upper-limb amputees, many express that they do not have to have a prehensor which looks like a hand. They would be pleased with a prehensor which functions as well as a hook but is more esthetic and less conspicuous looking (2).

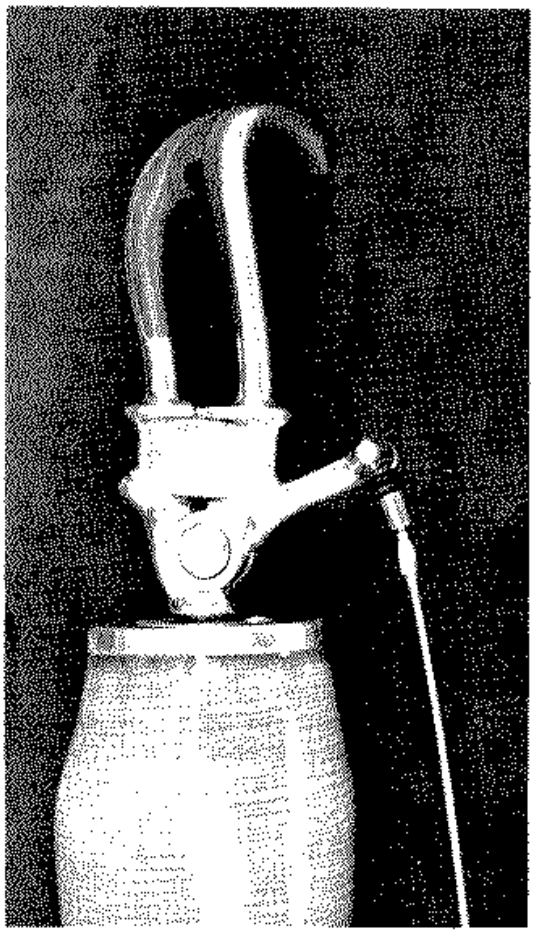

Figure 1.
Hosmer/Dorrance 5X Hook
Most Typical Prehensor
in the USA.

Approach

From the foregoing discussion, the concept arises of having a prehensor which is neither hook nor hand to satisfy the desires of upper-limb amputees. One notable attempt has been made to accomplish this. That is the work of the creative prosthetist Carl Sumida (3) and his evolution of the CAPP I prehensor for children and the CAPP II prehensor for adults.

The CAPP I prehensor has received some acceptance, and the CAPP II is now undergoing clinical trials. The important point is that the door has been opened to exploring a new concept.

The authors have taken a three-pronged approach to the challenge of designing new prehensors based on (a) the anatomy of the human hand, (b) function of grasping, and (c) appearance.

New Design Ideas

a. Parker design: see Figure 2.
This prehensor is derived from study of the anatomy of the human hand (4). It is voluntary closing (VC), uses primarily three-jaw-chuck grasp, has curvatures for multi-point grasp of cylindrical objects, and has a cutout in the dorsum for use of pencils and utensils.

b. LeBlanc design: see Figure 3.
This prehensor is based mainly on functional considerations. It is voluntary opening (VO) in the normally closed position and is voluntary closing against the opposite finger. It has finger tip grasp in the VO position and palmar grasp in the VC position. The finger tips handle objects up to 1-1/2 inches in diameter, and the proximal area handles 1-1/2 inches to 3 inches in diameter. Prior work has indicated that 90% of activities can be handled with 1-1/2 inches opening or less (5).

c. Nelson design: see Figure 4.
This prehensor is based mainly on esthetics. It is unique in that it has a rotary thumb which is normally closed in the VO position for finger tip grasp and then can be rotated around for palmar grasp in the VC position.

The operation of the Parker design is conceptualized as normally closed, thumb opening completely with a slight pull on the cable, and thumb closing with further pull on the cable - similar to the APRL Reflex Hook described in Reference (5). One unique feature being considered is cable take-up with thumb opening, which would allow a normally looser harness which would tighten for operation as the thumb opened for grasp.

The LeBlanc and Nelson designs are unique in that they offer different grasping surfaces and the option of using VO or VC prehension. That is, one could hold objects in VO position with fixed prehension force and no harness pull, or could hold objects in VC position with variable prehension proportional to harness pull.

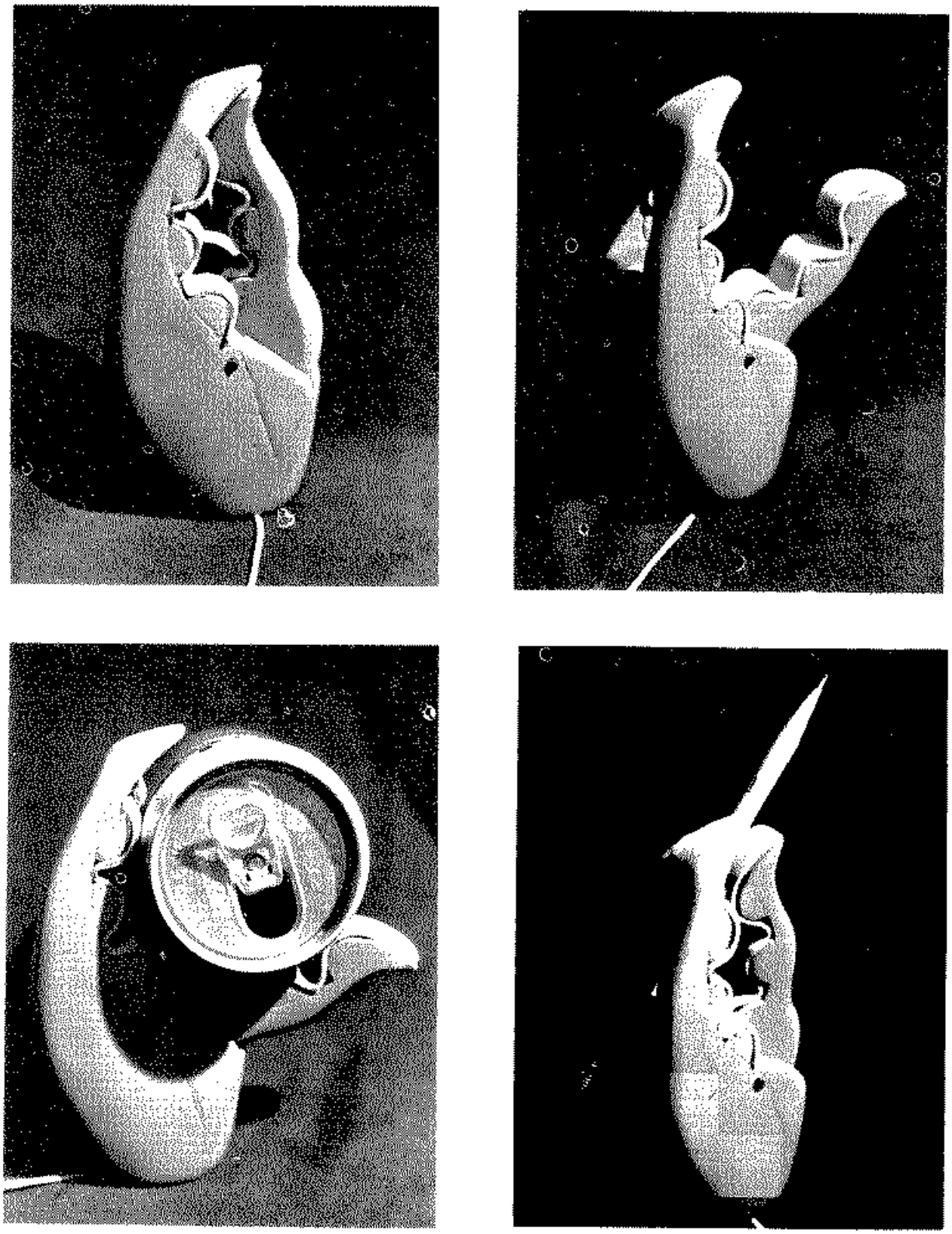

Figure 2.
Four Views of Parker Design Model.

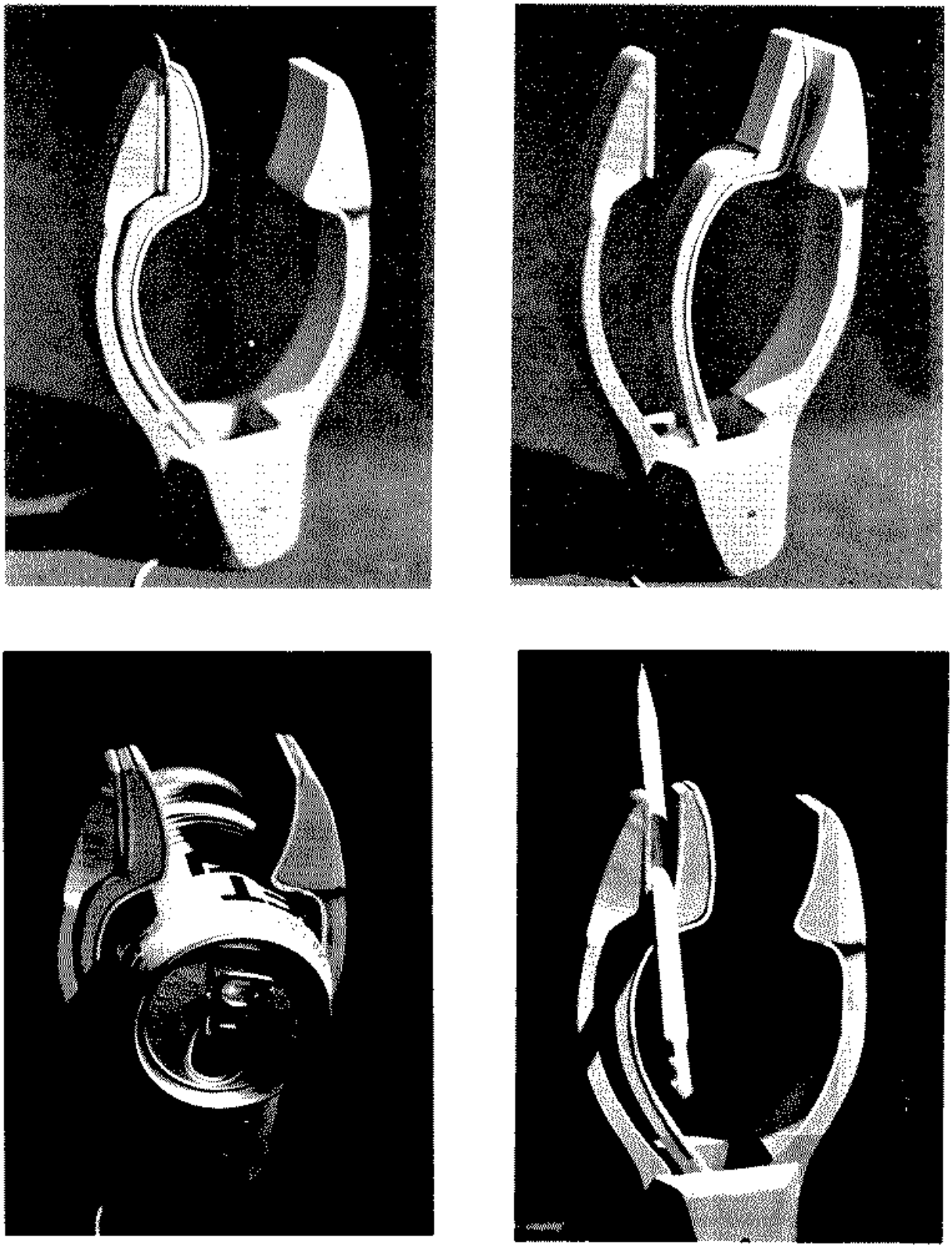

Figure 3.
Four Views of LeBlanc Design Model.

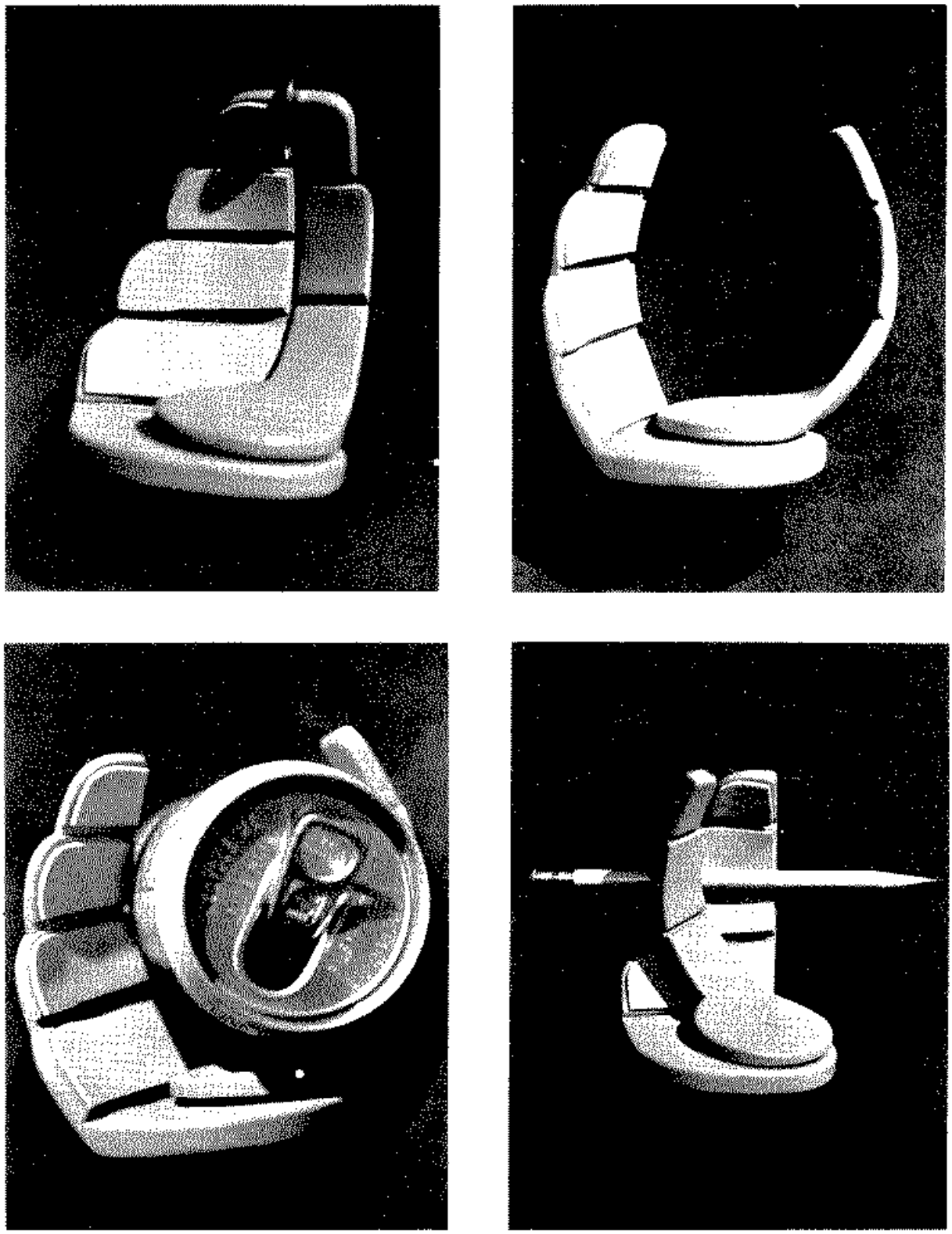

Figure 4.
Four Views of Nelson Design Mode

Testing of Ideas

Donna Meeks, OTR, has developed a questionnaire to solicit reactions of the three models compared to one another and compared to the standard Hosmer/ Dorrance 5X Hook. Opinions from amputees, professionals in prosthetics and lay people will be solicited and an attempt made to ascertain which of the three approaches seems the best or whether continued new thought should be given to prehensor design.

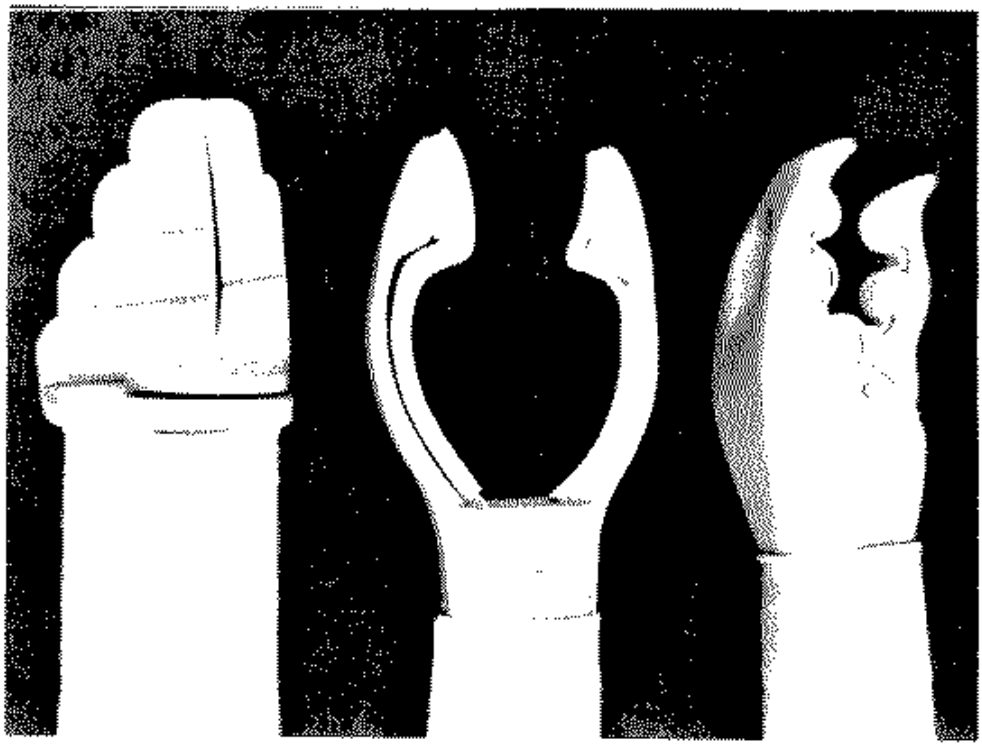

Figure 5.
Three Prehensor Models.

Future Work

Assuming that one of these designs seems superior to the others, then the plan is to build working prototypes of the best design to test in use with upper-limb amputees.

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References

1. Hosmer Dorrance Corporation, 561 Division Street, Campbell, California 95008, USA.

2. LeBlanc, M., "Innovation and Improvement of Body-Powered Upper-Limb Prostheses: A First Step", Clinical Prosthetics and Orthotics, Vol. 9, No 1, Winter 1985, p. 13.

3. Carl Sumida, CP, now deceased, work undertaken at Child Amputee Prosthetic Project (CAPP), UCLA Rehabilitation Center, 1000 Veteran Avenue Los Angeles, California 90024, USA.

4. Taylor, C., Schwarz, R., Anatomy and Mechanics of the Human Hand", Artificial Limbs, Vol. 2, No. 2, May 1955, p. 22.

5. Klopsteg, P., Wilson, P., et al., Human Limbs and Their Substitutes, McGraw-Hill Book Company, 1954, p. 227.

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