Acceptability of a Functional-Cosmetic Artificial Hand for Young Children *

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INTRODUCTION

I. *History*

The need for a functional and cosmetically-acceptable hand for juvenile amputees has existed for many years. In 1958 the Army Prosthetics Research Laboratory attempted to fill the void by developing a child's voluntary-opening hand, denoted as size No. 1. The Sierra Engineering Company contracted to manufacture this hand, and two other companies (Kingsley Manufacturing Company and Prosthetic Services of San Francisco) were enlisted to manufacture suitable cosmetic gloves.

Following preliminary testing of a prototype model, modifications to eliminate certain shortcomings were incorporated in 50 production models. A field test was initiated in April 1960, with evaluation of the cosmetic gloves included as an integral part of the study. Preliminary findings based upon experiences in fitting 20 children were reported in October 1960 (1). The results indicated that the hand was acceptable cosmetically and provided satisfactory function in the activities typically performed by the children. The general workmanship and cosmesis of the gloves provided by both manufacturers had also achieved a satisfactory level, after certain initial fabrication difficulties. However, several problems had been identified during this phase of the study, the most serious of which was a lack of glove durability. Ridges and sharp edges on the exterior of the hand apparently contributed to rapid glove damage.

It was decided to modify the original production-model hands and then refit them to the subjects in the study. These modifications included the elimination of glove-cutting edges, strengthening of the floating-finger attachments and the spring mechanism of the thumb, and raising the cable exit. In November 1960 "old" hands revised in this manner began arriving at New York University-Child Prosthetic Studies and in April 1961 the manufacturer produced a series of new hands which incorporated all of the above modifications.

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* Copies of the report here summarized are available from the Child Prosthetic Studies, Research Division, College of Engineering, New York University, 252 7th Ave., New York 1, N. Y.

(1) "Interim Report, Field Test—APRL-Sierra Child Size Model No. 1 Hand (Right)," Child Prosthetic Studies, Research Division, College of Engineering, New York University, N. Y. C., October 1960.

PLATE I
Child Wearing Artificial Hand and Glove

An Interim Report (2), summarizing the results of the field study to mid-May 1961, was prepared for the Subcommittee on Children's Prosthetics Problems and the results reinforced earlier findings concerning the acceptability of the hand and gloves. The APRL-Sierra Child Size Model No. 1 Right Hand was accepted as satisfactory for general use by child amputees on the basis of this report, and the study was terminated in the latter part of 1961.

Following the generally successful outcome of the No. 1 Right Hand evaluation, manufacture of the No. 1 Left Hand was initiated. In May 1961, NYU-Child Prosthetic Studies reported the results of a preliminary examination of two units manufactured by the Sierra Engineering Company (3). The hands appeared to be of excellent quality and workmanship, with minor exceptions, and in June 1961 the manufacture of 55 additional left hands for field test purposes was authorized.

During September and October 1961 NYU-Child Prosthetic Studies received two shipments totaling 40 hands from the manufacturer. These were found to be unacceptable because of manufacturing deficiencies and all were returned for modification. It was not until February 1962 that 37 hands were finally accepted for use in the field study. Another 14 hands submitted later were also found to be suitable, for a total of 51.

Another Interim Report (4) on the status of the field study was submitted at the October 1962 meeting of the Subcommittee on Children's Prosthetic Problems. It was reported that the APRL-Sierra Model No. 1 Left Hand was considered to be essentially satisfactory both mechanically and functionally, although more rigid quality control in manufacture and assembly was desirable. The recommendations of this report—that the hand and cosmetic glove be approved for commercial distribution—were accepted by the Subcommittee and the study was terminated in January 1963.

II. *Purposes of the Study*

The APRL-Sierra Child Size No. 1 Hand (both Right and Left) was developed in order to provide the juvenile upper-extremity amputee with a cosmetically acceptable terminal device, which would closely resemble the normal hand in size, shape and coloring. Maximum function, commensurate with cosmesis, simplicity of operation, strength considerations and reasonable cost, was a concomitant objective.

Since the field study of the Left Hand was essentially an extension of the Right-Hand Study, the general goals of both evaluations were identical:

1) to introduce the hand into clinical use;
2) to corroborate findings of laboratory studies;
3) to determine the acceptability, utility, application, and durability of the production-model hand and glove;
4) to investigate indications and contraindications for prescription.

In the light of the experience gained in the prior Right-Hand Study, three considerations were given closer attention in the Left-Hand evaluation:

1) Performance differences between the experimental hand and the

(2) "Interim Report, Field Test—APRL-Sierra Child Size Model No. 1 Hand (Right)." Child Prosthetic Studies, Research Division, College of Engineering, New York University, N. Y. C., May 1961.

(3) "Memorandum Report: Preliminary Considerations of the APRL-Sierra Child Size Model 1A (Left) Hand," Child Prosthetic Studies, Research Division, College of Engineering, New York University, N. Y. C., May 1961.

(4) "Interim Report, APRL-Sierra No. 1 (Left) Hand," Child Prosthetic Studies, Research Division, College of Engineering, New York University, N. Y. C., October 1962.

hooks previously worn were investigated in greater detail than was the case in the Right-Hand Study.

2) The short wear-life of the cosmetic gloves used in the Right-Hand Study presented a definite and challenging problem. In the course of the study the exterior of the experimental hand was extensively modified to eliminate sharp edges which might contribute to glove damage. The effectiveness of these changes was of particular interest in the Left-Hand Study.
3) The effect of hand wear on the child's school behavior was a planned aspect of the Right-Hand Study. Little data was secured on this significant subject, however, since the study overlapped two school years. With the earlier commencement of the Left-Hand Study (February 1962) these data were obtained for a limited number of children fitted during March and April 1962.

III. *Description of Hand*

The APRL-Sierra Child Size Model No. 1 Hand, both right and left, consists of a metal handshell and two movable fingers (index and middle) which articulate at the inter- and metacarpo-phalangeal joints. This type of articulation is designed to permit maximum finger travel without undue distortion of the cosmetic glove. The thumb may be set manually in two positions, with two finger-opening dimensions possible: with the thumb in the "small-opening" position gripping of objects 0 to 1⅜" (minimum) should be possible, while the "large-opening" thumb position should accommodate objects ⅝" to 2" (minimum). Foam or silicon rubber floating fingers (ring and little finger) are attached to the handshell with an insert pin and are non-functional.

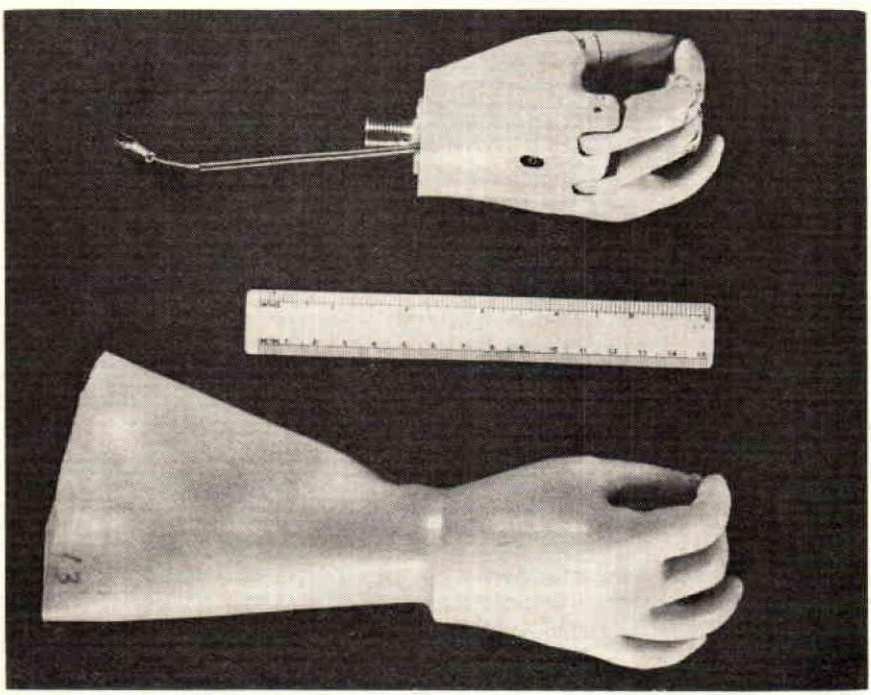

PLATE II

APRL-Sierra Child Size Model No. 1 Hand

Hand function is of the so-called "voluntary-opening" type, i.e., a pull on the control cable opens the fingers against a spring force which closes them when the cable is relaxed. The hand mechanism provides a pinch force of approximately two pounds at the fingers and requires about ten pounds of force to open the fingers fully. Incorporated in the mechanism is a "following" lock or "Bac-Loc," which prevents the fingers from opening when a force or load up to a maximum of ten pounds is applied against them.

The hand is designed to be of life-like proportions and shape, so that a realistic appearance is attained when it is covered with the appropriate cosmetic glove. The specified overall dimensions of the hand are:

length (with fingers closed)	3-5/8″
length (with fingers extended)	4-3/4″
width (at metacarpo-phalangeal joints)	2-3/16″
thickness (at metacarpo-phalangeal joints of index finger and thumb)	2-1/16″

Further details concerning the structural and functional characteristics of the No. 1 Hand may be found in the APRL Specifications Report 2-61 (5) and referenced publications.

SUMMARY

The findings from the study of the APRL-Sierra Child Size No. 1 (Right and Left) Hand are presented in this report. The experiences of 77 children are described, including 38 subjects fitted unilaterally with the right hand, 38 fitted unilaterally with the left, and one child fitted bilaterally. All children discussed in the report wore the experimental hand for a minimum of four months, except for seven subjects who rejected it prior to completion of the wear period planned for the study.

The overall age range of the sample (at the time of fitting) was from 4 years to 12 years 4 months. All levels of upper-extremity amputation (prosthetic type), from wrist-disarticulation to shoulder-disarticulation were represented. The one child fitted with both right and left hands was a bilateral below-elbow amputee.

Although the Right- and Left-Hand portions of the study were not conducted concomitantly, for the most part the findings were consistent and may be summarized jointly. They were:

I. *Overall Acceptance*

Less than 10 percent of the children in the study rejected the No. 1 Hand completely. The response of the remaining 90 percent ranged from highly enthusiastic to lukewarm. Actual (and planned future) wear of this majority group varied from exclusive full-time wear to part-time use primarily for social occasions. Cosmesis was the prime factor influencing the generally high level of acceptance. However, in the majority of instances cosmetic appeal was supplemented by an adequate degree of function.

Weight reduction and an improved operating efficiency (ratio of pull-to-pinch forces) would doubtless add to the acceptability of the No. 1 Hand. Both these improvements should be feasible.

II. *School Behavior*

Evidence from teachers, parents and children emphasized the importance of the school environment to the child. The school milieu emerges as perhaps the most critical social setting in which the child functions.

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(5) Riblett, V., and Hodge, J. W., Jr., "Tentative Standards, Hand, Mechanical, for Upper Extremity Amputees, Size 1," U. S. Army Prosthetics Research Laboratory, Walter Reed Army Medical Center, Washington, D. C., Specifications Report 2-61, June 1961.

Wearing the No. 1 Hand brought no revolutionary changes in school attitudes or behavior. Nevertheless, there was evidence that hand wear made a generally positive although variable contribution to the child's self-confidence and to the acceptance of the child by his peers and/or his teacher.

III. *Appearance of Hand*

A. *Hand Design*—The children participating in the study (and their parents) were almost unanimous in expressing a high measure of satisfaction with regard to the shape configuration of the No. 1 Hand.

B. *Hand Size*—The size of the No. 1 Hand was satisfactory, or at least acceptable, to the majority of the children in the study. It was too large for very few children, but too small for a larger number, either initially or as a result of normal growth. This problem of undersizing, however, would be obviated by the availability of a larger hand (No. 2) to provide a size continuum.

Children whose normal hand size approximated that of the experimental item, or came within acceptable limits, typically fell into the 4- to 8-year-old bracket.

IV. *Gloves*

In a number of individual instances, mismatching of shades was evident. In general, however, the coloring, tones, texture and fit of the cosmetic gloves used in the study were received enthusiastically by children and parents.

V. *Function*

The precise extent of usefulness of the No. 1 Hand in tasks typically performed by the children in the study was somewhat obscured by "halo" effects. However, the total evidence indicates that:

1. The No. 1 Hand provides less total function than the equivalent (Dorrance #10X) Hook worn by this age group of children.
2. The No. 1 Hand provides function equal to that of the appropriate hook for numerous activities.
3. The function of the hand was superior to that of the hook for some of the children in the performance of certain specific tasks.

VI. *Durability*

A. *Hand*—Although the No. 1 Hand does not appear to be excessively fragile, malfunctions and breakages occurred with sufficient frequency in the course of the study to be cause for concern.

It appeared that in some instances causes of breakage could be reduced or eliminated by manufacturing measures. It was obvious, however, that a great deal of the damage was attributable to the activity habits of the wearers. Thus, it would be anticipated that if hands were used on an unrestricted basis, a fall or some other violence done to the hand, the entrance of dirt and/or water into the mechanism, etc., would result in ultimate breakage or malfunction.

B. *Glove*—The lack of durability of the gloves used in the No. 1 Hand Study was the prime negative feature in the entire investigation. It was apparent that the gloves available for the hand were not strong enough for the treatment meted out to them. Deficiencies in stain and discoloration resistance presented lesser problems.

VII. *Conclusions and Recommendations*

The APRL-Sierra No. 1 Hand combines excellent appearance with a considerable degree of function. For many children, the hand's superior appearance offsets any functional inferiority to a hook.

Prescription of the No. 1 Hand may be considered for all unilateral, upper-extremity amputation levels from wrist-disarticulation to shoulder-disarticulation when the normal hand size does not exceed 6-1/4" in circumference at the metacarpal-phalangeal knuckles (excluding thumb) and length (radial styloid to thumb tip) does not exceed 3-7/8". This is true for both males and females.

The No. 1 Hand-and-Glove are relatively costly items. The initial cost, plus the expense and inconvenience of glove replacements and hand repairs, will undoubtedly tend to restrict purchase of the item. Manufacturing care to reduce potential breakage of hand parts and intensified efforts to develop a markedly more durable glove are recommended.

Because of possible limitations on hand usage related to glove and/or hand durability, it is recommended that concurrent prescription of a hook as a "spare" or "play" device be routinely considered.

Based on the results of the study, the No. 1 Hand definitely merits a place in the "armamentarium." Prior Interim Reports have recommended that steps be taken to make the No. 1 Hands, both right and left, generally available to prosthetic clinics. These recommendations are reaffirmed.

Dr. Warren Perry Named to New Post

Promotion of J. Warren Perry, Ph.D., to the newly created position Deputy Assistant Commissioner for research and training in the Vocational Rehabilitation Administration has been announced by Miss Mary E. Switzer, VRA Commissioner. Dr. Perry was formerly assistant chief of the training division.

Miss Margaret M. Ryan also has been promoted from the position of training consultant in social work to take Dr. Perry's former job.

Dr. Perry's major responsibility under the supervision of Assistant Commissioner James F. Garrett will be to serve as top consultant in planning and developing a nation-wide research and training program in the field of artificial limbs and braces for amputees and crippled persons.

Under the VRA research and training program in general, grants totaling millions of dollars are made annually.

Research grants are awarded to private, nonprofit groups, State and rehabilitation agencies, and other public organizations to pay part of the cost of activities to advance knowledge and methods for improving the rehabilitation of mentally or physically handicapped persons.

Teaching grants and traineeships go principally to university graduate schools, graduate students, and State rehabilitation agencies to reduce materially the shortage of professional workers in vocational rehabilitation.

Immediately prior to joining the staff of the Vocational Rehabilitation Administration, Dr. Perry was director of prosthetics education and assistant professor of neurology and psychology at Northwestern University Medical School. Previously, he was assistant professor of psychology at the University of Illinois and a lecturer in the department of psychology at the University of Chicago.

Dr. Perry was born in Richmond, Indiana, and received a B.A. degree from DePauw University in 1944. After a year of graduate work at Harvard University he obtained a Master's degree in psychology at Northwestern and completed his education at the same institution in 1955 by taking a Ph.D. degree.