The Choice of Terminal Devices

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SINCE the chief purpose of all other components of the upper-extremity prosthesis is to make it possible for the terminal device to be operated effectively, the hook or artificial hand is considered to be the most important component of any artificial arm. The terminal device (or devices, since they can quickly be interchanged for a given individual) plays the decisive role in determining the functional and cosmetic value of the prosthesis to the wearer. Of considerable importance, therefore, is a knowledge of the process by which the terminal device is chosen from among the many types available commercially *(19).* But the criteria for selection and prescription of hooks and hands present a confusing picture and often are difficult to isolate. Some amputees, because of long-standing habit, resist change and retain the hook or hand with which they were first fitted. Others rely on the advice of well-intentioned friends, who also may be amputees, and make frequent changes in the attempt to find what does not exist—the *completely* satisfactory device. Perhaps the largest group depend upon the prosthetist for guidance *(14).*

With the recent development of prosthetics clinic teams, usually consisting of a physician, a prosthetist, and a therapist *(3),* the tendency is for more and more amputees to have their terminal devices prescribed for them. Although the prescription of terminal devices by the clinic team is clearly the most desirable method, certain aspects of this process are confusing too because different clinic teams pursue different lines of thought in making decisions. Some clinics concentrate on occupational factors and attempt to prescribe in terms of success on the job. Other groups rely heavily on the amputee's personal preferences, while still others make their choices largely with regard to site of amputation, believing, for example, that a long-below-elbow amputee should be prescribed one terminal device, a medium-above-elbow amputee another.

Finally, many clinic teams have developed, through experience or persuasion, other relatively fixed preconceptions with regard to terminal devices and prescribe within the framework of established biases. Among these are a preference for canted hook fingers as opposed to straight fingers (or vice versa), a preference for either steel or aluminum construction, a preference for voluntary-opening as opposed to voluntary-closing (or vice versa), a distaste for artificial hands as being functionally of little or no value (rarely the reverse), a preoccupation with the desire to prescribe low-cost items (also rarely the reverse), and preferences or dislikes based on other specific features.

This discussion is not intended to be all-inclusive, nor is it meant in a critical vein. Its purpose is simply to illustrate the difficulty of reaching a valid decision in the prescription of a terminal device and to highlight the divergent opinions extant today. An attempt is made to explore the factors involved in the proper choice of a particular terminal device for a particular amputee.

To arrive at the best choice of a terminal device for a particular amputee involves a number of considerations. First, perhaps, are the psychological needs of the individual. These arise from a complex of the intangible judgments, desires, motivations, and preju-

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dices which lead an amputee to prefer certain characteristics of one terminal device over those of another. Then there is the nature of the environment in which the prosthesis is to be used, including the vocational and avocational considerations as well as the various requirements of daily living. And finally biomechanical (anatomical and physiological) characteristics may help to determine an amputee's capacity to use a particular terminal device. What bodily functions remain, and the degree to which these functions are useable, may both influence the selection of terminal devices. Such considerations, taken as a whole, compose the basic knowledge upon which a system of differential prescriptions may be developed.[3]

PSYCHOLOGICAL CONSIDERATIONS

On the basis of personal or psychological considerations, individual amputees express varied individual attitudes toward the function, appearance, and durability of terminal devices. Not infrequently these feelings are outgrowths of the experience of amputation itself and are related to problems of later psychological adjustment.

ATTITUDES RELATED TO APPEARANCE

Appearance probably is one of the first things that a patient thinks about after amputation. He questions what he will look like, what he will be able to do, and what people will think of him. Thus the appearance of a given terminal device can be a critical factor in its acceptance or rejection. Several studies have dealt specifically with the all-important role of cosmesis in prosthetic replacement, including the psychological dynamics of the process *{11).* Because these matters are discussed ably by Dembo and Tane-Baskin (page 47), they need not be elaborated upon here. But several other aspects of the problem may be considered.

[3] Throughout this paper the discussion applies primarily to the unilateral, upper-extremity, adult amputee. Several of the points made cannot, and should not, be considered as having validity for the special prosthetic problems of children, bilaterals, or cineplasty amputees.

The only means of satisfying the need for acceptable appearance by the upper-extremity amputee is to use the so-called "cosmetic hand," that is, a hand that approaches the configuration, texture, and color of the norma] hand. But to produce from inanimate materials a satisfactory mate for the normal hand involves a series of compromises. To the requirements of form and appearance add the need for adequate prehensile function and the necessity of manufacturing the device at a reasonable cost (which requires mass-production techniques, thereby making true custom-matching impractical), and any idealized prosthetic replacement becomes an impossibility *{5,10).* The problem, therefore, is to provide a relatively inexpensive terminal device having the general appearance of the remaining hand and possessing as much prehensile function as possible without too much sacrifice of cosmetic properties. The APRL No. 4C hand (Fig. 1) approximates these requirements *{5,10),* and improvements may be expected with the years. In terms of appearance, however, such artificial hands can never hope to be more than an approximate match for the normal hand. At best, an artificial hand can serve to disguise the fact of amputation from passers-by and casual contacts with whom intimate association is not intended.

In view of these circumstances, each amputee is faced with a psychological adjustment process when he first wears a prosthetic hand. The adequacy of his adjustment depends on his personal concept of how well the cosmetic hand matches the normal and on the extent to which he feels any differences are noticeable to others. Depending on the strength of these feelings, so-called "acceptance" will or will not be achieved. Moreover, each amputee must choose what is, for him, the best combination of functional replacement and cosmetic appearance. Because each terminal device is, by design, a compromise between these two factors, some devices emphasize cosmetic appearance at the expense of function, and vice versa. The final selection by the amputee reflects his intuitive weighting of these two features.

Although the problem of hand cosmesis has received considerable attention, and although the functional implications of hook-finger

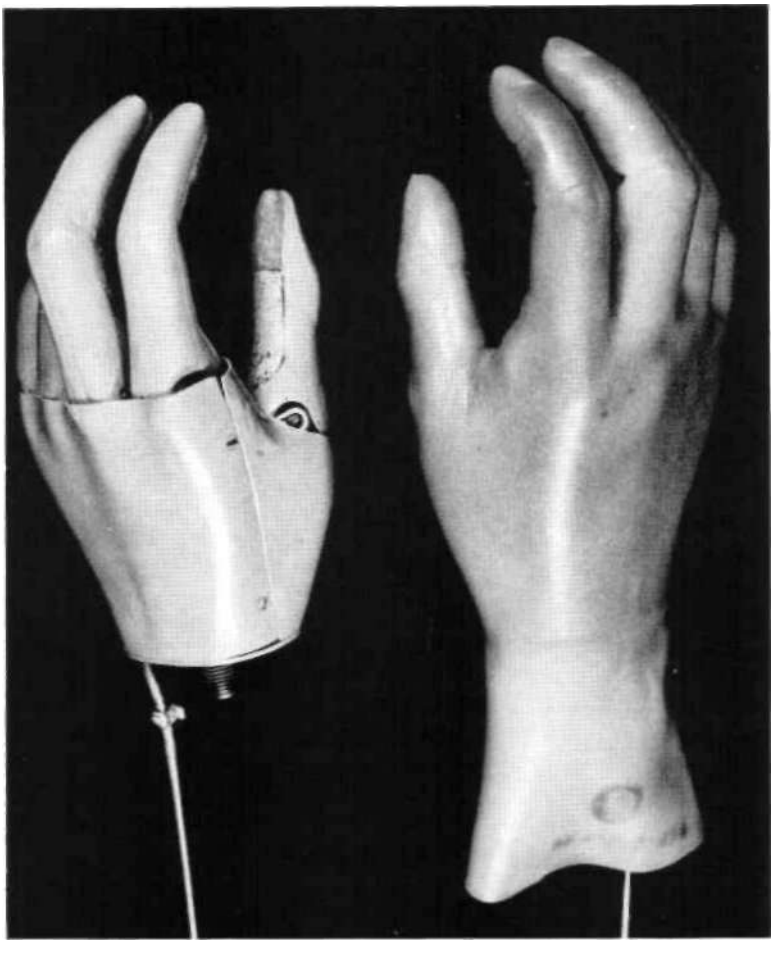


Fig. 1 The APRL No. 4C voluntary-closing artificial hand, with and without cosmetic glove. *Courtesy Armed Forces Institute of Pathology.*

shape have been studied extensively both within the Artificial Limb Program and by others, little has been done thus far with reference to alteration of hooks for cosmetic purposes. Co-workers in the engineering sciences advise that the fundamental geometry of hook fingers cannot be altered very radically without sacrificing some of the fundamental functions of holding, pushing, pulling, and hooking *(17).* But to date there has been no inquiry into the matter of external coloring, texture, and finish of hook case and fingers. While there is no experimental evidence to the effect that the metallic finish in current use is objectionable, either to amputees or to the public, the finish of hook fingers and case, as regards both color and texture, might very well undergo serious investigation.

That color and texture might be important considerations has been highlighted by the excellent reception accorded the child's prehension device in which the metallic core of the hook fingers has been covered with a flesh-colored plastic (Fig. 2). Some additional support for such procedures may be drawn from the field of dentistry, where, if the prosthetic restorations are to be visible, increasingly greater use is made of acrylics rather than of metals. Some preliminary studies of this matter are being started by the Prosthetic Devices Study, New York University.

If careful attention is being directed to the appearance of the terminal device, it seems equally important that care also be exercised in the choice of descriptive terms used to identify it. The prosthetic replacement for a missing hand generally is termed a "hand" or a "hook." Whatever this second device may be in fact, it is described by a word that, to many, raises questionable if not negative feelings. The word "hook" brings to mind such ideas as stevedoring, Captain Hook, catching fish, gang warfare, and unsuccessful vaudevillians. As a matter of fact, Merriam-Webster defines "hook" by using the following words: "snare," "trap," "catch," "seize," "hold," "gore," "pierce," "steal," or "lop off," as with a sickle.

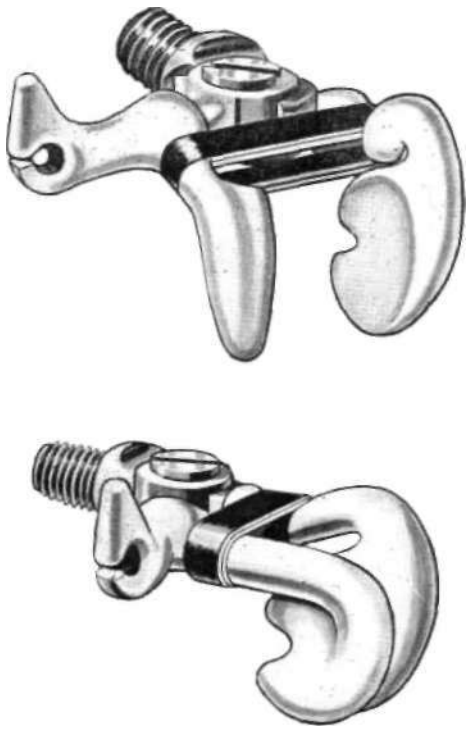


Fig. 2. The child's wafer hook, a Dorrance voluntary-opening device as modified at the Army Prosthetics Research Laboratory. The hook fingers are covered with a flesh-colored plastic molded in a special configuration. The plastic helps to protect both wearer and associates and provides more acceptable appearance as well.

Of course none of these synonyms are very pleasant. Viewed in the context of an individual who has the anxieties and other problems concomitant with amputation, the meanings of words take on a particular significance. In such a situation, the words used in communicating with the patient are most important to his welfare. It does not seem likely that most amputees look forward expectantly to being provided with a "hook," and therefore whatever can be done to provide this device with a more satisfactory identification would seem to be in order. Unfortunately, no concise, euphonious name comes immediately to mind. The somewhat longer, generic term "prehension device" has been suggested.

ATTITUDES RELATED TO FUNCTION

One of the most important requirements of a terminal device is reliability, so that the wearer may consistently perform specific activities successfully *(8,10).* As use of the device can approach the level of automatic behavior, as performance becomes more subconscious and can be accomplished with less awareness, the amputee approaches an important goal of personal readjustment. The extent to which an amputee is motivated to apply himself toward achieving this goal is a second determining factor in his use of a terminal device.

Just as the human hand reflects personality by the way in which it is used, so the use of a terminal device depends upon the personality of the wearer. Although the manner in which the terminal device is used is by no means as sensitive an indicator of the individual personality as is the human hand, nevertheless, in a gross sense, patterns of use of the terminal device reflect the personal needs of the wearer. One amputee, for example, may use his device in a restricted and limited way, perhaps as a paperweight, while depending chiefly on his normal extremity for general function. Such behavior may be motivated by the fact that he is rejecting himself as an amputee and does not wish to give further thought or effort to the problem of readjusting to his amputee status. Or perhaps he may not desire better prehensile function because he has shifted his performance patterns to the normal extremity and has become accustomed to the awkwardness and inefficiency of one-handedness.[4] In a similar situation, another amputee may be determined to master his prosthesis because he has become aware of his problem and of the advantages of two-handedness; he works to achieve a more normal type of prehension pattern. Once having been shown the advantages of the added utility and grace concomitant with expert prosthetic usage, addi-

[4] This is, in effect, the same type of behavior pattern found in the two-handed person who prefers to continue with the inefficient hunt-and-peck system of typing rather than expend the effort necessary to learn touch typing.

tional function is developed through continued use of the device.

In both instances, particular personality traits come into play—concentration, patience, vanity, drives of all sorts, reactions to pressures and frustrations, and so on. And although it would be desirable to be able to relate these personality traits precisely to specific types of terminal devices *(e.g.,* the more functional devices with careful, neat, orderly people and the less functional, simpler devices with less demanding, more easygoing people), it is, at present, impossible to do so. Nonetheless, as studies proceed, the relationship between terminal-device usage and the psychological needs of the wearer will become increasingly clear *(2,4).*

PSYCHOLOGICAL INFLUENCES ON DURABILITY

At the present stage of development of terminal devices, one of the major determinations necessary in prescription relates to durability in various occupational or avocational activities. It must be remembered that people differ in the care they give material things. Hammers, chisels, saws, automobiles, and prostheses, all of which are extensions of an individual's capacity for work, are handled very differently by different people. One person performs the duties of a steel puddler with greater gentility and care than another man uses when he repairs fine watches, and this difference is reflected in the use of their tools. Although the comparison is perhaps overdrawn for purposes of emphasis, the point is nevertheless true over a wide range of activities.

Similar considerations hold for terminal devices. Hence, reinforced steel terminal devices are destroyed quickly by some amputees; lighter, less durable terminal devices afford the careful amputee adequate usage over a long period of time. In an attempt to determine the causes of malfunction and breakage, the common approach is to look into *what* a man does. The important factor may instead be *how* he performs various activities. Although the importance of the first consideration should not be discounted, the second factor may be of even greater significance.

The way in which a task is done is clearly related to the performer's attitudes. With specific reference to amputee attitudes, it should, of course, be borne in mind that considerable aggression may be displaced toward prostheses and in turn referred toward terminal devices *(8,16,20).* In an effort to release some of the anger generated by amputation, the wearer may impose considerable maltreatment upon a terminal device. Actually a certain amount of secondary gain also is involved in the attention received when it is necessary to have the device serviced (*1*). Consequently, a second motivation exists for maltreatment of terminal devices. Until improved understanding as well as better prognostic measures of psychological mechanisms are available, prescription will have to depend partly, as it does today, upon the type of occupation and avocation in which an individual is engaged *(9).* Even when these limited criteria are used, however, it is important to know something more of the precise activities to be performed than is ordinarily the case.

ENVIRONMENTAL CONSIDERATIONS

The major day-to-day activities of amputees, just as is the case with normals, involve relations with other people, vocational pursuits, dressing and eating, personal hygiene, and recreational activities or hobbies. In the matter of interpersonal relationships, the cosmetic features of the terminal device probably have the major influence on the reaction of other people to the amputee. This is certainly true of the general public *(11),* though perhaps less true of an amputee's family and intimate friends.

HAND OR HOOK

Because cosmetic appearance is important, it seems reasonable to ask why, up to the present, most amputees have been hook wearers rather than hand wearers. One reason for this situation seems to lie in the personal preferences of some amputees who express distaste for the deceit they feel is involved in disguising an amputation with a cosmetic hand. This is true of a relatively small group, but a much more important reason lies in the widely held belief that, although a hand has

cosmetic advantages, it has little or no functional value.

It is doubtless true that a hook can do finer, more delicate work with its tip prehension, can hold some objects more securely, and can work in tight corners where a hand, by virtue of its bulk, cannot operate. In addition, the hook does not obscure vision as much as does the hand, an important consideration because of the absence of proprioception in the fingers of a terminal device. Despite these advantages of hook function, however, it must be pointed out that, since the advent of the APRL No. 4C hand *(5,6),* many tasks can be performed more easily with a hand than with a hook *(13).* Round objects, for example, such as a water glass or a soda bottle; long-handled tools such as a broom, shovel, or rake; and such items as paper, pencils, and telephones, to mention a few, can be grasped more securely with a hand than with a hook. The widespread notion that considers the hand as almost completely nonutilitarian is based on the fact that not until recently have artificial hands combined reasonable weight, reasonable ease of operation, good appearance, and satisfactory prehension characteristics. In raising the functional adaptability of the hand to the standard attained in the hook, the development of the APRL hand has gone much further than is generally realized. Future hand developments may very well complete the evolutionary process (5).

Even though the APRL No. 4C hand is the hand of choice, it can in no way be considered the ultimate. Among its shortcomings are the fact that it is available in one size only, that there is a serious tendency for the glove to tear and soil, and that maintenance requirements are greater than they should be. In spite of these disadvantages, the rate of amputee acceptance has been gratifying. In the field test of the APRL hand, 97 percent of the hand wearers and 84 percent of the hook wearers, or an average of 89 percent of both groups, found the device useful and acceptable. These general findings have been clearly verified by the upper-extremity field studies currently being conducted by New York University.

If such acceptance is possible under adverse circumstances, a truly superior hand should clearly be accepted and used by well over 90 percent of all arm amputees. As a matter of fact, if these data may be relied upon, it would seem that upper-extremity prescriptions of the future should properly include an artificial hand in every case except those isolated instances where peculiar psychological or environmental conditions contraindicate. Yet in all probability there will always be a need for the hook for specific occupational or avocational situations, as well as to satisfy the personal preferences of a limited sample of the amputee population. More and more, however, the hook will be thought of as a specialized tool to be used in specific situations, while the functional hand will be of sufficient versatility to be the device that is worn most generally.

Present information does not, for the most part, allow specific occupations to be related to particular hooks *(12,15),* for, as already noted, the manner in which an activity is performed may be more significant than the nature of the activity itself. It is known, for example, that some amputees use their hooks as a pounding instrument, as a hammer, or as a prying lever. If these habits are well established, the physical characteristics of the terminal device must be such that it can withstand this kind of use. It is necessary, then, to determine whether the individual uses his hook as a tool or whether he uses it to hold tools. If the hook is to be used as a tool, simple steel hooks, such as some of those offered by Dorrance (7), should be prescribed. If it is to be used as the normal hand is used, the aluminum Dorrance hooks with rubber-lined fingers, the Northrop-Sierra voluntary-opening two-load hook *(5,18),* or the APRL hook are, because of their more versatile grasping abilities, the devices of choice (Fig. 3).

HOOK MECHANISMS

From the standpoint of vocational usage, then, a primary distinction must be made in terms of durability, so that the device selected will withstand the use to which it is put. In making this distinction, the type of mechanism as well as the materials employed in the manu-

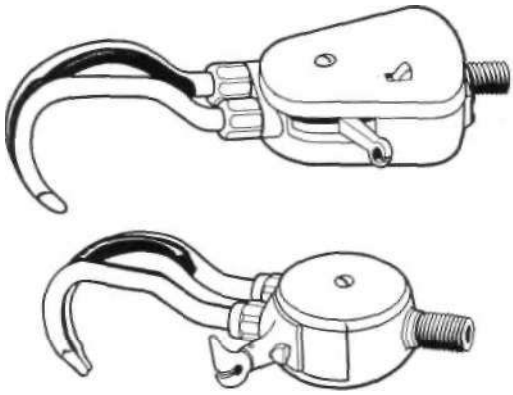


Fig. 3. The APRL voluntary-closing hook (above) and (below) the Norlhrop-Sierra voluntary-opening two-load hook. Both use rubber-lined, lyre-shaped hook lingers.

facture of the hooks are determining factors. Obviously, a hook having more complex mechanism and therefore more working parts (Fig. *4A)* will not stand up well under exposure to chemical action, extreme heat, or habitual use as a pounding or prying tool, whereas the simpler pincer type of design (Fig. *4B)* is relatively unharmed under any of these conditions. Once this major differentiation in terms of durability is established, a particular device can be prescribed with respect to the other features of the various devices available.

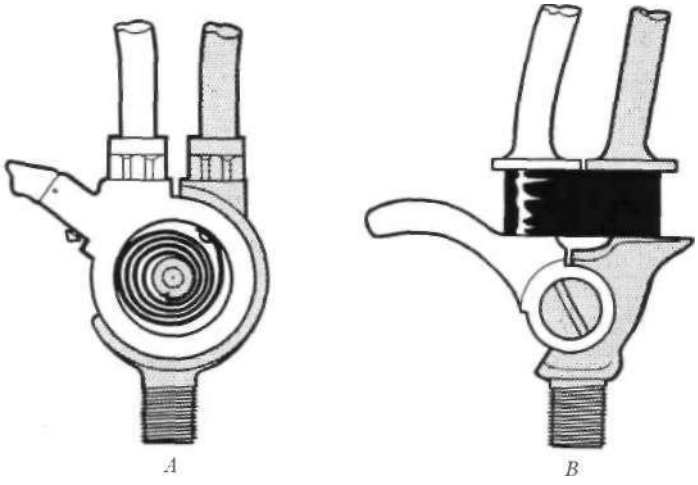


Fig. 4. Comparison of two types of voluntary-opening hooks. *A,* Northrop-Sierra two-load hook, with springs enclosed in housing; *B,* Dorrance hook, with exposed but easily replaceable rubber bands.

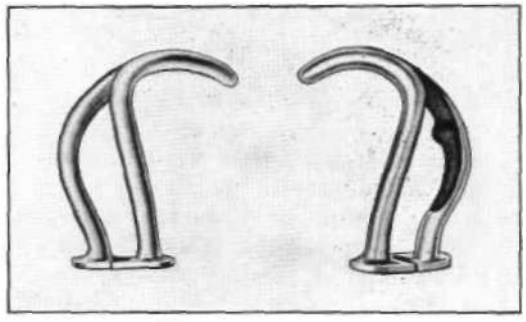


Fig. 5. Hook fingers of Dorrance design, with and without rubber linings.

RUBBER LININGS FOR HOOK FINGERS

Another feature which distinguishes between particular devices is whether or not they have rubber-lined hook fingers or metal contact surfaces, usually either ridged or corrugated (Fig. 5). Rubber linings were designed to provide improved frictional qualities. They do, in fact, afford a more secure grasp of such items as paper, glass, and other slick-surfaced objects. In addition, they permit grasp of some objects without danger of scratching or marring. Grasping abrasive or very hot objects, however, such as those a welder might handle, has a deleterious effect on the rubber. With the exception, then, of a few specialized occupations, the rubber linings are advantageous for the majority of amputees *(12).* It seems clear that consideration should be given to the development of a more durable material for finger lining so that its inherent advantages may be even more widely applicable.

SHAPE OF HOOK FINGERS

Finger shape is another general feature of terminal devices requiring consideration. Three kinds of hook lingers can be distinguished. They include the straight-approach, lyre-shaped fingers, such as those of the

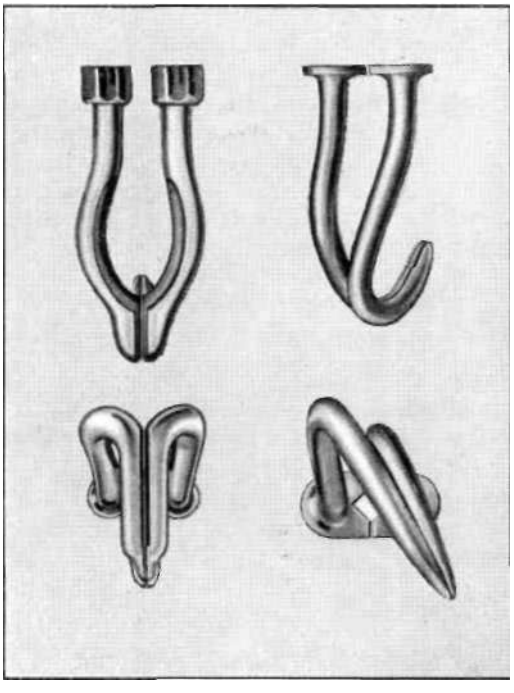
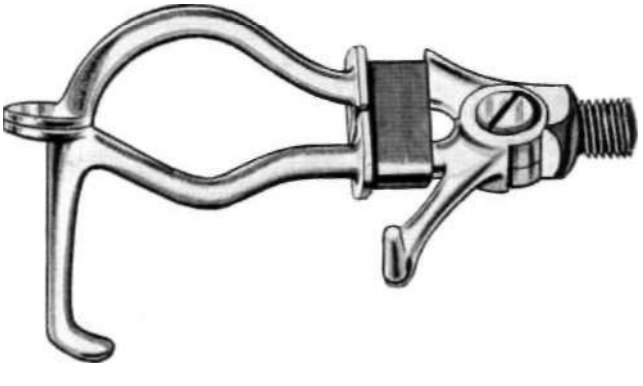


Fig. 6. Two views of straight-approach and of canted hook fingers. The straight fingers are exemplified in the APRL voluntary-closing hook and in the Northrop two-load voluntary-opening hook (5,6). The canted fingers are of Dorrance design

APRL hook (Fig. 3); the canted fingers, exemplified by the Dorrance No. 5 (Fig. 6), among others; and the specialized shapes, such as those found in the Trautman Locktite hook, for example, or in the Dorrance No. 3 (Fig. 7). Many amputees express a strong preference for either the lyre or the canted type. But these preferences are about equally divided between the two. Claims of advantages of one design over another appear to be based mostly on individual amputee experience. Present knowledge indicates that either type of finger can be used for most activities and that, in selecting a device, finger shape is not as important as are other factors.

With respect to specialized finger shapes, however, the situation is quite different. Knobs, projections, and finger geometry are designed so that these special hooks can be used with particular tools and for heavy manual labor. Farming and carpentry, for example, usually are considered to be occupations requiring such hooks as the Trautman or the Dorrance No. 3, No. 6, or No. 7. Although some amputees find these devices more satisfactory than others for individual needs, advantage in some particular function is achieved at the expense of ability to perform routine activities of daily living as effectively as with the other types of hooks. Hence, specialized designs should be prescribed only when vocational needs clearly warrant it.

Fig. 7. The Dorrance No. 3 hook, a voluntary-opening terminal device of highly specialized design sometimes used by farmers, laborers, mechanics, and others engaged in various kinds of manual work.



VOLUNTARY-OPENING OR VOLUNTARY-CLOSING

Voluntary-opening and voluntary-closing systems comprise the last major distinguishing feature of hooks. Voluntary-closing terminal devices offer finer control of the grasping functions because, at the discretion of the amputee, the finger pressure applied to an object may range from extremely light to quite heavy, firm grasps. Combined with the self-locking feature, graded prehension makes voluntary-closing terminal devices valuable for many activities. But the versatility of voluntary-closing devices is achieved at the cost of a more complicated system of operation. In contrast, most voluntary-opening devices, though comparatively simple to operate, cannot lock on an object and do not offer positive control of finger pressure (page 88).

Two points should be made regarding the voluntary-closing device. First, proper training is essential to effective utilization of the unique features offered. Second, amputees being fitted for the first time generally make excellent use of a voluntary-closing device because training is not complicated by habits acquired with a voluntary-opening device. Even considering the matter of durability, voluntary-closing devices, by virtue of their unique grasp features, are preferred to voluntary-opening models except where ingrained habit patterns and personal preferences contraindicate *(12)*. But the present voluntary-closing hook has several disadvantages also. They include higher cost, excessive backlash on locking, frequent malfunction, and the cosmetic factors of bulk and length. Continued development may, however, eliminate these negative features and thus enhance the inherent advantages.

AVOCATION AND DAILY LIVING

Avocational pursuits and the routine chores of daily living also need to be considered under the broad heading of environmental influences. With respect to avocations, the situation is somewhat analogous to that of occupational considerations, in that the range of activities covered is extremely wide. In his leisure time the amputee may read books, hunt or fish, do carpentry work or gardening, play golf or bowl, or sit and watch television. The considerations already discussed apply equally to the vocational and avocational life of the amputee. All of which highlights the danger of selecting a terminal device without considering all of the patient's activities. It may be that the amputee's job requires one device, whereas a different device might best suit his recreational activities. These requirements can sometimes be met by the use of more than one type of terminal device.

In contrast to the requirements of vocational and avocational pursuits, the routine of daily living involves certain activities common to all amputees—dressing, eating, personal hygiene, reading and writing, and so on—generally light tasks requiring no great strength or exertion. Cutting meat with a knife and fork, for example, buttoning and unbuttoning clothing, handling a telephone and billfold, tying a tie and shoelaces, and handling and lighting cigarettes are tasks requiring, instead of strength and exertion, sensitive manipulation and a secure grasp. Although many amputees use voluntary-opening devices effectively, any or all of these activities usually can be performed better with the more versatile voluntary-closing type, either hand or hook.

BIOMECHANICAL CONSIDERATIONS

SITE OF AMPUTATION

Some attempt has been made to use site of amputation as the criterion for deciding between voluntary-opening and voluntary-closing devices. It is argued that the voluntary-closing hook or hand requires more control motions for performance of a given activity and that the higher the site of amputation the greater is the effort involved in making a control motion, particularly when the site is considerably above the elbow. The conclusion is drawn that, since operation of voluntary-closing devices requires additional control motions on the part of above-elbow and shoulder-disarticulation amputees, such devices should be prescribed chiefly for below-elbow cases. Although generally the premise is true, the validity of the conclusion depends on the answers to two questions. The first concerns how much extra effort is involved in the additional control motions, and the second relates to how much more effort is required for a given control motion by an amputee with a short above-elbow stump. In a word, the problem revolves around the effort tolerance of the individual and around the importance to the amputee of any increments in control effort. Present evidence does not answer these questions, and the factor of site of amputation has been, up to now, of limited value as a guide to prescription of a terminal device.[5] Perhaps further study will lead to the development of

[5] The one exception is the wrist disarticulation or the very long below-elbow stump, where for cosmetic reasons the site of amputation limits the choice of terminal device. In these cases, the device selected must be short enough so that the length of the prosthetic arm approximates that of the sound arm.

criteria for terminal devices specially designed for use with specific levels of amputation.

STUMP STRENGTH

Where lack of strength in the stump cannot be remedied by therapeutic measures, the weight of the terminal device becomes a matter of serious concern. When, in such cases, a hook is the device of choice, the lighter aluminum hooks should be selected in preference to the heavier steel hooks *(7,18).* With regard to hands, it may be noted that, although the lightest functional hand now weighs more than any one of the hooks, a hand is not necessarily contraindicated, since it may be of the greatest psychological importance in individual cases. If, however, arm amputees are to be provided with the most suitable hand, a lighter model is clearly required.

Of additional concern is the fact that strength must be considered in relation to the length of the stump. If the stump is very short, its resistance to the moment produced by the weight of some terminal devices may be marginal or inadequate. In that case, the weight of the terminal device again may be an important consideration even if good muscular strength is present. Parenthetically it should be mentioned that the voluntary-closing hook often is not prescribed because the one model available is heavier than most other hooks. It appears that consideration should be given to providing voluntary-closing operation in more than one hook size.

RANGE OF MOTION

Considered alone, range of motion may have no bearing on the selection of the terminal device because the excursion required for operation is approximately of the same magnitude for any hook or hand. Furthermore, in the case of most terminal devices, a reduced range of control motion, whether of the humerus or of the scapulae, usually can be compensated for (provided sufficient force is available) by modifying the lever ratio of hook or hand.

SUMMARY

Because, then, so many factors influence the prescription of a terminal device, the one chosen usually represents a compromise based upon consideration of the psychological, environmental, and biomechanical circumstances. Among the major psychological considerations is the fact that selection and use of a terminal device is obviously related to the particular personality needs of the individual amputee. But determination of the precise pattern of this relationship requires further research. Since a prosthetic hand is the only means of providing amputees with a "cosmetically satisfactory" appearance, such devices will be preferred by the large majority of amputees, especially as further improvements are made in design.

The cosmetic aspects of hook design have received insufficient attention, especially with reference to color, texture, and finish. Further, the matter of terminology deserves consideration. Because of its negative connotations, the word "hook" probably ought to be dropped from the vocabulary of prosthetics.

As far as function is concerned, reliable, automatic performance of the terminal device is of first importance to amputees. In any case, wearers of upper-extremity prostheses must necessarily accept a compromise between appearance and function, for there is no such thing as "ideal" replacement. The extent to which amputees can effect this compromise determines the degree of their acceptance or rejection of the terminal device. Finally, the durability of terminal devices is dependent more upon the psychological attitudes and adjustment patterns of the amputee than upon his occupational and avocational pursuits.

As for the major environmental considerations, it may be said that the APRL hand, despite limitations imposed by cost and maintenance, is considered a useful device which approaches, and even surpasses in some ways, the utility of a hook. The artificial hand should therefore not be thought of solely as a cosmetic, nonutilitarian device. But at present hooks are still of major utility and importance. In choosing a hook, the manner in which it is to be used, as well as the possibility of exposure to heat or chemical action, are the determinants in the selection of either a rugged, steel device with no working mechanism or a lighter

aluminum one. When relatively careful use can be anticipated, so that durability is not a major factor, hooks with working mechanisms should be used because of their more diversified prehensile function.

Hook fingers with rubber linings are considered generally advantageous except when contact with objects prone to damage the rubber is anticipated. Consideration should therefore be given to improving the wear characteristics of finger linings. The distinction between canted fingers and straight-approach, lyre-shaped fingers is not especially important, since many amputees are proficient with both types. But finger shapes of odd or unconventional design should be selected with great care, since they are highly specialized and are not considered applicable to a variety of vocational, avocational, and daily-living activities. Although there are definite disadvantages in the present voluntary-closing hook, and consequent limitations to its prescription, this type of operation offers the amputee more versatile prehensile function than does any other hook. Accordingly, efforts should be directed toward providing voluntary-closing operation in several styles of hooks and toward eliminating troublesome maintenance problems with this type of mechanism.

Among the major biomechanical considerations are stump length and strength. Short or weak stumps usually require prescription of lightweight, aluminum hooks and hands. The importance of the weight factor indicates the desirability of developing lighter terminal devices, with particular reference to the functional hand. While biomechanical considerations play a major role in prescription of other prosthetic components, they appear to have no further influence on choice of terminal device.

In conclusion, it should be noted that the major factor restricting the search for knowledge and understanding of the principles involved in prescription and use of terminal devices is the limited number of independent design features that are built into any one terminal device. Since each variation in design is not available independently, neither freedom of prescription nor a complete analysis of the relative value of each feature is possible. Until this problem is resolved, systematic studies of the relationships between various terminal devices and the needs of individual amputees are seriously limited.

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