Studies of the Upper-Extremity Amputee

III. The Treatment Process

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THE amputees who took part in the NYU Upper-Extremity Field Studies obtained their new prostheses through a treatment process characterized by seven clear-cut steps. These were preprescription examination, prescription, preprosthetic therapy (if indicated), fabrication of the prosthesis, initial checkout, training, and final checkout.

The preprescription examination was conducted at the beginning of the treatment process in order to obtain information that would be useful in formulating the prescription and planning the entire treatment program for the patient.

As for prescription, the research and educational program strongly encouraged the clinic-team approach, wherein the physician, as clinic chief, involved the prosthetist, the therapist, the patient, and frequently other individuals, such as the social worker or the vocational counselor, in the prescription process. The resulting prescription not only covered the strictly medicosurgical aspects of management but also specified the type of prosthesis and components that were to be used and the training the patient was to receive.

The preprosthetic phase of treatment, when indicated, was directed toward providing the patient with the necessary strength and range of motion to operate his prosthesis and toward conditioning his stump for wearing it.

In the fabrication process, the prosthetist, working with the patient, carried out the construction and fitting of the prosthesis in accordance with the specifications of the prescription.

Initial checkout, which was done on a team basis, consisted of a systematic inspection and evaluation of the prosthesis to ensure that accepted standards of construction and function were achieved. This step was accomplished before the amputee received training and before he was permitted to wear his prosthesis for any extended period.

Training consisted essentially of two parts —controls training and use training. The purpose of controls training was to develop the ability to open and close the terminal device, control prehension force, operate the wrist unit, interchange terminal devices, and, in the above-elbow cases, flex the prosthetic elbow and operate the elbow lock. Use training was designed to develop the ability to utilize the prosthesis in practical tasks related to daily-living activities and to occupational requirements.

Final checkout was performed after the completion of training or after an initial period of wear. It paralleled initial checkout in that many biomechanical evaluation procedures were repeated to determine if wear had given rise to any difficulties or deficiencies. But in addition to the evaluation of the prosthesis itself final checkout also included an evaluation of training and of the amputee's ability to use the prosthesis at a practical level.

This paper is primarily an account of the experiences and opinions pertaining to the treatment process as obtained from interviews with 359 adult, male amputees both at the beginning and at the end of their participation

in the studies. The information concerning checkout and training is supplemented by clinical data from records of an additional 410 amputees who participated in clinical aspects of the study.

The general characteristics of the research group of 359 amputees closely parallel those of the 1630 amputees in the survey group (Section II). Between the two groups there were no significant differences with respect to age, height, weight, marital status, cause of amputation, or strength and range of motion on the side of the amputation, although there were slight differences in educational level, in experience with arm prostheses, and in the relative frequency of below- and above-elbow types. These data are presented in Appendix I (page 85).

In interpreting the data in this section, certain considerations should be kept in mind. First of all, a considerable portion of the information is based on the amputees' recollections of past events. The differences that may exist between the recollection of events and the events as they actually happened constitute a possible source of error. A second consideration has to do with the amputees' interpretations of the questions asked during the interviews, especially at the beginning of the study. Terms such as "clinic," "prescription," "checkout," "physical therapy," and "training" may have had widely varying meanings for different subjects. For example, a subject might have said that the prosthesis he was wearing at the beginning of the study had been subjected to a checkout when in reality it had been given only a cursory inspection instead of the systematic examination and evaluation that constituted a "checkout" in our meaning of the term.

A third factor has to do with the number of amputees who were able to give meaningful responses to these questions. In some instances and for various reasons usable responses were not obtained from the entire group. In some cases questions were not answered. In most instances, however, classifiable responses were obtained from at least 80 percent of the group, and it seems reasonable that these responses are representative of the attitudes of the entire group.

On the positive side, there is good reason to assign a considerable degree of importance to the opinions and reactions expressed by the subjects, since, in the last analysis, the amputee is the final judge of his prosthesis. The extent to which he accepts and approves of the process through which he obtains his prosthesis may have considerable bearing on the extent to which he accepts and uses the device.

PRESCRIPTION

Prior to their participation in the research studies, only 17 percent of the amputees had ever received an arm that was prescribed by a clinic team (physician, limbfitter, and therapist). In the great majority of cases, decisions as to the type of limb and components had been made either on an individual basis by the limbfitter or the amputee or jointly by both limbfitter and amputee. Fifty-six percent of the amputees approved of this procedure, the most frequent reason (21 percent) given for approval being that they were consulted concerning their choice.

In the group (44 percent) that did not approve of the preprogram procedure through which they had received a limb, 14 percent reacted negatively to the fact that they were not consulted. It was somewhat surprising to find that an additional 18 percent expressed the opinion that the amputee should *not* be consulted. Of the total group, 12 percent felt that the doctor should prescribe the prosthesis. Apparently a significant number of amputees prefer to trust the judgment of others in the matter of prosthetic replacement. Others (and the number probably increases with their prosthetic experience) prefer to become personally involved in the selection of components best suited to their needs.

Since all of the prescriptions for the new prostheses and related treatments were arrived at on a clinic-team basis, the amputees were asked the following question to obtain their reactions to the team method of prescription: *Do you think that prescription of a new arm by a clinic consisting of a doctor, limbfitter, and therapist is a good procedure?* Ninety-four percent of the amputees answered in the affirmative. Compared to the mixed reactions concerning the preprogram procedures, the

figure of 94 percent clearly indicates that the amputees preferred the new procedure. By far the most frequent reason given for this response was that the combined experience which could be obtained through the clinic procedure was useful. Typical comments were:

". . . more heads are better than one."
". . . experience of several people is helpful."
". . . no aspect is overlooked."

Other reasons that were mentioned relatively frequently can be classified under these headings:

". . . prevents errors."
". . . team members act as a check on each other."
". . . amputee becomes involved in the prescription."

Among the 6 percent who did not approve of the procedure, the most common reason offered was that:

"An old wearer knows what he needs."

To obtain information on the parts the various clinic members played in prescription, the amputees were asked: *Who was most influential in deciding the kind of arm you should havef* The replies are summarized in the accompanying chart.

TERMINAL DEVICES

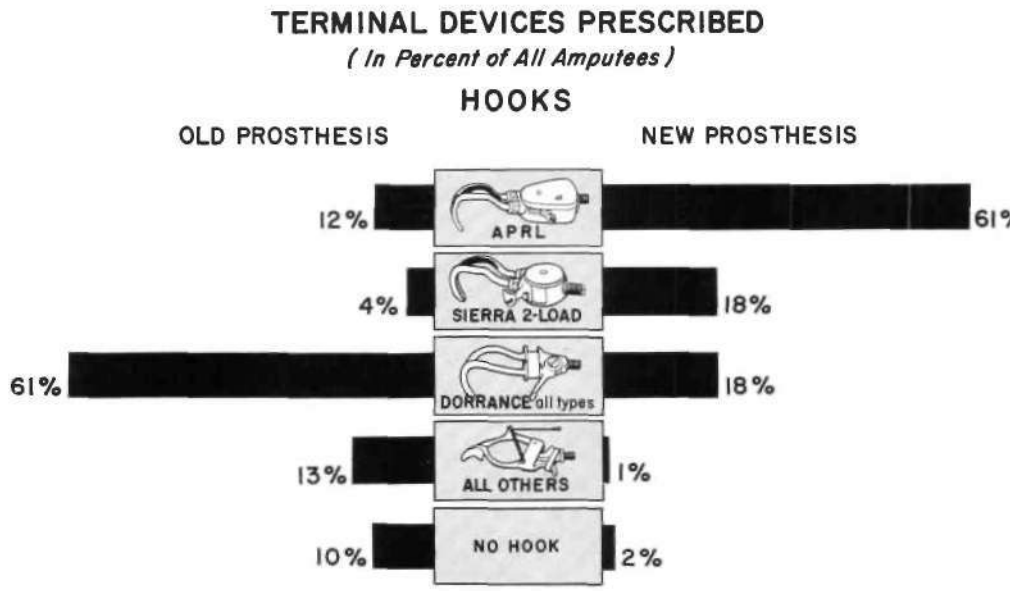
The next two charts show the relative frequency with which the various types of terminal devices were prescribed in the research study. For purposes of comparison, data on the hands and hooks that were being worn at the beginning of the study are included under the heading "Old Prosthesis."

In interpreting the prescription data on hands and hooks, consideration should be given to the fact that it was a policy of the research program to encourage the prescription of APRL hands and hooks in order to obtain additional data for evaluation of these devices. This accounts for part, but by no means all, of the changes in terminal components of the old and the new prostheses. Other factors involved in the changes were related to an increasing tendency on the part of clinic groups to prescribe aluminum hooks and hooks with rubber or neoprene facings and to a natural interest in the possibilities of voluntary-closing terminal devices with their wide range of grasp forces. In the case of the APRL hand, the wide range of grasp forces was combined with improved appearance. This natural curiosity and interest in new devices is reflected in the increased use of the Sierra two-load hook also.

WRIST UNITS

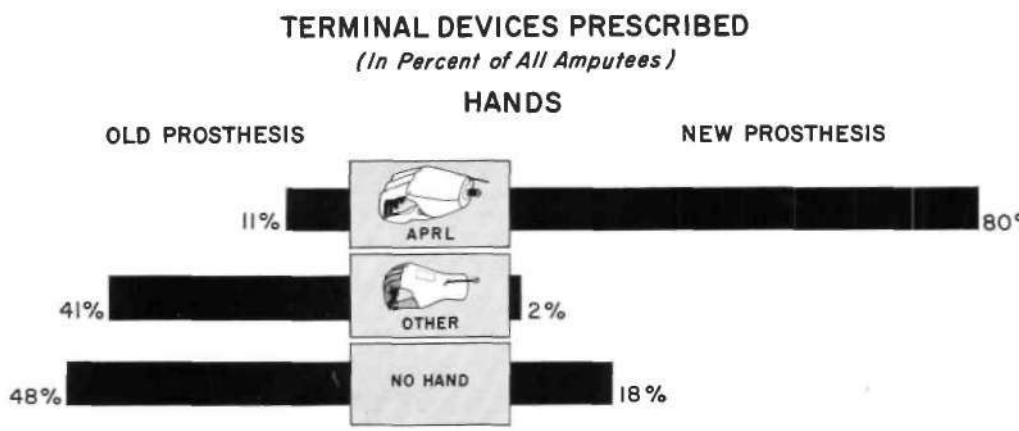
The new prostheses showed a marked increase in the prescription of positive-locking wrist units with the "quick-change" disconnect. The chief reasons for this increase related to:

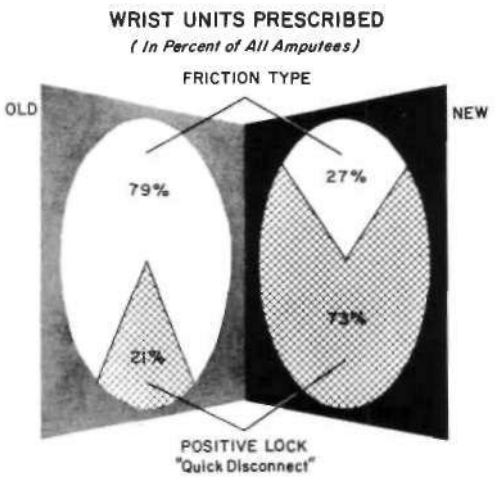
1. Specific vocational or avocational indications for a positive lock to control rotation.
2. Prescription of both hand and hook for approximately four out of five subjects. A substantial majority of these cases required a wrist unit with a "quick-change" feature to facilitate interchange of hand and hook.



WRIST-FLEXION UNITS

There were only two wrist-flexion units on the old prostheses. Both cases were bilateral amputees. Twenty-two wrist-flexion units were prescribed in the research group. Ten were for bilateral amputees; six were for above-elbow, four for shoulder-disarticulation, and two for below-elbow amputees.





BELOW-ELBOW HINGES

A marked increase in the number of flexible hinges prescribed reflects the increased awareness of the value of utilizing residual rotation of the forearm stump whenever possible so that the need for pre-positioning the terminal device with the sound hand can be reduced or eliminated entirely. An additional advantage of flexible hinges is that they are less likely to damage the sleeves of the wearer's clothes.

BELOW-ELBOW CUFFS

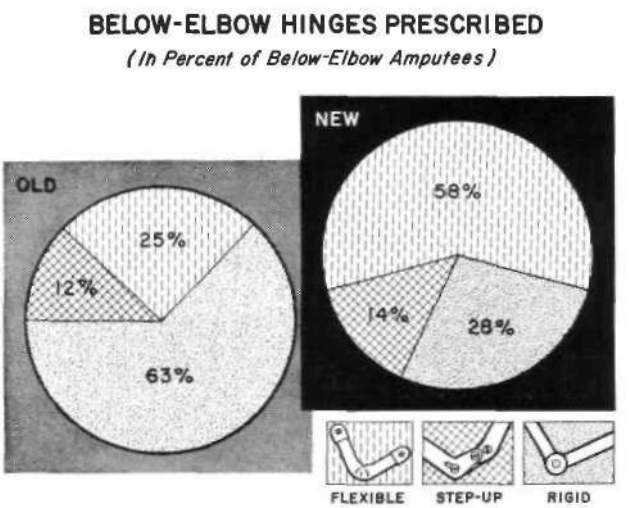
Prescription for below-elbow cuffs showed a marked change toward smaller cuffs and elimination of straps. This change is a result of increased recognition of the desirability of providing a cuff large enough to give adequate stability and suspension but which would also have minimum bulk, would restrict motion as little as possible, and would give greater comfort.

ELBOW UNITS

A guiding principle in the prescription of prosthetic elbow units for above-elbow and shoulder-disarticulation prostheses was that locking should be accomplished independently by controls attached to the harness, without recourse to operation of controls by the sound hand. The extent to which this principle was applied can be seen from the data, which show that all elbow units prescribed were harness-operated. This is a highly significant change from the data relating to the old prosthesis, which show that only 46 percent of the old elbow units were harness-operated.

SOCKETS

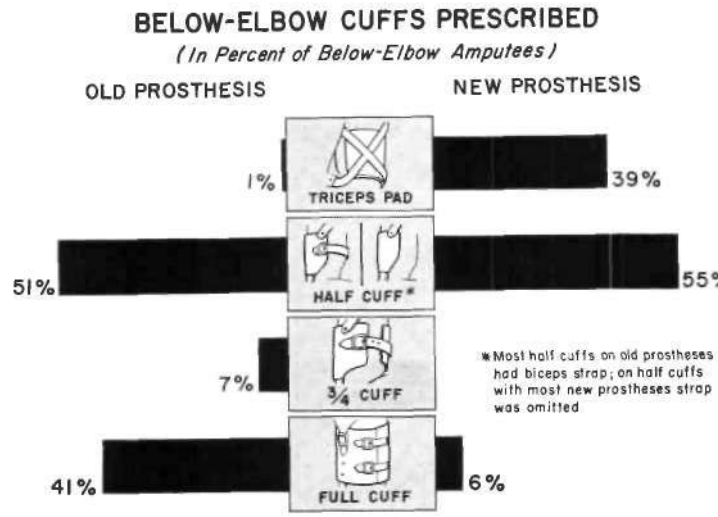
Practically all of the prescriptions for the new prostheses specified plastic laminate as the material to be used in fabricating the socket. The data on the socket material used in the old prostheses show that 37 percent were made of plastic, 28 percent were made of leather with a steel frame, and the remainder were made of fiber and metal, wood, or leather. Approximately four out of five of the new prostheses had double-wall sockets, as compared to less than one out of five of the old prostheses. Twelve percent of the old and 14 percent of the new below-elbow sockets were



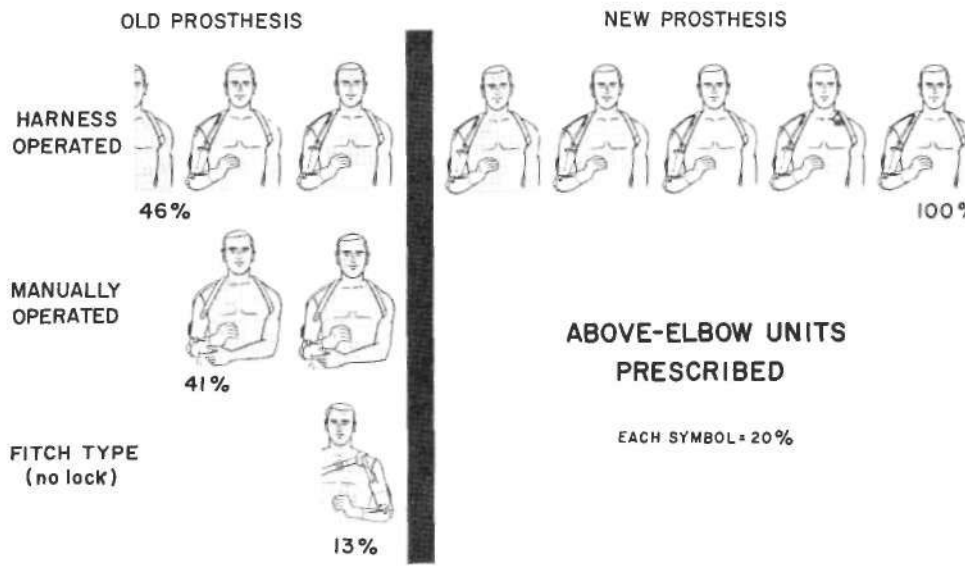
of the split-socket, step-up type in both the old and the new prostheses.

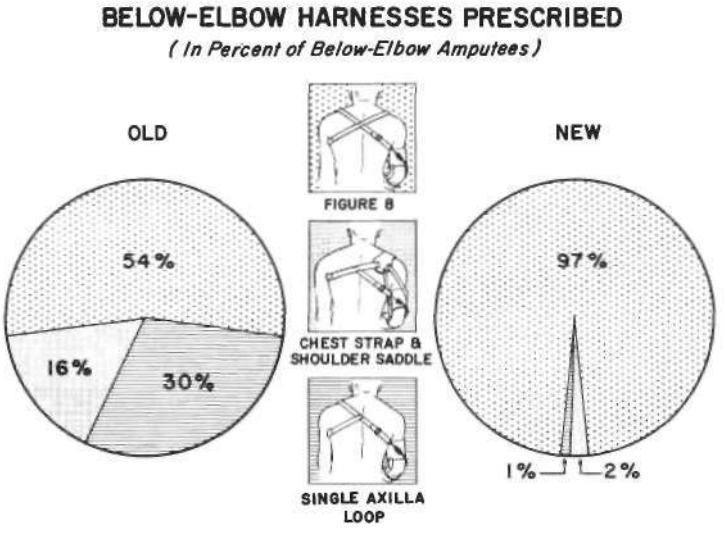
HARNESSES

The data on harnesses show a highly significant increase in the number of figure-eight harnesses prescribed for below-elbow and above-elbow cases with the new prostheses as compared with the old. The reasons for this increase are related to the favorable attitude of the program toward this simple type of harnessing, except for cases wherein heavy lifting was expected. Practically all of the shoulder-disarticulation amputees had chest-strap harnesses on both the old and the new prostheses.



Vinyon tape was specified in 96 percent of the prescriptions for new prostheses, and cotton webbing or nylon or dacron tape were prescribed in the remaining 4 percent.

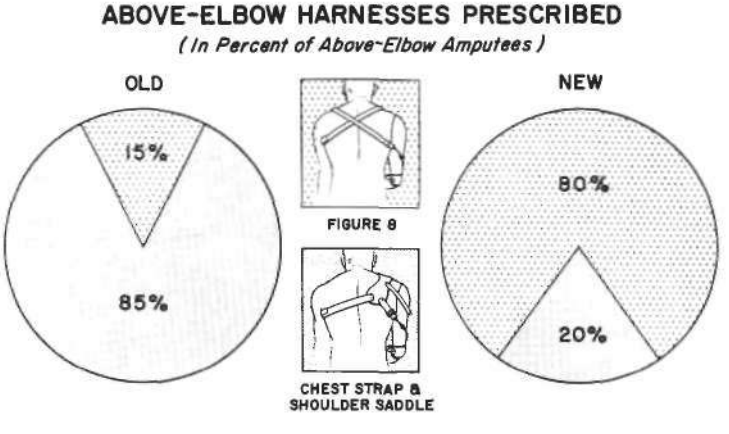




In the old prostheses, 83 percent of the harnesses were made of cotton webbing, 8 percent were of leather, and the remaining 9 percent were made of vinyon or nylon tape. The marked shift to the use of vinyon tape was due primarily to the presumably superior characteristics attributed to vinyon with respect to dimensional stability, washability, fraying, and resistance to bacteria and fungi.

CONTROL SYSTEMS

All of the prescriptions for new prostheses called for the use of the Bowden cable in the control system. In the old prostheses, 58 percent utilized Bowden cable; the remainder utilized nylon cord, leather, or steel cable without a housing. The change to Bowden cable was effected to take advantage of its higher efficiency in transmitting forces.



PREPROSTHETIC THERAPY

Four out of ten subjects said they had received treatment by some form of exercise or other physical therapy prior to their entrance into the study. The same proportion of the group indicated that their stumps had been bandaged to bring about shrinkage.

In response to the question, *Do you think these* [preprosthetic] *treatments were helpful?,* 79 percent replied in the affirmative and offered the following reasons (in order of decreasing frequency): increased strength, increased range of motion, helped stump shrinkage, reduced pain, improved function, reduced flabbiness.

During the course of the research studies, preprosthetic exercise or other physical therapy was prescribed for 13 percent of the amputees treated. That only a relatively small proportion of the subjects received preprosthetic

treatment is accounted for by the fact that most of the amputations occurred quite some time before the amputees participated in the program. In most cases, treatment consisted primarily of exercise to increase strength and range of motion of the stump. Other physical-therapy measures, such as diathermy, massage, and hydrotherapy, accounted for a relatively small proportion of treatments. Almost all of the subjects indicated that treatment was received daily.

Seven percent of the amputees had their stumps bandaged to cause shrinkage. About two thirds of this small group indicated that bandaging had been continued over a period of 4 to 12 weeks; the remainder of the group said that bandaging had been continued for more than 12 weeks.

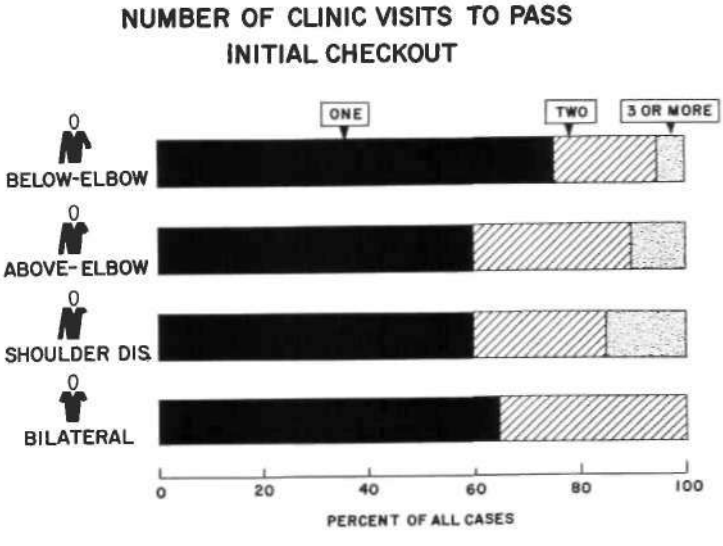
Of those who did receive preprosthetic treatment, 88 percent considered the treatments helpful. The reason given most frequently was that the treatments increased strength and range of motion. About one out of five subjects mentioned stump shrinkage as the chief beneficial effect.

INITIAL CHECKOUT

With reference to arms worn prior to entrance into the program, the subjects were asked: *Was your arm checked for fit, comfort, and function before it was delivered to youf* Four out of five indicated that their prostheses had been subjected to some form of initial checkout or evaluation, even though this was not done on a formal basis. One third of this group said that the limbfitter had made the check. Thirteen percent designated the physician as having made the check, and 9 percent said the check was made at the hospital. The others did not provide specific information as to who performed the checkout or evaluation.

A basic principle guiding operations in the Field Studies was that the amputee would not be permitted to wear his new prosthesis or proceed to training until initial checkout had been passed successfully. If deficiencies were encountered that would interfere with wear or training, recommendations for correction were made, and the amputee was scheduled to appear again so that initial checkout could be completed.

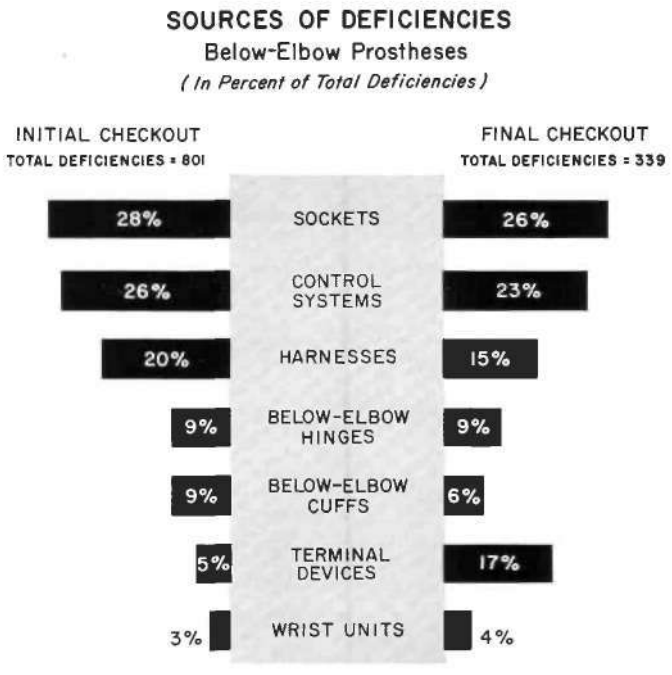
Several factors serve to explain why a relatively large proportion of amputees had to appear before the clinic two or more times in order to pass initial checkout. One is that the checkout procedure proved to be highly effective in directing attention to the necessary corrections and adjustments in individual components and to the prosthesis as a whole. A second related to the relatively high and rigid standards established by the checkout procedure. A period of time was generally required before the prosthetic experience necessary to meet these standards was gained.



The relatively greater frequency with which above-elbow and shoulder-disarticulation amputees failed to pass initial checkout on the first appearance, as compared to below-elbow amputees, was for the most part due

to difficulties in harnessing. In addition, the relatively small number of shoulder disarticulations seen meant that it took correspondingly longer to obtain substantial experience in their fitting and harnessing.

While a majority of prostheses passed initial checkout on the first presentation, this does not mean that no deficiencies were found at initial checkout in these cases. More often than not, a number of minor deficiencies were found, which resulted in a "provisional pass" rather than a "pass." When a provisional pass was given, recommendations were made for correction of the minor deficiencies found. When the amputee reported for his first training period, a check was made to see that the recommended changes had been effected.



Among the below-elbow subjects, the most frequent deficiencies found at initial checkout were in connection with sockets. With above-elbow amputees, the deficiencies found most frequently were in connection with harnessing. The fewest deficiencies were encountered with wrist units. The charts show the order in which the various components ranked according to the number of deficiencies found.

The amputees taking part in the study were asked: *Do you think it was worth while that the new arm was checked for fit, comfort, and function before it was delivered to you?* Ninety-four percent of the replies were *yes.* The most common reasons given for these replies were:

". . . to correct and prevent problems."
". . . provides a check on fit."
" . . provides a check on comfort."
". . provides a check on prescription."

Some of the comments of those few who did not think it was a good procedure were:

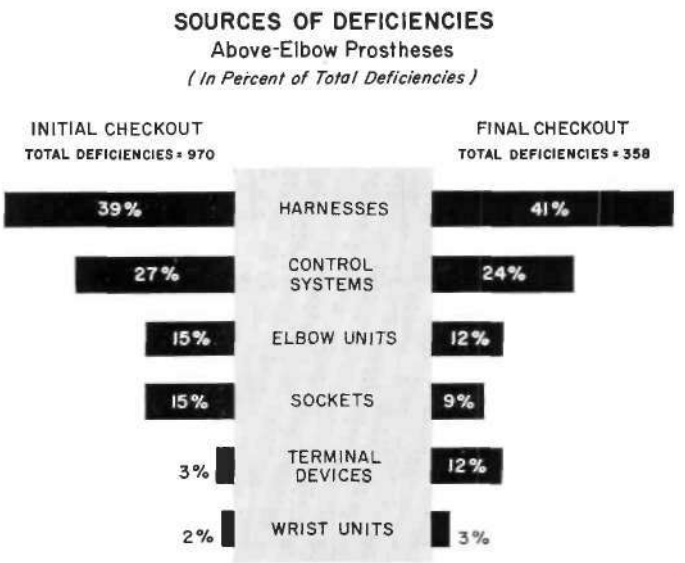
" . . made no necessary changes to arm."
". . . am intelligent enough to decide for myself if it is comfortable."
". . . could be checked out at limbshop."
" . . had to wear it first to see if anything was wrong."

TRAINING

The data pertaining to previous training showed that 42 percent of the amputees had received prosthetic training sometime prior to the beginning of the study. Eighty-nine percent of this group expressed the opinion that this training was helpful. Three fourths of the amputees who received no previous training said they thought training would have been helpful, while the remaining fourth thought it would have been of no use.

Data obtained from the clinical studies showed that 81 percent of the subjects received

training, that 14 percent received no training, and that owing to incomplete records the training status was indefinite for the remaining 5 percent. Among the amputees who received no training, the most common reasons offered were: the amputee had worn a prosthesis before and previous training was considered adequate; the amputee passed the prosthetic-use test without training; the amputee declined training.



In response to a query concerning the value of prosthetic training, four out of five amputees replied in the affirmative. Among the most frequent reasons given for the affirmative answer were:

"... training gives an idea of what can be done with the prosthesis."
". . . learned mechanical operation of components."
". , . expedited use of arm."

Of the group who did not believe that training was valuable, there were proportionately twice as many below-elbow as above-elbow amputees. They offered such comments as:

". . . using an arm is easy."
". . training was not well organized."
"... I would rather learn my own way."
"... amputee was left on his own too much."
". . . training helped very little."
". . training was not long enough "

In response to the question, *Do you believe the training you were given in the use of your new prosthesis could be improved?*, 41 percent answered in the affirmative. About one fourth of those who answered in the affirmative expressed the opinion that there should be more training in activities of daily living. An equal number thought that more time was needed. Among the group that expressed the opinion that more time was needed there were more than three times as many above-elbow amputees as there were below-elbow amputees.

Other suggestions for improvement of training were:

". . . there should be more enforced training."
". . . provide a training manual which would allow the amputee to practice at home."
". . . adapt training to occupational needs."
". . . there is not enough supervision of training."

The total training time for an individual amputee ranged from half an hour to 99 hours, but more than nine out of every ten amputees received less than 20 hours of training. Except for bilateral amputees, more than eight out of every ten amputees received 10 hours or less of training. The average number of hours of training for each amputee type is based on the great majority of amputees (94 percent) who required less than 20 hours of training. Of the small remaining group of amputees (6 percent), one half received from 21 to 30 hours of training; the other half received from 30 to 99 hours. It must, however, be emphasized again that the larger part of this group had had previous prosthetic experience.

The average length of individual training sessions for the amputees in the clinical studies was one hour and forty minutes. There was no significant difference in the figures for below-elbow, above-elbow, shoulder-disarticulation, and bilateral amputees. For almost 50 percent of the amputees, the length of the individual sessions was one hour.

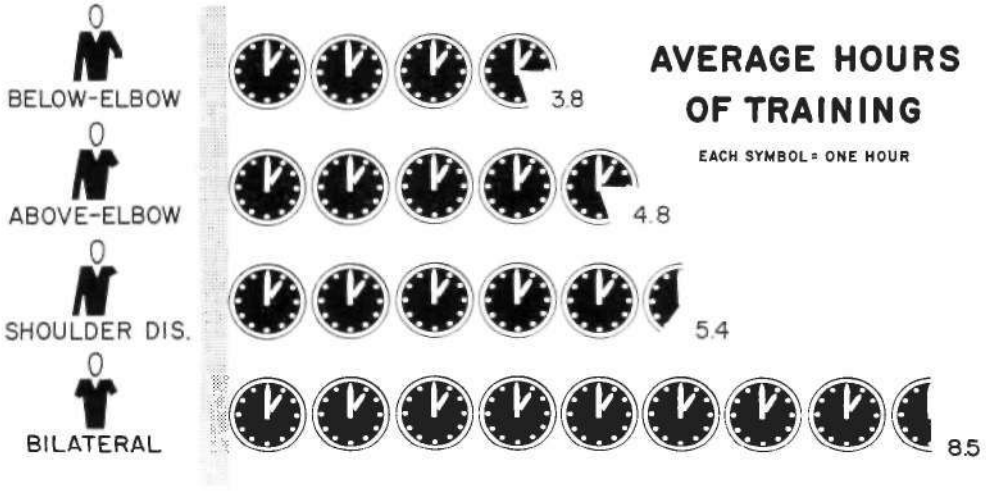
In reply to the question, *Did any difficulties arise in connection with the operation or comfort of your new prosthesis during training or the initial period of use?,* 54 percent of the amputees replied in the affirmative. Among the below-elbow subjects, the socket was the most frequent source of difficulties relating to fit and comfort, while among the above-elbow group the harness constituted the major source of trouble. With respect to function, operation of terminal devices and the control system were the most troublesome. The control system was the most common source of difficulty with respect to maintenance.

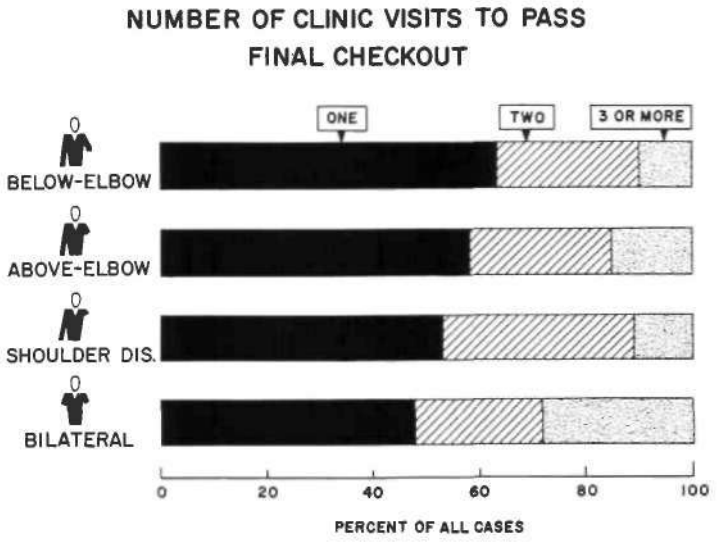
FINAL CHECKOUT

Prior to participation in the Field Studies, less than 30 percent of the amputees had had their prostheses rechecked for fit, comfort, and function after the period of initial wear or training. In accordance with the procedures described in Section I, *all* prostheses in the Field Studies were subjected to final checkout after the completion of training or the initial period of wear. At this time not only was the prosthesis given a systematic and thorough inspection and evaluation but, in addition, an appraisal was made of the patient's ability to use the prosthesis, and a careful examination was made to see if there were any medical or surgical problems that might interfere with successful wear and use. Clinics considered that an amputee had "passed" final checkout only when there were no further surgical, medical, or prosthetic problems of any kind that required attention.

Sixty percent of the prostheses passed final checkout on first presentation, 26 percent passed on second presentation, and 14 percent required more than two appearances to pass final checkout. This compares with 69 percent, 24 percent, and 7 percent, respectively, for initial checkout.

The decrease in the number of prostheses that passed final checkout on first presentation, as compared with initial checkout, was due chiefly to the results of wear of the prosthesis, the emphasis on the amputee's ability to use the prosthesis, the apparent need for additional training, and the need for modifications which





had been overlooked at the initial checkout or on which judgment had been withheld until the effect of wear could be determined. The actual number of deficiencies found at final checkout was, however, smaller by far than the number at initial checkout. Among the below-elbow amputees, the total number of deficiencies recorded at final checkout was only 339 as compared with 801 at initial checkout. The corresponding figures for above-elbow amputees were 358 at final checkout and 970 at initial checkout. These figures show clearly that the prostheses were far better at final checkout than they were at initial checkout, even though it took a little longer to get through the checkout procedure.

As was the case at initial checkout, the difficulties found most frequently at final checkout were related to socket fit for the below-elbow amputee and to harnessing for the above-elbow amputee. The fewest difficulties were encountered in relation to wrist units. The order in which various components ranked according to the number of deficiencies found is to be seen in the combined data for initial and final checkout.

The effects of wear and use were to be seen in the continued difficulties with fit and comfort of the below-elbow socket at final checkout and also in the relative increase in deficiencies encountered with terminal devices. The more common deficiencies in the latter case were related to malfunctions of hand or hook, staining of or damage to the cosmetic glove, and excessive backlash with voluntary-closing devices.

At both checkouts, deficiencies of the elbow unit rank fairly high on the list. Analysis indicates, however, that most of these difficulties were not with the internal mechanism but rather with other factors such as adjustment of the harness and control attachments that activate the elbow lock.

In response to the question, *Do you think it was worth while that your arm was rechecked for fit, comfort, and function after training and initial period of wear?,* 90 percent of the replies were in the affirmative. The most frequent reason for this reply was that the recheck permitted problems to be corrected. Typical comments were:

". . . gives an opportunity to correct problems after wear."

". . . experts can see difficulties better."

". . . it is important to find out if arm still functions properly."

"... it provides a general check."

SUMMARY

The amputees' experience in the field-studies program differed quite markedly from their previous prosthetic experience with respect to prescription and final checkout. Prior to their participation in the study, less than one out of five had ever had a prosthesis that was prescribed by a clinic team, and less than one third had had their previous prostheses subjected to a final comprehensive checkout.

The differences with respect to preprosthetic treatment, initial checkout, and training were less marked. Relatively fewer amputees received preprosthetic treatment in connection with the new prostheses than was the case in connection with the prostheses that were being worn at the beginning of the study. This, of course, can be accounted for by the lessened need for these services with increased prosthetic wear.

Although a substantial majority of the amputees said that their previous prostheses had been subjected to some form of initial checkout or evaluation, these had not been done on any formal or systematic basis and had in general not involved the application of standards of acceptance.

Forty-two percent of the amputees who had worn a prosthesis *prior* to the beginning of the study had received training in its use, although the nature or extent of this training is not clear from the data. More than eight out of ten subjects received training with the prostheses obtained in the research program.

Amputee opinion pertaining to the treatment process, as indicated by the data gathered, was for the most part strongly in favor of the new procedures. Ninety-four percent of the amputees approved of the team method of prescription. Eighty-eight percent of those who received preprosthetic treatment said the treatments were helpful. Ninety-four percent were of the opinion that initial checkout was worth while.

Four out of five amputees were of the opinion that the training they received in the use of their prostheses was valuable. But 41 percent of the group thought that training could be improved. The most frequent suggestions for improvement were to increase the amount of training time and the amount of training in meaningful activities of daily living.

The final checkout to which all of the prostheses in the research studies were subjected was particularly comprehensive and designed to uncover any medicosurgical, prosthetic, training, or other factors that might interfere with successful wear and use. Nine out of ten amputees were of the opinion that this procedure was worth while.

All in all, the treatment process inaugurated as part of the studies was considered valuable and achieved a high degree of amputee acceptance.