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The Munster-Type Below-Elbow Socket, an Evaluation

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SHORT stumps have always presented fitting problems in both upper- and lower-extremity amputation sites for the obvious reasons of small attachment area and a lack of useful range of motion. In an attempt to alleviate these problems for upper-extremity amputees, Drs. O. Hepp and G. G. Kuhn *(1)* of Minister, Germany, developed fitting techniques for the below-elbow and the above-elbow amputee, respectively, that provide a more intimate encapsulation of short stumps.

For the below-elbow amputee, the general characteristics of this technique (Fig. 1) are:

1. The elbow is set in a preflexed position (average 35 deg.). Because of the reduced range of useful motion, the socket is flexed so as to position the terminal device in the most generally useful area.
2. A channel is provided at the antecubital space for the biceps tendon to avoid interference between socket and biceps tendon during flexion.
3. The posterior aspect of the socket is fitted high around the olecranon, taking advantage of this bony prominence to provide attachment and stability to the socket.

For the above-elbow amputee, the characteristics of the technique are:

1. The socket is fitted high on the acromian, utilizing this bony structure to retain the socket in position and provide stability.
2. The axillary section of the socket conforms closely around the tendons of the pectoralis major and latissimus dorsi muscles to enable the patient to exert the force of these major muscles in moving his prosthesis.

In an earlier study (4), amputee clinics reported a favorable experience in fitting preflexed arms (that is, arms bent to provide a certain amount of preflexion) to children with short and very short below-elbow stumps. Since the Hepp-Kuhn technique seemed to represent an improvement in fittings of the preflexed type, New York University initiated a preliminary investigation of the procedure for adult amputees of this type. This study took place in the early part of 1961 and was limited to two short-below-elbow subjects. This exploratory study yielded generally positive outcomes in terms of function and comfort. One short-above-elbow amputee was also fitted with encouraging results.

The present evaluation is an extension of the initial study with major emphasis given to below-elbow fittings. Concurrently, further exploration of the above-elbow fitting technique was undertaken and is continuing, although not reported in this article.

For lack of a better term, the fitting procedures employed in this study are referred to as the "Munster-type" techniques. It should be emphasized that no claim is made that the techniques are identical to those followed by Drs. Hepp and Kuhn. New York University

[1] Based upon *The 'Müensler" Type Fabrication Technique for Below-Elbow Prostheses,* published by Adult Prosthetic Studies, Research Division, School of Engineering and Science, New York University, New York, N.Y., in June 1964 *(3).* The study reported was conducted under the auspices of the Subcommittee on Evaluation of the Committee on Prosthetics Research and Development, National Academy of Sciences—National Research Council, 2101 Constitution Ave., N.W., Washington, D.C. 20418. The research was sponsored by the Vocational Rehabilitation Administration, Department of Health, Education, and Welfare.

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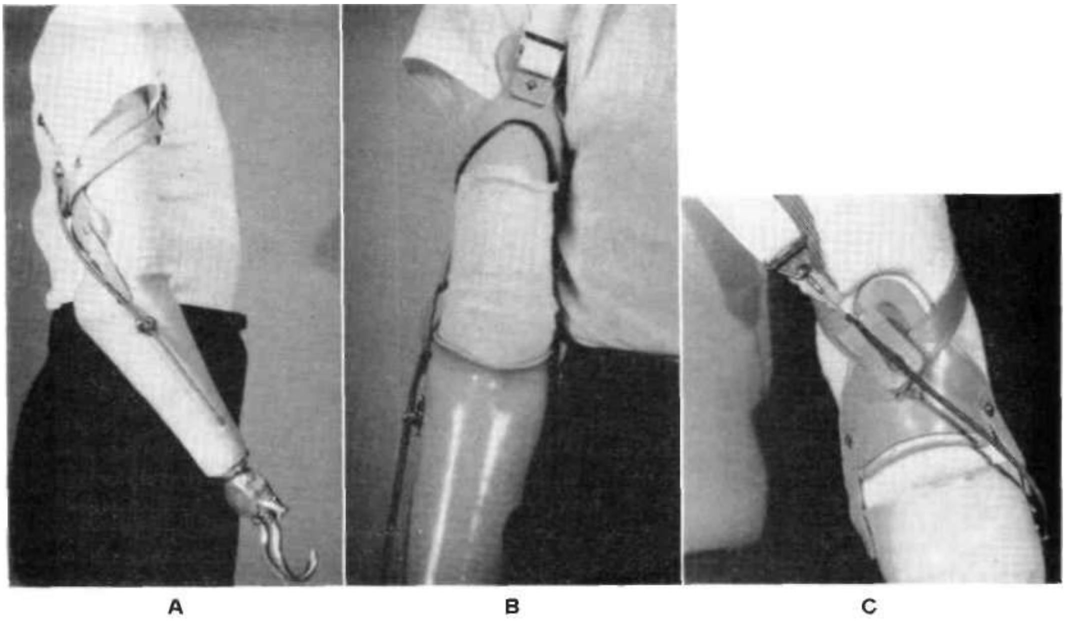


Fig. 1. Miinster-type fitting for below-elbow amputee A, Lateral view indicating the preflexion angle; B, anterior view indicating high trim line; C, posterior view indicating high olecranon fit and the small triceps pad,

personnel witnessed a demonstration of the techniques given by Dr. Kuhn in 1960 and had available the cited reference. However, none of the New York University fittings were either directly or indirectly supervised or checked by the developers.

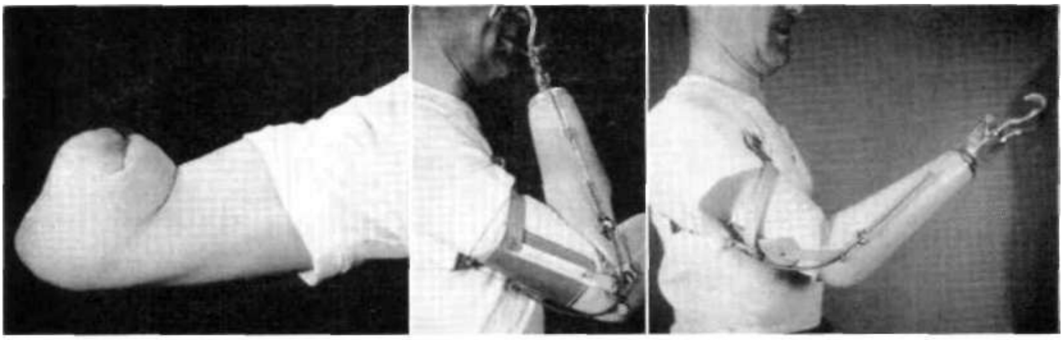
Both logic and prior experience suggest that the greatest benefit from the Miinster-type below-elbow fitting technique may accrue to subjects with short and very short below-elbow amputations in that the step-up hinges and split sockets characteristic of typical United States fittings for these categories could be eliminated. Historically, step-up hinges have lacked durability. Moreover, a price is paid for the step-up characteristic by a corresponding decrease in lifting power. Contrariwise, it is apparent that the range of elbow flexion is reduced by the Miinster-type fitting. This reduction may or may not be significant in terms of amputee function (Fig. 2).

THE SAMPLE

The sample in this study consisted of eight adult below-elbow amputee subjects (including one bilateral amputee) whose stumps were relatively short—from 3-1/4 in. to 5-1/2 in. measured from the medial epicondyle to the end of the stump. The physical characteristics of the sample and a description of their previously worn prostheses are given in Tables 1 and 2.

METHODOLOGY

The Miinster-type techniques for fitting below-elbow prostheses, as understood by New York University personnel, were followed in fabricating experimental arms for the eight subjects in the sample. In one case (WP), however, the anterior trim line (channel for biceps tendon) was reduced in order to provide this bilateral amputee with a greater range of elbow flexion. All prostheses incorporated triceps pads, leather hinges, and figure-eight harnesses. Six of the eight subjects (OB, PL, TM, WP, ES, and PW) were fitted with polyester porous sockets fabricated in accordance with the technique developed at the Army Medical Biomechanical Research Laboratory (formerly the Army Prosthetics Research Laboratory) (2). The other two subjects (DC and QS) were fitted with nonporous plastic sockets.



A B C

Fig. 2. Comparison of split socket and Munster-type fitting of very short below-elbow case. *A*, Very short below-elbow stump—3-1/4 in.; B, split socket with step-up hinge provides 140 deg. of elbow flexion; C, Miinster-type fitting permits less elbow flexion but enables the amputee to carry considerably greater weight with flexed prosthesis unsupported by harness.

TABLE 1. CHARACTERISTICS OF THE SAMPLE ($N = 8$)

Subject	Sex	Age	Site	Stump Length (in.)	% of Sound Side	Occupation
OB	M	64	LBE	5 3/8	54	Salesman
DC	M	35	RBE	3 1/4	34	Administrative Research Assistant
PL	M	60	RBE	4 7/8	51	Unemployed
TM	M	41	RBE	3 1/2	33	Public Relations Representative
WP	M	40	LBE	5 1/2	52	Social Worker
			RBE	4	37	
ES	F	38	LBE	4	47	Teacher
QS	M	53	LBE	4 1/4	40	Unemployed
PW	M	45	LBE	5 1/2	56	Attorney

TABLE 2. CHARACTERISTICS OF CONVENTIONAL PROSTHESES

Subject	Terminal Device	Wrist Unit	Socket	Hinges	Harness
OB	APRL Hand	Friction	Plastic Porous Laminate	Single Pivot	Half Cuff Figure-8
DC	Sierra 2 Load Hook	Friction	Plastic Split-Socket	Step-up	Half Cuff Figure 8
PL	Becker Hand	Friction	Wood	Single Pivot	Full Cuff None
TM	APRL Hook	Quick Disconnect	Plastic Porous Laminate	Single Pivot	Half Cuff Figure-8
WP					
R	English Hook	Quick Disconnect	Leather	Single Pivot	Half-Cuffs
L	English Hand	Friction	Leather	Single Pivot	Modified Bilateral Figure-8
ES	Passive Hand	Friction	Wood	Single Pivot	Half Cuff No Harness
QS	Dorrance Hook	Hosmer FM-100 Quick Disconnect	Plastic	Polycentric	Half-Cuff Figure-8
PW	APRL Hand	Friction	Plastic Porous Laminate	Flexible Leather	Half-Cuff Figure-8

The evaluation consisted essentially of a "before" and "after" comparison of status. The prosthetic status of all subjects in this study was assessed prior to their fitting with the Minister-type prosthesis in order to obtain a basis for later comparison. At one month and at six months after delivery of the experimental prosthesis, the prosthetic status of the subjects was reevaluated and comparisons between the conventional and experimental prostheses were drawn.

The stumps of all subjects were examined prior to the experimental fitting in order to identify their condition (scars, irritations, discolorations, etc.). This examination was repeated at the specified intervals to see what effect, if any, the experimental socket had had on the physical condition of the stump.

Two self-administering rating scales completed by all subjects elicited their opinions regarding prosthetic comfort, function, and cosmesis. A questionnaire was administered prior to the experimental fitting to assess the amputees' opinions regarding their conventional prostheses. A comparative questionnaire was administered in the post-fitting evaluations to compare the experimental and the conventional prosthesis in the factors previously rated.

A prosthetic-usefulness schedule (J) was applied to the six subjects who had previously worn a functional prosthesis to investigate their opinions concerning the relative value and comparative ease of performance of the conventional and experimental prostheses in the areas of work, home tasks, social life, dressing, and eating.

Three evaluation procedures were administered to the six subjects who had previously worn functional prostheses, as follows:

1. The angles of preflexion and maximum flexion were measured on both conventional and experimental prostheses, as well as the amount of vertical downward force the amputees could resist with their elbows flexed at 90 deg. (live lift) and fully extended (axial load).

2. The accuracy of positioning control exhibited by the amputees was measured with both conventional and experimental prostheses. Scoring of performance on the positioning control test (J) was in terms of accuracy and speed

3. The amputees' ability to perform a series of 12 bimanual practical activities was rated on a seven-point scale. For each activity, six factors were rated independently but simultaneously by two experienced examiners. This evaluation was administered initially to the amputees with their conventional prostheses and then repeated with the experimental prostheses at the one-month and at the six-month post-fitting evaluations.

RESULTS

STUMP EXAMINATIONS

In all cases a period of two to three weeks was required for the subjects to become adjusted to the more intimate fit of the Miinster-type socket. During this initial wear period, the usual complaint was of an irritation in the medial epicondylar area, which was corroborated by visual examination. However, after this adjustment period, the experimental socket had no observed or reported effects on the amputation stump, although amputees were generally aware of increased pressure on the olecranon when the forearm was flexed.

AMPUTEE REACTIONS

Comparative reactions to the conventional and experimental prostheses were obtained from the eight subjects in the sample. The factors investigated and the amputees' ratings are presented in Table 3.

It is clear from Table 3 that, with few exceptions, the amputees reacted very favorably to the Miinster-type prosthesis. Sixty per cent of the responses were favorable toward the experimental item while only five per cent were unfavorable. The two factors which brought forth negative reactions were comfort (two subjects) and adjustments (two subjects). These negative reactions reflect difficulties experienced by these two amputees in adjusting to the intimate fit of the Miinster-type socket. However, all seven subjects in the sample who had previously worn rigid hinges of one type or another cited the elimination of these hinges as a definite contribution to comfort.

No differences in reactions which could be attributed to socket porosity, or lack of it, were noted. The fact that the wear period for most of the subjects was confined to the winter months may explain this lack of difference.

The data on effort and control are of particular interest. All subjects in the sample reported improvement in these factors as a result of wearing the experimental prosthesis. Further questioning revealed that the ampu-

TABLE 3. AMPUTEE REACTIONS, EXPERIMENTAL VS. CONVENTIONAL ($N = 8$)

Factors Compared	Composite Opinions				
	Much Better	Somewhat Better	Same	Somewhat Worse	Much Worse
Comfort	—	5	1	2	—
Weight	5	1	2	—	—
Effort	5	3	—	—	—
Function	5	2	1	—	—
Control	7	1	—	—	—
Noise	1	1	6	—	—
Adjustments	—	—	6	2	—
Cosmesis	2	4	2	—	—
Activities	4	1	3	—	—
Durability	1	—	7	—	—
Totals	30	18	28	4	—
Percentage	37	23	35	5	—

tees' opinions regarding improved prosthetic control with less expenditure of effort appeared directly attributable to the more intimate fit of the Miinster-type socket. This reaction was commonly expressed by such statements as: "The prosthesis feels a part of me" and "I feel right-handed again." Several subjects reported that the Miinster-type sockets did not tend to slip off their stumps under load, as was the case with their conventional sockets. One subject cited the more secure fitting of the Miinster-type socket to be particularly advantageous in performing overhead activities because his stump did not slip out of the socket when he performed a pulling motion with the prosthesis.

The reactions of the two subjects (ES and PL) who had previously worn nonfunctional prostheses (for 15 and 20 years, respectively) are noteworthy. Neither became especially skillful prosthesis users in the course of the study, but both did come to use their terminal devices for grasp, which they had not previously done. Their highly positive responses to the experimental item and the fact that it changed their prosthetic status from that of nonusers to users after so long a period were considered quite unusual. Since both patients were fitted with porous laminate sockets, the role of the Miinster-type fitting is not completely "pure" but, at least, must be regarded as contributory.

Of the six subjects who had previously worn functional devices, five were able to perform the same number of activities with the experimental prostheses as with the conventional, while one subject reported increased prosthetic function with the Miinster-type prosthesis (for example, he was able to carry a coat on his flexed forearm and was able to use his prosthesis in steering a car). However, all six amputees indicated that activities were easier to perform with the experimental prosthesis because the close-fitting socket afforded better control and the elimination of the rigid hinges provided greater freedom.

In no case was there any evidence that the decreased range of motion with the experimental prostheses caused an appreciable decrease in prosthetic function. Since unilateral amputees routinely use their prostheses as assistive devices, there are few activities that are performed prosthetically at the extreme ends of the flexion-extension range. Bilateral subjects, however, are dependent on their prostheses for all upper-extremity functions and therefore require a greater range of motion. To provide the bilateral subject in our sample with an increased range of elbow flexion on his dominant side (40 deg. to 120 deg.), the anterior trim line was lowered. In addition, a wrist-flexion unit was provided to facilitate the performance of tasks close to his body.

FUNCTIONAL EVALUATION

Biomechanical Data

The Miinster technique provides an intimate encapsulation of the amputated stump

TABLE 4. COMPARISON OF ELBOW-FLEXION RANGE ($N = 9$)

Subject	Preflexion		Maximum Flexion	
	Conventional deg.	Experimental deg.	Conventional deg.	Experimental deg.
OB	12	20	97	85
DC	15	34	135	95
PL	15	45	120	110
TM	15	32	105	97
WP				
R	15	40	110	100
L	15	40	135	120
ES	30	35	125	116
QS	15	30	135	113
PW	15	35	135	104
Means	16.33	34.55	121.88	104.44

TABLE 5. COMPARISON OF HOLDING FORCES ($N = 7$)

Subject	Live Lift (ft./lbs.)		Axial Load (lbs.)	
	Conventional	Experimental	Conventional	Experimental
OB	18	22	40	50
DC	2	10	35	70
TM	18	24	50	60
WP				
R	4	12	35	30
L	9	31	40	29
QS	9	10	40	21
PW	14	23	30	45
Means	10.57	18.85	38.57	43.57

which results in a decreased range of motion. Forearm rotation is virtually eliminated, and the elbow flexion-extension range is significantly reduced. However, this type of fitting frequently increases the amputees' ability to resist moments about the elbow and to sustain axial loads.

A comparison of the flexion ranges of the conventional and experimental prostheses is presented in Table 4.

The preflexion angle of the Münster-type socket ranged from 20 deg. to 45 deg., with an average of 35 deg. The exact preflexion angle was planned for each subject contingent on such factors as stump length, natural elbow motion, and amputee preference. Maximum flexion of the experimental sockets ranged from 85 deg. to 120 deg. with an average of 105 deg.

Table 5 compares the maximum holding forces that amputees (the six who had previously worn functional prostheses) were able to maintain with both prostheses. "Live lift" refers to the amount of vertical downward force (applied at the terminal device) that an amputee can resist while maintaining his elbow at 90 deg. (Fig. 3). To allow for different forearm lengths, the data are expressed in foot-pounds. "Axial load" refers to the amount of vertical downward force applied at the terminal device that an amputee was able to resist with his elbow in an extended position. A complaint of pain or one-inch slippage

Fig. 3. Live-lift test.

Fig. 4. Axial-load test.

of the socket on the stump was taken as the maximum tolerable load (Fig. 4).

In all cases the amputees were able to resist a greater force in the live-lift test with their Miinster-tvpe prostheses than with their conventional prostheses. For three subjects (DC, \VP, and PYV) the differences were very significant. In subject DCs case, this difference can be readily understood since he had previously worn a split socket and step-up hinge with an inherent mechanical disadvantage. For subjects WP and PW (prior single-pivot and flexible-hinge wearers, respectively), it is speculated that their improved lifting power was directly related to the more intimate fit of the experimental sockets. However, it is not clear why the same ratio of improvement did not obtain for the other subjects.

Four of the six subjects were able to resist a greater axial load with the Mtinster-type prostheses than with their conventional prostheses. The maximum axial load on the experimental prosthesis for the other two subjects was limited by stump pain, particularly in the epicondylar area.

Positioning Control Test

The positioning control test investigated the amputees' ability to control their prostheses; that is, to bring the terminal device to a desired location in space with measured speed and accuracy. Specifically, it tested the skill of the amputees in striking designated targets in the vertical (on the wall) and horizontal (on a table) planes. Three different sequences were applied in the vertical plane and two in the horizontal. Accuracy was measured by the distance of a mark (made by a pencil held in the terminal device) from the target. Superior prosthetic performance therefore is indicated by the lower scores and performance times. Tables 6 and 7 present the data for the three vertical and two horizontal sequences of the positioning control tests, respectivelv.

Analysis of the data of the positioning control test reveals minimal differences between the conventional and the experimental prostheses. In the vertical sequences, these differences favored the experimental prostheses slightly, with regard to accuracy, but the reverse is true regarding speed. In the horizontal sequences the experimental prostheses were slightly favored in both accuracy and speed. However, none of the differences proved statistically significant.

Practical Activities Test

Comparative performance data were obtained on five subjects in the sample. Two of

TABLE 6. POSITIONING CONTROL TEST SCORES (VERTICAL SEQUENCES) ($N = 7$)

Subject	Sequence I				Sequence II				Sequence III			
	Accuracy (in.)		Speed (sec.)		Accuracy (in.)		Speed (sec.)		Accuracy (in.)		Speed (sec.)	
	Conv.	Exp.	Conv.	Exp.	Conv.	Exp.	Conv.	Exp.	Conv.	Exp.	Conv.	Exp.
OB	.23	.23	14	15	.20	.28	30	40	.19	.29	34	43
DC	.14	.17	15	12	.15	.18	33	25	.23	.14	38	27
TM	.18	.12	17	14	.21	.14	32	39	.28	.15	37	47
WP												
R	.21	.18	16	21	.27	.16	36	52	.25	.18	60	64
L	.19	.14	15	19	.30	.21	42	47	.20	.13	48	51
QS	.20	.24	10	9	.17	.22	26	19	.27	.21	30	40
PW	.31	.21	11	13	.34	.25	27	26	.29	.23	38	37
Means	.20	.18	14	15	.23	.21	32	35	.24	.19	41	44

TABLE 7. POSITIONING CONTROL TEST SCORES (HORIZONTAL SEQUENCES) ($N = 7$)

Subject	Sequence I				Sequence II			
	Accuracy (in.)		Speed (sec.)		Accuracy (in.)		Speed (sec.)	
	Conv.	Exp.	Conv.	Exp.	Conv.	Exp.	Conv.	Exp.
OB	.15	.16	22	22	.25	.26	21	22
DC	.25	.15	11	10	.23	.16	14	11
TM	.10	.19	17	17	.07	.10	21	21
WP								
R	.20	.16	17	18	.19	.15	25	21
L	.22	.10	17	19	.20	.15	20	18
QS	.15	.15	15	11	.25	.23	18	18
PW	.21	.22	14	11	.20	.17	19	16
Means	.18	.16	16	15	.20	.17	20	18

the remaining three subjects were not tested because they had no prior experience with a functional prosthesis. The third subject (WP) had previously worn English-made components (terminal devices, wrist units) which it was not possible to duplicate in his experimental prosthesis. Since these different terminal devices would have introduced an extraneous variable into the experimental situation, the data from this subject are not included here.

Performance data were obtained on a 12-item practical activities test. The activities were: using a pencil sharpener, tying a necktie, tying a shoelace, carrying several packages, filing a fingernail, hammering a nail, opening a jar, putting on a glove, using a can opener, using a paper clip, using a telephone and taking a message, and removing bills from a wallet. Six factors, each rated on a seven-point scale, were considered for each test activity. The factors were: position of the prosthesis for use, grasp of the object (secure or insecure), position of object for use (efficient or inefficient), maintenance of position of object during use (efficient or inefficient), appearance of performance (natural or unnatural), adequacy of general performance (efficient or inefficient). The average scores for each subject in these six factors are presented in Table 8, with the higher scores reflecting better performance. The average performance times for each subject are shown in Table 9.

TABLE 8. COMPARATIVE PERFORMANCE RATINGS (N = 5)

Subject	Prosthesis Positioning for Use		Factors									
			Grasp Security		Object Positioning for Use		Maintenance of Object Position during Use		Appearance of Performance		General Adequacy of Performance	
	Conv.	Exp.	Conv.	Exp.	Conv.	Exp.	Conv.	Exp.	Conv.	Exp.	Conv.	Exp.
OB	5.3	5.5	5.3	5.5	5.2	5.5	5.3	5.5	5.1	5.5	5.1	5.5
DC	6.2	6.3	6.2	6.3	6.2	6.2	6.2	6.3	6.1	6.1	6.3	6.6
TM	5.9	6.1	5.9	6.1	5.9	6.0	5.9	6.0	5.9	6.0	5.9	6.0
QS	5.8	5.9	5.8	5.6	5.8	5.7	5.5	5.6	5.5	5.5	5.6	5.9
PW	5.8	6.0	5.8	6.0	6.0	6.0	5.8	6.0	5.8	5.8	6.0	5.8
Means	5.8	5.9	5.7	5.9	5.8	5.8	5.7	5.8	5.6	5.7	5.7	5.9

TABLE 9. COMPARATIVE PERFORMANCE TIMES (N = 5)

Subject	Time (sec.)	
	Conventional	Experimental
OB	12.8	10.8
DC	6.2	6.1
TM	7.0	7.6
QS	12.5	14.6
PW	6.8	7.6
Means	9.0	9.3

The data from Table 8 indicate that there were apparently no significant differences in performance between the Munster-type and conventional prostheses, and the time comparisons in Table 9 present no clearcut patterns. Two implications of these findings are of interest. First, the obvious and measurable decrease in range of forearm flexion imposed by the Munster-type fitting has no discernible effect on the bimanual performance of unilateral amputees. Second, the highly favorable reactions of subjects to the function and control aspects of the experimental arm were not corroborated by the performance-test data. This apparent lack of agreement may derive from two factors, either singly or in combination: some subtle but important differences in performance did exist but were not detectable by the observational testing procedures applied, or the more intimate and perhaps better fit of the experimental prosthesis (as compared to the conventional) created a "halo" effect which positively affected opinions concerning other aspects of the prosthesis. That is to say, since the prosthesis felt better, it must necessarily perform better.

APPLICABILITY OF THE TECHNIQUE

Since it was hypothesized that the experimental item might have prime applicability to amputees whose stumps fell into the very short or short categories, attention was focused in the study on the fitting of such subjects. However, it was also of interest to investigate the range of stump lengths (or types) for which the Munster-type fitting might be suitable.

In the New York University sample the shortest stump fitted was 3-1/4 in. To investigate the possibility of fitting stumps *shorter* than this, a cast and check socket were made for a bilateral amputee with a 2-1/2 in. below-elbow stump on one side (currently wearing a stump-actuated elbow lock) and an above-elbow stump on the other side. Since the below-elbow stump virtually disappeared at 90 deg. of flexion, it was thought that this was the absolute maximum flexion angle that might be obtained. This limitation was not considered acceptable for the dominant prosthesis of a bilateral amputee. It was also considered that this stump length was very near the lower limit for acceptable fitting, even for a unilateral amputee.

With respect to maximum stump length, two limiting factors are observed:

Fig. 5. View of Miinster-type socket showing the sharp angle of the proximal opening in relation to shaft.

1. Stumps of mid-length and longer usually have some amount of pronation-supination which can be harnessed in a conventional below-elbow socket (with flexible hinges), but not in the Miinster-type socket.
2. The configuration of the Miinster-type socket (proximal opening at a sharp angle to the shaft) presents progressively increasing difficulty to donning and doffing as stump length increases (Fig. 5).

In the New York University series, in which the longest stumps fitted were *5-1/2* in. (two subjects), neither of the above considerations was significant in either case. It is estimated, however, that the slumps of these two subjects were approaching the upper length limit to which the Miinster-type socket could be applied without sacrifice of residual pronation-supination, or modification of the proximal socket to facilitate donning and doffing.

Subject to further study, therefore, it appears that the Miinster-type socket can be applied to the range of below-elbow-stump types for which rigid hinges (step-up, multiple action, and single-pivot) are typically prescribed at present. Some consideration probably should be given to the development of a prosthesis that will permit stump-actuated pronation and supination of the terminal device, yet retain the stability afforded by the Miinster-type socket.

SUMMARY AND CONCLUSIONS

The applicability of Miinster-type fittings was investigated by New York University. The sample for this study consisted of eight subjects with below-elbow amputations ranging from 3-1/4 in. to 5-1/2 in. (34 to 52 per cent). The results of the evaluative procedures, which included interview techniques and performance testing, indicated the following:

1. A brief "breaking-in" period was required by all subjects to adjust to the more intimate fit of the Miinster-type socket. After this initial period of adjustment, the experimental sockets had no observable or reported effects on the amputation stumps except a slight increase in pressure on the olecranon during lifting activities. The use of soft (Silastic) inserts over the epicondyles and olecranon to ameliorate these factors is under investigation at New York University.
2. The subjective opinions of all subjects were heavily in favor of the Miinster-type prostheses.
3. The decrease in flexion range had no appreciable effect on prosthetic function for the unilateral amputees. For bilateral subjects, modification of the anterior trim line and provision of a wrist-flexion device may be necessary for performance of tasks close to the body.
4. The lifting and holding forces demonstrated by the amputees were generally better with the Miinster-type prostheses.
5. The data from the positioning control and practical activities testing were inconclusive.

The evidence suggests, therefore, that the Miinster-type prostheses are functionally advantageous with considerable cosmetic and comfort appeal for amputees with very short to medium below-elbow stumps.

RECOMMENDATIONS

Based on the results of this study, it is recommended that:

1. The Munster fabrication technique be accepted as a satisfactory means of fitting below-elbow amputees. Prime applications would be for patients with unilateral losses whose stump lengths were classified in the short and very short categories.
2. Upon completion of the detailed fabrication manual now being prepared by New York University, the Munster below-elbow fabrication technique be introduced into the curricula of the Prosthetics Education Programs.

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