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Amputees and Their Prostheses[1]

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INFORMATION on 8,698 amputations was collected during a period of approximately two years, ending June 30, 1967. This information was extracted from case-record forms provided by 44 prosthetics facilities in 30 states. The case-record form used was initially developed and standardized by the Conference of Prosthetists of the American Orthotic and Prosthetic Association. Its purpose was to encourage prosthetists in the accurate recording of pertinent information relating to the amputee and his prosthesis. Duplicate copies of the case-record forms were submitted to the Committee on Prosthetic-Orthotic Education (CPOE)[5], National Research Council, in order that significant data could be identified and reported.

"The Facility Case Record Study: A Preliminary Report" (3) and "Children with Amputations" (2), both reporting findings emerging from this study, have been published previously.

Data analyzed in the study included those related to age, sex, level and cause of amputations, reamputations, stump length and contractures, work status of amputees, referrals, months to delivery of prosthesis, age of replaced prosthesis and reason for replacement, components most frequently prescribed for upper- and lower-extremity prostheses, and source of payment for prostheses.

METHODS

Each of the 44 facilities submitted case record forms on amputees as they were seen. Three forms were utilized, one for the amputee's medical history, one for the lower-extremity prosthesis, and one for the upper-extremity prosthesis. In cases where the meaning of the data was uncertain, follow-up forms were sent to the prosthetics facilities to clarify or add to the information provided.

A coding system was devised, and information was transferred from the case-record forms to coding sheets and then to IBM cards and magnetic tape. Selection of pertinent data for retrieval was determined by an ad hoc group and the staff of CPOE.

In order to make comparisons between different areas of the country, the states represented in the study were arbitrarily grouped into five geographical regions (Fig. 1).

SUBJECTS

The study included 8,323 amputees with a total of 8,698 amputations. Statistics in this study refer only to patients fitted with a prosthesis; amputees not fitted are not included. Table 1 indicates the types of cases included in the study.

Amputees or amputations being fitted for the first time were considered "new" cases. Amputees or amputations being

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[5] The Committee on Prosthetic-Orthotic Education is supported by the Social and Rehabilitation Service, Department of Health, Education, and Welfare, and by the Prosthetic and Sensory Aids Service of the Veterans Administration.

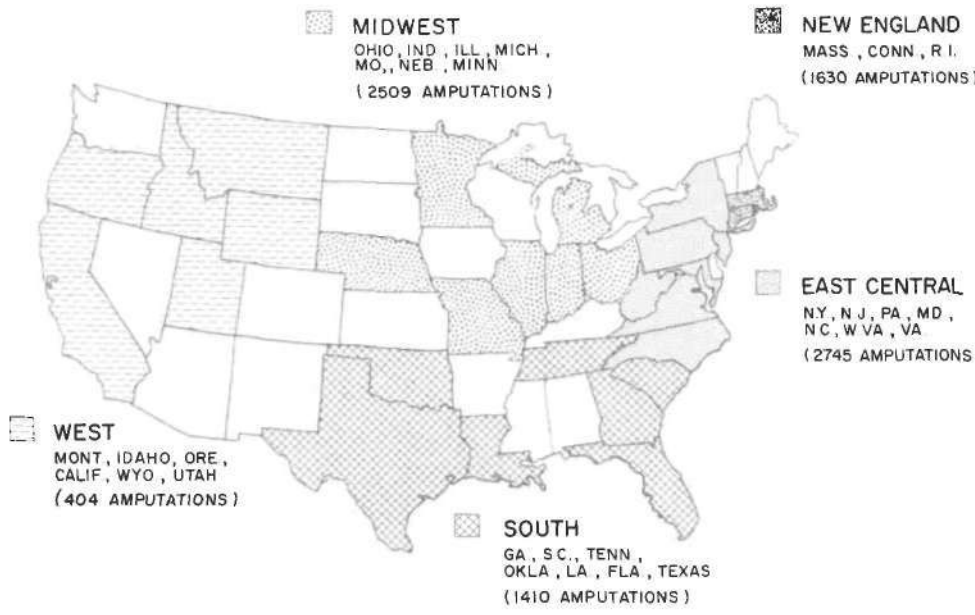


Fig. 1

TABLE 1. NUMBER OF EXTREMITIES FITTED
(N = 8,323)

Unilateral	7,954
Bilateral	356
Double	8
Triple	4
Quadruple	1

TABLE 2. "NEW" AND "OLD" AMPUTATIONS, BY SEX
(N = 8,698)

	Males	Females	Total
"New"	2,969	1,065	4,034
"Old"	3,879	785	4,664
	6,848	1,850	8,698

fitted with replacement prostheses were considered to be "old" cases. There was a total of 4,034 "new" amputations and 4,664 "old" amputations (Table 2). Amputations in males accounted for 6,848 amputations, and amputations in females, 1,850—a ratio of 3.7:1.

FINDINGS

AGE OF AMPUTEES

Table 3 shows the age of amputees fitted in prosthetics facilities during the two years covered by this study. The incidence of amputations for males peaked in the fifth decade; for females, the peak was reached in the seventh decade. Forty-eight per cent of the amputees were 51 years of age or older, 30 per cent were over 61 years, and 12 per cent were over 71 years. The fact that 23 per cent of the amputees were fitted with either a new or a replacement prosthesis after 65 years of age has Medicare implications. (It should be noted that Medicare was in effect during only the second year of data collection.)

LEVEL OF AMPUTATIONS

Amputations of the lower extremity accounted for 86 per cent of the total number of amputations (Table 4). Of these, 53

per cent were at the below-knee level. In the upper extremity, 57 per cent of the amputations were at the below-elbow level.

There was no significant difference in the incidence of left- and right- side amputation in either the upper or lower extremities. A total of 4,386 left-limb and 4,312 right-limb amputations was reported. The right upper extremity was involved slightly more than the left, 605 to 573, and the left lower extremity fractionally more than the right, 3,813 to 3,707.

CAUSE OF AMPUTATION

Causes of amputation were considered in four categories: congenital, tumor, trauma, and disease. Cases of infection, gangrene, or osteomyelitis resulting from trauma were classified under "trauma." Cases of trauma associated with vascular disease were classified under "disease."

Causes of amputation were analyzed by age group and level. Of the 8,698 amputations reported in this study, the cause was known for 8,487 cases; both cause and age were known for 8,394 cases. Fifty per cent of all amputations were caused by trauma, 37.3 per cent by disease, 8.4 per cent were of congenital origin, and 4.3 per cent were due to tumor. Table 5 shows the relative incidence of amputation by cause and level.

In Figure 2 the total number of amputations by cause of amputation and age is indicated. Amputees most frequently fitted

TABLE 3. DISTRIBUTION BY AGE AND SEX, 8,593 AMPUTATIONS

Age Group	Amputations (Male)		Amputations (Female)		Total	
	No.	%	No.	%	No.	%
0-10	265	4	197	11	462	5
11-20	475	7	199	11	674	8
21-30	608	9	123	7	731	9
31-40	852	13	114	6	966	11
41-50	1,377	20	232	13	1,609	19
51-60	1,271	19	307	17	1,578	18
61-70	1,136	17	378	20	1,514	18
(61-64)					(582)	(7)
(65-70)					(932)	(11)
71-80	642	9	239	13	881	10
81-90	127	2	38	2	165	2
91+	10	--	3	--	13	--
Total	6,763		1,830		8,593	

TABLE 4. DISTRIBUTION BY LEVEL, 8,698 AMPUTATIONS

Level	Lower Extremity		Level	Upper Extremity	
	No.	%		No.	%
Hemipelvectomy	20	--	Forequarter	13	1
Hip disarticulation	89	1	Shoulder disarticulation	43	4
Above knee	3,051	41	Above elbow	276	23
Knee disarticulation	115	1	Elbow disarticulation	31	3
Below knee	4,020	53	Below elbow	676	57
Syme's	168	2	Wrist disarticulation	77	7
Partial foot	35	--	Partial hand	60	5
Congenital NOS	22	--	Congenital NOS	2	--
Total	7,520		Total	1,178	

TABLE 5. INCIDENCE OF AMPUTATION BY CAUSE AND LEVEL, 8,487 AMPUTATIONS

Lower Extremity	Congenital	Tumor	Trauma	Disease	Total
Hemipelvectomy—Hip disarticulation	5	66	18	17	106
Above knee	95	212	1,151	1,520	2,978
Knee disarticulation	27	3	58	24	112
Below knee	255	50	2,085	1,522	3,912
Syme's	47	1	81	36	165
Partial foot	8	1	22	3	34
Congenital NOS	21	--	--	--	21
Subtotal	458	333	3,415	3,122	7,328
Upper Extremity					
Forequarter—Shoulder disarticulation	12	18	22	3	55
Above elbow	17	9	230	16	272
Elbow disarticulation	12	2	15	2	31
Below elbow	181	5	461	16	663
Wrist disarticulation	20	--	57	--	77
Partial hand	10	--	49	--	59
Congenital NOS	2	--	--	--	2
Subtotal	254	34	834	37	1,159
Total—upper and lower extremity	712 (8.4%)	367 (4.3%)	4,249 (50%)	3,159 (37.3%)	8,487

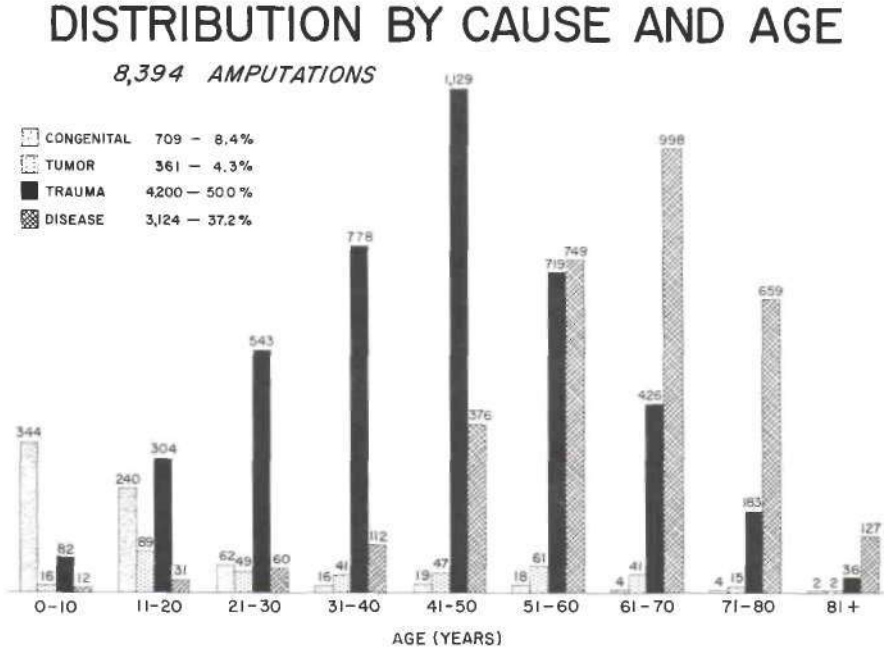


Fig. 2

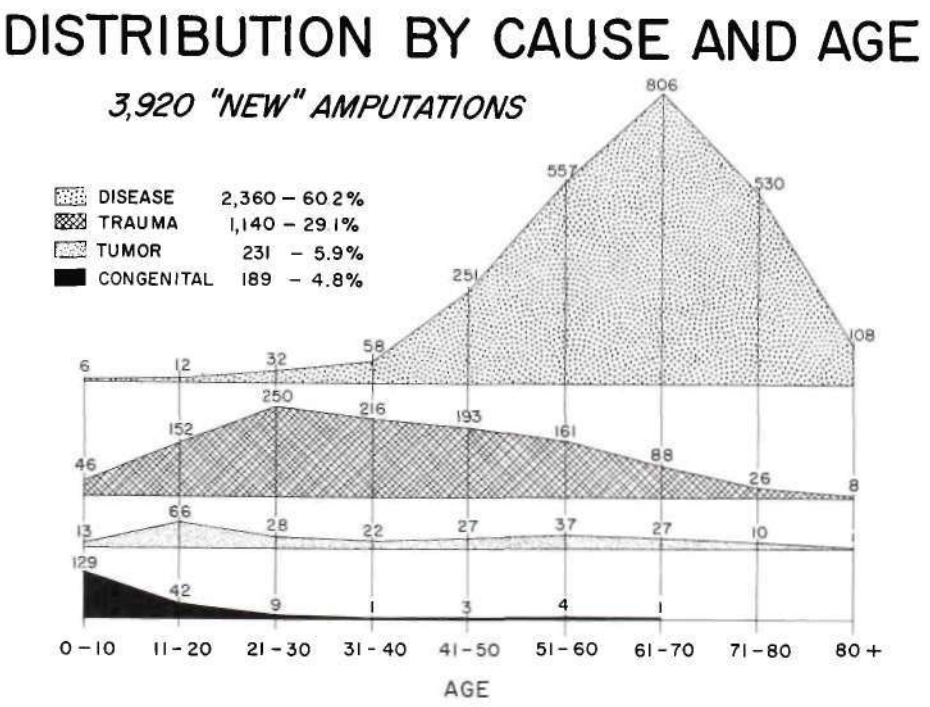


Fig. 3

or returning for replacement in the first ten years of life were those with congenital limb deficiencies. Amputations for trauma led all other categories fitted or returning for replacement between the ages of 11 through 50. In the third, fourth, and fifth decades, this group accounted for 76 per cent, 82 per cent, and 72 per cent, respectively, of all cases fitted or returning. Of those fitted in the sixth decade of life, the incidence was almost equally distributed between traumatic amputations and amputations due to disease. After age 60, the latter group led all other categories by a ratio of more than 2:1.

"New" Cases by Cause

Analysis of all amputations entered in the study gives an overview of the type of amputee being seen and fitted in prosthetics facilities, as reported above. Analysis of those being fitted for the first time, however, provides a picture of persons amputated during the two-year period of data collection and gives a better current indication of cause related to age, sex, and level of amputation.

It is probable that the statistics on age are slightly distorted, since age was reported as of the time of fitting. Age at the time of amputation, therefore, would be less, and to a variable degree.

In the group of "new" amputees, cause was reported for 3,963 cases, and both cause and age for 3,920. Figure 3 indicates the incidence of amputation by age. Of the "new" cases, 60.2 per cent of amputations were caused by disease, 29.1 per cent by trauma, 5.9 per cent by tumor, and 4.8 per cent were of congenital origin.

The predominance of trauma as the cause of amputation in the overall amputee population of the study (Fig. 2) is in striking contrast to the predominance of

TABLE 6. SEX, AGE, AND LEVEL, 191 "NEW" CONGENITAL AMPUTATIONS

Age	Upper Extremity			Lower Extremity			Total		Grand Total
	Male	Female	Total	Male	Female	Total	Male	Female	
0–10	43	34	77	24	28	52	67	62	129
11–20	11	11	22	16	4	20	27	15	42
21–30	3	3	6	1	2	3	4	5	9
31–40	--	--	--	1	--	1	1	--	1
41–50	1	1	2	1	--	1	2	1	3
51–60	--	--	--	2	2	4	2	2	4
61–70	--	--	--	1	--	1	1	--	1
71–80	--	--	--	--	--	--	--	--	--
Unknown	1	--	1	--	1	1	1	1	2
Total	59	49	108	46	37	83	105	86	191

TABLE 7. SEX, AGE, AND LEVEL, 235 "NEW" TUMOR AMPUTATIONS

Age	Upper Extremity			Lower Extremity			Total		Grand Total
	Male	Female	Total	Male	Female	Total	Male	Female	
0–10	2	2	4	6	3	9	8	5	13
11–20	3	2	5	30	31	61	33	33	66
21–30	--	--	--	15	13	28	15	13	28
31–40	4	4	8	6	8	14	10	12	22
41–50	1	2	3	13	11	24	14	13	27
51–60	3	1	4	22	11	33	25	12	37
61–70	1	2	3	14	10	24	15	12	27
71–80	1	1	2	6	2	8	7	3	10
81+	--	--	--	1	--	1	1	--	1
Unknown	--	--	--	2	2	4	2	2	4
Total	15	14	29	115	91	206	130	105	235

disease as a cause of amputation when only new patients are considered (Fig. 3). In the overall picture, the ratio of trauma to disease is 1.3:1, whereas in new patients the ratio is reversed, and disease as a cause of amputation outnumbers trauma 2:1.

Thus, the total sample data obviously includes a considerable number of traumatic amputees who lost their limbs at an earlier age and survived to require replacement prostheses. However, the noteworthy finding is that, in the period surveyed, disease-caused amputations were occurring at double the rate of those attributable to trauma.

Congenital. In the 191 reported "new" amputations of congenital origin, 105 were in males, 86 in females (Table 6). Of this number, 137 did not require amputation surgery, while 54 did. This surgery presumably involved the conversion of anomalous limbs to stumps that were more suitable for the fitting of a prosthesis. Eighty-three amputations occurred in the lower extremity, of which 44 were at the below-knee level. Of 108 upper-extremity amputations, 78 were at the below-elbow level. Thirty-two per cent of congenital amputations were not fitted until after 11 years of age.

Tumor. Of 235 "new" amputations caused by tumor, 206 (88 per cent) were of the lower extremity (Table 7). There were 120 amputations at the above-knee level, accounting for 58 per cent of the lower-extremity amputations. An additional 27 per cent were at a level higher

than above-knee, i.e., hip-disarticulation or hemipelvectomy. Males outnumbered females 130 to 105.

The highest incidence of tumor (66 cases or 29 per cent) occurred in the second decade of life. Within this decade, no particular pattern of incidence is discernible (Table 8). These data are somewhat at variance with those reported by Taft and Fishman (7) from a study conducted by the staff of New York University Child Prosthetic Studies. This study, which involved a larger sampling (278 children whose amputations were caused by tumor), showed a gradual increase in incidence beginning about the 6-8 year period and peaking in the 14-16 year group. Unfortunately, the age groupings are slightly different from those of our study, so an exact comparison cannot be made. However, both studies agree that tumor occurs most frequently in the second decade by a wide margin.

TABLE 8. INCIDENCE OF TUMOR-CAUSED AMPUTATIONS IN SECOND DECADE
(N = 66)

Age	Number
11	9
12	6
13	6
14	6
15	6
16	8
17	6
18	5
19	7
20	7

Trauma. Of the 1,156 new cases of amputations resulting from trauma, amputations in males accounted for a total of 1,050, and those in females for 106, a ratio of approximately 10:1 (Table 9). The highest incidence of trauma-related amputations occurred in the third decade (250 cases), followed closely by that in the fourth decade (216 cases). The number of amputees in these two decades accounted for 41 per cent of all new cases where age was known. The incidence of amputations in females varied only slightly in each decade between the ages of 11 and 60. The incidence of amputations in males exhibited a sharp rise through the second and third decades, and then receded gradually.

In every decade the involvement of the lower extremity exceeded that of the upper. Actually, the lower extremity was involved 1.9 times as often as the upper, 753 times as opposed to 403.

Disease. Sixty per cent (2,381 cases) of all new amputations were caused by disease (Table 10). Although males outnumbered females by more than 2:1 in this category, the relative percentages of males and females in each age group were closely parallel, e.g., 980 or 61 per cent of males

TABLE 9. SEX, AGE, AND LEVEL, 1,156 "NEW" TRAUMA AMPUTATIONS

Age	Upper Extremity			Lower Extremity			Total		Grand Total
	Male	Female	Total	Male	Female	Total	Male	Female	
0–10	15	3	18	26	2	28	41	5	46
11–20	53	6	59	79	14	93	132	20	152
21–30	94	4	98	138	14	152	232	18	250
31–40	65	4	69	136	11	147	201	15	216
41–50	68	6	74	104	15	119	172	21	193
51–60	43	6	49	101	11	112	144	17	161
61–70	23	--	23	59	6	65	82	6	88
71–80	4	--	4	21	1	22	25	1	26
81+	1	--	1	6	1	7	7	1	8
Unknown	8	--	8	6	2	8	14	2	16
Total	374	29	403	676	77	753	1,050	106	1,156

TABLE 10. SEX, AGE, AND LEVEL, 2,381 "NEW" DISEASE AMPUTATIONS

Age	Upper Extremity			Lower Extremity			Total		Grand Total
	Male	Female	Total	Male	Female	Total	Male	Female	
0–10	--	1	1	3	2	5	3	3	6
11–20	2	--	2	5	5	10	7	5	12
21–30	3	1	4	20	8	28	23	9	32
31–40	2	3	5	39	14	53	41	17	58
41–50	3	6	9	156	86	242	159	92	251
51–60	4	3	7	392	158	550	396	161	557
61–70	2	--	2	537	267	804	539	267	806
71–80	1	--	1	357	172	529	358	172	530
81+	1	--	1	82	25	107	83	25	108
Unknown	--	--	--	15	6	21	15	6	21
Total	18	14	32	1,606	743	2,349	1,624	757	2,381

were over the age of 61 years, while 464 or 62 per cent of females were also over the age of 61. After 40 years of age, a sharp rise in the incidence of amputations caused by disease was noticeable. Approximately one-third of the amputations occurred in the seventh decade. Eighty-five per cent of all new amputees in the disease category were over the age of 51 years, and 49 per cent were in the Medicare age group.

In disease-caused "new" amputations, involvement of the lower extremity greatly exceeded that of the upper, the ratio being 73:1.

COMPARISON WITH AMPUTEE CENSUS

The Glattly study *(4),* reported in 1964 and commonly referred to as the "Amputee Census," included only "new" amputees. It is of interest to compare the findings of that study with the present one. Findings of our study relating to the sex and age of new amputees and the cause, side, and level of amputations closely parallel the findings of the Glattly study. Comparative data of the two studies are depicted in Figures 4, 5, 6, and 7, and Table 11.

In our study, newly fitted amputees 51 years of age and older accounted for 60.2 per cent of the total, as compared with 58.8 per cent in the Amputee Census (Fig. 4). In both studies, the highest incidence of amputation was in the seventh decade. Because many geriatric amputees are not fitted with prostheses, the incidence of amputation in the older age groups would presumably be even higher if statistics on nonfitted amputees were included.

In both studies, male amputees exceeded female amputees by approximately three to one (Fig. 5).

The distribution of right- and left-side amputations was almost equal in both studies, and lower-extremity amputations still accounted for about 85 per cent of all new fittings (Table 11). In Figure 6 a higher incidence of below-knee amputations and a lower incidence of above-knee amputations were evident in the more recent study. Among new patients in this study, there was a total of 3,254 above- and below-knee amputations. Of these, 50.9 per cent were above-knee.

The relative incidence of truama as a cause of amputation decreased by four per cent from the Glattly to the present study, and the incidence by cause in other categories increased, but by relatively small amounts (Fig. 7).

ORIGINAL LEVEL OF AMPUTATION FOR DISEASE CORRELATED WITH GEOGRAPHICAL AREA AND AGE

The original level of amputation for disease was examined for 2,242 new cases whose amputations were at either the above- or below-knee level. Comparisons were made between below- and above-knee as the choice of amputation level in each of the five geographical areas (Table 12). Below-knee appeared to be the site

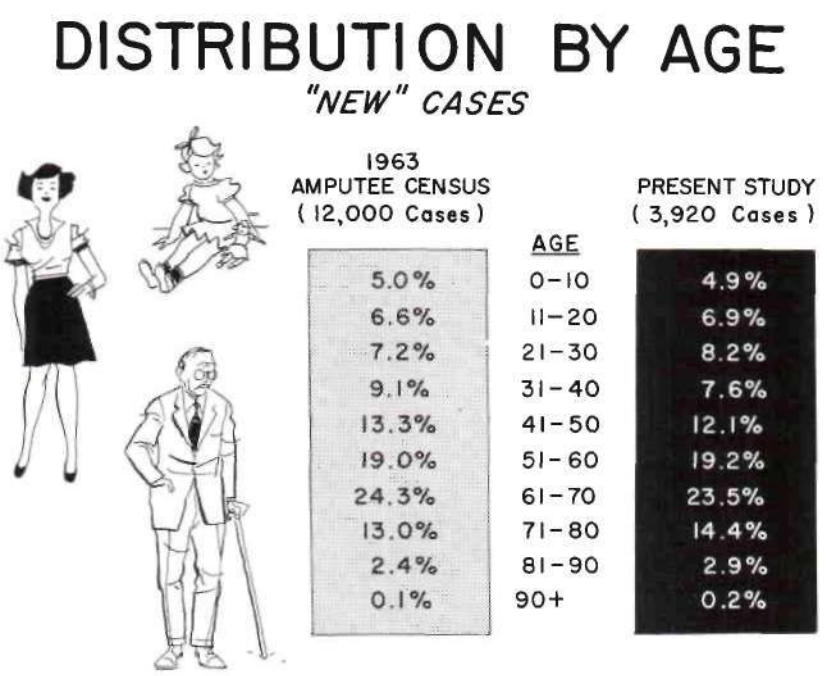

DISTRIBUTION BY AGE
"NEW" CASES
1963
AMPUTEE CENSUS
(12,000 Cases)
PRESENT STUDY
(3,920 Cases)
AGE
5.0%
6.6%
7.2%
9.1%
13.3%
19.0%
24.3%
13.0%
2.4%
0.1%
0-10
11-20
21-30
31-40
41-50
51-60
61-70
71-80
81-90
90+
4.9%
6.9%
8.2%
7.6%
12.1%
19.2%
23.5%
14.4%
2.9%
0.2%

Fig. 4

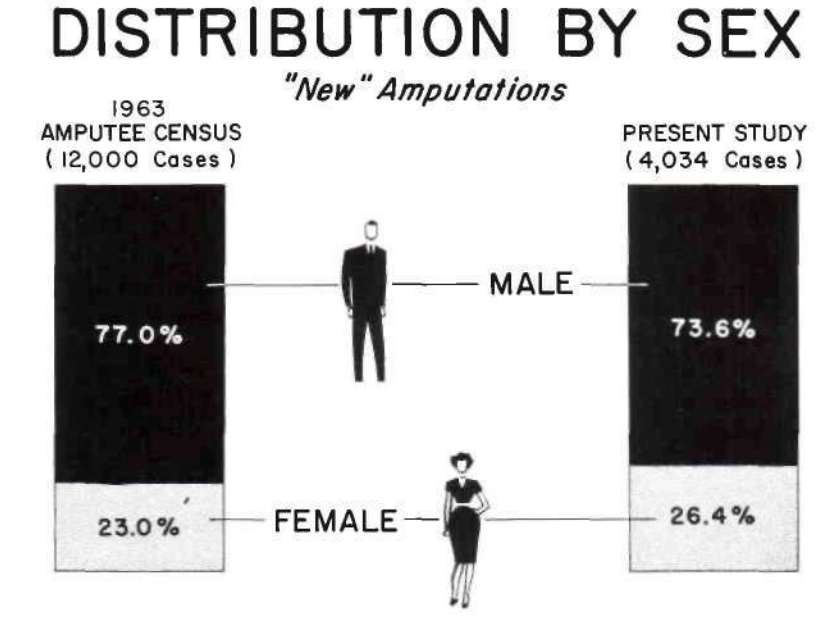

DISTRIBUTION BY SEX
"New" Amputations
1963
AMPUTEE CENSUS
(12,000 Cases)
PRESENT STUDY
(4,034 Cases)
77.0%
MALE
73.6%
23.0%
FEMALE
26.4%

Fig. 5

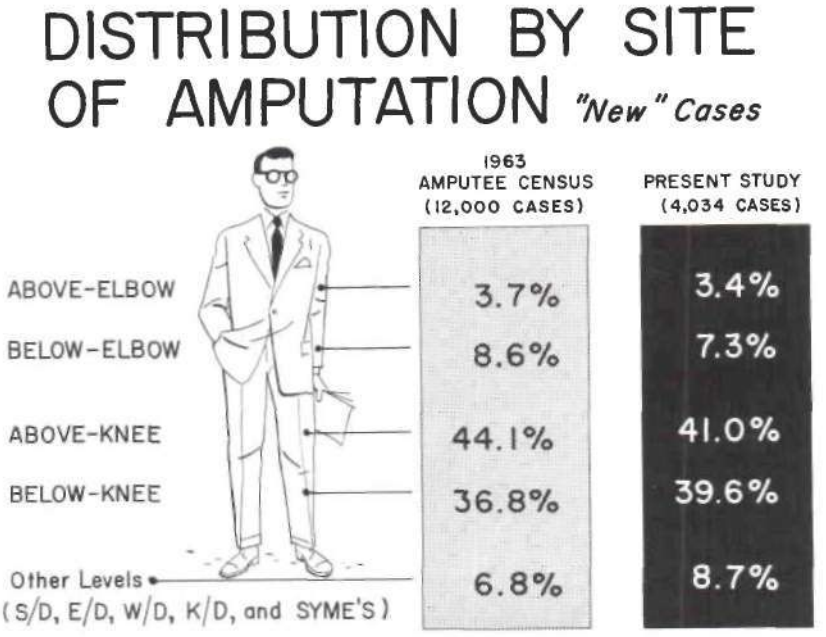

DISTRIBUTION BY SITE
OF AMPUTATION "New" Cases
1963
AMPUTEE CENSUS
(12,000 CASES)
PRESENT STUDY
(4,034 CASES)
ABOVE-ELBOW
BELOW-ELBOW
ABOVE-KNEE
BELOW-KNEE
Other Levels
(S/D, E/D, W/D, K/D, and SYME'S)
3.7%
8.6%
44.1%
36.8%
6.8%
3.4%
7.3%
41.0%
39.6%
8.7%

Fig. 6

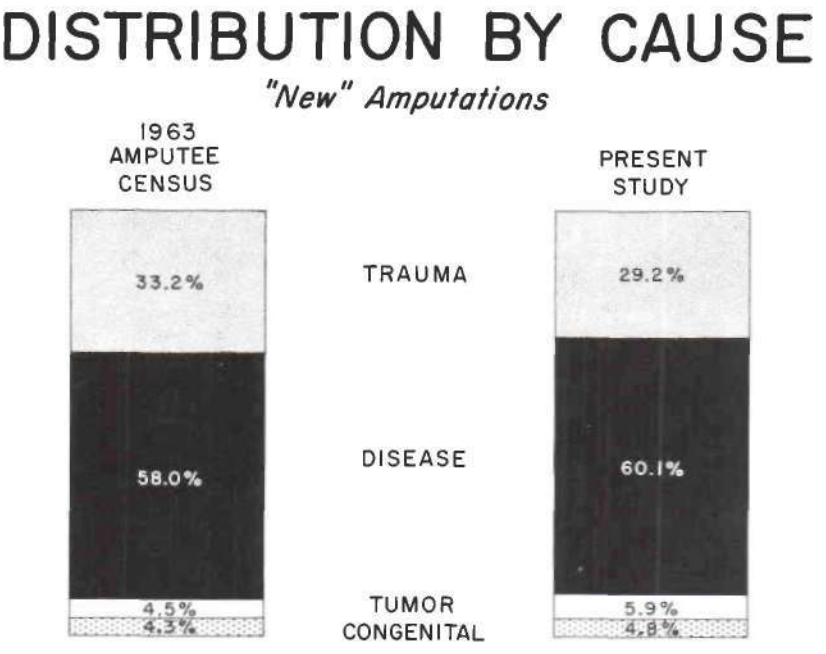

DISTRIBUTION BY CAUSE
"New" Amputations
1963
AMPUTEE
CENSUS
PRESENT
STUDY
TRAUMA
DISEASE
TUMOR
CONGENITAL
33.2%
58.0%
4.5%
4.3%
29.2%
60.1%
5.9%
4.8%

Fig. 7

of choice in less than half the total number of cases. The South led the other geographical areas in percentage of amputations at the below-knee level (54 per cent), followed in order by the Midwest (51 per cent), New England (48 per cent), East Central (46 per cent), and the West (45 per cent).

A look at the site of the original disease-related amputation for new patients 41 years of age and above revealed some interesting statistics (Table 13). In the fifth decade, below-knee was selected in preference to above-knee in 58 per cent of the cases. This percentage gradually decreased over the next two decades to a low of 43 per cent in the seventh decade. After the seventh decade, there was an increase to 47 per cent in the eighth decade and to 50 per cent after the eighth decade. For all new amputations for disease in patients 41 years of age and above, above-knee was selected in 52 per cent of the cases, below-knee in 48 per cent.

The lack of a consistent pattern in these data is intriguing. A progressive decrease in the proportion of below-knee amputations with increase in age might logically be anticipated. Surgeons, for example, might wish to be more sure of obtaining healing in older patients and elect to amputate at the above-knee level. However, other factors than age of patient obviously enter into the selection of amputation level.

TABLE 11. DISTRIBUTION BY SIDE AND EXTREMITY, "NEW" AMPUTEES

	1963 Amputee Census (12,000 Cases)	Present Study (3,920 Cases)
Left side	49.2%	51.2%
Right side	50.8%	48.8%
Upper extremity	14.9%	14.4%
Lower extremity	85.1%	85.6%

TABLE 12. ABOVE KNEE VERSUS BELOW KNEE AS SELECTED SITE OF ORIGINAL AMPUTATION, 2,242 "NEW" PATIENTS IN DISEASE CATEGORY

Geographical Area	Above Knee		Below Knee	
	No.	%	No.	%
New England	302	52	281	48
East Central	412	54	356	46
South	129	46	154	54
Midwest	269	49	279	51
West	33	55	27	45
Total	1,145	51	1,097	49

TABLE 13. ABOVE KNEE VERSUS BELOW KNEE AS SELECTED SITE OF ORIGINAL AMPUTATION CORRELATED WITH INCREASING AGE, 2,134 "NEW" PATIENTS IN DISEASE CATEGORY

Age Group	Above Knee		Below Knee	
	No.	%	No.	%
41–50	95	42	133	58
51–60	252	49	267	51
61–70	443	57	329	43
(61–64)	--	(58)	--	(42)
(65–70)	--	(57)	--	(43)
71–80	268	53	241	47
81+	52	50	53	50
Total	1,110		1,023	

SPECIFIC CAUSES OF TRAUMATIC AMPUTATIONS

Trauma was listed as the primary or precipitating cause of 4,306 amputations ("old" and "new" cases). As noted earlier, some of this number were classified in categories other than trauma, since trauma was not considered the primary cause of amputation; hence, the number 4,306 exceeds the number of cases actually coded in the trauma category. Of these 4,306 instances where trauma was mentioned, there were 392 cases where the type of trauma was unknown, so, for purposes of this analysis, reference will be to the 3,914 cases where type was known.

Figure 8 summarizes the causes of traumatic amputations. In this category, men were affected ten times as frequently as women: 3,561 to 353. In males, cars, industrial accidents, and war each accounted for approximately 20 per cent of the cases. On the other hand, automobiles were by far the outstanding cause of traumatic amputations in women (49 per cent), with no other cause approaching this in frequency. It is noteworthy that the ratio of male to

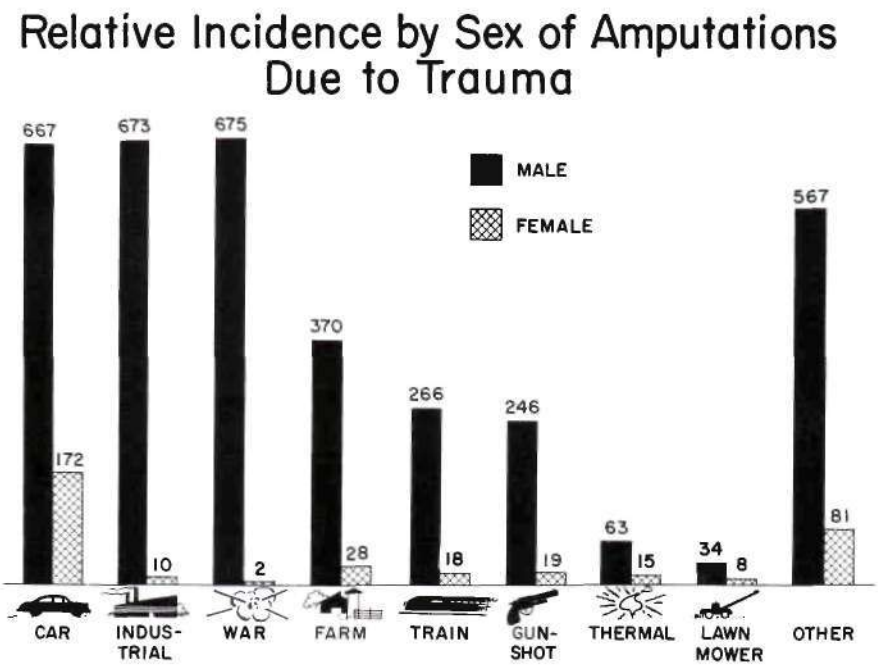


Fig. 8

TABLE 14. CAUSES OF TRAUMATIC AMPUTATIONS CORRELATED WITH SEX, SIDE, AND LEVEL, 3,914 "OLD" AND "NEW" CASES

Cause	Right Upper Extremity		Left Upper Extremity		Right Lower Extremity		Left Lower Extremity		Total		Grand Total
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	
Car	28	4	45	8	277	82	317	78	667	172	839
Industrial	148	7	105	3	227	--	193	--	673	10	683
War	28	--	30	--	296	--	321	2	675	2	677
Farm	97	3	67	4	107	14	99	7	370	28	398
Train	4	--	14	1	121	11	127	6	266	18	284
Gunshot	23	3	23	2	95	5	105	9	246	19	265
Thermal	8	1	11	2	24	4	20	8	63	15	78
Lawn mower	2	--	3	2	11	3	18	3	34	8	42
Other	49	3	38	7	231	30	249	41	567	81	648
Total	387	21	336	29	1,389	149	1,449	154	3,561	353	3,914

female automobile-caused amputations was in the order of 4:1, in contrast to the 10:1 overall ratio. Since it is not known whether these female victims were predominantly drivers or riders, the full significance of these data is not clear.

Table 14 relates cause of trauma to sex, side, and level of amputation. Involvement of the right upper extremity in males was greater than the left. This preponderance was especially evident in farm and industrial accidents and is doubtless re-

TABLE 15. SPECIFIC CAUSES OF "NEW" AND "OLD" TRAUMATIC AMPUTATIONS IN MALES

Cause	"New" Amputations			"Old" Amputations		
	No.	%	% Excluding War	No.	%	% Excluding War
Car	201	20	21	466	18	24
Industrial	287	29	29	386	15	20
War	19	2	--	656	26	--
Farm	107	11	11	263	10	14
Train	52	5	5	214	8	11
Gunshot	64	6	7	182	7	10
Thermal	24	2	2	39	2	2
Lawn mower	15	2	2	19	1	1
Other	225	23	23	342	13	18
Total	994			2,567		

lated to handedness. In car accidents, the left upper extremity was involved significantly more than the right for both males and females, 62 per cent as compared with 38 per cent. One can speculate that this incidence might be attributable to the fact that many motorists ride with the left elbow extending beyond an open window. In the small sample of train accidents, the involvement of the left upper extremity in males was also considerably greater than the right but, because of the small number, this probably was without significance.

The left lower limb was involved slightly more than the right in males, and the right and left limbs almost equally in females.

Table 15 compares causes cited for "new" traumatic amputations in males with those given for "old" traumatic amputations. Twenty-six per cent of the amputations of "old" cases were due to war injuries, whereas only 2 per cent of the new cases were due to this cause. At the time of this study, the Vietnam War had not yet exerted its full impact. The greatest increase in trauma-caused amputations was seen in the industrial-accident category. Industrial accidents caused 29 per cent of the "new" traumatic amputations, but only 15 per cent of the "old" amputations. Elimination of war cases from the total number avoids distortion of the data due to the preponderance of old war injuries, and thus presents a somewhat truer comparative picture of other traumatic causes. With war injuries eliminated, industrial accidents accounted for 29 per cent of the "new" amputations and 20 per cent of the "old" amputations, which still reflects an increased incidence of amputations caused by industrial accidents. Industrial accidents exceeded all other categories as the cause of amputation in new patients.

REAMPUTATIONS OF THE LOWER EXTREMITY

Reamputations were studied in relation to cause, original level of amputation, and present level. Level was reported for 396 reamputations of the lower extremity. Some members of this group had second reamputations, but for the purposes of this study, only the original and present level of amputation were considered. An attempt was made to exclude simple revisions that involved no shortening of bone.

In reviewing the figures presented here, it should be remembered, again, that only those patients fitted with prostheses at the time of the study are considered. Despite this limitation, analysis of the available data is thought-provoking. Of 396 reamputations reported, 189 were in the disease-related category involving a total of 3,122 cases (Table 16), and 182 were in the trauma-caused group with 3,387 total cases (Table 17). Thus, ream-

TABLE 16. REAMPUTATIONS—DISEASE; ORIGINAL COMPARED WITH FINAL LEVEL

Original Level and No. of Cases	Final Level—189 Reamputations						
	Hemipelvectomy	Hip Disarticulation	Above Knee	Knee Disarticulation	Below Knee	Syme's	Total
Hip disarticulation (10)	1	--	--	--	--	--	1
Above knee (1,432)	--	6	9	--	--	--	15
Knee disarticulation (23)	--	--	2	--	--	--	2
Below knee (1,543)	--	1	67	3	22	--	93
Syme's (44)	--	--	2	--	9	--	11
Partial foot (70)	--	--	22	--	41	4	67
Total (3,122)	1	7	102	3	72	4	189

TABLE 17. REAMPUTATIONS—TRAUMA; ORIGINAL COMPARED WITH FINAL LEVEL

Original Level and No. of Cases	Final Level—182 Reamputations				
	Above Knee	Knee Disarticulation	Below Knee	Syme's	Total
Above knee (1,094)	15	--	--	--	15
Knee disarticulation (55)	1	1	--	--	2
Below knee (2,091)	45	4	65	--	114
Syme's (103)	3	--	23	3	29
Partial foot (44)	1	--	14	7	22
Total (3,387)	65	5	102	10	182

putations in the first group ran a shade over 6 per cent, those in the second group a shade under 6 per cent. Stated in reverse, approximately 94 per cent of the cases in both groups did not require reamputation. The statistics for specific levels are also quite fascinating. In disease-related below-knee amputations, approximately 6 per cent required reamputation versus approximately 5 per cent in the like trauma group. In the above-knee group, the comparative proportions are 1 per cent versus 0.6 per cent. At the Syme's level, comparative figures are 25 per cent versus 28 per cent, and for partial feet 96 per cent versus 25 per cent. The reasons for the sharp increase in reamputations at the last two levels are worthy of further study. It would also be of interest to know whether partial foot amputations, for example, were or were not successfully performed on many patients who were never fitted with prostheses.

For the 189 (48 per cent) reamputations due to disease, Table 16 gives the final as compared to the original level. Of 93 below-knee amputations requiring reamputation, 22 (24 per cent) remained in the same segment, 67 (72 per cent) were converted to an above-knee level, 3 to a knee-disarticulation, and 1 to a hip-disarticulation level. Of the 15 original above-knee amputations, 9 were reamputated in the same segment and 6 became hip disarticulations.

Of the 11 Syme's reamputations reported, 2 were reamputated to an above-knee level and 9 to a below-knee level. Of the 67 reamputations at the partial foot level, 22 were converted to an above-knee, 41 to below-knee, and 4 to a Syme's level.

Causes of reamputation for patients in the disease category were indicated for 181 of the 189 reamputations. In some instances, two causes of reamputation were cited. In each instance where a cause was mentioned, it was counted as contributing to the reamputation. The total number of contributing causes to reamputation in the disease category therefore was 192 (Table 18). "Recurrence of the original cause of amputation" accounted for almost half (48 per cent) of the reasons cited for reamputations. This generalized response is interpreted as meaning a continuance of the original vascular problem responsible for the initial amputation. Specific causes cited were a nonhealing wound (18 per cent), gangrene (12 per cent), infection (5 per cent) stump breakdown (3 per cent), and "other" (14 per cent).

Most reamputations in the disease category occurred very shortly after the original surgery, 49 per cent occurring in less than 1 1/2 months, and 60 per cent occurring in less than 2 1/2 months. Eighty-two per cent occurred in the first year following the amputation.

In the category of traumatic amputations, levels for 182 reamputations of the lower extremity were reported. Of the 114 amputations at the below-knee level requiring reamputation, 57 per cent (65 amputations) remained at the below-knee level, a percentage considerably higher than was the case for reamputations due to disease. Forty-five amputations were converted to above-knee levels and 4 were converted to knee disarticulations. There were 29 Syme's reamputations, of which 23 were converted to below-knee, 3 to above-knee, and 3 remained at the Syme's level. Of the 22 partial foot reamputations, 14 were converted to below-knee levels, 7 to Syme's and 1 to above-knee.

Causes of reamputation were known for 157 of the trauma cases. As with reamputations in the disease category, every instance where a cause was mentioned was counted. There were 165 contributing causes to reamputations (Table 19). In 71 instances (43 per cent), "other" was coded as the cause of reamputation. Included in the "other" category were causes that could not be readily classified, such as "stump not satisfactory for prosthesis," "shorten bone and remove neuroma," "painful stump." The median number of months between amputation and reamputation was six.

TABLE 18. CAUSES OF REAMPUTATION—DISEASE CATEGORY
(N = 192)

Cause	No.	%
Recurrence of original cause	92	48
Nonhealing wound	35	18
Gangrene	23	12
Infection	10	5
Stump breakdown	6	3
Poor scar	2	1
Other	19	10
Miscellaneous combinations	5	3

TABLE 19. CAUSES OF REAMPUTATION—TRAUMA CATEGORY
(N = 165)

Cause	No.	%
Infection	28	17
Gangrene	22	13
Nonhealing wound	17	10
Stump breakdown	10	6
Bony overgrowth	7	4
Poor scar	4	3
Other[a]	71	43
Miscellaneous combinations	6	4

[a] Includes "stump not satisfactory for prosthesis," "shorten bone and remove neuroma," "painful stump," etc.

TABLE 20. REAMPUTATIONS OF THE LOWER EXTREMITY
(N = 396)

Original Level and No. of Cases	No. of Reamputations	No. and % in Same Segment	No. and % in Higher Segment
Hip disarticulation (82)	2	--	2 (100)
Above knee (2,897)	31	25 (81)	6 (19)
Knee disarticulation (112)	6	1 (17)	5 (83)
Below knee (4,046)	223	98 (44)	125 (56)
Syme's (201)	43	3 (7)	40 (93)
Partial foot (128)	91	--	91 (100)
Total (7,466)	396	127 (32)	269 (68)

There were 16 reamputations for congenital amputees and 6 for patients whose amputations were caused by tumor. Three of the latter were reamputated because of recurrence of the tumor. Reported reasons for reamputations in congenital amputees were too diverse for classification, except that 4 reamputations were because of bony overgrowth.

Table 20 summarizes the total number of reamputations for each level and includes the percentage of reamputations converted to a higher segment or remaining in the same segment.

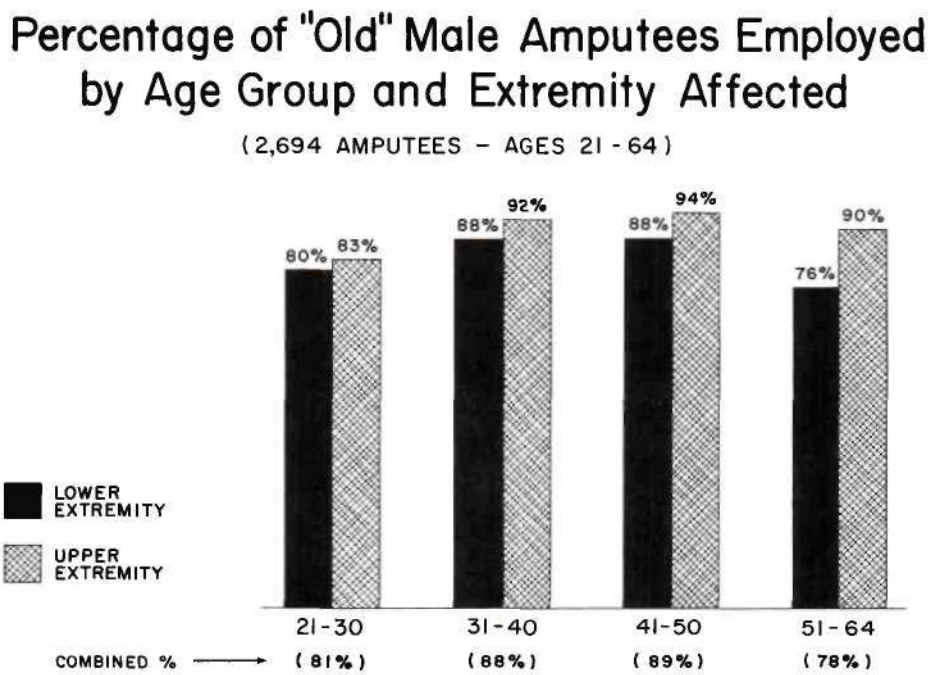
Bony overgrowth was cited eight times as a reason for reamputation: four tibial overgrowths, two fibular overgrowths, and

two not specified. All of these reamputations were performed on children, with the exception of one on a 27-year-old amputee. While not implicit in the data, it is conceivable that this 27-year-old had had bony overgrowth for a long time prior to reamputation (his first amputation occurred at age 10).

STUMP LENGTH AND CONTRACTURES

There were 2,602 above-knee amputations for which the presence or absence of contractures of the hip was reported. Of this group, 1,345 had either no flexion contracture or a contracture of less than 5 deg, and are not included in this analysis, other than the notation that they comprised over half of the group reported. Stumps with 5+ deg of contracture ranged in length from 2 - 2 1/2 inches to 14 - 15 1/2 inches. Three stumps had flexion contractures of more than 60 deg. Hip-flexion contractures were greatest in the very short stump. The average contracture at the above-knee level fell in the 5-9 deg range.

There were 3,781 below-knee amputations for which the presence or absence of knee contractures was reported. Of this number, only 12 per cent were reported as having contractures of 5 deg or more. In general, the shorter the stump, the more severe the contracture. Considering only those cases reporting contractures of 5 deg or more, stumps averaging more than 7 1/2 in. in length had average contractures of between 5 and 9 deg; for stumps between 4 and 7 1/2 in. long, contractures averaged between 10 and 14 deg; and for stumps 3 1/2 in. and less in length, contractures averaged 15 to 19 deg. The average contracture, excluding those of less than 5 deg, was 10-14 deg. Three stumps had contractures of 60 deg or more.



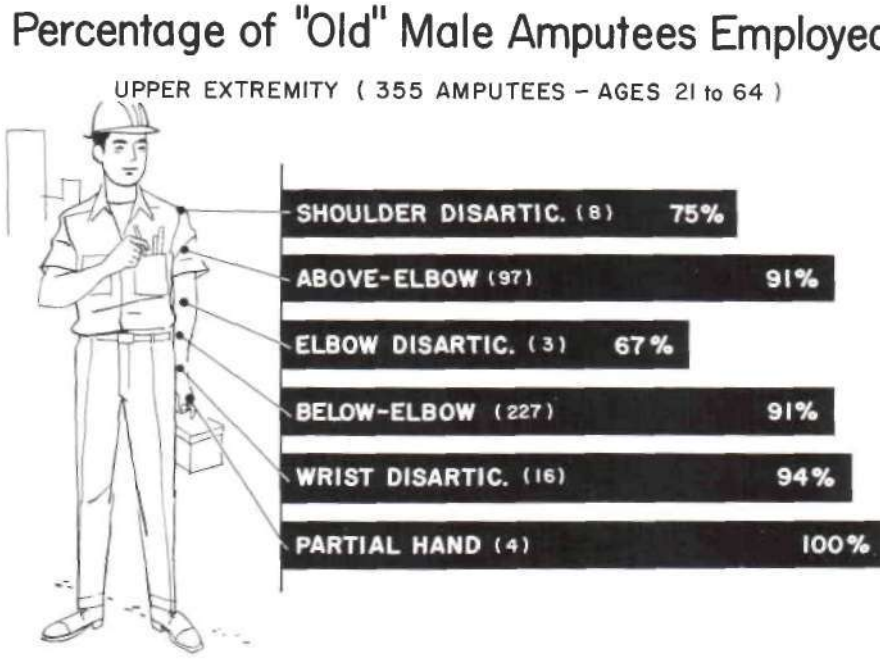


Fig. 10

WORK STATUS

The work status of "old" male amputees between the ages of 21 and 64, with 2,694 amputations, was reported. "New" amputees were not studied, since the majority of the group had not yet had time to return to employment. Eighty-four per cent of the "old" amputees in the cited age group were employed, the highest employment rate (89 per cent) occurring in the 41- to 50-year-old age group (Fig. 9). In each of the age groups studied, a higher rate of employment was reported for upper-extremity than for lower-extremity amputees. It should be noted here that only 6.4 per cent of amputees between the ages of 21 and 64 were reported as not being gainfully employed. The remainder of the group (9.3 per cent) were students, retired, or fell into some other category. This percentage of unemployment is a little higher than that reported for the national average for the years 1965, 1966, and 1967 (4.5, 3.8, and 3.8 per cent respectively).

The rate of employment in relation to each upper- and lower-extremity amputation level appears in Figures 10 and 11.

Work status was reported for 383 female amputees between the ages of 21 and 64. Of this number, 200 were housewives, 148 were gainfully employed, and only 18 were not gainfully employed. Seventeen had either retired or reported their work status in some other category.

REFERRALS

The majority (58 per cent) of cases fitted at prosthetics facilities were referred by amputee clinics; 26 per cent were referred by physicians; 16 per cent were not referred. Of the "new" cases, 5 per cent were not referred to prosthetics facilities by either a clinic or physician,

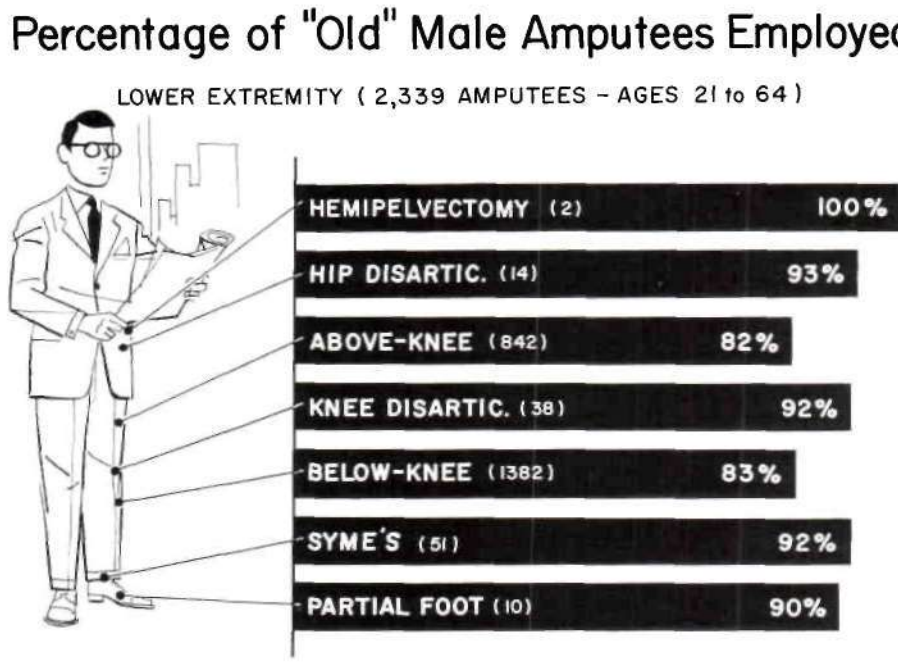


Fig. 11

as contrasted to the 26 per cent of the "old" cases not so referred.

MONTHS TO DELIVERY OF PROSTHESES

For "new" amputations, the time from amputation (or from birth for congenital amputees not requiring surgery) to date of delivery of the prosthesis was analyzed by level and cause for the five geographical regions (Table 21). The median period to delivery for all prostheses was 6 months. Comparing geographical areas, the median was 5 months for New England, the Midwest and West, 6 months for the South, and 7 months for the East Central region. Of the 3,588 prostheses with times to delivery reported, 71 were delivered in 1 month or less, 67 were not delivered for 99 months or longer. Thirty-seven of the latter were for congenital amputations not requiring surgery, i.e., 37 children were not fitted with their first prosthesis until after the age of eight years, three months. A comparison of time to delivery by levels indicated that the median time lapse was 5 months for the below-knee prosthesis and 6 months for all other levels. Time to delivery of prostheses ranged from a median of 4 months for below-knee prostheses in the New England area and the West to a median of 10 months for below-elbow prostheses in the East Central region. These data will provide a basis for later comparisons in areas where programs of immediate and early prosthetic fitting have been instituted.

Data on months to delivery were analyzed by cause of amputation and related to geographical regions (Table 22). The shortest median length of time for delivery was 3 months for congenital amputees who had had surgery. The longest time was for congenital amputations without surgery, where the median was 31 to

TABLE 21. MEDIAN NUMBER OF MONTHS TO DELIVERY OF PROSTHESIS BY LEVEL AND AREA, 3,588 "NEW" CASES

Level	New England	East Central	South	Midwest	West	Median of Total Cases
Above elbow	6	9	7	5	5	6
Below elbow	6.5	10	6.5	5	6	6
Above knee	5	7	6.5	5	5	6
Below knee	4	7	6	5	4	5
All other levels	8	8	6	5	5	6
Median no. of months, all levels	5	7	6	5	5	6

TABLE 22. MEDIAN NUMBER OF MONTHS TO DELIVERY OF PROSTHESIS RELATED TO CAUSE, 3,537 "NEW" CASES

Cause and No. of Cases	New England	East Central	South	Midwest	West	Median of Total Cases
Tumor (222)	4	5	4	4	5	4
Disease (2,119)	5	7	6	5	5	6
Trauma (1,015)	5	7	6	4	5	5
Congenital, with surgery (53)	3	6.5	3	3	--[a]	3
Congenital, without surgery (130)	31–36[b]	25–30[b]	37–48[b]	37–48[b]	--[a]	31–36[b]

[a] Too few cases for data to be valid.

[b] Median range.

36 months; however, it should be recognized here that this median also represents the median age of congenital amputees not requiring surgery who were being fitted for the first time. Median time to delivery for amputations caused by tumor was 4 months; by trauma, 5 months; and by disease, 6 months.

AGE OF REPLACED PROSTHESES AND REASONS FOR REPLACEMENT

The average age of replaced prostheses for all patients was 6.1 years. For children up to 21 years of age, it was 2.5 years, and for adults, 6.7 years.

Comparisons of the ages of replaced prostheses for above- and below-elbow and above- and below-knee amputees in relation to the age of the patient (by decade) are shown in Table 23. In almost every instance, the "life" of the prosthesis increased with the age of the patient. The average life of above-elbow prostheses for 124 amputations was 9.2 years. The range was from 2.5 years for the child through the age of 10 years to 16.7 years for amputees over the age of 61. The average age of below-elbow prostheses for 349 amputations was 6.5 years, ranging from 2.5 years for the child through age 10, to 10.3 years for amputees over age 51. The average age of above-knee prostheses for 1,269 amputations was 6.2 years, with a range from 2.2 years for the child in the first decade, to 8.1 years for amputees over age 71. The below-knee prosthesis

TABLE 23. AVERAGE AGE (YEARS) OF REPLACED PROSTHESES ($N = 3,943$)

Age of Patient	Below Elbow (349 Cases)	Above Elbow (124 Cases)	Below Knee (2,201 Cases)	Above Knee (1,269 Cases)
0–10	2.5	2.5	1.7	2.2
11–20	2.8	4.2	2.5	3.1
21–30	4.0	6.0	4.1	4.7
31–40	7.9	8.6	4.9	6.0
41–50	7.7	10.0	5.8	6.5
51–60	10.3	12.1	6.8	7.1
61–70	} 10.3	} 16.7	7.8	7.0
71+			8.6	8.1
Average age of prosthesis	6.5	9.2	5.8	6.2

TABLE 24. AGE OF REPLACED PROSTHESES RELATED TO CAUSE OF AMPUTATION AND SEX ($N = 4,279$)

Cause	Males		Females		Total No. of Cases	Average Age (Years)
	No. of Cases	Average Age (Years)	No. of Cases	Average Age (Years)		
Congenital	265	3.7	206	3.2	471	3.5
Tumor	65	4.5	61	5.6	126	5.0
Disease	543	5.0	171	5.1	714	5.1
Trauma	2,608	6.7	256	7.1	2,864	6.8
Not reported	87	6.5	17	7.9	104	6.7
Total	3,568	6.2	711	5.4	4,279	6.1

had the shortest life, averaging 5.8 years for 2,201 amputations, and ranging from an average of 1.7 years for the child through age 10, to 8.6 years for amputees over 71 years of age.

In comparing ages of replaced prostheses by cause of amputation and the sex of the amputee, it is found that prostheses for congenital amputees had the shortest life, averaging 3.5 years, and prostheses for traumatic amputees had the longest life, averaging 6.8 years (Table 24). The growth rate of children in the congenital group undoubtedly accounts for the more frequent replacements of prostheses evident here. Replacement of prostheses for patients in the disease category occurred, on average, every 5 years, and there was very little difference between replacements for males and females. The life of prostheses for tumor patients also averaged 5 years; however, prostheses for males in this category needed more frequent replacement, lasting 4.5 years as compared with an average 5.6 years for females.

It is interesting to note that the age of replaced prostheses for males averaged 6.2 years, and that of females 5.4 years. The large number of males in the trauma category may account for this difference, inasmuch as the average life of prostheses in this category is longer than in others.

Table 25 indicates the reason for replacement of prostheses. The majority of prostheses were replaced because they were worn out. "Worn out" was listed as the sole or contributing cause of replacing

TABLE 25. REASONS FOR PROSTHESIS REPLACEMENT

Reason	Percentage of Times Cited, Singly or in Combination				
	Tumor	Congenital	Trauma	Disease	Total
Worn out	50	33	67	44	58
Outgrown	12	52	6	4	12
Unsatisfactory	6	5	4	4	4
Stump shrinkage	7	1	5	14	6
Weight loss	12	3	7	10	7
Weight gain	8	1	5	11	6
Change type of prosthesis	1	--	1	1	1
Provide two prostheses	1	1	1	--	1
Other	3	4	4	12	5

a prosthesis in 58 per cent of the cases. It was the leading reason for replacing prostheses of persons whose amputations were caused by tumor (50 per cent), trauma (67 per cent), and disease (44 per cent). As would be expected, the primary reason for replacing prostheses of congenital amputees was that the prosthesis was "outgrown." In 52 per cent of replacements for congenital amputees, the prosthesis was outgrown; in 33 per cent of the cases it was worn out.

"Unsatisfactory" was cited as the reason for replacement in four per cent of the cases. However, it should be noted that although the "unsatisfactory" category was meant to include only those cases in which problems arose relating to fabrication or patient tolerance, it was often cited for other reasons which rendered the prosthesis unsatisfactory. Had this item

TABLE 26. AVERAGE AGE OF "WORN OUT" PROSTHESES RELATED TO AMPUTATION LEVEL, 2,898 CASES

Level and No. of Cases	Average Age of Prosthesis (Years)
Above elbow (103)	10.0
Below elbow (236)	8.1
Above knee (893)	7.6
Below knee (1,489)	7.3
All other (177)	7.4
Total (2,898)	7.6

been interpreted correctly, the percentage undoubtedly would have been lower.

The average age of all "worn out" prostheses that were replaced was 7.6 years (Table 26). This exceeds the average age of prostheses replaced for any reason (6.1 years) by a year and a half. This higher age undoubtedly reflects the longer life of the prostheses of traumatic amputees reported above, since "worn out" was the sole or contributing factor for 67 per cent of the replacements in the trauma category. Additionally, the lower average age of all the replaced prostheses was affected by the inclusion of children's prostheses, which had shorter lives.

COMPONENTS FOR UPPER-EXTREMITY PROSTHESES

The components most frequently used for upper-extremity prostheses at the above- and below-elbow levels are depicted in Figure 12. The voluntary-opening hook was used with 87 per cent (201 instances) of the above-elbow prostheses and 90 per cent (517 instances) of below-elbow prostheses. The preference for this type of hook was reflected in all areas except the West, which showed a preference for the voluntary-closing hook with below-elbow prostheses. New England was the only area that did not prescribe the voluntary-closing hook at all.

The hand-type terminal device was utilized to a limited extent, being prescribed 309 times as opposed to the hook-type device which was prescribed 806 times. Many amputees for whom hooks were prescribed were also equipped with hands. Where hand-type devices were reported, the voluntary opening hand was prescribed for above-elbow prostheses 40 per cent of the time (36 cases) and for below-elbow prostheses 36 per cent of the time (79 cases). Both the East Central and Midwest areas preferred voluntary-closing hands for use with above-elbow prostheses. The East Central and Western areas preferred voluntary-closing hands for below-elbow prostheses. New England showed a preference for the passive hand with the below-elbow prosthesis.

The simple friction wrist unit was overwhelmingly preferred to quick-change types in all geographical areas, being used with 83 per cent of above-elbow and 85 per cent of below-elbow prostheses.

Although the triceps pad was used with 56 per cent of the below-elbow prostheses, its use ranged from 35 per cent in the South to 94 per cent in the New England area. The South preferred the half cuff. Plastic laminate was the cuff material of choice in 61 per cent of the total cases, although the East Central and Western areas preferred leather to the extent of 54 per cent and 55 per cent respectively.

The double-wall socket was used in 89 per cent of the above-elbow and 77 per cent of the below-elbow prostheses. Preflexed sockets, some of which also had double walls, were used in 11 per cent of the below-elbow prostheses. Sixty-one per cent of the preflexed sockets were utilized by children.

In 98 per cent of the upper-extremity prostheses, the sockets were made of plastic.

The elbow unit with internal lock was the item of choice for above-elbow prostheses in all geographical areas, being used in 78 per cent of all fittings. Seventeen per cent of all elbow units had spring-flexion assists. Sixty-four per cent of the elbow hinges used in below-elbow prostheses were flexible, the range being from 44 per cent in the West to 92 per cent in New England. The Midwest showed almost equal preference for the single-pivot (47 per cent) and the flexible hinge (50 per cent).

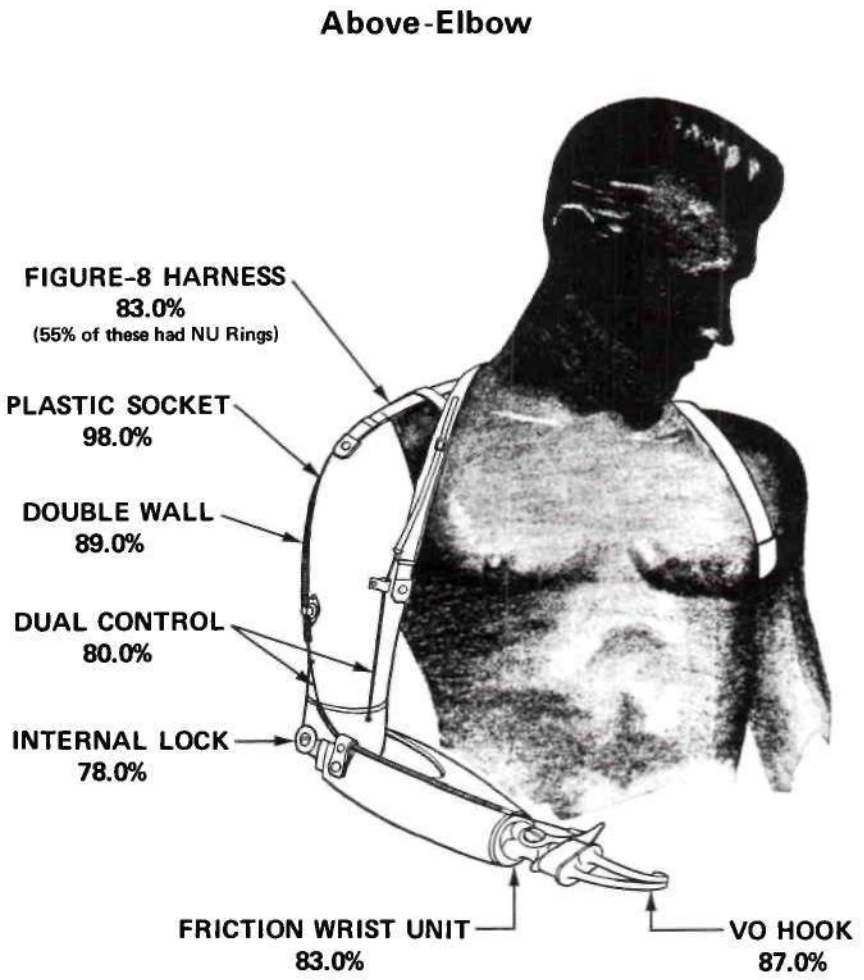


Fig. 12a. Most frequently used components for above-elbow prostheses.

Dual-control systems were used in 80 per cent of above-elbow and single control in 96 per cent of the below-elbow prostheses.

Eighty-three per cent of the harnesses for above-elbow prostheses were of the figure-eight type, the majority of this group (55 per cent) being equipped with the Northwestern University harness ring. The East Central area and the West showed a preference for the figure-eight harness without the ring. Of the 14 cases with reported type of harness in the West, none used the ring with the figure-eight. The South used the ring to the greatest extent for above-elbow prostheses. Ninety-two per cent of the below-elbow harness were of the figure-eight type, 59 per cent of these being equipped with rings. The East Central, South, and Midwest areas showed greatest preference for the ring figure-eight harness; the New England and Western areas used the figure-eight harness without the ring almost as often as with it.

COMPONENTS FOR LOWER-EXTREMITY PROSTHESES

Components most frequently used for above- and below-knee prostheses appear in Figure 13. The various geographical areas showed more consistency in pre-

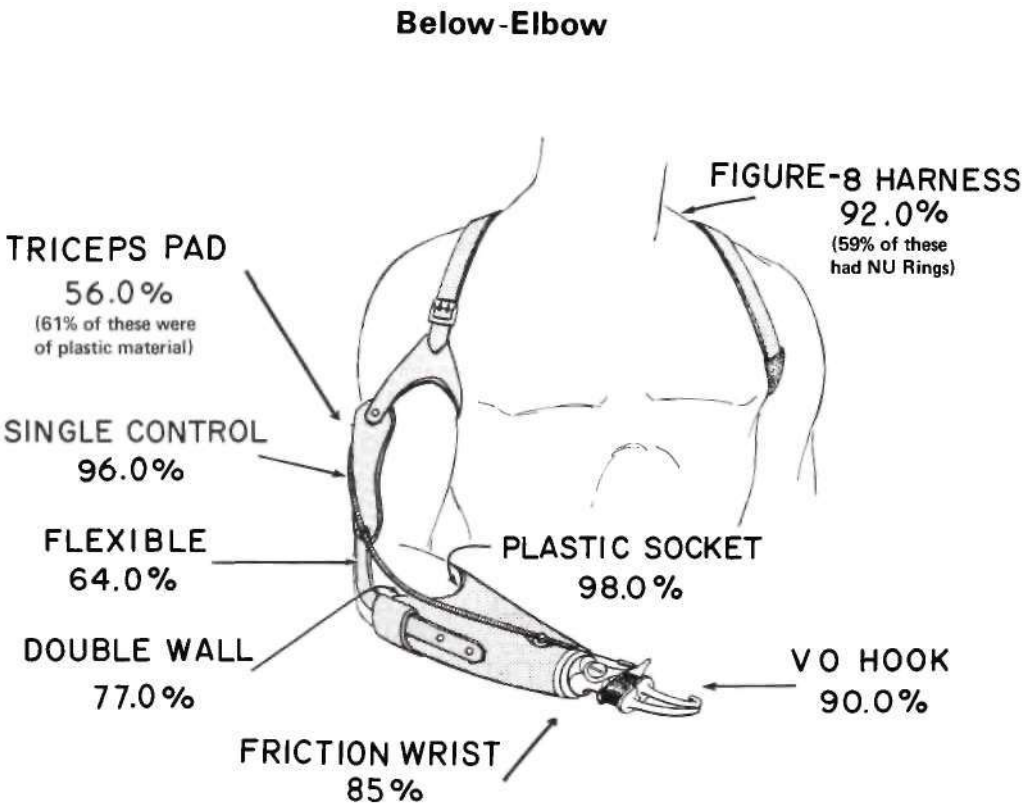


Fig. 12b. Most frequently used components for below-elbow prostheses.

scription of lower-extremity than upper-extremity components. In most instances, only the percentage varied, not the type of component.

The SACH foot was prescribed for 55 per cent of the above-knee and 73 per cent of the below-knee prostheses. In area comparisons, the South showed the greatest usage of the SACH foot, and the Midwest the lowest. For the above-knee prosthesis, prescription of the SACH foot rose from 76 per cent in the first to 83 per cent in the second decade, and then gradually declined with advancing amputee age. In the below-knee group, the SACH foot was prescribed 96 per cent of the time for children under 10 years of age; the percentage declined steadily to a low of 56 per cent in the eighth decade, then rose to 63 per cent for the group of amputees 81 years of age and over.

Wood was used as the shank material in 95 per cent of the above-knee and in 90 per cent of the below-knee prostheses.

The most frequently used knee component for above-knee prostheses was the single axis, with friction being used in 74 per cent of the fittings. Twelve per cent of the knees were single axis with manual locks. Eight per cent of the knees were hydraulic, with the West showing the greatest preference (17 per cent) and the Midwest the least (4 per cent). In instances where metal joints were reported for below-knee prostheses, the lap joint was specified in 48 per cent of the cases and the clevis joint in 22 per cent. The type of joint was not specified in 30 per cent of the cases.

For above-knee amputees, the quadrilateral socket was used in 85 per cent of the prostheses. It was the overwhelming

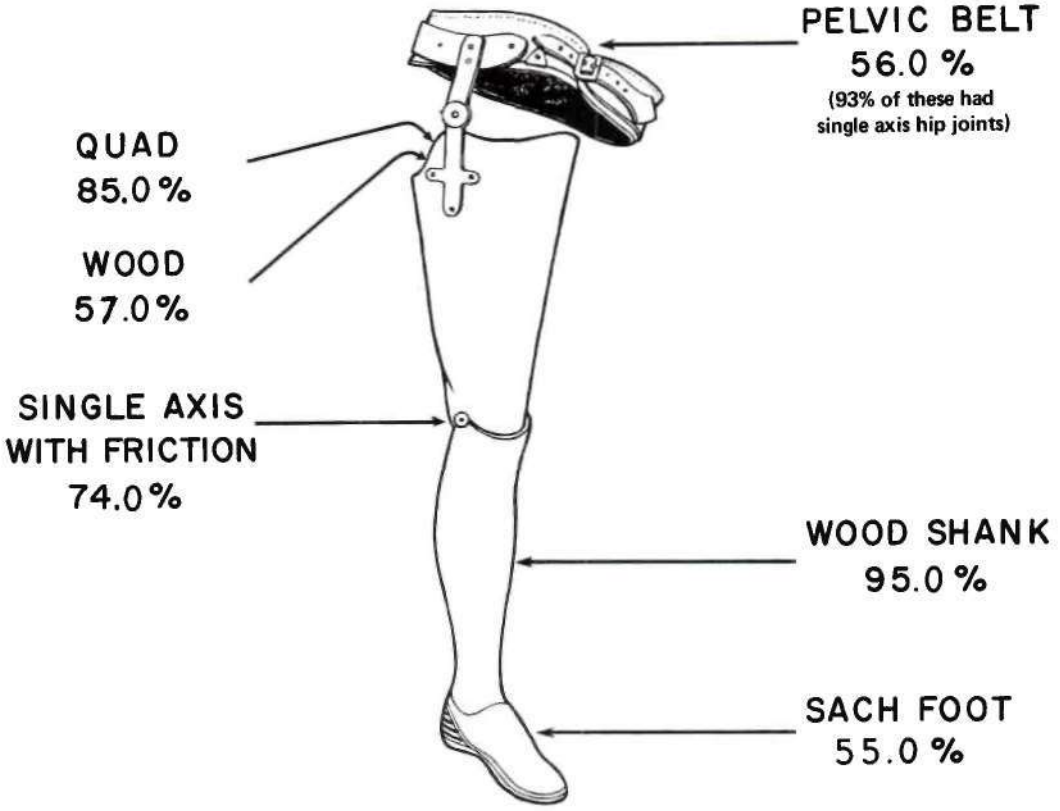


Fig. 13a. Most frequently used components for above-knee prostheses.

choice in each of the geographical areas. The socket of choice for below-knee amputations was the patellar-tendon-bearing. Preference for this socket averaged 58 per cent, the South and West showing greatest utilization, 79 per cent and 82 per cent respectively, and the New England and Midwest areas the least utilization, 44 per cent and 47 per cent respectively.

Wood was used most often for above-knee sockets, averaging 57 per cent, although the South showed a preference for plastic, using it for 55 per cent of all sockets. Below-knee sockets were most often (55 per cent) fabricated in plastic. New England showed a preference for leather sockets, and the Midwest preferred wood (41 per cent) to either plastic or leather.

The pelvic belt was the preferred method of suspension (56 per cent) for above-knee prostheses. Only in the West did the use of suction, either alone or in combination with other suspension, exceed the use of the pelvic belt. In correlating methods of suspension with age, it was noteworthy that during the second, third, and fourth decades, suction alone was preferred to all other types of suspension. In all other decades, the pelvic belt was preferred.

In considering types of suspension reported for all below-knee prostheses, the knee cuff alone was the choice of suspension in 36 per cent of the cases. It was least used in the Midwest (22 per cent). The South and West utilized the knee cuff alone most frequently (55 per cent). When type of suspension for the patellar-tendon-bearing prosthesis is analyzed by age group, it is found that, while the knee cuff alone was used for 62 per cent of all

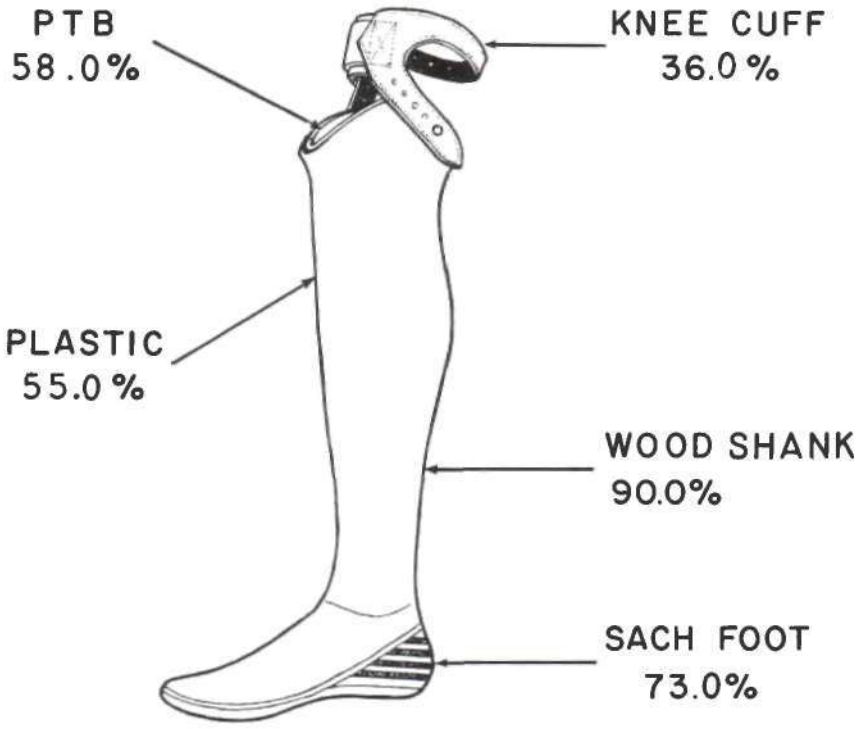


Fig. 13b. Most frequently used components for below-knee prostheses.

the prostheses, greatest usage occurred in the second decade (73 per cent) and next greatest in the third decade (71 per cent). Least use of the knee cuff alone occurred in the very young child (48 per cent), but the inclusion of cases where a waist belt was used in conjunction with the knee cuff raised this percentage to 68.

SOURCES OF PAYMENT

Tables 27, 28, and 29 indicate the sources of payment for prostheses. More than one source was sometimes listed, in which case they are reported under "combinations of the above "or" "other". Medicare had been in operation only one year prior to the conclusion of this study and presumably would rank considerably higher as a source of payment at the present time. As mentioned earlier, over 23 per cent of the amputees in this study were in the Medicare age bracket.

Source of payment was given for 8,631 prostheses (Table 27). The greatest contributors to defraying the costs of prostheses were State Bureaus of Vocational Rehabilitation (22.5 per cent) and the patient himself (22.8 per cent). Next in order were the Veterans Administration (14.3 per cent), welfare (10.8 per cent) and insurance (9.9 per cent).

The Children's Bureau paid for 46.5 per cent of the prostheses for children up to the age of 21. Through the wage-earning years, 21 to 64, State Bureaus of Vocational Rehabilitation paid for 31.9 per cent of the prostheses, the amputee for 24.3 per cent, and the Veterans Administration for 19.3 per cent. During the retirement years, 65 and over, the amputee alone paid for 29.9 per cent of the prostheses, Social Security and Medicare for 19.5 per cent, and welfare for 15.3 per cent.

A further analysis of sources of payment relating to the wage-earning years yields some interesting facts (Table 28). The Veterans Administration paid for 30 per

TABLE 27. SOURCE OF PAYMENT FOR PROSTHESES BY AGE GROUP
($N = 8,631$)

Source of Payment	Age Group: Number of Cases and Percentage of Category Total				Total
	Age Not Reported	Children	21–64 Years	65 and Older	
Self	31	28 (2.5)	1,317 (24.3)	592 (29.9)	1,968 (22.8)
Bureau of Vocational Rehabilitation	21	49 (4.3)	1,729 (31.9)	145 (7.3)	1,944 (22.5)
Veterans Administration	16	6 (0.5)	1,044 (19.3)	172 (8.7)	1,238 (14.3)
Welfare	10	200 (17.7)	416 (7.7)	302 (15.3)	928 (10.8)
Insurance	13	70 (6.2)	681 (12.6)	90 (4.5)	854 (9.9)
Children's Bureau	6	525 (46.5)	13 (0.2)	--	544 (6.3)
Social Security (Medicare)	4	--	10 (0.2)	386 (19.5)	400 (4.6)
Family	1	190 (16.8)	39 (0.7)	27 (1.4)	257 (3.0)
Combinations of above and "other"	--	62 (5.5)	170 (3.1)	266 (13.4)	498 (5.8)
Total	--	1,130	5,419	1,980	8,631

TABLE 28. SOURCE OF PAYMENT ("OLD" AND "NEW" PROSTHESES) FOR THE 21–64 WAGE-EARNING YEARS

Source	Males			Females		
	"Old" (%)	"New" (%)	Total (%)	"Old" (%)	"New" (%)	Total (%)
Bureau of Vocational Rehabilitation	32	28	31	43	34	38
Veterans Administration	30	10	23	1	1	1
Self	23	22	22	39	35	37
Insurance	8	24	14	2	7	5
Welfare	5	10	7	8	13	11
Combinations of above and "other"	2	6	3	7	10	8

TABLE 29. SOURCE OF PAYMENT RELATED TO EMPLOYMENT DURING THE 21–64, WAGE-EARNING YEARS ("OLD" CASES ONLY)
($N = 3,055$)

Source	Gainfully Employed		Not Gainfully Employed		Other	
	No.	%	No.	%	No.	%
Bureau of Vocational Rehabilitation	830	35	52	28	134	28
Veterans Administration	668	28	51	27	78	17
Self	599	25	17	9	145	31
Insurance	180	7	18	10	23	5
Welfare	68	3	45	24	60	13
Combinations of above and "other"	55	2	4	2	28	6
Total	2,400		187		468	

cent of replacement prostheses, but only 10 per cent of new prostheses. This statistic doubtless reflects the continuing supply of prostheses to veterans of World War II and the Korean War and a decreased number of fresh cases. More "new" male amputees were supported by insurance or compensation than "old" male amputees, 24 per cent as opposed to 8 per cent. This may reflect the policy of some insurance companies to pay for the first prosthesis only. On the other hand, it may indicate an increase in opportunity for insuring oneself against disability and a greater awareness of the values of health insurance. In comparing source of payment for males and females in this age group, one notices the higher level of support by the amputees themselves and the Bureaus of Vocational Rehabilitation for the female group, and also the very low percentage of females supported by insurance or compensation.

In correlating source of support with occupation, only "old" amputees were considered, since in most instances "new" amputees had not yet returned to work at the time the data forms were submitted. Amputees were studied in three categories: those gainfully employed, those not gainfully employed, and those who were students, housewives, or retired (Table 29).

Of the 3,055 "old" cases included above, only 187, or 6 per cent, were reported as not being gainfully employed. The Bureaus of Vocational Rehabilitation paid for 35 per cent of the prostheses for the gainfully employed group, the Veterans Administration for 28 per cent, and the amputee for 25 per cent. For the group of amputees not gainfully employed, the Bureaus of Vocational Rehabilitation were the source of payment for 28 per cent of the prostheses, the Veterans Administration for 27 per cent, and welfare for 24 per cent. In the 468 amputations of students, housewives, or retired amputees, 31 per cent of the prostheses were paid for by the amputee, 28 per cent by the Bureaus of Vocational Rehabilitation, and 17 per cent by the Veterans Administration.

DISCUSSION

In recent years, there has been increasing interest in defining the characteristics of the amputee population, and also in providing amputees with functional stumps and prostheses. Much progress has been made in understanding the amputee and his problems, and in the fabrication of improved prosthetic components. This study has sought to document some of the characteristics of the amputee and his prosthesis during a particular period in time—the approximately two years ending June 30, 1967.

Certain characteristics of amputees, namely sex and age, and the cause, side, and site of amputation, were well established in Glattly's study of 12,000 new amputees for whom data were collected over a two-year period, ending in 1963. In the present study of over 8,000 amputees, 4,034 of whom were new, data were likewise collected over a two-year period which ended in 1967, four years later. Unless some catastrophic event had occurred immediately before or during either of the two periods, it would be expected that in large samples such as these, the sex and age of the amputee and side and cause of the amputation would be relatively constant. Such was indeed the case, indicating that the sample in the latest study was a valid cross-section of the amputee population. As noted before, neither the Medicare Act nor the conflict in Vietnam had exerted a significant impact on this study. Although medical advances over a number of years have been largely responsible for the increasing age of the amputee, with a resulting shift from trauma to disease as a predominant cause of amputation, such changes would not be expected to exert a significant difference in as short a period as four years.

In amputations caused by disease, the site of amputation can be influenced by

medical judgment at a particular time. In the vast majority of cases where amputation is categorized as disease, the amputees had vascular insufficiency. For this condition, amputation at a level above the knee had been widely advocated for many years because it was felt that this procedure facilitated healing. It has been found, however, that amputation may be performed at a below-knee level, with primary healing occurring in the majority of cases (6). By preserving the knee joint, amputation at this level greatly enhances the rehabilitation potential of the patient.

Burgess has reported that most below-knee amputations for ischemia heal primarily, and with proper prosthetic care do not break down (7). Lim reports that 92 per cent of below-knee amputations were successful when a popliteal pulse was present, and 75 per cent were successful when pulse was absent (5). He also reports a lower mortality rate for below-knee amputees, 16 per cent as opposed to 35 per cent for above-knee amputations. Tracy cites a 90 per cent successful healing rate for below-knee amputations for ischemic gangrene *(8).*

Although the increase in the percentage of below-knee amputations in our study, as compared with the Glattly study, is relatively small in view of the *potential* increase, it is nevertheless an encouraging trend, and it is to be hoped that a dramatic increase will be reflected in future surveys as the results of ongoing educational programs take effect.

Although the incidence of amputations due to trauma appears to have declined, as far as percentage of the total amputee population is concerned, this does not necessarily imply a decrease in the overall incidence of traumatic amputations. Actually, the increasing age of amputees, with its corollary of increasing incidence of amputations due to disease, is certainly partly responsible for the decline in percentage of trauma cases. In the younger age groups, trauma continues as the major cause of amputations. The Public Health Service report *(9)* published in 1964 shows that "absence of major extremity," classified as an accident "while at work," occurred almost three times as often as amputation caused by "moving motor vehicles." In the present study, the ratio was closer to 1:1 than 3:1, i.e., moving vehicles as a cause of traumatic amputations was almost equal to that of industrial accident. A higher percentage of auto accidents than industrial accidents occurred in the female group, a pattern which is typical of other reported findings. These results may indicate improved safety controls in industry, or may underscore the soaring rate of automobile accidents, or both. The large number of amputations resulting from trauma continues to have strong implication for improved accident-prevention programs and more effective human-factors engineering. The need for greater safety of design, particularly in cars and industry, continues to be great.

It is of interest to note that prosthetic prescription varied among the geographical areas, some areas having a greater tendency than others to incorporate newer prosthetic techniques. It might be expected that the latest prosthetic developments would be incorporated into prosthetic practice in those areas which were near the prosthetic—orthotic educational centers (New York, Chicago, and Los Angeles) or in areas of greatest concentration of prosthetic facilities (California, Pennsylvania, New York, and Illinois), or amputee clinics (New York, Pennsylvania, California, and Texas). With the exception of the West, where newer developments were used in a high percentage of cases, there appeared to be no relationship between the nature of prosthetic services provided and the factors cited above. Both the South and the West showed a more consistent use of newer techniques than did the other areas.

The provision of prosthetic services reported in the study indicates that much improvement is to be desired as far as length of time for delivery of the prosthesis is concerned. The time between

the date of amputation (or reamputation) and delivery of the prosthesis was inordinately long, ranging from a median of four months for patients whose amputations were caused by tumor to six months for patients with vascular disease. The provision of temporary prostheses and immediate postsurgical fitting of prostheses would help shorten this time lag.

The finding that a relatively high percentage of congenital amputees (32 per cent) were not fitted until after their eleventh birthday is distressing. Since current philosophy is to fit congenital amputees at a very early age, it would be interesting to know the reason for this reported delay. Whether the fault lies with amputee clinics, or with parents who are either reluctant to take their children to clinics or are ignorant of the prosthetic opportunities available to them, is not evident from the present analysis. The implication is that more needs to be done at the educational level. The growth and implementation of dynamic treatment programs would surely result in a much more optimistic picture.

A composite picture of amputees reported in this study would present the following profile:

1. The congenital amputee seen in prosthetic facilities was a male under 10 years of age with involvement at the below-knee level.

2. The amputee whose amputation was caused by tumor was a male between 11 and 20 years of age whose amputation was at the above-knee level.

3. The traumatic amputee was a male now between the ages of 41 and 50 years who had received his amputation between the ages of 21 and 30 years. His amputation was at the below-knee level and was most likely received as a result of a car accident, industrial accident, or war injury.

4. The amputee whose amputation was caused by disease was also a male, between the ages of 61 and 70 years, who was amputated during these same years. His amputation was as likely to be at the above-knee level as at the below-knee level.

SUMMARY

1. This study, which extended over a two-year period ending in June 1967, presents data on 8,323 amputees with 8,698 amputations, all of whom were fitted with prostheses.

2. Of the "new" amputations seen in prosthetic facilities, 60 per cent were caused by disease, 29 per cent by trauma, 6 per cent by tumor, and 5 per cent were of congenital origin.

3. Of all amputations, "new" and "old," being fitted in prosthetic facilities, 50 per cent were caused by trauma, 37.3 per cent were caused by disease, 8.4 per cent were of congenital origin, and 4.3 per cent were caused by tumor.

4. The greatest incidence of disease-caused amputations occurred in the seventh decade, those of trauma in the third decade, and those of tumor in the second decade.

5. Males outnumbered females in every category, the ratio for "new" amputations of males to females being approximately 2:1 for disease, 10:1 for trauma, and 1.2:1 for both congenital causes and tumor.

6. Eighty-six per cent of the total number of amputations were of the lower extremity, with 53 per cent of this group being at the below-knee level.

7. Although automobile accidents were cited as the single greatest cause of all traumatic amputations, war injuries, industrial accidents, and automobile accidents were cited almost equally for male amputees.

8. Forty-eight per cent of all reamputations were in the disease category, 60 per cent of these occurring within two and one-half months of the original amputation. The reamputation rate for below-knee amputations caused by disease was not significantly higher than that for trauma-caused amputations—approximately 6 per cent in both instances.

9. Degree of contracture reported at both hip and knee varied inversely with

the length of the stump. Excluding contractures of less than 5 deg, the average hip flexion contracture for above-knee amputations was in the 5-9 deg range; the average knee flexion contracture for below-knee amputations fell in the 10-14 deg range. Fifty-two per cent of those cases reporting presence or absence of contractures had either no contracture or one of less than 5 deg.

10. Unemployment rate for "old" male amputees between the ages of 21 and 64 was 6.4 per cent, slightly higher than the national average for the years covered by the report.

11. Fifty-eight per cent of patients were referred to prosthetic facilities by amputee clinics, 26 per cent by physicians, and 16 per cent were not referred.

12. The median time from amputation to delivery of a prosthesis was six months, the below-knee prosthesis being delivered in the shortest length of time. Congenital amputees who required surgery received prostheses in a median time of three months postsurgery. Patients in the disease category waited the longest time—six months.

13. Prostheses had an average life of 6.1 years, with the life of the prosthesis increasing with the age of the patient. Below-knee prostheses generally and prostheses for congenital amputees had the shortest life. Prostheses for males lasted longer than those for females. "Worn out" was the primary reason given for replacing a prosthesis.

14. Prosthetic prescription varied in the geographical areas, some regions demonstrating a greater tendency than others to incorporate newer prosthetic techniques. Generally, as the age of the amputee advanced, there was a tendency to use the older types of components, e.g., pelvic hands, articulated ankles.

15. The Children's Bureau was the largest single source of financial support for the purchase of prostheses for children, and the State Bureaus of Vocational Rehabilitation provided the greatest financial support for amputees during the wage-earning years. The Veterans Administration paid for a high percentage of prostheses for males who were in the "old" category. In all, the federal government paid entirely for 48 per cent of all prostheses and provided partial support for another 3 per cent.

ACKNOWLEDGMENTS

Grateful appreciation is extended to the 44 facility owners and their staffs who provided the data on which this study is based.

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The Use of External Support in the Treatment of Low Back Pain

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1 HE origin of therapeutic procedures can generally be traced to local efforts directed toward resolving continuing disability of the patient. In the treatment of low back pain, this approach often included designing special supports by individual physicians and orthotists. Such independent activity in numerous locales resulted in a long list of brace designs, many of which carry impressive eponyms that tend to stress differences rather than elements of commonality.

To compile the available information concerning bracing, the American Academy of Orthopaedic Surgeons published the *Orthopaedic Appliances Atlas (1)* in 1953. Of the 30 types of spinal support described in that volume, 17 were specifically designed for the sacroiliac or lumbosacral areas. Ten years later, in 1962, a survey of orthopedic services in the United States by Nattress and Litt (2) identified 30 braces, of which 22 corresponded to the design customarily considered effective at the lumbosacral region. These two reports, along with the present study, described a total of 40 different devices designed for low back problems.

Details of designs are readily available, but objective criteria to weigh the relative merits of the different devices are almost nonexistent. As a consequence, physicians generally make their selection either by adopting the customs observed during their training, or by accepting the preference of the local orthotist. Undoubtedly, some braces have withstood the test of time, while others have become items only of historical interest. Superimposed on this background, the more recent introduction of prefabricated parts for brace construction has probably influenced the frequency with which certain types of braces are prescribed.

The extent to which these influences have altered the availability and prescription of brace designs today has not been reported. Also unknown is the nature of the relationship between the etiology of the low back pain and the type of support that clinicians have found to be effective. Identification of this type of information is pertinent because the subject of orthotics is now being presented in formally organized courses on a nationwide basis.

This paper records the results of a three-phase study conducted in 1968-69 by the Subcommittee on Orthotics, Committee on Prosthetic-Orthotic Education (CPOE) of the National Research Council. Approval of the Executive Committee of the American Academy of Orthopaedic Surgeons was obtained. The purpose of the survey was to identify the current practices of orthopedic surgeons with respect to external supports for the management of low back pain.

METHOD

PILOT STUDY

An unstructured pilot questionnaire was sent to 150 orthopedic surgeons selected because of their considerable experience in the management of low back pain. They were asked to list the types of support they prescribed, and to indicate the clinical conditions for which each support

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was chosen. The results of this pilot study formed the basis for the next phase of the investigation.

The 90 physicians (60%) who responded were explicit in their choice of a device and the clinical indication for its use. Eighty-three reported frequent prescription of external support as part of their therapeutic program. (Two said they never used external supports, and five indicated they rarely prescribed such aids.)

Within each class of support (brace, corset, cast), a similar pattern of practice was evident. Numerous designs were listed, but most were mentioned only occasionally. The majority of the respondents preferred one or two types of support. Within a total of 12 different braces reported, three-fourths of the physicians listed the Chairback (Knight) and Williams braces (Figs. 1, 2, and 3). Six other designs were mentioned only once. Identification of corset preference was a bit clouded by the indiscriminate use of both generic and trade names. The generic term "lumbosacral" was specified by half of those responding. An additional one-fourth of the pilot-study participants used trade names such as Camp, Spencer, and Winchester. The next most frequently mentioned device was the sacroiliac belt (8%). Of the six casts identified, the flexion jacket was preferred by more than half of the pilot-study orthopedists; the second choice was the body jacket (19%).

In designating the clinical conditions warranting external support, two response patterns developed in the pilot survey. Seven types of disability were mentioned frequently and in explicit terms, viz., postoperative fusion, spondylolisthesis, chronic backache, acute strain, disc syndrome, degenerative joint disease, and the postoperative disc. Several other conditions, identified by a wide variety of terminology, were mentioned with moderate to rare frequency.

NATIONAL SURVEY OF AAOS

The findings of the pilot survey were used to construct a questionnaire applicable for a comprehensive national study. This questionnaire was sent to the membership of the American Academy of Orthopaedic Surgeons (AAOS). The form (presented at the end of this article) was a check sheet on which physicians were asked to match the types of support they prescribed with the clinical conditions they treated in this manner.

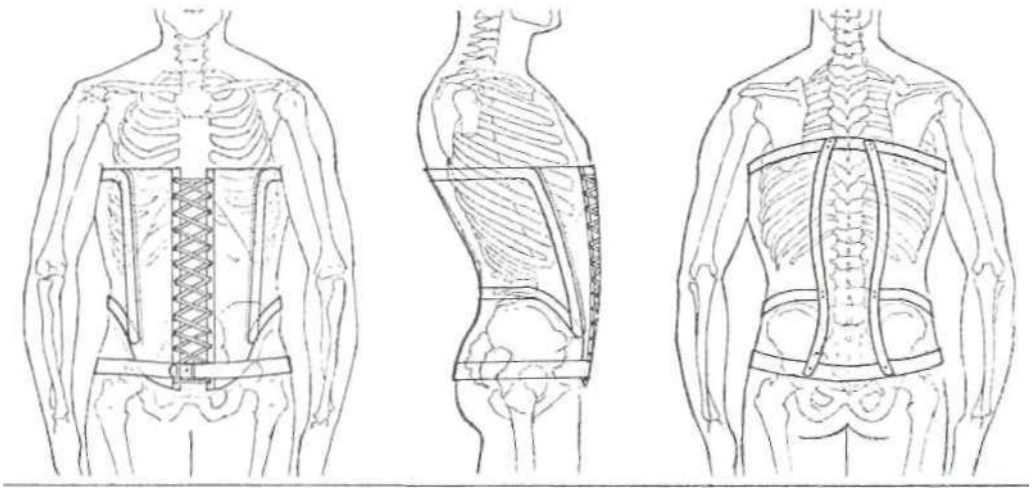

Fig. 1. The Knight dorsolumbar brace.

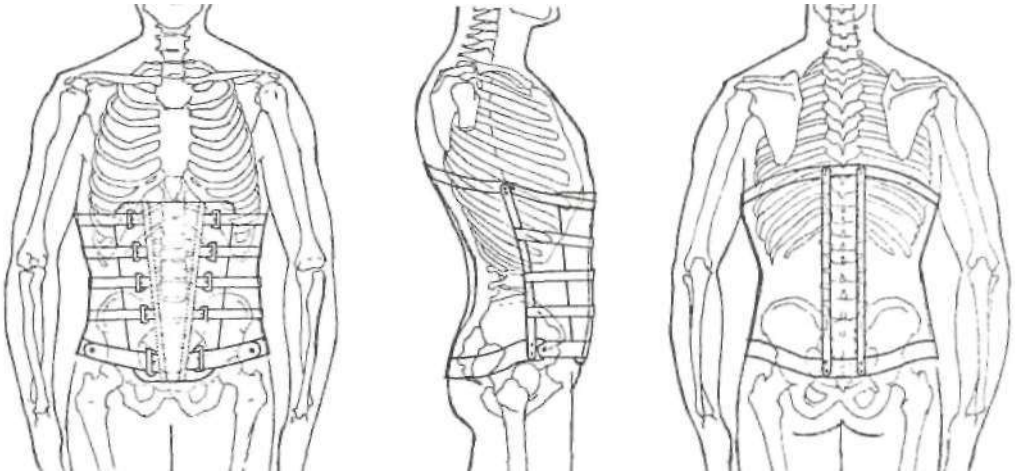

Fig. 2. A typical modification of the Knight brace.

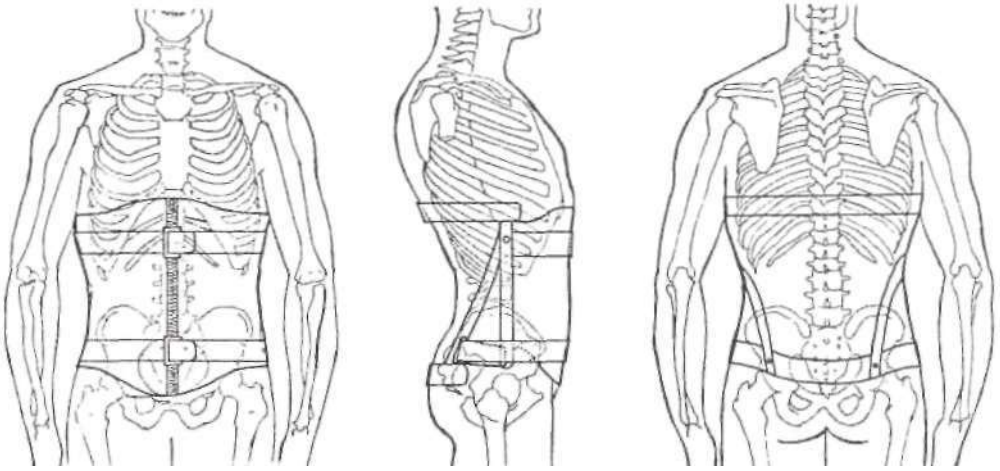

Fig. 3. The Williams lumbosacral brace. (Illustrations from *Orthotics for Physicians and Therapists,* Prosthetic-Orthotic Education, Northwestern University Medical School, Chicago, HI.)

The following supports, all of which were more than rarely mentioned in the pilot study, were included. (The restriction on corset choice was the result of a decision to use generic rather than trade names in order to avoid repeating the confusion produced in the pilot study.)

Braces

1. Chairback (Knight)
2. Williams
3. Norton-Brown
4. Goldthwaite
5. Bennett

Corsets

1. Lumbosacral
2. Sacroiliac

Casts

1. Flexion
2. Body jacket
3. Cast with one leg

Eleven clinical conditions were selected for the national inquiry, based upon the

returns of the pilot study and upon the clinical experience of the NRC committee. Provision was made throughout for physicians to indicate devices or clinical problems other than those listed on the form. The questionnaire was also designed to indicate the relative frequency ("usually" or "rarely") of the prescriptions.

SURVEY OF THE FUNCTIONS OF SUPPORT

Late in 1968, a second national survey was conducted among the AAOS membership to determine prevailing opinions about the functions of the various types of support. The purpose of this phase of the study was to attempt to relate the anticipated function of the external support to the different preferences in prescription.

Profiting from the findings of part one of the national survey, the list of supports was again shortened. This time, the orthopedists were queried about two braces (Williams and Chairback [Knight]); "corset" was listed as a single category, as were the flexion casts. A miscellaneous category was added for other comments. (The questionnaire appears on page 57.)

Six probable functions were selected for study. These included: immobilization of the spine, restriction of lumbosacral motion, unloading of the intervertebral disc, support of the abdomen, correction of posture, and psychological effect. As always, there was a provision for other choices.

RESULTS

On the first national survey, 5,215 questionnaires were mailed. With the aid of one follow-up, 3,140 (60%) were returned completed. An additional 1% of the returns were incomplete because the physicians had retired or their practices did not include patients with low-back problems.

In the second phase of the study, the same number of forms were sent out, with 2,192 (42%) being filled in and returned. No follow-up mailing was conducted,

Annotated responses or explanatory letters accompanied 1,034 (33%) of the questionnaires. These consisted of: (*a*) identification of the type of device they preferred if it was not specifically mentioned on the form; *(b)* comments regarding precise fitting or construction characteristics considered to be important; (*c*) reasons for not prescribing external support; and (*d*) other modes of treatment which should accompany use of a support.

USE OF SUPPORTS FOR LOW-BACK PROBLEMS

Most of the orthopedic surgeons indicated use of a judicious selection of braces, casts, and corsets; the average physician reported that he used three different devices in his practice. A small group stated that they used only one type of device: a brace (4%), a corset (4%), or a cast (1%). Only 14 respondents stated that they "never used support" for the patient with a low-back problem.

Among the clinical indications, the inclusion of the term "fracture" caused considerable confusion in the information collected. Either all types of braces are used for fractures in the "low back," or the orthopedist's attention was directed to fractures of the spine in general. The latter seemed highly probable, as most indicated that a brace other than those listed was used. Typically, these were the Jewett, Taylor, and Baker types, commonly used for lesions in the thoracic and thoracolumbar areas. As the extent of this confusion could not be identified, all data referring to "fracture" were omitted from the analysis.

Certain characteristics in the prescription of external support became evident. A majority of the profession used the same groups of devices. The nature of the disability dictated the frequency of prescription as well as the type of support preferred.

SUPPORT PREFERENCE

The lumbosacral corset is the most popularly used low-back support, followed by the Chairback (Knight) spinal brace. Utilization of the other types of

support fell far behind these two leaders (Table 1).

The degree of dominance by the lumbosacral corset varied with the method of comparison; 28.5% of the physicians indicated use of the lumbosacral corset for at least one condition. When all clinical indications were considered, preference for the lumbosacral corset was 44.2%. The Chairback brace was used by 21% of the physicians for 22% of the clinical conditions listed. All other types of support were used less than 9% of the time. The Williams brace was third in popularity. A variety of casts preceded any other choice of brace or corset (Table 1).

As "lumbosacral corset" is a generic term that overlooks design differences between the Camp, Winchester, Spencer, and other specific corset styles, a comparison was made with the designated preferences for the total group of "low-back braces." The relative preference between the corset and the low-back brace again depended on the method of comparison. The use of a brace at some time was indicated by 40.2% of the physicians, in comparison to 32.4% for corsets. However, when all the clinical indications were totaled, the preference reversed, with the corsets dominating (46.7% in contrast to 39.0% for braces).

Some geographic patterns for brace preference were found, especially for those used less frequently (Table 2). The middle and southeastern sections of the United States were the only areas where the Williams brace was used widely; it was fourth in preference on the West coast. With the exception of New York, no mention of it was made in the eastern or New England states. The Bennett brace was second in popularity in Maryland and third in Ohio. Predominance of the Norton-Brown *(3)* brace was restricted to Massachusetts and Maine, a note consistent with the fact that the originators are from Boston.

TABLE 1. SUPPORT PREFERENCE

Support	By Individual Physician (% Response)	For All Clinical Indications (%)
Lumbosacral corset	28.5	44.2
Chairback (Knight) brace	21.1	22.4
Williams brace	9.9	8.3
Body cast	9.2	6.3
Flexion cast	8.4	5.0
Body cast + 1 leg	6.0	2.6
"Other" braces	5.6	3.7
Goldthwaite brace	2.4	1.4
"Other" corsets	2.3	1.3
Bennett brace	2.1	1.9
Norton-Brown brace	1.5	1.3
Sacroiliac corset	1.6	1.2
"Other" casts	1.2	0.5

TABLE 2. SUPPORT PREFERENCE BY STATES

Support	Number of States with this Level of Preference		
	First	Second	Third
Lumbosacral corset	43.5[a]	5.5[a]	1
Chairback (Knight)	6.5[a]	35.5[a]	3
Williams	0	3.5[b]	19.5[b]
Body cast	0	1	10
Flexion cast	0	2	7
Bennett	0	1	1
Norton-Brown	0	0	2
"Other" braces	0	1	2

[a] Three states showed equal preference for the lumbosacral corset and Chairback brace, thus this value was divided between both columns.

[b] One state showed equal preference for the Chairback and Williams braces as second choice.

CLINICAL INDICATIONS

The survey form asked the physician to check whether he rarely or usually used some type of support for each of ten clinical conditions listed (Table 3). Three patterns of use were apparent. The responding physicians seldom used external support in the treatment of an acute strain (17%), for an obese person with pain (19%), or during the postoperative period following disc surgery (28%). When support was used for these conditions, it was generally a corset.

At the other extreme, most physicians used support following spine fusion (84%), for treatment of spondylolisthesis (70%), and for pseudoarthrosis (66%). In these in-

TABLE 3. EXTERNAL SUPPORT PREFERENCE BY CLINICAL ENTITY

Clinical Entity	Total Listing	Frequency of Use		Support Preference		
		Rarely (%)	Usually (%)	Brace (%)	Corset (%)	Cast (%)
Postoperative fusion	3590	16	84	51	20	29
Spondylolisthesis	3472	30	70	59	33	28
Pseudoarthrosis	2784	34	66	57	28	15
Preoperative trial	2523	46	54	37	25	38
Disc syndrome	3164	49	51	34	51	15
Chronic backache	2635	52	48	29	67	4
Degenerative joint disease	2818	52	48	32	64	4
Postoperative disc	1677	72	28	31	65	4
Obesity and pain	1453	81	19	13	84	2
Acute strain	1552	83	17	14	77	9

TABLE 4. BRACE PREFERENCE BY CLINICAL ENTITY, ANALYSIS OF 7,142 RESPONSES

Clinical Entity	Number and Percentage of Listings													
	Chairback		Williams		Norton-Brown		Goldthwaite		Bennett		Other		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Postoperative fusion	845	11.9	153	2.2	65	0.9	45	0.6	51	0.7	157	2.0	1,316	18.3
Spondylolisthesis	856	12.0	396	5.6	46	0.6	56	0.8	72	1.0	84	1.0	1,510	21.0
Pseudoarthrosis	769	10.8	150	2.1	49	0.7	38	0.5	49	0.7	98	1.4	1,153	16.2
Preoperative trial	403	5.7	141	2.0	25	0.4	20	0.3	37	0.5	51	0.7	677	9.6
Disc syndrome	338	4.8	305	4.3	29	0.4	28	0.4	30	0.4	52	0.7	782	11.0
Degenerative joint disease	378	5.3	120	1.7	15	0.2	32	0.5	36	0.5	76	1.0	657	9.3
Chronic backache	215	3.0	120	1.7	13	0.2	23	0.3	19	0.3	43	0.6	433	6.1
Postoperative disc	187	2.6	63	0.9	20	0.3	9	0.1	15	0.2	39	0.4	333	4.5
Obesity and pain	45	0.6	47	0.7	5	0.1	10	0.1	6	0.1	21	0.3	134	1.9
Acute strain	62	0.9	30	0.4	8	0.1	6	0.1	8	0.1	33	0.5	147	2.1
Total	4,098	57.6	1,525	21.6	275	3.9	267	3.7	323	4.5	654	8.7	7,142	100.0

stances, the most common type of support was a brace.

The orthopedists were evenly divided as to the advisability of prescribing any type of support in treating the degenerative back, the disc syndrome of chronic backache, or as a preoperative trial. A similar lack of agreement was indicated concerning the type of support preferred. As a preoperative trial, there was equal preference for a brace or cast. For the other disabilities, the preferred support was the lumbosacral corset.

Comparison between the specific brace design and the clinical condition (Table 4) showed that the Chairback was the most frequently used brace in each situation, and the Williams brace ranked second in preference. Spondylolisthesis and the disc syndrome were the most common indications for the Williams brace. Spondylolisthesis was also the primary reason for using the Bennett brace. Otherwise, preference for the Norton-Brown, Goldthwaite, and Bennett braces paralleled the use of back support in general.

FUNCTION OF EXTERNAL SUPPORTS

Three approaches to the data collected on functions of supports seemed pertinent: the general expectation for external supports, the types of support chosen for

each of these functions, and the functions expected of each of the support designs.

The function most commonly ascribed for external support was restriction of lumbosacral motion (30%); abdominal support was second (19%), followed by postural correction (15%) and immobilization of the spine (12%).

To restrict lumbosacral motion, the Chairback (Knight) brace or a corset were equally preferred. The Williams brace was the third specific device indicated for this purpose, although a larger number of physicians indicated that they used some type of cast to restrict motion.

Abdominal support was most often assigned to the corset. This dominated its next competitor, the Chairback (Knight) brace, by a ratio of two to one. Again, the Williams brace ranked third for the function of supporting abdominal muscles.

Postural correction was almost equally divided between the corset and a Williams brace, although the use of casts was not uncommon.

An interesting situation developed in the category of spinal immobilization. It was the only function identified for the flexion cast, yet this device was fourth in preference. The support most often indicated for spinal immobilization was the Chairback (Knight) brace, a finding which probably reflects its national popularity.

While external supports are seldom used for psychological reasons, when the practice is followed the corset is the most popular device, followed by the Chairback brace.

The concept of unloading the disc has obviously not been accepted by the majority of orthopedic surgeons, since only 8% indicated this as a function of external support. However, those who did think in these terms showed a strong preference for the Williams brace, with a cast as an alternate.

Focus on the individual types of support showed that the prime functions of the corset were considered to be abdominal support and restriction of lumbosacral motion. The Chairback (Knight) brace was assigned the same functions, but with greater emphasis on restriction of motion. This function was also considered the main purpose of the Williams brace, with correction of posture as its second indication. Casts were generally used to restrict lumbosacral motion, although a surprisingly larger number were also assigned the function of correcting posture. Consistent with the belief that immobilization, as opposed to restriction of lumbosacral motion, is seldom accomplished with external support, even casts were assigned this as a third function.

In addition to completing the survey form, a third of the respondents (1,034) added notes to further explain their preferences. These varied from a single listing of a specific brace to lengthy letters explaining their philosophies of low-back management. A majority of these replies were focused on either the fitting or construction characteristics of their support preferences.

Sixty respondents emphasized the advantages of using exercise early in the treatment of low back pain. Two purposes were expressed: to avoid external support and to overcome the muscle weakening and contracture development that accompanies prolonged immobilization. One respondent summarized this philosophy very succinctly by stating he "never prescribed support without a plan to eliminate it." A smaller group (30) felt that the disadvantages were sufficient to preclude any prescription of external support. All who said they "never" or "rarely" used support emphasized instead their reliance on an organized program of exercise. Specific application of this philosophy was frequently mentioned in relationship to postoperative management of spine fusions. Many respondents also brought out the fact that the treatment of low back pain must be individualized to fit the particular patient's need. This fact must never be forgotten, of course, and the purpose of the survey was not to contradict the concept of individualized patient care, but merely to identify the

spectrum of external support which physicians have found adequate to meet their multiple goals.

DISCUSSION

The potential list of 40 external-support designs for low back pain has been severely pruned by the influences of prolonged clinical experience, greater intermingling of orthopedists through professional meetings, and the use of prefabricated parts. Notes by some of the respondents indicated that cost, emphasis on exercise, and early surgery are other important influences.

The clinical indications for use or nonuse of external support were rather sharply defined, but there is no comparable distinction between the accepted styles of support. The latter was indicated by the overlap between clinical entity and support design, as well as by the identification of the functions of the different devices. The mechanical characteristics and the limitations of these various designs which lead to such ambiguity have yet to be objectively identified.

Investigators (3) have found that, unless the support is carefully designed, motion at the lumbosacral joint could be increased with the support rather than restricted. Personal experience indicates that this might also lead to increasing the patient's pain.

A problem still not studied is identification of the characteristics of the patients which govern the choice of support.

SUMMARY

The lumbosacral corset is the most commonly prescribed external support for low back pain. The Chairback (Knight) and Williams braces are next in preference, with a cast being used least frequently. There is a definite relationship between the etiology of the low back pain and the type of support chosen. The major indication for support prescription is to restrict lumbosacral motion.

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