

# Experiences with the Total-Contact Prosthesis

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At the request of the Finnish Disabled Ex-Servicemen's Association, New York University arranged for a series of lectures on the fabrication of total-contact, above-knee sockets to be given in Helsinki in 1963. The lectures were intended for prosthetists and other interested persons. Since then some 300 prostheses of this type have been fabricated in Finland.

The total-contact socket (7, 2) is a further development of the conventional open-end socket. The proximal portion of a total-contact socket has the same contours as the corresponding portion of an open-end socket. The ischial seat, the relatively high anterior and lateral walls, the bulge into the femoral triangle, and the reliefs for the rectus femoris, for the adductor longus, and for the hamstring tendons are similar in both the open-end socket and the total-contact socket. The main difference is that the total-contact socket completely encases the stump, while the open-end socket, as its name implies, is open distally.

This means that, in the total-contact socket, the stump end is surrounded by a vacuum which keeps the prosthesis in position without a pelvic joint and belt. The total-contact socket is kept in place by its intimate fit around the stump. There is a moderate vacuum during swing phase. The intimate fit of the total-contact socket, which is made of plastic, has been designed with a view toward imitating the mechanism of the physiological pumping action performed by the muscles while walking. The patellar-tendon-bearing (PTB) prosthesis acts in a similar fashion. The pumping effect is accomplished by the amputee as he walks. In fact, a principal advantage of the total-contact socket is the mild, gentle counterpressure on

the distal end of the stump during the stance phase. This positive pressure, alternating with the negative during the swing phase, improves circulation and reduces edema in the stump.

The total-contact socket is designed to reduce pressure on the stump proximally and increase the pressure distally. In cases where the diaphysis has been cut, the stump end never tolerates strong pressure. Therefore, pressure must be very carefully modified in each case.

Distally, the plastic socket is joined to a wooden knee. The shank, too, is made of wood, to which a SACH foot is attached. Plastic has certain advantages over other materials. It is readily washed with soap and water. The surface can be made very smooth and free from pores. The chief drawback is airtightness. Plastic does not permit an exchange of air. The result is perspiration, particularly in the summer. Sweat gradually breaks down the plastic. In winter plastic is cold. Sometimes there are allergic reactions to plastic.

In the Department of the State Supervisor of Prosthetic Services of the Ministry of Social Affairs, a follow-up study has been made of amputees fitted with total-contact prostheses. Initially, the amputees are given, for trial, prostheses which are not quite finished, although fit for wear. Some four to six weeks later the patients and their prostheses are examined at the Department of the State Supervisor, where the prostheses are approved or some modification or correction is prescribed. Only after this examination are the prostheses given their final finish. This applies to all prostheses paid for by the state. Six months after the patients have been fitted with their prostheses a questionnaire is sent to them, which they accomplish and return.

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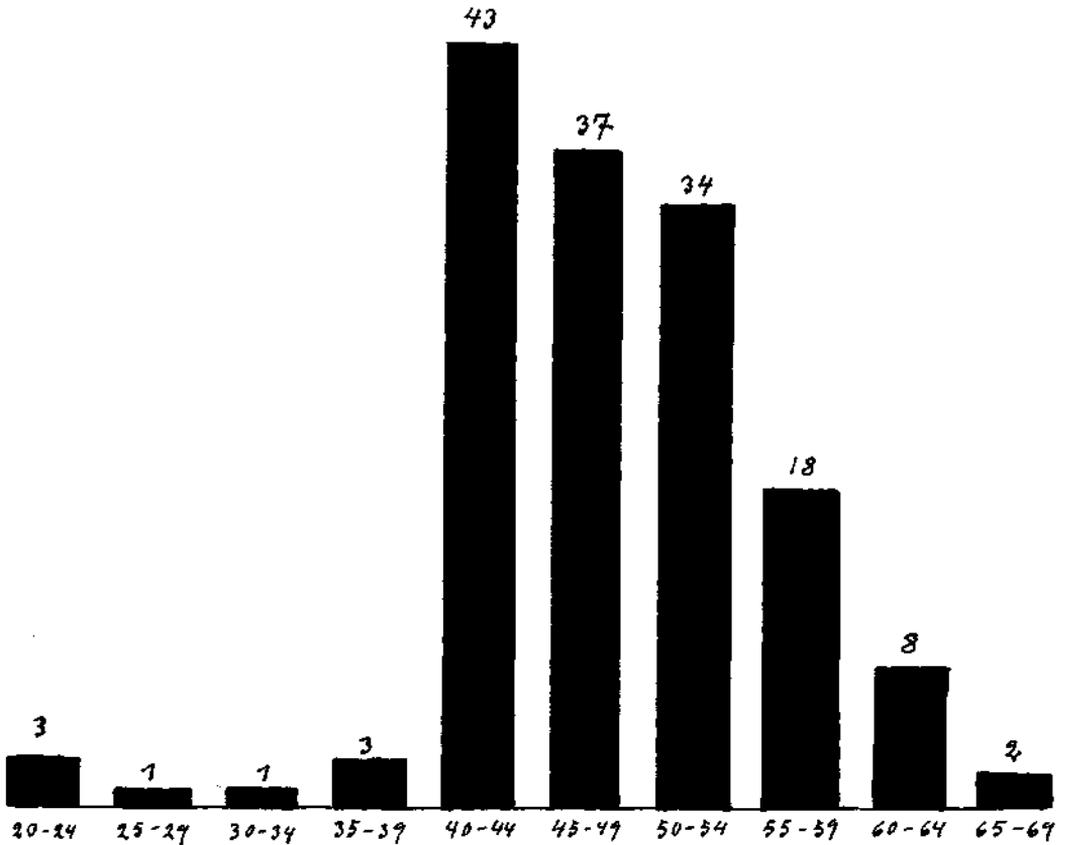


Fig. 1. Ages of the amputees when they were fitted with total-contact prostheses.

Record cards are kept for all amputees on which are entered notations concerning new prostheses, repairs, and modifications.

The present study covers 150 amputees fitted with total-contact prostheses. Of the amputees, 143 (95.3 per cent) were ex-servicemen and 7 (4.7 per cent) were insured civilians.

Figure 1, which shows the ages of the amputees, indicates that the age group of 40 to 54 years is the largest. The high mean age of the ex-servicemen is accounted for by the time that has elapsed since World War II. The series includes two cases from the Finnish civil war of 1918. The youngest amputee was 24, the oldest 67. Only one was a recent amputee. In principle, every above-knee amputee should be fitted with a total-contact prosthesis from the outset in order to become used to it as soon as possible. This would accelerate the remodeling of the stump. Still,

the stump of a recent amputee is often tender and swollen for some time. The total-contact prosthesis demands much of the stump. Consequently, a recent amputee may need a new socket at frequent intervals.

Table 1 shows the occupations of the patients in the series. It is of major interest to ascertain whether the total-contact prosthesis can be worn while performing heavy labor of different kinds, particularly outdoors and at low temperatures. In northern Finland temperatures may be as low as -40 deg. C. Therefore, the occupations have been precisely specified. Whenever possible, amputees will usually choose labor that is not too heavy. The series includes 23 farmers (15.3 per cent), 1 lumberman, and 11 fitters. After World War II, retraining of invalids was arranged in the form of courses for watchmakers, storekeepers,

TABLE 1. THE OCCUPATIONS OF THE PATIENTS

Agriculturalist	1
Architect	1
Blacksmith	3
Bricklayer	1
Businessman	1
Carpenter	2
Chauffeur	2
Dental Mechanic	3
Disabled, retired	14
Doorkeeper	4
Elementary school teacher	3
Engineer	2
Farmer	23
Filer (machine shop)	3
Fisherman	1
Fitter	11
Gardener	1
Housewife	2
Lawyer	1
Lumberman	1
Managing Director	5
Noncommissioned officer	3
Office clerk	13
Outdoor man	1
Photographer	1
Shoemaker	5
Shopkeeper	3
Storekeeper	5
Student	2
Tailor	1
Teacher	5
Technician	2
Traveler	1
Turner	1
Unskilled worker	7
Upholsterer	1
Watchmaker	4
Welder	5
Unknown	5
Total	150

fitters, shoemakers, etc. These occupations appear in the table.

Figure 2 shows the lengths of the amputation stumps. The total-contact prosthesis has been worn successfully by amputees whose stumps measured only 10 cm to 15 cm. This series includes 10 such cases, but in two of these cases it became necessary to abandon the total-contact prosthesis. One of these patients received a conventional, wooden, open-end prosthesis; the other was fitted with a leather prosthesis.

These cases (No. 8 and No. 9 in Table 2) will be discussed later.

Replies to the questionnaire are presented below:

1. *Have you worn your prosthesis regularly; if not, for how long have you worn it?* According to the replies, 108 (72 per cent) had worn their prostheses regularly, while 42 (28 per cent) had not been able to do so for a variety of reasons.

2. *Why have you not been able to wear your prosthesis regularly?* The replies were compared with the record cards, and causes were elicited as follows:

The knee joint in the prosthesis was too stiff.

In eight cases there was profuse perspiration and a repulsive odor.

In one case the prosthesis was too warm in the summer and too cold in the winter.

In one case the prosthesis was too cold in the winter.

In five cases the socket did not fit.

The amputee put on weight and the socket became too tight.

The inner surface of the socket became granular.

The stump swelled.

There were pains in the stump.

Walking was difficult because of a heart condition.

In two cases the socket split.

There was a jarring sound from the knee joint of the prosthesis.

In one case the amputee was so used to his old prosthesis that he preferred it.

The SACH foot became loose, the socket was tight, and the knee mechanism functioned differently from what it did in the old prosthesis.

In three cases the skin became irritated.

In one case the stump was operated upon after the prosthesis had been finished.

The socket became too wide.

The stiffness of the knee mechanism was a hindrance while fishing.

The socket became too tight.

In many cases modification and repair of the prosthesis put an end to the trouble.

3. *Have you worn your prosthesis (a) when working indoors, (b) when working outdoors, (c) when working outdoors in very cold weather?* Of those replying to the questionnaire, 128 (85.3

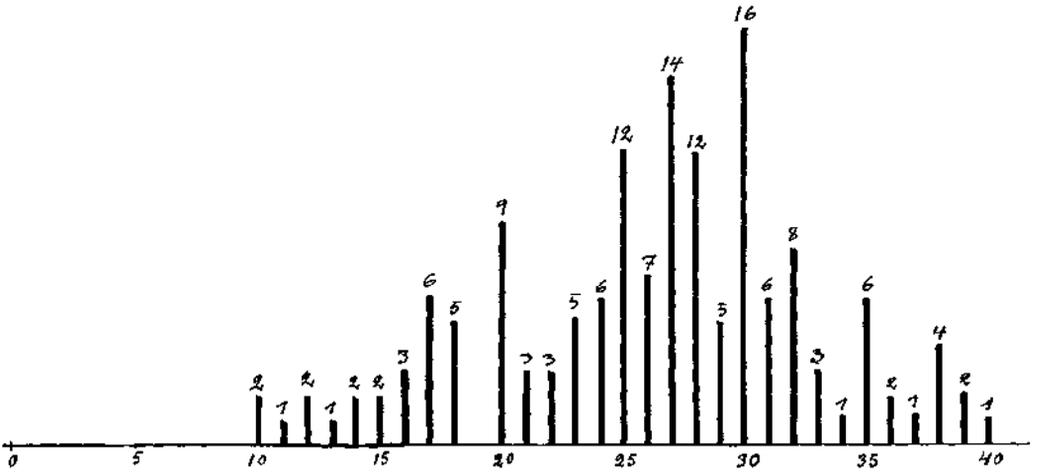


Fig. 2. Lengths of the amputation stumps.

per cent) had worn their prostheses while working indoors, 100 (66.7 per cent) had worn their prostheses while working outdoors, and 72 (48.0 per cent) had worn them outdoors in very cold weather. Some amputees had been in a position to wear the prosthesis only during the warm season at the time of the questionnaire.

4. *Have you worn your prosthesis in some additional—part-time—occupation?* (The intention was to elicit data regarding incidental jobs, recreation, and hobbies.) Only eight amputees indicated that they had such activities: fishing in one case, gardening in one case, agricultural work and lumbering in two, work as a doorkeeper in one case, two cases in which the patients had built their own cottages, and one case in which the amputee participated in ball games.

5. *Have you previously used a prosthesis of some other material (wood, leather, or light metal)?* Conventional prostheses of wood had been worn by 147 amputees (98 per cent), one (0.7 per cent) had worn a leather prosthesis,

and one (0.7 per cent) had worn a prosthesis of light metal. One patient (0.7 per cent) was a recent amputee and had been fitted with his first prosthesis.

6. *Have you been satisfied with your prosthesis?* There were 112 (74.5 per cent) satisfied wearers and 38 (25.5 per cent) who were dissatisfied.

7. *Do you think this prosthesis is (a) better than, (b) just as good as, (c) not as good as your previous limb?* The replies were as follows:

Better	81 (54.0 per cent)
Just as good	36 (24.0 per cent)
Not as good	33 (22.0 per cent)

8. *What defects or drawbacks have you observed in your total-contact prosthesis?* Listed below are the complaints of 39 patients (26 per cent). In 32 cases the stump had caused trouble and in seven cases there was something wrong with the prosthesis. But no sharp distinction can be drawn between these two groups. Quite frequently, the prosthesis is the ultimate source of the discomfort.

Amputation stump		Prosthesis	
The skin did not tolerate the prosthesis	12	Plastic socket split	2
Perspiration from the stump and an unpleasant odor	15	Socket was too closed	2
Cold in winter	2	Socket did not fit	1
Stump end became discolored	1	Knee mechanism too stiff	1
Warm in summer, cold in winter	2	Socket too tight	1
	32		7

9. *Has perspiration of the stump constituted a problem?* In 33 cases (22 per cent) perspiration had been profuse, in 99 cases (66 per cent) moderate, and in 17 (11.3 per cent) it had caused no trouble. Only one patient (0.7 per cent) stated that perspiration gradually became less of a problem. As a rule, summer was the worst season from this standpoint.

10. *Has perspiration caused any repulsive odor?* The replies of 113 amputees (74.7 per cent) were in the affirmative, while 37 patients (25.3 per cent) replied in the negative. When the odor of the sweat in the closed socket mingled with the odor of the plastic, which is particularly strong in new sockets still containing traces of the solvents used in the fabrication, the effect is extremely disagreeable to both the amputee and his environment. The plastic socket can be washed with soap and water, but personal hygiene varies widely. Many patients have stated that perspiration is not a major problem, if the stump and the prosthesis are washed regularly.

11. *Has the skin on the stump tolerated the total-contact prosthesis?* In 118 cases (79.0 per cent) the skin on the stump had shown no symptoms, while in 32 cases (21.0 per cent) it had not tolerated the strain of the intimate fit of the socket.

12. *Have reddening of the skin and eczema occurred?* In 51 cases (34 per cent) there had been reddening, which may be a transient phenomenon of no significance, but 23 amputees (15.3 per cent) had had eczema, and ulceration had occurred in 18 cases (12 per cent).

13. *Has the end of the stump become discolored after adoption of the new prosthesis?* Discoloration of the end of the stump had occurred in 34 cases (22.7 per cent). This phenomenon is the result of circulatory disturbances in the end of the stump. The most frequent cause is that pressure on the blood vessels is too strong.

14. *Did reddening, eczema, or ulceration of the stump occur before you started wearing a total-contact prosthesis?* Reddening had occurred in 60 cases (40 per cent), eczema in 45 (20 per cent), and ulceration in 5 (3.3 per cent). These replies do not differ greatly from those to question No. 12. But it must be remembered that the previous, conventional prosthesis of wood, leather, or light metal had been worn

for a long time, while the total-contact prosthesis had been worn only one-half year to one year. Therefore, the two groups cannot be directly compared.

15. *What are your experiences with the new prosthesis outdoors in cold weather?* Thirty-two patients (35.1 per cent) had not experienced discomfort during the winter, while 61 (64.9 per cent) had found their prostheses very cold.

16. *Have you skied with the new prosthesis?* Only 23 (15.3 per cent) patients answered in the affirmative. As a rule, above-knee amputees are not likely to participate in this sport. The below-knee amputees found on skis are much more numerous.

17. *If you experienced phantom pains previously, have they been aggravated or alleviated after adoption of the new prosthesis?* The replies were as follows:

No previous phantom pains	32 (22 per cent)
Phantom pains aggravated	15 (10 per cent)
Phantom pains unchanged	94 (62.3 per cent)
Phantom pains alleviated	8 (5.3 per cent)
	149 (99.6 per cent)

18. *Have you had pains in the amputation stump (a) after adoption of the new prosthesis, (b) with the old prosthesis?* Sixty-six patients (44 per cent) had experienced pain after adoption of the new prosthesis, and 66 (44 per cent) had had pains while wearing their old limb. In this respect the type of prosthesis seemed to make no difference. But it should be noted that no direct comparison is possible because the total-contact prosthesis had been worn for a shorter period than the old one. In nine cases the total-contact prosthesis was abandoned in favor of the open-end prosthesis previously worn. These cases were subjected to a more detailed study, presented in Table 2.

The table discloses that the occupations of the patients had little to do with the failure. The ages of the patients did not differ from the mean age of the series as a whole. In two cases the stump was short, 12 cm and 15 cm, respectively. In the entire series there were 10

TABLE 2. AMPUTEES WHO COULD NOT WEAR THE TOTAL-CONTACT PROSTHESIS

Case No.	Occupation	Stump Length cm	Previous Prosthesis	Cause of Failure
1	Welder	33	Open-end	Excessive perspiration, odor, discoloration of the stump end, eczema
2	Welder	25	Open-end	Perspiration, odor, coldness
3	Farmer	31	Open-end	Perspiration, odor, coldness
4	Student	15	Open-end	Perspiration, odor, ulceration
5	Fitter	27	Open-end	Perspiration, odor, eczema
6	Retired	20	Open-end	Perspiration, swelling, ulceration
7	Carpenter	28	Open-end	Perspiration, odor
8	Farmer	12	Open-end	Perspiration, odor, ulceration, eczema, discoloration of the stump end
9	Farmer	30	Open-end	Perspiration, odor, allergy, eczema, discoloration of the stump end

stumps measuring 10 cm to 15 cm, three measuring 16 cm, six measuring 17 cm, and five measuring 18 cm. In all cases except the two mentioned at first, fitting with a total-contact prosthesis proved successful. In general, short stumps constitute a problem to the prosthetist. No. 8 in Table 2 was one of a number of amputees who had not been able to wear any prosthesis without complications. No. 9 was the only patient who was tested for allergy.

As appears from the replies to the questionnaire, perspiration and skin changes constituted problems in the wearing of total-contact prostheses. These troubles arose from the properties of the socket: its intimate fit around the stump, and the airtightness of the plastic material. Partly because of the solvents used in the fabrication, the plastic socket sometimes has an irritating effect on the skin, especially when it is new. This irritation is increased by the decomposition of the sweat caused by the heat of the closed socket. In a considerable number of cases, however, the difficulties may have been caused by inadequate curing of the plastic laminate. Also, prostheses made of wood or leather are not free from perspiration.

The possible occurrence of allergic reactions is another problem. In Finland, amputees suspected of allergy are remitted to the Dermatological Department of the Helsinki University Central Hospital. The present series includes only one such case. Perhaps the question of allergy has not been sufficiently taken into account.

The majority of the remaining troubles were readily dealt with in the prosthetist's shop.

It should be emphasized, however, that the view of the total-contact prosthesis derived from the replies that have been reported may be too unfavorable. To the amputee, it is a great advantage to be able to walk with greater ease than with a conventional prosthesis, because of the firm adherence of the total-contact socket to the stump. No pelvic joint and belt are needed. As mentioned earlier in this article, a principal advantage of the total-contact socket is the mild, gentle counterpressure on the distal end of the stump during the stance phase. This positive pressure, alternating with the negative during the swing phase, assists circulation. Some of the cases with dermatologic problems had poor fits, usually as the result of stump changes. In a number of cases, the difficulties may well have been caused by inadequate curing of the plastic laminate. Also, a number of the problems did not relate to the principle of the total-contact socket as such but would have occurred with other designs.

#### SUMMARY

This study was performed on 150 amputees fitted with total-contact prostheses. It is based on personal follow-up examinations, replies to questionnaires, and data obtained from record cards kept on the amputees.

The age group 40 through 54 years is the largest. War veterans constitute the majority (96.3 per cent of the series).

Seventy-two per cent had worn their pros-

theses regularly from the outset, and 74.5 per cent were satisfied with them. The airtightness of the socket elicited unfavorable reactions from the skin of a number of the patients (21 per cent). Twenty-two per cent of the amputees complained of profuse, and 66 per cent of moderate, perspiration of the stump. Some of the cases with dermatological problems had poorly fitting sockets, usually as the result of stump changes. In a considerable number of the cases, the difficulties may well have resulted from inadequate curing of the plastic laminate. The majority of the problems were readily dealt with in the prosthetist's shop.

The skin requires meticulous hygiene. In contrast to leather and wood, the plastic socket is readily washed. Conventional prostheses are not free from dermatological problems.

The total-contact prosthesis has been used

in the performance of heavy labor and while outdoors in cold weather.

Some of the problems of the patients did not relate to the principle of the total-contact socket and would have occurred with other designs.

The gentle, alternating, positive and negative pressure afforded by the total-contact socket to the patient as he walks improves the circulation of the stump and constitutes one of the socket's main advantages.

#### LITERATURE CITED

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