Experiences with the PTB Prosthesis

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The original patellar-tendon-bearing (PTB) prosthesis was constructed at the Biomechanics Laboratory of the University of California. For details regarding the anatomical and physiological considerations (J), the biomechanics *(4),* and the construction *(2),* the reader is referred to the June 1962 issue of *Artificial Limbs.*

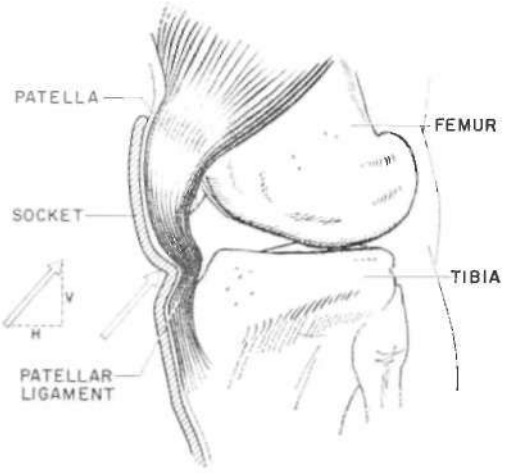

Fig. 1. Vertical cross section of anterior portion of PTB socket. The supporting force, as shown by the arrow, acts on the lower patellar ligament.

In Finland about 1,000 PTB prostheses have been manufactured since 1959. Although the name of these prostheses and the main principle of their construction imply that weight is borne on the lower patellar ligament (Fig. 1), this is not the only weight-bearing area. Both tibial condyles and, to some extent, the distal end of the stump share the weight. The distribution of weight in these areas necessitates truly individual fitting.

For technical details of fabrication of PTB prostheses, the reader is referred to the issue of *Artificial Limbs* which has been cited. Here it is sufficient to say that a plaster cast of the stump is taken first. Then an intimately fitting, distally closed socket of hard plastic and a socket insert of sponge rubber are made. Distally, the socket is joined to a wooden shank, to which a SACH foot is attached (see Figure 2 for views of a finished prosthesis). It is not essential that the socket be made of plastic, but at present this seems to be the best material available. It is relatively easy to laminate a plastic shell from a plaster model. The plastic socket withstands moisture and is, therefore, relatively resistant to perspiration, and it is readily cleaned. The drawbacks are the airtightness of the material, the risk of its causing allergic reactions, and, perhaps, the poorer heat insulation in cold weather compared with materials previously used. These points will be discussed later.

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 PTB prostheses. Initially, the amputees are given, for trial, prostheses which are not quite finished, although fit for wear. After three weeks the patients and their prostheses are examined at the Department of the State Supervisor, where either the prostheses are approved, or some modification, correction, or repair 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 PTB prostheses a questionnaire is sent to them. At the Department of the State Supervisor, record cards are kept for all amputees, on which are entered notations concerning modifications and repairs. Thus it is easy to check on what happens to the various prostheses.

This article is based on the examinations of

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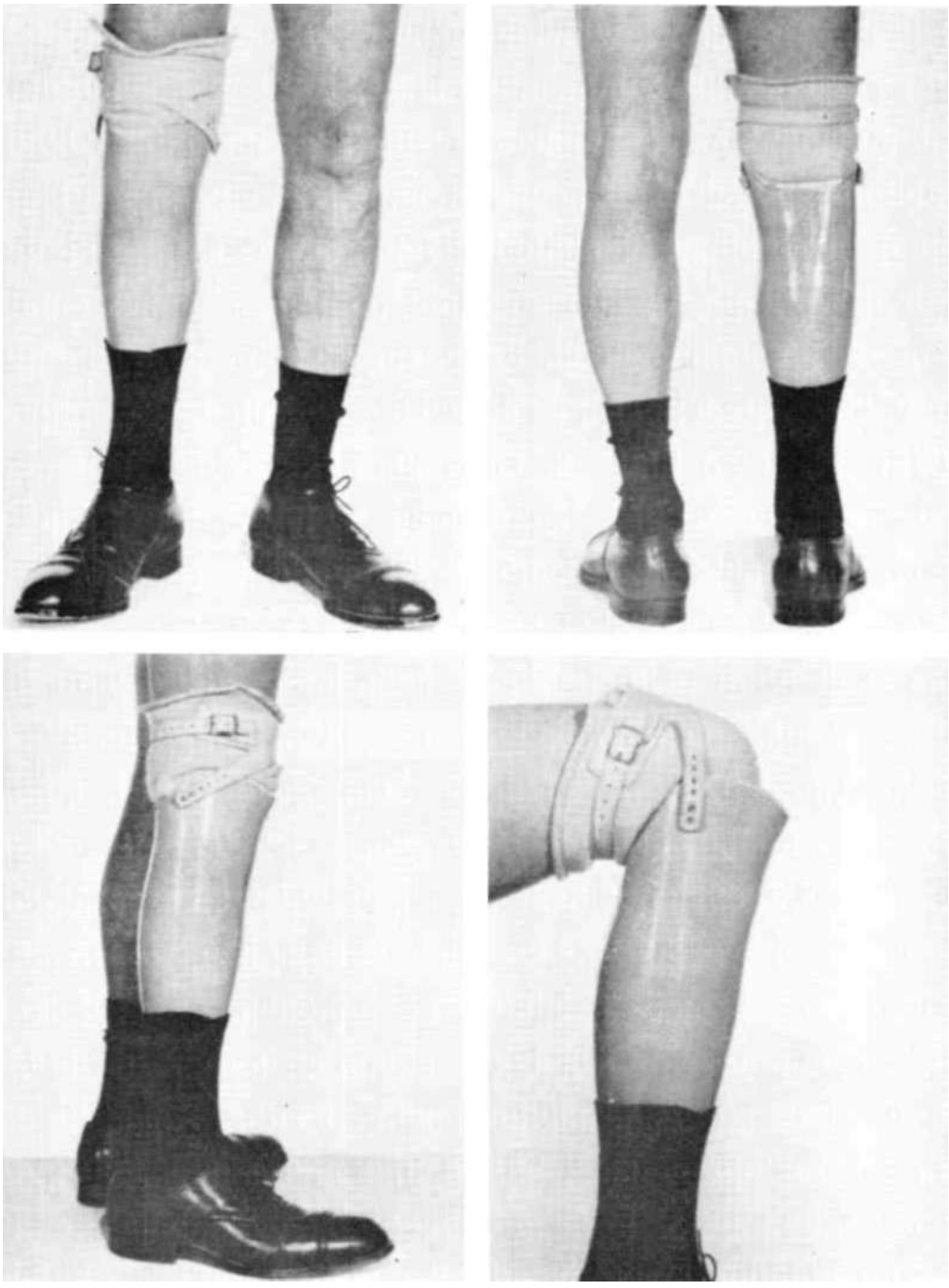

I 'ig. 2 Finished PTB prosthesis using supracondylar cuff as only means of suspension.

the amputees and their prostheses three weeks after the initial issue, data obtained from the questionnaires distributed to the amputees when they have worn their prostheses for six months, and data obtained from the record cards.

The study covers 228 amputees fitted with PTB prostheses. Prostheses from different workshops differ somewhat from each other, since standardization of the products is a problem in Finland, as it is elsewhere, perhaps. Therefore, only genuine PTB prostheses have been included in this study.

Figure 3 shows the ages of the amputees, disclosing that the age group of 40-54 years is the largest. The youngest patient was 20, while the oldest was 75. Ex-servicemen account for 94.3 per cent of the series. The remainder are insured civilians. Only one of the cases in the series was a recent amputee whose initial fitting was with a PTB prosthesis. This does not imply that recent amputees are fitted for theoretical reasons with so-called "conventional" prostheses. On the contrary, it should be an advantage to be fitted from the outset with a PTB prosthesis, although it goes without saying that recent amputees offer special problems because of the longer duration of stump changes.

Table 1 shows the occupations of the patients in the series. From the standpoint of prescription, it is of major interest to ascertain

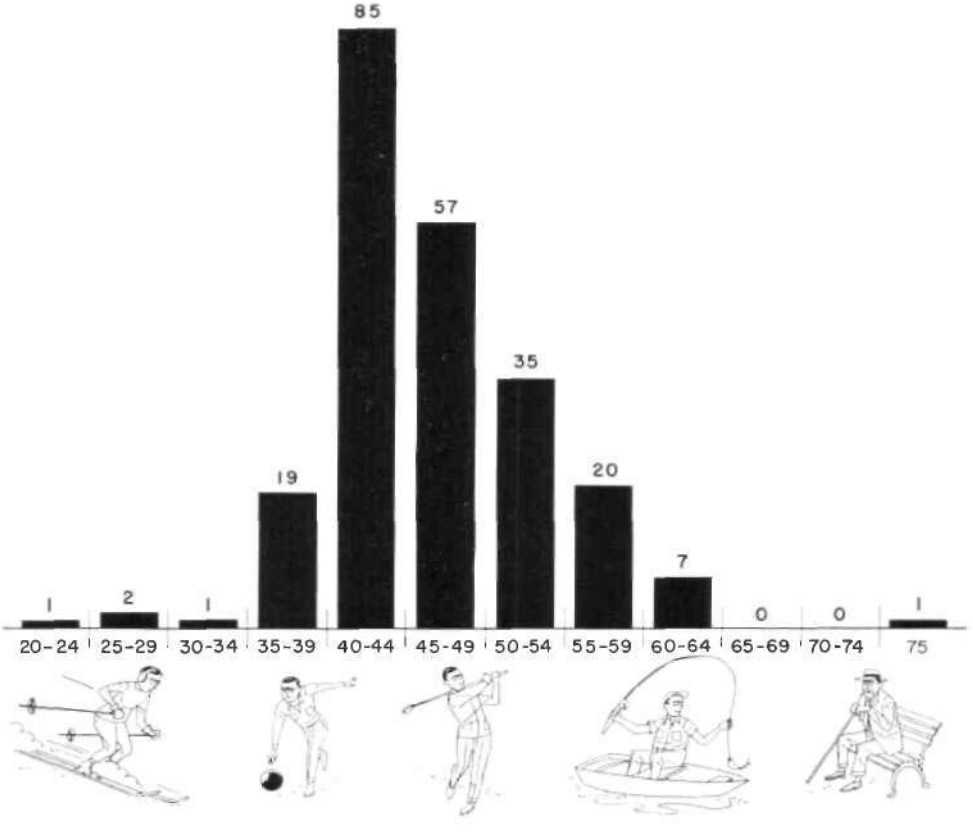

Fig. 3. Ages of the amputees when they were fitted with PTB prostheses.

TABLE 1. THE OCCUPATIONS OF THE PATIENTS

Agriculturalist	2
Architect	1
Building contractor	4
Building supervisor	1
Building worker	2
Businessman	1
Caretaker	1
Carpenter	2
Chauffeur	9
Community secretary	1
Craft-school teacher	2
Customs supervisor	1
Disabled, retired	5
Doorkeeper	2
Draftsman	1
Economist	2
Electrical worker	12
Elementary-school teacher	3
Engineer	3
Farmer	55
Farmhand	2
Foreman	10
Filer (machine shop)	4
Goldsmith	6
Housewife	2
Industrial worker	3
Insurance agent	1
Insurance supervisor	1
Journalist	1
Lawyer	1
Lumberman	2
Managing director	1
Metal worker	2
Molder	2
Music teacher	2
Night watchman	2
Noncommissioned officer	2
Painter	7
Physician	2
Porter	2
Shopkeeper	6
Smallholder	4
Storekeeper	5
Technician	9
Turner	5
Unskilled worker	19
Vulcanizer	1
Watchmaker	1
Welder	2
Workhouse internee	1
Unknown	10
Total	228

whether the PTB prosthesis can be worn while performing heavy labor, considering the absence of a thigh corset and the greater stress on the knee joint.

Table 1 discloses that the series includes 59 farmers or smallholders, 21 industrial workers, two lumbermen, and 7 painters. It stands to reason that amputees, whenever possible, choose labor that is not very heavy. Many farmers admitted that they had abandoned the heaviest tasks. However, others in the series mentioned lumbering as a part-time occupation. It was learned that some amputees had worn the PTB prosthesis without a thigh corset while walking on soft, uneven ground and on snow; in other cases, a short above-knee corset had been added almost immediately or when the PTB prosthesis had been worn for some time. It is apparent that stump length and the stability of the knee are important factors.

Figure 4 shows the lengths of the stumps in the series. In general, cases with a stump length of less than 12 cm. required a thigh corset, the length of which was about one-half or one-third the length of the thigh corset of a conventional prosthesis. The shortest stump in the series measured 6 cm., and the longest 35 cm. The series includes nine bilateral amputees (3.9 per cent).

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, 210 amputees (92.1 per cent) had worn their prostheses regularly from the outset.

2. Why have you not been able to wear your prosthesis regularly? When the replies were compared with the record cards, it appeared that 18 (7.9 per cent) had not been able to wear their prostheses regularly. In three cases the cause could not be elicited. In 15 cases the causes were as follows:

The skin became irritated in three cases, and in one case an allergy set in.

In two cases the socket became too loose.

The stump did not tolerate the pressure; it became tender.

There was pressure on the stump when the patient drove his car.

Ulceration of the stump occurred in three cases.

The prosthesis was cold in the winter, and it slipped off when the patient walked in the snow.

The stump swelled when the patient was riding a bicycle.

Stairs were a problem.

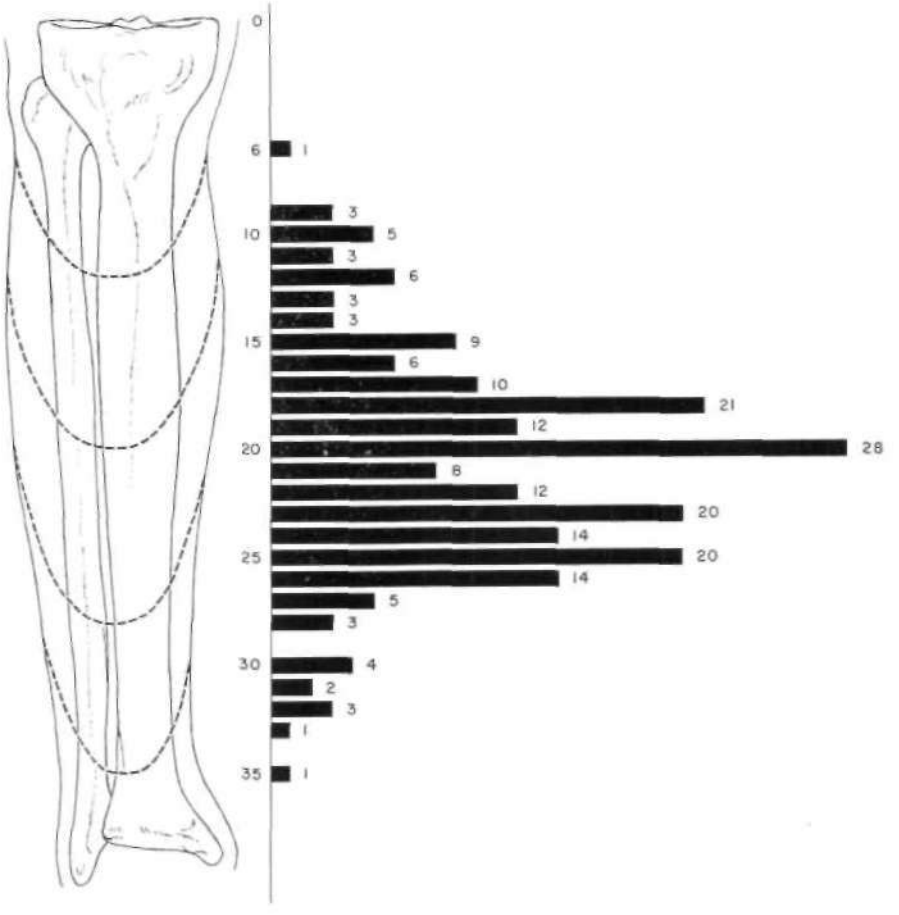

Fig 4. Lengths of the amputation stumps.

The closed socket caused excessive perspiration of the stump.

3. Have you worn your prosthesis (a) *when working indoors, (b) when working outdoors, (c) when working outdoors in very cold weather?* A total of 223 (97.8 per cent) had worn their prostheses while working indoors; 208 (91.2 per cent), while working outdoors; and 140 (61.4 per cent), while working outdoors in very cold weather.

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 21 replies were obtained on this point. One patient was a chauffeur, two were building their own houses, one was building a summer cottage, two fished, five were doing agricultural work, three did lumbering, six did gardening, and one was a night watchman.

5. *Have you previously used a prosthesis of some other material (wood, leather, or light metal)?* The majority had used conventional prostheses of wood or leather. Only a few had worn prostheses of light metal. Some amputees had had prostheses of all three materials in the course of years.

6. Have you been satisfied with your prosthesis? There were 206 (90.4 per cent) satisfied wearers. Only 22 (9.6 per cent) complained.

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 than previous prostheses	207	(90.8 per cent)
Just as good as previous prostheses	8	(3.5 per cent)
Not as good as previous prostheses	12	(5.3 per cent)

First prosthesis (recent amputee)	1 (0.4 per cent)
Total	228 (100.0 per cent)

The great majority were satisfied with the PTB prosthesis. What appealed to them most was its lightness and the freedom from a thigh corset. This enabled the development of the thigh muscles in a short time. However, not all the amputees were able to manage without a thigh corset.

8. What defects or drawbacks have you observed in your PTB prosthesis? Listed below are the complaints of 26 amputees (12.3 per cent). In eight cases the complaints apply mainly to the stump, and in 18 to the prosthesis, but it is not always possible to distinguish sharply between the two.

Amputation stump	Prosthesis
Allergic reaction	Cold in the winter (two cases)
Circulatory disturbance	Socket closed and too warm (three cases)
Ulceration	Socket became too loose (two cases)
Itching	Socket pressed on the stump
Stump shrinkage	Flexion of the knee during work impossible because socket extends above knee
Perspiration	Unstable on slippery ground and without a thigh corset
Edema	Unstable in soft snow
Fatigue	Unstable on soft ground
	Excessive strain on the knee without a thigh corset
	Insert wears out too rapidly
	Heel of the SACH foot is too soft
	Toe of the SACH foot gradually bends upward
	Toe wears out too rapidly
	Difficult to ski

9. Has perspiration in the amputation stump constituted a problem? The replies were as follows:

Perspiration a problem	161 (70.6 per cent)
Perspiration not a problem	39 (17.1 per cent)
Initially excessive perspiration, later not	19 (8.3 percent)
Less perspiration than with other prostheses	9 (4.0 per cent)
Total	228 (100.0 per cent)

Owing to the closed, air-tight socket, perspiration was a major problem, particularly in the summer. It should be borne in mind, however, that this problem also occurs with conventional prostheses, although perhaps not to the same degree. The possibilities for reducing the perspiration problem are discussed later.

10. Has the skin on the stump tolerated the prosthesis? The skin tolerated the prosthesis well in **190** cases (83.9 per cent), better than with other types of prostheses in 14 cases (6.5 per cent), and not so well as with others in 24 cases (9.2 per cent).

11. Have reddening of the skin and eczema occurred? A total of 75 amputees complained of reddening and eczema, while 153 had no such symptoms.

12. Did reddening, eczema, or ulceration of the stump occur before you started using a PTB prosthesis, and, if so, for how long? In 157 cases (68.9 per cent) such symptoms had arisen from the use of conventional prostheses of wood, leather, or light metal.

13. What are your experiences with the new prosthesis outdoors in cold weather? A total of 142 amputees had worn their prostheses outdoors during the winter, and temperatures of -20 to -40 deg. C had caused no problem. Many had skied as much as 30 km. Only five (3.5 per cent) had found the new prosthesis too cold. Replies were as follows:

No complaints	111 (78.2 per cent)
Better than previous prostheses	5 (3 . 5 per cent)
Somewhat colder than previous prostheses	21 (14.8 per cent)
Very cold	5 (3 . 5 per cent)
Total	142 (100.0 per cent)

It developed from the replies that the vast majority of the patients had been able to wear their PTB prostheses regularly from the outset. Eighteen amputees had experienced discomfort of various kinds. In many cases there were only minor complaints, and the source of the trouble was readily dealt with. Sometimes the complaints related to phenomena always associated with the manufacture and fitting of prostheses.

It is noteworthy, too, that the patients wore their prostheses while performing hard labor.

The vast majority of the patients were satisfied. The dissatisfied wearers numbered 22 (9.6 per cent). The causes for complaint are specified in Table 2. The ages and stump lengths of these patients are indicated in the tabulation to permit evaluation of their possible influence. Data regarding all the modifications needed to make the prostheses fit for use, even the smallest repairs, were obtainable from the amputee cards.

TABLE 2. CAUSES OF COMPLAINT AND DISSATISFACTION WITH THE PTB PROSTHESIS

Case No.	Age yrs.	Stump Length cm.	Cause	Treatment
1	62	20	Unknown	No measure needed
2	54	15	Became too loose	Socket shell tightened
3	53		Ulceration	Socket insert exchanged
4	47	20	Became too loose	Socket shell tightened
5	49	15	Poor fit of socket shell	Socket shell tightened
6	54	20	Became too loose	Both socket shell and insert exchanged
7	49	15	Poor fit of socket shell	Both socket shell and insert exchanged
8	37	25	Knee was excessively strained	Thigh corset with sidebars supplied
9	44	19	Knee was excessively strained	Thigh corset with sidebars supplied
10	50	18	Stump shrinkage	Both socket shell and insert exchanged
11	59	21	Stump shrinkage	Both socket shell and insert exchanged
12	41	17	Inflammation of the stump	No measure needed
13	50	28	Became too loose	Socket insert exchanged twice
14	47	22	Circulatory disturbances in the stump	No measure needed
15	52	14	Became too loose	Socket shell tightened
16	45	13	Became too loose	Thigh corset with sidebars supplied, socket insert exchanged twice
17	46	28	Became too loose	Both socket shell and insert exchanged
18	61	15	Knee excessively strained	Thigh corset with sidebars supplied
19	41	16	Became too loose	Socket insert exchanged twice
20	49	12	Skin problems due to perspiration	First a thigh corset with sidebars was made, then a leather prosthesis
21	43	12	Unknown	No measure needed
22	46	23	Became too loose	Socket insert tightened

It is a characteristic feature of the PTB prosthesis that it immediately starts remodeling the stump, because of the intimate fit of the socket. During the first few weeks the stump shrinks, so that the socket becomes too loose. It can be seen in Table 2 that this occurred in 11 cases, or 50 per cent of the dissatisfied wearers. These patients were fitted with a new socket insert, and occasionally also with a new socket shell, which implies that a large part of the prosthesis had to be rebuilt. In many cases the insert had to be modified several times. These possibilities must be reckoned with when this type of prosthesis is prescribed.

The regeneration of the thigh muscles in those who managed without a thigh corset has already been mentioned. This phenomenon results from the greater muscular activity required to control the movements and the stability of the knee with the PTB prosthesis. After three weeks none of the wearers was able to use his old prosthesis with a thigh corset, because the corset had become too tight.

The genuine PTB prosthesis is furnished with only a narrow strap fixing it above the knee. In six cases it was necessary later to provide a thigh corset with sidebars, but the length of the corset was one-third to one-half of what is usual for conventional prostheses. These amputees had stumps which measured 12,13,15,19, 22, and 25 cm., respectively. Only half of these can be said to be particularly short. Obviously, the need for a thigh corset depends not only upon the length and shape of the stump, but also upon the stability of the knee. In three of the cases the knee had been strained. In one case the PTB prosthesis, even after being furnished with a thigh corset and sidebars, had to be replaced with a conventional prosthesis, but this was an exceptional case.

Excessive perspiration in the stump, particularly during the summer, constituted a major

problem. The closed socket insert and the air-tight material are its main causes, but the muscular atrophy because of inactivity and the resultant poor circulation contribute. A gradual decrease in perspiration might be expected to occur, considering the development of the musculature and improved circulation resulting in all amputees who manage without a thigh corset, and considering also the pump effect exerted on the stump by the tight-fitting socket. A similar effect has been observed as a result of placing a sponge-rubber pad at the bottom of conventional prostheses of patients with chronic eczema and ulceration of the stump (*1*). In the present series, however, a later decrease of perspiration was observed in only 8.3 per cent of the cases. In addition, four per cent reported that perspiration has all the time been less of a problem with the new prostheses.

When perspiration of the stump is excessive, skin complications—eczema and ulceration—are likely to occur. Data on skin symptoms in the present series were compared with corresponding data relating to the use of conventional prostheses. The comparison is hampered by the fact that the observation time is shorter for the PTB prostheses than for the older types. Results of the comparison were as follows:

	PTB	Conventional Prostheses
Reddening, eczema, ulceration	75 (32.9 per cent)	157 (68.9 per cent)
No complications	153 (67.1 per cent)	71 (31.1 per cent)
Totals	228 (100.0 per cent)	228 (100.0 per cent)

It appears that with the PTB prosthesis skin complications were about half as common as with conventional prostheses.

In cold winter weather, the PTB prosthesis is somewhat colder than prostheses made of leather or wood, but nonetheless satisfactory and fit for use.

In general, the difficulties arising in the present series were due mainly to reduction in the volume of the amputation stump, instability of the knee, and, in some cases, shortness of the stump, which necessitated the construction of a thigh corset. Also, skin complications sometimes occurred as a result of the excessive perspiration caused by the closed-socket insert. The first-mentioned circumstances were easy to cope with, while the skin changes constituted a real problem. In some cases, an opening was made in the distal end of the socket insert, or a number of small holes were drilled in the socket. In certain cases, a sponge-rubber pad was utilized, partly to exert a continuous light pressure on the stump and partly to absorb the moisture accumulating in the bottom of the socket insert.

When the PTB prosthesis was first introduced into Finland, we hesitated to prescribe it to amputees who move about much outdoors on soft ground; for instance, on fields and meadows, in the forest, and on snow. This group of persons consists mainly of farmers and lumbermen and the population of northernmost Finland. Our apprehensions have been confirmed only in occasional cases, and the general impression of the PTB prosthesis is favorable. The advantages far outweigh the drawbacks. In particular, the lightness of this prosthesis, the hygienic properties of the plastic material, and the regeneration of the thigh muscles should be emphasized.

Reference to the literature shows that others have encountered the same problems that are described here. Frank A. Witteck (5), writing in the June 1962 issue of *Artificial Limbs*, warned against prescribing the PTB prosthesis in cases with instability of the knee, to very heavy amputees, and in bilateral cases. However, if the stumps have been satisfactory, we have even fitted bilateral cases with PTB prostheses, and no special problems have occurred.

In our experience, the PTB prosthesis is contraindicated only in cases with instability of the knee and with very short stumps or with stumps of unsatisfactory shape.

Because numerous, careful fittings are required in these cases, it is desirable that a prosthetist's shop be within easy reach. The PTB prosthesis makes heavy demands on the skill of the manufacturer.

SUMMARY

This study was carried out on 228 amputees fitted with PTB prostheses. It is based on per-

sonal 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 comprise 94.3 per cent of the series, the remainder being insured civilians. In some cases the prostheses were worn by amputees engaged in heavy labor under difficult conditions. Of the amputees, 92.1 per cent were able to wear their prostheses regularly from the outset, and 90.4 per cent were very satisfied. In particular, they emphasized the lightness of the prostheses and the absence of tight thigh corsets, resulting in a sense of ease and freedom.

In some cases, complications were caused by a decrease in stump volume, a result of the intimate fit of the socket. This necessitated a change of socket insert, which is readily accomplished, and sometimes of the socket shell as well, which in effect amounts to making a new prosthesis. In certain cases, instability of the knee, the shape of the stump, and a stump length less than the optimum gave rise to symptoms which could be alleviated only by giving the amputee a thigh corset. The series includes four such cases (1.8 per cent).

PTB prostheses were also prescribed in bilateral cases, of which there were nine (3.9 per cent).

The study shows that the PTB prosthesis has been successfully worn in cold winter weather, although it is somewhat colder than prostheses made of wood or leather.

In all the amputees the thigh muscles developed enormously within a few weeks.

Excessive perspiration in the stump was a problem in many cases. This phenomenon is due to the intimate fit of the plastic socket. A gradual decrease of the perspiration was noted in 8.3 per cent. However, four per cent stated that, from the outset, perspiration had been less of a problem than with their previous prostheses. It should be borne in mind that during the warm season perspiration tends to be a problem with all prostheses.

The PTB prosthesis without a thigh corset is contraindicated in cases with instability of the knee and in cases with a very short stump or with a stump of unsatisfactory shape. Furthermore, caution is indicated in the prescription of this prosthesis to farmers, lumbermen, and others who move on soft and slippery ground.

The PTB prosthesis requires very careful fitting, and extreme care must be exercised in its manufacture. In cases where there is a long distance between the place of residence and the prosthetics facility, this is not perhaps the most appropriate type of prosthesis.

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