The Army Medical Biomechanical Research Laboratory Porous Laminate Patellar-Tendon-Bearing Prosthesis

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In warm or humid climates, the problem of heat and perspiration within a nonporous plastic laminate prosthesis covering a substantial area of the body is particularly troublesome. The accumulation of sweat in a patellar-tendon-bearing (PTB) socket or a shoulder cap, combined with the inability of the laminate to permit evaporation or diffusion of water vapor, frequently causes mild to severe discomfort and even skin lesions sufficiently severe to require that the use of the prosthesis be suspended. Moreover, when a rubber (Kemblo) and leather liner is used, the sweat may cause it to deteriorate.

Initial efforts of the U.S. Army Medical Biomechanical Research Laboratory (AMBRL) to produce porous plastic laminates for prosthetic applications were well received when applied to upper-extremity devices *(2,3);* but, when the same technique was applied to PTB prostheses, the strength and durability of the material proved to be inadequate *(4,5).* In addition, problems of low porosity, nonreproducibility, and increased fabrication time were cited as serious deficiencies in the technique *(8).*

In 1966, AMBRL reported on the development of an epoxy porous laminate which when fabricated according to the instruction manual *(6)* offered the following claimed advantages over prior techniques utilizing polyester resins:

1. The new laminates were two and one-half times stronger under laboratory test conditions.
2. The new technique produced laminates which were twice as porous as prior versions.
3. The fabrication procedure was simpler, required only one curing temperature, and could be reproduced more reliably.

DESCRIPTION OF THE TECHNIQUE

STUMP-CASTING PROCEDURES

The stump-casting and cast-modification procedures are essentially the same as those taught in the various prosthetics educational programs. However, the positive stump model is prepared for a suction lamination. This technique, which involves the use of a vacuum pump to make the PVA bag conform to the socket contours, is familiar to many prosthetists but is not a routine procedure in the fabrication of a PTB socket with soft insert.

FABRICATION PROCEDURES

The procedures for fabricating a porous epoxy laminate PTB socket with a soft distal end differ from those used in the polyester lamination system as follows: the utilization of Silastic Elastomer 385 and Foam Elastomer 386 to form the soft distal end, and the procedure of impregnating the Banlon and nylon stockinette with a predetermined quantity of resin mixture consisting of epoxy EPON, Versamid, pigment, and methylene chloride.

[1] Based upon *The AMBRL Porous Laminate Patellar - Tendon-Bearing Prosthesis,* published by Prosthetics and Orthotics, New York University Post-Graduate Medical School, New York, NY., in March 1968 *(1).* The study was conducted under the supervision of Sidney Fishman, Ph.D., Project Director, with financial support from a special grant from the Children's Bureau, Department of Health, Education, and Welfare.

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Preimpregnation of the stockinette and evaporation of the solvent prior to layup result in a stronger, more porous socket.

FINISHING PROCEDURES

Standard finishing procedures are not used because they would reduce the porosity of the socket. A procedure in which indexing pins are used to align the porous shank with the socket is detailed in the 1963 AMBRL instruction manual *(4)* and is incorporated in the NYU revision of the 1966 AMBRL manual (7).

The one variation from the AMBRL procedure that was introduced in the finishing process by NYU was the use of polyurethane as a buildup material over the socket instead of A.C. polyethylene wax (steps 51 and 52 in the 1966 AMBRL manual). Polyurethane foam was believed to offer the prosthetist a faster method for accomplishing the external buildup over the socket. The foam also permits the use of power equipment for shaping, which the wax does not.

PRELIMINARY EVALUATION

A preliminary evaluation completed at NYU in March 1967 *(9)* critically considered the epoxy porous laminate procedure in the following respects on the basis of four fittings on below-knee amputees: the fabrication process, amputee reactions, durability, and laboratory tests. The fittings were carried out in the New York metropolitan area during a period of very hot, humid weather in the summer of 1966, which afforded ideal conditions for investigation of amputee reactions to socket porosity.

In summary, the conclusions of the preliminary evaluation were:

That the May 1966 AMBRL instruction manual was generally clear and easy to follow. However, the finishing procedures lacked the completeness of those set forth in the June 1963 AMBRL manual. A revision of the former was prepared, incorporating details of this part of the technique. The procedures were consistent with accepted prosthetics practice, and no unusual equipment was necessary.

That the actual time required for fabrication was approximately one and a quarter hours longer than that required for fabrication of the conventional PTB prosthesis. The bench time can be reduced somewhat if the suction hose is inserted into the oven, eliminating the necessity of setting up the undercut areas of the stump model prior to placement of the socket in the oven for curing.

That the coloring and the finish of the experimental prostheses were uniform, and the porosity was highly acceptable. Since no socket liner is used in this procedure, but rather a soft distal end, the amputee's tolerance to a "hard" socket was incidentally investigated. None of the amputee subjects in this preliminary evaluation noted any adverse reaction to the lack of a soft insert. All reported a significant reduction in discomfort associated with perspiration during the period of wear, remarking that the stump socks were much less saturated at the end of the day.

That the experimental prostheses were significantly lighter in weight, with an average reduction of 32 per cent. The prostheses showed no signs of breakdown or clogging of the pores over a six- to 12-month period of wear, and showed excellent retention of original conformation. All are still being worn satisfactorily after 18 months.

On the basis of this preliminary evaluation, the Subcommittee on Child Prosthetics Problems of the Committee on Prosthetics Research and Development recommended that a field study be initiated to evaluate the porous laminate technique on a broad sample of juvenile subjects.

SCOPE AND OBJECTIVES OF THE FIELD STUDY

Six clinics (Atlanta, Birmingham, Durham, Memphis, New Orleans, and Orlando), all located in hot, humid climates in the southern and southeastern sections of the United States, were invited to send a prosthetist representative to a three-day course in the fabrication of the AMBRL porous laminate PTB prosthesis, conducted at New York University in May 1967. Each clinic agreed to fit five subjects during the summer of 1967 with porous PTB prostheses fabricated by or directly under the supervision of the prosthetist attending the course.

The field study was designed to evaluate the AMBRL porous laminate used in the following respects:

1. Fabrication procedures.
2. Subjective reactions (comfort and cosmesis).
3. Medical considerations (stump hygiene and skin condition).
4. Durability and adjustments.

THE SAMPLE

The sample consisted of 20 subjects—11 males and nine females between four and 20 years of age. Five were from Atlanta, three from Birmingham, three from Durham, two from Memphis, and seven from New Orleans. There were seven right and ten left below-knee amputees, two bilateral amputees (one right below-knee and left Syme's; one bilateral below-knee), and one unspecified. Eleven of the amputations were congenital, ten acquired, and one unspecified. All subjects were experienced prosthesis wearers, the prior prosthesis having been worn for seven months to three years.

The types of prostheses worn by these subjects prior to the study are listed as follows:

PTB sockets	
With side joints and lacer, without liner	3
With supracondylar cuff, with liner	8
With supracondylar cuff, without liner	6
Syme's prosthesis	2
Other or unspecified	3
	22

METHODOLOGY

At least, five clinic visits by each amputee subject were required for the appropriate evaluations. An outline of the procedures follows.

FIRST VISIT (SCREENING AND PRESCRIPTION)

At the first visit, clinic personnel discussed the purpose of the study with patient and parents, indicating the type of data that would be requested. A porous laminate PTB prosthesis was to be prescribed at this time. For purposes of uniformity, all experimental limbs were to use supracondylar suspension. General biographical information was recorded, as well as subjective comments concerning the previously worn prosthesis.

SECOND VISIT (DELIVERY)

The porous laminate prosthesis was delivered at the second visit, and initial reactions of the subject and the clinic team were recorded. The prosthetist's report was initiated and retained by the prosthetist for submission at the termination of the study, as a means of recording fabrication and maintenance problems.

THIRD VISIT (ONE MONTH POSTDELIVERY)

The child's stump was examined to ascertain if any dermatological changes had occurred which might be attributable to the porous socket. Subjective reactions to the experimental prosthesis and reactions of the subject to the prosthesis as compared with the previously worn prosthesis were recorded.

At this time the experimental prosthesis was rendered nonporous by the application of Saran Wrap, duplicating the procedure used in the preliminary evaluation at NYU. The prosthesis was then worn under these conditions for a two-week period of hot weather.

FOURTH VISIT (AFTER WEAR WITH SARAN WRAP)

The stump was examined for dermatological changes. Any differences reported by the subjects as a result of eliminating socket porosity were assessed. The Saran Wrap was then removed.

FIFTH VISIT (AFTER SIX WEEKS' WEAR OF THE POROUS PROSTHESIS WITHOUT SARAN WRAP)

Subjective and comparative reaction were once more elicited. The prosthetist's report was submitted.

FIELD STUDY RESULTS

During the NYU course of instruction in this technique, one prosthetist was adversely affected by the epoxy resin. The difficulty had been noted occasionally in earlier studies. The developer has recognized the potential hazard, and appropriate handling precautions must be carefully observed.[3]

[3] Disposable gloves should be worn when handling all resins and solvents. Face shield or goggles are advisable when pouring or mixing the resins.

The epoxy resins (EPON 815) and curing agents (T-l) and, to a lesser extent, Versamid 140, are primary skin irritants. When in contact with the skin for a sufficient period of time, these materials are capable of producing a contact dermatitis in most individuals. In a relatively few hypersensitive workers, they can

FABRICATION PROCEDURES

Telephone contacts with the participating prosthetics facilities during the course of the field study indicated that, with one exception, the fabrication procedures posed no serious problems. One facility was unable to duplicate the procedures because of difficulties with equipment. (Adequate temperature control is mandatory for successful preparation; this facility's oven temperature could not be reliably maintained for precuring the layup material.) Prosthetists' fabrication reports were received from five of the participating clinics.

All reports indicated that two or three additional hours were required to fabricate a porous PTB prosthesis. Phases of the process cited as time-consuming were the weighing, processing, and curing; breakouts and reassembly; finishing; and the preparation of the soft distal end.

No criticisms were made of the instructions contained in the manual. The process, however, was evidently more demanding than the conventional technique. Close attention to accuracy and detail is essential for successful preparation of the porous laminate.

The increased fabrication time and effort, the need for some special materials, and the necessity for adequately ventilated work areas may result in some cost increases. One clinic expressed concern about the attitude of the local state agency in this respect, and one prosthetist suggested that the increased cost be borne in mind when the prescription is written.

REACTIONS OF SUBJECTS AND CLINIC PERSONNEL

The experimental limbs were generally considered superior to the previously worn prostheses in several respects. Initial reactions to the porous prostheses, elicited immediately after delivery, are shown in Tables 1 and 2. After a one-month period of wear, corresponding reactions of the subjects and the clinics were recorded; these results appear in Tables 3 and 4.

Examination of Tables 2 and 4 (comparative reactions) indicates few changes from the positive first impression as wear increased, with a trend toward more emphatic positive comments.

One month after delivery, the patient, his parents, and the clinic were asked their preference between the previously worn prosthesis and the experimental prosthesis. The results are shown in Table 5. In addition, the clinics were asked if they would prescribe a porous laminate prosthesis for other patients. Three clinics said "Yes," one said "No," and one said "Probably."

TABLE 1. REACTIONS OF PATIENTS AND CLINICS ON DELIVERY OF POROUS PROSTHESIS

(N = 22)

Rating	Patients' Reactions			Clinics' Overall Reaction
	Comfort	*Weight*	*Appearance*	
Very satisfactory	8	13	9	5
Satisfactory	14	9	10	13
Unsatisfactory	0	0	1	1*
Very unsatisfactory	0	0	1*	0
No response	0	0	1*	3

* Prosthesis not yet completed

produce an allergic type of dermatitis in a relatively short period of time.

Intermittent skin contact with these materials will not usually cause a dermatitis among normal workers; however, because of the occasional hypersensitive individual who cannot always be identified in advance, the precautionary measures suggested above should be used at all times.

In addition to the foregoing precautions, good general ventilation is highly recommended.

The first case of dermatitis usually indicates that proper handling procedures are not being observed, although in a very hypersensitive individual this is not necessarily true. The dermatitis should be treated promptly, and the source of contact should be ascertained and eliminated. The rash may be alleviated in most instances by soaking with warm Burow's Solution for 15-30 min., three or four times daily. Rashes that do not respond to treatment should be seen by a physician

Based upon Handling Precautions for the Resin-Solvent System Used for Preparing Porous Laminates, an intramural memorandum issued by AMBRL in May 1967.

After four weeks of wear, the prostheses were covered with Saran Wrap to eliminate the porosity of the sockets while leaving the prostheses intact. No change was made in fit, weight, alignment, or other factors that might affect reactions. The subjects were asked to wear the experimental limbs under these conditions for a two-week period of hot weather. Seventeen subjects reported data for this test period. The majority indicated that perceived heat within the socket increased and that perspiration became a problem (introducing dermatological problems and discomfort). Table 6 lists the reactions of the subjects regarding the test period utilizing the Saran Wrap.

TABLE 2. COMPARISON OF POROUS PROSTHESIS WITH PREVIOUSLY WORN PROSTHESIS
($N = 22$)

Rating	Patients' Reactions			Clinics' Overall Reaction
	Comfort	*Weight*	*Appearance*	
Better	9	13	9	7
Same	13	5	9	9
Worse	0	4	3	2
No response	0	0	1	4

TABLE 3. REACTIONS TO POROUS PROSTHESIS ONE MONTH POSTDELIVERY
($N = 22$)

Rating	Patients' Reactions				Clinics' Overall Reaction
	Comfort	*Weight*	*Appearance*	*Heat*	
Very satisfactory	9	12	8	3	7
Satisfactory	11	8	11	14	8
Unsatisfactory	1	0	0	1	2
Very unsatisfactory	0	0	0	1	0
No response	1	2	3	3	5

TABLE 4. COMPARISON OF PRESENT PROSTHESIS WITH PREVIOUSLY WORN PROSTHESIS
($N = 22$)

Rating	Patients' Reactions			
	Comfort	*Weight*	*Appearance*	*Heat*
Much better	12	14	8	10
Better	8	2	4	8
Same	0	5	5	3
Worse	0	0	3	0
Much worse	1*	0	0	0
No response	1	1	2	1

* Socket adjustments required

Comparison of Table 6 with Table 2 shows a significant change in the perception of heat within the socket. Of those subjects offering opinions, 90 per cent considered the experimental prosthesis very satisfactory or satisfactory prior to the application of Saran Wrap, and 10 per cent considered it unsatisfactory. With the Saran Wrap, only 27 per cent reported the prosthesis satisfactory, and 73 per cent considered it unsatisfactory or very unsatisfactory—certainly a very dramatic reversal of reactions on the part of the wearers.

Since no changes were introduced in fit, weight, or alignment, it was not expected that perception of socket comfort would change significantly under the test conditions, except to the extent that comfort might be affected by heat in the socket. Prior to the test period 95 per cent reported satisfactory reactions to comfort, while 5 per cent considered the prosthesis unsatisfactory; with the use of Saran Wrap, 83 per cent considered the experimental limb satisfactory and 17 per cent unsatisfactory.

An uninterrupted six-week wear period followed the study of the effects of the Saran Wrap covering. At this time, subjects and clinic teams were asked to submit a non-comparative assessment of the experimental prosthesis and a separate questionnaire comparing the experimental prosthesis to the one worn before the field study. The results appear in Tables 7 and 8. These data were received regarding 17 experimental prostheses.

After a three-month period of wear, subjects and clinics were asked to indicate preferences as to the type of prosthesis to be worn in the future (Table 9). When clinics were asked if they would recommend the porous laminate prosthesis for other patients, three

TABLE 5. PREFERENCE FOR FUTURE USE BY PATIENTS, PARENTS, AND CLINICS

Respondent	Number Preferring Porous	Reasons for Preference	Number Times Mentioned	Number Preferring Prior	Reasons for Preference	Number Times Mentioned	No Response
Patients (N = 20)	16	Cooler	12	1	Durability	1	3
		Lighter	10				
		Appearance	3				
		Comfort	3				
		Better function	2				
		Soft end	2				
		Easier donning	1				
		Less irritation	1				
Parents (N = 20)	14	Child prefers	5	1	Porous hard to keep clean	1	5
		Lighter	4				
		Comfort	2				
		Cooler	2				
		Less perspiration	2				
		Alleviates skin problems	1				
		Function	1				
		Soft end	1				
Clinics (N = 5)	4	Alleviates dermatitis	4	1	Relief difficult	1	0
		Lighter	4		Durability	1	
		Cooler	3				
		Function	1				
		Patient preference	1				

said "Yes," one said "No," and one said "Possibly."

MEDICAL CONSIDERATIONS

A definite decrease in stump hygiene difficulties was specifically reported for two subjects in the study, leading to a recommendation by one clinic that the porous laminate be considered in cases presenting dermatological problems. There were no instances of deterioration of stump condition that could be related to the porous laminate, although socket adjustments were required in some cases.

DURABILITY AND ADJUSTMENTS

Two clinic chiefs and their prosthetists expressed doubt that the porous laminate prosthesis would be sufficiently durable for patients who give their prostheses extremely heavy use. No such problems were encountered in an 18-month follow-up of the adult patients participating in the original NYU study of the epoxy porous prosthesis. The developer implies that adequate strength can be provided with this technique, even for heavy subjects, although only limited supporting data for this contention are available.

TABLE 6. REACTIONS TO A TWO-WEEK PERIOD WITH SARAN WRAP
(N = 17)

Ratings	Patients' Reactions		Clinics' Overall Reaction
	Comfort	*Heat*	
Very satisfactory	6	0	3
Satisfactory	8	4	5
Unsatisfactory	1	3	2
Very unsatisfactory	2	8	3
No response	0	2	4

One prosthesis fitted with side joints and thigh corset, which compromised the requested supracondylar suspension, showed repeated

TABLE 7. REACTIONS TO POROUS PROSTHESIS APPROXIMATELY THREE MONTHS POSTDELIVERY ($N = 17$)

Rating	Patients' Reactions				Clinics' Overall Reaction
	Comfort	*Weight*	*Appearance*	*Heat*	
Very satisfactory	12	12	11	6	9
Satisfactory	4	5	5	8	4
Unsatisfactory	1	0	1	2	3
Very unsatisfactory	0	0	0	0	0
No response	0	0	0	1	1

TABLE 8. COMPARISON OF POROUS PROSTHESIS WITH PREVIOUSLY WORN PROSTHESIS ($N = 17$)

Rating	Patients' Reactions			
	Comfort	*Weight*	*Appearance*	*Heat*
Much better	10	12	8	10
Better	5	5	4	4
Same	1	0	3	3
Worse	0	0	1	0
Much worse	1*	0	1	0

* Socket adjustment required

breakdown. If side joints are to be provided, the porosity of a substantial socket area must be sacrificed in order to provide adequate strength. Consequently, porous lamination may not offer as significant an advantage for these patients. In view of this problem, reservation of the porous laminate procedure for the PTB-type of fitting without side joints may be indicated. This point merits further investigation.

One prosthesis was reported to have delaminated between the insert and the outer wall. However, it appears that this complaint referred to a failure of the bond between socket and shell and not to delamination *per se.* Two other prostheses showed marked wear during the period of study, although no functional problems were encountered.

Adjustments are more difficult to perform on the porous laminate socket, since it is impossible to fill in an area without sacrificing porosity. It is also more difficult to relieve an area. Because the finished laminate is so much thinner than conventional products, reducing the area may render it too weak for normal use.

DISCUSSION

The high level of acceptance of the experimental prosthesis is supported by repeated references to three principal factors.

"Increased comfort" is a broad term which encompasses, both directly and indirectly, the decreased weight of the porous limbs compared to the previously worn prostheses, decreased perspiration (with concomitant dermatological improvement) and reduction of heat within the socket, and the added comfort of the soft distal end.

WEIGHT

To confirm the subjective impression of lighter weight, the weights of previously worn prostheses and experimental prostheses were compared. Table 10 indicates the percentage of weight reduction for the 14 prostheses where such data were available. It can be seen that the average reduction is approximately 25 per cent.

PERSPIRATION AND HEAT

Approximately one-third of the reasons cited for the preference of the porous laminate for future use related to the diminution of perspiration and the perception of the experimental limb as cooler. The results of the two-week test period (experimental socket covered with Saran Wrap) dramatically illustrate the importance of socket porosity in this regard.

SOFT DISTAL END

In their preliminary testing, both the developer and New York University found no serious problems occasioned by the change from an insert to a hard socket with soft distal end. The observation was borne out in the field study during which the incidental investigation of the soft distal end elicited several positive comments (one clinic, although

TABLE 9. PREFERENCES FOR FUTURE USE BY PATIENTS, PARENTS, AND CLINICS

Respondent	Number Preferring Porous	Reasons for Preference	Number Times Mentioned	Number Preferring Prior	Reasons for Preference	Number Times Mentioned	No Response
Patients	15	Lighter	8	1	Appearance	1	1
		Cooler	6				
		Comfort	3				
		Better function	2				
		Cosmesis	2				
		Better fit	1				
Parents	14	Better function	4	1	—	—	2
		Lighter	4				
		Cooler	2				
		Child's preference	1				
		Comfort	1				
		Cosmesis	1				
		No odor	1				
		Less skin problems	1				
Clinics	2	Lighter	5	3	Durability	3*	0
		Cooler	4		Experimental sockets not adequately porous	2	
		Better function	3				
		Patient preference	2				
		Comfort	2		Cosmesis	1	
		Appearance	1		Cost	1	
		Reduction in skin problems	1		Porous harder to fit or modify	1	

* Despite preference for porous laminate in one case

TABLE 10. PERCENTAGE OF WEIGHT REDUCTION ($N = 14$)

Weight of Prior Prosthesis (in pounds and ounces)	Weight of Porous Prosthesis (in pounds and ounces)	Percentage of Reduction
3 – 8	2 – 5	53
4 – 8	2 – 8	44
5	5	0
4 – 8	3 – 8	22
1 – 8	1 – 4	17
5 – 8	3	30
4	4 – 14	0
5	3	40
3 – 4	2 – 6	27
3 – 12	2 – 5	38
1 – 4	1 – 4	0
1 – 2	1 – 2	0
5 – 4	3	43
5 – 4	3 – 8	33

recommending a standard laminate in the future fitting of a patient to provide greater durability, would recommend that the new prosthesis incorporate the soft distal end procedure).

AMPUTEE AND CLINIC REACTIONS

Patients and their parents were almost unanimous in their acceptance of the porous prosthesis (nearly 95 per cent of the patients and their parents preferred the experimental technique), whereas the clinics exhibited much less enthusiasm. At the close of the study, only two of the five clinics would definitely prefer the porous laminate for future use. It is important to note that the two clinics which recommended the porous laminate for future use accounted for the fitting of 11 of the 17 subjects who completed this phase of the

study. Reluctance to prescribe the porous laminate resulted in extremely limited samples from the three clinics who preferred the standard technique.

Two of the clinics rejecting the porous laminate for the future use of the patients fitted in the study might, however, recommend the porous prosthesis for *other* patients. Therefore, only one clinic categorically rejected the experimental prosthesis.

Several suggestions may be advanced to help resolve this apparent discrepancy of opinion. During the study, as early as one month postdelivery, four reports were received which indicated dissatisfaction with the appearance of the experimental limbs. The poor appearance was specifically related to difficulties in keeping the comparatively rough surface clean. It was noted that the porous prostheses tended to appear dirty after only a short period of use, with one experimental prosthesis being rejected for this reason. Interrogation cf adult patients involved in the preliminary laboratory study showed that the prostheses are in fact difficult to clean and that they gather varying amounts of dirt, but none of the patients spontaneously complained of this problem. It might be expected that children would be less sensitive to this problem than adults.

A further explanation for the clinics' less emphatic endorsement may lie in the increased cost factors (due to two to three hours' increase in fabrication time and materials), the need for some specialized equipment, and the occasional allergenic reactions of shop personnel to the uncured resin-solvent system. Therefore, the prosthetists' reluctance to utilize the technique may have been transmitted to the clinics.

SUMMARY

The AMBRL porous laminate technique as applied to the PTB prosthesis was evaluated over a three-month period on 20 children at five juvenile amputee clinics in the southern section of the country. Essential aspects investigated were the fabrication process, subjective reactions, medical considerations, adjustments, and durability.

The data indicated that porous laminate PTB prostheses were generally well accepted by patients and parents but less so by clinic personnel. The developer's claims of reduced perspiration, added comfort, decreased dermatological problems, and lighter weight were generally corroborated; weight reduction was the most consistently reported advantage.

Increased fabrication time and some increase in the complexity of the fabrication process were cited as problems. Cosmetic characteristics elicited both favorable and unfavorable remarks; the propensity of the porous laminate to collect and trap dirt particles caused some dissatisfaction, while the textured appearance of the porous laminate was preferred in some instances.

Concern was expressed regarding the durability of the porous laminate, particularly when applied to a prosthesis which was subjected to arduous use, although the experimental evidence was apparently insufficient for such concern.

Based upon patients' and parents' preference for the experimental limbs, including instances of improvement in stump condition, it appears that the porous laminate PTB is a significant and worthwhile addition to prosthetics technology. Other applications of the porous laminate may also be recommended, particularly for those patients with substantial body areas enclcsed within a socket, with severe perspiration problems, or where a lightweight prosthesis is indicated. Shoulder caps, transthoracic sockets, above- and below-elbow sockets, or hip-disarticulation and hemipelvectomy applications may be considered. Informal observations of several upper-extremity fittings have again indicated that the porous laminate offers distinct advantages in terms of decreased perspiration and weight.

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