Volume 37
Number 2

Orthotics and Prosthetics

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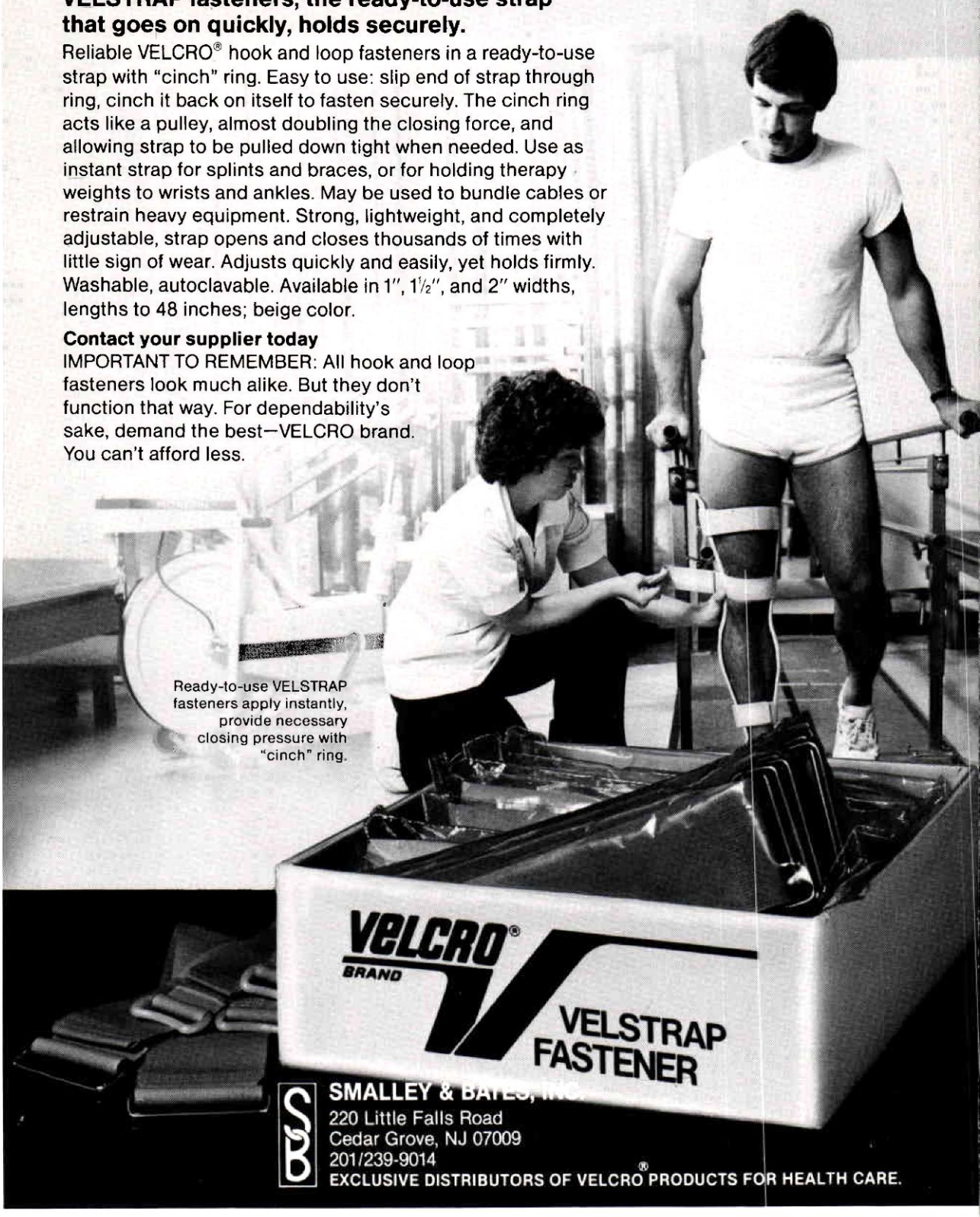

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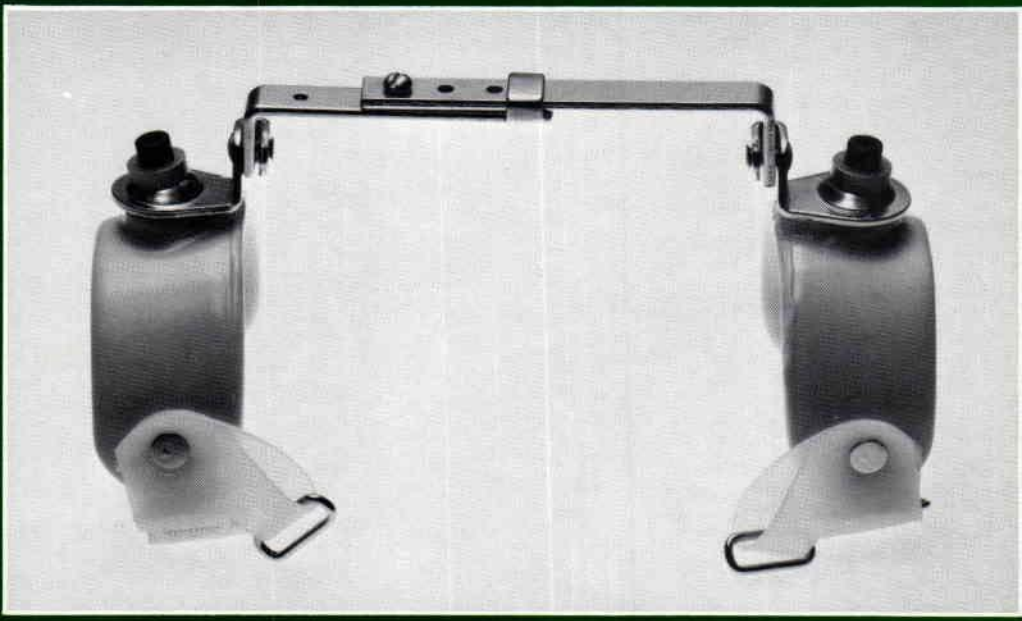

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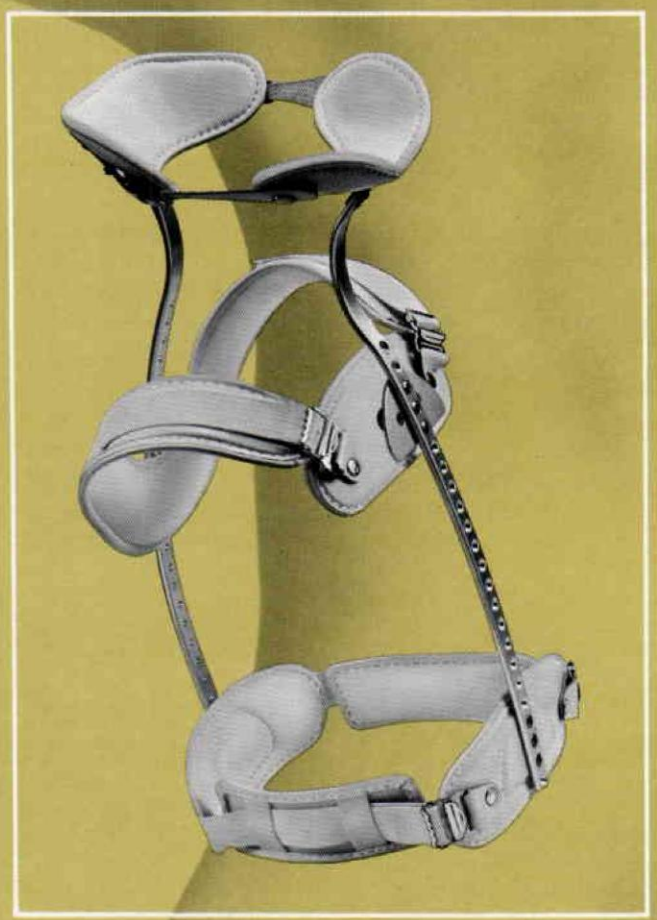

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Orthotics and Prosthetics

Volume 37, No. 2

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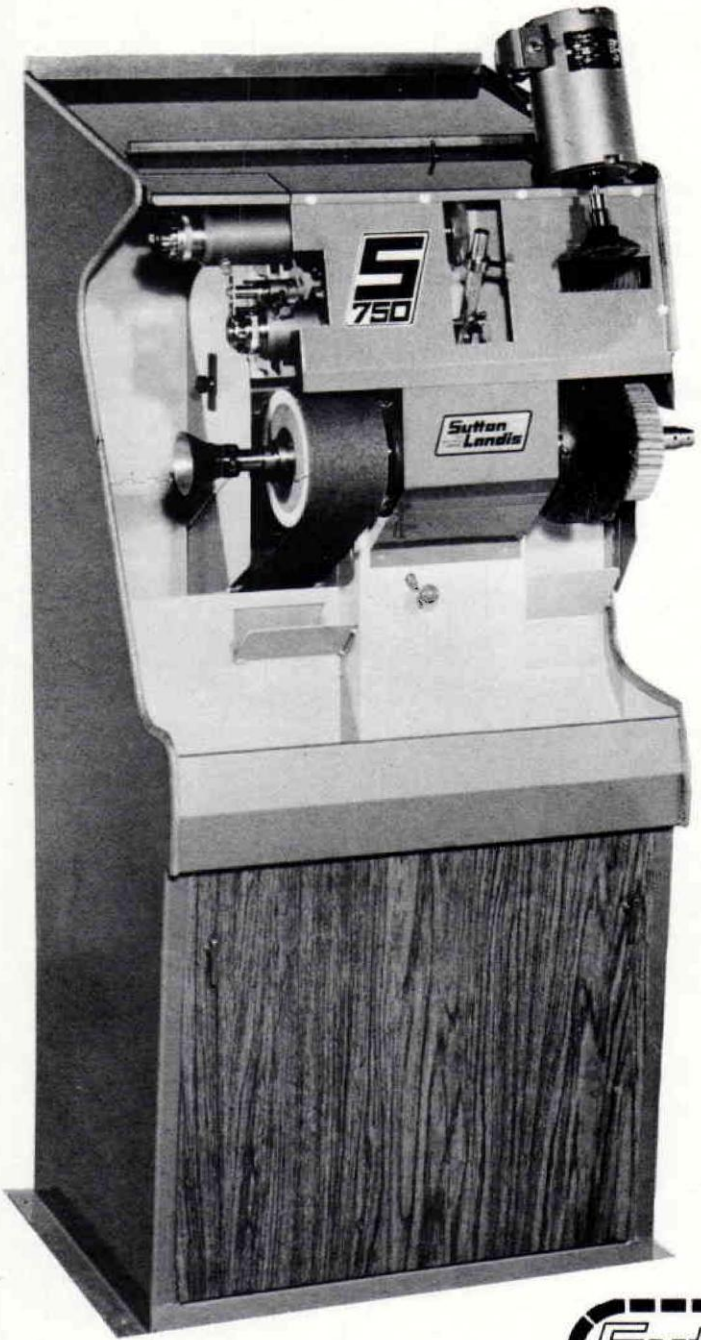

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Meetings and Events

Please notify the National Headquarters immediately concerning additional meeting dates. It is important to submit meeting notices as early as possible. In the case of Regional Meetings, it is mandatory to check with the National Headquarters prior to confirming date to avoid conflicts in scheduling.

1983

November 11, "Seating and Mobility Systems," Gillette Children's Hospital, St. Paul, Minnesota. Contact: Brett Day, Continuing Education Dept., Gillette Children's Hospital, 200 E. University Ave., St. Paul, Minnesota 55101, 612-291-2848.

November 12–13, Seating Symposium, Northwestern University, Chicago, Illinois. Sponsored by the Academy Midwest Chapter. Contact: Robert Picken, CP, Educational Chairman, Academy Midwest Chapter, 345 East Superior, Room 1723, Chicago, Illinois 60611, 312-649-8006.

November 13–18, 2nd International Symposium on Design for the Handicapped, Tel-Aviv, Israel. Contact: Dr. E. Chigier, Kenes, P.O.B. 29784, Tel-Aviv 61297, Israel.

November 14–18, Afro-Asian Conference on Role of Play in Child Development, including sub-theme, "Play for the Disabled Child," under the auspices of UNESCO, New Delhi, India. Contact: Dr. Paul Chowdhry, Secretary General, Afro-Asian Conference, c/o National Institute of Public Cooperation and Child Development, 5 Siri Institutional Area, Hauz Khas, New Delhi 110016, India.

November 15–18 (tentatively), Seventh Annual International Rehabilitation Film Festival, New York, New York. Contact: Rehabfilm, RIUSA, 1123 Broadway, New York, New York 10010.

December 9–11, "Surgery and Rehabilitation of Complex Problems of the Upper Limb," Sheraton Bal Harbour, Miami Beach, Florida. Presented by the Department of Orthopaedics and Rehabilitation, University of Miami School of Medicine. Contact: JoAnn Harris, Coordinating Assistant, Department of Orthopaedics and Rehabilitation, P.O. Box 016960, University of Miami School of Medicine, Miami, Florida 33101.

December 12–13, UCLA Seminar, "Amputation Surgery Immediate Post Surgical Prosthetic Techniques for Physicians/Prosthetists." Contact: Peggy Colton, Program Coordinator, UCLA P.O.E.P., Rm. 22-46 Rehab. Center, 1000 Veteran Ave., Los Angeles, California 90024.

December 12–13, 30th Annual Meeting of the Council of World Organizations interested in the Handicapped, UNESCO Headquarters, Paris, France. Contact: Chairman, CWOIH, 432 Park Avenue South, New York, New York 10016.

December 15–18, Second International Symposium on Integration of the Disabled, Mar del Plata, Province of Buenos Aires, Argentina. Contact: Dr. Jose Orozco, Instituto Naçional de Rehabilitation del Sur, Ruta 88 Km. 4Y2, Camino 2 Necochea, Estafeta Postal No. 18,7.600 Mar del Plata, Provincia Buenos Aires, Argentina.

1984

January 25–29, Academy Annual Meeting and Seminar, Dutch Resort Hotel, Lake Buena Vista, Orlando, Florida. Contact: Academy National Headquarters, 703-836-7118.

April 1–4, Asian and Pacific Convocation on Rehabilitation, to examine how a wide cross-section of people can work in partnership with disabled people, sponsored by R.I. New Zealand, Rehabilita-

tion League and Accident Compensation Corporation, Wellington, New Zealand. Contact: Accident Compensation Corporation, Private Bay, Wellington, New Zealand.

April 6–7, New England Academy Chapter Annual Meeting, Worcester Marriott, Worcester, Massachusetts.

April 12–15, AOPA Region IV Annual Meeting, Waverly Hotel at the Galleria, Atlanta, Georgia.

April 19–22, AOPA Region V Annual Meeting, Amway Grand Plaza Hotel, Grand Rapids, Michigan.

April 19–24, 1st International Meeting on Leisure, Recreation, and Sports, organized by the Rehabilitation International Commission and sponsored by R.I., the Japanese Society for Rehabilitation of the Disabled and the governments of Gamagori City and Aichi Prefecture, Gamagori, Japan. Contact: Japan Sun Industries, Kamegawa, Beppu 847-01 Japan.

May 3–4, AOPA Regions I, II, and III Combined Annual Meetings, Concord Hotel, Kiamesha Lake, New York.

May 13–19, 9th International Congress of Physical Medicine and Rehabilitation, Jerusalem, Israel. Contact: Kenes, 29 Mamred Street, P.O.B. 29784, 61297 Tel-Aviv, Israel.

June 1–3, AOPA Region IX, COPA and the California Chapters of the Academy Combined Annual Meeting, Lake Arrowhead, California.

June 4–8, 15th World Congress of Rehabilitation International on theme, "Information, Awareness and Understanding for Integration of Disabled Persons and Society," Lisbon, Portugal. Contact: (Program) Rehabilitation International, 432 Park Avenue South, New York, New York 10016.

June 12–July 4, 7th World Wheelchair Games (formerly Paralympics), University of Illinois, Champaign, Illinois. Contact: Prof. Timothy Nugent, Rehabilitation Education Center, 1207 South Oak Street, Champaign, Illinois 61820.

June 16–28, 1984 International Games for the Disabled, sponsored by the International Sports Organization for the Disabled, Nassau County, Long Island, New York. Contact: Mr. Michael Mushett, Director, 1984 International Games for the Disabled, c/o Special Populations Unit, Eisenhower Park, East Meadow, New York 11554.

June 17–22, "1984—The Bright Side," The Second International Conference on Rehabilitation Engineering, combined with the 7th Annual Conference on Rehabilitation Engineering, Congress Centre, Ottawa, Ontario, Canada. Sponsored by the National Research Council of Canada, the Rehabilitation Engineering Society of North America, and the Canadian Medical and Biological Engineering Society. Contact: Conference Services, National Research Council of Canada, Ottawa, Ontario, Canada K1A 0R6.

June 21–24, AOPA Region VI and the Academy Midwest Chapter Annual Combined Meeting, Holiday Inn, Merriville, Indiana.

June 28–30, AOPA Regions VII, VIII, X, and XI Combined Meeting, North Shore Convention Center, Lake Coeur d'Alene, Idaho.

September 30–October 5, 16th Congress of the International Society for Orthopedic Surgery and Traumatology (SICOT), London, England. Contact: Conference Services, Ltd., 3 Bute Street, London, SW7 3EY, United Kingdom.

October 16–21, AOPA General Assembly and International Congress, Fontainebleau Hotel, Miami Beach, Florida. Contact: AOPA National Headquarters, 703-836-7116.

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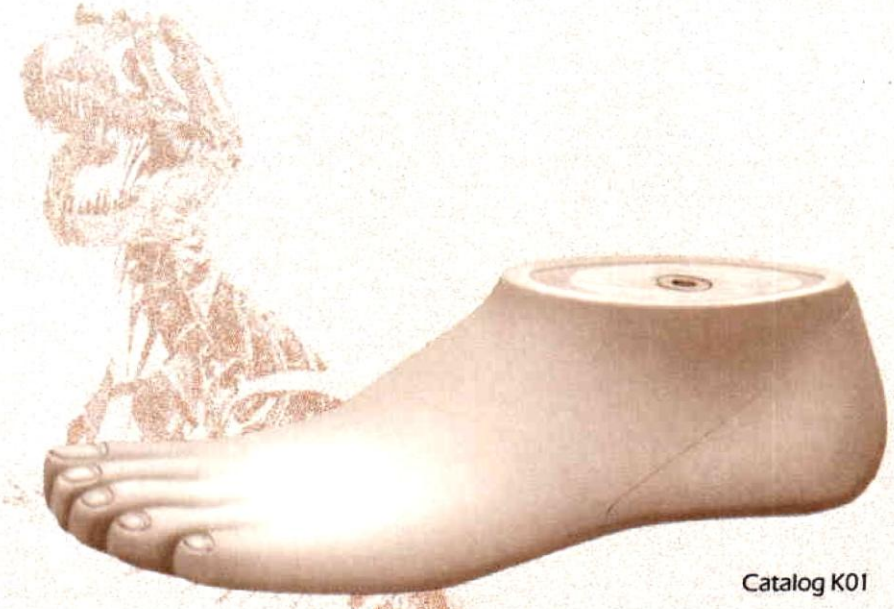

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The Two Stage Myoelectric Hand for Children and Young Adults

Eric Baron, C.P.O.
Susan D. Clarke, O.T.R.
Carol Solomon, M.S.W.

When myoelectric components became available for young below elbow amputees, the Child Amputee Prosthetics Project (CAPP) at the University of California at Los Angeles undertook a study to determine how children would benefit from such fittings. The goals of the study were:

- to establish criteria for selection of candidates.
- to identify maintenance needs unique to the myoelectric fittings for children.
- to evaluate the functional potential of myoelectric hands for children.
- to develop evaluation, fitting and training techniques appropriate for different age groups.
- to evaluate the attitudes of children and their parents toward the myoelectric prosthesis with regards to its functional and cosmetic potentials.

PROSTHETIC COMPONENTS AND EQUIPMENT EVALUATED

At the time of the study, two myoelectrically controlled hands were readily available in sizes which were appropriate to our population; the Otto Bock child size hand and the Systemteknik hand, number one (small) often referred to in the literature as the "Swedish Hand." Both were used in conjunction with the Otto Bock 6 volt two stage electrode system. A myoelectric hand and electrode set-up and the Otto Bock myotester with dual dials were used for electrode sight locations.

CRITERIA FOR SELECTION OF SUBJECTS

Following a review of criteria established for adult myoelectric hand candidates, the staff established the following list of criteria for selection of children to participate in the study.

- Child and family are highly motivated to participate in the myoelectric hand study.
- Child has a functional or cosmetic need that can be met by the myoelectric hand.
- Child is of an appropriate size for the myoelectric hands available.
- Child has two suitable electrode sites.
- Child has an appropriate length residual limb.
- Child has a consistent wearing pattern if currently wearing a prosthesis.
- Child can make the required visits for training and evaluation.
- Child and family are conscientious about maintaining current prosthesis.

- Child will restrain him/herself when activities may cause damage to the myoelectric hand.
- Child is able to wear an intimately fitting socket without a prosthetic sock.
- Child does not object to having restricted range of motion at the elbow.

The following operational definitions were used to apply these criteria.

- Approximate size: sound hand is the same size or slighly larger than available myoelectric hand.
- Consistent wearing pattern: wears prosthesis regularly for certain activities or periods of the day.
- Required number of visits: regular visits to CAPP facility and/or therapy training facility until prosthesis is completed and child has achieved developmentally appropriate functional use of the prosthesis.
- Appropriate length residual limb: the residual limb must be long enough to accommodate the electrode sites comfortably within the socket and short enough to keep the overall length of the finished prosthesis no longer than is cosmetically acceptable to the child and family.

DATA COLLECTION

Data used to complete this report were collected using a variety of methods. Standards medical reports provided information on individual treatment plans and outcomes. Individual records were kept by both prosthetists and therapists to record method of approach to treatment, hours of training, type of equipment, and treatment media used. These provided greater detail than the medical records. Electrical component and prosthesis maintenance records were kept by the prosthetists.

Two forms were created to gather information. The occupational therapists devised the Bimanual Functional Skills Evaluation to record functional use of the prosthesis and determine preference for the type of prosthesis used in each activity. This was administered for both the myoelectric prosthesis and the body-powered prosthesis if one was worn. The social worker constructed the "Attitudes Toward Change in Prosthetic Fitting" questionnaire which was used during an open-ended structured interview to gather information from both the children and/or their parents about attitudes toward the prosthesis and other persons reactions to it.

POPULATION

Fourteen subjects participated in this study. Nine were fit with the Otto Bock hand and five with the Systemteknik #1 hand. All of the participants were unilateral congenital upper limb amputees. Eleven children had below elbow deficiencies, and three had wrist disarticulation deficiencies. Age of subjects at the time of the myoelectric fitting ranged from three years and three months to 17 years of age. Two of the participants were male and 12 were female (Fig. 1).

Prosthetic fittings prior to the study varied. Five of the subjects had worn CAPP terminal devices. Three wore body-powered hands and three interchanged Dorrance hook and body-powered hand. One subject had worn an OCCC switch-operated electric hand, but was currently not wearing a limb, another child wore an opposition post, and one child had never been fit with a prosthesis prior to the myoelectric fitting. Many of the children had had experience with other types of terminal devices during their earlier prosthetic programs. Twelve of the subjects had been fit with a prosthesis before two years of age.

Prosthetic wearing patterns varied among the subjects. Of those wearing prostheses, nine were full-time wearers and two wore their limbs part-time, primarily for school and social occasions. The child fit with an opposition post wore it for specific activities only.

Initially, criteria established for selecting subjects were rigidly adhered to. As time passed some exceptions were made, notably two families with high motivation, but a poor history of attendance and follow-up were accepted. These exceptions substantiated the validity of the criteria as both these children failed to complete the study.

Figure 1

Subject Data—Two-Stage Myoelectric Hand for Children and Young Adults

Case Number	Subject Number	Age	Sex	Amputee type	Side of amputation	Accepted for study	Type of terminal device—body powered	Type of terminal device—myoelectric	Pre-study wearing pattern	Post-study wearing pattern
492	1	12-2	M	Sh. B/E	L	Yes	Hand	O.B. 7¼	F	F-Body/M
595	2	11-5	F	W/D	R	Yes	Hand/ Hook	O.B. 6¾	F	F-Myo
597	3	11-8	F	Sh. B/E	L	Yes	Hand	O.B. 6¾	F	P-Myo
1035	4	3-3	F	W/D	R	Yes	0	Swed. Hand	0	P-Myo
720	5	12-6	F	Sh. B/E	L	Yes	Hand	O.B. 7¼	F	F-Myo
739*	6	9-3	F	W/D	L	Yes	Post	O.B. 6¾	P	0
752	7	6-10	F	B/E	L	Yes	CAPP T.D.	O.B. 6¾	F	F-Body
939	8	4-8	F	B/E	L	Yes	CAPP T.D.	Swed. Hand	R	P-Myo/Body
946	9	3-8	F	B/E	L	Yes	CAPP T.D.	Swed. Hand	F	F-Myo
1015	10	8-0	F	B/E	R	Yes	Hand/ Hook	O.B. 6¾	F	F-Myo
1002	11	3-8	F	B/E	R	Yes	CAPP T.D.	Swed. Hand	F	F-Myo
682	12	10-4	F	B/E	L	Yes	Hand/ Hook	O.B. 6¾	F	F-Myo
977*	13	4-8	M	B/E	R	Yes	0	Swed.	0	0
726	14	7-2	F	B/E	R	Yes	CAPP T.D.	O.B. 6¾	F	F-Body/Myo

*Did not complete study.

METHOD

Subjects whom the staff felt might meet the criteria for participation in the study were asked if they would like to participate. Those who accepted were scheduled for an evaluation. At the first visit the family was given an orientation to the study. Estimated number of visits to the center were given, treatment techniques described and data gathering methods explained. The prosthetist and occupational therapist demonstrated the operation of a myoelectric prosthesis and described its functional potential.

If the child and his parents met all criteria and were interested in participating, testing to locate suitable electrode sites was begun. For children over six, it was usually possible to find sites at the first visit. Younger children sometimes required more than one session to grasp the concept of contracting a muscle to produce an action in the myoelectric hand.

The prosthetist scheduled time to take a negative impression for the initial socket as soon as the sites were well-established. When criteria established for the definitive socket were met, final fabrication and fitting were completed. Controls training was continued until the child could operate the hand smoothly and consistently. This was followed by use training.

Following attainment of prosthetic skills at a developmentally appropriate level, the child was asked to complete the *Bilateral Functional Skills Evaluation*. At the same visit or a later one, the social worker interviewed the parent(s) and/or child and completed the attitude questionnaire.

PROSTHETIC FITTING TECHNIQUE

Locating and Developing Electrode Sites

Criteria for the selection of electrode sites were established as follows:

- Selected muscles can be contracted voluntarily and consistently.
- Selected muscles are not used to actively move the elbow.
- Electrode sites fall within the socket area and will not interfere with fit or comfort of the socket.

Equipment used to locate and develop electrode sites included a myoelectric hand set-up with battery and electrodes and the Otto Bock dual dial myotester. An elastic Velcro® strap to hold electrodes in place and water to dampen the skin and improve contact were sometimes used (Fig. 2). The myoelectric hand set-up proved to be the most effective feedback system for reinforcing appropriate muscle contractions in young children. The Otto Bock myotester was used for control training with some older subjects and for all subjects to evaluate the electrode sites more precisely before the actual cast of the limb was taken.

The prosthetist and therapist worked together to locate electrode sites. During the initial site location session, the electrode gains were set at five or six. This allowed the myoelectric hand to respond quickly to a minimal contraction which improved feedback. Muscle contractions in the child's residual limb were elicited by first asking the child to wiggle any residual nubbins or dimples while the trainer palpated to locate the belly of the muscle being used. This usually triggered a flexor muscle on the medial side of the residual limb. The appropriate electrode was then placed on the belly of the strongest muscle with the electrodes in line with the muscle fibers. Since it was usually a flexor, the closing electrode was used. The trainer opened the hand by touching the open electrode and encouraging the child to "wiggle his nubbin" and contract the muscle which closed the hand (Fig. 3). In this manner the child mastered one control at a time and was less confused. Once a consistent signal could be generated, as demonstrated by repeated controlled operation of hand closing, a second control site was located. To elicit an extensor muscle contraction in the residual limb, it was usually most effective to ask the child to forcibly extend the wrist and fingers of the sound hand. This produced a sympathetic response in the extensor muscles of the residual limb and usually stimulated a weak contracture which could be palpated on the lateral surface of the limb

Fig. 2. A myoelectric hand and electrodes were used to locate electrode sites.

(Fig. 4). The opening electrode was then placed over this muscle and the procedure for operating the hand reversed. The child was asked to open the hand by extending the sound wrist and tightening the muscle in the residual limb. The trainer closed the hand by touching the other electrode. Finally both electrodes were held on the residual limb and the child was asked to open and close the hand (Fig. 5).

Usually it was possible to generate at least minimal signals from two appropriate muscles at the first visit. When two sites were established the myotester was used to evaluate the child's ability to generate and separate the myosignals. If one muscle was obviously stronger than the other or they had difficulty separating signals, the gains on the electrodes were adjusted to improve the situation. When successful opening and closing of the hand was accomplished, the electrode sites were re-evaluated by the prosthetist to assure they could be incorporated into the socket. If either of the sites was not suitable, the trainer moved one electrode at a time toward a more suitable site keeping the contacts in line with the muscle fibers and re-testing until optimum sites for function and comfort within the socket area were located. If muscle contractions were weak or erratic, further training was carried out before final sites were selected.

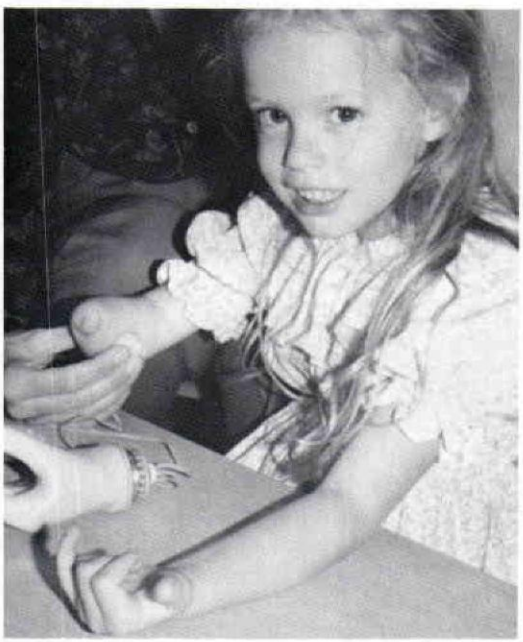

Fig. 3. The trainer encourages the child to "wiggle the nubbin" on her residual limb to stimulate a contraction.

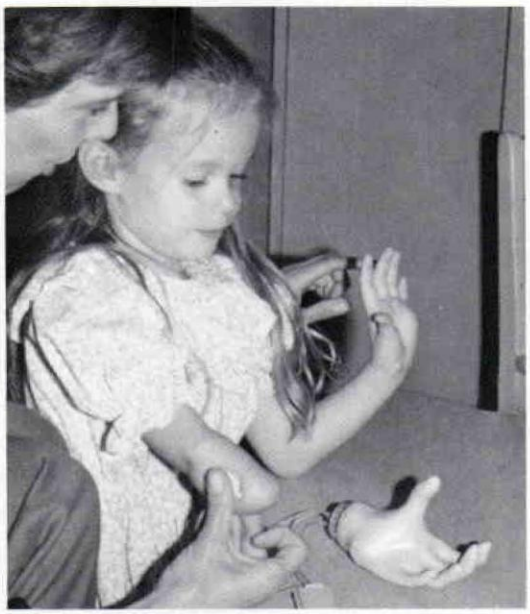

Fig. 4. Asking the child to extend the wrist of her sound arm often produces sympathetic extensor contraction in the residual limb.

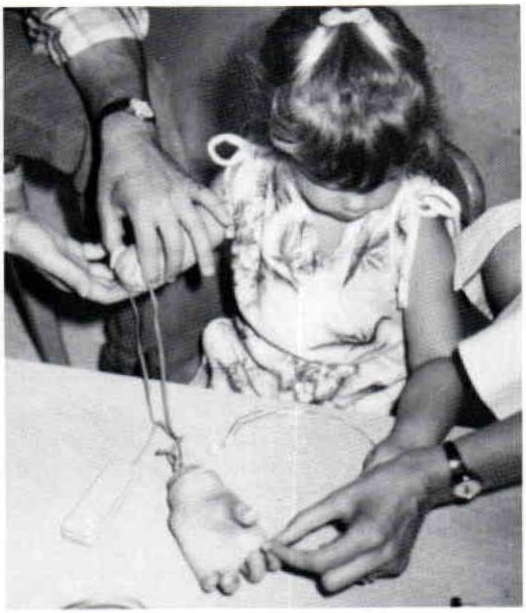

Fig. 5. After locating the flexor and extensor sites, both electrodes were used at the same time.

Additional training for those children who could not generate adequate signals at the first visit consisted of using the techniques described above to strengthen the muscles and improve voluntary control and separation of signals. This was done by holding the electrodes in place with an elastic Velcro® strap and having the child practice opening and/or closing the hand. The addition of toys requiring two-handed manipulation at this time as well as during the initial evaluation provided motivation and reduced anxiety (Fig. 6).

NEGATIVE IMPRESSION PROCEDURE

Once adequate muscle sites were located, a 2-stage negative impression was taken of the patient's residual limb. The first stage consisted of a plaster splint encircling the proximal brim and cubital fold areas. A string was tied securely around the apices of the epicondyles (Fig. 7), olecranon, and through the cubital fold, and the limb was passively moved into full elbow flexion by the prosthetist and held until thoroughly dried (Fig. 8). This slight

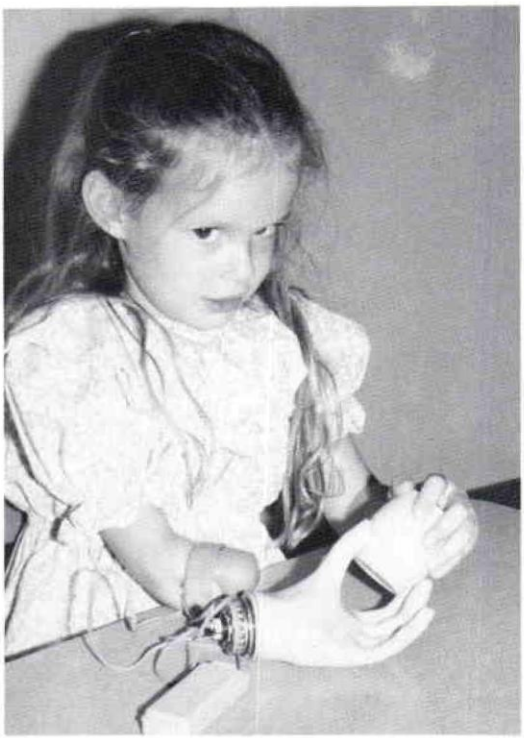

Fig. 6. Encouraging the child to manipulate toys with the powered hand provides motivation and reduces anxiety.

Fig. 7. The string casting was used for the negative impression.

Fig. 8. The elbow is held in full flexion until the plaster is set.

variation of the German casting technique taught by Otto Bock is essential for independent suspension of the prosthesis due to the lack of developed humeral condyles in the children fitted. The second stage of the impression was completed with the arm extended incorporating the remaining portion of the residual limb in plaster bandage (Fig. 9). This two-stage technique allows for full displacement of the cubital fold tissue with maximized elbow range of motion without reducing the total suspension of the prosthesis. The dried cast was removed and a hole placed distally so the cast could be used as a check socket. By pulling the residual limb back into the cast, range of motion as well as suspension can be initially evaluated by the prosthetist.

Modification of the Positive Model

Variations in modification techniques primarily focused on the proximal brim area in order to achieve adequate independent suspension of the prosthesis. Because of the lack of well developed condyles and the amount of soft tissue coverage in children, suspension of the socket was best achieved by cupping the socket in tightly over the supre-olecranon area against the

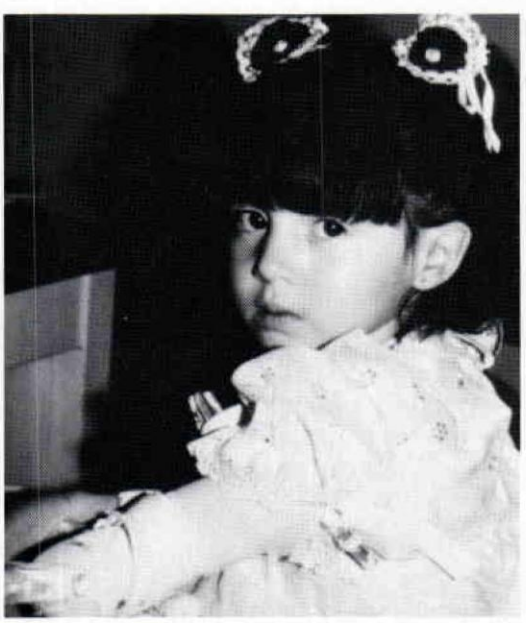

Fig. 9. The elbow is extended and the remaining tissue of the residual limb is cast.

triceps tendon with the counter pressure rected from the cubital fold area which corresponds to the string placement from the cast (Fig. 10).

With the appropriate amount of tension created, the suspension of the socket is adequate as well as comfortable for the patient. Remaining cast modifications were completed in the usual manner for myoelectric fitting—for example, distal buildup for pull tube clearance and a slight flattening of the model over the established electrode placement sites.

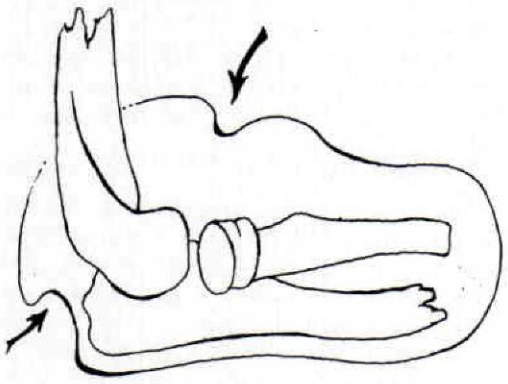

Fig. 10. Prosthetic suspension is enhanced by undercutting in the cubital fold and supra-olecranous areas.

The Definitive Socket

Flexible polyester resin was the primary choice of materials for socket fabrication. This proved to be adequate except for three cases in which allergic type skin reactions from the socket were observed. In these cases a highly inert thermoplastic was substituted (i.e., polypropylene or Surlyn®) and skin reaction diminished within 24 hours.

Once the plastic socket was fabricated a fitting took place which allowed the prosthetist to evaluate:

- Socket fit.
- Independent suspension of socket.
- Electrode placement contact against skin.
- The child's ability to operate the myoelectric controls.

Upon satisfactory accomplishment of these objectives the fabrication of the prosthesis was completed using the standard technique as recommended by Otto Bock. The only exception to this procedure is with the use of Swedish size #1 myoelectric system. With this system the interchangeable battery was used in conjunction with the Otto Bock clip receptacle (13E52=2) and the battery connection cable was replaced by #33 AWG-2 conductor retractile microphone cable (Fig. 11). The clip receptacle was attached to an elastic strap or polyethylene cuff and secured around the upper arm with the battery located posteriorly. The cable passed into the posterior proximal forearm and the terminal end connected to the Swedish hand connector. Once the cable was fed into the forearm of the prosthesis it was secured permanently in order to prevent any unwanted removal. This use of a small retractile cable in conjunction with the clip receptacle provided us with a reliable electric connection to the externally placed battery which remained intact throughout the young child's daily physical demands on the prosthesis (Fig. 12).

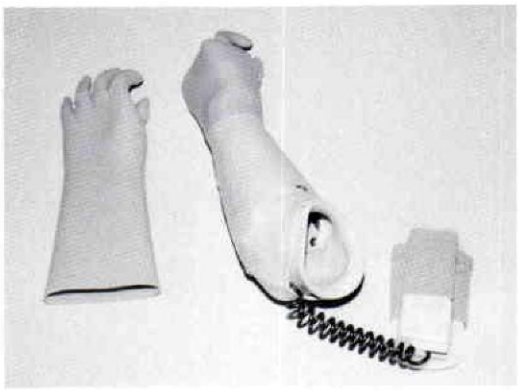

Fig. 11. When the Swedish hand was used, the Bock clip receptacle was used to hold the battery, and a retractile microphone cable replaced the battery connection cable. The battery is secured over the triceps.

TRAINING METHODS

Control Training

Controls training refers to that part of the training process when the child is learning to operate the prosthesis, but does not yet have enough skill to incorporate it into functional activities. In the early stages of

Fig. 12. The battery location for the Swedish hand provides a reliable connection for children.

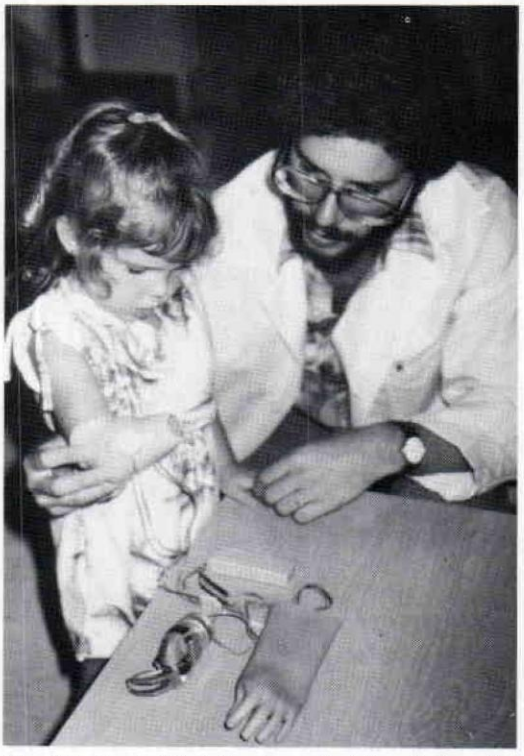

Fig. 13. Control training is undertaken before the prosthesis is completed.

our study most children were seen a number of times for controls training after electrode sites were identified and before the prosthesis was completed. The socket with the electrodes in place and hand attached was used for training before the prosthesis was assembled (Fig. 13). As the staff became familiar with the procedure, it became evident that once electrode sites which met our criteria were established, further training did not lead to developing better sites. Therefore, fabrication of the prosthesis could begin immediately. Further controls training was carried out in a manner that fit the needs of the family. Children who traveled great distances and had a limited time for training were usually seen daily and controls training was begun before the finished prosthesis was available. Using the electrode-hand set up and Velcro® strap to hold the electrodes in place or the socket and electrodes if they were available, the child was encouraged to place objects in the hand while operating the controls and to complete simple tasks such as threading beads or assembling nested toys. It was important to select activities that did not require active positioning of the hand as it had to be used while lying on the table in the supinated position. When children lived in the vicinity of CAPP, weekly visits were initially scheduled for controls training using this method during the period of fabrication. However, as the study progressed it became evident that controls training could be completed in the prosthesis and the variety of activities available to the child were far greater and more motivating than those that could be used when working with the incomplete set-up. Although children who had controls training daily learned to operate the hand more precisely in the beginning, their final functional use patterns did not appear to vary from those of children who received controls training in the completed prosthesis on a less frequent basis.

Use Training

Following fitting of the prosthesis, use training was carried out in much the same manner as for a child receiving a body-powered prosthesis with an unfamiliar terminal device. Instructions in donning and removing the prosthesis and care and maintenance were provided for the parents and children by the therapist and prosthetist at the time of delivery of the limb. Pulling into the socket with a pull sock was very important, especially for the child with a short below elbow deficiency, as it was the only way to assure that the electrodes and electrode sites lined up appropriately and provided consistent feedback.

Children who had had previous experience with body-powered prostheses needed encouragement to try tasks requiring firm grip and active use of the hand above shoulder level to break up old patterns established to meet the limitations of the body-powered limb (Fig. 14 and 15). Working away from the body and without the support of a table was important for the young child or those with a very short residual limb to develop tolerance to the added weight of the myoelectric prosthesis. If the child was not accustomed to a hand type terminal device, experimenting with placing objects of different shapes and sizes in the hand was emphasized. In general, trainig tasks were selected that were appropriate to the developmental level and the interest of the specific child. Emphasis was placed on activities which

Fig. 15. Using the prosthesis above the shoulder level is a new experience for children accustomed to body powered prostheses.

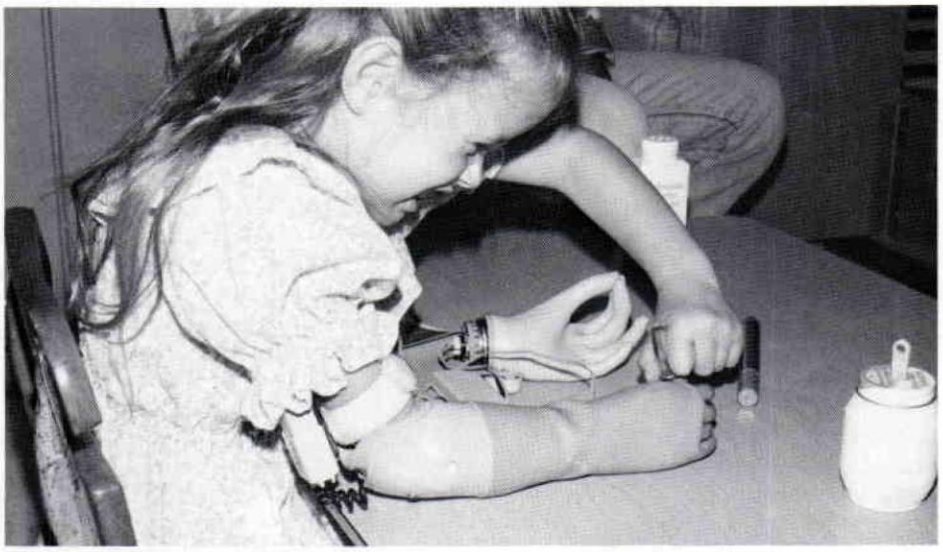

Fig. 14. Children who were accustomed to connectional body powered prostheses needed training to use the prosthesis away from the body and to support the added weight of the powered prosthesis.

required a wide variety of grasp patterns and working at varied heights and in different positions.

Although no children were sent to local facilities for controls training because of the requirements of the study, those children who had occupational therapy available in their home communities were encouraged to receive use and skills training in these facilities. It was found that therapists familiar with working with limb deficient children readily adapted their programs to working with the child with a myoelectric hand. The community therapists were invited to attend a session at CAPP at which time they received an orientation to the myoelectric hand, instructions in care and maintenance of the myoelectric prosthesis and were familiarized with the functional potential of the hand.

RESULTS

Prosthetic Maintenance Needs Unique to Myoelectric Prostheses

Data gathered on care required to maintain a well fitting and functioning prosthesis focused on three aspects of treatment. They were average life expectancy of the socket, component failures, and maintenance of the electrical parts of the prosthesis.

The average life of the socket was of particular interest because of the more intricate type of fitting required for the myoelectric prosthesis. Previous reports from England of myoelectric fittings for children suggested refitting at six month intervals in order to maintain proper fit of the prosthesis.

All of our subjects were fit using the variations of standard techniques as previously described. Eight of the patients have required at least one additional fitting since the beginning of the study. We have included these additional fittings in our report to give a more reliable figure. Based on a total of 22 fittings, the average socket life was found to be 15.4 months, the median was 14 months. Recognizing that potential and actual limb growth varies significantly among individuals it is interesting to note that the longest socket life was 30 months on a subject with a very short below elbow limb deficiency and the shortest was 8 months fit on a female with a wrist disarticulation limb deficiency.

There were few maintenance problems due to component failure during the study, and only two related to abuse or misuse of the prosthesis. In one case a child exposed her prosthesis to salt water while at the beach and the hand was destroyed. A second incident of abuse occurred when a child broke out the wrist unit and battery case of her prosthesis by using her prosthesis to serve a volley ball. There were two cases of component failure not related to abuse. One electrode and one cable proved faulty.

It should be noted that the criteria for selection of candidates related to previous maintenance history on prostheses, and willingness to restrict use of the limb in activities which may be injurious to it, automatically biases the sample away from the heavy duty prosthesis user. Only one young man participated in the study and of the eight rejected four were males. Interest in cosmetic aspects of the myoelectric fitting were also higher for females and also influenced the sample.

The connection of the clip receptacle wire in the fittings requiring an external battery was the major repair problem. We used a variety of types of wire to connect the clip receptacle to the electric hand, all of which failed at some point during the fitting. Once the retractable cable was used, a consistently reliable electric connection could be maintained. Subsequently all of the clip receptacle wires have been replaced by the retractable cable and we have had no failures to date.

A second problem developed related to battery use and charging requirements. Our initial instructions to the patients and families were to charge batteries after each use. After a period of time patients began to experience a shorter use period from each battery. Our concern led us to become better informed on the proper use of nickle-cadmium batteries requiring us to alter our instructions for proper use. Patients or parents were then instructed to fully drain batteries before charging due to the inher-

ent "memory" properties of the rechargeable battery. These new instructions as well as recommending annual replacement of the batteries have greatly improved the reliability of this particular component.

Functional Skill Levels

Data on functional use of the myoelectric prosthesis were gathered by observation of the children while they completed the *Bimanual Functional Skills Evaluation.* Nineteen tasks which required bimanual manipulation of objects were included in the evaluation. Typical items were shoe tying, hammering nails, and jumping rope. Some of the items, such as cutting meat, were above age level for the younger children. All subjects were able to accomplish all age-appropriate tasks presented with the their myoelectric and their body-powered prosthesis when one was available.

Upon completion of the evaluation they were asked how they preferred to accomplish each of the 19 tasks. The overwhelming preference was for use of the myoelectric prosthesis. Out of a total of 209 responses to 19 different tasks, preference for the myoelectric prosthesis was indicated 112 times. The body-powered prosthesis and the myoelectric one were rated equally functional for completing tasks 66 times, and the body-powered prosthesis was indicated as preferable only five times. The subjects indicated a preference for accomplishing a task without using a prosthesis only six times out of the possible 209 responses.

Graceful arm movement and ease of operation of the myoelectric prosthesis as well as the added advantage of the stronger grip provided by the hand was observed in children using the myoelectric hand. The skillful use of "body english" and alternate grasp patterns such as holding objects against the chest rather than in the terminal device made it possible for the children to complete the tasks requiring power grip with the body-powered limb. Although functional levels were not remarkably different, the esthetic and energy saving features of the myoelectric limb were definitely observable.

Attitudes Toward Myoelectric Prostheses

Twelve children and/or their parents were interviewed by the social worker who completed the "Attitudes Toward Change In Prosthetic Fitting" questionnaire. The interview took place after the child had become reasonably proficient in operating the myoelectric limb. The major reasons given for wanting to try the myoelectric hand were cosmesis (40 percent) and freedom from the restrictions of a harness (40 percent). Curiosity in new advances or better function accounted for the remaining 20 percent. Sixty percent of the respondents felt the myoelectric prosthesis met their original expectations. Reasons most often given for the prosthesis not meeting expectations included disappointment in cosmesis and function.

The major advantages of the myoelectric hand were identified as stronger gripping power, which improved function; better cosmesis; and improved comfort and convenience because of the elimination of the harness. Major disadvantages identified were lack of durability of the glove, fear of injuring the mechanism of the hand, problems with batteries and, for the younger children, the added weight of the hand. Both parents and children were asked to identify the major problems with the myoelectric prosthesis. Heat and skin reactions to wearing the prosthesis without a sock was cited most often, added weight and mechanical breakdowns were each cited three times. Four children could not think of a major problem although their parents listed some of the above.

Wearing patterns were reviewed following the experience with the myoelectric fitting. Eleven children continued to wear their myoelectric limbs exclusively or in combination with their body-powered limbs. One child has reverted to full-time wearing of her body-powered prosthesis due to financial hardship (they moved out of the Variety Club area).

Of those wearing myoelectric limbs, eight wear them exclusively and three in combination with their body-powered limb. Three children have increased their

wearing time, two slightly reduced it and five have maintained the same wearing pattern. All children combining wear of both prostheses have maintained the same wearing pattern as before myoelectric fitting. The child who had not been fit before the study maintains a part-time wearing pattern.

The children and their parents were each asked which limb they would choose if they had to make a choice. The response was in favor of the myoelectric fitting (66 percent). Reasons given by the children and their parents for choosing to wear the myoelectric limb were "I love it," "it feels more natural," "my arms are freer," "it's easier to operate," and "more cosmetic." Reasons for choosing the body-powered prosthesis were durability and cost factors.

When asked how friends reacted to the myoelectric hand the response was universally positive from both parents and children. Initial curiosity with the hand was cited often, but no negative responses were elicited.

SUMMARY AND RECOMMENDATIONS

Review of the criteria established for the selection of subjects for the study substantiated their validity. In all, 22 children were considered for the study. Eight were rejected; three because their residual limbs were too short to allow comfortable placement of the electrodes within the confines of a self suspending socket, two because they were not developmentally ready to focus on learning to operate the myoelectric hand, and two because required maintenance on their current prostheses due to hard wear indicated that the myoelectric hand would not hold up under their use pattern. One was rejected for a history of poor follow-up and maintenance of the body-powered prosthesis. Two others with poor follow-up histories were fit and failed to complete the study and are currently not wearing any prosthesis. Of the twelve who completed the study, all met each of the criteria. Since the study was completed, an additional ten subjects have been selected and fitted using the original criteria. All are currently wearing their prostheses consistently.

The results of our analysis of maintenance needs on myoelectric prostheses have allowed us to predict socket life expectancy more accurately, reduced our maintenance procedures, and improved our instructions for parents and therapists. The myoelectric fittings have required the same or fewer visits to the prosthetist for general maintenance as compared to traditional body-powered fittings. Harness adjustments and cable breakage are no longer necessary and the life of cosmetic gloves is similar to that of those worn on body-powered hands in spite of greater use of the device for prehensile skills.

The functional potential of the myoelectric hand as measured by the *Bilateral Functional Skills Evaluation* proved equal or superior to the body-powered prosthesis worn by those children who were previously fit. In no case did a child become dependent in an activity previously performed independently. Tasks which were more easily completed with the myoelectric hand were those which required power grip and working in positions above shoulder level, or with the humerus extended. Fitting of a body-powered prosthesis as well as a myoelectric prosthesis was necessary for those children who were full-time wearers and participated in activities that might be injurious to the mechanism or glove of the myoelectric hand.

The evaluation, fitting, and training techniques developed and refined during this study have become standard procedures for fitting of myoelectric limbs at CAPP. Variations in the negative impression procedure developed for congenital amputees have made it possible to fit shorter residual limbs than were previously expected. Techniques for use training developed for this study are easily taught to therapists and allow most children to receive the majority of their training in their own community.

The study of attitudes toward the myoelectric hand revealed that it is well accepted by the children and their families as

substantiated by the wearing and use patterns of the subjects as well as their personal preferences for the myoelectric hand. Repeated statements that the myoelectric prosthesis feels more natural and allows more freedom of movement indicate that, to the children, the fitting appears closer to a natural limb than previous fittings.

This study has successfully established the feasibility and functional benefits of fitting children with myoelectric hands. The findings also dispell any concern that children with congenital limb deficiencies might be unable to master coordinated use of myoelectric control systems. The data most surprising to the staff was the 15.4 month average socket life, which far exceeded previous reports. The reliability and durability of the components, especially the hands, were also above expectation, considering the unique demands placed on them by children. Although considerable amounts of sand were poured out of a number of Swedish hands none failed to function well during the study. The discovery of the retractible cable was a turning point for both subjects and prosthetists. It solved the major breakdown problem which had required extra trips to the prosthetic facility for the parents and reduced wearing time for the children. Attitudes toward the prosthesis improved considerably on all counts when this problem was eliminated.

Unfortunately, children with high level and/or bilateral upper limb deficiencies, who are most in need of the potential advantages of myoelectric controls, were not served by this study. It is hoped that future research can build on the knowledge gained from myoelectric fittings and lead to development of more functional prostheses for this group of children.

ACKNOWLEDGMENTS

The Child Amputee Prosthetic Project at UCLA gratefully acknowledges the support provided by the Variety Club International, Tent #25, and the Sherrill C. Corwin Variety Club Electronic Limb Bank which help generate funds to assist in payment of the extra costs involved in fitting myoelectric prostheses. This is partially supported by a grant from the United States Public Health Services/Child Health Services Grant #USPH-MCJ063080-28-0.

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Flexible Above Knee Socket Made from Low Density Polyethylene Suspended by a Weight Transmitting Frame

Össur Kristinsson

INTRODUCTION

Ten years ago, a bilateral amputee came to us to be fitted for new prostheses. The prostheses he was wearing consisted of external brace joints, hyperextended knees, Sach feet in plantar flexion (to compensate for the hyperextension of the knees), and laced leather sockets. Suspension was provided by hard lacing and shoulder straps. His residual limbs were in bad condition, distally and proximally. They were rather long, with the patellas fixed under the femurs which had been cut just above the epiphyses.

The new prostheses which we fabricated for him consisted of more acceptable alignment, total contact suction sockets, and multi-axis feet. Although the patient's old sockets were uncomfortable while standing, they were comfortable when he was seated. Being employed as a goldsmith, a great deal of his work day was spent sitting. The patient was also used to tactile feedback accommodated from the leather sockets. The sockets on his new prostheses were rigid plastic, and compared to the old ones, extremely uncomfortable when he sat. Because of this, the patient rejected the new prostheses and asked us to make leather sockets similar to his old ones to replace the rigid plastic. Because of this, we began to look for a socket material that was a compromise between the rigid plastic and leather socket materials. This led to a flexible socket attached to an external rigid frame, the subject of this article.

SILICONE SOCKETS

The flexible sockets were fabricated using soft laminating resins like silicone, polyester, acrylic, polyurethane, and lynadure. The laminates were usually made up of nylon stockinette with one or two layers of fiberglass stockinette between each layer. This, in combination with silicone resin, yields a flexible socket which is relatively unstretchable. In the beginning, the rigid frame had both medial and lateral bars to connect the distal socket to the proximal brim. The use of carbon fibre allowed us to eliminate the lateral bar. When we started using low density polyethylene as a socket material, we also deleted the lateral quarter of the brim, ending up with a fork-like structure which is used today.

FABRICATION METHODS

Socket

The socket is vacuum formed with a low density polyethylene sheet by conventional technique. We heat the sheet in an infrared oven and drape it over a moist plaster of paris positive model. An O ring and double adhesive tape are placed over the valve ring, which then is placed in position over an air channel that has been drilled through the length of the positive model. Polyethylene has a rather large shrinking coefficient. To overcome this problem, we usually make the positive model for a flexible socket slightly larger than for a rigid socket. At this point, a check socket should be used to insure a good fit between the socket and the frame. However, if this is done the socket cannot be placed back on the positive model, so it will need to be refilled with plaster before laminating.

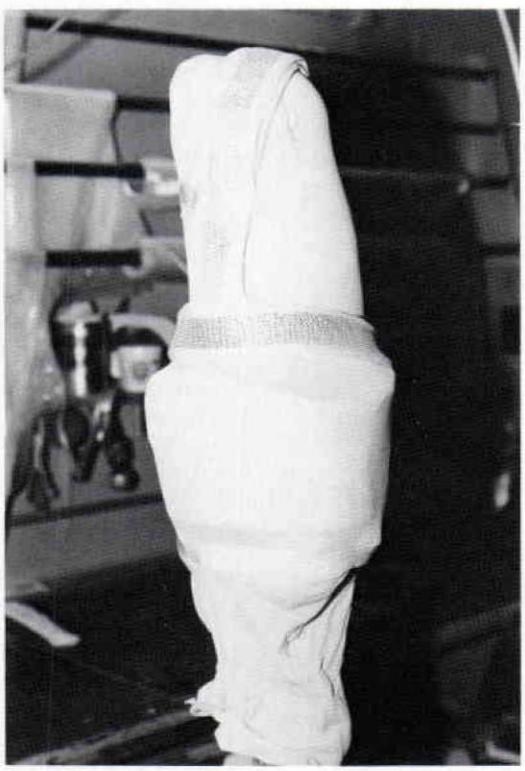

Fig. 1. The fiberglass and carbon fibre lay-up for the socket frame.

If one does laminate directly over the newly molded socket, expect a loose fitting between the socket and the frame, as the socket shrinks after being removed from the positive model. To date, we are not familiar with any techniques for eliminating this shrinkage factor.

Frame

The frame is laminated with nylon stockinette, several layers of fiberglass and about ten layers of carbon fibre tape (Figure 1). We use acrylic resins, but polyester resin works as well. The socket and the frame are riveted together. In Stockholm and Uppsala, double adhesive tape is used to fix the socket to the frame, without rivets. As the rigid frame covers less than 40 percent of the socket, it is easy to add or

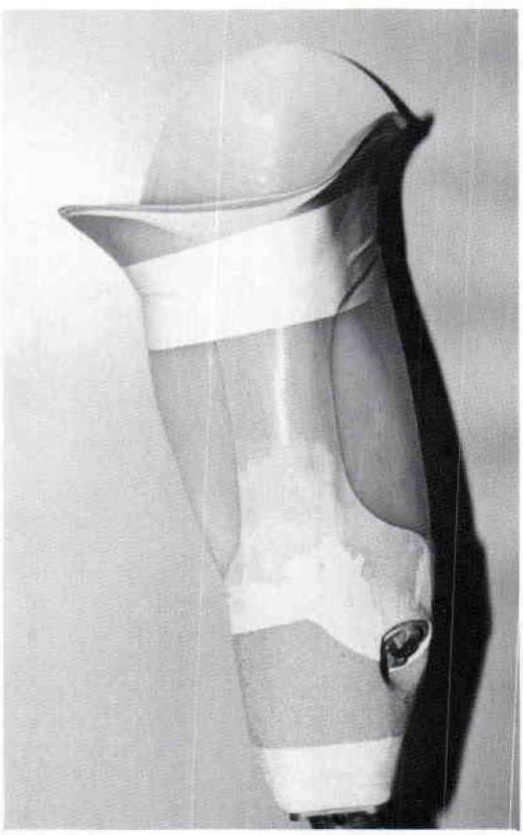

Fig. 2. Medial view of the carbon fibre and fiberglass reinforced acrylic frame. The frame has only a medial strut connecting the proximal socket to the distal end. Less than 40 percent of the socket surface is covered by the frame.

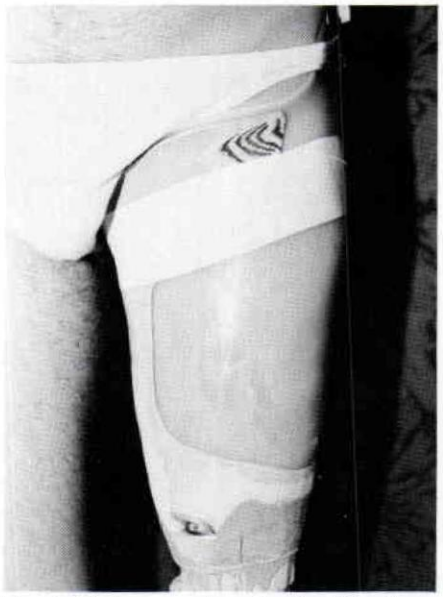

Fig. 3. Patient wearing the flexible above knee socket. Note that the frame extends only to the center of the rectus femoris channel anteriorly. The flexible low density polyethylene socket can conform naturally to the muscle expansion and other forces.

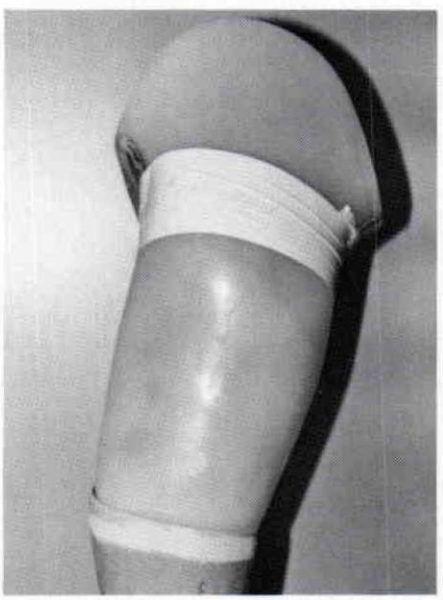

Fig. 4. Lateral view of the flexible socket. In this view tape is seen holding the socket to the frame for the fitting. When finished, the socket is fastened to the frame either by riveting or using double face tape. Over 300 of these sockets have been used, mostly in Stockholm.

remove material from the positive model. If the length of the positive model is not altered, and if build-up material has not been added or removed at the proximal brim area, a new socket can be fabricated over the altered positive and, of course, will fit the original frame.

It is usually unnecessary to alter the alignment when a smaller socket is replacing a larger one, which is obviously an advantage when dealing with a new amputee regarding the rapid volume decrease. Our observations indicate that atrophy in the residual limb is somewhat less with the use of a flexible socket than it is with the use of a conventional rigid socket. These are, however, only observations and have not been statistically confirmed.

Finishing

Conventional methods are used to finished the prostheses; however, we do not laminate over the socket. When the patient is not concerned with cosmesis, the polyethylene socket is left uncovered, thus providing for rapid heat exchange, tactile contact, and better dynamic interaction between the residual limb and socket. Also, the socket exchange is simple and inexpensive with this type of appliance.

SUMMARY

Approximately 300 prostheses with this type of socket have been made, most of them in Stockholm. To date only two breakdowns have occurred, both due to lamination failures.

Our goal in using a socket of this type is to achieve a socket with excellent suspension, one that adapts itself well to the various contours of the stump during ambulation, and one which is simple and relatively inexpensive to change.

There are four fitting centers involved in this project. To date, there have been no reports of undue maintenance requirements or dissatisfaction on the patient's part with a flexible socket over a conventional rigid one.

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Prosthetic Finger Retention: A New Approach

H.W. Herring, Jr., D.M.D.
Eric H. Rommerdale, C.D.T.

INTRODUCTION

The problem of replacing external parts of the body missing from surgery or trauma often falls to the maxillofacial prosthodontist. One of the major problems associated with somatoprosthetic replacement is inadequate retention of the prosthesis. This may stem from the weight of the prosthesis, inadequate tissue support, and/or the particular area of the body to be replaced. A number of means have been employed to enhance retention. Among the more common are adhesives, adhesive tape, and attachment to eyeglasses. The purpose of this article is to describe a technique which eliminates the need for adhesive materials and which uses tissue displacement as a primary means of retention. This technique can be utilized whenever the prosthesis encompasses more than 180° of the affected area. An ideal indication is prosthetic replacement of a finger.

TECHNIQUE

1. An impression of the remainder of the finger to be replaced is made with irreversible hydrocolloid in a paper cup. The impression is immediately poured with dental stone, vacuum-spatulated to obtain a dense, bubble-free working cast.

2. With a suitable instrument such as a cleoid-discoid carver, two parallel indentations approximately .75 mm deep and 1.0 mm wide are inscribed into the working cast around its entire circumference (Figure 1.) The first indentation is placed

Fig. 1. Scribed (or beaded area) of stone cast of amputated finger.

no less the 5.0 mm from the tip of the working cast with the second indentation no closer then 3.0 mm from the first.

3. The prosthesis is now waxed to form. The nailbed is formed by using an Eylure Nail* which is removed prior to fabrication of the mold.

4. The prosthetic finger is then fabricated from MDX-4-4210 elastomer** which has been tinted prior to placement in the mold[1] (Figure 2). Processing is accomplished at 276°F for four hours.

5. The processed finger is recovered from the mold, trimmed, finished and tried on the patient to determine fit, contour and degree of retention (Figure 3). The prosthesis is then extrinsically tinted to better match the patient's skin tone.

6. The acrylic nail is trimmed to the desired shape and length and attached to the nailbed using a thin layer of Silastic 89† or Prolastic Medium #1 or 2†† diluted with a small amount of xylene.

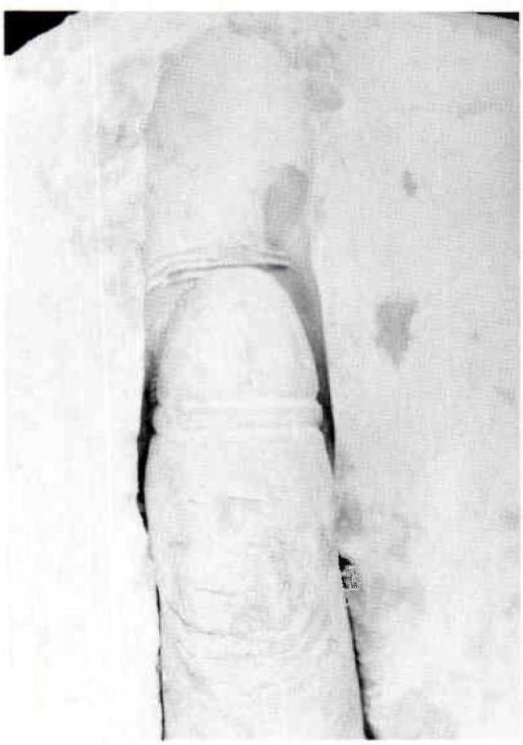

Fig. 2. Stone finger in mold ready to receive base shaded elastomer.

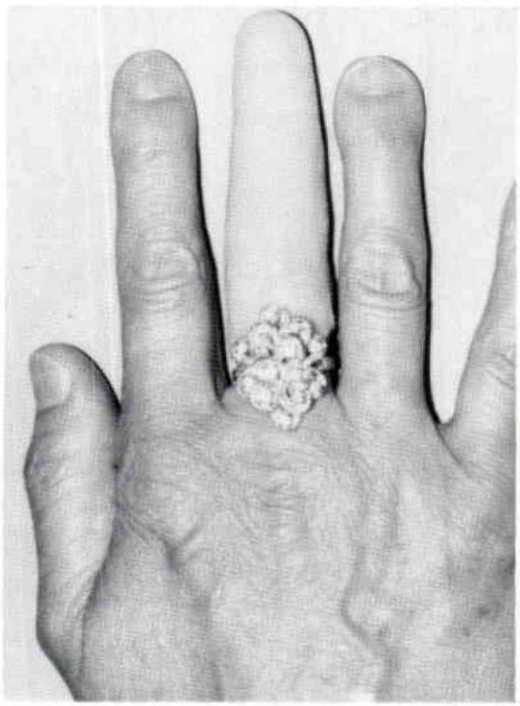

Fig. 3. Untinted finger prosthesis made from Dow Corning MDX-4-4210 elastomer.

The completed prosthesis is fitted to the patient with instruction for proper use and care, and advice on the use of makeup for the purpose of making the margin of the prosthesis less noticeable. After wearing the prosthesis from three to five days, the indentations which have been positively reproduced into the prosthesis will displace the finger tissue sufficiently to provide excellent retention without the use of adhesives and without compromising normal blood flow. The principle is similar to the function of a posterior peripheral seal or a maxillary complete denture where tissue is selectively placed to create additional retention.

In addition, the prosthesis may be so fabricated that additional retention will be gained by making the prosthesis fit the entire length of the remaining finger. A ring may then be placed over the prosthesis onto the finger rendering additional retention as well as increased cosmetic effect (Figure 3). Finally, the mold is labelled with skin tone formula information and stored for future use.

SUMMARY

A technique for providing a definitive form of retention has been described which eliminates the use of adhesives. The technique can be utilized whenever the prosthesis encompases more than 180° of the affected area.

CITATIONS

* Eylure of London, Ltd., 16E 52nd St., New York, New York 10022
** Dow Corning Corp., Midland, MI
† Dow Corning Corp., Midland, MI
†† Prolastic Co., Inc., 4 Chelmsford Road, Rochester, New York 14618

REFERENCE

[1]Duncan, J.D. and Rommerdale, E.H., *"Base Shade Determination of a New Elastomer for Maxillofacial Prosthesis" J. Prosthet Dent* 44:654–655, 1980.

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Low Back Pain and the Cottrell 90/90 Backtrac® System

Wallace Lossing, C.O.

INTRODUCTION

Chained to their jobs, our patients don't exercise regularly. They become weekend athletes for an hour or two of abusive activity. Sinking deeper and deeper into soft mattresses and over-stuffed chairs, they place more and more strain on their backs.

We have created the problem of lower-back pain. As Dr. Kenneth Casy, a pain specialist at the University of Michigan states, "Low-back pain is largely a social problem. It's as much due to the way we live as anything else!"[1]

If back pain is a social problem, it is one about which the American public is not very well informed. Most Americans are still living in a state of innocence about their backs. People do not realize how they are abusing their backs, how they can avoid back problems, why their backs give them trouble, or what can be done to alleviate back pain once they get it.

STATISTICS

But what about the current back problem? Next to the common cold, low back pain is probably our most common discomfort. About 80 percent of all Americans will have a severe backache sometime during their lives.[2] What about the 75 million Americans who have back problems now, and the additional 7 million who will be added to the back patient rolls each year?[3] What do we receive for the $5 billion a year we spend on tests and treatments for back ailments?[4] Can we reduce the $12 to $20 billion we pay in disability claims, lawsuit awards, and other settlements resulting from back injuries?[5]

There are other costs, not measured in dollars, which back pain extracts. The number one disabler in the United States is chronic pain, and the most common chronic pain syndrome is lower back pain.[6] The National Center of Health Statistics claims that of the 75 million Americans who suffer from chronic pain, 23 million have back pain.[7] We know that in the United States 93 million workdays are lost each year because of back problems, but what of the emotional and personal costs of lower-back pain? A study conducted by Johns Hopkins Medical Center revealed that 70 percent of chronic pain sufferers go through divorce and 20 percent contemplate or actually attempt suicide.[8]

PROBLEM DEFINITIONS

What is this pain we are describing? How is it being diagnosed? Isn't the patient's uncertainty over his or her condition related to our own uncertainty in diagnosing and treating their lower back

pain? Most physicians will admit that low-back pain is a very confusing and frustrating disease to treat. Objective findings on low-back pain are random, uncertain, and debatable. X-rays are not very helpful in diagnosing low-back pain because approximately 25 percent of the population exists comfortably with abnormal vertebrae.[9] A complete lack of controlled clinical trials on various treatments of low-back pain has allowed the controversy to continue.

The causes of low-back pain remain rather muddled. Throughout the past 100 years various causes for low-back pain have been proposed. We have focused on the sciatic nerve theory and the sacroiliac joint theory. Faulty body mechanics, the disc theory, and muscle spasms are other explanations for low-back pain. It is believed that 80 percent of lower-back pain is caused by overworked muscles, a herniated or ruptured disc, or the facet-joint syndrome.[10]

Today we place greater emphasis on holistic health, on treating the patient as an entity of mind and body. We also find the renewed emphasis on psychoneurosis and the "pain personality" as explanations for the prevalence of low-back pain among specific types of persons.

The causes of low-back pain are so numerous that giving a specific diagnosis remains difficult, if not impossible. As Orthopedist Edwin Guise of Henry Ford Hospital, physician for the Detroit Lions, says: "You have to think of everything from poor posture to cancer."[11] New techniques, such as computed tomographic scanning, have improved the diagnosis of conditions such as lateral or central spinal stenosis, which are not readily identified by myelography. Incomplete initial diagnosis, however, remains a problem in treating the lower back. A lower-back patient may very well encounter varying diagnoses if he visits more than one physician.

In the last twenty years we have found, in addition, that we cannot treat the patient with back problems in isolation. We have realized the immense potential for self-abuse which lies in treating the lower-back patient. Physicians, physical therapists, nurses, and orthotists alike are faced with the potential of malpractice litigation. Concerned for his or her patient, the health care provider is surrounded by the negative feelings and cynicism of some insurance carriers, attorneys, employers, and even patients themselves. The patient's own health and well being may be pushed aside by any one of the actors in the low-back pain scenario who are looking out for their own narrow self-interest.

Increasing government intervention in the treatment of the patient, in this case those who suffer from low-back pain, has increased the burden of documentation, while calling for decreased use of acute care facilities. High quality patient care is, however, demanded as well.

Our concern for the back patient is also diverted more and more these days by increasing costs. Which drugs, fixation devices, and diagnostic procedures should we use in treating the patient? Today our choice is often shaded by the economy. This trend could very well hamper the development of new techniques and therapeutic measures.

The strains and stresses of modern living have created patients who suffer from psycho-social dysfunctions, as well as from organic disease. We find ourselves ill-prepared to deal with such patients. How do we relate to a pain-ridden, drug-dependent back patient and motivate him or her to tolerate pain in another, less destructive fashion? How do we motivate a low-back patient whom we suspect of malingering to return to work and a productive life?

In general, we are dedicated to the delivery of high quality care to our patients. It is important for us to feel confident that an accurate diagnosis has been made and that correct treatment has been prescribed. We wish to serve our patient well.

More specifically, we want to provide the patient with relief from pain and restore range of motion, muscle strength, and balance. We want our patients to get well and then stay well. And so we provide training, a maintenance fitness program, and consider the patient's personal adjustment to his back pain. We suggest

weight reduction if it's necessary because we know that a sagging pot belly weighing 10 pounds puts 100 pounds of weight at the disc.

CONTEMPORARY TREATMENT

Current treatments for lower-back pain now include rest, traction, applications of heat and cold, self-hypnosis, and nerve blocks, steroid injections, biofeedback, electrical stimulation, orthoses, and psycho-therapy.

Today we know that up to 90 percent of all backaches go away within a few weeks no matter what therapy is used.[12] Active treatment, however, may speed healing. When a patient calls complaining about lower-back pain, one physician automatically suggests bedrest for four days. The physician makes an appointment only if the patient has not substantially recovered during that time. Only two or three percent of all low-back patients require surgery.

The majority of patients having back surgery do well, and there are many of them. For example, 200,000 laminectomies are performed in the United States each year.[13] However, it has been variously estimated that the failure rate on back surgery remains between ten percent and 40 percent. After surgery ten to 30 percent of back patients are pain free; 75 percent are improved, but still have some pain; and ten to 20 percent have not been helped at all by their surgery.[14]

A NEW ALTERNATIVE

Additionally, new, non-invasive modes of treatment for lower-back pain have been developed. A new approach to back pain is the Cottrell 90/90 Backtrac® system which has dramatically shortened hospital stays and reduced the need for surgery. The cost of the entire system is less than the cost of one day in the hospital. Primarily a home-care system, the patient is directly involved in his or her own care.

Backtrac® works by flattening the lumbar spine and reducing the lumbar curve. It simply and effectively achieves anterior pelvic tilt. Pelvic tilt tends to elongate the lumbar intervertebral disc spaces, which reduces pressures on any herniated disc. By stretching the lumbar paraspinal musculature, this sytem also provides relief from spasm.

The "90/90 position" decreases or eliminates the pain of acute lumbar disc protrusion. It is indicated for use in treating muscle spasms, overstretched or tearing ligaments, back sprains and strains and some facet syndrome patients. It is also suitable for pregnant and obese patients.

PHYSICAL EXAMINATION

The "90/90" test performed during a routine back examination can indicate strongly whether a patient will benefit from Backtrac®.

The physician singly lifts up on the calves of the patient exerting a vertical force (Figure 1). Many times the patient, who at that moment is having back pain, will indicate a sense of relief. As the calves are released, the back pain may reoccur. The test also tends to separate functional from organic back problems. Functional patients may say the test makes them feel worse or are noncommittal. A positive "90/90" test indicates a favorable prognosis for treatment in the Backtrac® system.

DESCRIPTION OF COMPONENTS AND USAGE

The Backtrac® system for clinic or home use (Figure 2), consists of a collapsible, lightweight A-frame and an easily-applied, single pull pelvic belt. The specially designed belt fastens between the legs to an overhead pulley clamp and locking device on the A-frame. This achieves the direct 90 degree upward pull on the pelvis. The patient's own weight provides the pull to produce the degree of pelvic tilt. Placement accessories, the cervical thoracic wedge, the knee bolster and add-pad, insure proper positioning for the patient.

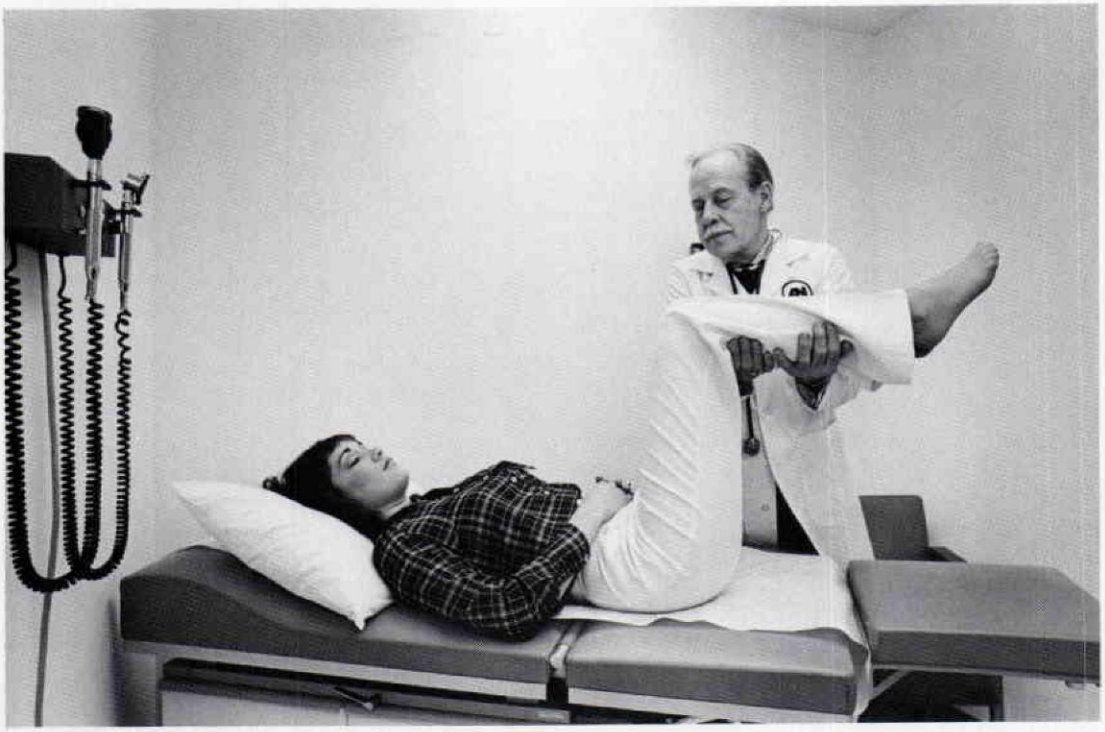

Fig. 1. Physician lifts calves, exerting vertical force.

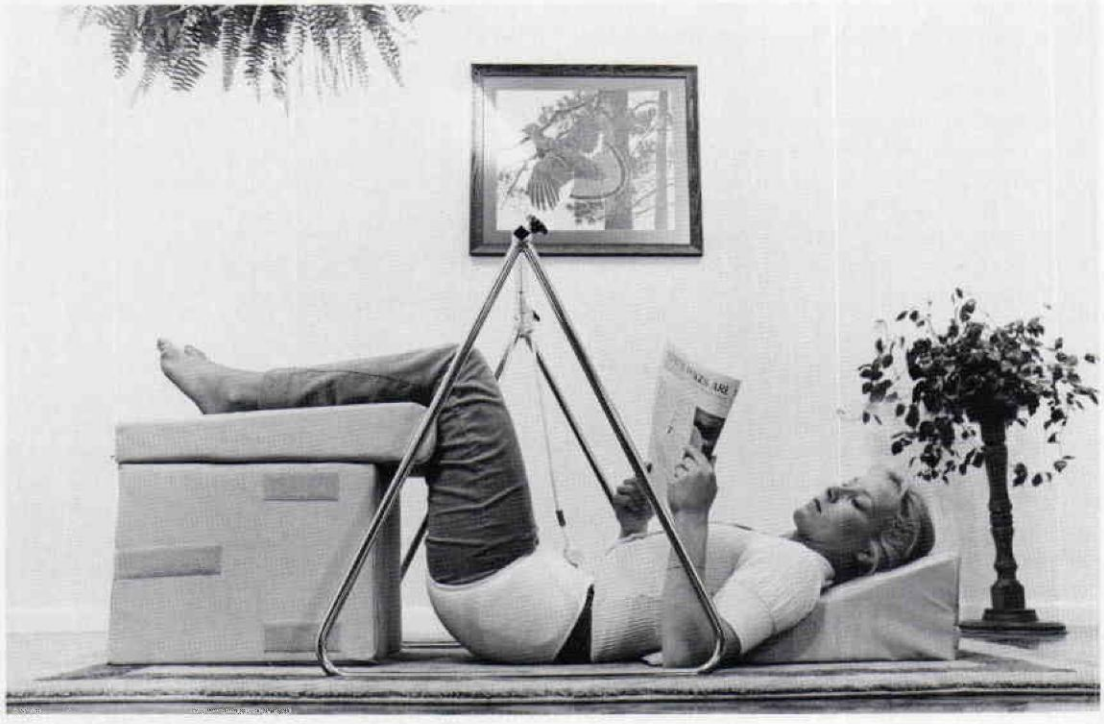

Fig. 2. Backtrac® system for clinic or home use.

Fig. 3. Backtrac® overhead pulley clamp locking device.

The acute contained herniated lumbar disc patient or those with severe strain should always be admitted as an in-patient should be placed on complete bed rest. Traction in Backtrac® is achieved by using the hospital bed modified with an overhead pulley clamp locking device (Figure 3), and with a single pull pelvic belt and the positioning accessories, also shown. On the first day of treatment, the patient's tolerance should dictate the length of involvement in Backtrac®. Four sessions could be scheduled per day with the actual initial session lasting only 15–20 minutes. Each session should be extended by five to ten minutes over the previous one. Eventually the four hour-long sessions are scheduled daily but always to the patient's tolerance. Once the patient is discharged from the hospital, Backtrac® sessions continue at home. Always start the patient slowly with initial sessions only ten to 20 minutes long. For patients with chronic recurring back problems the neck petal (Figure 4), should be used initially for cervical positioning instead of the wedge. Gradu-

Fig. 4. Backtrac® neck petal for cervical positioning.

ally increase the length of the session by five or ten minutes, four times a day, so that the final session is an hour long. Patients continue at home with the A-frame, belt and positioning accessories under the physician's direction, usually for three to four months, but always depending on need and diagnosis.

RESULTS

Backtrac® has already helped thousands of back patients return quickly to normal, active lives. It has reduced dramatically the need for surgery.

An x-ray study (Figure 5) illustrates a patient's spine while lying supine without Backtrac® traction (top half) and then showing the same patient in Backtrac® (bottom half). The figure clearly illustrates that the lumbar curve is reduced and the back flattened. Another x-ray study (Figure 6), presents a patient supine without traction with an old lumbo-sacral fusion; in Backtrac® the lumbar curve is again reduced.

Yet another study using a myelograph depicts a patient standing in extension (Figure 7). After Backtrac® traction the reduction is observed, (Figure 8), and the patient is pain free.

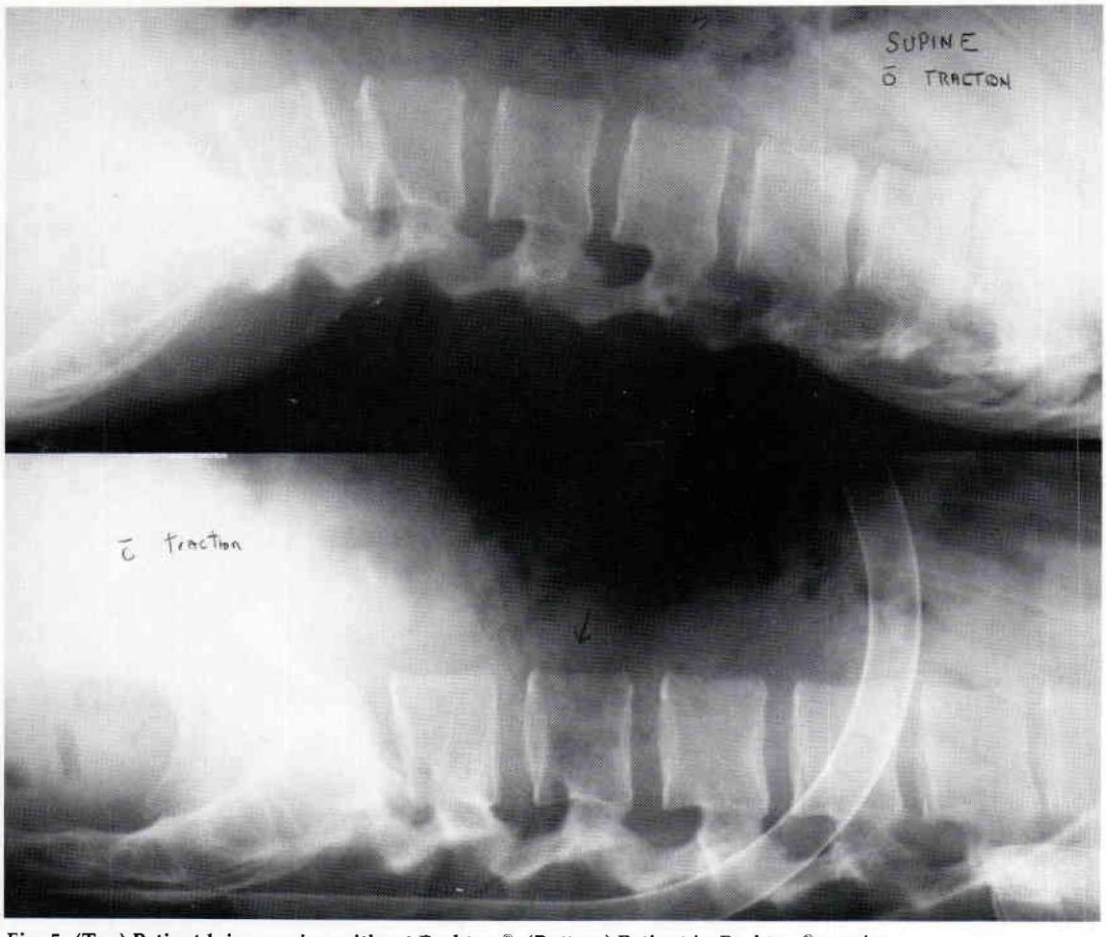

Fig. 5. (Top) Patient lying supine without Backtrac®. (Bottom) Patient in Backtrac® traction.

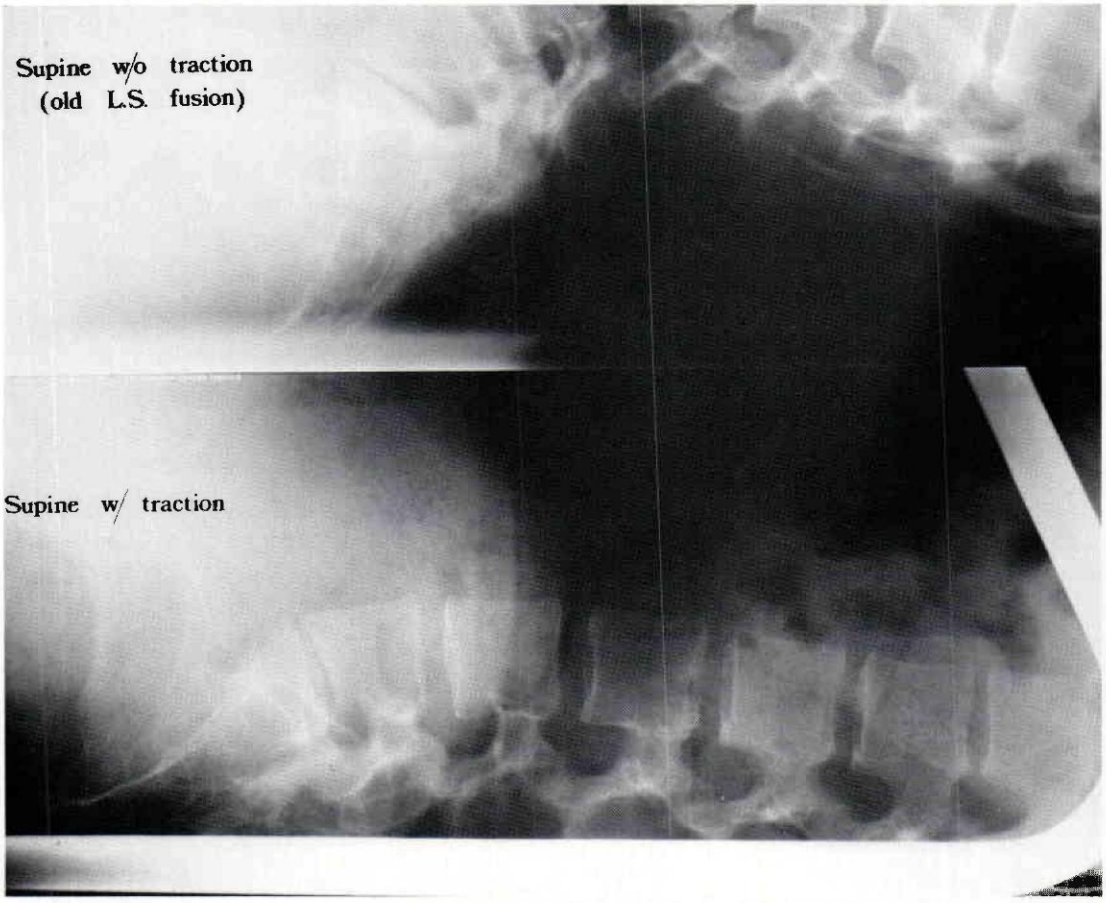

Fig. 6. (Top) Patient supine without traction with an old lumbo-sacral fusion. (Bottom) Patient in Backtrac® traction.

DISCUSSION

Today we are beginning to realize the effect which emotions, attitudes, thoughts, and behavior patterns have on the body, and on the back specifically. We are considering the total patient and his or her diet, work, residence, relationships, feelings, and level of exercise. We are not suggesting that all disease is caused by the mind. We do, however, believe that there can be emotional and mental causes of disease, as well as physical, nutritional, and chemical ones. Some back specialists have suggested that in as many as 80 percent of all cases, back pain is not due to an organic problem, but to such elusive factors as stress, worry, and other mental attitudes. For those other patients for which an actual mechanical cause can be determined and who meet the indications stated here, the Cottrell Backtrac® has proven effective.

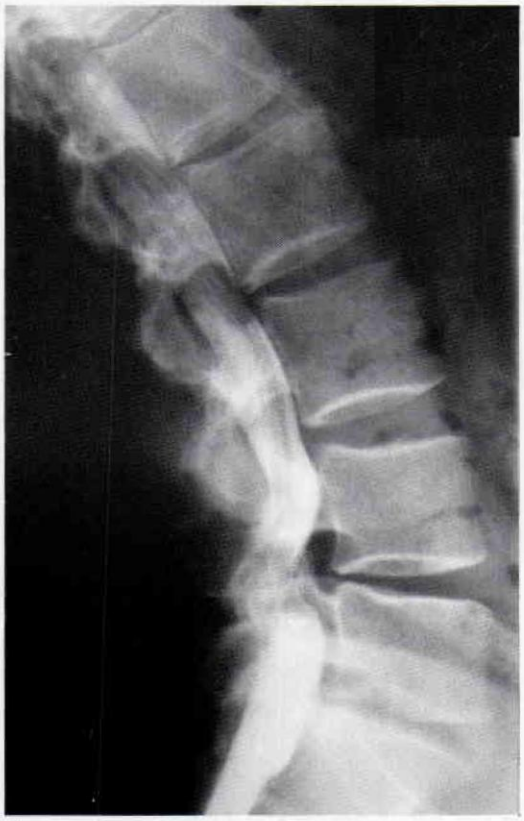

Fig. 7. Patient standing in extension.

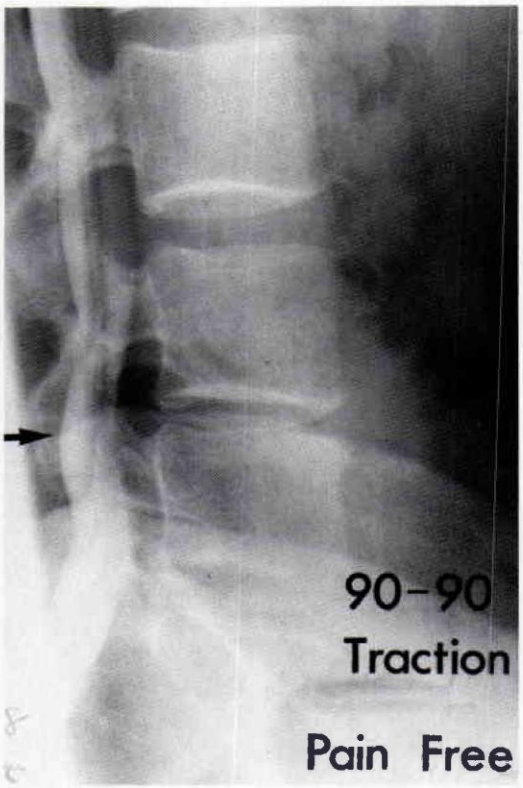

Fig. 8. After Backtrac® traction, the reduction is observed.

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The Halo-Girdle Orthosis Application

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INTRODUCTION

After twenty-five years of use, the Halo has proven to be an effective instrument for spinal stabilization.[1,2,4] It is now widely used throughout the nation and in twenty foreign countries.[10,11] Many variations have arisen yet the principle of stabilization has not changed.[3,5,6,7]

In June of 1973, O'Brien, presented the "Halo-Hoop" for total spine fractures.[11] The Halo-Girdle followed this as an alternative to using pins through the pelvis. Alternatively, the Halo-Vest,[9] introduced in 1970, is primarily used for unstable cervical spine fractures and is the most frequently used halo unit. Since its advent, many articles have described its advantages over the first unit fabricated at Rancho Los Amigos Hospital in 1956.[8,9,13,14]

At present, the girdle is used instead of the vest when stability is required for special situations such as the following:

1. Thoracic spinal fracture together with cervical spinal fracture.
2. Fractured ribs, as well as spinal fractures.
3. Open wound about the chest area together with spinal fractures.
4. Presence of a thoracic spinal tumor to be stabilized by external fixation.

This article describes the step-by-step procedure for applying the Halo-Pelvic Girdle and several of the problems which can occur with its use.

Description and Application

Figure 1 shows the plastic portions of the girdle. Figure 1A shows the anterior outer plastic portion, B, the posterior outer portion and C, the plastic liners with sheepskin in place. The sheepskin is se-

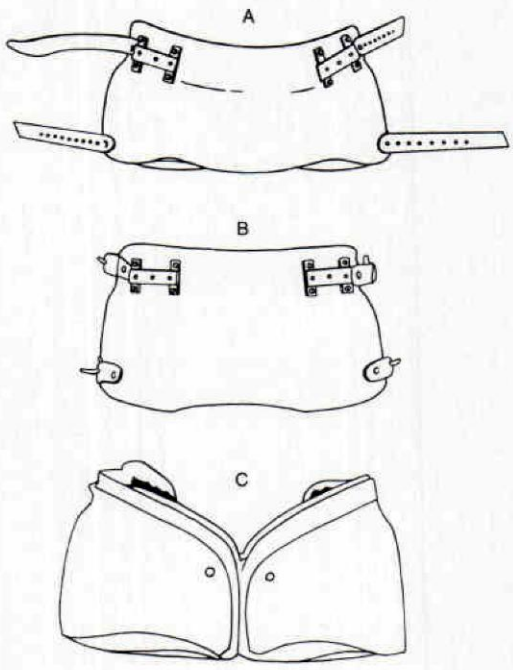

Fig. 1. (A) Anterior portion (B) Posterior outer portion (C) Both anterior and posterior portions in place with liner.

cured to the plastic liners with velcro for easy replacement.

The posterior portion of the girdle is put on first (Figure 2). This can be done by rolling the patient or raising the buttocks area to get the girdle well-seated while keeping the spine centered. The patient is rolled back to the full supine position so that plastic liners with sheepskin can be inserted on both sides. There is a red line cut into the liner to show when it is at the midline of the body. The anterior portion is then put in place and strapped to the posterior portion (Figure 3).

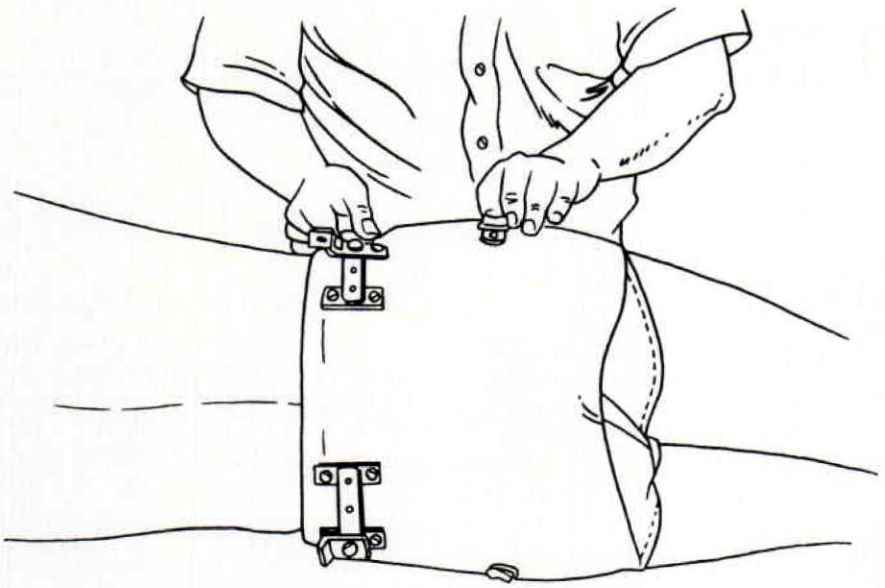

Fig. 2. Application of the posterior portion is done first by either rolling the patient to his side or elevating buttocks (note: centering girdle with respect to the spine is essential).

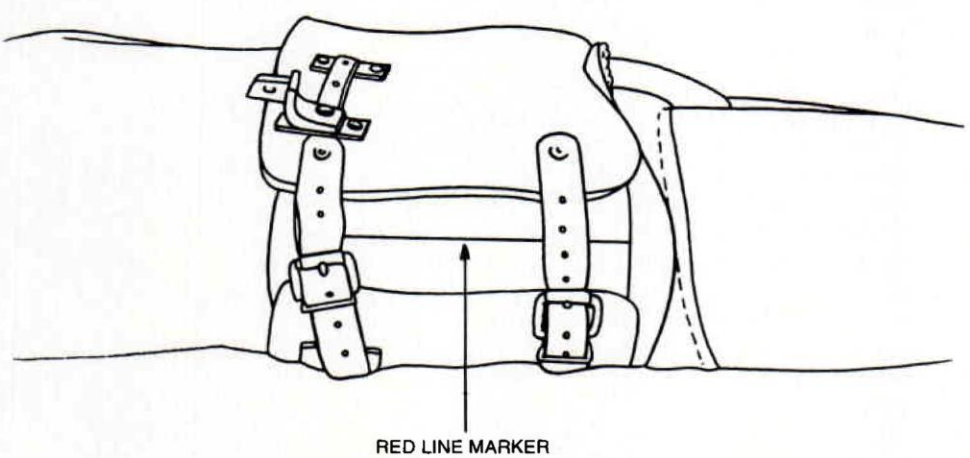

Fig. 3. Anterior portion is secured to the posterior with straps. Sheepskin liner is marked with a red line showing midline.

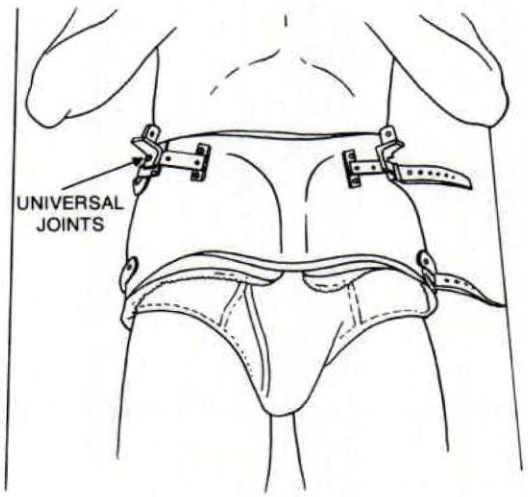

Fig. 4. Anterior view showing attachments of universal joints to two stainless steel brackets.

Figure 4 shows the full anterior view with the universal joints (A) attached to the two stainless steel brackets. It should be noted that the sheepskin does extend below the girdle to give padding for the sitting position. Figure 5 emphasizes that there must be at least 90 degrees of flexion range clearance for sitting which is cut into the anterior portion of the girdle and liner. In Figure 6, the posterior upright stablizer bars (A) are then coupled to the right angle bars (C) with a clamping block (B) to gain proper length for over-the-shoulder clearance. When the patient has a barrel chest, the straight upright bars sometimes have to be contoured to clear the lower border of the rib cage (D). Both posterior upright stablizier bars are shown here with one already attached. The unattached side is laid alongside to obtain the proper length before attaching it on the other side.

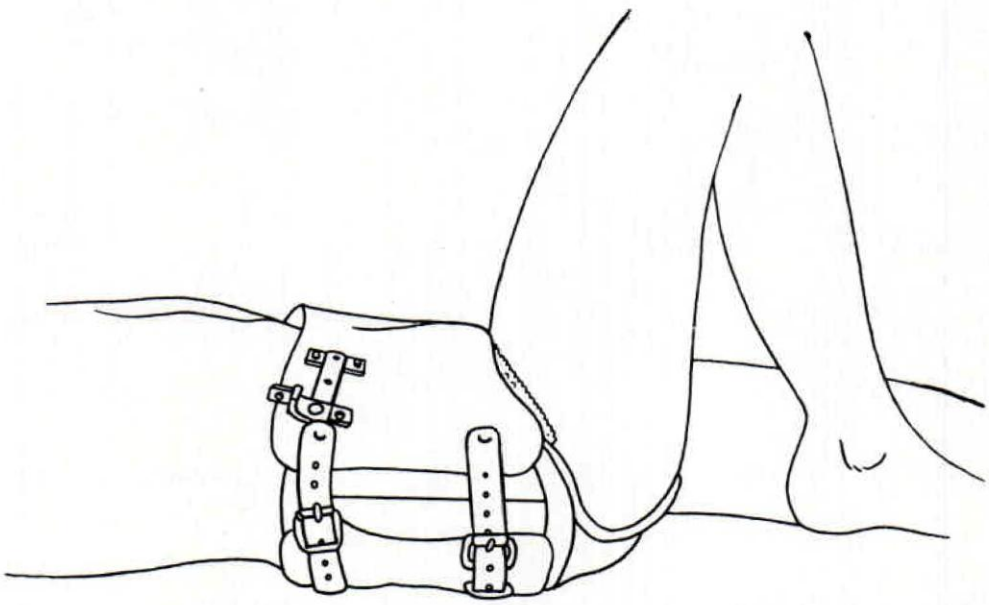

Fig. 5. Ninety degrees of hip flexion must be allowed in the girdle.

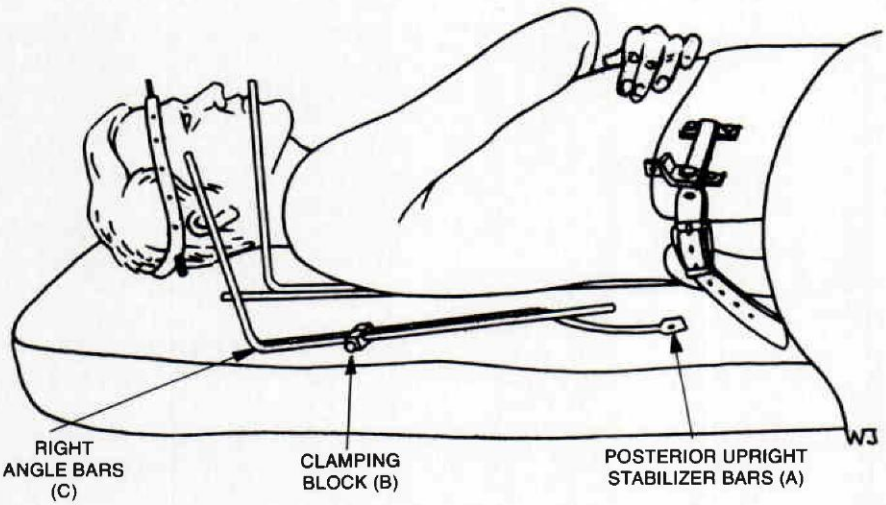

Fig. 6. Posterior upright stabilizer bars are coupled to the right angle bars to gain proper over-the-shoulder clearance.

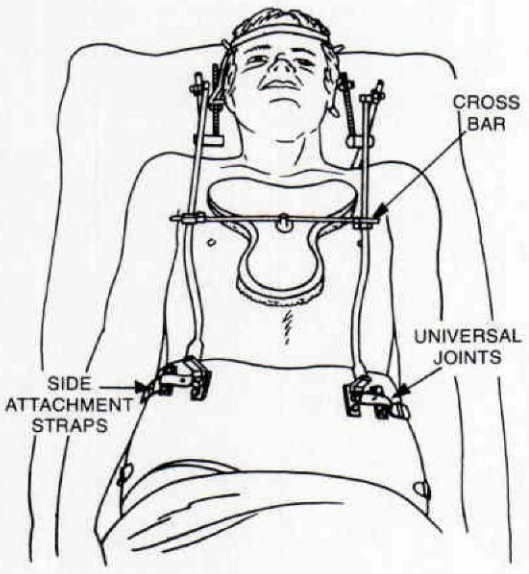

Fig. 7. Upright bars may need to be contoured to avoid contact with body.

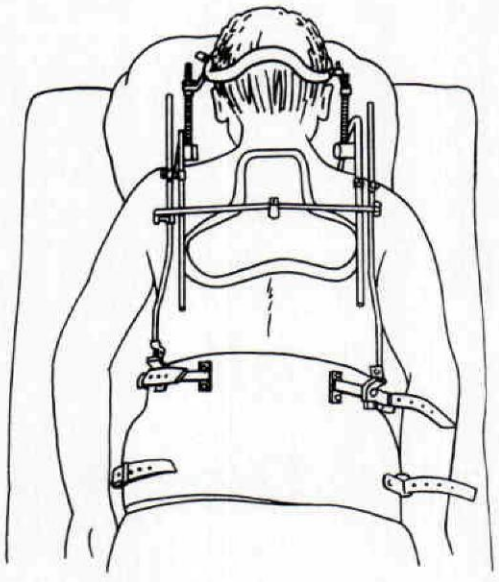

Fig. 9. Positioning of the posterior pad (note: adjustability in all directions).

Figure 7 shows the anterior view. Note the upright bars are bent out to avoid contact with the body, although this does not always have to be done. The anterior chest pad is shaped differently from the posterior pad seen in Figure 9.

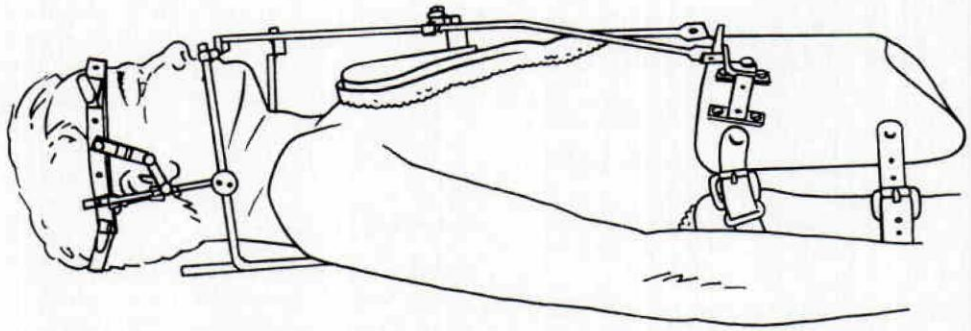

Fig. 8. Position of the anterior chest pad with relation to height and amount of space between the chest and pad.

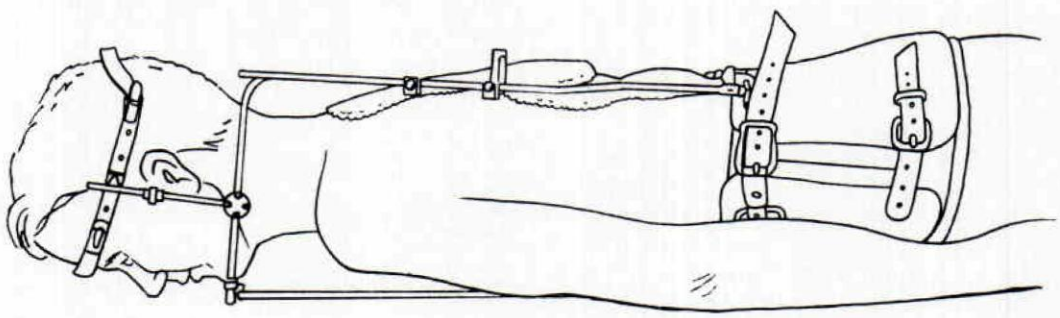

Fig. 10. Lateral view showing placement of the posterior structures.

The lateral view (Figure 8) shows the position of the anterior chest pad; i.e. the height and the amount of space between the chest and pad. There must be enough clearance for the patient to expand his chest, but not so much as to compromise stability. To gain this clearance the cross bar can be contoured (Figure 7).

Figure 9 illustrates the posterior view of the halo-girdle unit, and particularly the posterior pad. This pad can be moved up or down and even turned upside down according to the patient's needs. The clamping blocks for the two upright bars can be placed anywhere on the uprights so as not to cause pressure on the body (Figures 6B, 9 and 10).

Figure 10 is a lateral view with the patient in the prone position to demonstrate more clearly the posterior structures. Figure 11 illustrates the manner in which the halo ring is joined to the lower assembly and how the flexion-extension adjustment is secured to the threaded upright and the halo ring.

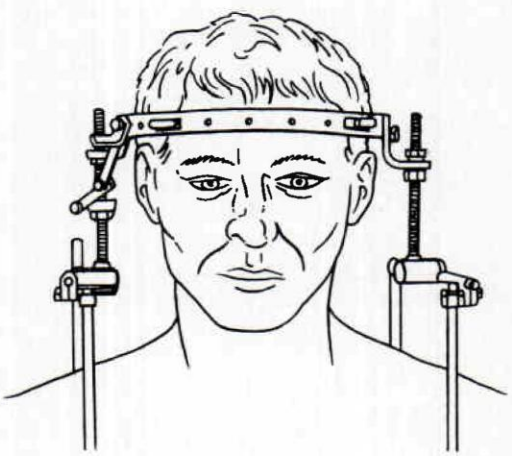

Fig. 11. Attachment of halo ring to lower assembly.

COMMON PROBLEMS WITH THE HALO-GIRDLE

1. The anterior section presses into the thigh when sitting (Figure 5).

   Solution: Trim the anterior brim and liner to allow for sitting.
2. The clamping block on the posterior uprights causes pressure when recumbent (Figure 6).

   Solution: Bend the uprights at the base to achieve clearance for the bars from the body. The clamping blocks can be moved upward or downward until freedom from pressure is achieved.
3. Too much or not enough pressure is transmitted by the anterior and posterior chest pads.

   Solution: The cross bars (Figures 7, 8, 9, and 10) need to be contoured outward or inward to give the proper clearance. The set screws must then be tightened to assure the space is maintained
4. Skin care under the pelvic portion of the brace.

   Solution: The pelvic girdle units can be disassembled by sections for cleaning and inspection of the skin. Skeletal traction is not lost when taking the pelvic section down for skin inspection. For example: With the patient supine, the two bolts that attach the uprights to the anterior outer portion of the girdle (Figure 7A) can be removed, the straps unfastened, (Figure 7B), the anterior piece removed, the liners slipped out (Figure 3A) and then care can be given to the skin. This can be done in the prone or supine position without losing traction on the spine as long as only either the anterior or posterior uprights are loosened at one time.

CONCLUSION

For the patient with multiple spinal injuries or with associated chest injuries, the halo-girdle is an excellent alternative to the plaster body cast for external immobilization. Use of this brace allows early ambulation, excellent skin care, and little restriction of chest excursion.

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A Thermoplastic Endoskeletal Prosthesis

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INTRODUCTION

With the advent of new materials and improved surgical techniques, new types of prosthetic devices are being developed. Despite these recent improvements, however, the basic needs with regard to prosthetic design have stayed the same. Comfort, function, and, to a lesser degree, adjustability, durability, cosmesis, weight, and expense have all become factors in prosthetic design and their prescription. To continually strive for such basic improvements, and to give both the patient and prosthetist an alternative from which to choose, the following system has been developed.

This system incorporates components that have been used before in other prostheses but never before in this combination to provide a prosthesis that can be modified for temporary, definitive, or extra-ambulatory use.

Briefly, the system consists of an endoskeletal prosthesis made of polyvinyl chloride (PVC) tubing, a thermoplastic total contact socket, and a prosthetic foot.

The advantages of such a system are as follows:

Adjustability: changes in alignment, foot placement, and socket contour can be accomplished by heating the PVC tubing or socket in the desired location to modify it as needed.

Weight: The socket and pylon together weigh on the average of one and one-half pounds and the average finished prosthesis weighs between two and three pounds, depending on the foot used.

Expense: The cost of materials required is less than that of a conventional endoskeletal prosthesis and fabrication time is reduced by 50 percent.

Adaptability: The system can be modified to meet the patient's needs whether they be for temporary or definitive use, and because of the waterproof components, can be adapted for water activities.

DESCRIPTION OF COMPONENTS

The success or failure of any system depends in part on its components. The components in this system have been used before in other prostheses but never in this combination.

The socket is made of a thermoplastic material called colyene.[1] Colyene is a copolymer made of 85 percent polypropylene and 15 percent polyethylene. Colyene has the same working characteristics as polypropylene, but is more durable be-

cause of added polyethylene. This allows the copolymer to flex, thereby increasing its impact resistance.

The reasons behind the incorporation of thermoplastic materials in socket design are: (1) adjustability—the socket can be modified with a heat gun or eliminate the need to grind or add filler to the inside of the socket in order to make adjustments; (2) ease of fabrication—since conventional layup procedures are not required, this reduces the fabrication time and materials cost; and (3) flexibility—the socket is flexible proximally, which makes it more comfortable for the patient, yet remains rigid enough to distribute the pressure in the desired weightbearing areas.

The endoskeletal pylon is made of schedule 40, 1¼" ID tubing commercially available at most plumbing supply stores. The PVC tubing can be heated to change the alignment and foot placement. The tubing is held to the socket and foot using PVC plugs[2] in combination with hose clamps to secure it in place. THe PVC is then reinforced with fiberglass to prevent breakage.

Conventional foam and lamination procedures can be followed or a cosmetic cover can be applied if desired. If a conventional system is desired, a ¾" wooden block is added distal to the foot plug and foamed in the conventional manner. If a cosmetic cover is desired, Ethafoam or an Otto Bock cover can be used.

FABRICATION

Conventional alignment procedures are followed using a vertical alignment fixture.[3] Once the angular relationship between the socket and foot is established, the socket is filled with plaster. When set, the socket is removed to obtain a positive mold. The cast is then smoothed and sealed with ambroid varnish or spray sealer to eliminate moisture.

Since all thermoplastics (i.e., polypropylene and polyethylene) shrink after foaming due to the stress put in the plastic during fabrication. A three ply prosthetic sock must first be applied over the cast before the plastic is pulled, otherwise the socket will be too small.

A distal end pad is fabricated by heating a 6" × 6" × 3/16" thick piece of pelite and two 6" × 6" × 1" thick pieces of Plastazote™ and formed to the distal end of the cast. The pieces are glued together using Barge® cement and applied temporarily to the three-ply sock using rubber cement. The pad is tapered proximally so there is a smooth transition from the cast to the distal end pad (Figure 1). If this is not done, a ridge will form on the inside of the socket along the proximal border of the distal end pad causing irritation.

To find the angle at which the distal end pad is to be trimmed, the cast is placed back in the vertical alignment fixture. A piece of PVC tubing is cut according to

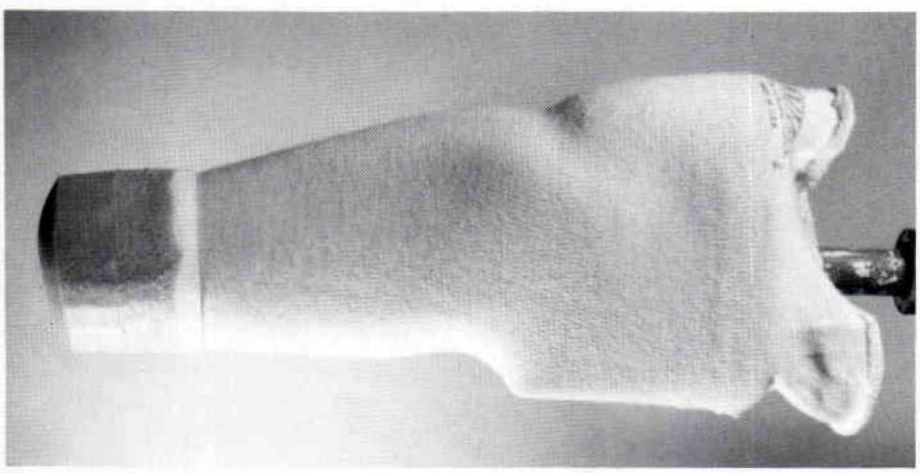

Fig. 1. Distal end pad trimmed flush with cast.

Fig. 2. Determining angle of distal end pad.

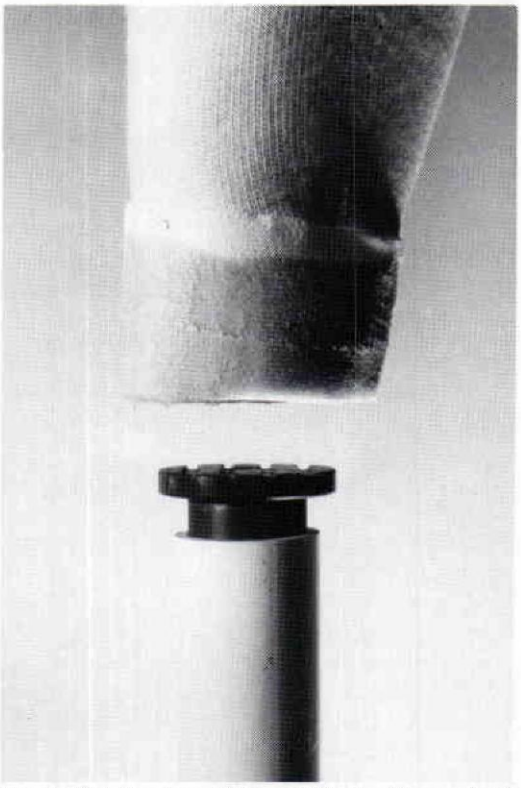

Fig. 3. Distal end pad trimmed flush with proximal PVC plug.

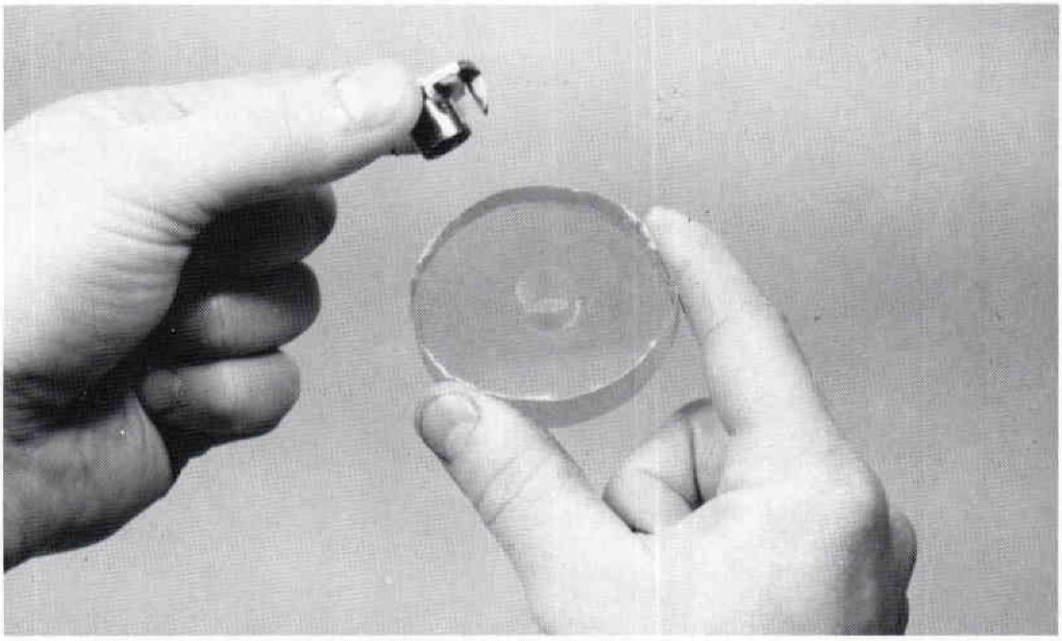

Fig. 4. 3/8" T nut is placed through the 1/2" Lexan attachment plate.

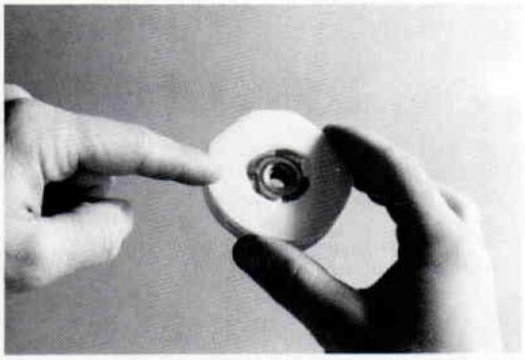

Fig. 5. 1/16" Pelite is added to the attachment plate to make it flush proximally so it can be glued to the distal end pad.

length, and with two PVC plugs placed on either end of the tube, is secured to the foot plate (Figure 2). The distal end pad is then trimmed so it can lay flush against the proximal PVC plug (Figure 3).

A semi-circular attachment plate of 1/2" Lexan is fabricated. Cut just larger than the proximal border of the PVC plug, it is drilled in the middle using a 15/32" drill. Do not make the attachment plate perfectly round because it may rotate within the socket and cause loosening. A 3/8" T nut is placed through the hole after the prongs have been removed, so it can lay flush against the Lexan plate (Figure 4). After sanding the T nut and Lexan to roughen the surfaces, the two pieces are epoxied together. A good bond is critical, otherwise rotation and loosening of the pylon occurs.

To make the attachment plate flush proximally so it can be glued to the distal end pad, a 1/16" piece of Pelite is added to the same side of the Lexan as the T-bolt head. The pad is circular in configuration and extends past the top of the T nut (Figure 5). The attachment plate is then glued to the distal end pad and static alignment checked before the socket is fabricated (Figure 6).

Conventional drape molding procedures are followed because it assures maximum and uniform material thickness throughout the socket. Using a vacuum adapter[4] (Figure 7) to hold the cast, a 1/2" wide piece of 3/16" thick Plastazote™ is wrapped proximally around the cast and taped in place to facilitate easy socket removal. A nylon hose is pulled over the entire cast and taped to the mandrel, then a one inch wide piece of dacron felt is wrapped around the mandrel next to the cast and secured in the adapter. The dacron felt keeps the plastic from pulling inside the tube which causes the plastic to break and eliminates suction (Figure 8).

A piece of colyene of an appropriate size is heated in an oven at 450 degrees for eight to ten minutes or until clear. It is then removed from the oven and pulled over the cast and sealed along the posterior section of the socket and to the vacuum adapter tube after which 20 to 25 inches of mercury vacuum is applied (Figure 9).

Once the plastic has cooled sufficiently, it can be removed from the cast by cutting along the proximal Plastazote™ trim strip. Only cut into the Plastazote™; any deeper and the sock cannot be reused. The cast is broken out in the conventional manner. The socket is trimmed and then finished as desired. Do not trim the posterior seam until it has been removed from the cast

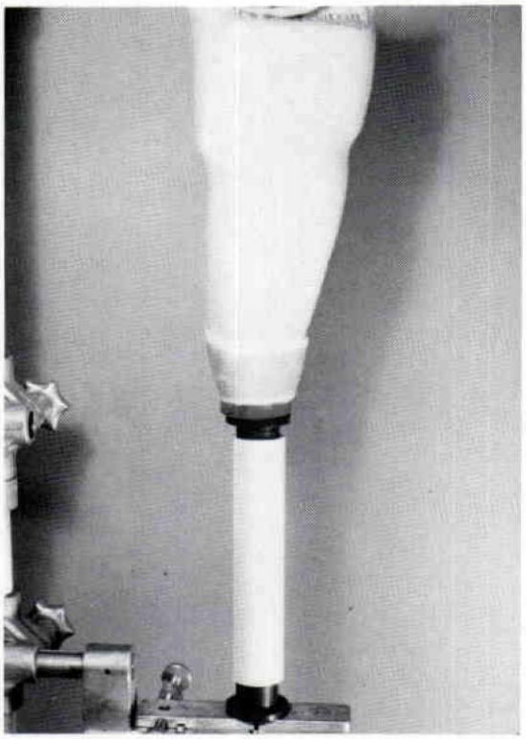

Fig. 6. The alignment is checked before the socket is fabricated.

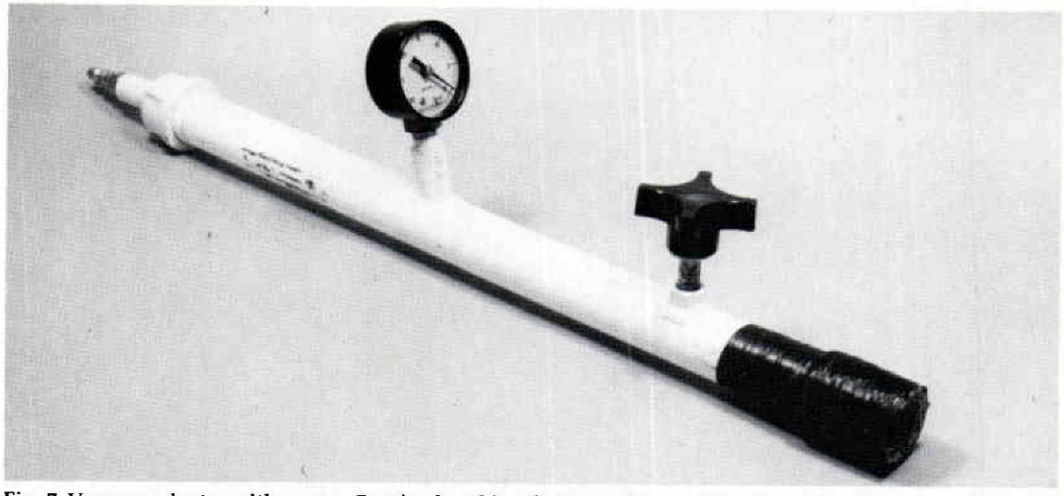

Fig. 7. Vacuum adapter with gauge. Cast is placed in adapter and secured in place. The plastic is sealed to the electrical tape while the vacuum is drawn from the other end.

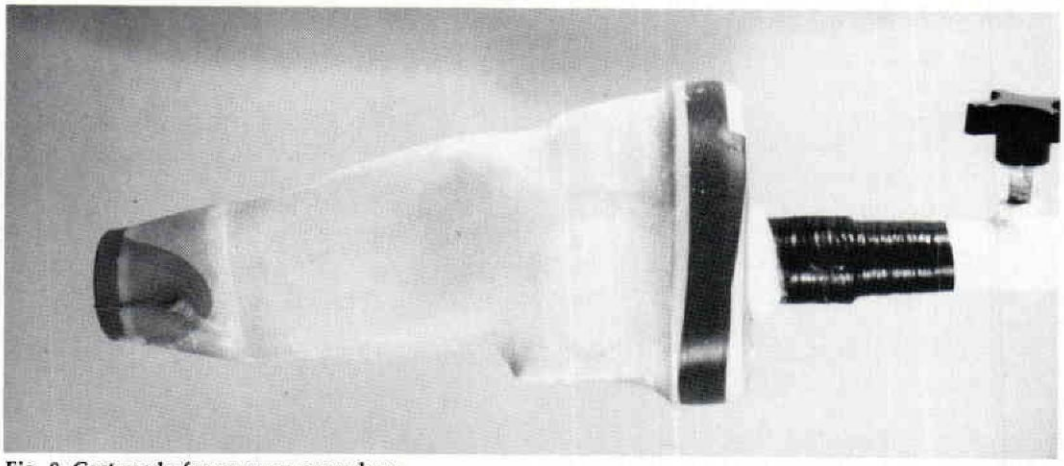

Fig. 8. Cast ready for vacuum procedure.

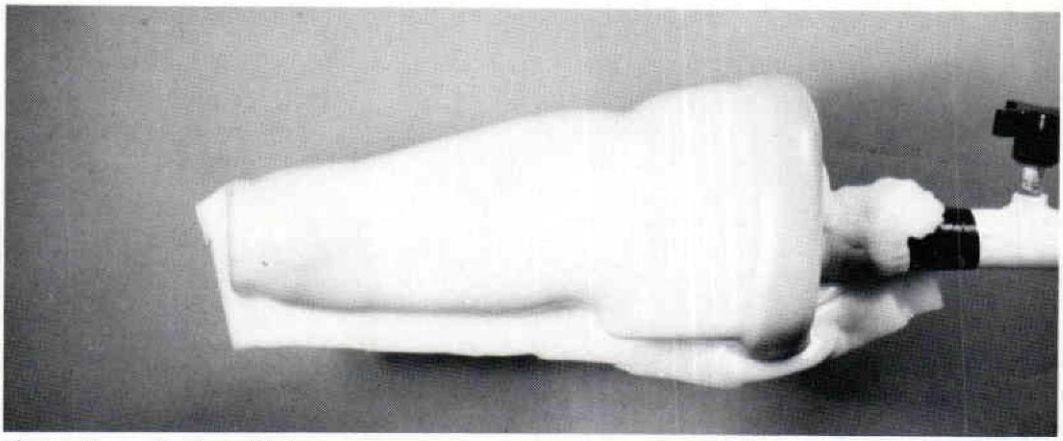

Fig. 9. Thermoplastic molded over cast.

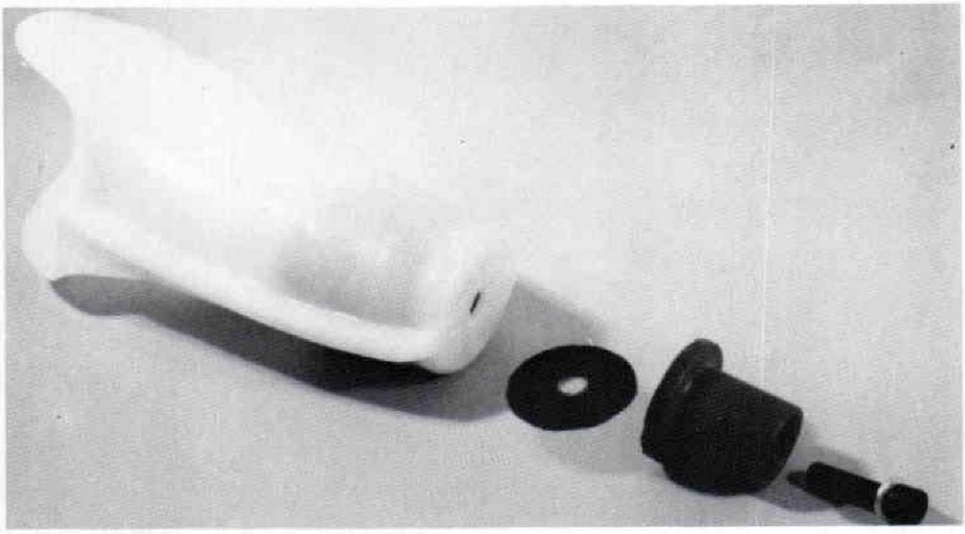

Fig. 10. Socket assembly.

because it has a tendency to split. When trimming the posterior seam, leave 3/8" to 5/8" of the seam exposed. This ensures good adhesion if welding is not possible and makes riveting feasible if necessary. Distally, grind the plastic flat so that the PVC plug can lay flush against the socket and drill a 3/8" hole for the socket bolt. Do not drill past the plastic into the metal threads on the T nut.

Assembly is straightforward. The socket and foot components are assembled as shown in Figures 10 and 11. During the trial fitting, abrasive screen washers are used to eliminate rotation. But because of the rotational forces, they will tear with extended use. Therefore, once the initial fitting is complete, remove the screen washers and epoxy the PVC plugs in place.

A 3/8" × 1 1/2" hex bolt is used on the socket and a 3/8" × 3" hex bolt in combination with a 3/8" T nut is used on the foot. When securing these hex bolts, care must be taken not to overtighten them. Optimal wrench torque is 15 ft/lbs (Figure 12).

The PVC tubing fits snugly over the PVC plugs and is held in place with 1 1/4" stainless steel hose clamps (Figure 13).

DYNAMIC ALIGNMENT

Any alignment changes can be accomplished by heating the PVC tubing and bending it to the desired location to adjust either foot position and/or alignment. Difficult changes in alignment can often be solved by putting the prosthesis back in the vertical alignment fixture to find some point of reference. When heating the PVC tubing, heat a large section to contour the adjustment. Do not make sharp bends in the tubing because this promotes breakage.

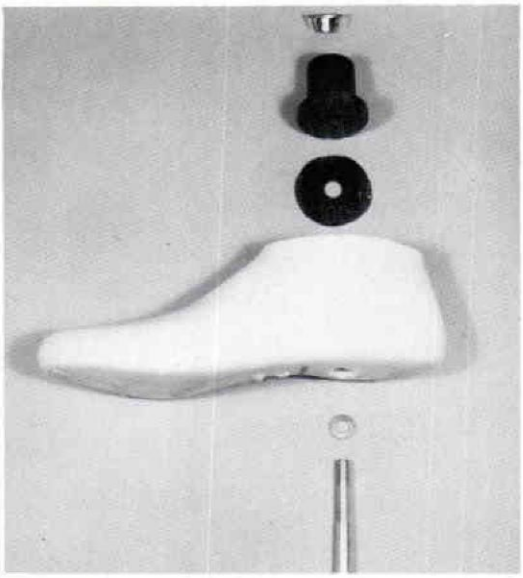

Fig. 11. Foot assembly.

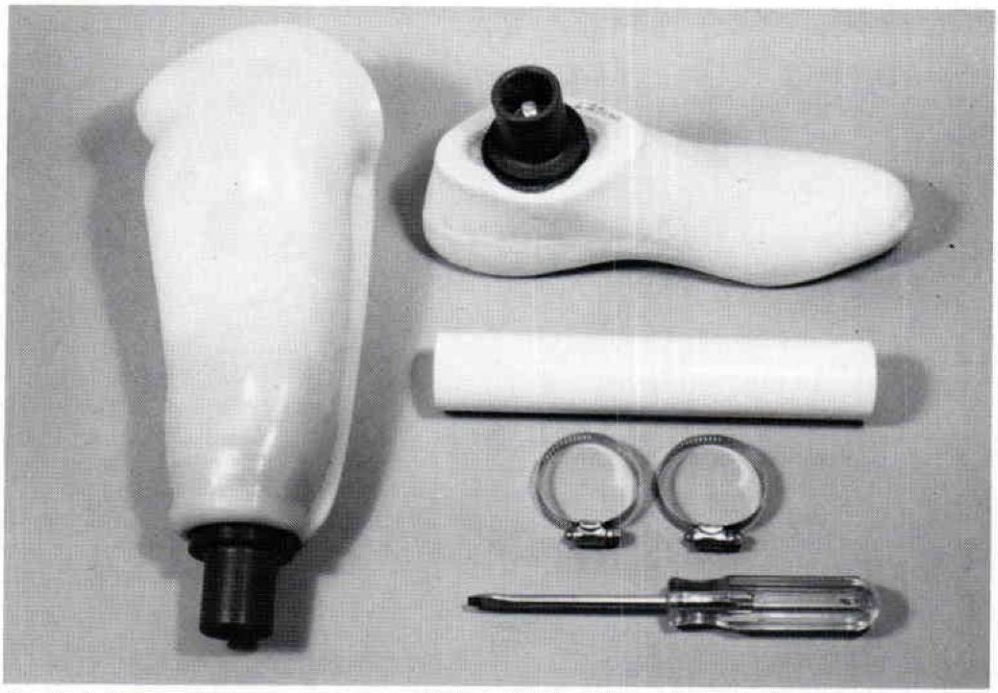

Fig. 12. Socket and foot components assembled and PVC tubing ready for application.

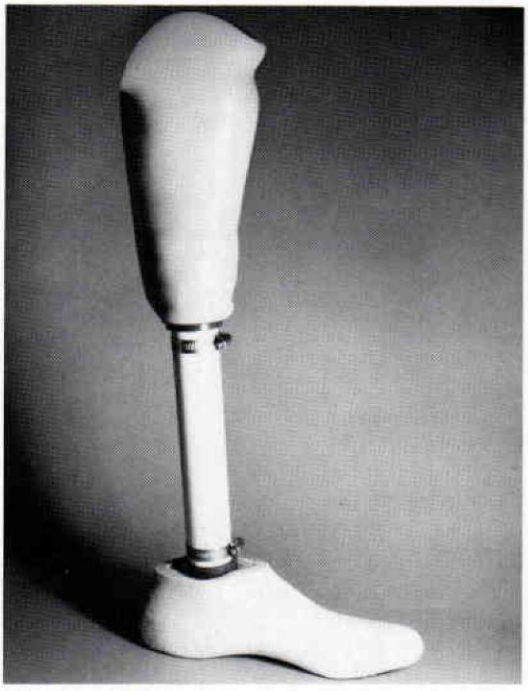

Fig. 13. Prosthesis complete and ready for dynamic alignment.

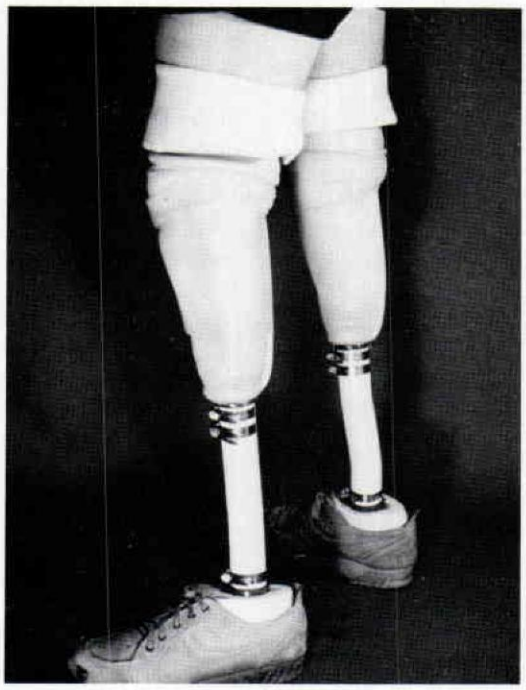

Fig. 14. Bilateral below knee prostheses, incorporating SAFE feet and rubber latex suspension sleeves for water activities.

FINISHING

Once the prosthesis has been dynamically aligned, the PVC tubing must be reinforced with fiberglass. After making proximal and distal reference lines on the PVC tubing and plugs, the tubing can be removed. Roughen the tubing and reinforce it with four to six layers of fiberglass cloth. The PVC plugs are then glued back in place using PVC glue. Before gluing PVC plugs, make sure all alignment changes have been made because once the PVC plugs are glued and PVC reinforced, any further adjustments cannot be made. A cosmetic cover or conventional lamination may then be added if desired (Figure 14).

DISCUSSION

Designed as a temporary/preparatory prosthesis, the system works well for the newer amputee because it accommodates changes in the socket due to residual limb atrophy and changes in alignment from improved gait patterns. While this system was designed to be lightweight, adjustable and inexpensive, other factors, including durability, should also be considered in its prescription. Because it was designed to be temporary, careful attention needs to be directed towards reinforcing the system to prevent breakage and/or limiting the prosthesis to the less aggressive amputee. When wearing this prosthesis, the patient must be able to come in for regular checkups (every 4–6 weeks). If he is unable to do this, or shows an unwillingness to follow the recommendations of the prosthetist or physician, this prosthesis should not be prescribed.

When using this system, its adaptability should also be considered. This system can be made waterproof, depending on the type of foot used, so that the patient can use the prosthesis in the shower or for water related sports activities. Various types of other mechanisms can also be attached to the PVC tubing and foot for prototype development or patient evaluation before a definitive prosthesis is made.

CONCLUSION

The level of prosthetic care can increase only as the result of incorporation of new ideas and technology. It is through this mix that the above temporary endoskeletal prosthesis was developed. Based on the needs of amputees, this system provides the patient with a lightweight, adjustable, inexpensive and adaptive prosthesis that can be used by patients to increase their level of rehabilitation.

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Evanston, Illinois 60202

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Campbell, California 95008

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Evanston, Illinois 60202

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ACKNOWLEDGEMENTS

The staff at the Prosthetics Research Study Center in Seattle, Washington is especially thanked for its participation in the development of this report.

Drew Hittenberger, C.P., is Chief of Research Prosthetics at the Prosthetics Research Study Center in Seattle, Washington.

Prosthetic Modifications for the Treatment of Marginally Viable Below-Knee Amputations

Kevin S. Garrison, C.P.

INTRODUCTION

When one is confronted with a marginally viable below-knee amputation which has an open suture line or other epidermal problems related to post-operative treatment, what is the best prescription for these patients prior to temporary prosthetic fitting? This type of residual limb is found mostly with geriatric amputees, and is often complicated by paraesthesias associated with Diabetes Mellitus (Figure 1).

The ultimate goal for the prosthetist is to produce a snugly fitting, carefully contoured socket, which offers the maximum amount of area for weight bearing. This leads to better control and comfort while ambulating on a lightweight prosthesis. This is a goal which may be achieved by utilizing special modifications to the prosthesis, thus allowing these types of amputees to progress rapidly and comfortably throughout their prosthetic rehabilitation.

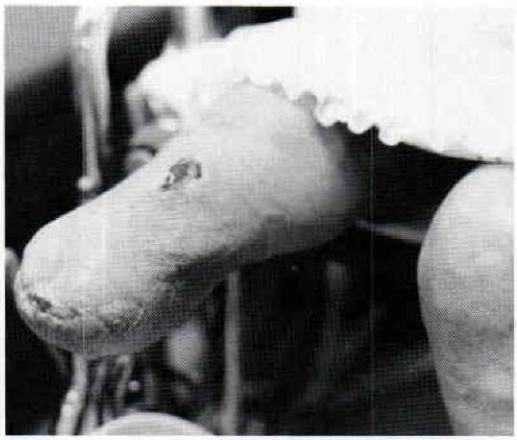

Fig. 1. A marginally viable below the knee amputation showing slow healing suture line and pressure sore.

PROSTHETIC MODIFICATIONS

Joints and Corsets

One modification, allowing early ambulation for the amputee with a slow healing suture line, is the addition of a thigh corset using either polypropylene or nylon knee joints.[1] (Figure 2). The thigh corset offers some control of weight bearing on the distal one-third of the residual limb. With the addition of two or three two inch Velcro® closures, the corset is easily adjusted by the patient (Figure 3). The polypropylene or nylon knee joints offer the advantages of lightness and ease of workability (Figure 4). These joints work quite well in supporting weights of up to 180 pounds. However, one must take caution when setting the shape of the uprights on heavier patients. A gradual bend in the upright will support weight better than a radical bend will. This will also lead to less

Fig. 2. A completed below the knee prosthesis utilizing polypropylene knee joints and Velcro® closures.

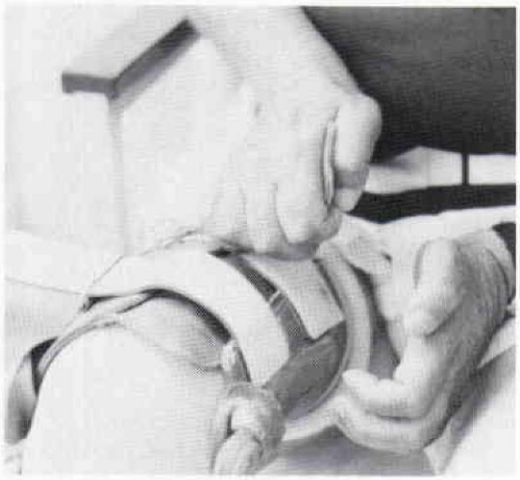

Fig. 3. A thigh corset with Velcro® closures is easily adjusted by the patient.

problems of breakage. These knee joints should also only be used on patients with a sound knee joint, as they offer limited medio-lateral stability. The joints can be used on a long term basis with a moderately active patient. This modification to the prosthesis can work well, but only with a qualified physical therapist routinely monitoring the patient's progress on the prosthesis until healing has occurred.

Special Inserts

In addition to, or apart from the thigh corset and side joints preparation, specially fabricated inserts should be created on an individual basis when dealing with an asensitive residual limb of a geriatric amputee.

If a patient's weight is 120 pounds or less, and he has a moderate activity level, a very soft insert composed of an inner layer of 1/8 inch Plastazote™, and an outer layer of 1/8 inch PPT[2] produces an equitable environment for the residual limb. The Plastazote™ will stay compressed after use in the most dense tissue areas, where pressures are concentrated, while constantly adjusting to changes. This is backed by a layer of PPT, which offers continual protection for the residual limb, and resists compression. Due to the combined total durometer of the Plastazote™ and PPT insert, adequate support effectively helps patients who fall in the lightweight and moderately active category.

Patients who weigh 130 pounds or more and who are moderately to highly active, can benefit from an insert composed of an inner layer of 1/8 inch PPT and an outer layer of Pelite. PPT offers direct tissue shear stress protection while being backed by the firm durometer of the Pelite. This combination of materials offers an environment that will protect the residual limb

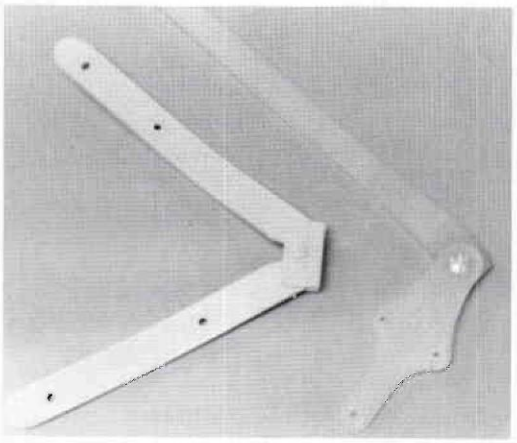

Fig. 4. Nylon (left) and Polypropylene (right) knee joints work well in supporting weight of up to 180 pounds.

throughout the entire day by relieving the tissues of stress which could lead to skin breakdown. The typical patient requiring this type of insert might be a moderately active 200 pound, six foot tall man with a four inch residual limb. This residual limb would be subjected to intense pressure at all times, thus necessitating this type of insert.

Young, highly active below-knee amputees can also benefit from the control of tissue breakdown. This type of insert absorbs a majority of the compound torques and pressures on the residual limb under stressful conditions, while still offering little increase in the overall weight of a sport-type prosthesis.

An insert made solely of ¼ inch PPT offes excellent protection for the patient with a very short, predominantly bony, well atrophied below-knee residual limb with very little or no protective tissue. Patients with moderate activity levels and weighing up to 130 pounds can benefit from this tissue supplemental material. This material can prevent tissue irritation, which is so common amongst these patients. This insert also allows the patient to ambulate comfortably without the need for a multiple prosthetic sock fitting. As normal atrophy occurs, this type of insert aids in the protection of the residual limb, even as the initially intimate fit begins to fade.

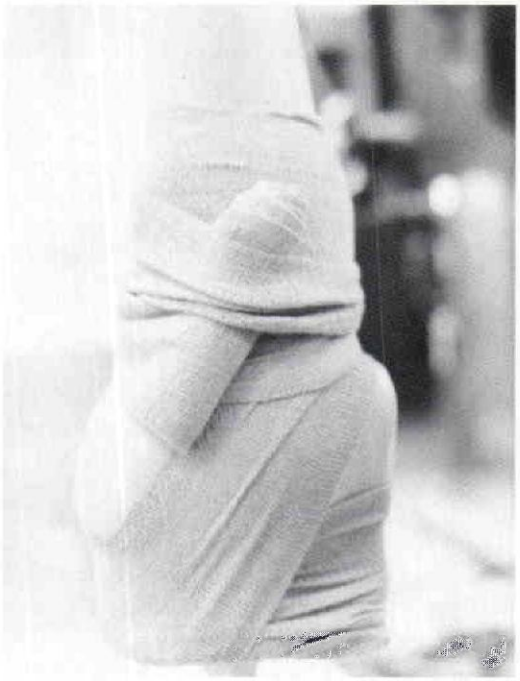

Fig. 5. Plastazote™ forms similarly to Pelite around a positive model.

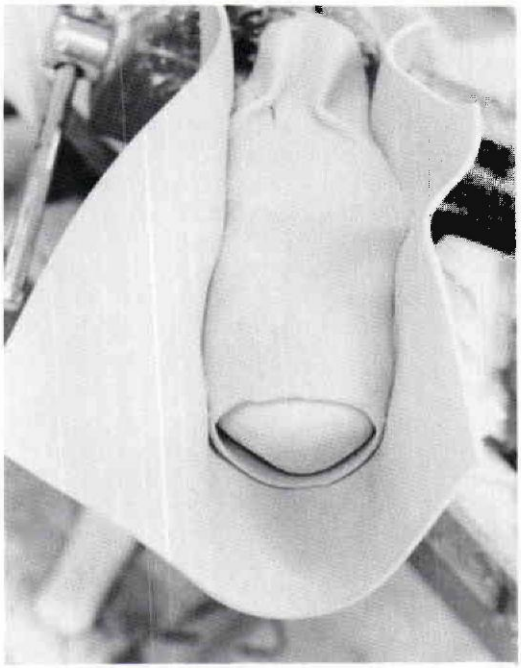

Fig. 6. Starting at a point on the anterior of the positive mold, contour the PPT by carefully applying it around the posterior where the PPT can be trimmed to permit one seam.

FABRICATION

The Plastazote™-PPT insert can be fabricated quite rapidly and simply. A suggested method is to cut out a measured area of ⅛" Plastazote™ just as you would in producing a standard Pelite insert. Complete and apply this to the positive mold as you would with a Pelite insert, only use much less heat (Figure 5). After it has been adequately shaped to the positive mold, cover it completely with a thin coat of Barge®, or similar type contact cement. Then apply a coat of the adhesive to an equal area of ⅛" PPT. Starting at a point on the anterior of the positive model, contour the PPT by carefully applying it around to the posterior where the PPT can be

trimmed to show only one seam in the posterior (Figure 6). Proceed to cap the insert as desired. Caution should be taken when gluing the PPT so as not to apply adhesive to the coated side of the material, marked with the brand name, as the adhesive will remove the coating from the material leaving a weak bond. It is preferable to obtain uncoated PPT material and avoid this problem.

The PPT-Pelite type insert is fabricated differently than the above type, but is still very easy and quick to create. Cut an appropriate area of 1/8" Pelite and an equal area of PPT and bond the two materials together with a thin coat of adhesive. Skive the edges approximately 1/2" as you would in constructing a Pelite insert. Sanding the skive is recommended over cutting a skived edge. Prepare a cone as in the standard Pelite insert technique. Heat the Pelite, which is on the outside, until it is slightly pliable, and carefully pull the inverted cone over the positive model and shape as you would a standard Pelite insert. Again, cap the insert as you normally would (Note: It is suggested that the A.P. modification of the positive model be tightened by 1/8" to 3/16".

Fabricating the 1/4" PPT insert is different from the others mentioned above, as by itself it is not thermal molding and tends to maintain its original shape. Produce this insert in the same manner as a standard Pelite insert, except that the application over the positive model is done without the use of heat. It is simply pulled carefully into place. It is suggested that you modify the positive mold to produce a one-ply fit.

All three insert types should be laminated into the socket using the same vacuum settings and techniques as with a standard Pelite insert. Care must be taken on the breakout of the positive model so as to protect the finished insert. Socket pulling as a means of separating the socket from the positive model is not recommended, due to possible damage to the insert. The inserts should always be marked for trimming after the patient has been ambulating and is still in the prosthesis, and the nonconforming PPT is pushed into place. There is approximately 1/2" of displacement in the material under loading as it is made to conform to the socket shape (Figure 7). These lightweight special inserts can easily be fabricated and replaced when necessary and the longevity is similar to that of a Pelite insert. Modifications can be made by adhering Pelite to the outside of the insert in the appropriate areas, thereby accommodating volume changes of the residual limb. A thin coat of adhesive works quite well in the bonding of all these materials.

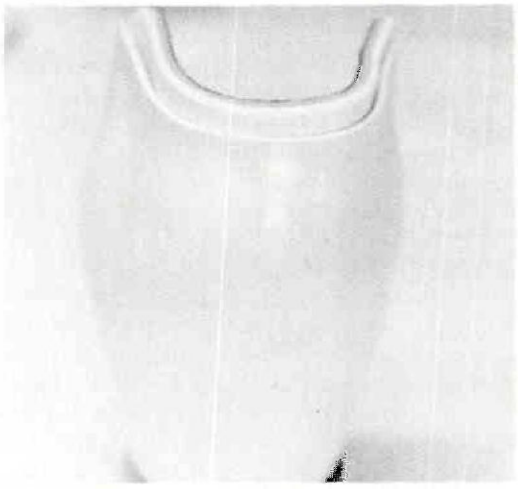

Fig. 7. Mark the insert for trimming with the patient in the prosthesis to allow for approximately 1/2 inch of displacement under loading.

SUMMARY

In conclusion, if careful attention is taken in fitting special below-knee residual limbs, higher success rates and more rapid prosthetic rehabilitation can be achieved. Use of special materials and fabrication techniques can assist the prosthetist in this endeavor.

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[3]PPT is available through Professional Technology, Inc., 21 East Industry Court, Deer Park, New York 11729.

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A Case History: Protecting the Head and Face

George W. Gills, C.O.
Gary Fields, C.O.

INTRODUCTION

Individual and specialized needs of patients subjected to facial and head injuries secondary to a fall, have prompted the design and manufacture of various styles of protective headgear. These commercially available helmets utilize modern materials in order to make them both safer and more acceptable to the patient. Polycarbonate, for example, is a clear and lightweight plastic that is sometimes used for fabricating the face-guard section. In addition, some companies will "customize" the headgear to further accommodate individual problems. However, it is not reasonable to think that a pre-fabricated design can satisfy all the needs of every patient. Custom fabrication is necessary for select cases in order to yield the most functional and acceptable device possible.[1]

PATIENT BACKGROUND

This patient is a ten year old female who has a medical history that includes a serious seizure disorder and poor balance. This condition has caused her to fall (face-forward) on numerous occasions, sustaining several maxillofacial injuries.

The patient's mother contacted this office after unsuccessful trials with pre-fabricated headgear. She stated that they were all too heavy and contributed to the child's poor posture and balance. Her head was actually drooping from the excessive weight of the "off-the-shelf" helmets. Custom fabrication was clearly indicated.

FITTING AND FABRICATION

It was decided that a pre-fabricated "boxing-type" helmet would be most suitable to serve as a skull protector as well as the foundation for the face guard. This design is commercially available and is both lightweight and well padded

Basically, the face guard is comprised of three strips of Orthoplast approximately two inches in width. The total length of each strip depends upon the individual patient requirements. First, the forehead section is molded. It extends just posterior to the midline on both sides. In this case, the overall length is approximately eighteen inches.

Five copper rivets are used to secure the forehead strip to the helmet after the entire face guard is completed. The inferior crossbar is molded next, and extends downward at a slight forward angle to protect the chin. It is folded in the middle in order to achieve sufficient rigidity for protection and is attached at the midlines

of the helmet with four speed rivets. The superior crossbar is then formed and also folded in the middle. It is attached with two speed rivets on both sides, and placed in such a position so as not to interfere with vision or eating. The Orthoplast is folded in a direction away from the face with the rounded surface towards the face (Figure 1).

RETENTION STRAP

The original chin strap had to be removed as it was not secure enough and could easily be opened by the patient. The mother feared that her daughter would remove it whenever left unattended.

A strap was devised that utilized an inside "D" ring and an outside buckle arrangement (Figure 2). The strap first passes under the chin and through the ¾" "D" ring. It is then brought back under the chin and follows around the right lateral side of the neck. Finally, it secures into the buckle which is distal and inferior to the left ear. A soft tongue is sandwiched between the "D" ring and the buckle to prevent discomfort to the back of the neck. The "D" ring and the buckle are attached to the earflap with elastic so that a sudden jolt to the helmet is partially absorbed in the strap. These simple modifications to the original chin strap accomplished two goals: the helmet is held on more securely, and it cannot be easily opened by the patient.

SUMMARY

A one-pound protective helmet with a face guard was fabricated for a patient who was subject to maxillofacial injuries as a result of falling. The positive results achieved justified the fabrication and fitting time required.

REFERENCES

[1]E. Hartwig; F. Wenzel; C. Hintz, "Maxillofacial Protective Headgear," *Orthotics and Prosthetics*, Vol. 31, No. 1, pp. 25–28, March, 1977.

Mr. Gills is with Capital Orthopedics, Inc. of Bethesda, Maryland. Mr. Fields works with Capital Orthopedics, Inc. Rockville, Maryland.

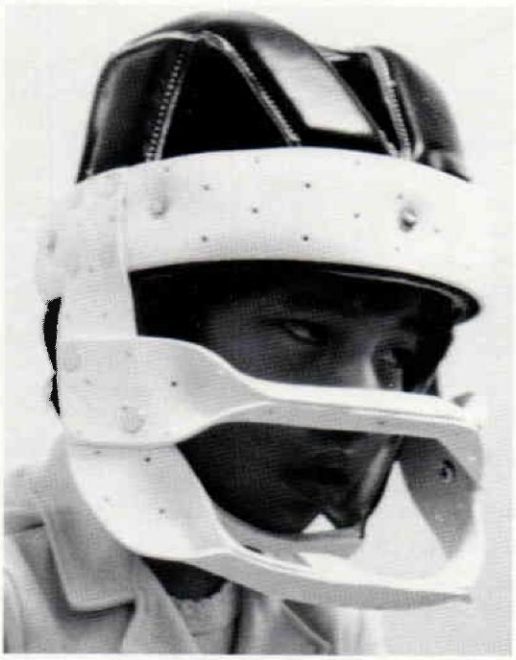


Fig. 1. Protective headgear worn by the patient with a seizure disorder. Prefabricated headgear did not work with this patient due to its weight.

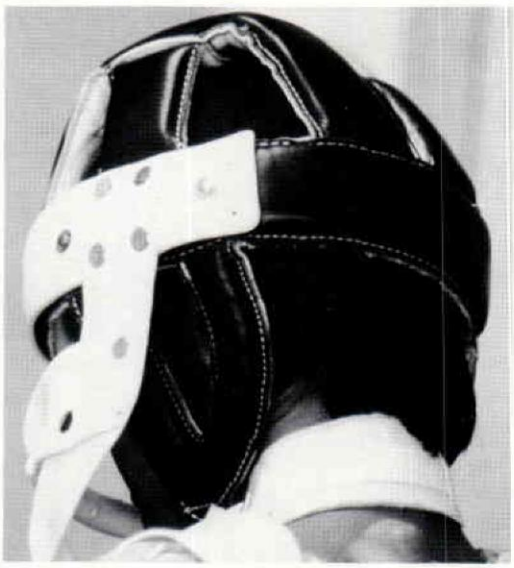


Fig. 2. The orthoplast frame attached to the boxing headgear. Seizures cause the patient to fall face forward and the impact must be absorbed by the headgear without breakage. The strap extends from the chin piece around the back of the neck to hold the helmet on more securely and to prevent the patient from removing it.

Technical Note:

The USMC Prosthetic Skin

Judd E. Lundt, B.S. Engr.
Timothy B. Staats, M.A., C.P.

INTRODUCTION

Coverings and artificial limbs have enjoyed limited popularity for over twenty years. While early versions, made primarily of polyvinyl chloride were usually applied to exoskeletal below knee prostheses, it was not until introduction of endoskeletal prosthetic components with their soft foam covers that their utility became apparent.

The USMC prosthetic skin (Figure 1) was initially developed in 1974 as a protective cover for soft foam endoskeletal below knee prostheses. Today it is available in both caucasian and negroid skin tones in a variety of sizes for all applications from below knee to hip disarticulation prostheses.

Characteristics of the USMC prosthetic skin are its toughness, thinness, elasticity—particularly in the longitudinal direction—and its slow rebound to stretch. Because of this, little additional limitation in knee flexion will result with the above knee exoskeletal prosthesis when the skin is

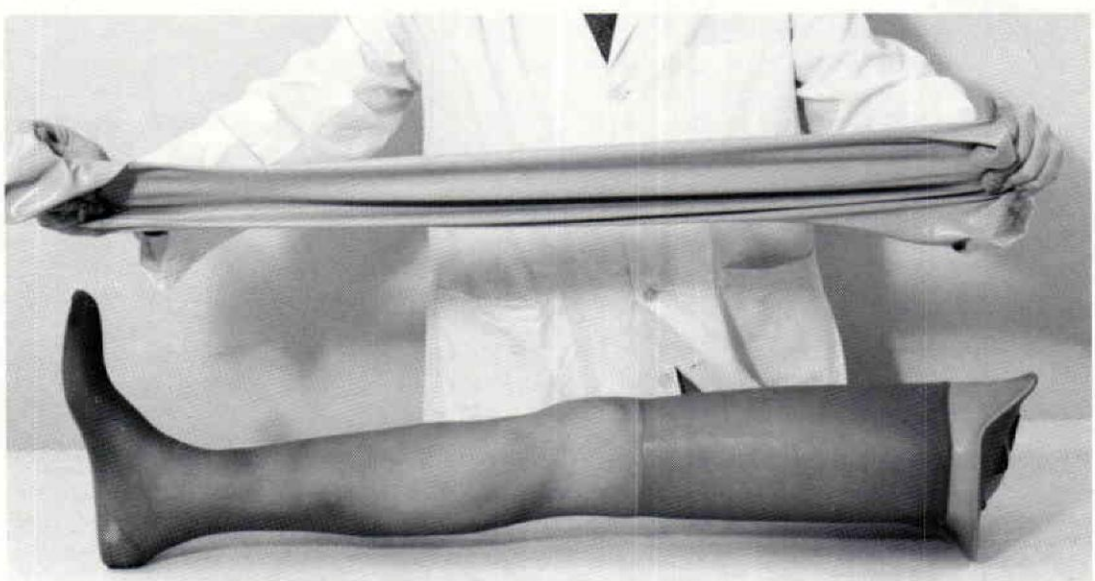


Fig. 1. The prosthetic skin is very elastic in the longitudinal direction to minimize interference with knee function.

Fig. 2. The skin is gathered and carefully pulled over the foot. The use of heat is not recommended.

used over the soft foam cover. Furthermore, if properly sized, the skin will not collapse or significantly distort the underlying foam.

As with any thin material designed to fulfill the above requirements, the USMC prosthetic skin is not completely impervious to tears and abrasions. Damage, if it does occur, is most likely during and through improper application procedures. However, when correctly installed, and with proper patient care, many months of service will be realized.

PREPARATION PROCEDURES

If the skin is to be used over an exoskeletal system all outer surfaces must be padded with at least 1/16" of soft foam such as Aliplast™ or Plastazote™ to prevent wear-through. All rivets, buckles or protruding components must also be carefully covered. The posterior aspect of the ankle where the counter of the shoe contacts the foot must be undershape to permit the addition of foam in this area (Figure 2).

With the endoskeletal prosthesis it is necessary to leave the foam cover somewhat oversized to compensate for the slight compression caused by the skin covering. Care must also be taken to accentuate the knee cap shape so that its lines will remain cosmetic during knee flexion.

For the hip disarticulation prosthesis, additional padding for cosmetic appearance should be considered through use of an oblong buttocks pad glued to the socket. When using the USMC prosthetic skin in this application it is suggested that a nylon hose (preferably a panty hose) be pulled over the entire limb. Protective padding is applied over all rough edges and exposed screw heads to prevent them from wearing through the skin. When proper padding is completed, the skin should be applied by using the following procedure.

APPLICATION OF THE PROSTHETIC SKIN

The USMC prosthetic skin is applied in a manner similar to donning a stocking. It should be gathered, however, rather than

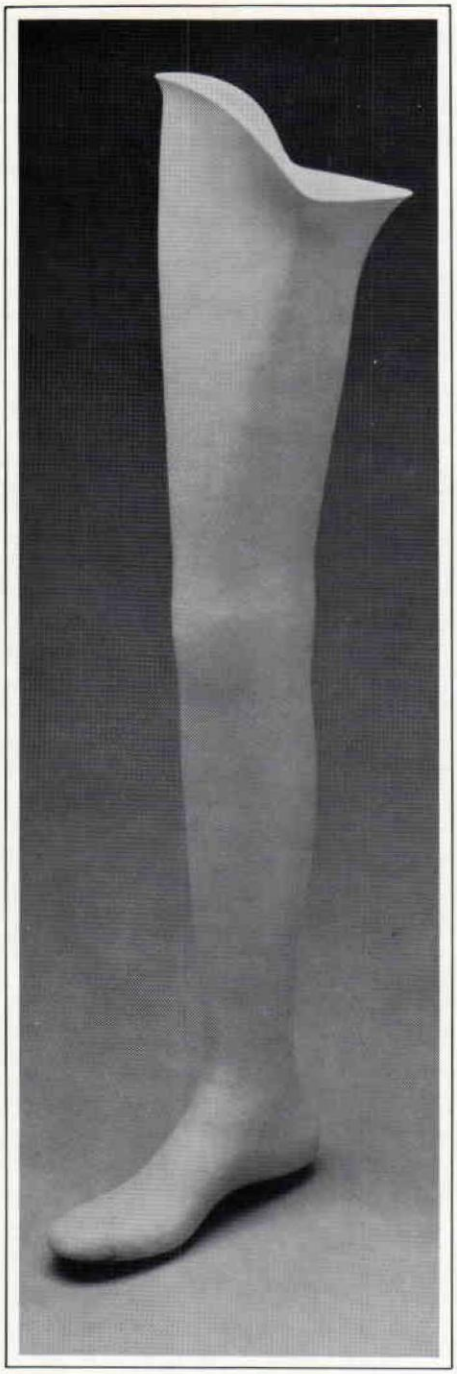
rolled on starting with the foot. After carefully pulling the skin over the foot, it is stretched proximally using the pads of the fingers (Figure 2). Particular attention to preventing the fingernails from digging into the elastic material is essential to prevent tearing. Once over the foot it is stretched longitudinally until all wrinkles are removed. The use of heat to soften the skin material to facilitate stretch is neither necessary nor recommended.

Fig. 3. When using the skin over a soft leg cover, it is cemented directly to the lower end of the cover.

When installed over a below knee prosthesis the skin may be permanently glued to the proximal brim with Barge™ and trimmed or, if desired, left long and used as an auxiliary suspension by attaching to a garter belt.

When using on an above knee prosthesis it may be necessary several times during the first few weeks to remove wrinkles that develop from creep in the skin material. Because of this characteristic, permanent attachment of the skin at the proximal aspect should be postponed until all evidence of creep has been resolved. The skin works exceptionally well over the Hydracadence foot and lower leg cover as well as over the Mark V Multiplex and OHC Four Bar Systems. With these components, the skin is cemented directly to the soft lower leg covers (Figure 3).

Hip disarticulations may require an extra length skin for an exceptionally long prosthesis; however, with shorter limbs a standard above knee length will suffice.



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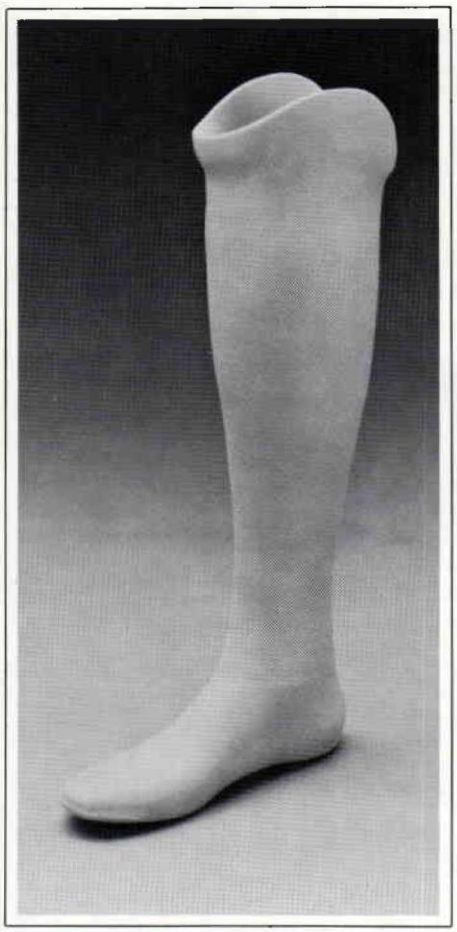

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RE: CALL FOR CONTRIBUTED PAPERS FOR THE 1984 ASSEMBLY SCIENTIFIC PROGRAM

The American Orthotic and Prosthetic Association is an organization whose 800-plus membership consists of firms involved in the design, manufacture, and fitting of orthoses and prostheses. The primary objective of AOPA is to promote high levels in achieving this goal, each year the Association provides a forum, via its annual National Assembly, for orthotics and prosthetics professionals to share information on the many new ideas and/or concepts of or relating to orthotics/prosthetics. Nearly everyone working in orthotics and prosthetics in the United States attends the Assembly, along with many professionals from abroad. The 1984 Assembly will be held at the Fontainebleau Hotel, Miami Beach, Florida on October 16–21, 1984.

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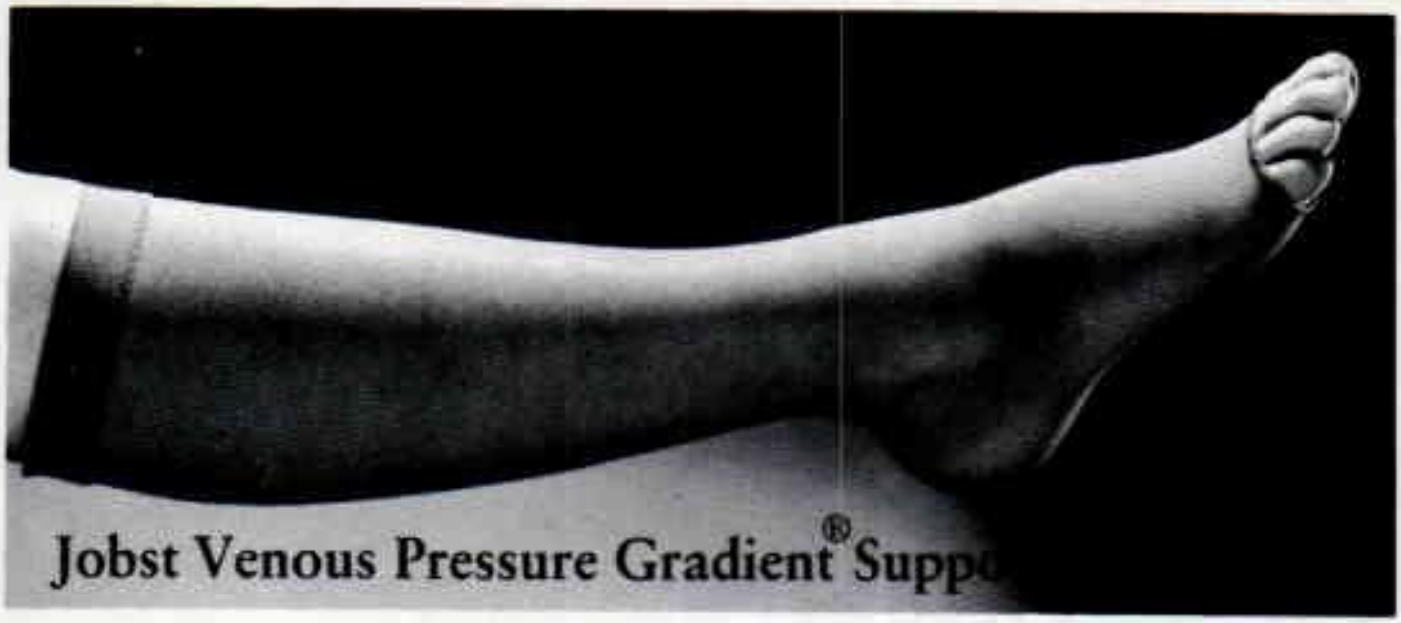

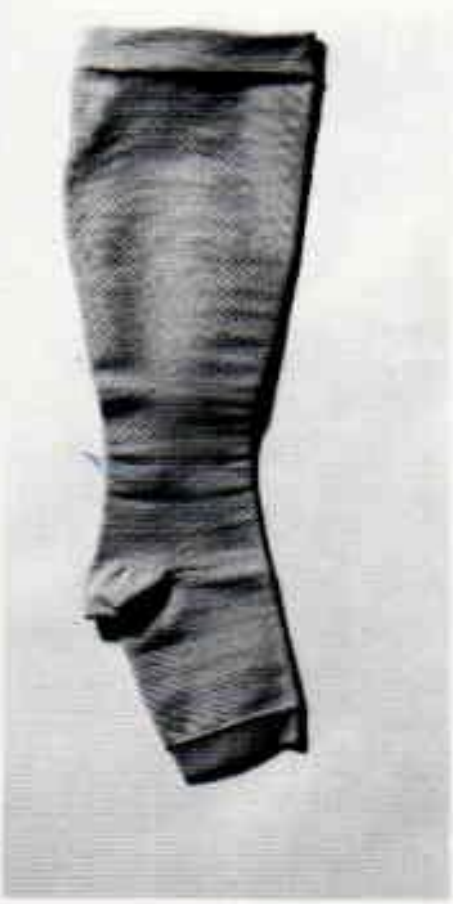

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REVIEWS

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Manual On Management of the Burn Patient, Maude H. Malick, O.T.R., A.S.H.T., Judith A. Carr O.T.R., Harmarville Rehabilitation Center, Educational Resource Division, P.O. Box 11468, Guy's Run Road, Pittsburgh, PA 15238. 256 pages, Glossary, Bibliography, Sources of Supply, Index. $23.00.

This is the fourth of a series of books dealing with aspects of upper extremity orthotics from the occupational therapist's perspective. As with the other members of the series it is very well done and should prove to be of use to all individuals called upon to deal with burn patients. The illustrations, as always, are particularly well done and include color photographs as well as black and white photographs and line drawings.

Following their usual pattern the authors proceed in a logical fashion starting with general and fundamental topics essential to understanding the treatment of burns and passing on to specific modes of treatment. Separate chapters deal with such topics as hand management, scar hypertrophy and contracture, gradient pressure techniques, and specialized pressure techniques. Details and patterns for the fabrication of such devices as transparent face masks and hand orthoses of various patterns are given.

Any orthotist in the position of working with occupational therapists and others who deal with burn patients should have this book available.

A Manual For Amputees, Brig. I.C. Narang, M.S., F.I.C.S., (Retired), L-32 Tara Apt. Kalkaji, New Delhi-110 014, India, available from the author $3.00 (U.S.) plus postage, payable in advance.

For years Brigadier I.C. Narang, a surgeon, was Commandant of the Artificial Limb Fitting Center, Pune, India. This book is the result of his many years experience and is intended as a guide for prospective and new amputees and the parents of child amputees. The contents do not differ greatly from the several such booklets published in this country and the material is well thought out and carefully explained. Its chief interest lies in the glimpses into the lives of Indian amputees and Indian society's attitude toward amputation that it affords.

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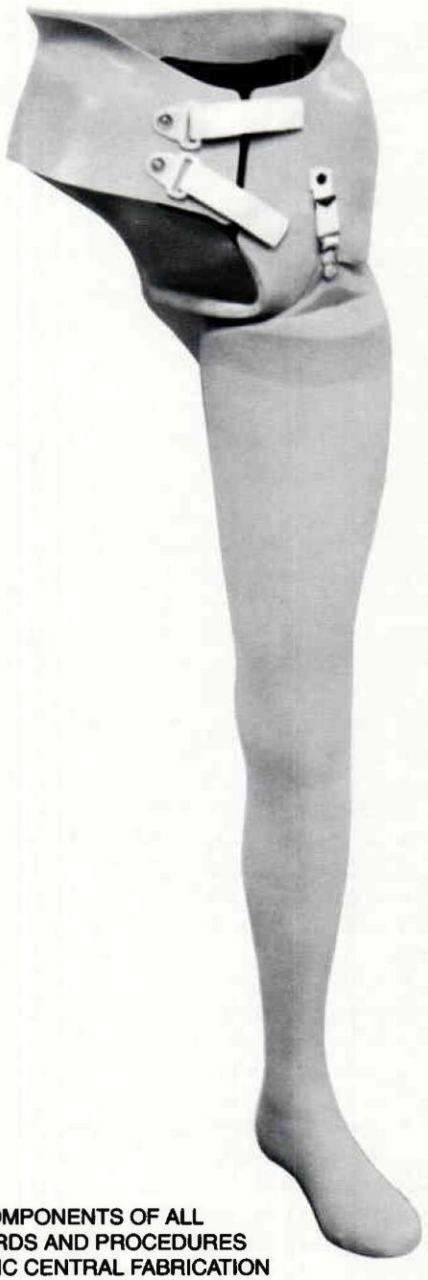

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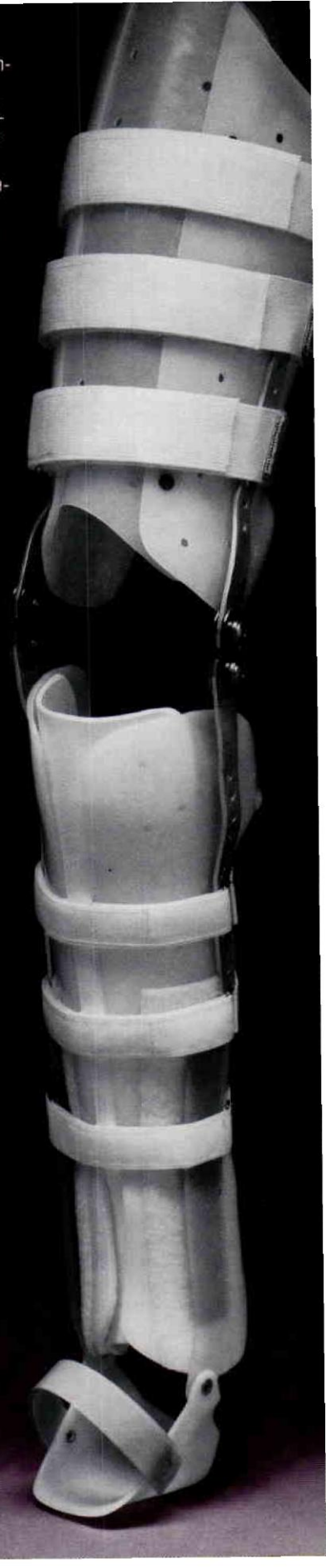

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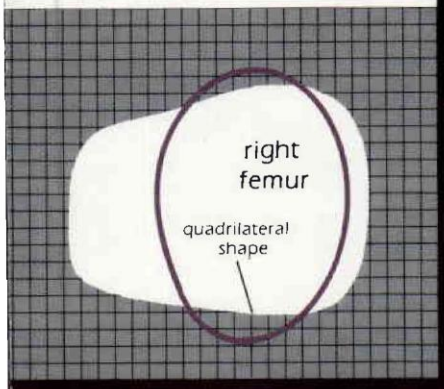

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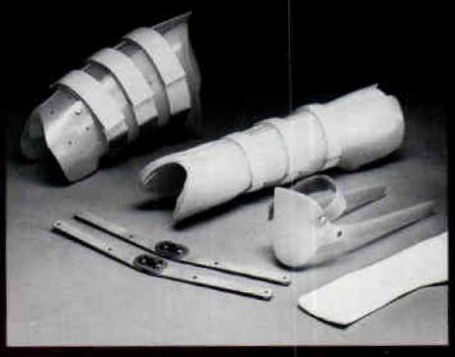

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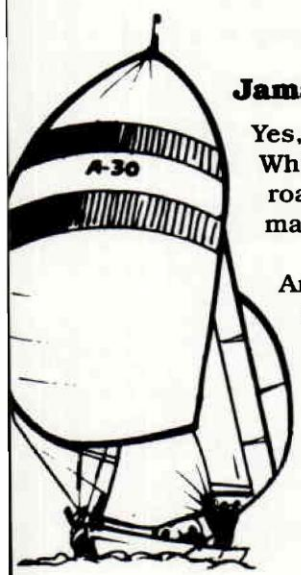

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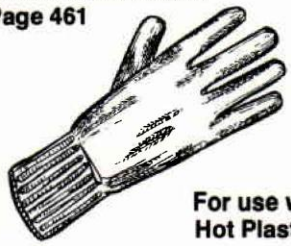

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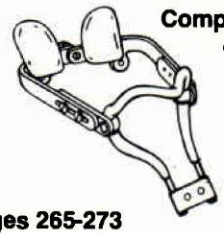

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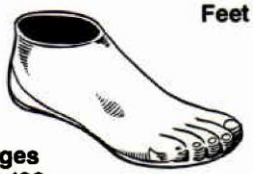

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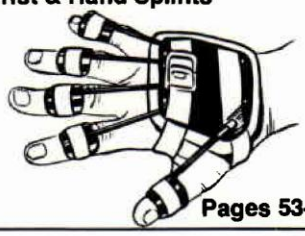

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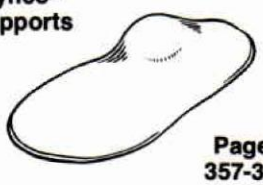

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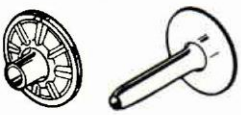

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