BELOW-KNEE PROSTHETICS RESEARCH, TRAINING AND PRACTICE

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Editor's Note: From June 15 to June 18, 1959, Mr. Nattress participated in the second week of the pilot course in "Below Knee Prosthetics" at the Oak Knoll Naval Hospital under the auspices of the Biomechanics Laboratory of the University of California, Berkeley.

Approximately three years ago the Prosthetics Devices Research Project (now termed the Biomechanics Laboratory) of the University of California, Berkeley, began work on the problem of fitting the below-knee amputee. This was the beginning of a new cycle of research, training and practice which has been seen in prosthetics since 1946: first with upper extremity prosthetics; more recently with above-knee prosthetics; and now with below-knee prosthetics.

RESEARCH

Background. Research seldom yields results unless some definite objectives are formulated at the start. Perhaps these objectives include existing accepted practice, perhaps they include hypotheses or maybe just "guess-timates." Regardless, these objectives are the guides for research.

In the case of below-knee prosthetics the objectives for research were established at a meeting of leading prosthetists and consultants held in April 1957. The participants in this meeting, held at the Biomechanics Laboratory, were: Dr. Miles H. Anderson, Mr. Carlton Fillauer, Mr. James Foort, Mr. John Galdik, Mr. Henry Gardner, Mr. Charles A. Hennessy, Mr. William E. Hitchcock, Mr. William H. Hoskinson, Mr. Frank Moos, Dr. Eugene F. Murphy, Mr. Chester Nelson, Mr. C. W. Radcliffe, Mr. Raymond E. Sollars and Mr. Howard Thranhardt.

During this week of discussion, demonstration and practical application, the "state of the art" of below-knee prosthetics was examined, general areas of agreement were defined, and areas of disagreement, which could not be resolved, and of question, were identified as the objectives for research.

Following this, the techniques utilized in numerous facilities were observed, evaluated, and additional facts were added to the growing body of knowledge concerning below-knee prosthetics. Among the techniques observed were those of the following facilities: The Schindler Artificial Limb and Truss Co., the Emmett Blevens Co., Fillauer Surgical Supplies, the Aunger Artificial Limb Co., and the Navy Prosthetics Research Laboratory. The work of these facilities must certainly be recognized in the yielding of what is now termed "the one best technique."

As can be seen, many different techniques have been used for the fitting of below-knee amputation stumps into weight bearing sockets. Although seemingly different, these techniques have generally resulted in what could be considered satisfactory below-knee prostheses. Time and space do not warrant a description of all of the techniques in use today or a discussion of their relative merits. Suffice it to say, the resulting prosthesis technique is not, in fact cannot, be credited to any one person or facility, though it is related to almost all of those mentioned above.

The Technique. The resulting technique is referred to as: The Patellar Tendon Bearing—Cuff Suspension Prosthesis. It is composed of the following structural elements:

"1. A closed-end plastic laminate socket with removable soft insert liner. The major weight-bearing areas are one or more of the following: The patellar tendon, the distal tibia and the fibial condyles.

"2. A Solid Ankle-Cushion Heel (SACH) foot with the socket aligned in initial flexion over the middle third of the foot.

"3. A cuff-type suspension which eliminates the need for side joints and thigh corset in a high percentage of cases.

"4. A waterproof plastic finish." [1]

The effect of this technique is reached through four progressive stages: Measuring, cast taking, fitting and alignment. Sufficient and accurate measurements are basic in the fabrication of any prosthesis. The cast taking stage consists of making a plaster wrap of the below-knee stump and, before the cast is set, applying controlled pressure to compress the soft tissue and establish weight bearing areas. The fitting stage uses the combined results of the first two stages in modifying the plaster model of the stump. From this the socket is made. The socket and a foot is then attached to a Below-Knee Adjustable Shank and the alignment stage is accomplished. The prosthesis is then finished. Though other, intermediate stages could be identified, these are the four crucial stages, the ones on which success or failure of the technique depend.

Two aspects in this technique must be recognized by the practicing prosthetist. First, and perhaps most important, the socket technique may be considered as applicable in the fitting of all types of below-knee amputations. The cast taking technique, when carefully followed, will produce an accurate model of the amputee's stump which is then modified in a systematic manner in order to obtain a functional, weight-bearing socket. The characteristics of this socket with the high anterior, medial and lateral walls, the pre-flexion of the socket, the compression of soft tissue, the relief of pressure sensitive areas, and the closed end of the socket result in a more stable, as well as more functional, prosthesis.

The second aspect is the suspension technique. While cuff suspension of this prosthesis is to be desired (the principle being that the least amount of harness or corset the better) it is fully recognized that problems will occur in the universal application of this aspect in below-knee prosthesis fitting. These problems include: (1) Insufficient stump length, (2) Knee instability, (3) Previous dependence upon side joints and corset, (4) Painful stump, and (5) Attitude of the prosthetist. This last, of course, often determines the initial or subsequent approach to the other problems and will result in any discrepancy in the application of the technique from facility to facility.

The conclusion to be drawn concerning this technique is that: (1) The Patellar Tendon Bearing socket is a technique to be generally applied; and (2) This socket may be suspended in a number of ways, the most desirable of which is by Cuff Suspension.

Experience. The consideration of this technique must not end here, for, on the experience of a number of prosthetists who have applied this

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[1] *Manual of Below-Knee Prosthetics.* (Berkeley, Calif.: Biomechanics Laboratory, University of California, 1959) p. 3.

technique for upwards to a year, there are certain problems which the prosthetist in a competitive enterprise must be prepared to meet.

The most serious problem is that of shrinkage. This is probably the major problem encountered in all lower extremity fittings, especially with new amputations or in converting wearers to a different type of prosthesis. Shrinkage in the Patellar Tendon Bearing socket, if not attended to immediately, will lead to secondary problems of instability and pain with the possible result of rejection of the prosthesis by the patient and the prosthetist. While this problem may be corrected by adding liners and wearing additional stump socks, a new socket should be fabricated when the stump has reached a degree of stabilization. If this is not done, the principle of the socket will be defeated, for total contact and patellar tendon bearing will be considerably altered, if not completely lost.

Fabricating a new socket calls for repeating the cast and fitting procedures as well as the alignment procedure. From a practical point of view the only reusable section of a below-knee prosthesis, in this instance, would be the foot and part of the shank. Fabricating a new socket, therefore, requires almost the complete remaking of the prosthesis.

Other problems which may arise can be classed as: (1) Faulty modification of the stump model, (2) Secondary problems of shrinkage, and (3) Wearing-in of the prosthesis. The first of these should be observed and corrected during the alignment stage of prosthesis fabrication. The latter two may be observed and corrected through a systematic follow-up of the patient, which should be the procedure in applying any prosthesis to a patient.

TRAINING

Let us next take a look at the training that will be available in the fitting and fabricating of the Patellar Tendon Bearing-Cuff Suspension Prosthesis for the 1959-60 academic year. Since our concern is primarily with the prosthetist, we will mention only the times and locations of his courses. However, it should be noted that there are courses for physicians and therapists which will be held concurrently with the courses for prosthetists.

There will be eleven courses in Below-Knee Prosthetics for Prosthetists given as follows:

Dates	*Institution*	*Course No.*	*Tuition*
1. Nov. 30 to Dec. 18, 1959	University of California Los Angeles	X480	\$150.00[2]
2. Dec. 7 to Dec. 18, 1959	New York University	7414A	\$125.00
3. Jan. 4 to Jan. 15, 1960	New York University	7414B	\$125.00
4. Jan. 4 to Jan. 22, 1960	University of California Los Angeles	X480	\$150.00[2]
5. Feb. 8 to Feb. 19, 1960	Northwestern University	611	\$125.00
6. Feb. 15 to Mar. 4, 1960	University of California Los Angeles	X480	\$150.00[2]
7. Mar. 7 to Mar. 18, 1960	New York University	7414C	\$125.00
8. Mar. 7 to Mar. 18, 1960	Northwestern University	611	\$125.00
9. Mar. 21 to Apr. 8, 1960	University of California Los Angeles	X480	\$150.00[2]
10. Mar. 28 to Apr. 8, 1960	New York University	7414D	\$125.00
11. May 9 to May 20, 1960	Northwestern University	611	\$125.00

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[2] The course given at U.C.L.A. is a three-week course, the last week of which is devoted to refresher seminars and demonstrations relating to new developments in upper and lower extremity prosthetics.