# ORTHOPEDIC LEG BRACES:

## Analyses of Fabrication Methods

**ANTHONY STAROS**

**Chief, Prosthetic Testing and Development Laboratory, Prosthetic and Sensory Aids Service, Veterans Administration**

The Prosthetic Testing and Development Laboratory has been conducting systematic studies of orthopedic bracing for a period of four years. These studies are chiefly analyses of leg brace designs. From such investigations, the Laboratory attempts to illustrate structural and functional limitations in present designs and to emphasize advantageous design details. Such investigatory work, besides developing the present brace technology, provides a base for researchers who strive for constant improvement in orthopedic bracing.

Studies of brace designs encompass the problems of fabrication methodology. The fabrication procedure for an orthopedic leg brace depends, to a great extent, on the choice of constituent materials and components. There are many combinations of materials and parts which can be utilized; therefore, there are many fabrication methods. Rather than attacking the problems of each and every method of fabrication, it is sound procedure for a research and development laboratory to analyze the general management treatment of fabrication needs. Results of such an evaluation are contained in these three Laboratory reports:

(1) Prosthetic Testing and Development Laboratory, Special Report 18-3, *Analysis of Orthopedic Leg Brace Fabrication*, October 1, 1953.

(2) Prosthetic Testing and Development Laboratory, Special Report 18-31, *Time Required to Fabricate a Leg Brace Using Prefabricated, Mass-Produced Parts*, October 15, 1953.

(3) Prosthetic Testing and Development Laboratory, Special Report 18-32, *Cost Analysis of Leg Brace Fabrication*, October 19, 1953.

This article summarizes the procedures and the findings of these three reports.

### Evaluation Procedure

As a beginning, one fabrication method was selected for analysis: a method requiring fabrication of a "typical" ischial weight-bearing, leg-thigh brace with bilateral bail lever lock knee joints. In this typical fabrication, all components (except standardized parts such as screws, rivets, etc.) were constructed utilizing medium carbon steel. (These studies did not include the required leather work and plating.) But in performing the analysis, cognizance was made of an alternate fabrication method—one utilizing prefabricated, mass-produced parts. Consideration was also given to possibilities of work division among two or more technicians. In the final analysis, cost comparisons were made.

These investigations were carried out consecutively:

*Step 1.* Utilizing one skilled orthotist, the operations required to fabricate the "typical" brace including operations required to make all components, were timed and analyzed. (Report 18-3)

*Step 2.* The overall time required to fabricate a duplicate "typical" leg brace (in which prefabricated, mass-produced parts were utilized) was measured. (Report 18-31)

* Reviewed in the Veterans Administration and published with the approval of the Chief Medical Director. The statements and conclusions published by the author are the result of his own study and do not necessarily reflect the opinion or policy of the Veterans Administration.

# TOTAL TIME = 941.7 Min.

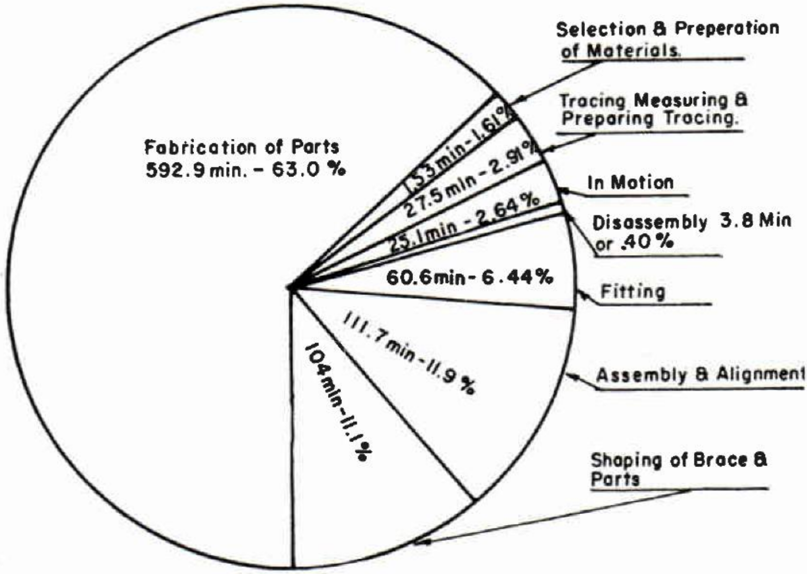



Figure 1. Graph of Operation Types Showing Time Consumed on each (in minutes and in percentage of total consumed time.)

*Step 3.* Cost analyses of six fabrication methods were developed for the "typical" brace. (Report 18-32)

*Findings of Step 1:*

a) The operations required for a bracefitter or bracemaker to fabricate a leg brace can be grouped by operation-types. (See Figure I.)

b) The largest *number* of operations are those of the "in motion" type.

c) The most time consuming operation-type is "fabrication of parts." (Approximately 9 hours and 53 minutes out of a total of approximately 15 hours and 42 minutes, as shown in Figure I.)

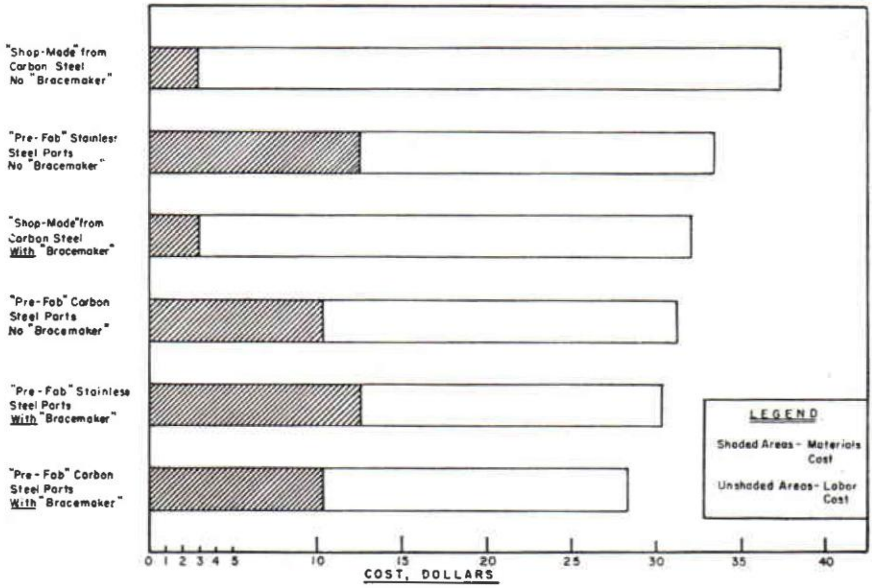
d) A large percentage (over 27%) of the time needed for parts fabrication is consumed by two simple and routine operations: the cutting of parts and the grinding and bevelling of parts.

e) A large part (over 60%) of the time needed in parts fabrication probably would not be necessary if prefabricated, mass-produced parts were used. The amount of machinery and equipment needed for leg brace fabrication using prefabricated, mass-produced parts would be considerably less than that needed for fabrication using "shop-made" parts.

f) Each of the many operations requires different degrees of fabricating skill. Two levels of skill seem indicated as with a classification differentiation between bracemakers and bracefitters.

As shown in (e) above, over 60% of parts fabrication time can probably be eliminated by using prefabricated parts. This means that about 6 hours of the total 9 hours and 53 minutes needed for parts construction would be unnecessary. The time required for the entire fabrication was

FIGURE 2.
CHART OF LEG BRACE FABRICATION COSTS




15 hours and 42 minutes. Subtracting the estimated 6 hour saving from the time for complete fabrication would reduce the overall fabrication time, when using prefabricated parts, to an *estimated* time slightly over 9½ hours.

*Findings of Step 2:*

a) The time, as measured, for fabrication of a similar "typical" brace (as in Step 1) but with the use of prefabricated parts was 9 hours and 40 minutes.

b) The proximity of this *measured* time to the *estimated* time tended to substantiate the operation by operation classifications made in Step 1.

*Findings of Step 3:*

Figure 2, *Chart of Leg Brace Fabrication Costs*, shows the six methods for which analyses of approximate expenditures were made. These analyses were developed after making a work division as suggested by finding (f) of Step 1 (above). In three of the six methods, a bracefitter has the assistance of a lower level technician or bracemaker; in the other three, the fitter has no assistance. Assumptions were made regarding the magnitude of labor rates, and no consideration was given to fringe expenses and to overhead and sales costs.

a) As is shown in Figure 2, the "team-effort" with work division between bracefitter and bracemaker decreases the overall cost of leg brace fabrication.

b) The use of prefabricated components, chiefly by lowering labor costs, results in a leg brace of lower overall fabrication cost.

From these findings, it is possible to make certain conclusions. If a suitable leg brace can be obtained using existing prefabricated, mass-produced components, the use of such a method seems indicated. However, it must be ascertained that the prefabricated parts are of equivalent quality to parts which can be self-produced. Present Laboratory studies of such quality indicate, in general, that currently available mass-produced components are being made with satisfactory designs and quality control. Of course there are defects in some designs. Nevertheless, most of these commercially produced components are at least equivalent in quality and function to the shop-made components already examined by the Laboratory. (Prosthetic Testing and Development Laboratory, Interim Report 18-2, *General Leg Brace Investigations*, September 1, 1952.) In most cases, braces made using prefabricated parts can be fitted and adjusted adequately. The prefabricated components have the possible advantage of interchangeability of constituent parts for repair replacements.

When using either prefabricated parts or shop-made parts, however, it seems sound management procedure to divide the required tasks between lower level technicians and the more highly skilled bracefitters. The steps which necessarily require the skill and judgment of the certified orthotist can be separated from these tasks which can be performed adequately by a man with less ability. The lower level technician, as a matter of fact, is aided by templates, guide lines, and jigs.

The skilled orthotist who has obtained a professional knowledge of anatomy, of pathological conditions and their requirements in appliances, and of engineering principles underlying his occupation may thus be free to assume a more professional role in the field. He may then devote an increasing amount of time to meetings; prescription team groups; to the more demanding steps in the fabrication procedure such as tracing, measuring, and fitting; to the training and supervision of the younger, less skilled workers; to participation in clinic team evaluation of the final product; and to the study of new developments. All these responsibilities demand and can justify the steadily increasing professional level and technical competence of orthotists.

The reports summarized in the foregoing discussion may serve other purposes. The detailed listing of the operations required to make a leg-thigh brace may provide a basis for further education and research. For one, the enumeration of the operations can be used as a guide in teaching the steps required to make this particular type of appliance. As pointed out previously, there are variations in the procedure depending on the type of brace being fabricated. However, templates, tracings, and jigs have general utility; the description of their use may offer an educational aid. It is possible that the operations, individually, and the sequences of operation groupings may be further studied, using industrial engineering techniques. Finally, it would be possible to publish a simple, industrial engineering handbook of basic principles which can be utilized to assist the management of prosthetic and orthopedic shops.

The Prosthetic Testing and Development Laboratory under the Research and Development Division, Prosthetic and Sensory Aids Service of the Veterans Administration is responsible for research and development efforts contributing to the constant improvement in prosthetic and orthopedic technology. Through testing, materials analyses, design, studies of fabrication methods, and other techniques of research and development engineering, the Laboratory provides data of assistance to Veterans Administration groups, commercial suppliers and manufacturers, and professional groups who are involved in the production, prescription, and fitting of prosthetic and orthopedic devices. By means of reports and personal consultations, these findings are made available to all interested groups.