Orthotics and Prosthetics, Volume 38, Number 3, Autumn, 1984, pp. 69–75.

Technical Note:

A New Concept in the Fabrication of Double Upright Orthoses

Karl W. Bremer, Jr., C.O.

INTRODUCTION

The concept of having the uprights for a double upright knee ankle foot orthosis (K.A.F.O.) formed using templates and a pneumatic pressure system has intrigued the author for a number of years. Many ideas have been pursued in an attempt to develop a system that was economical, efficient, easy to use, in need of little maintenance, took up a relatively small amount of space, and could be set up on a standard work bench.

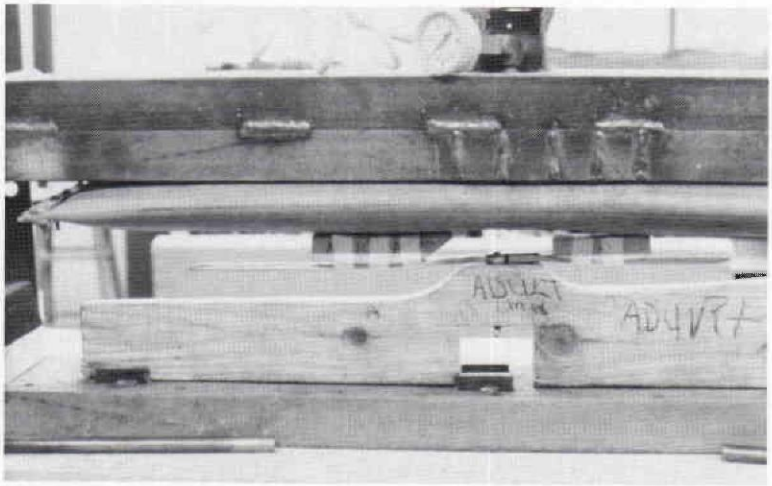
Using the pneumatic forming system in conjunction with carbon fiber composite material, which is used for the bands of ankle foot orthoses (A.F.O.) and K.A.F.O.'s, has made it possible to achieve substantial savings in time. A single K.A.F.O. can be produced in two to 2½ hours time, which is approximately one-third the time otherwise necessary. The orthotist or orthotic technician, requiring less skill, is capable of producing three or four double upright K.A.F.O.'s a day.

THE PNEUMATIC PRESS

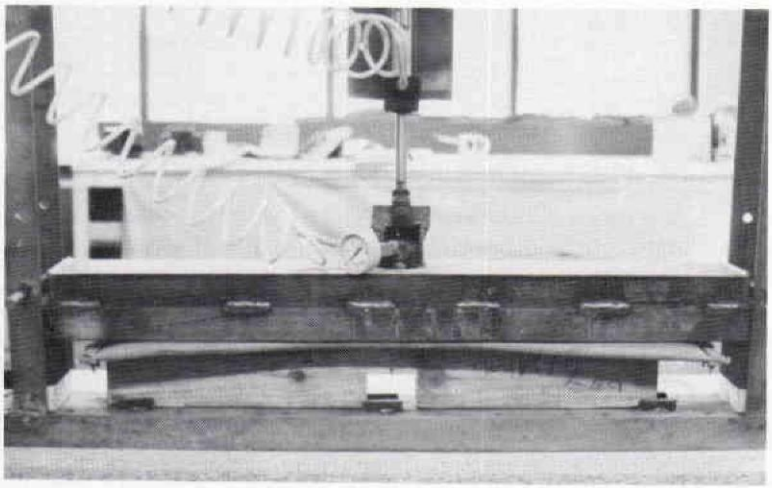
The Press* consists of an air bag mounted in a steel support frame. The bag (a section of fire hose) is six inches in diameter and 36 inches long, sealed at both ends, and connected to the shop air system by a nozzle in the middle. At 100 p.s.i. (pounds per square inch), 4,320 pounds of pressure is exerted in the expanded state. This is sufficient for bending stainless steel uprights up to 3/16" by 3/4" in size. Aluminum uprights are annealed for ease of forming and to lessen the chance of breakage. For annealing, the uprights are heated with a torch and the temperature checked, using white soap, which turns a dark brown, or wood, which skates across the surface like soap, and then quenched in cold water for faster cooling. Air cooling also works, and of course 2024T3 grade aluminum alloy regains most of its hardened properties in 24 hours.

A series of ten templates ranging from infant to adult sizes are used to form the uprights (Figure 1). In 80 percent of the cases, the one standard adult template is used. Use of a template not only speeds the process, but also diminishes marring of the surface and rotation about the long axis of the upright. For any given patient, 90 percent of the required bends can be formed using a standard template. The remaining ten percent of the contouring is done by hand (Figures 2–7).

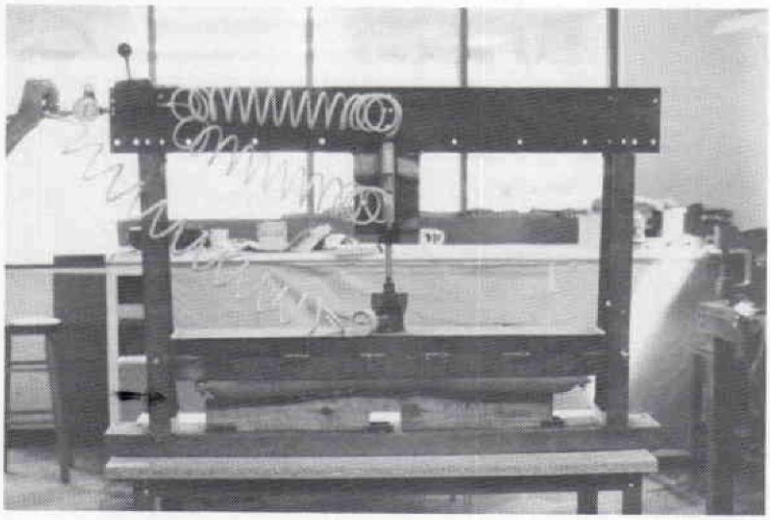
The benefits of using the pneumatic press become evident when forming bilateral K.A.F.O.'s with double uprights, providing the lower extremity tracings have a standard non-atrophied shape. In conjunction with the use of the carbon fiber material, a substantial time savings is achieved. This reduces the time required for completing the orthosis to a total of approximately four and one half to five hours. The four uprights are pressed and shaped within a 20 to 25 minute period.



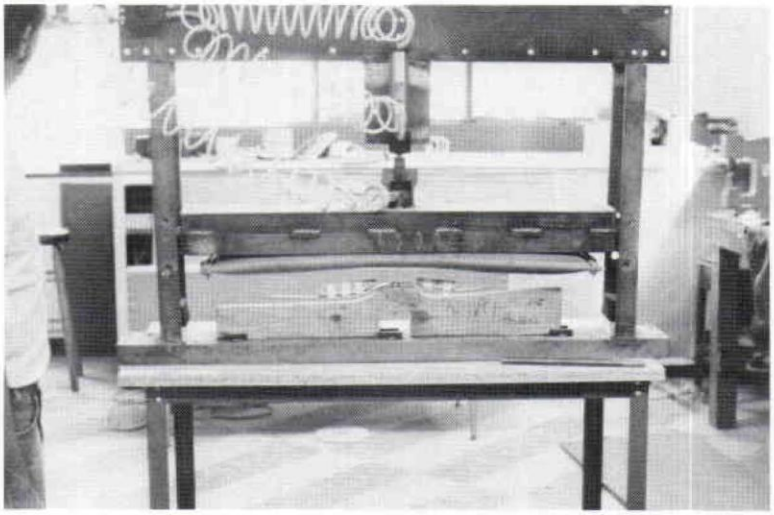
Step 1. In this case, the standard adult template is used with the aid of a pair of compression blocks. These are used when more pronounced bends are necessary. Upright has been annealed and bolted to the template.



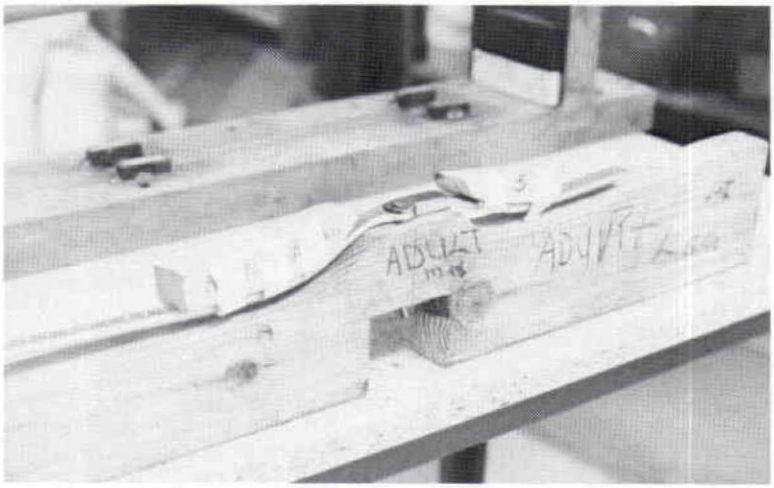
Step 2. The pneumatic bag is lowered into position and the steel safety pins are inserted.



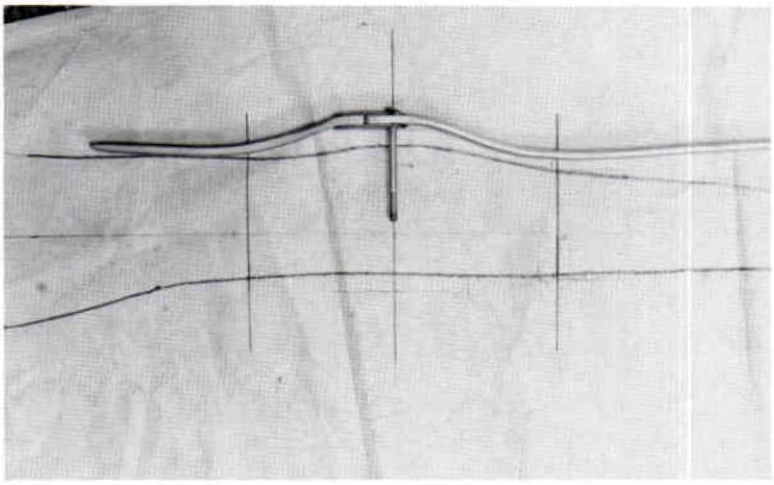
Step 3. Air is forced into the air bag at 80 P.S.I. (Notice expansion of the bag).



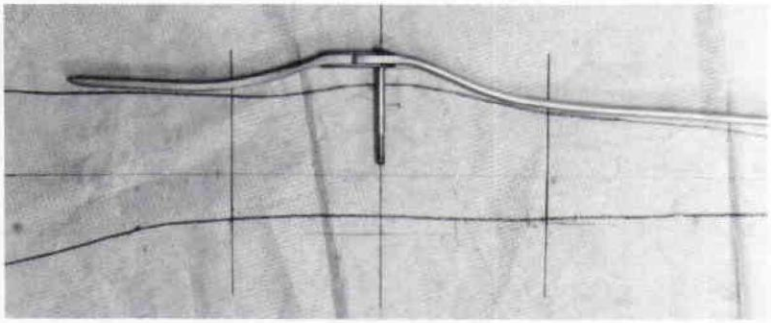
Step 4. Air bag is raised.



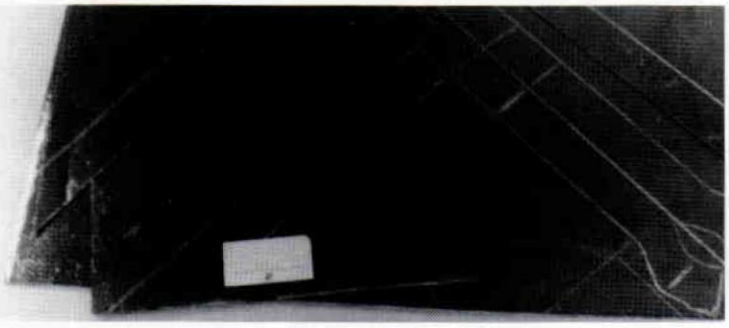
Step 5. The template is removed from the press.



Step 6. Upright is removed from the template and checked against the tracing. Distal bend at calf band will be done by hand.



Step 7. The upright has been corrected and checked against the tracing. Time from Step 1 to Step 7 is 10 minutes.



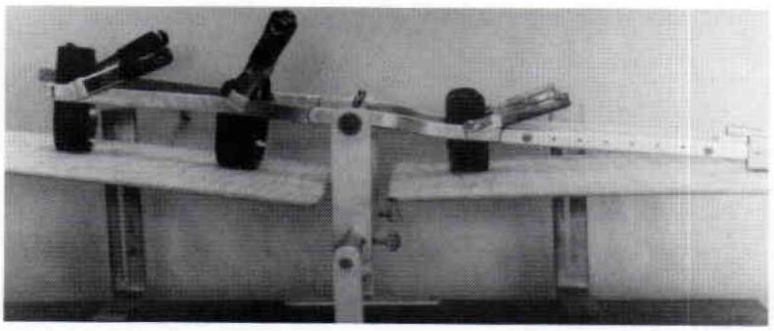
Step 8. Bands are predrawn on carbon fiber to minimize waste. An average of 20% of the carbon fiber material is wasted.

SUBSTITUTION OF CARBON FIBER COMPOSITE BANDS FOR ALUMINUM BANDS

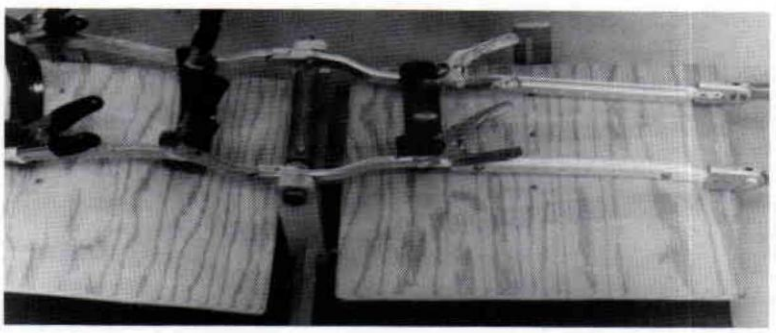
The use of carbon fiber composite is the result of several years of experience looking for a substitute for aluminum bands. Initially, 1/8" nyloplex was used. Nyloplex is easy to shape, and has beneficial rigidity and memory properties. However, we found that it tended to crack when riveted with metal rivets and when subjected to prolonged stress. As a substitute we tried 1/8" and 3/16" polyvinyl chloride. It is not brittle like nyloplex and otherwise is easy to shape and has good memory. However, its lack of rigidity rendered it unacceptable.

Experience with carbon fiber composite inserts, to reinforce the ankle sections of L.S.U. Reciprocating Gait Orthoses, led us to use carbon fiber composite material† in sheet form (Figure 8). To date, this has proven to be the material of choice. Bands ranging in width from 1¼"-1½", depending upon patient size, are laid out on a sheet of the composite material, so as to minimize waste. The bands are cut out using a bandsaw with a skip tooth blade. The two-ply carbon sheet is adequate for small to medium size orthoses on children up to age 12. On larger patients the three-ply sheet is recommended. To minimize the possibility of wrinkles developing when the bands are formed, the bands should be cut out on a bias so the fibers are at a 45° angle relative to the direction of bend. This will also cause the edges to radiate outward from the patient and appreciably increase the resistance to torque. So far, only one instance of breakage has occurred amongst 150 bands. In this instance, the two, two-ply bands on a K.A.F.O. failed. These were changed to a pair of three-ply bands without further incident.

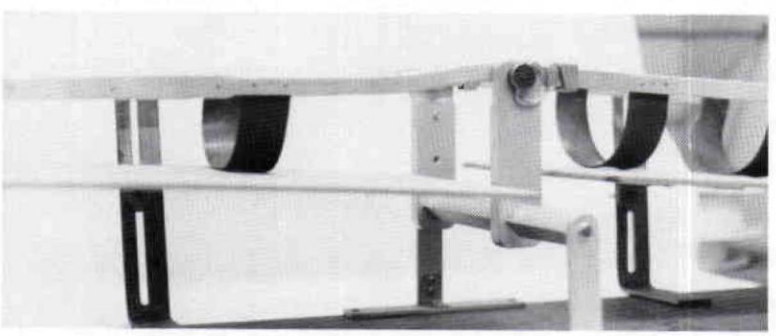
To form the bands, a special device is used. The properly contoured uprights are attached to the extensions and stirrup. They are then mounted in the knee joint alignment fixture which has been set to the proper medial-lateral diameter as dictated by the patient's measurements (Figures 9–11). The depth and tilt of the thigh and calf bands are established by setting the



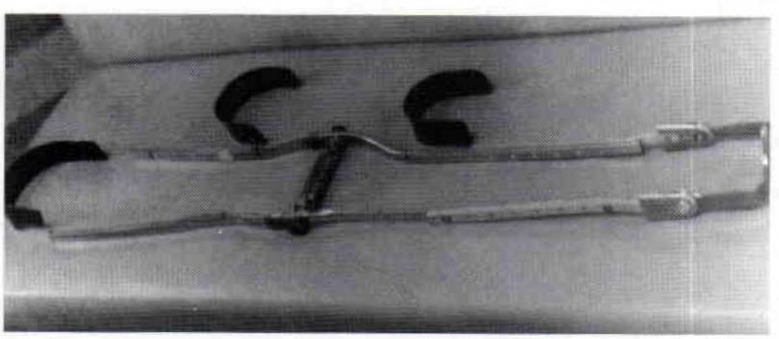
Step 9. Uprights are transferred to the K.A.F.O. jig. Bands are cut out, heated with a heat gun, and clamped into position. The depth of the bands is predetermined with the two horizontal tables.



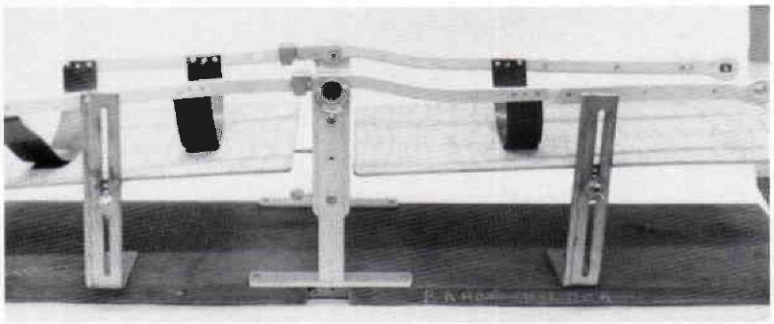
Step 10. Top view. Bands will be removed, trimmed, and attached to uprights. Orthosis is then ready for leather. Time: 2 hours.



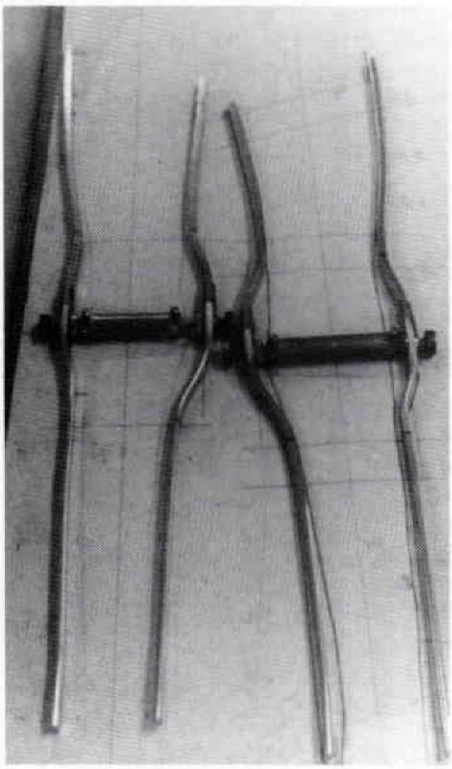
Step 11. Close-up view.



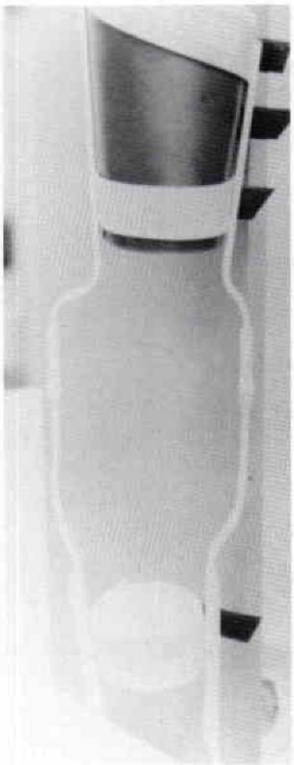
Step 12. Bands finished and ready for attachment.



Step 13. Bands finished and riveted to the uprights. If not satisfied with the shape of the bands, adjustments can be made by re-heating.



Step 14. Uprights for bilateral K.A.F.O.'s that have been pressed out. Time: 30 minutes at this step. This includes annealing, pressing, and assembling.



Step 15. Carbon fiber bands on finished K.A.F.O. patient has severe damage to the knee joint.

Step 16. Completed child's double upright K.A.F.O. with carbon fiber bands.

two horizontal tables. The bands are heated, secured in place with spring loaded clamps, and allowed to cool for 2½ minutes (Figures 12, 13).

COST AND TIME COMPARISONS

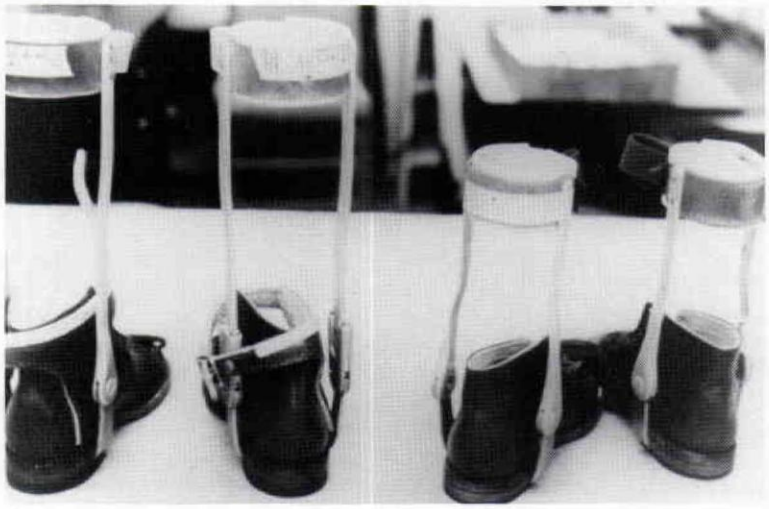
A carbon fiber band costs about $7.50. Five minutes or less is needed to put the three bands in place, ten minutes is needed to finish and attach the bands, for a total of 15 minutes.

An aluminum band costs about $2.50 per band. It takes about 15 to 20 minutes to put each band in place or about one hour to position and attach all three.

It takes approximately two to two and one half hours to fabricate a K.A.F.O. using the pneumatic press and carbon fiber composite bands, versus six hours to fabricate a K.A.F.O. using the conventional technique and materials.

Step. 17. (above) Carbon fiber bands on genu valgum patient. Single upright K.A.F.O.'s with aluminum pelvic band.

Step 18. (right) Use of carbon fiber composite bands in double upright A.F.O.'s.



AUTHOR

Mr. Bremer is President of the Bremer Brace Company, Inc., 1724 South Orange Avenue, Orlando, Florida 32806.

*Available from Bremer Brace Company, Inc., 1724 South Orange Avenue, Orlando, Florida 32806.

†Available from Durr-Fillauer Medical, Inc., Orthopedic Division, 2710 Amnicola Highway, Chattanooga, Tennessee 37406.