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Vacuum-Forming Procedure for the Fabrication of Non-Standard Spinal Orthoses

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Today in orthotics there are many plastic orthotic modules readily available to the orthotist in the management of scoliosis and other spinal problems. The modular systems can be used most effectively in correcting and/or positioning, achieving good results in many cases. What about the patient who is hard to fit with a modular orthosis or the orthotist who would like a more intimate fit by controlling the modifications of the positive model?

The "Drape Vacuum-forming Procedure" is a simple procedure for the fabrication of a "custom" orthosis that can be carried out easily by two people.

Fabrication

The first step in preparing the positive model for the vacuum-forming procedure is to draw a mid-line with indelible pencil down the posterior aspect of the model (Fig. 1).

A long shaft ½-in. diameter drill is used to drill a hole from the distal to proximal surfaces parallel to the midline and from 1-½ inches to 2 inches below posterior aspect of the model (Figs. 2-4). If the drill shaft is shorter than the length of the cast a hole can be drilled from the proximal end to meet the one started from the distal end, or vice versa.

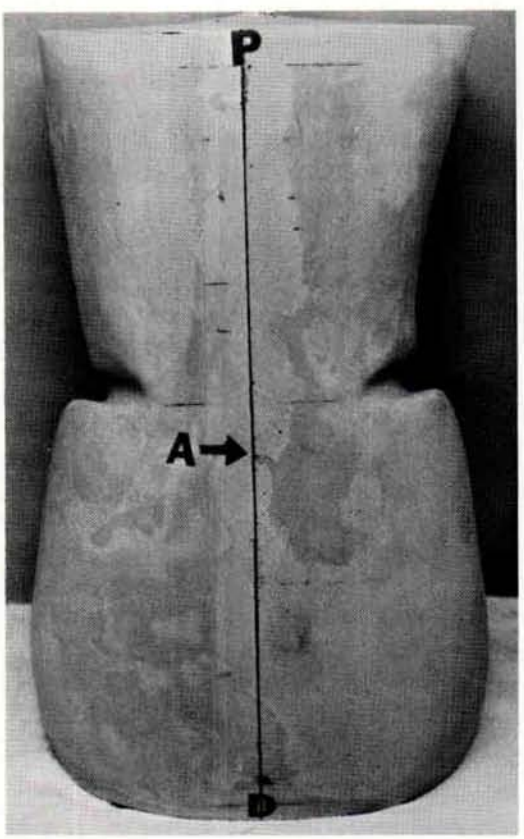

Fig. 1. The mid-line is used as a reference point for aligning bit when drilling longitudinal shaft.

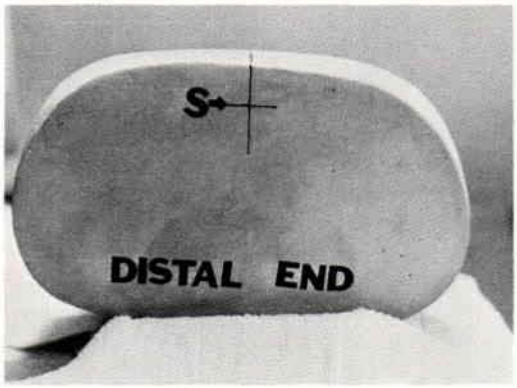

Fig. 2. Longitudinal shaft must be well below posterior surface to accommodate for irregularities in the posterior surface of the model, and to prevent cave-in from the drilling of the surface holes.

A #29 drill is used to provide holes approximately ½ in. apart down the mid-line drawn on the posterior aspect of the model to connect with the longitudinal shaft (Figs. 5 and 6) to permit evacuation of air between the model and the plastic when the plastic is draped over the model.

An air hose should be used to clear plaster debris from all surface holes and the main shaft. Once all holes are drilled and cleared, the interface is applied. The interface I prefer is medium density Pelite, non-perforated, 5 mm (3/16 inches), because of its resistance to compression during the vacuum-forming procedure.

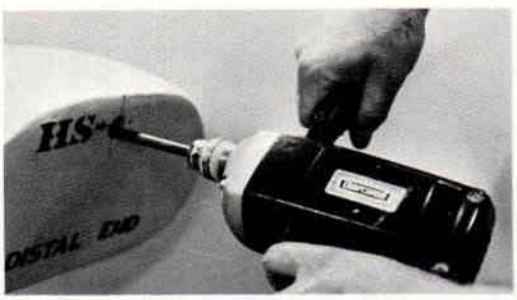

Fig. 3. The drill bit must be held level to posterior surface. It must not deviate from mid-line when drilling shaft. H.S. — horizontal shaft.

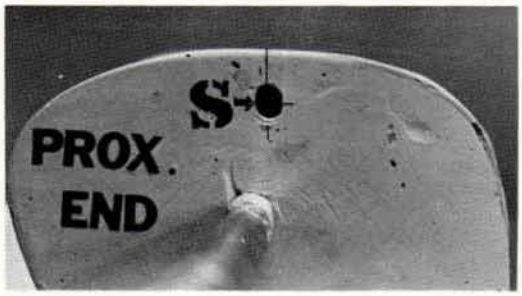

Fig. 4. If the shaft of the drill is not long enough to reach the proximal end a hole to meet it is drilled.

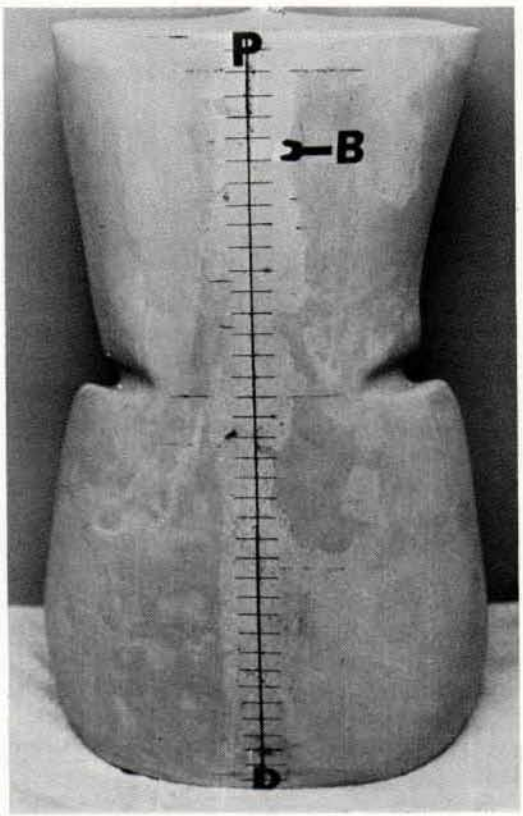

Fig. 5. Surface holes are drilled approximately ½ inch apart to direct the flow of vacuum air evenly from around model when the plastic is draped and suction is applied.

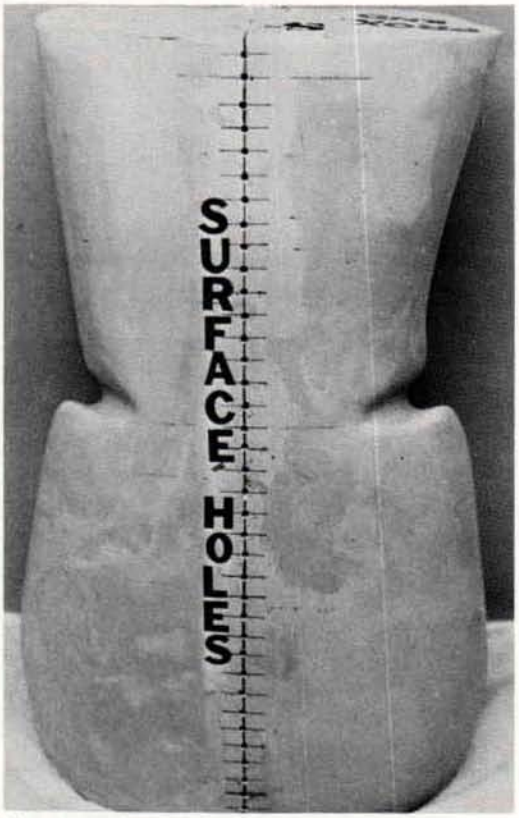

Fig. 6. Surface holes are used for evacuation of air from around the model, and for alignment of the posterior seam when draping plastic on model.

The Pelite is heated at 265 deg F about one minute or until moldable. It is then stretched and wrapped with Ace bandage to conform to the model (Figs. 7 and 8). When the Pelite is cool, one side of the interface is stapled as close as possible along the surface holes (Fig. 9). Excess material is cut off, and the procedure is repeated on the opposite side (Fig. 10).

The polyethelene may be formed directly over the Pelite liner in which case the two materials are bonded to each other. However, I prefer to place a layer of cotton stockinet (Fig. 11) over the liner-covered model to prevent bonding because this arrangement permits the insertion of pads between the liner and shell if needed and finishing is easier when the two materials are separate. Proximal and distal end caps fabricated of Plastizote and about one inch larger in diameter than the proximal and distal ends are put into place and the proximal Plastizote cap is heated in the center with a heat gun and pulled over the end of the pipe to form a nipple (Fig. 12). A small "X" is cut into the top of the

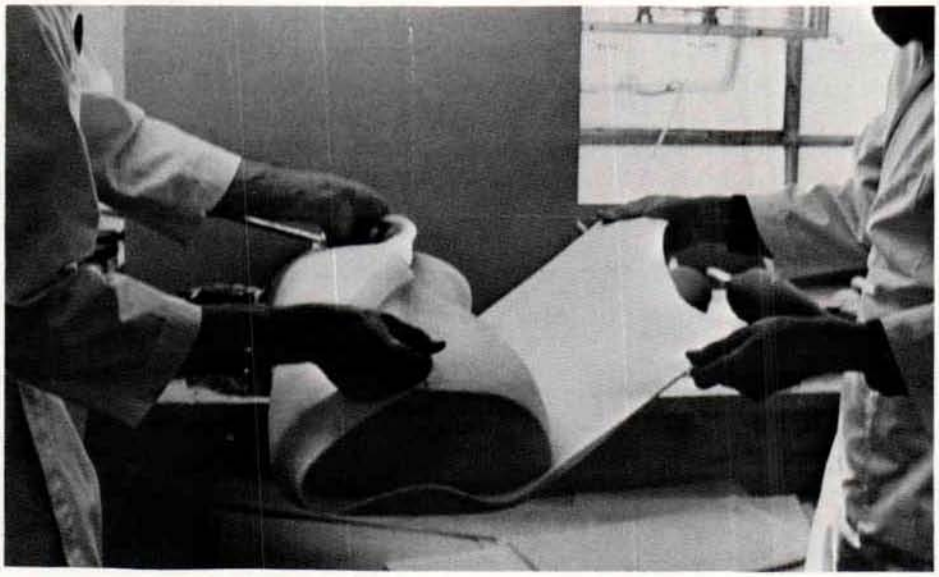

Fig. 7. The Pelite interface is heated, then stretched over the model.

Fig. 8. Ace bandage is used to hold Pelite in place.

nipple and pulled down, exposing the pipe.

The proximal cap is sprayed with a foam type of upholsterer's contact cement and attached to the model. The nipple opening is taped securely with electrical tape at the base of the pipe forming an air-tight connection. The distal cap is then placed on the model and an "X" marked on the Plastizote indicating the location of the horizontal shaft hole (Fig. 13). The "X" area is again heated to form a nipple and cut as before. The vacuum supply hose is placed into the distal end cap nipple and taped securely. It should extend about ½ inch beyond the inside of the nipple so that it may be inserted

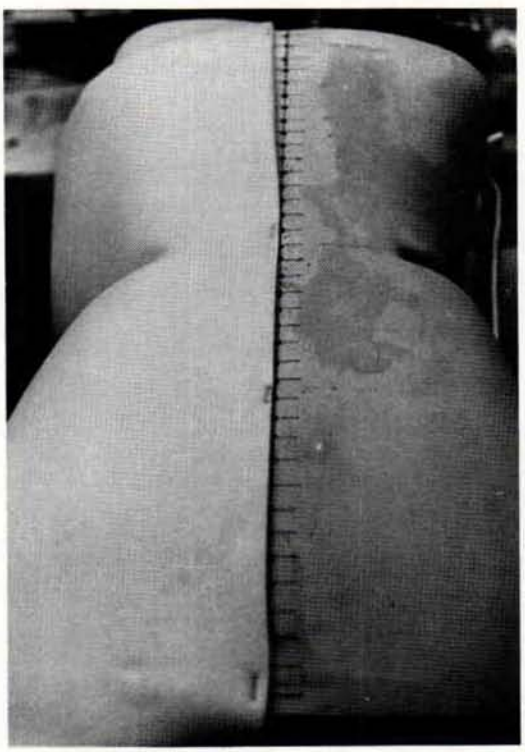

Fig. 9. When the Pelite is cool one edge is stapled as close as possible along the surface holes.

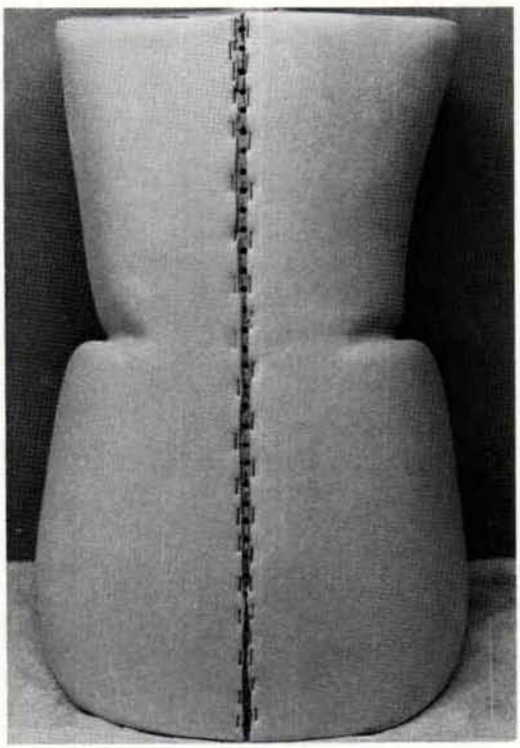

Fig. 10. Excess Pelite is cut off and the edge is stapled along the surface holes.

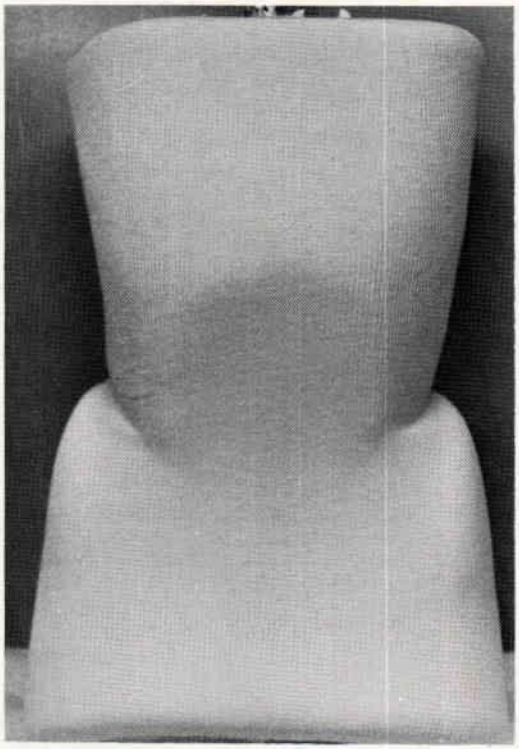

Fig. 11. Cotton stockinet is used to provide a non-adhering interface between Pelite and plastic sheet.

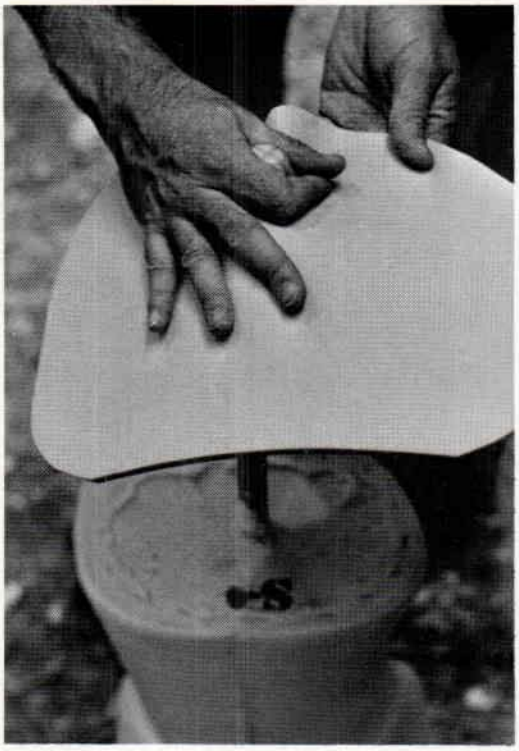

Fig. 12. The polyethylene foam Plastizote end cap is heated and a nipple is formed to be used to secure end cap to pipe.

Fig. 13. Locating distal horizontal shaft to form nipple.

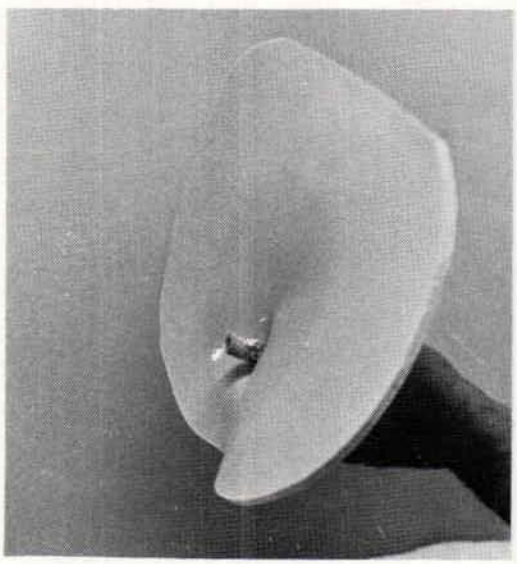

Fig. 14. The vacuum supply hose is inserted in the distal end cap nipple and taped securely.

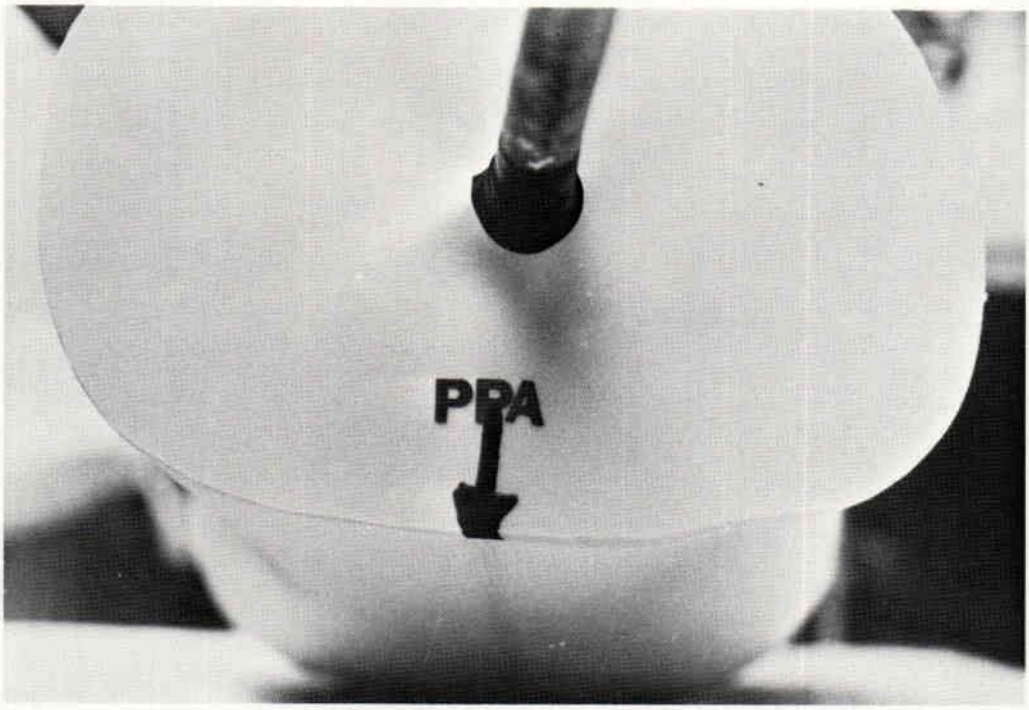

Fig. 15. P.P.A. (posterior proximal arrow) points to surface holes and is used for alignment of plastic when molding.

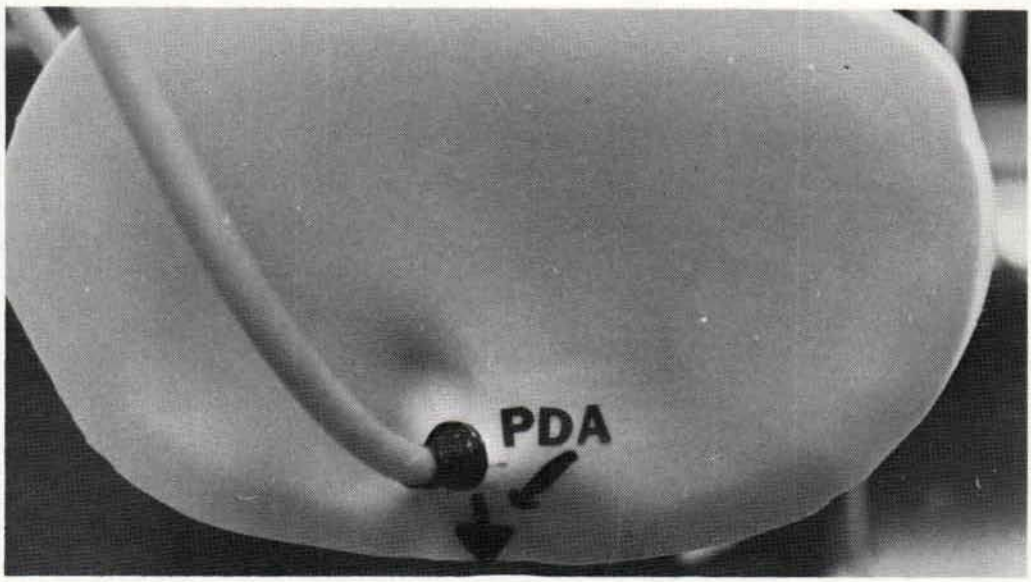

Fig. 16. P.D.A. (posterior distal arrow) points to surface holes and is used for alignment of plastic when drape molding.

into the horizontal air shaft when the cap is cemented to the model as before (Fig. 14). After the Plastizote end caps are cemented in place they are trimmed about the periphery to about ¼ in. from the stockinet to insure a good contact surface between plastic and the end caps so the vacuum can draw the air around the model.

The openings of the longitudinal hole are located and marked on the proximal (Fig. 15) and distal (Fig. 16) end caps with an arrow. The anterior surface of the model is bisected and the location is marked on the Plastizote end caps, proximal and distal (Fig. 17). The cotton stockinet is then sprayed with a Silicone parting agent or is powdered so that plastic will not adhere to the Pelite or stockinet.

IT IS VERY IMPORTANT that the end caps are kept clean to insure proper adherence of the plastic. The end caps are cleaned with acetone and the model is now ready for the vacuum-forming phase.

The thermoplastic I like to use is 5 mm. (3/16 inch), low density polyethelene. I prefer the low density polyethylene for its combination of physical strength characteristics. Polyethylene has exceptional resistance to chemicals and a fair drawing ratio (2.5:1). An orthosis fabricated from low density polyethylene is easier for a patient to don and will not fatigue and crack from flexure of the orthosis when it is donned.

To determine the size of the material for draping, two measurements are needed. The largest diameter of the model, plus 7.5 cm. (3 in.) is the circumferential width. The length of the model plus 3.75 cm. (1-½ in.) will give you the total length of the material.

The plastic is placed on a bench and the circumferential width of the model is divided in half; markers are placed proximally and distally on the plastic (Fig. 18). The "alignment marks" insure the proper alighment of the plastic to the proximal and distal marks on the model during the draping phase of the vacuum-forming procedure.

It is best that the oven be preheated to 265-270 deg F (125 to 130 C.) before insertion of the plastic. The moldability of the plastic varies according to the type of oven used and the heating time involved. For example, it will take approximately 35 to 40 minutes at 265-270 deg F for moldable condition to be reached in a non-circulating gas oven while a Grieye's electric circulating oven

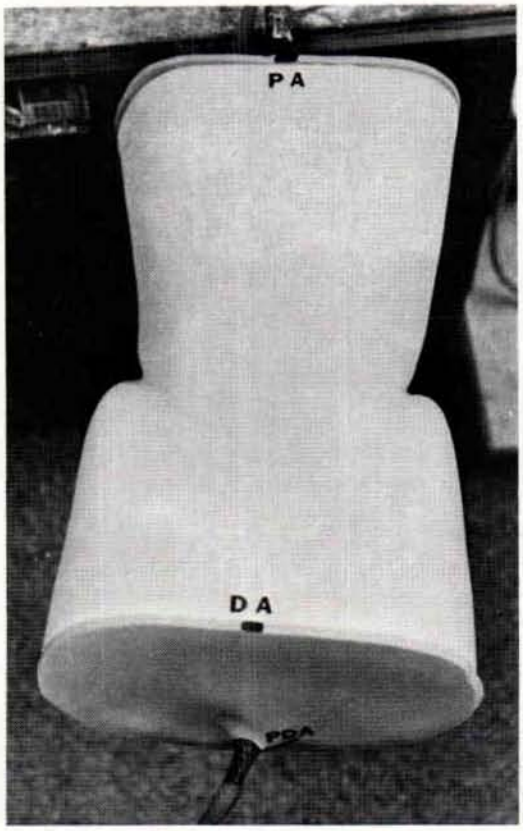

Fig. 17. Proximal anterior alignment mark and distal anterior alignment mark on end caps.

will require 15 to 20 minutes for the same amount of material. This time is based on a piece of plastic 35 in. x 22 in. x 3/16 in.

The plastic is heated at a low temperature to prevent surface pooling and shringkage caused by higher temperatures. Lower temperatures actually expand the material from 1.5 cm. (½ inch) to 2.5 cm. (1 inch), in length and width. Obviously, at the lower temperature the material retains its solidity and is easier to handle when being removed from the oven for draping.

The plastic is now placed in the oven; 15 to 20 minutes for a circulating oven, or 35 to 40 minutes for a non-circulating oven. When the plastic reaches the stage of moldability it becomes transparent throughout. The vacuum pump is turned on and set at 20 to 28 inches of mercury vacuum. The heating tray is taken from the oven and the heated plastic removed by two people grasping the corners of either end. The plastic is lifted from the tray and held over the model. It is then lowered to the model, the alignment marks on the plastic coinciding with the proximal and distal alignment marks on the model (Fig. 19). The ends of the plastic are released and permitted to hang; the corners are taken proximally and brought together at the proximal posterior (alignment arrow). The plastic is pressed to the end cap, making sure the polyethylene adheres to the Plastizote

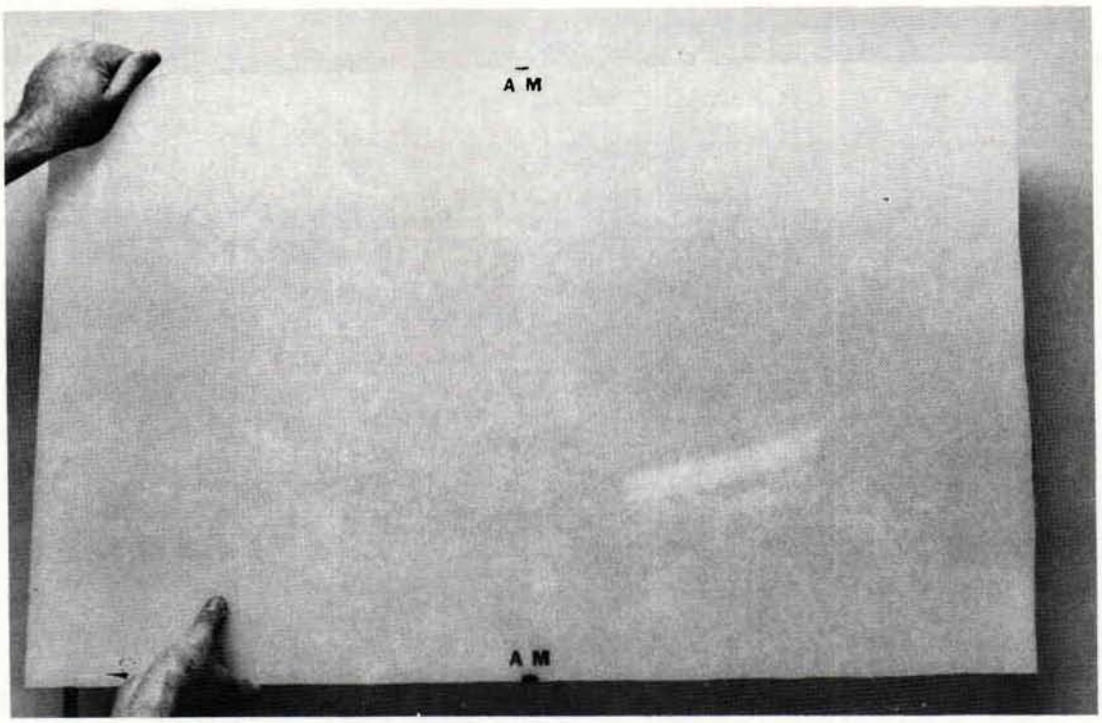

Fig. 18. A.M. (alignment mark). These alignment marks will coincide with proximal and distal alignment marks on end caps when plastic is draped onto model./ This also will allow equal amount of material to fall to each side; thus reducing the amount of stretch needed to bring ends of plastic to midline and maintaining a uniform thickness throughout.

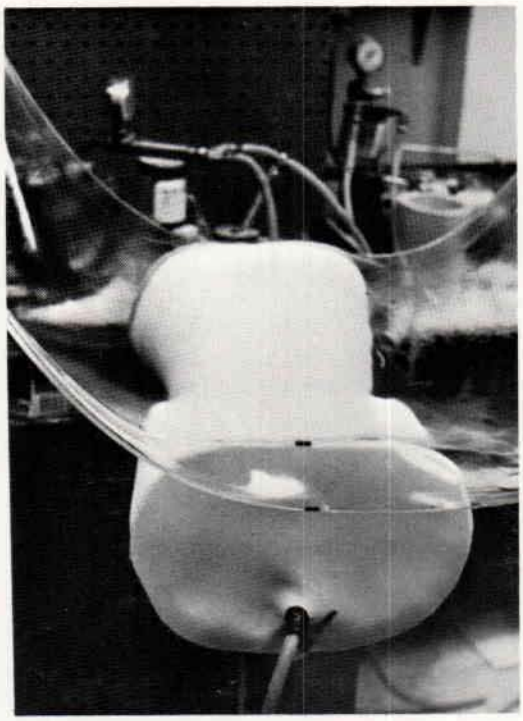

Fig. 19. Heated plastic is aligned over model.

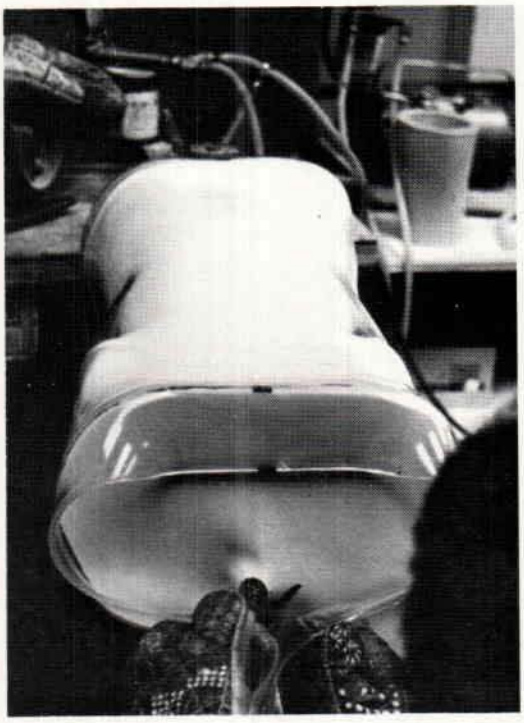

Fig. 21. The heated plastic is molded over the distal end cap.

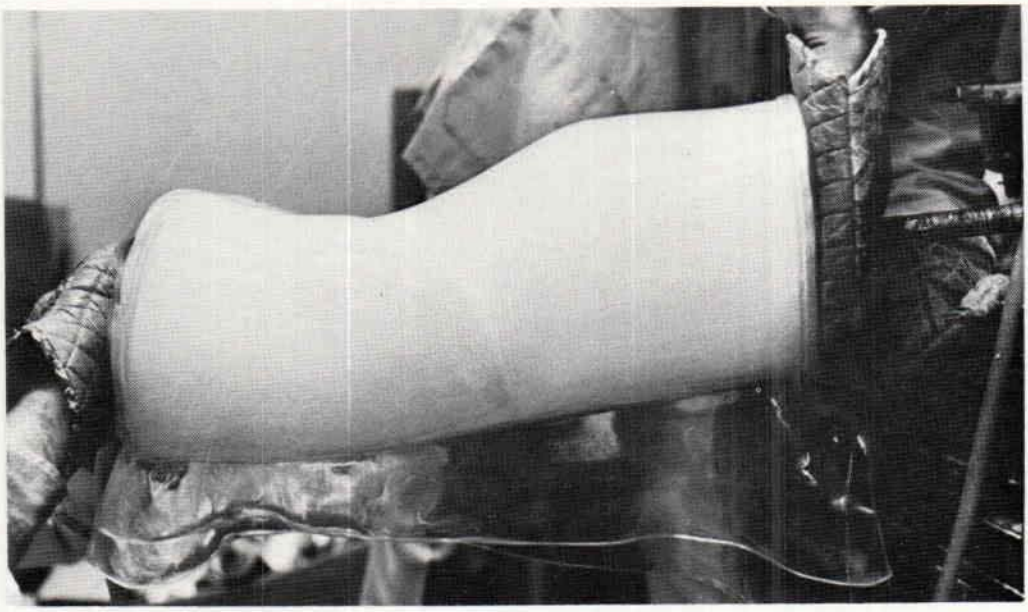

Fig. 20. The heated plastic is molded over the proximal end cap.

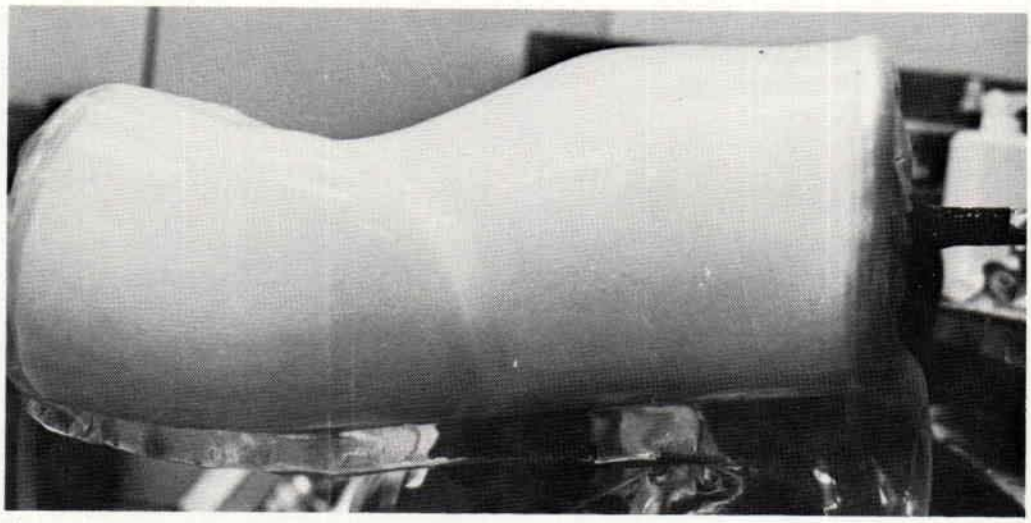

Fig. 22. The heated plastic is pressed together along the surface holes and the air is withdrawn.

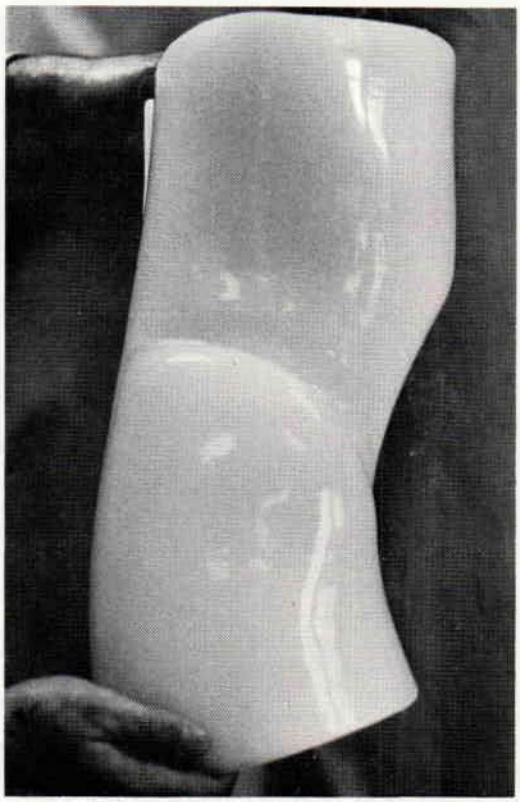

Fig. 23. Lateral view of orthosis just after removal from model.

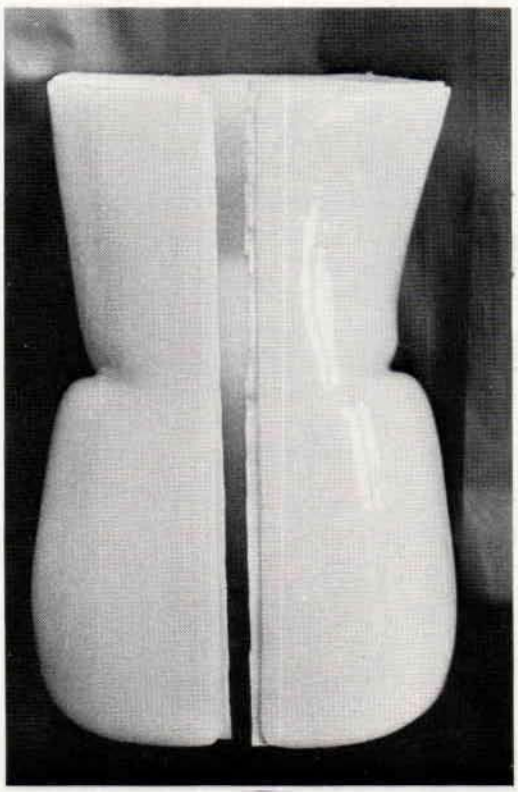

Fig. 24. Posterior view of orthosis just after removal from model.

(Fig. 20). This is repeated on the distal posterior area (Fig. 21). When the ends of the plastic are properly aligned and the plastic is pressed circumferentially to the end caps, the plastic along the surface holes is pressed together and the vacuum process begins evacuating the air from around the model, forming the plastic to the model (Fig. 22).

The vacuum pump remains on until the plastic is cool and once again opaque. The plastic is then trimmed from the model when it has been completely cooled as shown in Figures 23, 24, and 25.

Summary

This paper presents a simple method of drape vacuum forming of T.L.S.O. and L.S.O. Using this procedure an orthosis can be fabricated for the difficult, non-standard patient.

Here at the Rehabilitation Engineering Center of Children's Hospital at Stanford, we have fabricated over 100 T.L.S.O. and L.S.O.'s, using this procedure.

The longitudinal shaft and surface holes that are used for suction and alignment can be placed anteriorly, lateral or posterior, depending on where opening is needed in the orthosis. Finally, this is not the answer to all vacuum-forming procedures, but just one that may help manage the unusual needs of some of our patients.

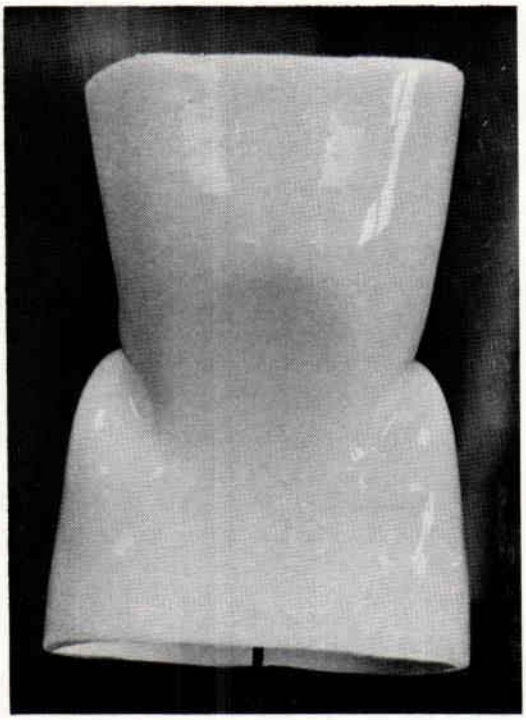

Fig. 25. Anterior view of orthosis just after removal from model.

Footnotes

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