Fabrication Technic for Inflatable Splints

by

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INTRODUCTION

Inflatable appliances most frequently used for fracture immobilization of extremities, reduction of edema, and compression dressings have been commercially available for many years (1). Most of these appliances are in the form of an envelope which is wrapped about the limb to form a cylinder and fastened by means of a zipper, or Velcro. The cylinder is then inflated through a valve mounted on the outside wall of the envelope. These envelopes are usually fabricated from polyethylene sheeting or nylon fabric impregnated with Neoprene.

In this paper the three steps for fabrication of inflatable latex appliances are described. The illustrations and the various steps of the procedure describe the fabrication of an inflatable neck splint (figures 1A, 1B); the technic, however, is versatile and can be used in the fabrication of a variety of appliances.

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FABRICATION OF DIPPING MODELS

Selection of the material (metal, plastic, dental stone) used for the dipping models will be determined by the configuration of the appliance. An aluminum dipping model was used for the inflatable neck splint (figure 2) because of the relatively flat contours which were required. In another use, Orthoplast might be chosen be-

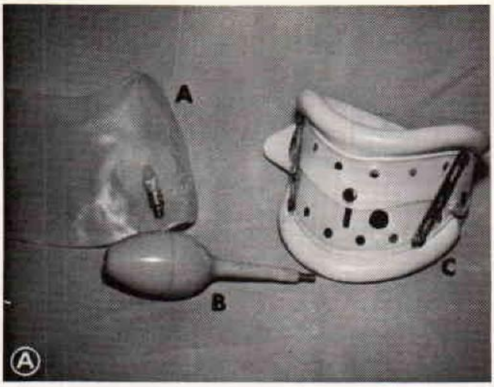

FIGURE 1A—Component parts of inflatable neck splint, (a) bladder, (b) atomizer bulb, (c) Myo Cervical Collar.

FIGURE 1B—Patient J. A. wearing inflatable neck splint following release of neck contracture requiring split thickness skin grafts.

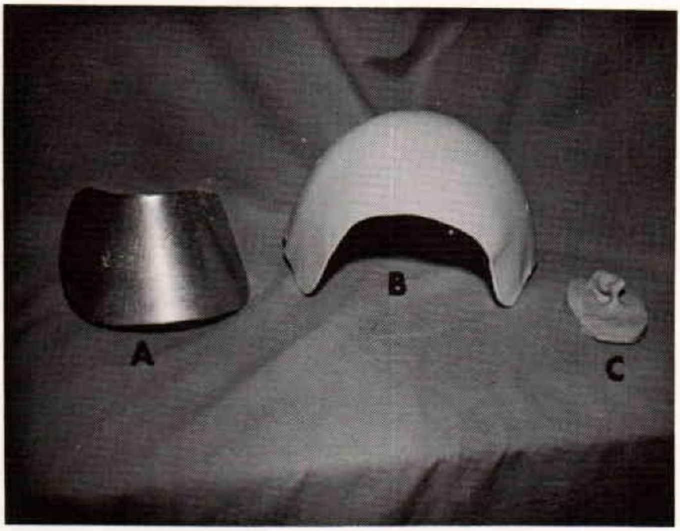

FIGURE 2—Dipping models of (A) Aluminum, (B) Orthoplast and (C) Dental Stone.

cause of its elastomeric properties which allow the material to be stretched or drawn. More intricate models have been made in dental stone when adaptation of the appliance to the defect has been critical, as would be the case in the use of an inflatable obturator. After choosing the material for the dipping model, it is contoured to the shape of the finished appliance, taking into consideration the dimensional changes which will occur during bladder inflation.

A handle must be incorporated into the model for purposes of suspending it in the liquid latex and in the oven (figure 3A). The handle should be located on that portion of the model which will be least difficult to seal with a gusset. (This procedure is described in detail in the section on assembly.)

A dipping model is also needed for fabrication of the filling tube into which a metal air valve will be inserted (figure 3B). This model is made from a 1¼″ diameter metal rod with a 1¾″ diameter metal disc soldered to one end. The disc is necessary to create a collar on the filling tube for attaching it to the wall of the bladder. Since this dipping model will be used for fabricating all filling tubes, regardless of the type of inflatable appliance being constructed, the metal rod should be at least eight inches in length for universal use.

PREPARATION OF LATEX FILM PARTS

The latex material used to fabricate the inflatable appliances is one which was developed at this laboratory (2). This material is a latex dispersed synthetic elastomer: a terpolymer of butyl acrylate (90%), methyl methacrylate (7.5%) and methacrylamide (2.5%). The terpolymer is compounded with 37 parts of poly (ethyl methacrylate) as a reinforcing agent. In addition, 1.765 parts of formaldehyde, which acts as a crosslinking agent, are added during the compounding procedure. The compounding formula is represented below:

Material	Parts
Terpolymer latex	100.0
Poly (ethyl methacrylate)	37.00
Formaldehyde	1.765

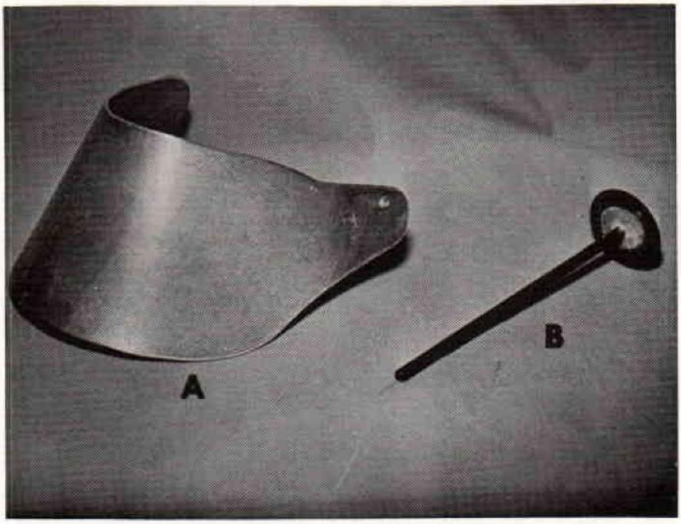

FIGURE 3—Dipping models for inflatable neck splint (A) bladder model with handle, (B) filling tube.

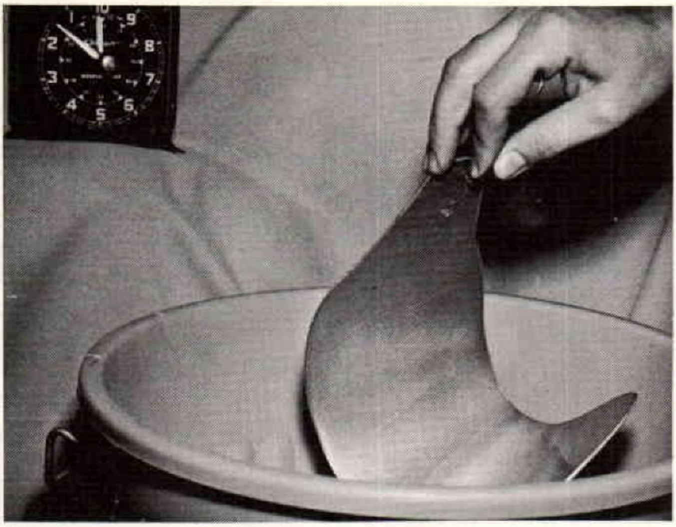

FIGURE 4—Dipping the model into the liquid terpolymer.

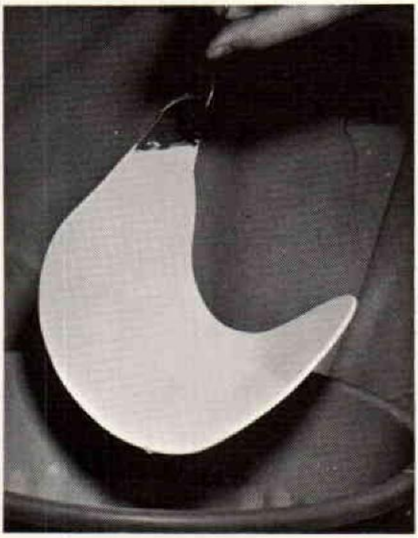

FIGURE 5—Terpolymer coated model. Note the milky opaque appearance.

When compounding this terpolymer latex, all calculations must be made on the basis of total *solids* of each material. (A detailed description of the compounding procedure, MR 6-68, can be obtained from this laboratory upon request.)

This material is essentially a chemically saturated elastomer which is inherently flexible without the addition of plasticizers. It shows excellent outdoor weathering, is oil resistant and can be steam autoclaved. The elastomer is crosslinked, dimensionally stable and compatible with body tissues. Another unique and very important feature of this particular material is the relative ease with which the latex film can be processed (3). The fabrication technic in this paper is dependent upon the use of this terpolymer, however, other dipping latices may be available which will provide satisfactory results.

A coagulant is necessary to prime the dipping model for deposition of the compounded latex. The coagulant solution is made by thoroughly mixing 20 gm of calcium nitrate with 80 gm of denatured alcohol.

After a generous application of a dry release agent (polytetrafluoroethylene spray) to the model, it is immersed in the coagulant and air dried for several minutes to allow all excess coagulant to drip off. With a wire hook inserted into the handle, the model is slowly immersed in the liquid terpolymer where it is suspended for 90 seconds (figure 4). This dwell time

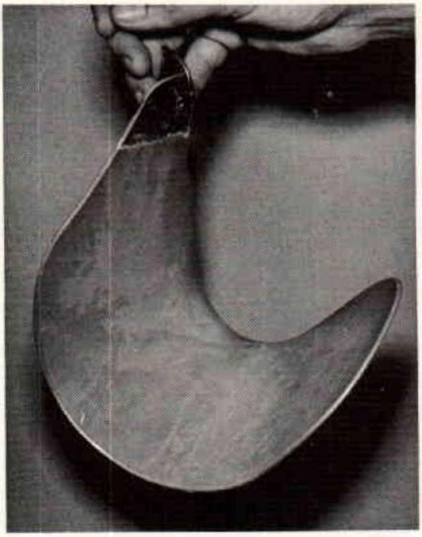

FIGURE 6—Translucent appearance of the terpolymer following the initial oven cure.

will create a film thickness of 13 mils $\pm$ 2 mils; less dwell time will create a thinner film and vice versa. The terpolymer coated model (figure 5) is carefully removed and placed in a 60°C oven to cure for one hour. During the oven cure, care must be taken to be sure the model is freely suspended and will not touch any object. The same procedure is followed with the dipping model for the filling tube.

During the oven cure, the milky white appearance of the terpolymer will be lost and the film will become transluscent as the water is driven off (figure 6).

For ease in removing the film from the models, they should be immersed in water for approximately ten minutes. The water which is resorbed into the film will make the film softer and more pliable. The film is removed from the model by gently rolling or sliding it over itself, starting from the opening created by the handle

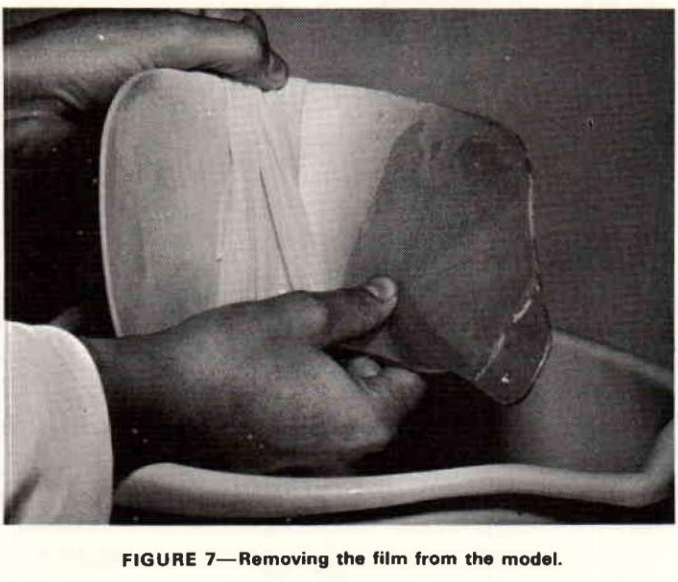

FIGURE 7—Removing the film from the model.

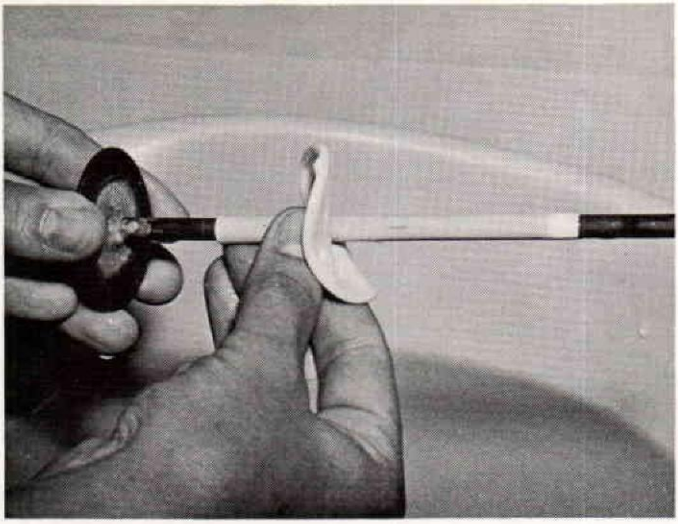

FIGURE 8—Removing the film from the filling tube dipping model.

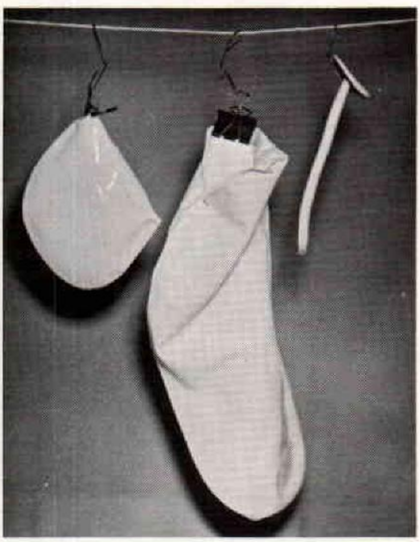

FIGURE 9—Air drying of the bladder components after they have been thoroughly leached.

(figure 7). Keeping the film wet during this procedure will prevent the film from sticking to itself. The film is then immersed in water for at least 18 hours to leach out the soap, coagulant, and any other impurities which might be present.

The open end of the bladder will eventually be sealed by adding a gusset. The gusset for the inflatable neck splint is formed on the same (or a duplicate) dipping model used to fabricate the main body of the appliance, however, the film is cast only on one half of the model.

The film is removed from the tube dipping model by cutting the film away from the bottom portion of the metal disc and then gently slipping the film over the end of the rod (figure 8).

After these three parts have been thoroughly washed of impurities, they are air dried for approximately one hour, or until they become transluscent once again. This can best be done by suspending them "clothesline fashion" (figure 9). The latex film is somewhat tacky at this stage and tends to adhere to itself quite tenaciously. To prevent this from occurring, an attempt should be made to prevent the films from touching themselves or other objects. After this air cure, the three sections of the appliance—the bladder, gusset and filling tube—are placed in an air circulating oven at 100°C for the final thirty minute cure to complete the crosslinking or polymerization process. The parts are now ready to be assembled (figure 10).

ASSEMBLY OF THE APPLIANCE

To create a symmetrical appliance, the bladder is folded in half

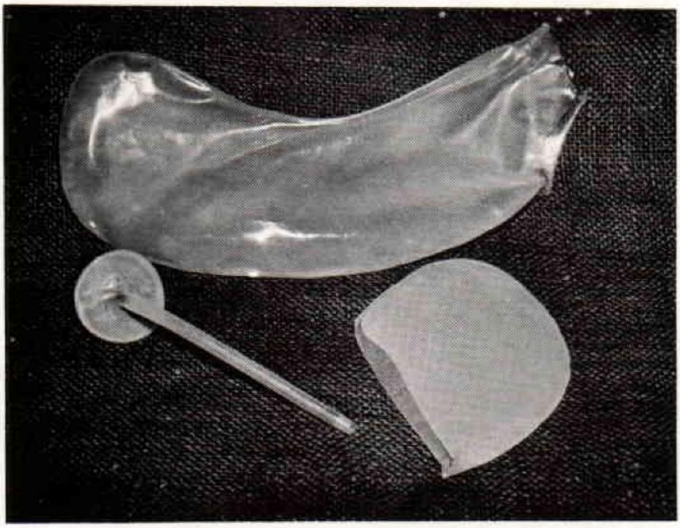

FIGURE 10—Three parts necessary for fabrication of the bladder following the final oven cure.

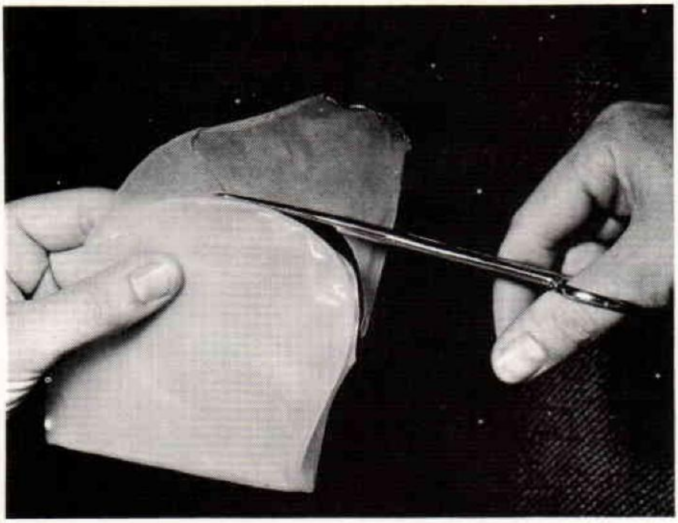

FIGURE 11—Cutting the open end of the bladder to create a symmetrical appliance.

FIGURE 12—Placement of the filling tube in the bladder.

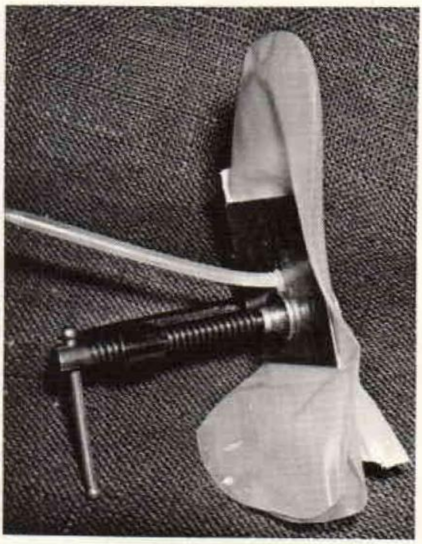

FIGURE 13—Gentle pressure applied with use of a "C" clamp to insure an adequate bond of the filling tube to the bladder.

and the open end is cut to match the closed end (figure 11).

To facilitate donning and inflating this appliance by the patient, the air inlet tube is positioned in the center of the anterior wall of the bladder and the tube is left at least four inches long. A $^5/_{16}$″ hole is made in the bladder for the filling tube which will permit insertion of the filling tube without any creasing or binding at the base. A thin film of terpolymer is applied to the collar of the tube and it is drawn through the opening from the inside of the bladder to the outside (figure 12). A small piece of polyethylene film is placed between the collar of the tube and the inside posterior wall of the bladder to prevent the walls of the bladder from being accidentally glued to each other. Two three inch square aluminum plates, one with a $^5/_{16}$″ diameter hole in its center through which the air tube is drawn, and the other padded with several thicknesses of gauze are placed in position on the bladder. Gentle pressure is applied to the plates for approximately four hours with a "C" clamp, lock grip pliers or vise (figure 13).

The gusset is cut from the half bladder so that when it is placed inside the open end of the bladder it will extend 1/8" beyond the bladder and approximately 1" into the bladder (figure 14). A film of terpolymer is applied to the gusset. Polyethylene film, gauze padding and the metal plates are placed around the bladder and pressure applied.

A thin coat of liquid terpolymer is applied to the base of the metal air valve (figure 15). The air filling tube is stretched open with a suitable instrument and the valve is placed in position. A coat of terpolymer is applied to the filling tube around the base of the valve. Three individual pieces of thread

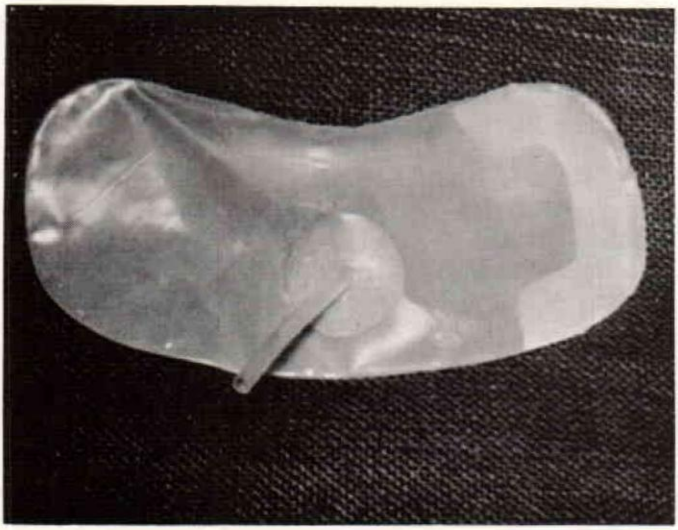

FIGURE 14—Placement of gusset to seal the open end of the bladder.

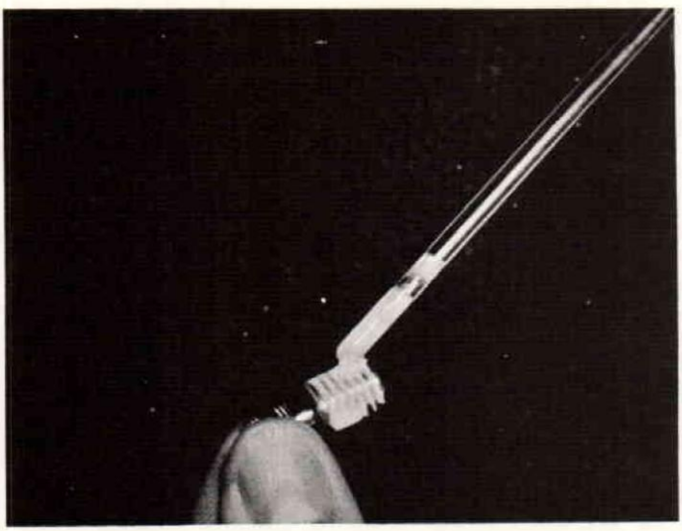

FIGURE 15—Applying a thin coat of liquid terpolymer to the base of the metal air valve.

are tied securely around the valve base and a second coat of terpolymer is applied. This will prevent accidental dislodgment of the valve from the filling tube and insure an air tight seal (figure 16).

After the metal plates are removed from the gusset area, it may be necessary to air cure the bladder for several hours to insure complete evaporation of the water from the terpolymer latex which was used as the adhesive. The adhesive bond will be quite weak until this occurs. However, at this time the bladder should be gently inflated and those parts of the bladder which may have adhered

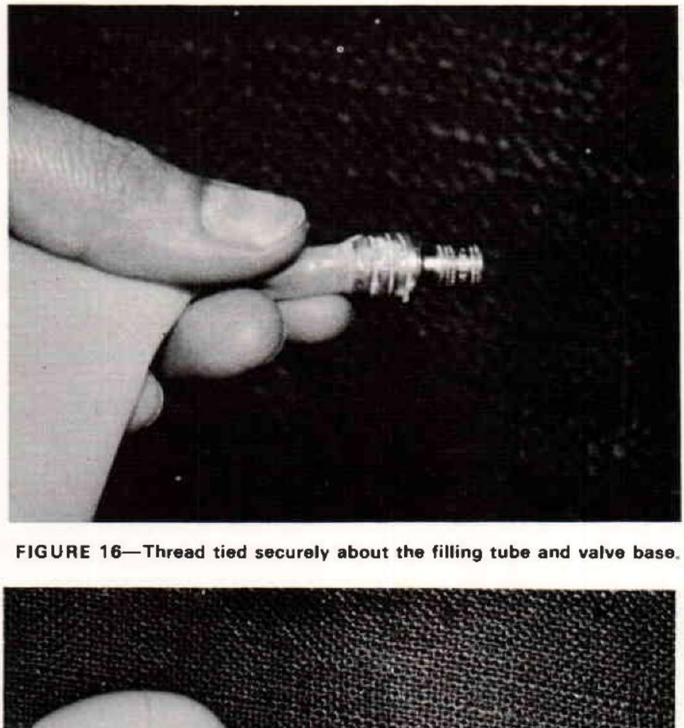

FIGURE 16—Thread tied securely about the filling tube and valve base.

FIGURE 17—Atomizer bulbs adapted to fit the air valve.

to each other, due to some of the terpolymer having been forced into the bladder interior when pressure was applied to the gusset area, carefully separated. If there are any areas where a complete seal has not been obtained, a light application of the terpolymer latex should be applied. Air curing of the terpolymer latex will be complete when the milky white appearance has disappeared.

To be absolutely certain that the bladder is air tight, it should be inflated and held under water while gentle pressure is applied. Any tiny pinholes through which air is escaping must be sealed befor the final finishing steps.

The tacky feel of the bladder and its strong tendency to adhere to itself can be prevented by forcing talcum powder into the bladder. Excess material, such as droplets of terpolymer which may have formed during the dipping procedure, and all rough surfaces can be removed by gently sanding with rotary equipment using an arbor and fine grit band.

Inflation of the bladder is accomplished with a hand atomizer bulb adapted with a piece of flexible tubing which can be easily fitted over the valve stem or a threaded metal adaptor which can be screwed into the valve stem (figure 17).

DISCUSSION

The total fabrication time for this technic spans a period of two days, however, the initial steps of dipping, curing and removing the films from the models only require approximately 1½ hours and about 20 minutes of actual working time. The parts can be washed overnight and the remaining fabrication procedures completed the second day.

The latex material used is one which is both simple to manipulate and possesses excellent physical properties for this type of application. If a puncture should occur in the bladder, a small amount of the liquid terpolymer latex can be applied to the area which, after several hours of air curing, will provide an excellent seal.

If necessary, the bladders can be sterilized by standard autoclave procedures.

The materials used to compound the terpolymer latex are commercially available, but do require the final compounding procedure to be completed by the user.

SUMMARY

The technic for fabricating latex inflatable bladders has been described in detail. Although the appliance which is described has been designed for use with the commercially available Myo Cervical Collar as an adjunct to surgical prevention and treatment of cervical scar contracture (4), the fabrication technic is applicable to many inflatable bladder designs.

ACKNOWLEDGMENT

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