A TECHNIQUE FOR MAKING HAND SPLINTS FROM STYROFOAM AND PLYWOOD

David Woodruff Thomforde*

ABSTRACT

A technique has been developed in Paraguay, for making hand splints from styrofoam, plywood and paper. Sheet styrofoam is cut to fit the palmar surface of the forearm and glued to plywood, to provide strength. Pieces of paper are glued over the styrofoam and then painted with oil paint. Velcro is used to make straps. The splints made thus, far include a resting hand splint for a flaccid hand, a finger-spreader splint for a spastic hand, a resting hand splint for a patient with shortening of the wrist flexors, a thumb support splint for a weak but functional thumb, a thumb positioning splint for a non-functional adducted thumb, a wrist cock-up splint and a resting hand splint for a person with rheumatoid arthritis to prevent ulnar deviation.

The advantages and disadvantages of this technique are compared with those of other alternative splinting materials (PVC, metal, plaster of Paris bandage, leather, bamboo and polypropylene). The major advantages of this technique are low cost, high adaptability to the individual hand, use of techniques known by local artisans, low-cost tools and ease of repair or modification. The major disadvantages are non-availability of materials in some places, need to develop new relationships between rehabilitation professionals and local artisans and difficulty with thorough disinfecting. Future applications of the techniques for making dynamic hand splints and foot splints are discussed. This technique appears to have promise in low to middle income countries such as Paraguay.

INTRODUCTION

One issue facing rehabilitation professionals in developing countries such as Paraguay, is that of appropriate materials for making hand splints. Low-temperature thermoplastics are used in developed countries, to make high-quality splints in a short time, but are too expensive for the majority of patients in less wealthy countries. The low-temperature thermoplastic needed to make a resting hand splint would cost slightly less than the equivalent of a week's salary for a minimum wage professional in Paraguay, or about $US40.

Rehabilitation professionals around the world are using alternative materials such as plaster of Paris bandage (1,2,3), polyvinyl chloride (PVC) (4,5), metal (6), leather (7), bamboo (8) and polypropylene (9,10), depending on what is locally available. Some excellent splints are made with these materials, but they also have their drawbacks.

Plaster of Paris bandage splints are inexpensive (around $US2 in Paraguay) and can be made in 20 minutes, by a skilled rehabilitation professional using widely available tools. They can be made to fit well to the patient’s hand and are strong when first made. But they are heavy, are not easy to clean and usually do not last a long time. It is difficult to modify them after they are first made.

PVC splints are made from 2-mm sheets of PVC or from PVC tubes. They are easy to clean, are light, strong and last a long time. PVC tubes are inexpensive and widely available. PVC sheets are less widely available and more expensive. The PVC sheet material is easier to mold than the tube material. Once the process for working with either material is mastered, splints can be made quickly. The splints can be made using a kitchen oven and simple tools. But the material must be heated to be shaped, so must be placed on a plaster mold of the hand (which complicates the fabrication process), or on the heavily wrapped hand of the rehabilitation professional or patient (which limits the degree that the splint can fit to the patient’s hand). In addition, the skills needed to work with PVC are rare, or absent, in most communities, so the rehabilitation professional will have to make the entire splint or train others in some tasks. The splints cannot be modified after they are first made. In most cases, technicians make these splints with guidance from rehabilitation professionals.

Splints made of used sheet metal or pieces of tin can, are very inexpensive and light. They are pounded to form the shape of the patient’s hand. Communities in some cultures may have artisans with the skills. The tools needed are widely available in most communities. But unless the splints are very well made, they are not strong. They also cannot be shaped directly on the patient’s hand, but must be hammered on a form and then placed on the hand, so they may not fit well to the hand. These splints are uncommon, and are not usually made by rehabilitation professionals.

Bamboo splints are light, inexpensive and easy to clean. Most communities, where bamboo grows, have local artisans with the necessary skills and tools to make the splint, after training from a rehabilitation professional. But the malleability of bamboo is limited, so the splint will not fit well to the hand. Bamboo that can be bent may not be strong enough for a splint.

Leather splints are light, inexpensive and last a long time. Most communities have leather-professionals with the needed tools and skills. But the leather must be placed wet on the patient’s hand, fastened tightly and left there for a number of hours until it dries; so the method is not appropriate for spastic or painful hands, and the splints are not easy to clean.

The leather needs a metal reinforcement to be strong. These splints are usually made by community artisans.

Polypropylene splints are easy to clean, light, strong and last a long time. But they are expensive (a splint may cost more than 3 weeks salary for a minimum wage professional in Paraguay), require sophisticated heating equipment and skills are not available in many communities, and cannot be modified after they are first made. In most cases, orthopedic technicians make these splints.

A summary of these advantages and disadvantages is presented in Table 1.

TABLE 1. SUMMARY OF ADVANTAGES AND DISADVANTAGE OF DIFFERENT SPLINTING MATERIALS

	Plaster of Paris	PVC	Bamboo	Leather	Metal	Polypr-opylene	Styrofoam and wood bandage
Cost	+	0	+	+	+	-	+
Time to make	+	0	0	-	-	-	0
Strength	+	+	0	-	+	+	+
Long-lasting	-	+	+	+	+	+	+
Ease of cleaning	-	+	0	-	+	+	+
Ease of modifying	0	-	+	+	0	-	+
Uses locally available skills and tools	0	-	+	+	+	-	+
Weight	-	+	+	+	-	+	+
Good fit to patient's hand	+	-	-	+	0	+	+

Key - (+) - relative advantage
(0) - neutral
(-) - relative disadvantage

In addition, it is my observation that many splints made from these materials place the thumb in extension, in the same plane as the hand. The physical characteristics of the materials may promote this.

I have been experimenting with a new technique for combining styrofoam (to create a shape which molds to the hand), plywood (to give it strength) and paper (to create a smooth surface). Velcro straps are used to fasten the splint to the patient's hand. Over the past 2 years, I have made over 40 splints, with a gradually evolving process.

I have developed 7 different models thus far:

- a resting hand splint for a flaccid hand
- a finger-spreader splint for a spastic hand
- a resting hand splint for a patient with shortening of the wrist flexors
- a thumb support splint for a weak but functional thumb
- a thumb positioning splint for a non-functional adducted thumb
- a resting hand splint for a person with rheumatoid arthritis to prevent ulnar deviation
- a wrist cock-up splint

The cost of the materials ranges from US$ .50 to US$ 2.50 in Paraguay. The time necessary to make the splints varies from 30 minutes to 2½ hours. Patients have been using various editions of these splints for up to 1½ years with satisfactory results. Over the past three months, I have also trained 15 professionals and technicians in the process. Currently, one has started independent splint production.

METHOD

The following are the steps for making the resting hand splint for an adult (the steps for a child are the same, but thinner styrofoam is used):

1) lay the patient's hand on a piece of paper and trace around the hand and the distal 2/3 of the forearm; mark the metacarpal-phalagial (MCP) joint arc, the proximal interphalangial (PIP) joint arc, the thenar crease and the heel of the hand; the fingers should be together and the thumb abducted.
2) cut the shape out of the paper, fold the thumb under and mark the shape on 2½ cm-thick styrofoam; cut the shape out with a small disposable blade knife, or cutter.
3) cut the paper drawing at the heel of the hand; trace the hand portion on to 5 cm-thick styrofoam and cut the shape out.
4) place the hand in a relaxed resting position with the thumb tip and index finger tip almost touching; for a patient with a flaccid hand, this will be the resting position (8) with the wrist at 15-20 degrees extension, the MCP, PIP and DIP (distal interphalangial) joints in 10-20 degrees of flexion, the thumb in opposition and the thumb flexed about 10 degrees in relation to the forearm; measure the forearm-metacarpal angle on both the ulnar and the radial side of the hand (I use folded paper since goniometers are rare in Paraguay); on the radial side of the hand, this figure can be used for the MCP, PIP and DIP joint angles as well, since they are very similar in the resting position; on the ulnar side of the hand, the MCP and PIP joint angles should be independently measured.

5) mark the outline of the hand on both side of the 5 cm-thick styrofoam cutout of the hand, using each joint angle and the distances between the joints as measured on the paper tracing of the hand; use the cutter to shape the styrofoam in conformity to the hand shape, making sure to maintain the metacarpal and carpal arches and the longitudinal arch.
6) mark the thenar crease on the styrofoam and cut away the styrofoam proximal to it.
7) unfold the thumb from the paper pattern, and cut along the fold line in a distal to proximal direction, until the thumb is almost completely severed; place the paper pattern on the styrofoam; place the thumb so it is slightly flexed in relation to the forearm; mark the thumb position on the side of the styrofoam block; cut out the shape of the thumb.
8) put the paper pattern on the styrofoam to make sure the styrofoam is of the right shape; if the patient is available, put the styrofoam under his palm; make modifications as needed to achieve the resting position.
9) during shaping process of the 5 cm-thick styrofoam, the piece is shortened; therefore, place the 5 cm-thick styrofoam on the 2 /12 cm-thick styrofoam cutout of the hand and forearm, and cut the 2 1/2 cm-thick piece of styrofoam to the new shape.
10) place the modified 2½ cm-thick piece of styrofoam on 9 mm plywood, draw and cut out the shape; sand the edges; glue the two pieces of styrofoam together and the plywood beneath them both, using special styrofoam glue.
11) carve the forearm portion of the splint until it is gently concave.
12) cover the styrofoam with a cooked glue made of flour (manioc, wheat or corn) and water; apply small pieces of cement-bag paper wetted with the glue in collage fashion to cover the splint, smoothing down any rough spots.
13) after this is thoroughly dry, use white glue to fasten down any loose piece of paper; mix equal parts of white glue and water and paint the paper.
14) after this is thoroughly dry, paint the splint with at least two coats of oil paint.
15) glue velcro to strapping material to make three straps; these are fastened to the plywood with screws; the straps are tightened using metal rings.

The other hand splints are variations on this theme. In the finger-spreader splint, the paper pattern is traced with the fingers and thumb abducted. A wooden block is shaped to fit between the thumb and index and fastened to the plywood. The wrist is kept at neutral. Small styrofoam wedges are cut to fit between the fingers.

In the wrist cock-up splint, the wood and styrofoam base is cut at the thenar and the distal palmar crease, and a wooden block is shaped to fit under the palm and padded.

In the resting hand splint for a patient with shortening of the wrist flexors, the base of styrofoam and the plywood are cut at the wrist crease, and are then joined by a triangle of wood at the angle of the thumb and the forearm. In addition, since the patient's hand cannot lay on a piece of paper for tracing, a light plaster of paris bandage cast is made of the patient's hand in the desired position, and all measurements and tracings are taken from that.

The resting hand splint to prevent ulnar deviation has padded pieces of plywood fastened to the ulnar side of the fingers and forearm, and to the radial side of the wrist to maintain the hand and arm in a straight line.

The thumb support splint uses a different process. An oval object is found, or shaped from clay, that fills the space between the thumb and palm while allowing for pinch. The object should extend beyond the IP joint of the thumb, but not extend beyond the proximal index finger crease. This shape is copied on paper, and expanded by 1 cm on all sides, and then a piece of 3 cm-thick styrofoam is cut that shape. The edges that touch the thumb and the web space are carved to be concave to the depth of 1 cm. Stick velcro is glued to the sides and the top of the splint. A strip of loop velcro is cut of length to fasten the thumb firmly to the splint. Another piece of loop velcro is cut to fasten to the radial side of the splint, extend down the arm and around the back of the wrist, loop around the wrist and cross the back of the hand before fastening to the top of the splint. The friction of the velcro on the arm keeps the thumb in opposition. Paper and paint are applied to the exposed styrofoam.

The thumb-positioning splint is made in much the same way as the thumb support splint, but the styrofoam piece is larger, extending beyond the MCP joint of the index finger, and also 5-cm thick, so as to provide stability from adduction pressure.

DISCUSSION

This technique is not perfect, and needs further improvement, hopefully both by other rehabilitation professionals and myself. In its present form, however, it does have some distinct advantages:

- the splints are easy to clean.
- while its cost is not on a par with the cheapest splints (bamboo and leather) it is a similar price to plaster of Paris bandage and much cheaper than high-temperature plastics.
- the tools needed to make the splints are widely available in most communities; many of the materials are also readily available.
- much of the time-consuming process (cutting wood, painting, drilling holes in wood, applying screws, applying paper) can be done by a community artisan rather than a rehabilitation professional; in countries such as Paraguay where rehabilitation professionals have very limited time to spend on each patient, and technicians with

these skills are plentiful and inexpensive in the community, this is an important consideration.

- the result is a strong splint (thus far, lasting up to 6 months without major repair) that can be easily modified by cutting off the paper and paint, cutting away or gluing on styrofoam, and then re-applying paper and paint.
- some problems (worn-out velcro, loose straps, cracks in the painted surface) are bound to occur over time; a family member or community artisan can repair these problems; in addition, since screws hold on the straps, a community artisan or family member can modify the strap length by removing the screws and shifting the straps.
- some patients can perform some of the tasks (painting, papering, cutting) involved in making their splint as therapeutic activities to improve fine-motor coordination, one-handed skills and perceptual skills.
- the splints can be made using hand tools commonly available in Paraguayan communities, although use of an electric drill and jigsaw will speed up the process.
- the splints can be carved to fit well to the patient's hand, even if it is deformed and/or spastic.

There are some disadvantages, some of which may be alleviated as the techniques develop and are adapted to local conditions:

- in areas with few industries, plywood and sheet styrofoam may not be locally manufactured, so may be too expensive for patients to afford.
- in Paraguay, there has been almost no collaboration between rehabilitation professionals and community artisans; communication and payment systems will have to be developed; this will take up already scarce time for rehabilitation professionals, unless facilities can take a role.
- rehabilitation professionals will need to develop a new mind-set; with other materials, the rehabilitation professional shapes the material over the hand or a mold of the hand; with this technology, the rehabilitation professional must develop and use techniques for outlining the negative space surrounding the hand and shaping the splint accordingly.
- during rainy seasons, the paper and paint will dry very slowly and the production will be delayed considerably.
- in their present form, patients who need to have their splints completely disinfected cannot use this kind of splint, since it can neither be autoclaved nor immersed in disinfectant.
- the measure of the angles of the different joints of the hand is a complex process, not normally done by generalist rehabilitation professionals in Paraguay. This will require practice.

There is much room for expansion of this technology. Thus far, only static splints have been made, but if materials are available to make outriggers, these could be attached to the plywood and a finger-extension-assist splint could be made. This is only one option. I could be interested in hearing about the efforts of other people.

I have made 2 ankle-foot splints using this technology, making a plywood case and then molding the styrofoam around the foot and lower leg. The resulting splints were satisfactory for bed positioning but were too weak and too bulky for ambulation. It was also difficult to get the foot in and out of the splint, and difficult to apply the paper and paint. A different approach might be to make a plywood case that could taken apart and assembled around the foot.

Use of styrofoam from packaging would decrease the cost and increase the potential use of the technology. Techniques will have to be developed to fasten pieces together, since package styrofoam almost never has pieces large enough to cut the whole splint from.

For making splints where small structures are needed (active ulnar deviation splints, for example), other materials will have to be incorporated into the splints, and techniques developed to fastening them to the splint, since styrofoam lacks the strength to be used in small structures.

Rehabilitation professionals will continue to use the materials and skills available in their communities to make hand splints. In places where styrofoam, plywood and paper are available and other materials are too expensive, this technology should offer occupational rehabilitation professionals an attractive alternative material. A detailed description of the fabrication process can be obtained from the author.

*Independent Occupational Therapy Consultant
13556 Starbuck Street, Whittier, CA 90605 USA
dtandkh@hotmail.com

REFERENCES

1) Trombly CA, Scott AD. ***Occupational Therapy for Physical Dysfunction,*** Williams and Wilkins, Baltimore/London, 1977; 287-288.
2) Werner D. ***Disabled Village Children,*** Hesperian Foundation, Berkeley, USA, 199; 221.
3) Iaffei F. ***(Occupational Therapist), Personal Communication, Asuncion,*** Paraguay, 2004.
4) Hareau J ***(Occupational Therapist and Physical Therapist) Personal Communication,*** Asuncion, Paraguay, 2003.
5) Hobbs L, Mcdonough S, O'Callaghan A. ***Life After Injury,*** Third World Network, Malaysia, 2002, 428.
6) Hobbs L, Mcdonough S, O'Callaghan A. ***Life After Injury,*** Third World Network, Malaysia, 2002; 431,432.

7) Hobbs L, Mcdonough S, O'Callaghan A. ***Life After Injury,*** Third World Network, Malaysia, 2002; 430,431.

8) Hobbs L, Mcdonough S, O'Callaghan A. ***Life After Injury,*** Third World Network, Malaysia, 2002; 435.

9) Hobbs L, Mcdonough S, O'Callaghan A. ***Life After Injury,*** Third World Network, Malaysia, 2002; 430,428.

10) Gonzalez F ***(Orthopedic Technician), Personal Communication,*** Asuncion, Paraguay, 2004.

11) Pedretti, LW, ***Basic Practice Skills in Occupational Therapy for Physical Dysfunction,*** San Jose State University, San Jose, California, USA, 1997; 277.