

Shoulder Prosthesis

I. Introduction

Levels of Amputation

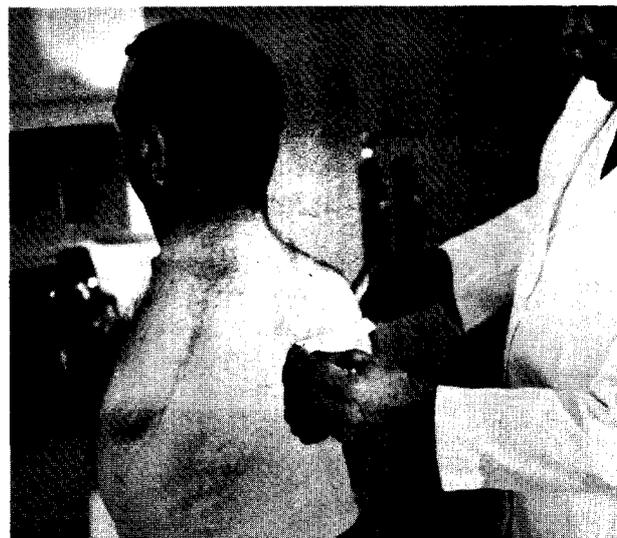
1. In the axilla level amputation, the head of the humerus is remaining but there is insufficient length of the stump to control a prosthetic humeral section.



2. In the shoulder disarticulation, the head of the humerus is absent and the scapula and clavicle are present. The patient normally has shoulder girdle motion remaining on the amputated side to control the prosthesis.



3. In the interscapulothoracic amputation, part or all of the scapula and clavicle are absent and the patient lacks shoulder girdle motion on the amputated side to control the prosthesis.



Discussion

Short Humerus (axillary level)

When the humeral head and neck are present, the use of a mechanical shoulder joint is considered only for those patients with very limited motion of the shoulder. The information gained by making the excursion tests (side C) on the prosthetic information sheet are helpful in making the Rx plan.

The addition of an externally powered elbow can greatly enhance the performance at this level. In some cases this method may even be the prescription of choice for the shoulder disarticulation.

Disarticulation

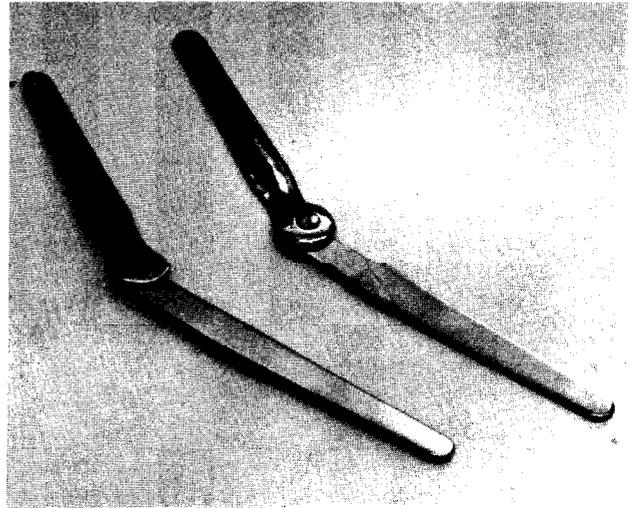
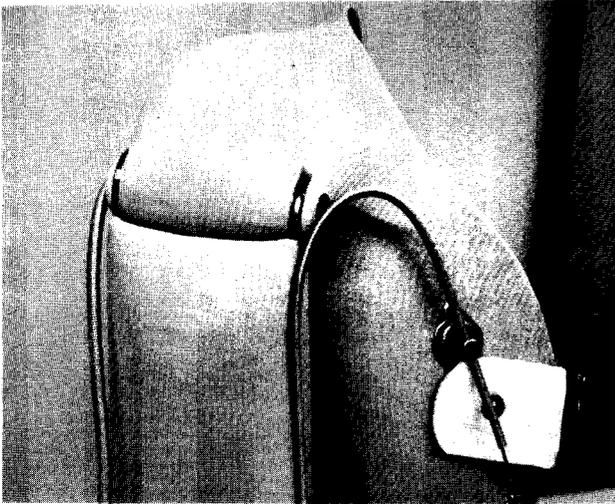
Limited range of motion in the shoulder girdle indicates the need for a mechanical shoulder joint which enables the wearer to passively preposition the humeral section for various activities. The condition also indicates that there is insufficient excursion of the cable to operate the prosthesis. Consideration should be given to assistive accessories such as excursion amplifiers or an electrically powered elbow unit.

Interscapulothoracic

Loss of the shoulder girdle indicates that the wearer cannot actively operate the prosthesis from the involved side. Excursion motion comes totally from the sound side. This means a total involvement of the sound shoulder and arm to operate the prosthesis. Amputees do not accept this concept of function and therefore, the prosthesis becomes little more than a passive holding vise or is worn for cosmetic reasons only.

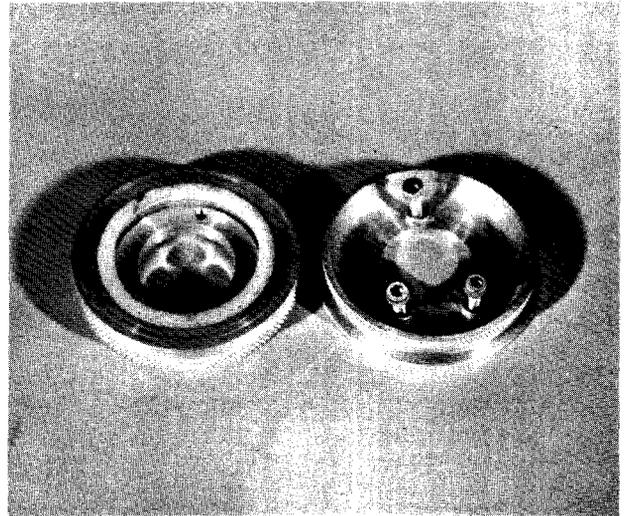
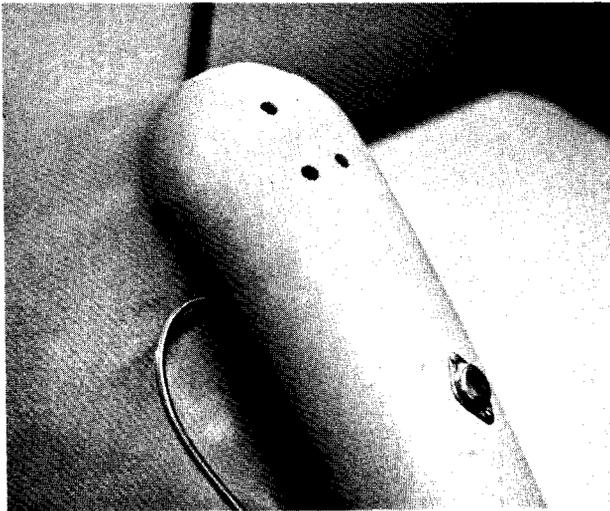
Use of external powered units should be utilized for the interscapulothoracic patient.

Fabrication techniques for the shoulder type prosthesis differ mainly with the type of shoulder joint that is to be used.



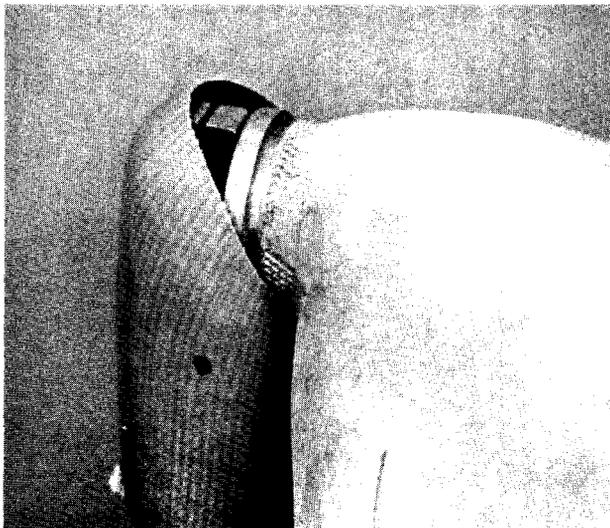
Abduction Joint

The abduction joint consists of two separate single pivot hinges. The joints are mounted on the socket so that a part of the shoulder or head of the humerus is between the joints. This joint makes a more cosmetic appearing socket. Separate friction adjustments are made with an Allen type wrench. The joints are mounted on the socket at a 30° degree angle to the sagittal plane. The humeral section is then moved into flexion and abduction in a manner similar to the normal arm when performing a hand to mouth operation.



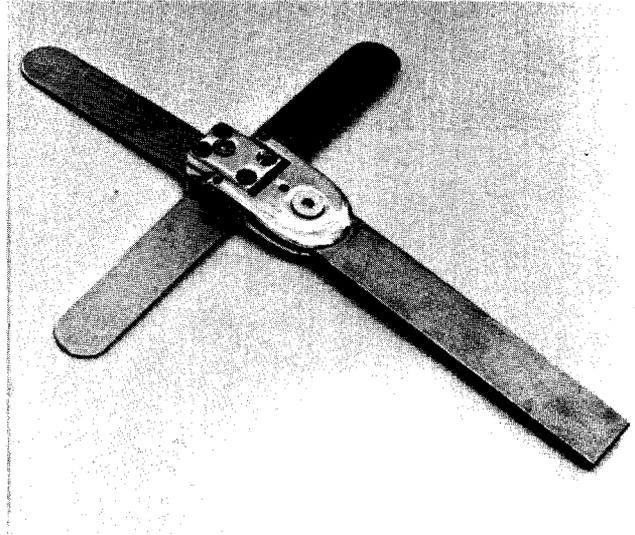
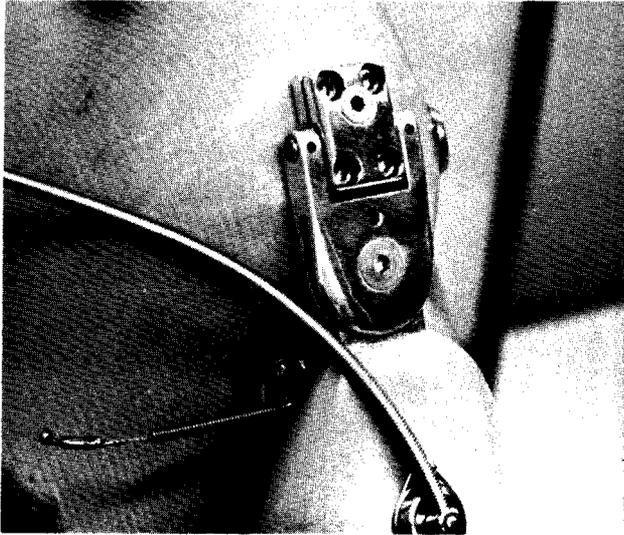
Flexion (Bulkhead) Joint

A medium size joint is used for the disarticulated humerus. (A superior friction arrangement to the previous joint). It is, however, less cosmetic in the finished prosthesis. It also should be mounted at an angle to permit flexion and abduction of the humeral section.



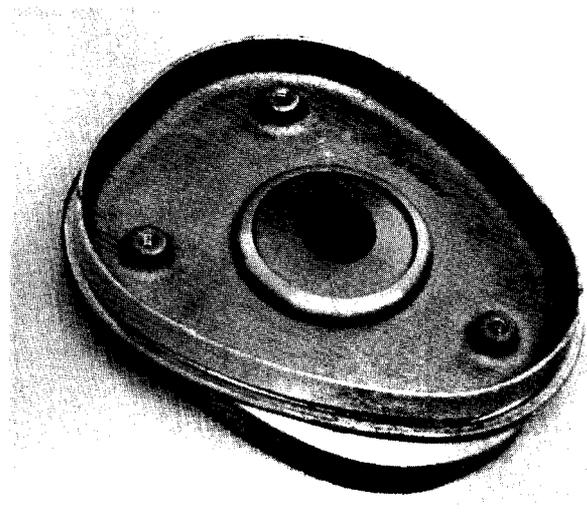
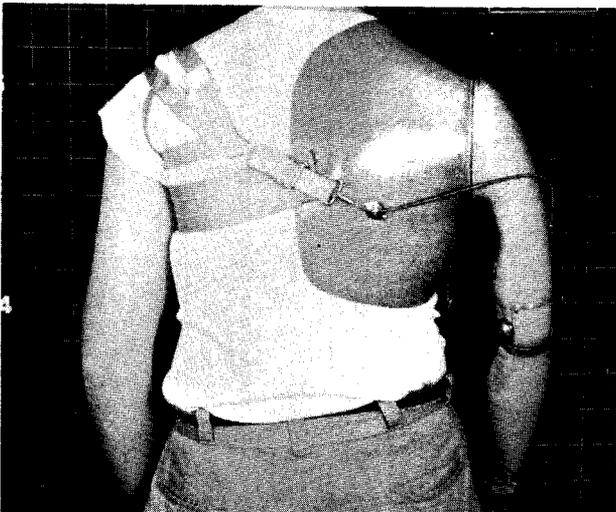
Flexion/Abduction ("Universal") Joint

This joint allows motion in all planes. Somewhat uncosmetic, it requires a double lamination to form a cap or covering.



Flexion/Abduction Joint

Attached to the socket by three metal strap in effect permits motion in all planes except extension. It can be used over the humeral head with little effect on cosmesis. A good joint for light duty as the friction adjustments do not work smoothly when turned up tightly.



Flexion (Bulkhead) Joint

An early model shoulder joint used mainly with interscapulothoracic type socket.

Since the step-by-step procedure for making the three different types of prostheses are similar, all three will be discussed together below. The main areas in which the three types differ will be emphasized.

II. Shoulder Prosthesis

A complete prosthesis (The ones shown are for bilateral shoulder disarticulations) generally weighs about 3 pounds. The average weight of the whole arm of the human body, including the hand is about 4.9 percent of body weight.



Information and Measurements (taken at the initial visit of the patient)

- List of materials:
- 1 goniometer
 - 1 straight edge ruler
 - 1 3'X3' piece of tracing paper

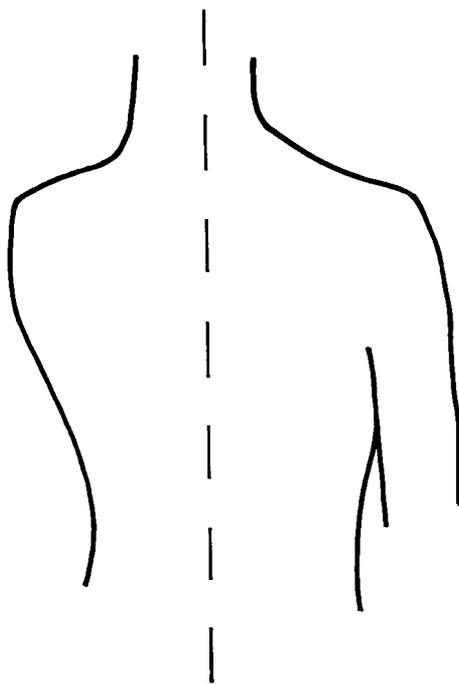
1. A sample information form is shown on page Complete the applicable portions of the form with particular attention to the following:

The names of the clinic and the physician should always be noted. The physician should be consulted when medical problems arise and the clinic may have to be consulted when problems occur with financing, therapy, training, etc.

Under "Condition of Stump," examine the stump to determine if any scars, neuromas or any other areas exist that are sensitive and need relief in the socket. Note the condition of the remaining bones and the existence of any bony prominences which will have to be relieved in the socket. Check the muscles to determine if they are adequate to control a prosthesis, and measure the stump ranges of motion (any remaining shoulder girdle motion) so that the socket can be made to allow for as much residual function as possible.

Under "Rx (Prescription) for Prosthesis" note the type of socket, components and materials that will be used for the prosthesis. Also note which components or materials have to be ordered from the manufacturer or supplier.

1. To determine the amount of buildup (if any) and shaping necessary to match the sound side, make a tracing of the amputated and sound sides. Using a plumb line, establish a vertical line bisecting the body.



2. To match the length of the prosthetic arm, measure the length of the sound arm from the acromion to the lateral epicondyle and from the lateral epicondyle to the thumb tip.



- 3. If a prosthetic hand is to be used, measure the circumference of the sound hand over the distal heads of the metacarpals to determine the size of hand. Check the manufacturers' catalogues to determine which size prosthetic hand and glove to order.

Examine the X-rays of the stump whenever possible. X-rays often reveal information which is helpful in designing sockets for optimum function and comfort. The presence of bone spurs or other overgrowth, fusion of bones or bone chips can also be detected.

- 4. Measure the ranges of motion of the shoulder girdle and record on the prosthetic information form. Do this bilaterally; measure the excursion :
- 5. (a) In the interscapulothoracic amputation, there will be insufficient excursion to operate the dual control system. To solve this problem, a passive elbow joint with manual lock can be used. The cable control used only for the terminal device is operated from the sound shoulder.

(b) Humeral head and true shoulder disarticulation:

When the shoulder girdle motions are normal, the excursion distance will be marginal in that the amputee will have to involve both shoulders to maximum range to operate the elbow to full flexion and the terminal device to full opening.

When the ranges of shoulder girdle motions are limited, the cable excursion distance should be amplified by one of the available accessories.

The Wrap Cast

- List of Materials: cotton stockinette (6 inches to 8 inches wide)
 scissors
 sheet (to drape the patient)
 elastic webbing
 Yates clamps
 bucket of water
 indelible pencil
 plaster bandage (about 6 inches wide)
 towel
 parting agent for cast

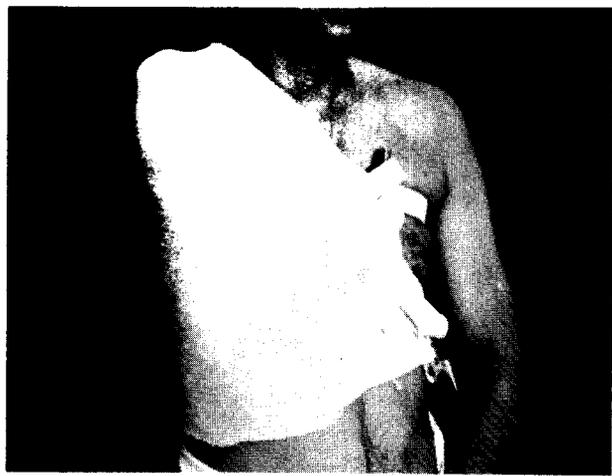
1. Determine the design of the socket for the patient to see how far the cast will extend.

Make the wrap cast according to the type of socket to be fabricated. Avoid a socket design which will tend to immobilize shoulder girdle movements necessary for prosthetic control. Sufficient skirting posterior over the scapula and inferior to the axilla, on the rib cage a distance of 2 or 3 inches will stabilize the prosthesis for the axilla level amputation.

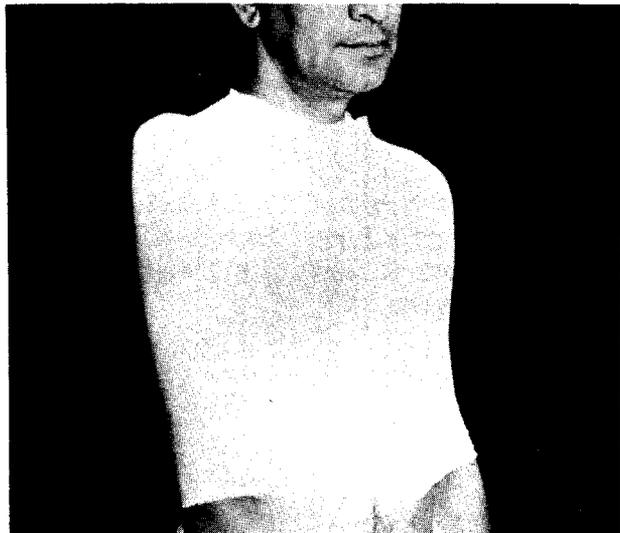
Disarticulation rules out the possibility of effectively capturing the rotatory motion of the shoulder. The need for stability has also increased, therefore, the area to be covered by the socket can be increased for stability and comfort for the wearer. In addition to the area described above, extend the wrap one half the distance to the nipple on the anterior and cover three or four ribs below the axilla. Loss of the shoulder girdle as in the interscapulorthoracic rules out the possibility of any active socket motion.

Therefore, the body socket for males should cover an area equal to the involved side rib cage. For a female, the anterior part of the socket is cut out for the breast. A shoulder flap for the opposite side is made to stabilize the socket on the body. When making the wrap, a separate slab of plaster can be formed over the opposite shoulder connected to the socket across the back.

2. Cut a length of 6 inch to 8 inch wide cotton stockinette long enough to cover the cast area. Slit the stockinette to open it, wet it so the plaster will adhere and place it on the patient as shown with elastic or webbing and clamps.



3. An alternate method of taking a cast is to pull the whole piece of stockinttte over the body without slitting it.



Outline the boney areas closest to the skin surface. Relief in the socket is usually needed for the acromion and spine of the scapula. The clavicle is also a sensitive area.

4. Using 6 inch wide plaster bandage, wrap the stump by lapping the bandage back and forth to make three or four layers for strength. Be sure to cover all the areas of the expected trim lines, which may be sketched on the stockinette if desired.



5. Smooth the plaster and mold it well to the body, especially where there are indentations and bony prominences.



6. After the plaster hardens, carefully remove the cast to avoid distorting it.



7. Inspect the inside of the cast to see that there are no wrinkles or unwanted bulges or indentations and that the cast covers the necessary area.

If the cast appears satisfactory, put a parting agent on the inside for making the model.

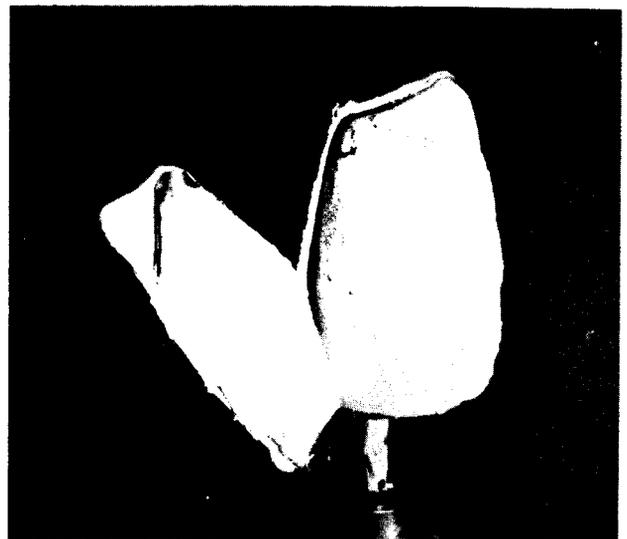
The Model

- List of Materials: plaster
mandre 1
knife
sureform files
sandpaper or screen
parting agent for model

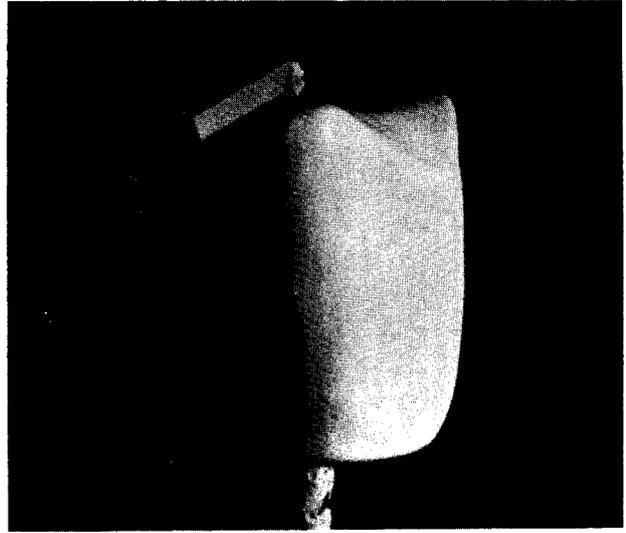
1. Pour a smooth mixture of plaster and water into the cast to form the model. Before the plaster hardens, insert the mandrel into the cast for later use when handling the model. The mandrel should not touch the sides of the cast.



2. After the plaster has set, carefully remove the cast from the model.



3. Smooth the whole model, being careful not to lose the identification marks. Make the plaster buildups as follows - about 1/4 inch over the clavicle and about 1/4 inch over acromion (if present) including the acromioclavicular joint. Blend the buildups into the model and smooth.



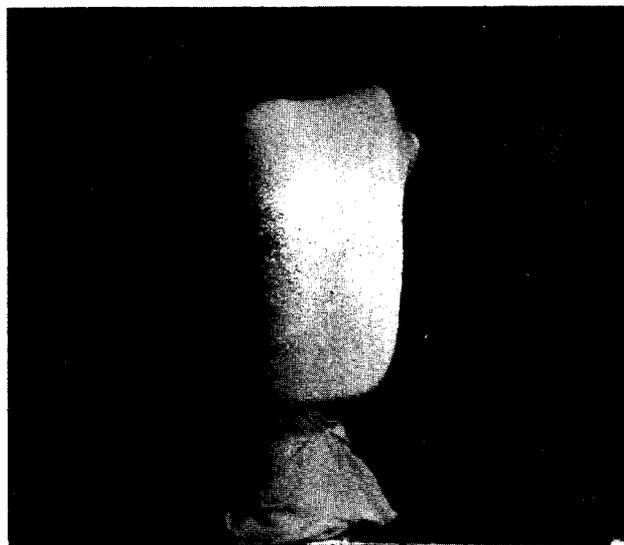
4. Put a parting agent on the model for ease in removing the wax check socket later.

The Wax Check Socket

List of Materials: cotton stockinette (6 inches or 8 inches wide)
scissors
string
molten wax
knife
wood burning tool
talcum powder
heat gun
plumb bob
straight edge ruler
plaster bandage
parting agent for wax check socket

The purpose of the wax check socket is to get a good socket fit and alignment before laminating the final socket of plastic.

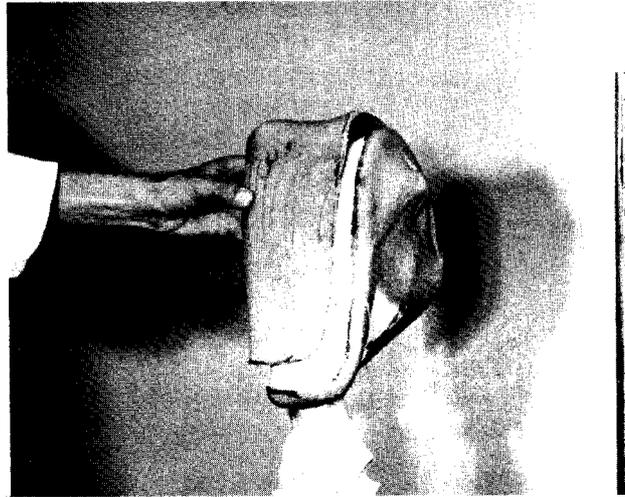
1. Put 6 layers of about 6 inch or 8 inch wide cotton stockinette on the model by either pulling the stockinette over the model or by cutting sheets of stockinette and tacking them to the mandrel side of the model.



2. Thoroughly impregnate the stockinette with molten wax.
A firm wax should be used such as Warco 180.

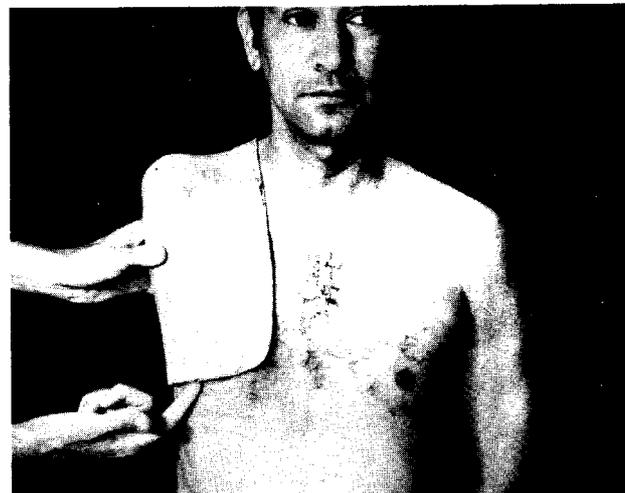


3. Immerse the model in cool water to harden the wax. Before the wax completely hardens, form it over the model with your hands to remove bridging of contours.



4. Cut the wax check socket to the approximate desired trim and pull it off the model. Smooth the edges and powder the inside before applying to the patient. Save the model in case another wax check socket has to be made.

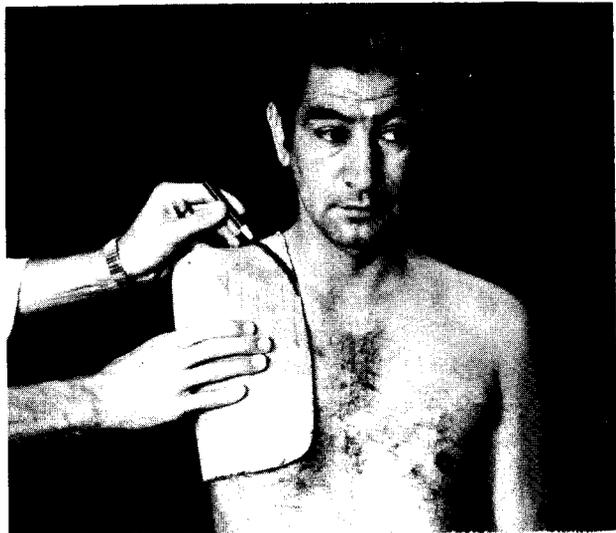
5. Place the wax check socket on the patient. Small windows can be cut in the socket for checking the fit.



6. Check to see that the reliefs for bony prominences and sensitive areas are adequate. Apply forces to the socket in different directions. Heat and form where necessary for relief. Make sure the distal edge of skirting does not dig into the rib cage. Flare the edge as needed.

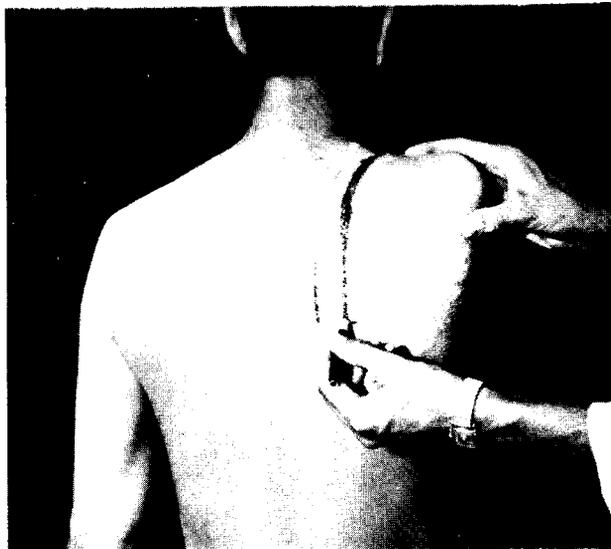


- 7. Check the trim lines on the socket as follows:
The proximal brim should allow for purchase of the socket on the stump but should also provide clearance for the neck during shoulder elevation or scapular abduction.



- 8. The posterior trim should allow enough skirting of the socket to provide rotational stability. For the three levels of amputation the trim usually is

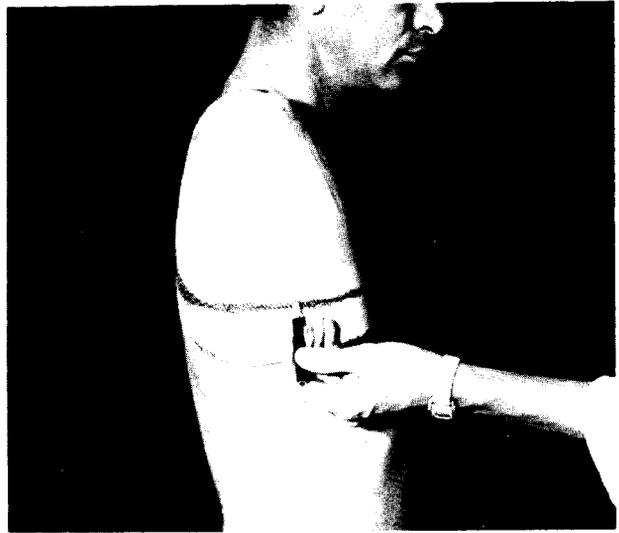
for the axilla level, midscapula;
for the shoulder disarticulation, trim at the vertebral border of the scapula;
the interscapulothoracic, just lateral to the spinal column.



The anterior trim line should allow enough material to provide rotational stability and should have a flared edge for comfort. For an interscapulothoracic amputee, it should extend almost to the centerline of the body. Avoid the nipple area wherever possible.



The top of the shoulder supports the socket and vertical loads and the side of the body provides a reaction point for forces on the forearm and terminal device. The lateral trim therefore, must extend distal enough for comfortable distribution of forces.



9. Check the trim lines for function and comfort by having the amputee adduct/abduct and depress/elevate his shoulder girdle. Trim the edges to allow as much range of motion and comfort as possible without sacrificing stability of the socket on the stump.

10. To align the mechanical shoulder joint on the socket later, three reference lines must be established on the wax check socket.

11. The superior proximal reference line represents the coronal plane of the body (projected for interscapulothoracic amputee). This establishes the frontal plane. A temporary harness to support the socket is desirable.



12. The anterior reference line is established by a plumb line on the anterior portion of the socket with the shoulders level.



13. The lateral reference line is at the center line of the side of the body when the amputee is standing erect.



14. After the fitting of the wax check socket is completed, examine the edges to make sure that they are smooth and rounded. Carefully reinforce the socket with plaster bandage so that it will not be distorted when making the mold.

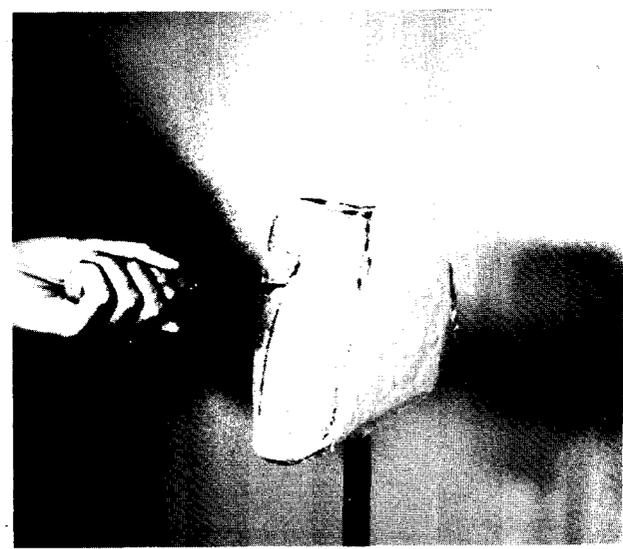
Making the Mold

- List of Materials: plaster
mandrel
awl
knife
sandpaper or screen
BB's
parting agent for mold

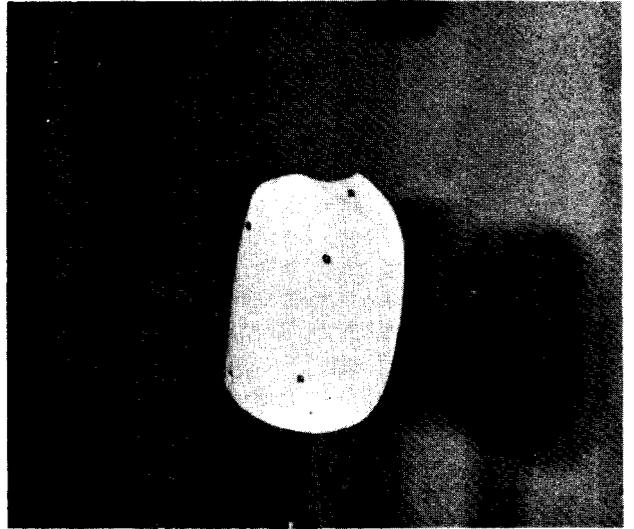
1. Make a hollow mold as described in the Materials section. Insert the mandrel for handling the mold.



2. When the plaster sets, remove the plaster bandage reinforcement and carefully mark two points on the mold through the wax check socket on each reference line. Remove the wax check socket by slitting it and pulling it off the mold.



3. Smooth the mold. The trim line should form a rounded, smooth edge on the plastic socket. Put BB's or round head screws in the mold, so the reference lines can be transferred to the plastic socket.

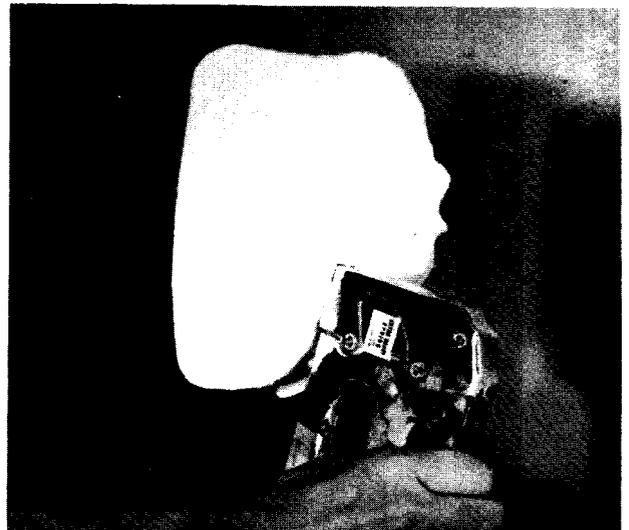


4. Apply a parting agent on the mold for the plastic lamination.

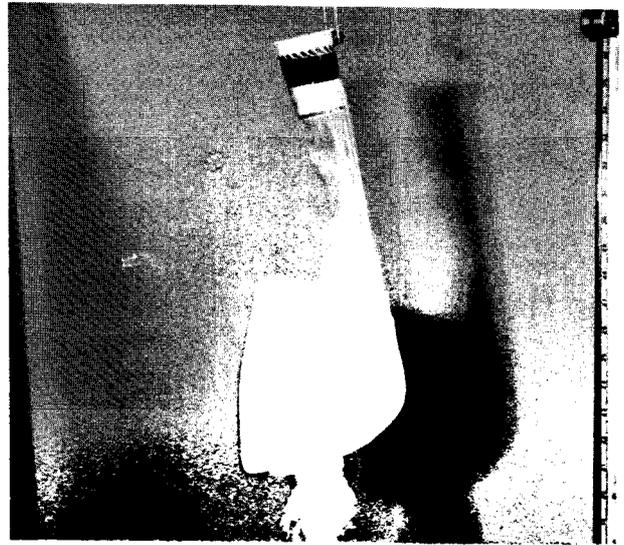
The Plastic Socket

List of Materials: dacron felt
nylon stockinette (6 inches or 8 inches wide)
scissors
string
PVA
polyester resin, catalyst, promoter, and color pigment
sander

1. Apply one layer of dacron felt and two layers of nylon stockinette on the mold. This can be accomplished by either making a dacron felt bag and pulling it and the stockinette over the mold, or by using sheets of the dacron and stockinette and tacking them to the mandrel side of the mold.



2. Make a PVA bag, wet it, and pull it tightly over the mold in such a way that vacuum can be used. Eliminate all wrinkles in the PVA bag and then tie it at the bottom. If possible, locate both the top and bottom of the bag on the mandrel side of the mold to eliminate wrinkles and excess resin on the socket. The use of vacuum is recommended to make a light but strong socket. Before laminating, test the vacuum system and the PVA for leaks and proper function. See page



3. Mix polyester resin with its promoter, catalyst and color pigment. Pour this mixture into the top of the PVA bag and work it into the stockinette. Tie the top of the bag to remove excess resin.



4. After the resin has set, locate the reference lines and scribe them on the socket. Now roughen the whole socket for adhesion of foam buildup and final plastic lamination.



Installing the Shoulder Joint and Making the Humeral Section

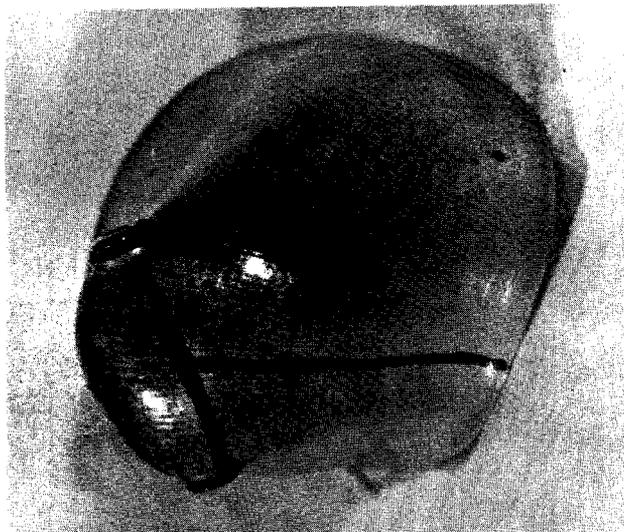
List of Materials: cardboard or polyethylene sheet
 masking tape
 polyurethane resin
 shoulder joint
 elbow unit turntable
 plumb bob
 straight edge ruler
 tracing taken during measurements
 drill (to make holes in straps)
 polyester resin, catalyst, promoter and color pigment
 nylon stockinette
 PVA
 sander

The procedures for installing any of the five kinds of shoulder joints on the three types of prostheses are similar. The main differences occur in the alignment of the shoulder joints. The alignment of each type of shoulder joint is shown below.

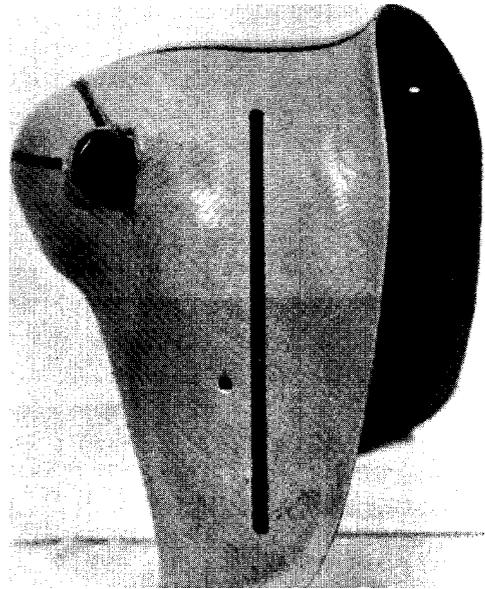
Transfer the alignment lines to the outside of the socket. Use the indentations made from the BBs or round head screws on the inside of the socket for this.

The Abduction Joint

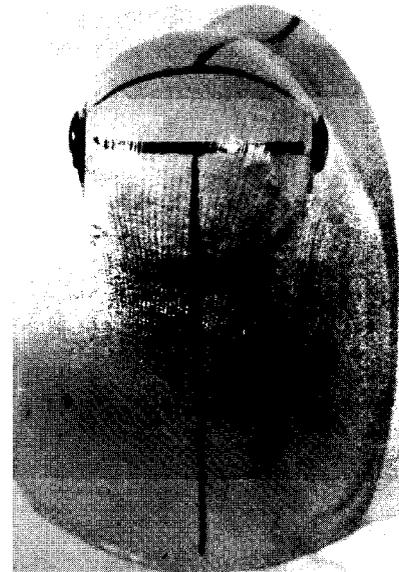
1. The abduction joint is internally rotated. The angle is usually about 30 degrees. In this position when the joint is abducted, it also flexes the humeral section. Mount the joints on a spacer for the interscapulothoracic. The "U" type alignment' jig is used when the shoulder girdle is present. Set the jig so that the joints will be close to the socket.



2. Align the socket so the anterior reference line is vertical. The axis must pass through the projected location of the head of the humerus. In the illustration, the socket is for a right shoulder.

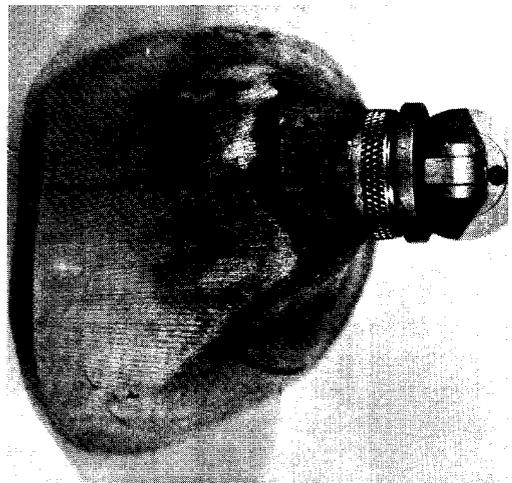


3. After the socket is lined up so the lateral reference line is vertical, position the joint so it is horizontal. Place the joints to follow the contour of the shoulder.

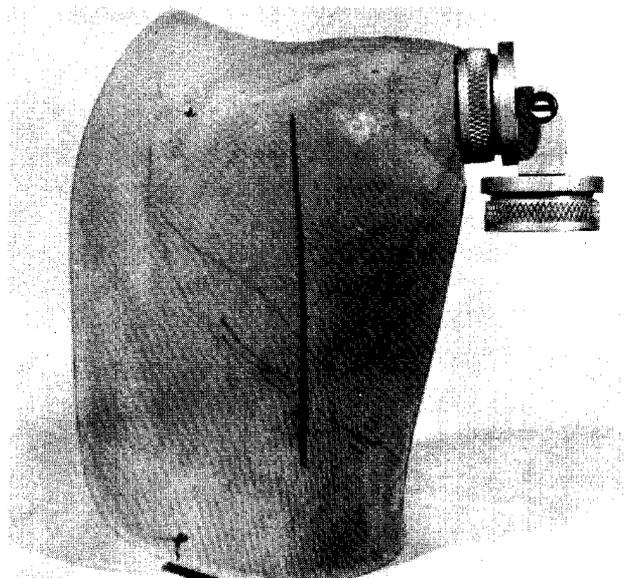


Flexion/Abduction (Universal) Joint

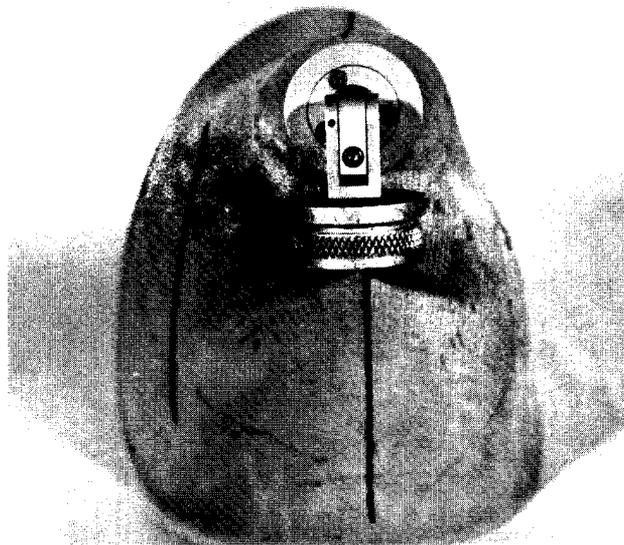
4. Since this joint has both flexion and abduction motion, it is aligned so the flexion axis is perpendicular with the proximal reference line and the abduction axis is parallel to the line as shown in the illustration.



5. Line up the socket so the anterior reference line is vertical and position the joint. The top edge should be even with the shoulder line and, with the tracing as a guide, the lateral edge should make the amputated side the same width as the sound side.

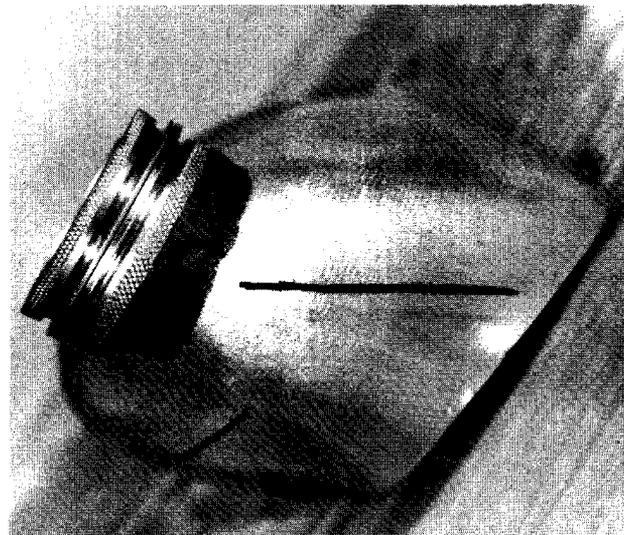


6. Line up the socket so the lateral reference line is vertical and position the joint so it is centered on the line.

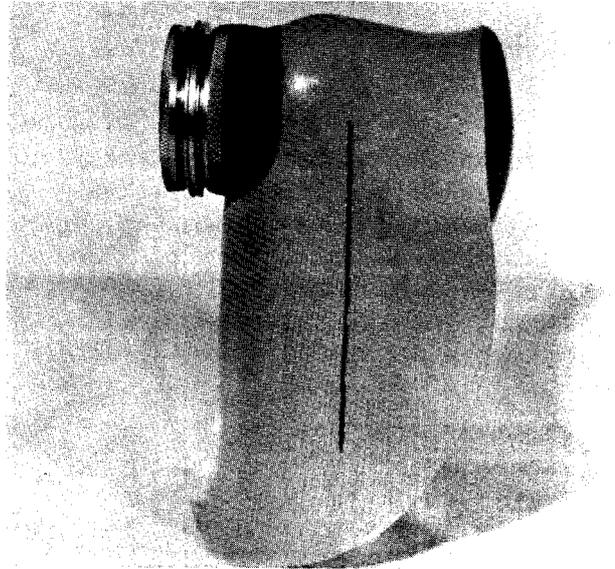


Flexion (Bulkhead and Ring) Joints

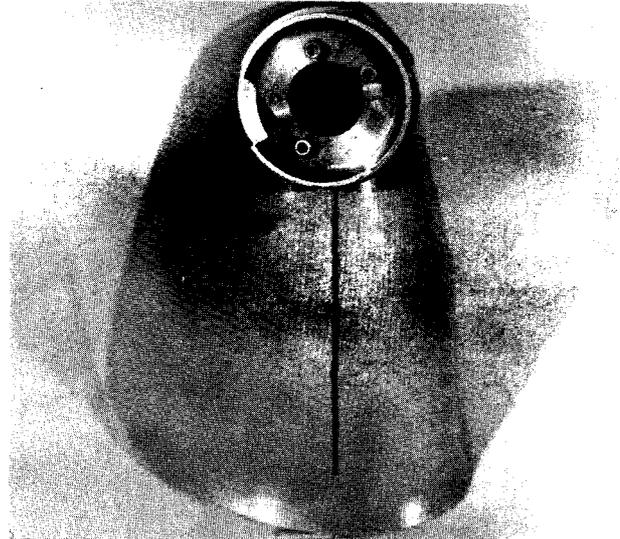
7. The flexion joint axis is externally rotated 30 degrees from the sagittal plane or as much as is cosmetically acceptable. When the joint is flexed, it also abducts the humeral section in relation to the body and puts the arm in a good functional position.



8. Position the socket so the anterior reference line is vertical and the joint face parallel to the line. The top edge should be even with the top of the shoulder and laterally at the projected location of head of the humerus.

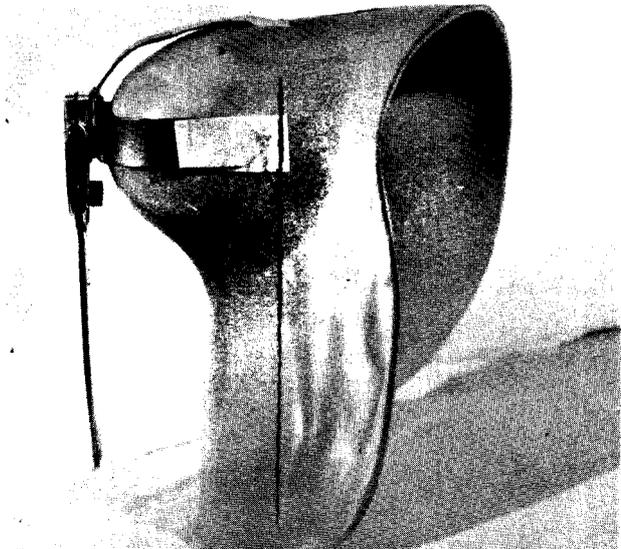


9. Center the joint axis on the lateral reference line.



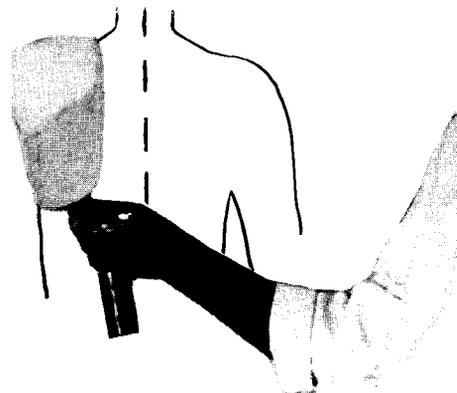
Flexion/Abduction Joint

10. This joint is installed in a similar manner as the universal joint except that it is positioned at the height of the head of the humerus. The lateral edge also makes the amputated side the same width as the sound side.



The step-by-step procedures for installing the flexion/abduction joint and making a humeral section for a shoulder disarticulation prosthesis are as follows:

- 1. The flexion/abduction joint is ideally suited to the shoulder disarticulation or humeral head remaining; when used for the interscapulothoracic, a build-up to cosmetic contour of normal side is made before aligning and placing of joint.

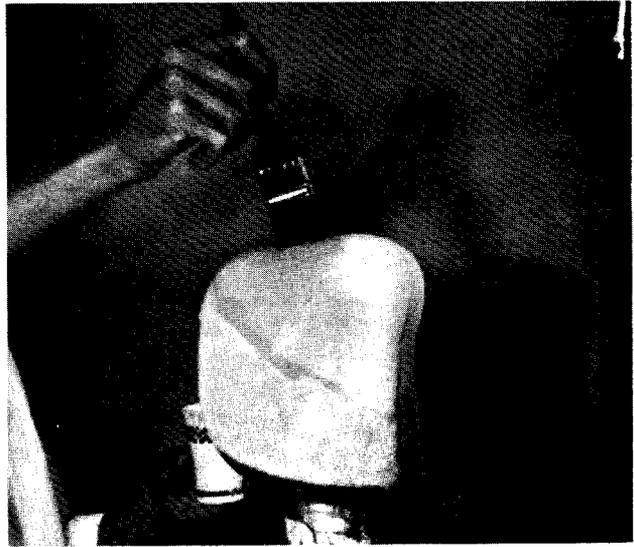


- 2. First, make a cardboard or polyethylene form for a foam build-up on the socket so the amputated side will match the sound side. Refer to the tracing and make the build-up larger than the sound side so it can be shaped down to match. Now pour the polyurethane resin into the form.
- 3. After the resin has set, remove the cardboard or polyethylene form. Shape the foam so the amputated side matches the sound side in width and there is an undercut as shown for the humeral section.

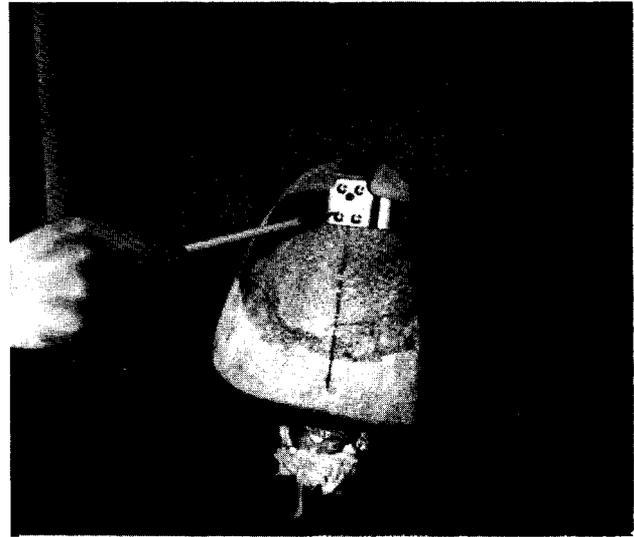
- 4. After the foam is shaped, align the shoulder joint as previously described. Drill holes in the straps so the resin will "grab" and hold the joint more securely. Bend the straps to the shaped foam.



- 5. Remove the joint and coat the foam with polyester resin to seal the air spaces to prevent air bubbles in the final lamination. When the resin sets, roughen the surface so the final lamination will adhere.

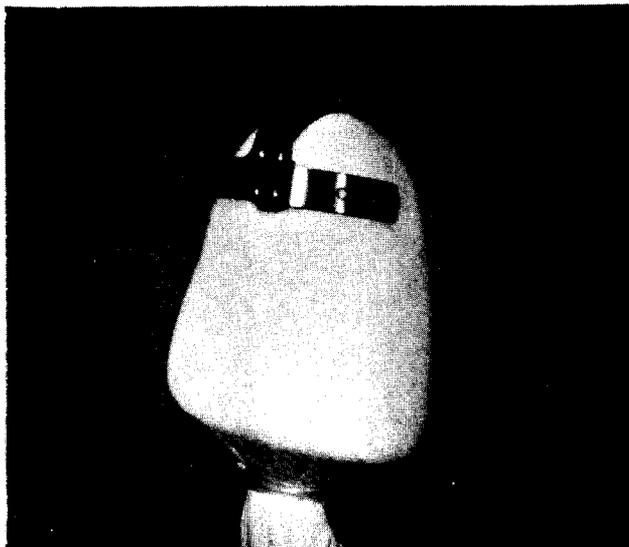


- 6. Remove the joint from the straps and place them into position and hold them in place with screws.

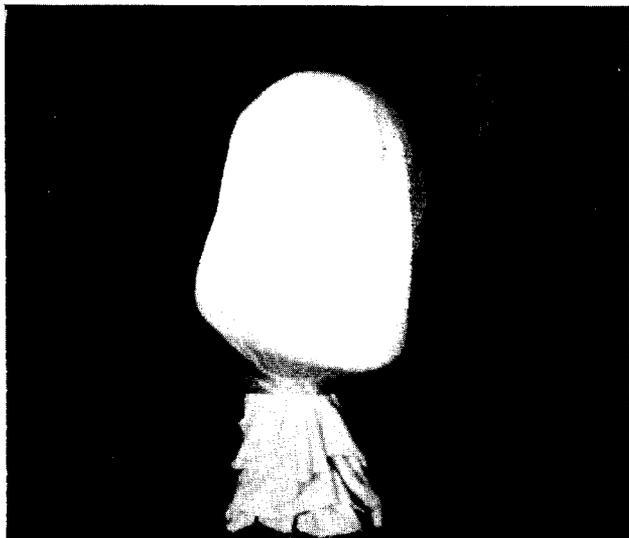


- 7. Remove the straps and put two layers of nylon stockinette over the socket and build-up, tying or tacking it on the mandrel side of the mold.

8. Reposition the straps holding them in place with screws through the attachment holes into the holes in the foam. Fill dacron felt in any spaces between the straps and the stockinette. A wood block can be used as a fairing for cosmetically inseting the joint.



9. Apply two more layers of nylon stockinette over the socket so the straps will be imbedded in plastic.

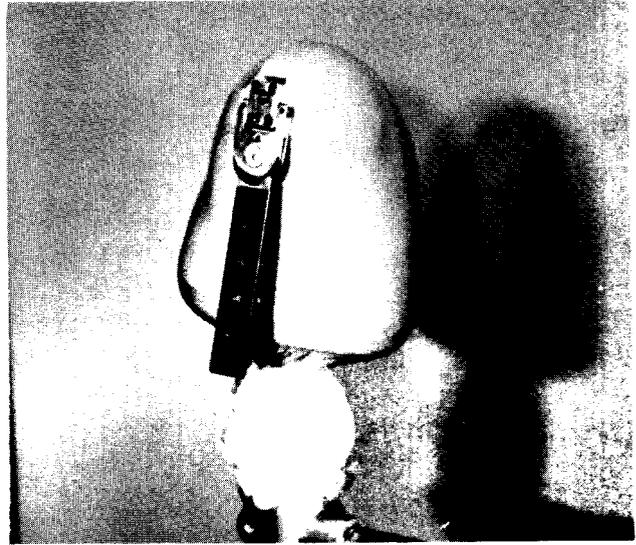


10. Make a PVA bag, mix the resin and laminate as indicated previously.

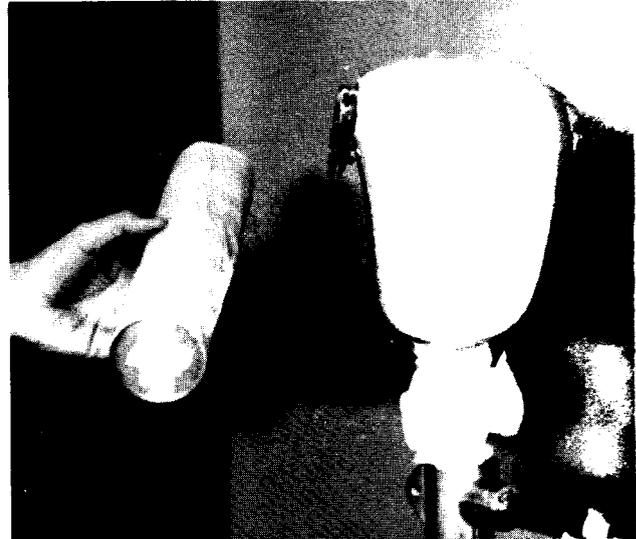
11. When the resin has hardened but is still hot, trim the plastic away from the attachment holes so the joint can be installed on the straps.



12. When the resin has set, attach the joint to the straps and prepare to make the humeral section.

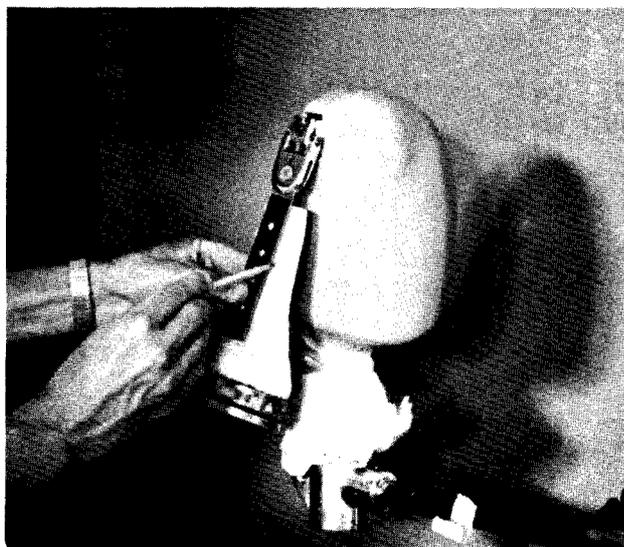


13. Make a humeral section form by shaping cardboard or polyethylene in a cylinder with the elbow unit turntable taped to one end of the form.

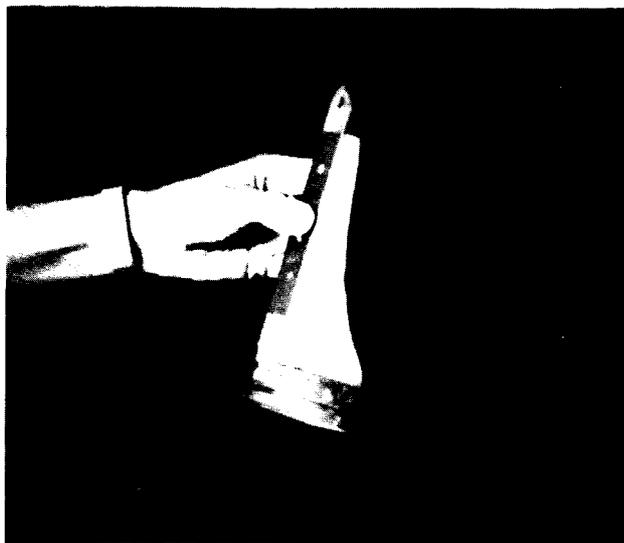


14. Make the form long enough so the length from the acromion to the elbow unit turntable matches the distance on the sound side from the acromion to the lateral epicondyle minus the distance from the elbow unit joint center to the turntable.
15. Pour polyurethane resin into the form. The humeral strap will be positioned on the foam after it sets.

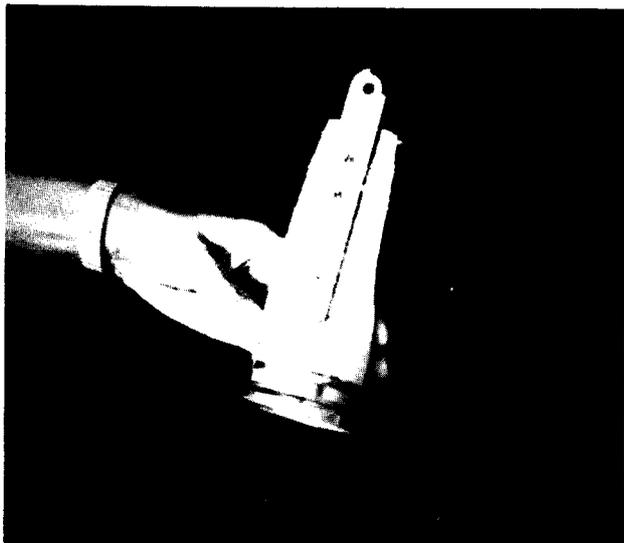
16. After the foam sets, remove the form and shape the foam so the humeral section is contoured to the socket, has clearance in the axilla area for clothing and is the correct length. The humeral strap should lie on the lateral surface of the humeral section. Outline the position of the strap on the foam.



17. For the flexion/abduction joint, remove the humeral strap from the joint, drill holes in the strap, and dig out the foam as marked so the strap is positioned in the foam with the lateral edge of strap flush to the surface.

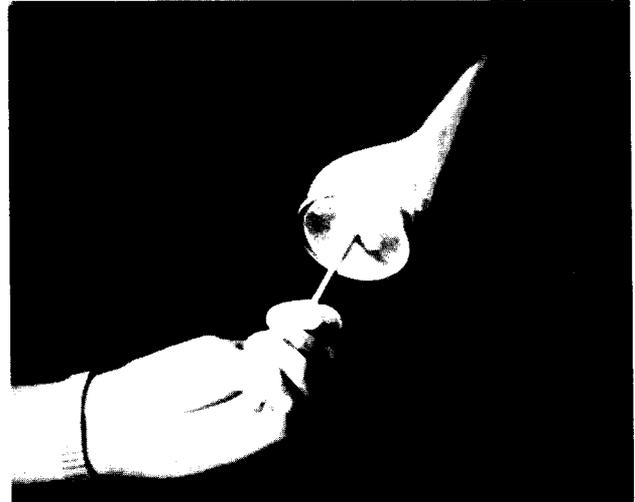


18. Adhere the strap in position on the humeral section with resin.

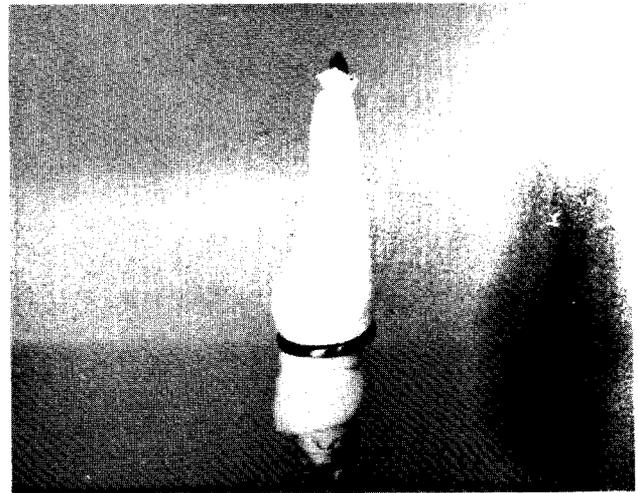


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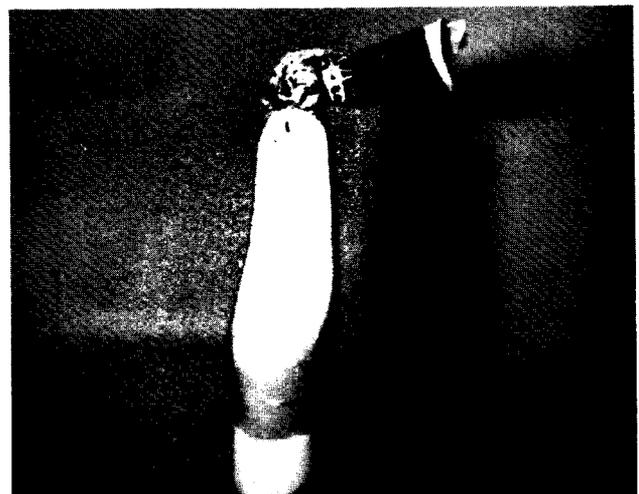
19. Coat the whole humeral section with polyester resin to seal the air spaces. Roughen the surface after the resin sets so the plastic lamination will adhere.



20. Make a mandrel for holding the humeral section when laminating by putting a dowel or rod through the hole in the turntable into the foam.

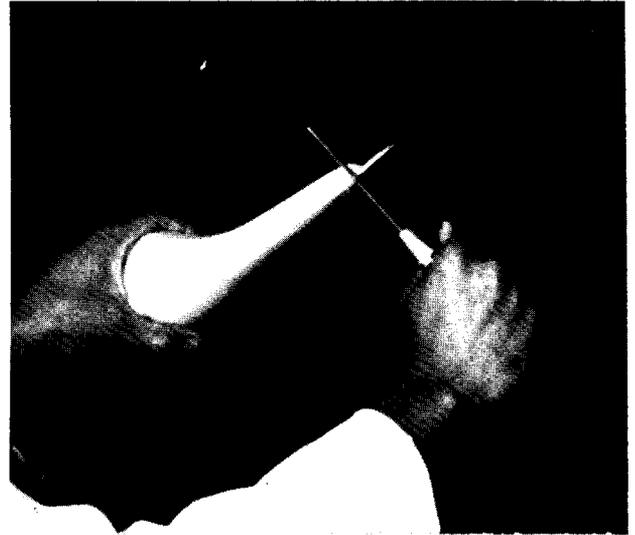


21. Pull two layers of 2 inch or 3 inch wide nylon stockinette by tying the stockinette at the groove in the turntable, doubling it back and tying it at the top.

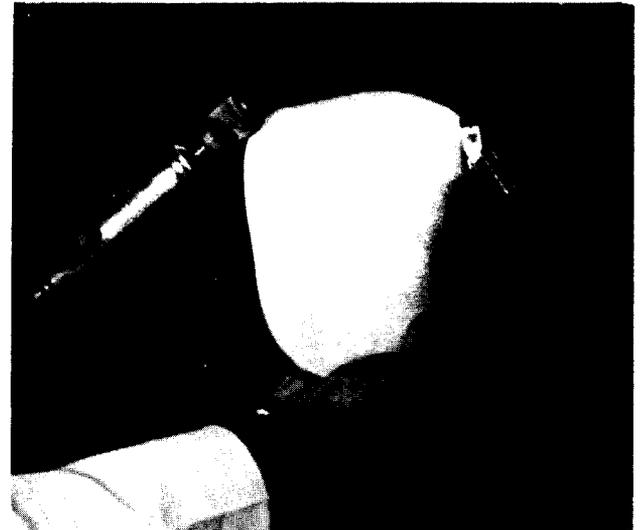


22. Make a PVA bag, mix the resin and laminate the humeral section. To eliminate the need for vacuum, pull the PVA bag tightly over the cylindrical shape. Tie the PVA bag at the top to remove excess resin.

23. After the resin sets and is still hot, trim the plastic from the part of the humeral strap that fits into the joint.



24. With a cast cutter, cut the socket to the approximate trim lines and remove it from the mold. Trim the socket to the lines previously established. The edges should be rounded and the inside should be very smooth.



25. Make any necessary additional trims to the humeral section and assemble the humeral section to the socket.



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Harnessing:

Harnessing the shoulder prosthesis is the most difficult of all the amputation levels. It requires all the prosthetic skills the prosthetist can apply in order to obtain acceptable results for the patient. Compared to the below elbow harnessing where a simple figure of eight provides ample unilateral excursion and mobility, the wearer of the shoulder type prosthesis has difficulty managing even the fundamental control functions. Elbow flexion and terminal device opening are provided by the harness and control system, but prepositioning the arm from the mechanical shoulder joint is purely passive and accomplished by the sound arm.

Scapular Abduction: (shoulder protraction)

Amputations which require the shoulder type prosthesis do not have sufficient unilateral shoulder motion to provide the necessary excursion of the cable to operate the prosthetic elbow and terminal device. The amount of excursion necessary to operate the prosthesis is approximately 5 1/2 inches. Unilateral scapular abduction can only produce an excursion of approximately 3 inches which is inadequate to operate the elbow unit and terminal device. Therefore, a harness which is designed to utilize only unilateral scapular motions such as the chest strap harness should not be applied to the shoulder prosthesis as the sole control source for dual control of the elbow unit and terminal device.

Biscapular shoulder motion is essential to produce the needed excursion to operate the prosthetic units. It must be pointed out, however, that harnessing which involves the sound arm and shoulder in an active way is not generally well received by the wearer.

Shoulder Elevation:*

Shoulder elevation as a source for prosthetic control operation has two major disadvantages. First, the reaction point, which is attached to either a waist or peroneal strap, thereby links the shoulder to the trunk or pelvis. This then requires trunk motion for prosthetic control operations and is most efficient only when standing. Secondly, the very act of shoulder elevation moves the terminal device away from the object of grasp instead of toward it.

Shoulder elevation is used for elbow lock operations in females and those cases without adequate chest expansion because of the small amount of excursion required and the sequence in which it occurs. In the presence of adequate chest expansion (males) for elbow lock operations, chest expansion can be used.

Biscapular Abduction:

The harness of choice for axillary level and shoulder disarticulation amputations is designed to utilize biscapular abduction. The application of an axillary loop to the harness provides the biscapular control. It also increases the excursion needed to the necessary amount to operate the dual control system. A separate, simple chest strap with elastic maintains the prosthetic socket on the body and can provide elbow lock control at the same time.

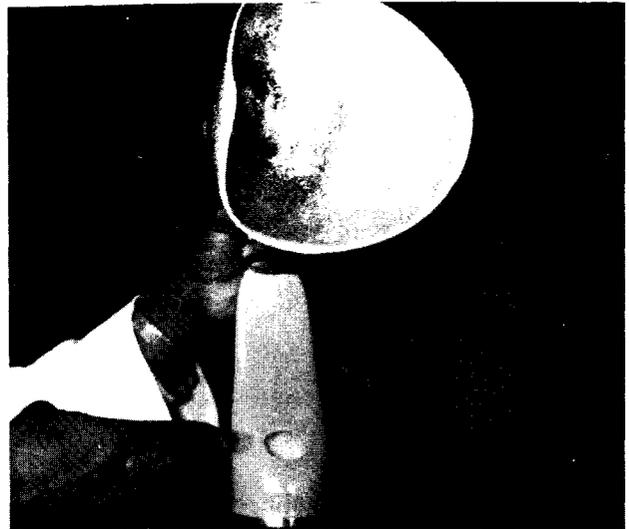
List of Materials for Harnessing Shoulder Prosthesis

elbow unit, forearm and terminal device
drill (to make about a 1 inch diameter hole in plastic)
9/16 inch wrench (for elbow turntable nut)
adjustable elbow flexion attachment
elbow spring assist
cable
large cable housing
swivel terminal
swaging tool or soldering kit
two retainers
diagonal shears
adjustable hanger
two 1/2 inch wide buckles
two anchors for elbow lock cable housing
1/2 inch hanger Yates clamps
polyethylene tubing for axilla
drill and tap for elbow flexion attachment screw
teflon liner
wood burning tool
1 inch hanger
swaging tool or soldering iron

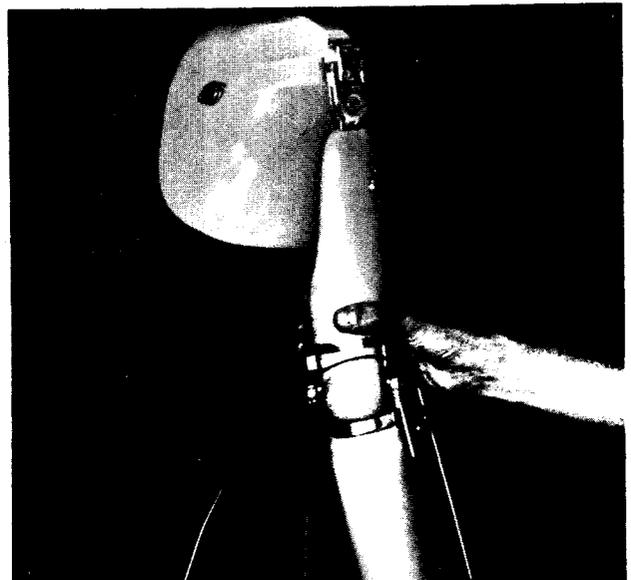
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Preparing the Arm for the Patient

1. Drill a 1 inch hole in the medial side of the humeral section and clear the foam at the turntable nut for installation and friction adjustment later.

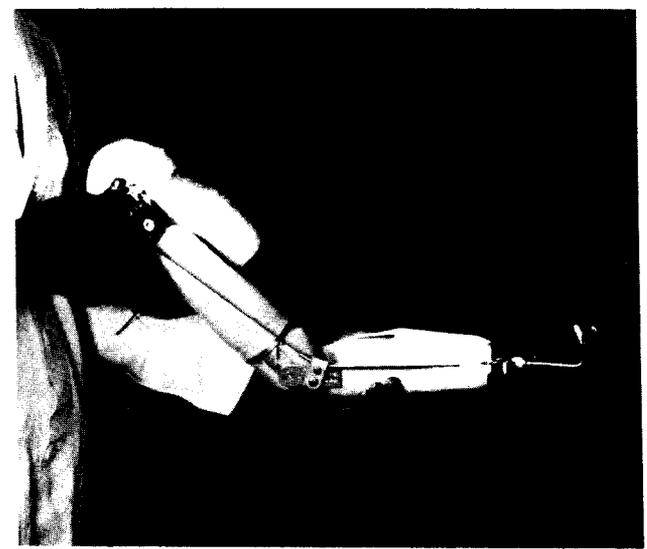


2. Assemble the elbow unit, forearm and terminal device to the humeral section. Attach the adjustable elbow flexion attachment at the lateral elbow joint and, if desired, the elbow spring assist device to the medial side of the elbow joint.



- 3. Cut the following:
 - a length of cable to reach from the terminal device through the elbow flexion attachment to the shoulder joint and medially approximately 3 inches past the edge of the socket.
 - a length of large cable housing to reach from the wrist to the elbow joint center.
 - a length of large cable housing to reach from the lateral elbow joint center to the shoulder joint and medially about 1 inch past the edge of the socket.

- 4. Swage or solder a triple swivel terminal to the cable and connect to the terminal device. Attach and cut the lower cable housing as shown. It should not interfere with the terminal device opening and should extend about 1/2 inch proximal to the elbow flexion attachment loop. The loop should now be riveted to securely hold the housing.



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5. Pronate the terminal device and extend the elbow for maximum cable excursion. Run the cable past the shoulder joint center so the cable will not inhibit shoulder joint motion. The cable should follow a smooth curve at the shoulder joint.

Place a base plate on the humeral section so that the control cable will pass anterior to the elbow joint axis approximately 1 inch when the elbow is extended. Moving the base plate attachment point on the humeral section to a lateral position increases the distance away from the elbow axis. Moving it toward the posterior decreases the distance.

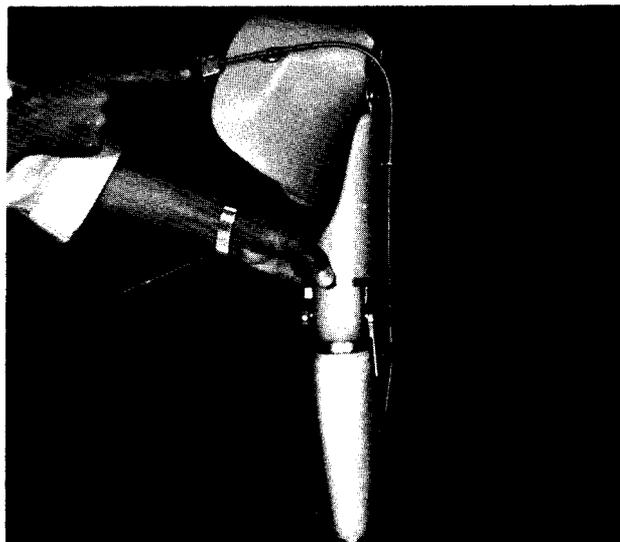
Temporarily position the base plate on the socket at mid scapula or so that there will be a smooth transition from the shoulder joint to the control strap. Plan to reposition if necessary during the harnessing.



6. Put two retainers on the upper cable housing and position the retainers and housing. The housing should follow a smooth line. The upper and lower cable housing should not meet when the elbow is fully flexed. The housing should extend to the edge of the socket.



7. Put the adjustable hanger on the cable so that it will not pinch the skin against the socket. Have the hook pronated and elbow extended at this time.



8. The waist band type elbow lock control will be shown here. Run the elbow lock cable and housing up by the shoulder joint center (so cable excursion will not change with shoulder joint motion) and down on the socket, as shown. The cable is ready to be connected to a waist band later. Put small anchors on the elbow lock cable housing to hold it in place and swage or solder a 1/2 inch hanger to the cable.

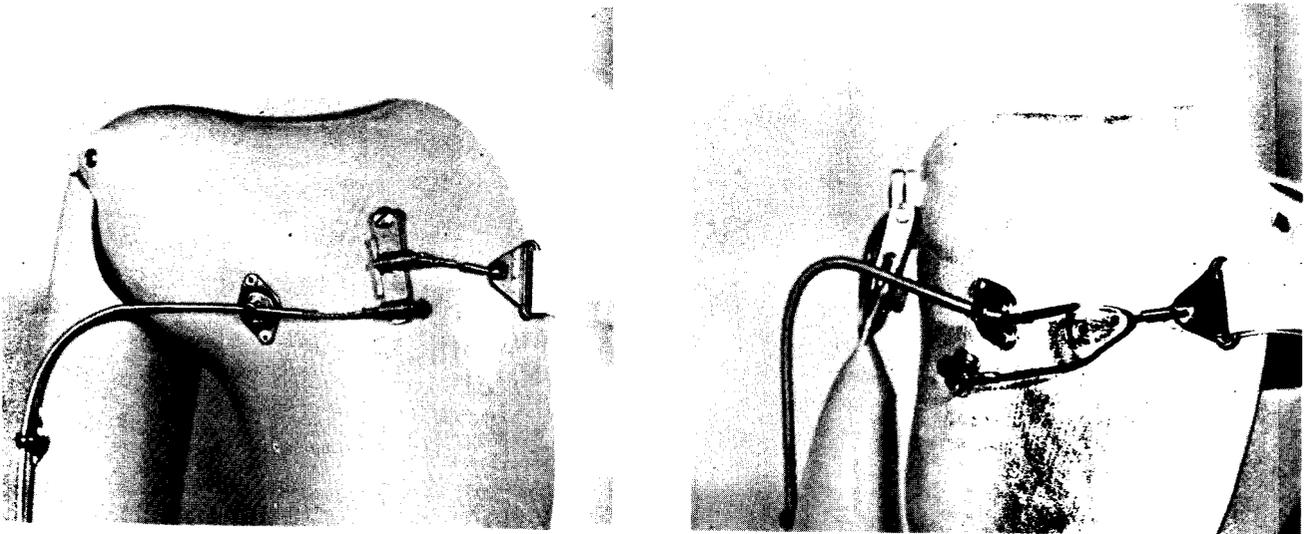


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2. Excursion Amplifiers

If the amputee has force but not enough excursion for control motion an excursion amplifier can be used. This decreases the required body excursion (but at the same time increases the required body force).

Two types of excursion amplifiers are shown below.



The pulley amplifier reduces the required body excursion in half (and doubles the required body force.) The mechanical advantage of the lever amplifier is that it can be varied by placement of the control strap cable on the lever.