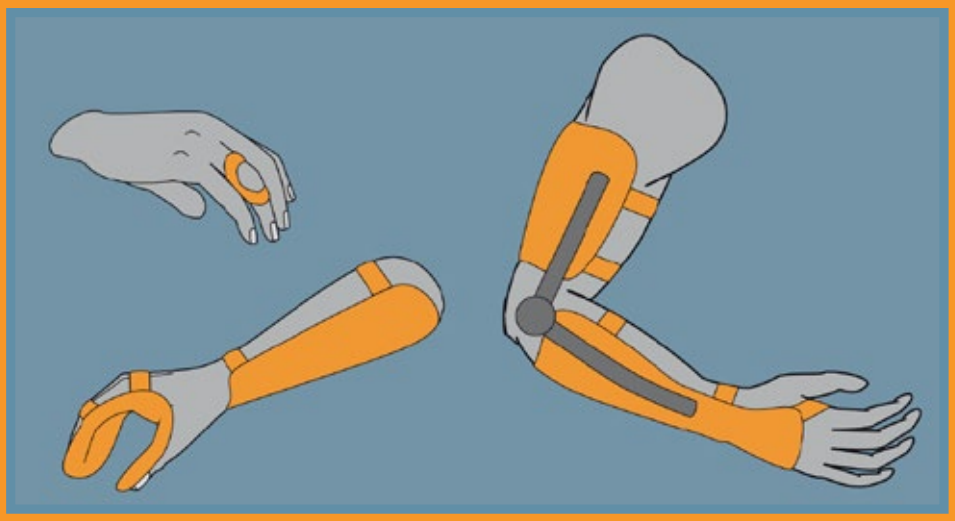
# MANUFACTURING GUIDELINES



# UPPER LIMB ORTHOSES

## Physical Rehabilitation Programme

ICRC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All photographs: ICRC/PRP

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# Foreword

## The ICRC polypropylene technology

Since its inception in 1979, the ICRC's Physical Rehabilitation Programme has developed – and promoted the use of – technology that is suited to the needs of specific contexts in which the organization operates, i.e. countries affected by war and low-income or developing countries.

The technology must also be adapted to the needs of the physically disabled in the countries concerned.

Therefore, it must be:

- durable, comfortable, easy to use and, for the user, easy to maintain as well;
- easy for professionals to repair;
- standardized, but compatible with the climate in different regions of the world;
- affordable, but modern and consistent with internationally accepted standards;
- readily available.

The choice of technology is of great importance for ensuring access to physical rehabilitation services and for promoting the sustainability of these services.

For all these reasons, the ICRC has chosen to develop its polypropylene technology instead of buying ready-made orthopaedic components, which are generally too expensive and unsuited to the contexts in which the organization works. The cost of the materials used in ICRC prosthetic and orthotic devices is less than that of the materials used in appliances assembled from commercial ready-made components.

When the ICRC launched its Physical Rehabilitation Programme in 1979, locally available materials such as wood, leather and metal were used, and orthopaedic components manufactured locally. In the early 1990s the ICRC began to standardize the techniques used in its various projects around the world; this was done for the sake of uniformity, but an even more important consideration was improving the quality of services for people with physical disabilities.

Polypropylene was introduced into ICRC projects in 1988, for manufacturing prosthetic sockets. The first polypropylene knee-joint was produced in Cambodia in 1991; other components, such as various alignment systems, were first developed in Colombia and gradually improved. In addition, a durable foot, made initially of polypropylene and ethylene vinyl acetate (EVA), and now of polypropylene and polyurethane, has replaced the traditional wooden/rubber foot.

In 1998, after careful consideration, it was decided to scale down local component production in order to focus on care for service users and training for personnel at country level.

## Objective of the manuals

The ICRC's *Manufacturing Guidelines* are designed to provide the information necessary to produce high-quality assistive devices.

The main aims of these informative manuals are as follows:

- to promote and enhance the standardization of ICRC polypropylene and low-temperature thermoplastic technologies;
- to provide support for training in the use of these technologies;
- to promote good practice.

This is another step forward in the effort to ensure that people with physical disabilities have access to appropriate services of good quality.

Physical Rehabilitation Programme
Health Unit
Assistance Division
ICRC

# Introduction

All orthotics should be prescribed by a doctor. Current upper-limb orthoses (ULO) can be ready-made or tailor-made, but both must be fitted to the patient by a professional (if possible, by an orthotist).

The aim of this document is to describe methods for manufacturing some of the most widely used ULO, working with polypropylene and low-temperature thermoplastic technologies. But the purpose of the document is not to detail all the existing ULO or to specify their positioning, which varies according to the pathology presented.

# Fundamentals

There are several ways of classifying orthoses:

- ready-made or tailor-made orthoses, depending on how they are manufactured
- functional/activity orthoses or inactivity orthoses, depending on their use
- articulated or unarticulated orthoses, depending on their design.

But in general, by combining several **mechanical principles**, orthoses achieve a variety of **therapeutic goals** and thus have many **indications**.

### Mechanical principles

One or several principles may be used in the same orthosis.

**Stabilization**
Stress on the segments is low.

**Motionless**
The segments are immobilized in a rest position.

**Mobile**
The orthosis guides segments in their movements.

***Free***
The segments can be moved in their full range of motion.

***With amplitude limitation***
Segment movements are limited to fixed minimum and maximum amplitudes.

### Posture

Constant directional force is applied to the segments.

**Static**

***Static and serial static***
The segments are immobilized in a stressed position and the correction is achieved by applying several orthoses (or modifications of the same orthosis), progressively positioning the segments in the desired position.

***Progressive static***
The segments are immobilized in a stressed position and the correction is achieved by using a non-elastic adjustable motor.

**Dynamic**

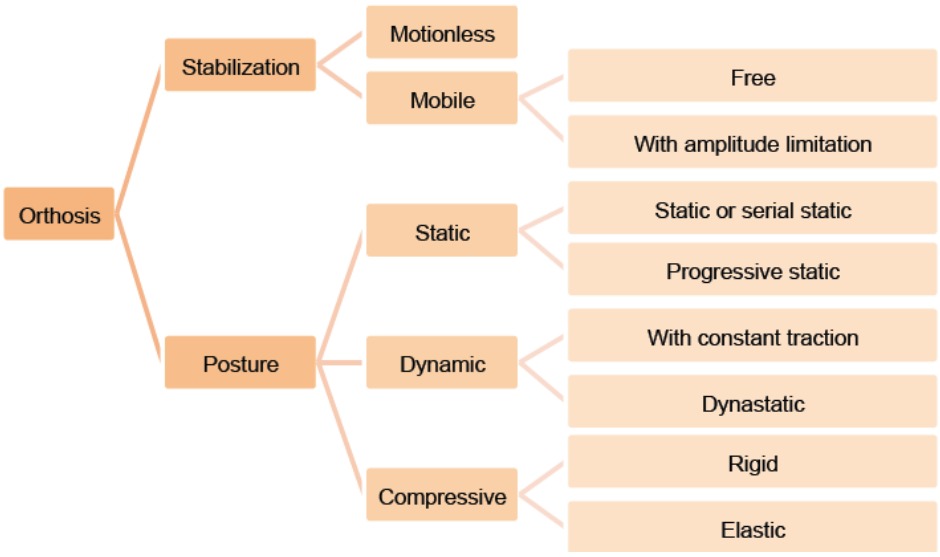
***With constant traction***
The force is exerted by an elastic or spring motor; it is constant, regardless of the position of the segments.

***Dynastatic***
The force becomes zero when the segments reach the desired position.

**Compressive**

***Rigid***
The force is continuous and is exercised by a rigid surface.

***Elastic***
The orthosis exerts an elastic stress, adapting to changes in segment volume but preventing any increase in that volume.




## Therapeutic goals and indications

**Immobilization**

*- of treatment areas*
The orthosis is worn at all times to promote healing (tendon and ligament injuries, etc.).

- ***during rest periods***
The orthosis is worn during periods of inactivity for its analgesic, anti-inflammatory and protective effects on the joints (rheumatoid arthritis, osteoarthritis, etc.).
Where there is constant pain with signs of inflammation, the orthosis immobilizes the affected joint plus the joint above and/or the joint below, as the case may be. Where there is active pain or permanent pain without signs of inflammation, the orthosis immobilizes only the joint involved.

**Stabilization**

***Free***
The orthosis stabilizes one or more joints in cases of deformity and improves the gesture (rheumatoid arthritis etc.).

***With amplitude limitation***
The orthosis prevents the joints from reaching painful or unstable amplitude sectors (dislocations etc.).

**Correction**

- ***of range of motion deficit (stiffness)***
The orthosis positions segments to recover lost range of motion (tendon adhesions, capsular ligament retractions, etc.). The device is of no use in cases of strictly passive limitation (ankylosis, arthrodesis, etc.).

- ***of deformity***
The orthosis positions the segments in the physiological functional position to combat the deformity.

**Compensation of a motor deficit**
The orthosis positions the segments to compensate the affected muscle groups and avoid muscle power imbalances leading to deformities and retractions (central and peripheral paralysis, etc.).

**Compression**

***Rigid***
By exerting constant compression on the healing areas, the orthosis reduces the neovascularization that is responsible for hypertrophic scars (burns etc.).

***Elastic***
By exerting variable compression, depending on segment volume, the orthosis promotes the reabsorption of subcutaneous collections of fluid (post-traumatic or venolymphatic oedema, etc.).

**Guiding cutaneous healing**
The orthosis positions the segments in a position of maximum cutaneous stretch where there is a retractile scar (burns etc.).

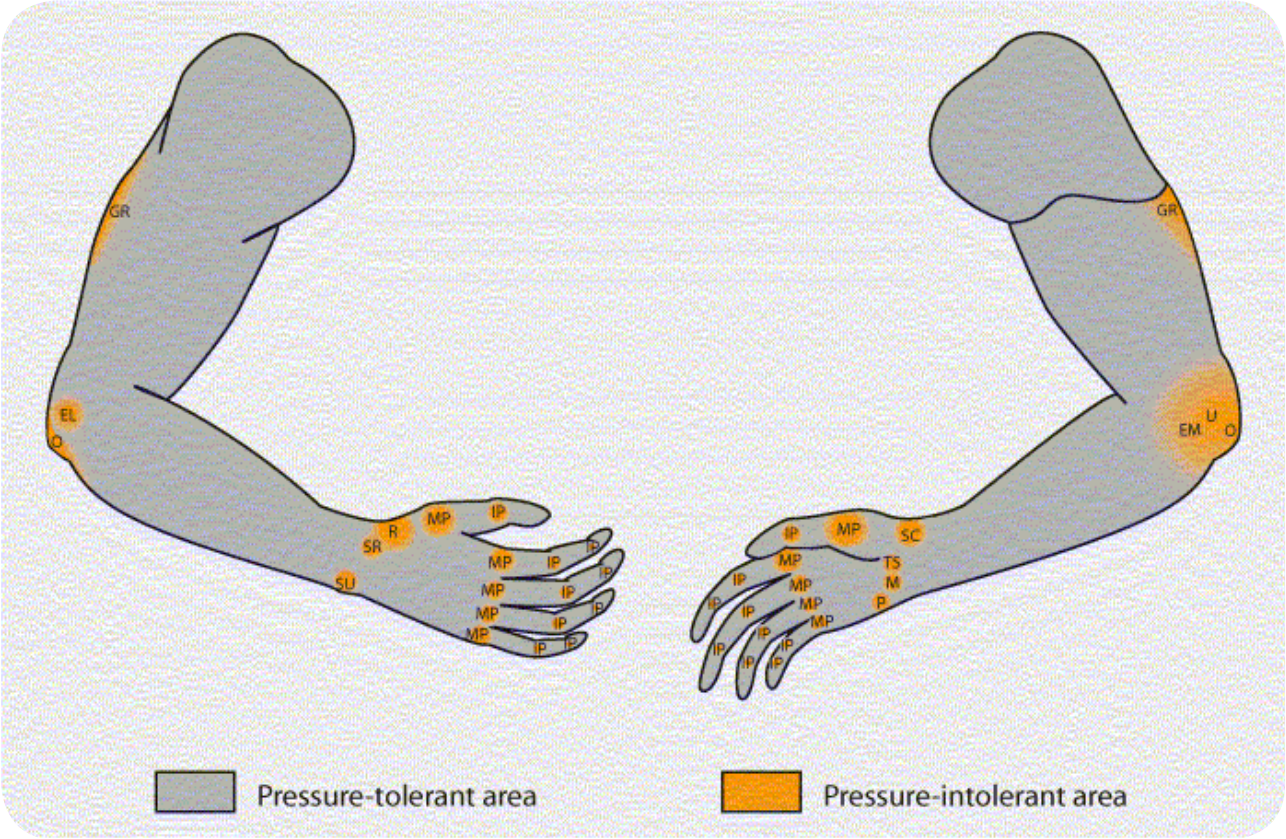
# Casting and rectification

Patient assessment, casting and rectification of positive cast impressions are performed in accordance with prosthetic and orthotic (P&O) standards.

Casting includes numerous variables (wrist included or not, angulations of the joints, and so on), depending on the type of orthosis to be created and the indication.

### Rectification

The correction will free a space in bony areas and areas of nerve vulnerability in the upper limb.

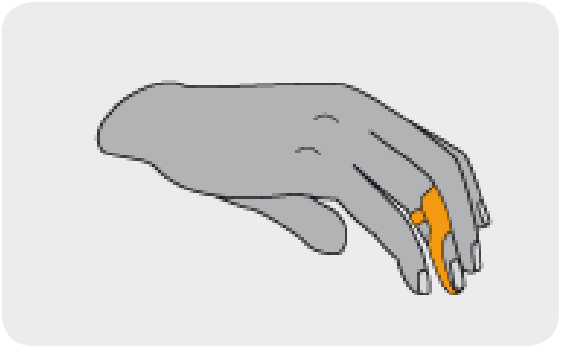



Bony areas:
EL (Lateral epicondyle), O (olecranon), SU (Ulnar styloid), SR (Radial styloid),
MP (Metacarpophalangeal joint), IP (Interphalangeal joint)
TS (Scaphoid tubercule), P (Pisiform), SC (Scaphoid), EM (Medial epicondyle).
Nerve vulnerability areas:
GR (Radial or torsion gutter of the radial nerve), R (Radial nerve), M (Median nerve),
U (Ulnar nerve).

# 1 STATIC INTERPHALANGEAL SPLINT (STAX FINGER SPLINT)

LTT

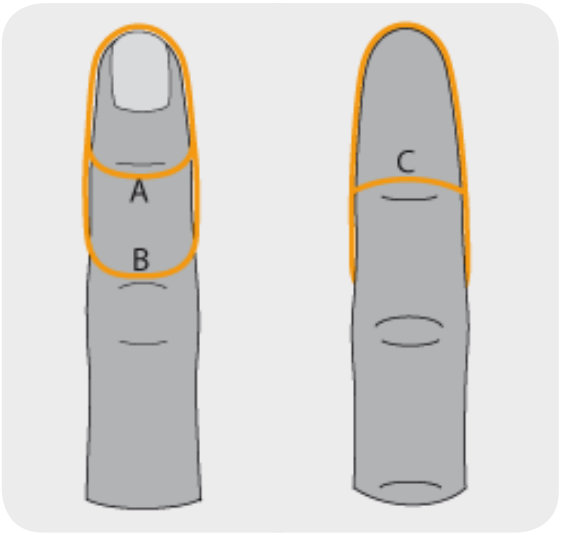
## 1.1. Action



- Stabilization and static posture in extension of the distal or proximal interphalangeal joint.
- Immobilization of treatment areas or during rest periods, correction of range of motion deficit or deformity and compensation of motor deficit (also stabilization with amplitude limitation).
- Can be used upside down to produce the opposite effect.

## 1.2. Trim line of the splint

### 1.2.1. Static distal interphalangeal splint, Stax finger splint




This orthosis can be adapted to the four distal interphalangeal joints of the hand.

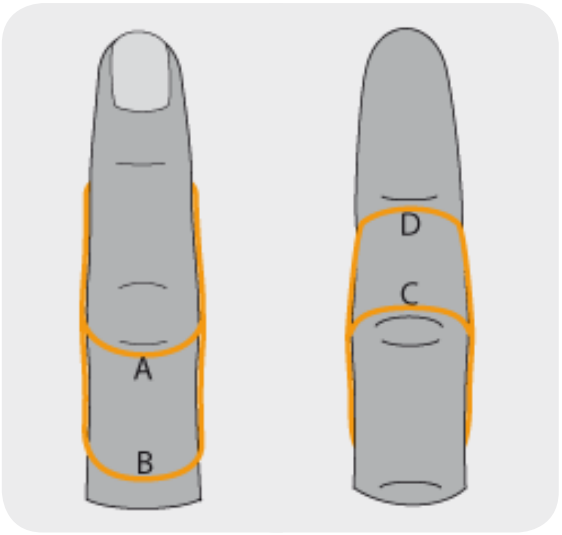
Mark the trim line as follows:

**A** On the dorsum of the finger, the distal edge is proximal to the distal interphalangeal joint.

**B** On the dorsum of the finger, the proximal edge is distal to the proximal interphalangeal joint.

**C** On the palmar face of the finger, the proximal edge is distal to the distal interphalangeal joint.

### 1.2.2. Static proximal interphalangeal splint




This orthosis can be adapted to the five proximal interphalangeal joints of the hand.

Mark the trim line as follows:

**A** On the dorsum of the finger, the distal edge is proximal to the proximal interphalangeal joint.

**B** On the dorsum of the finger, the proximal edge is distal to the metacarpophalangeal joint.

**C** On the palmar face of the finger, the distal edge is proximal to the distal interphalangeal joint, allowing it to flex (except for the thumb).

**D** On the palmar face of the finger, the proximal edge is distal to the proximal interphalangeal joint.

### 1.3. Creating a paper pattern

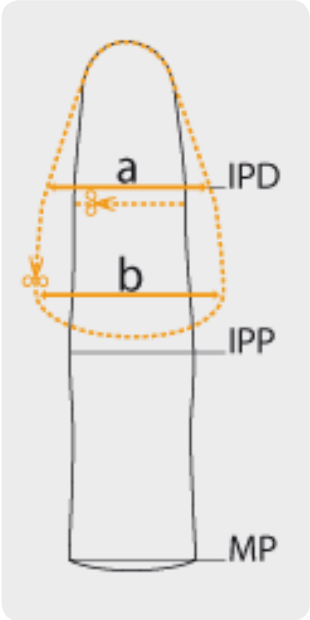
#### 1.3.1. Static distal interphalangeal splint, Stax finger splint

Position the patient's hand flat on a sheet of paper with the fingers extended and slightly abducted.

Draw the outline of the finger and mark the interphalangeal joints (IPP and IPD).
Measure the circumference of the finger at the distal interphalangeal joint and distally to the proximal interphalangeal joint.

Draw the pattern as illustrated:

- At the distal interphalangeal joint (IPD), the width of the pattern (a) is equal to half the circumference of the finger there.
- Slightly distally to the proximal interphalangeal joint (IPP), the width of the pattern (b) is equal to half the circumference of the finger there.
- Make a slit the width of the finger proximally to the distal interphalangeal joint (IPD).
- The pattern should be rounded and must not have any angles.




Cut out the paper pattern and try it on the patient's finger; check that the ends match.

#### 1.3.2. Static proximal interphalangeal splint

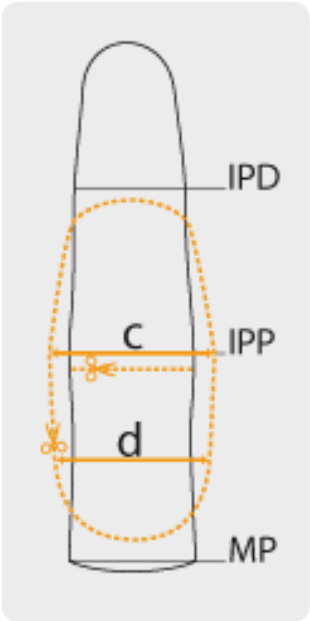
Position the patient's hand flat on a sheet of paper with the fingers extended and slightly abducted.

Draw the outline of the finger and mark the proximal interphalangeal and metacarpophalangeal joints (IPP and MP).

Measure the circumference of the finger at the proximal interphalangeal joint and distally to the metacarpophalangeal joint.

Draw the pattern as illustrated:

- At the proximal interphalangeal joint (IPP), the width of the pattern (c) is equal to half the circumference of the finger there.
- Slightly distally to the metacarpophalangeal joint (MP), the width of the pattern (d) is equal to half the circumference of the finger there.
- Make a slit the width of the finger proximally to the proximal interphalangeal joint (IPP).
- The pattern should be rounded and must not include angles.




Cut out the paper pattern and try it on the patient's finger; check that the ends match up.

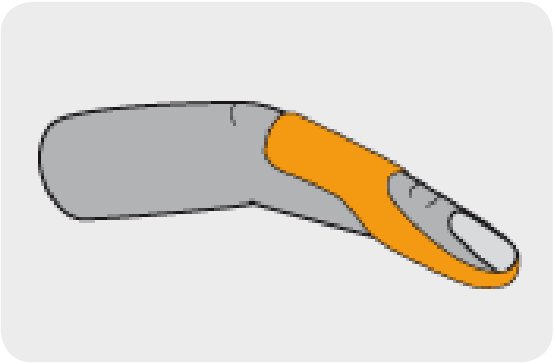
### 1.4. Cutting the low-temperature thermoplastic plate

Draw the pattern on a low-temperature thermoplastic plate.

Heat the plate in a bath at 65°C (C-Lite).

Cut the low-temperature thermoplastic plate on a support so as not to stretch the material.

### 1.5. Moulding the low-temperature thermoplastic



Position the patient's hand upright with the elbow on the table, the fingers slightly abducted, and the finger to be splinted straight.

Heat the plate in a bath at 65°C (C-Lite).

Insert the patient's finger into the slit, the rear part being dorsal.

Mould the thermoplastic, one hand forming the distal part and the other the proximal part. A twisted crease will appear on either side; flatten these creases gently.

### 1.6. Preparing the low-temperature thermoplastic shell

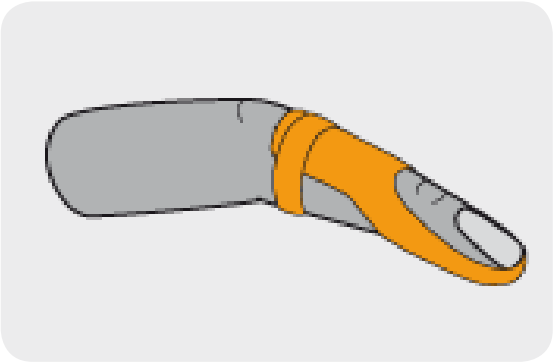
If necessary, grind and smooth the trim line.

### 1.7. Closure

Stick a Velcro hook 1 cm wide over the entire width of the back part of the splint.

Cut a Velcro loop strap 1 cm wide and hook it onto the Velcro hook at both ends.

### 1.8. Initial fitting and finishing



In accordance with international P&O standards, try the splint on the patient.

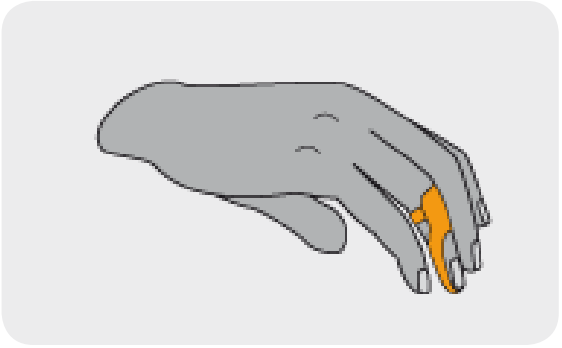
Modify the shell as required by reheating it locally with a hot-air gun (nozzle-tipped for greater precision), and then grind and smooth the shell.

Adjust the Velcro to reduce or limit the flexion of the interphalangeal joint as required.

## 2 STATIC INTERPHALANGEAL SPLINT (RING SPLINT)

LTT

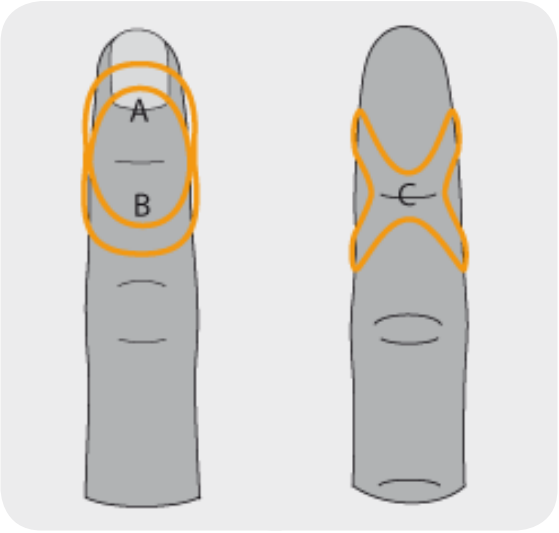
### 2.1. Action



- Mobile stabilization with extension limitation of the proximal or distal interphalangeal joint.
- Stabilization with amplitude limitation.
- Can be used upside down to produce the opposite effect.

### 2.2. Trim line of the splint

#### 2.2.1. Distal interphalangeal ring splint




This orthosis can be adapted to the four distal interphalangeal joints of the hand.

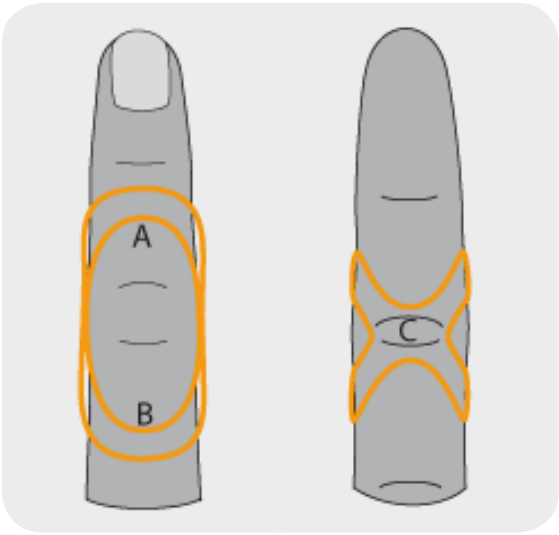
Mark the trim line as follows:

**A** On the dorsum of the finger, the distal part of the orthosis is distal to the distal interphalangeal skin folds.

**B** On the dorsum of the finger, the proximal part of the orthosis is proximal to the distal interphalangeal skin folds.

**C** On the palmar face of the finger, the orthosis is located on the flexion crease of the distal interphalangeal joint.

#### 2.2.2. Proximal interphalangeal ring splint




This orthosis can be adapted to the five proximal interphalangeal joints of the hand.

Mark the trim line as follows:

**A** On the dorsum of the finger, the distal part of the orthosis is distal to the proximal interphalangeal skin folds.

**B** On the dorsum of the finger, the proximal part of the orthosis is proximal to the proximal interphalangeal skin folds.

**C** On the palmar face of the finger, the orthosis is located on the flexion crease of the proximal interphalangeal joint.

### 2.3. Measuring and cutting the low-temperature thermoplastic plate

Measure the length of the figure-of-eight splint path using a tape:

- From the flexion crease on the palmar side of the finger, pass distal to the interphalangeal skin folds on the dorsum of the finger.
- Go around the finger to return to the flexion crease.
- Pass proximal to the interphalangeal skin folds of the dorsum of the finger and return to the flexion crease.

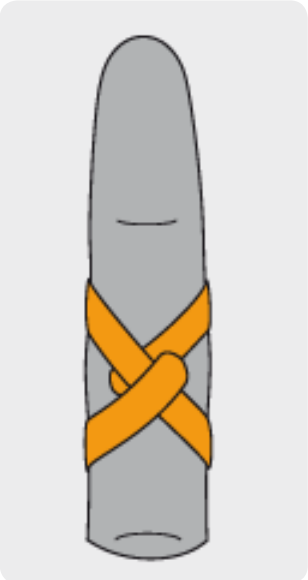
Cut a strip of thermoplastic 7 to 10 mm wide and the length of the splint path.

### 2.4. Moulding the low-temperature thermoplastic

Position the patient's hand upright with the elbow on the table, the fingers slightly abducted, and the finger to be splinted slightly flexed.

Heat the plate in a bath at 65°C (C-Lite).

Mould the thermoplastic describing the same figure-of-eight path as for the measuring.

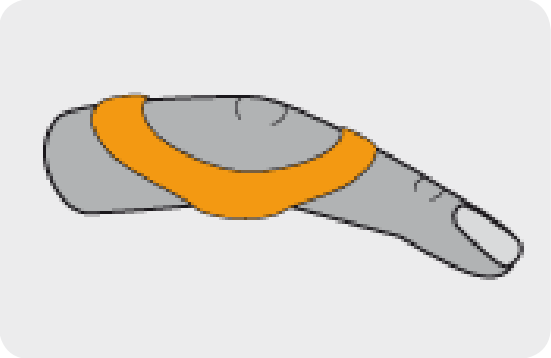


### 2.5. Preparing the low-temperature thermoplastic shell

If necessary, grind and smooth the trim line.

### 2.6. Initial fitting and finishing

In accordance with international P&O standards, try the splint on the patient.

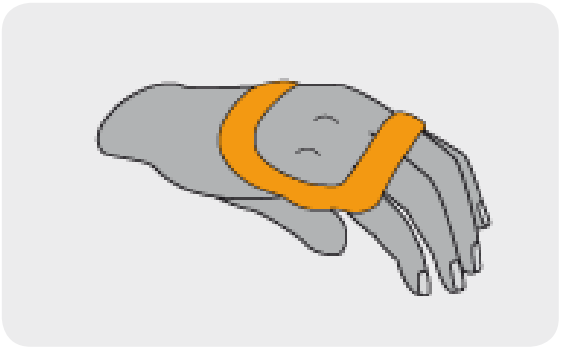


## 3 METACARPOPHALANGEAL BLOCK SPLINT (FIGURE-OF-EIGHT SPLINT)

LTT

### 3.1. Action

- Mobile stabilization with extension limitation of the metacarpophalangeal joints of the fingers (or only of the 4th and 5th), usually at 30-45° of flexion.
- Treatment, stabilization with amplitude limitation and compensation of motor deficit.



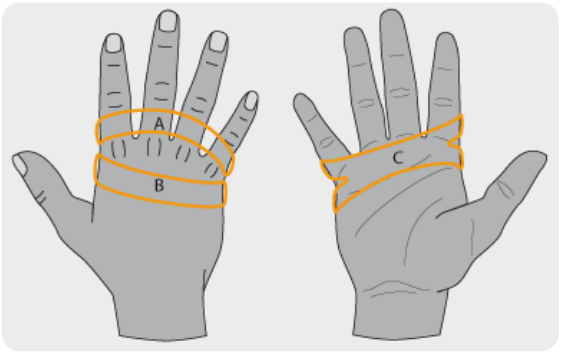
### 3.2. Trim line of the splint

Mark the trim line as follows:

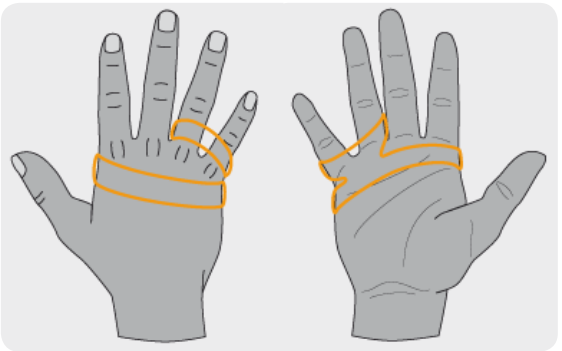
**A** On the dorsum of the hand, the distal part of the splint is distal to the metacarpophalangeal skin folds, bearing on the first phalanges.

**B** On the dorsum of the hand, the proximal part of the splint is proximal to the metacarpo-phalangeal skin folds, bearing on the metacarpals.

**C** On the palmar face of the hand, the orthosis is located on the metacarpal heads.




Note that the distal dorsal part must cover only the 4th and 5th finger (ulnar or medio-ulnar nerve palsy), passing between the 3rd and 4th finger to join the palmar part.



### 3.3. Measuring and cutting the low-temperature thermoplastic plate

Measure the figure-of-eight splint using a tape:

- Starting from the 5th metacarpal head on the palmar side of the hand, pass proximal to the metacarpophalangeal skin folds on the dorsum of the hand.
- Go through the 1st commissure to return to the 5th metacarpal head.
- Pass distal to the metacarpophalangeal skin folds on the dorsum of the hand and go through the 1st commissure (or between the 3rd and 4th finger if ulnar nerve palsy) to reach the 5th metacarpal head.

Cut a strip of thermoplastic 20 mm wide and the length of the splint path.

### 3.4. Moulding the low-temperature thermoplastic

Position the patient's hand upright with the elbow on the table and the fingers slightly abducted and flexed in the desired position.

Heat the plate in a bath at 65°C (C-Lite).

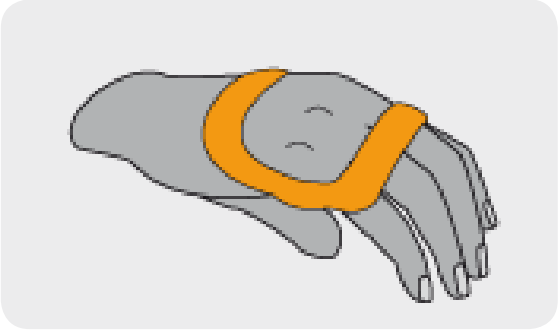
Mould the thermoplastic describing the same figure-of-eight as for the measuring.

### 3.5. Preparing the low-temperature thermoplastic shell

If necessary, grind and smooth the trim line.

### 3.6. Initial fitting and finishing

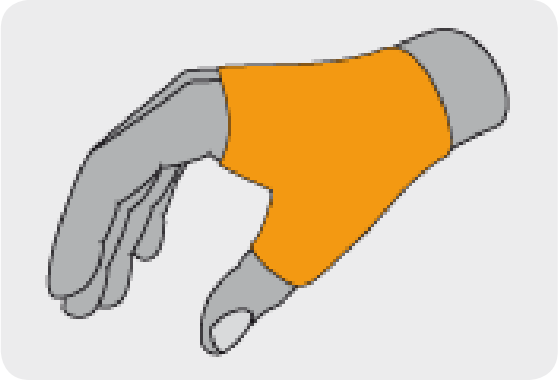
In accordance with international P&O standards, try the splint on the patient.



## 4 HAND-BASED THUMB IMMOBILIZATION SPLINT

### 4.1. Action

- Motionless stabilization and static posture of the trapeziometacarpal, metacarpophalangeal and interphalangeal joints (if included in the orthosis) of the thumb.
- Immobilization of treatment areas or during rest periods, correction of range of motion deficit or deformity and compensation of motor deficit.




### 4.2.Trim line of the splint

Mark the trim line as follows:

**A** On the dorsum of the hand, the distal edge is proximal to the metacarpal heads.

**B** On the dorsum of the hand, the proximal edge is distal to the ulnar styloid.

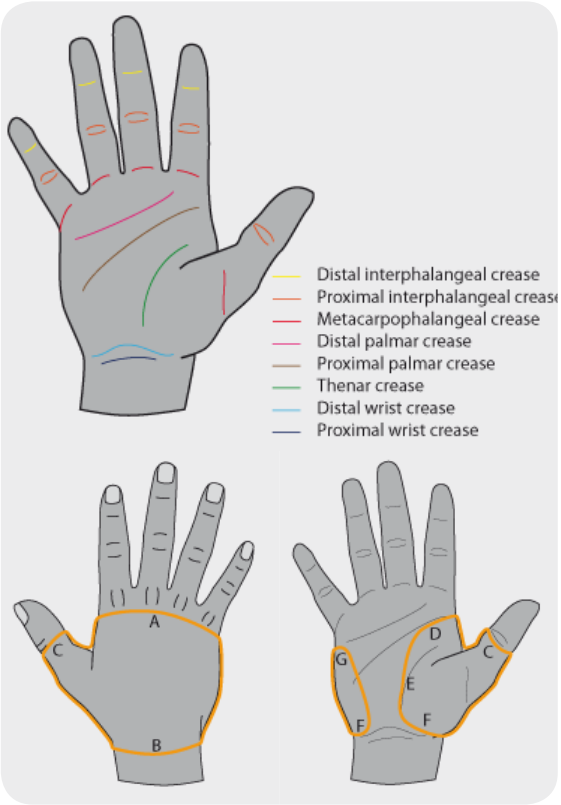
**C** At the thumb trough, the distal edge is proximal to the interphalangeal joint, if it has to be left free, or distal, if it has to be immobilized.

**D** On the palmar face of the hand, the distal edge of the C-bar is proximal to the proximal palmar crease, allowing free flexion of the 2nd finger.

**E** On the palmar face of the hand, the medial edge of the thumb trough includes the thenar crease to secure the thumb and stops distally to the distal wrist crease in order not to interfere with wrist motion.

**F** On the palmar face of the hand, the proximal edge stays distal to the distal wrist crease in order not to interfere with wrist motion.

**G** On the palmar face of the hand, the distal edge of the ulnar part is proximal to the distal palmar crease to allow flexion of the 5th finger.



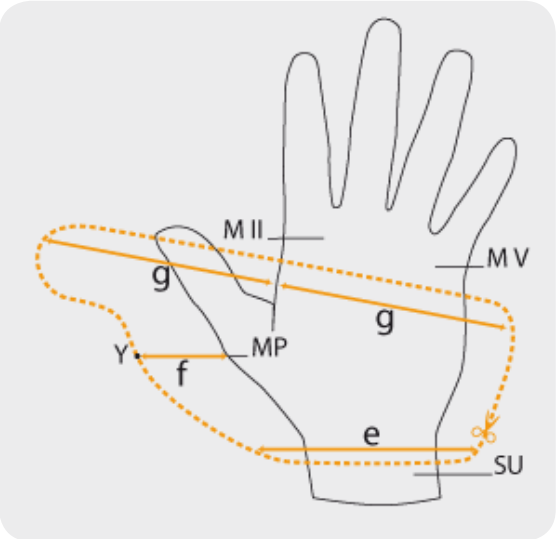
### 4.3. Creating a paper pattern

Position the patient's hand flat on a sheet of paper with the fingers extended and slightly abducted.

Draw the outline of the hand and mark the metacarpal heads of the 2nd and 5th finger, the ulnar styloid (SU) and the metacarpophalangeal joint of the thumb (MP).

Measure the circumference of the wrist.

Draw the pattern as illustrated:




- Draw the proximal edge of the pattern distally to the ulnar styloid, centred on the wrist, its width equal to half the circumference of the wrist (e).
- Draw the ulnar edge of the pattern, at the same distance from the outline of the hand, and stop proximally to the head of the 5th metacarpal (M V).
- Draw the distal edge of the pattern with a straight line proximal to the 5th and 2nd metacarpal heads and twice the width of the hand (g).
- Draw the radial edge of the pattern, first reaching a point (Y) 7-8 cm (f) outside the metacarpophalangeal joint of the thumb (MP) and then connecting with the proximal edge of departure.
- The pattern should be rounded and must not have any angles.

Cut out the paper pattern and try it on the patient's hand; check that the ends match up, especially around the thumb.

### 4.4. Cutting the low-temperature thermoplastic plate

Follow the procedure for cutting the low-temperature thermoplastic plate described in section 1.4.

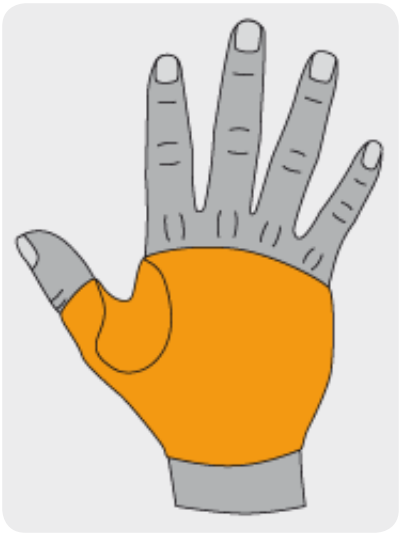
### 4.5. Moulding the low-temperature thermoplastic

Position the patient's hand upright with the elbow on the table, the fingers slightly abducted and the thumb in the desired position of immobilization (in the case of palmar abduction, make the tip of the thumb touch the 2nd and 3rd fingers).

Heat the plate in a bath at 65°C (C-Lite).

Mould the thermoplastic:

- The radial part of the pattern wraps around the thumb and goes through the first web space to be welded to the dorsal side of the splint.
- The ulnar part wraps around the hypothenar eminence.
- Flare the proximal edge at the wrist.
- Roll the distal edge of the thumb trough back to free the interphalangeal joint if it has to be left free.



### 4.6. Preparing the low-temperature thermoplastic shell

If necessary, grind and smooth the trim line.

### 4.7. Closure

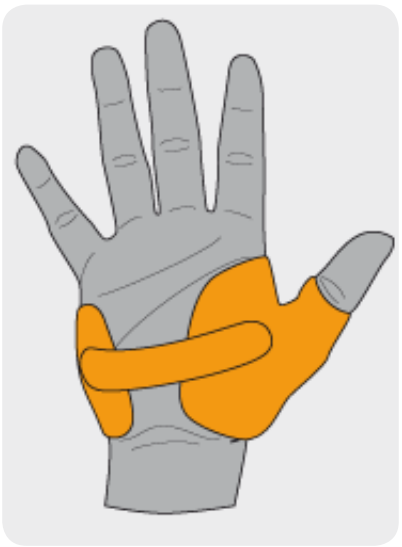
Glue a Velcro hook 3 cm wide to the palmar surface of the thumb trough (the edges can be embedded in the plastic with a soldering iron).

Hook a Velcro loop strap onto the thumb trough, mark its position on the palmar face of the ulnar part, and fix it by embedding it in the plastic, which has been preheated with a hot-air gun (or by sticking a Velcro hook 3 cm wide to the ulnar part).

### 4.8. Initial fitting and finishing

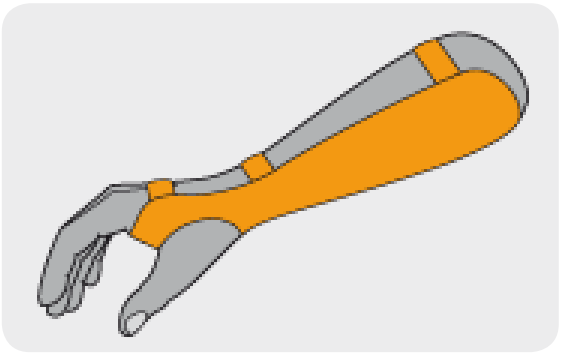
In accordance with international P&O standards, try the splint on the patient.

Modify the shell as required by reheating it locally with a hot-air gun (nozzle-tipped for greater precision), and then grind and smooth it.



## 5 WRIST IMMOBILIZATION SPLINT

### 5.1. Action



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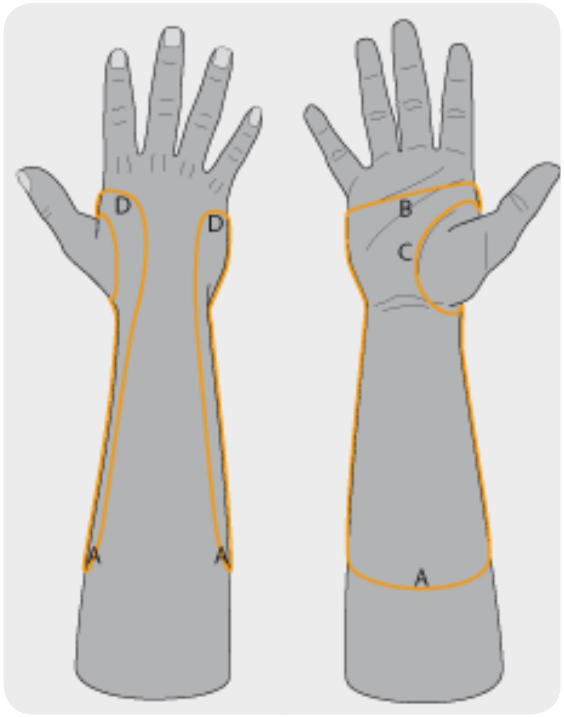
- Motionless stabilization and static posture of the wrist, splint with palmar, dorsal or ulnar shell.
- Immobilization of treatment areas or during rest periods, correction of range of motion deficit and compensation of motor deficit.
- Immobilization in maximum extension or flexion of the wrist is avoided (except for amplitude recovery) since it can cause carpal tunnel syndrome.

### 5.2. Trim line of the splint




Mark the trim line as follows:

**A** The proximal edge is located at the proximal third of the forearm.

**B** On the palmar face of the hand, the distal edge is proximal to the distal palmar crease from the 5th to the 3rd finger and proximal to the proximal palmar crease at the 2nd finger (for palmar creases see section 4.2).

**C** At the thumb, the edge leaves the thenar eminence free and follows the thenar crease on the palmar face.

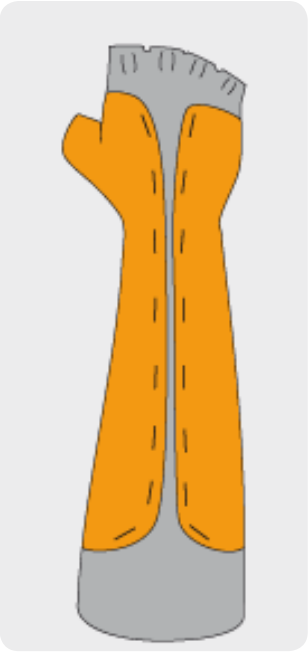
**D** On the dorsum of the hand, the distal edge is proximal to the metacarpal heads.

If the splint is made of polypropylene, continue with section 5.3; if it is made of low-temperature thermoplastic, skip to section 5.4.

### 5.3. Polypropylene splint

#### 5.3.1. The EVA layer

##### 5.3.1.1. Purpose of the EVA layer



The EVA layer (6 mm) can be moulded before the polypropylene is draped, for the following purposes:

- To improve comfort.
- To prevent skin breakage in patients with sensation loss.
- For orthoses used at night.

If EVA is not required, go directly to the section on vacuum-moulding the polypropylene.

##### 5.3.1.2. Moulding the EVA layer

Position the plaster model with the palm facing up.

Measurements of the sheet of EVA:

- Width = circumference of the elbow
- Length = length of the plaster model (forearm + hand)
- Thickness = 6 mm

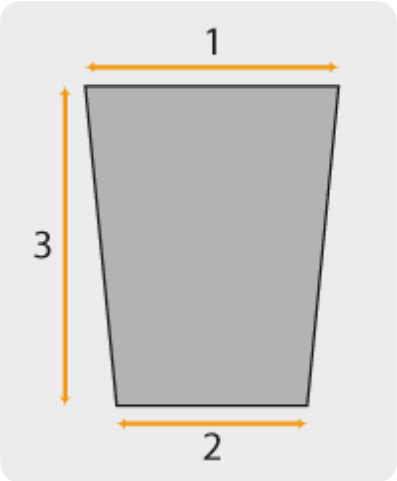
Heat the EVA at 120° for 3 to 5 minutes.

Drape the EVA manually over the plaster model and hold it in place until completely cool.

Cut off the surplus.

Staple the EVA onto the dorsal face of the plaster model.

### 5.3.2.Vacuum-moulding the polypropylene




Pull a stocking over the plaster model.

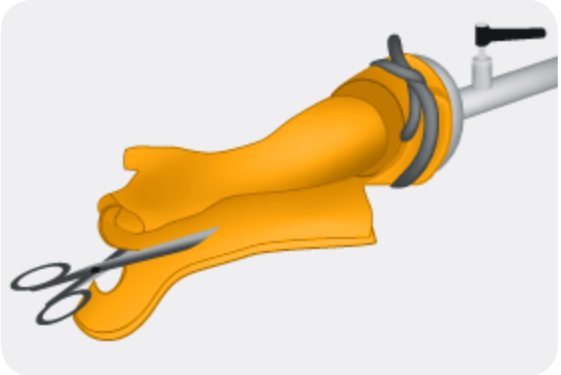
Dust the stocking with talcum powder.

Measurements of the sheet of polypropylene:

**1** Circumference of the elbow + 10 cm.
**2** Circumference of the hand + 10 cm.
**3** Length of the plaster model (forearm + hand) + 10 cm.

Thickness = 3 or 4 mm, depending on the patient's size.

Heat the polypropylene at 180° for 20 to 35 minutes, depending on the thickness of the material and the efficiency of the oven.



Drape the polypropylene over the plaster model and stick it together along the dorsal face.

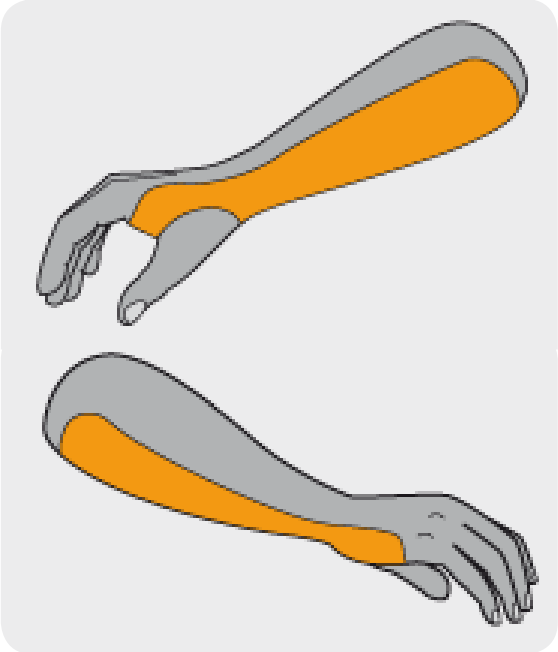
Using a cord or band, tighten the polypropylene around the suction cone.

Open the vacuum valve.

Cut off the surplus plastic while it is still hot.

Keep the vacuum on until the polypropylene cools.

### 5.3.3. Preparing the polypropylene shell



Draw the trim line on the plastic as described in section 5.2.

Following the outline, cut out the orthosis with an oscillating saw.

Remove the plastic shell from the plaster model and the stocking from inside the shell.

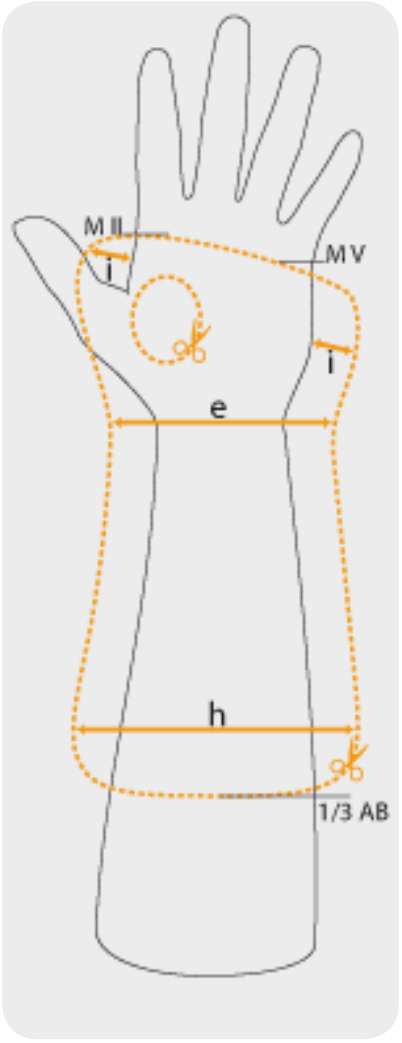
Grind and smooth the trim line.

If an EVA layer has been moulded, transfer the trim line to the EVA and cut off the surplus.

Then go to section 5.5.

## 5.4. Low-temperature thermoplastic splint

### 5.4.1. Creating a paper pattern




Position the patient's hand and forearm flat on a sheet of paper with the fingers extended and slightly abducted.

Draw the outline of the hand and forearm, mark the metacarpal heads of the 2nd (M II) and 5th (M V) fingers and the proximal third of the forearm (1/3 AB).

Measure the circumference of the wrist and of the forearm (at its proximal third).

Draw the pattern as illustrated:

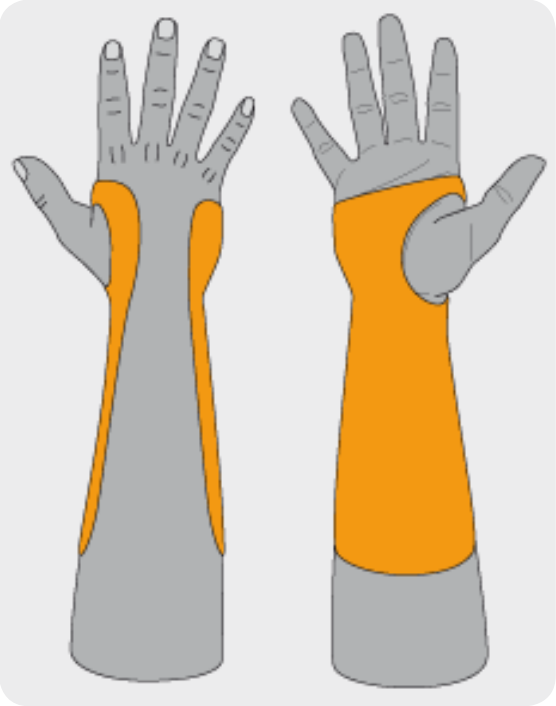
- At the proximal third of the forearm, draw the proximal edge of the pattern, centred on the forearm, its width equal to half of the circumference at this point (h).
- Draw the ulnar and radial edges in a straight line to the wrist, where the pattern is centred, its width equal to half the circumference of the wrist (e).
- Continue the ulnar and radial edges on either side of the palm at a distance of 3 cm (i) from the outline of the hand.
- Draw the distal edge of the pattern proximal to the metacarpal heads (M II and M V).
- Make a hole 3 cm in diameter, its border about 3 cm from the distal edge and 3 cm from the radial edge of the pattern.
- The pattern should be rounded and must not have any angles.

Cut out the paper pattern and try it on the patient's hand; check that the ends match up, especially around the thumb.

### 5.4.2. Cutting the low-temperature thermoplastic plate

Follow the procedure for cutting the low-temperature thermoplastic plate described in section 1.4.

### 5.4.3. Moulding the low-temperature thermoplastic



Position the patient's forearm on its dorsum, the wrist resting on a roll (rolled towel) and in the desired position of immobilization. The fingers should be slightly abducted and the thumb should touch the 2nd finger to preserve the physiological arches of the hand.

Heat the plate in a bath at 65°C (C-Lite).

Slip the patient's thumb into the hole in the plate.

- Mould the thermoplastic around the forearm and hand.
- Roll the plastic around the thenar eminence back to allow free motion of the thumb.
- Roll the plastic of the distal edge back to allow motion of the fingers.
- Flare the proximal edge.

### 5.4.4. Preparing the low-temperature thermoplastic shell

If necessary, grind and smooth the trim line.

## 5.5. Making the straps

### 5.5.1. Simple strap

This is preferred for low-temperature plastic orthotics and for closing small gaps as with patients of small size.

- Stick a Velcro hook onto the splint surface on both sides of the area to be closed (the edges can be embedded in the plastic with a soldering iron).
- Hook the ends of a Velcro loop strap onto the Velcro hooks (one end of the Velcro loop strap can also be fixed to the plastic with a tubular rivet).

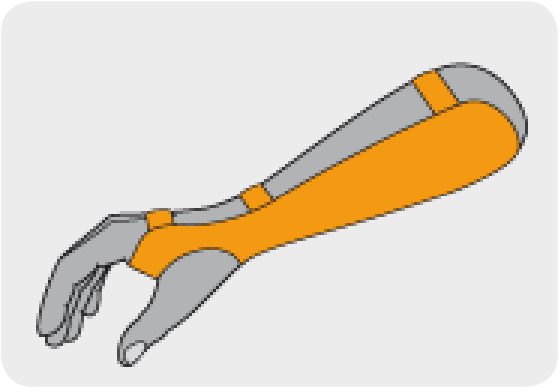
### 5.5.2. Strap with loop

This is preferred for polypropylene orthotics and when closure needs to be resistant. Sewn straps fit better and are more comfortable than the prefabricated ones.

- Fix the loop to the plastic orthosis (usually on the outside) with a tubular rivet; it should not be in contact with the patient's skin.
- Adjust the length of the straps once they have been fixed to the loop and, if possible, adjust again during the fitting.
- Fix the strap after making sure it is perpendicular to the general axis of the orthosis.
- Cover the surface of the strap in contact with the patient's skin with 3 mm EVA.

### 5.5.3. Positioning the straps

- One forearm strap fixed 10 mm from the proximal edge
- One wrist strap
- One hand strap fixed 10 mm from the distal edge



### 5.6. Initial fitting and finishing

If EVA foam is used, glue it temporarily to the inside of the orthosis.

Perform the initial fitting in accordance with P&O standards.

Modify the plastic as required and smooth the trim line.

If the inside is lined with EVA foam, glue it throughout, cut off the surplus and smooth the trim line.

## 6 THUMB AND WRIST IMMOBILIZATION SPLINT

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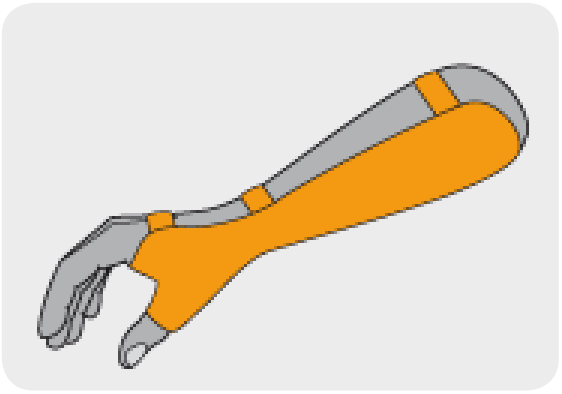
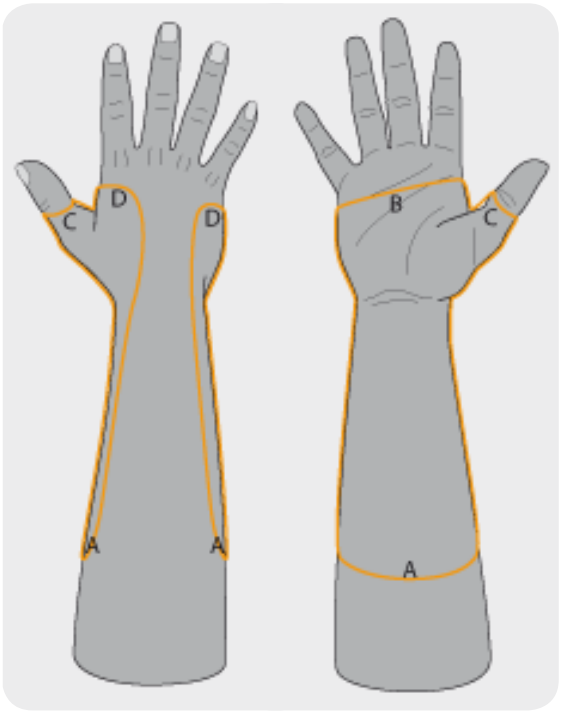
### 6.1. Action



- Motionless stabilization and static posture of the wrist and thumb.
- Immobilization of treatment areas or during rest periods, correction of range of motion deficit or deformity.

### 6.2. Trim line of the splint




Mark the trim line as follows:

**A** The proximal edge is located at the proximal third of the forearm.

**B** On the palmar face of the hand, the distal edge is proximal to the distal palmar crease from the 5th to the 3rd finger and proximal to the proximal palmar crease at the 2nd finger (see section 4.2. for palmar creases).

**C** At the thumb trough, the distal edge is proximal to the interphalangeal joint, if it has to be left free, or distal, if it has to be immobilized.

**D** On the dorsum of the hand, the distal edge is proximal to the metacarpal heads.

If the splint is made of polypropylene, continue with section 6.3; if it is made of low-temperature thermoplastic, skip to section 6.4.

### 6.3. Polypropylene splint

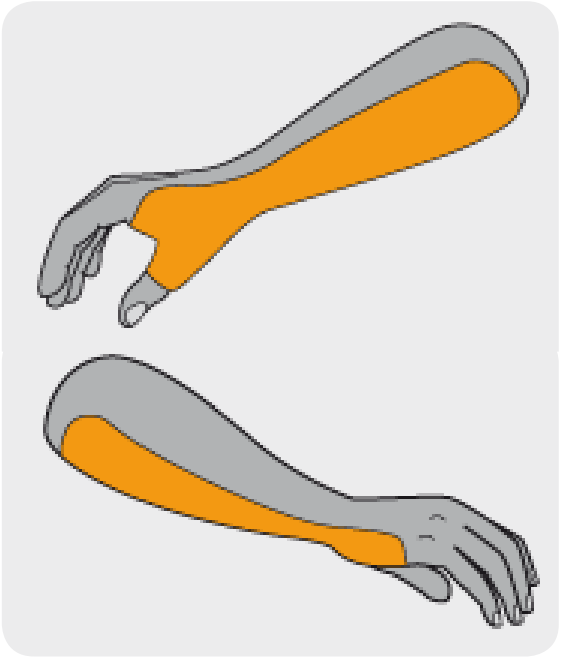
#### 6.3.1. Moulding the EVA layer

Follow the procedure for moulding the EVA layer described in section 5.3.1.

### 6.3.2. Vacuum-moulding the polypropylene

Follow the procedure for vacuum-moulding the polypropylene described in section 5.3.2.

If necessary, the polypropylene can be welded on the dorsal surface of the thumb as well as on the dorsum of the hand (D).



### 6.3.3. Preparing the polypropylene shell

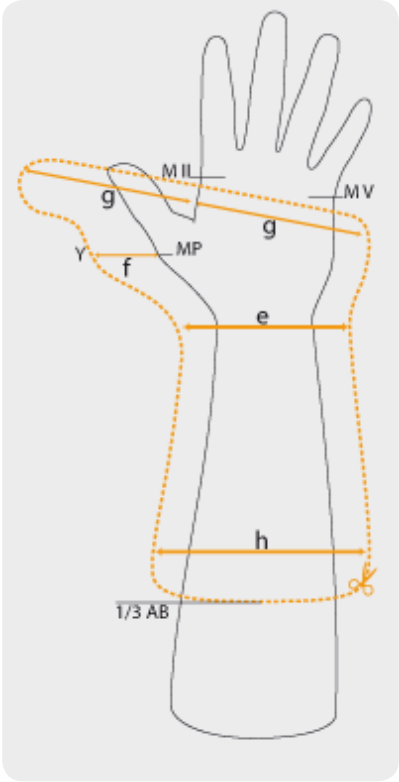
Follow the procedure for preparing the polypropylene shell described in section 5.3.3.

Note that the method for cutting the shell is described in section 6.2.

Then go to section 6.5.

## 6.4. Low-temperature thermoplastic splint

### 6.4.1. Creating a paper pattern




Position the patient's hand and forearm flat on a sheet of paper with the fingers extended and slightly abducted.

Draw the outline of the hand and forearm, mark the metacarpal heads of the 2nd (M II) and 5th (M V) fingers, the metacarpophalangeal joint (MP) of the thumb and the proximal third of the forearm (1/3 AB).

Measure the circumference of the wrist and of the forearm (at its proximal third).

Draw the pattern as illustrated:

- At the proximal third of the forearm, draw the proximal edge of the pattern, centred on the forearm, its width equal to half of the circumference at this point (h).
- Draw the ulnar and radial edges in a straight line to the wrist, where the pattern is centred, its width equal to half the circumference of the wrist (e).
- Continue the ulnar edge of the pattern at the same distance from the outline of the hand and stop proximally to the head of the 5th metacarpal (M V).
- Draw the distal edge of the pattern in a straight line proximal to the 5th and 2nd metacarpal heads and twice the width of the hand (g).
- Finish the radial edge of the pattern, first reaching a point (Y) 7-8 cm (f) outside the metacarpophalangeal joint of the thumb (MP), and then connecting with the radial edge, which has already been drawn, to the wrist.
- The pattern should be rounded and must not have any angles.

Cut out the paper pattern and try it on the patient's hand; check that the ends match up, especially around the thumb.

### 6.4.2. Cutting the low-temperature thermoplastic plate

Follow the procedure for cutting the low-temperature thermoplastic plate described in section 1.4.

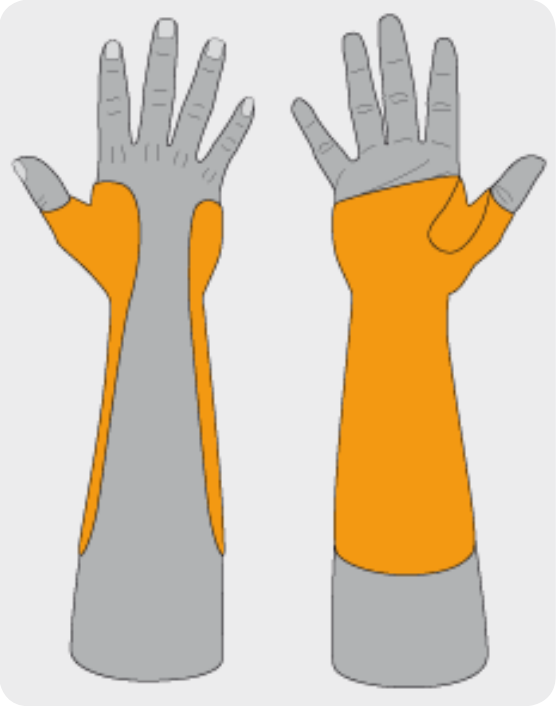
### 6.4.3. Moulding the low-temperature thermoplastic

Position the patient's hand raised with the palm facing up, the elbow on the table, the fingers slightly abducted, and the thumb in the desired position of immobilization (in the case of palmar abduction, make the tip of the thumb touch the 2nd and 3rd fingers).

Heat the plate in a bath at 65°C (C-Lite).

Mould the thermoplastic:

- The radial part of the pattern wraps around the thumb and goes through the first web space to be welded on the palmar side of the splint.
- The ulnar part wraps around the hypothenar eminence.
- Mould the forearm.
- Flare the proximal edge.
- Roll the distal edge of the thumb trough back to free the interphalangeal joint if it has to be left free.
- Roll the plastic of the distal edge back to free finger motion.

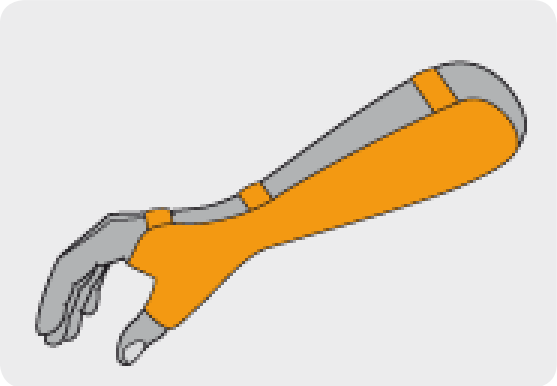


### 6.4.4. Preparing the low-temperature thermoplastic shell

If necessary, grind and smooth the trim line.

### 6.5. Making the straps

For the straps, follow the procedure described in section 5.5.



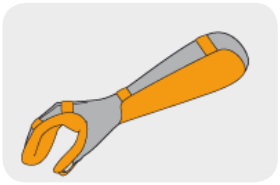
### 6.6. Initial fitting and finishing

Follow the procedure for the initial fitting and finishing described in section 5.6.

## 7 HAND AND WRIST IMMOBILIZATION SPLINT

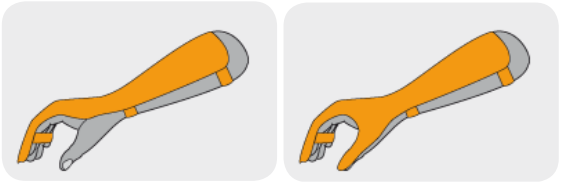
### 7.1. Action

#### 7.1.1. Palmar shell



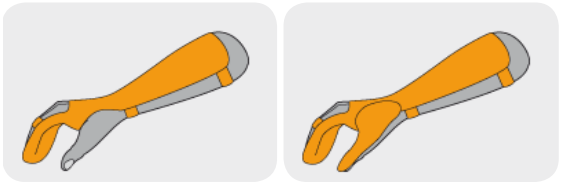

- Motionless stabilization and static or compressive posture of the wrist and hand.
- Immobilization of treatment areas or during rest periods, correction of range of motion deficit or deformity, compensation of motor deficit and rigid compression (also to guide cutaneous healing).

#### 7.1.2. Dorsal shell




- Motionless stabilization and static or compressive posture of the wrist and hand.
- Immobilization of treatment areas, stabilization with amplitude limitation, compensation of motor deficit and rigid compression (also to guide cutaneous healing).

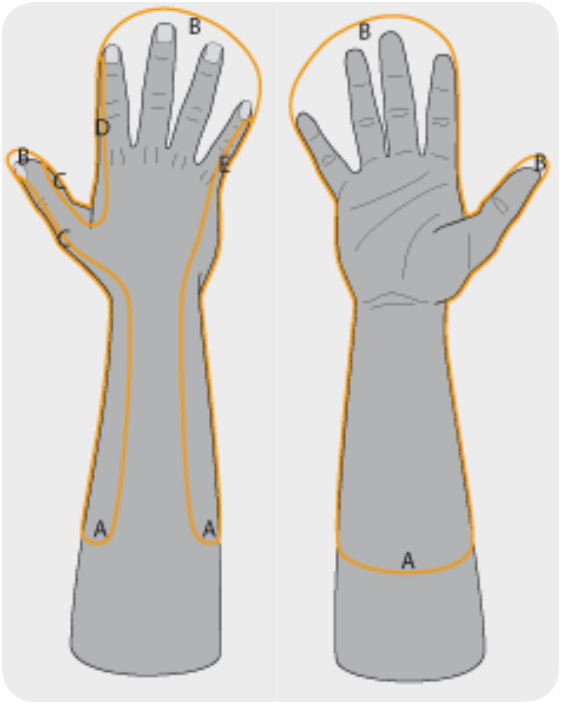
#### 7.1.3. Compound shell




- Static posture of the wrist and hand.
- Correction of range of motion deficit or deformity.

### 7.2. Trim line of the splint

#### 7.2.1. Palmar shell




Mark the trim line as follows:

**A** The proximal edge is located at the proximal third of the forearm.

**B** The distal edge extends 1 cm beyond the fingertips.

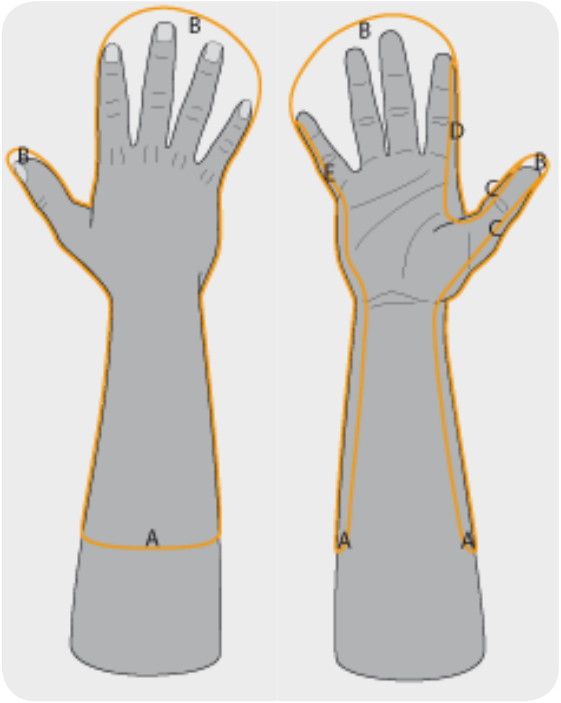
**C** At the thumb, the edge curves up 1 cm on either side.

**D** At the index (2nd finger), the edge curves up 1 cm on the radial side.

**E** At the little finger (5th finger), the edge curves up 1 cm on the ulnar side.

If the splint is made of polypropylene, continue with section 7.3; if it is made of low-temperature thermoplastic, skip to section 7.4.

### 7.2.2. Dorsal shell

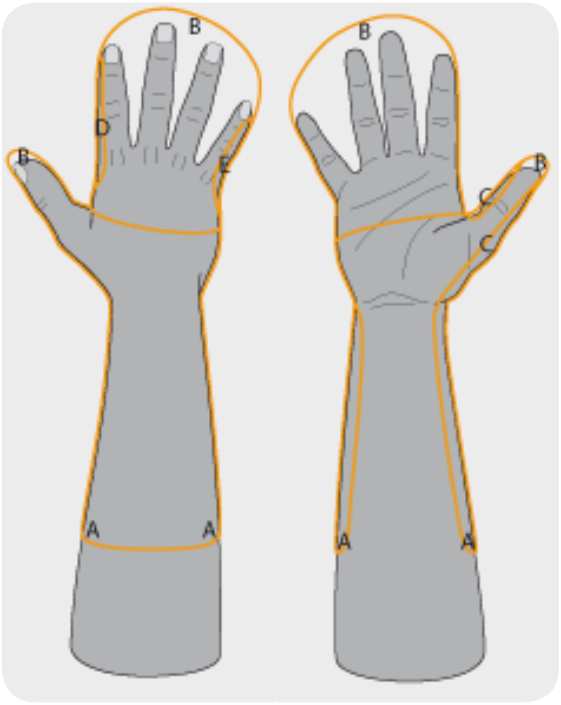



Mark the trim line as follows:

- **A** The proximal edge is located at the proximal third of the forearm.
- **B** The distal edge extends 1 cm beyond the fingertips.
- **C** At the thumb, the edge curves down 1 cm on either side.
- **D** At the index (2nd finger), the edge curves down 1 cm on the radial side.
- **E** At the little finger (5th finger), the edge curves down 1 cm on the ulnar side.

If the splint is made of polypropylene, continue with section 7.3; if it is made of low-temperature thermoplastic, skip to section 7.4.

### 7.2.3. Compound shell




Mark the trim line as follows:

- **A** The proximal edge is located at the proximal third of the forearm.
- **B** The distal edge extends 1 cm beyond the fingertips.
- **C** At the thumb, the edge curves down 1 cm on either side.
- **D** At the index (2nd finger), the edge curves up 1 cm on the radial side.
- **E** At the little finger (5th finger), the edge curves up 1 cm on the ulnar side.

If the splint is made of polypropylene, continue with section 7.3; if it is made of low-temperature thermoplastic, skip to section 7.4.

### 7.3. Polypropylene splint

#### 7.3.1. Moulding the EVA layer

Follow the procedure for moulding the EVA layer described in section 5.3.1.

#### 7.3.2. Vacuum-moulding the polypropylene

Follow the procedure for vacuum-moulding the polypropylene described in section 5.3.2.

Note that the welding of polypropylene will be dorsal for a palmar splint and palmar for a dorsal splint. If necessary, the polypropylene will be welded at the thumb in addition to the hand.

#### 7.3.3. Preparing the shell

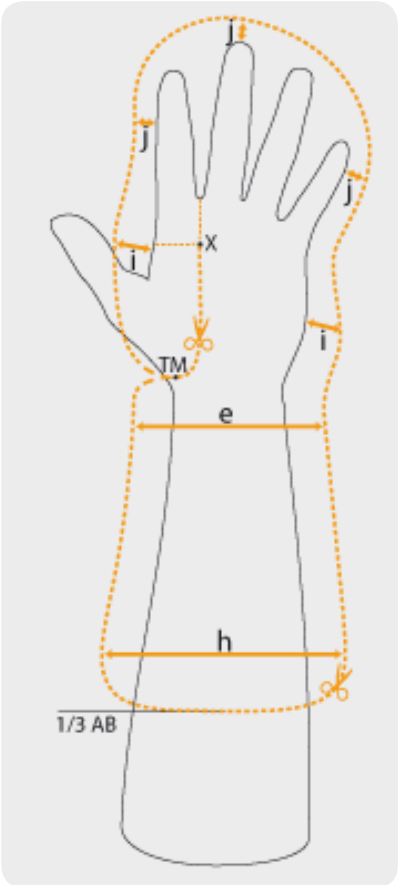
Follow the procedure for preparing the shell described in section 5.3.3.

Note that the method for cutting the shell is described in section 7.2.

Then go to section 7.5.

### 7.4. Low-temperature thermoplastic splint

#### 7.4.1. Creating a paper pattern




**Palmar shell**

Position the patient's hand and forearm flat on a sheet of paper with the fingers extended and slightly abducted.

Draw the outline of the hand and forearm, mark the trapeziometacarpal joint (TM) and the proximal third of the forearm (1/3 AB).

Measure the circumference of the wrist and of the forearm (at its proximal third).

Draw the pattern as illustrated:

- At the proximal third of the forearm, draw the proximal edge of the pattern, centred on the forearm, its width equal to half of the circumference at this point (h).
- Draw the ulnar and radial edges in a straight line to the wrist where the pattern is centred, its width equal to half the circumference of the wrist (e). The line of the radial edge then joins the trapeziometacarpal joint (TM).
- Continue the ulnar edge of the pattern at a distance of 3 cm from the outline of the palm (i) and then 1 cm from the 5th finger (j).
- Draw the distal edge of the pattern at a distance of 1 cm from the outline of the fingers (j).
- Finish the radial edge of the pattern first at a distance of 1 cm from the outline of the 2nd finger (j) and then 3 cm from the palm (i) curving round to the trapeziometacarpal joint (TM).
- Mark a point (X) in line with the second commissure and the top of the first commissure and draw a cut from this point (X) curving round to the trapeziometacarpal joint (TM).
- The pattern should be rounded and must not have any angles.

Cut out the paper pattern and try it on the patient's hand; check that the ends match up, especially around the thumb.

### Dorsal shell

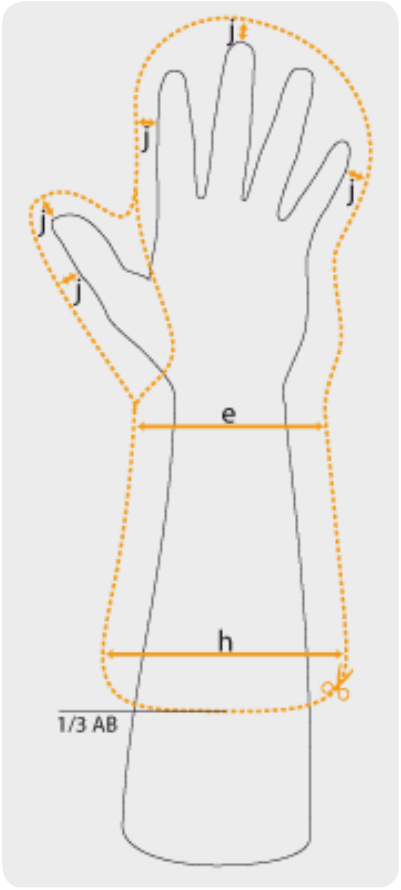
Position the patient's hand and forearm flat on a sheet of paper with the fingers extended and slightly abducted.

Draw the outline of the hand and forearm and mark the proximal third of the forearm (1/3 AB).
Measure the circumference of the wrist and of the forearm (at its proximal third).

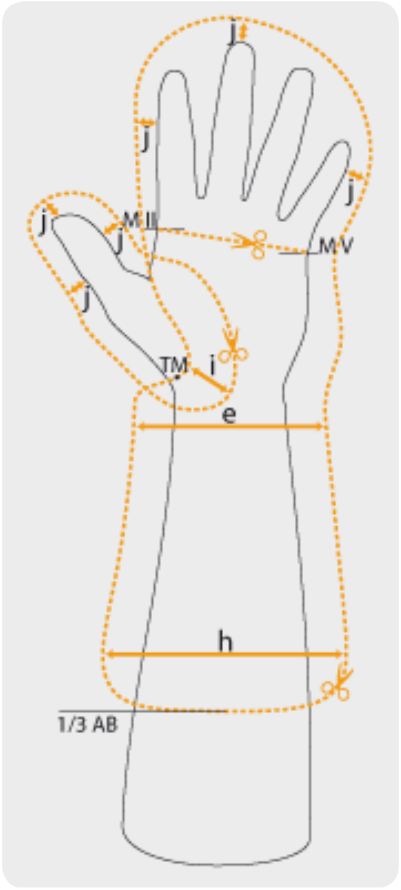
Draw the pattern as illustrated:

- At the proximal third of the forearm, draw the proximal edge of the pattern, centred on the forearm, its width equal to half of the circumference at this point (h).
- Draw the ulnar and radial edges in a straight line to the wrist where the pattern is centred, its width equal to half the circumference of the wrist (e).
- Complete the pattern by drawing the contour of the hand and fingers at a distance of 1 cm from the outline (j).
- Note that the splint can leave the thumb free; if this is the case, remove the thumb area of the pattern including the thenar eminence.
- The pattern should be rounded and must not have any angles.

Cut out the paper pattern and try it on the patient's hand; check that the ends match up.



**Compound shell**




Position the patient's hand and forearm flat on a sheet of paper with the fingers extended and slightly abducted.

Draw the outline of the hand and forearm and mark the trapeziometacarpal joint (TM), the metacarpal heads of the 2nd (M II) and 5th (M V) fingers and the proximal third of the forearm (1/3 AB).

Measure the circumference of the wrist and of the forearm (at its proximal third).

Draw the pattern or patterns as illustrated:

- At the proximal third of the forearm, draw the proximal edge of the pattern, centred on the forearm, its width equal to half of the circumference at this point (h).
- Draw the ulnar and radial edges in a straight line to the wrist where the pattern is centred, its width equal to half the circumference of the wrist (e). The line of the radial edge then curves round to the trapeziometacarpal joint (TM).
- Continue the ulnar edge of the pattern at a distance of 3 cm from the outline of the palm (i) and then 1 cm from the 5th finger (j).
- Draw the distal edge of the pattern at a distance of 1 cm from the outline of the fingers (j).
- Finish the radial edge of the pattern first at a distance of 1 cm from the outline of the 2nd finger (j) and then 3 cm from the palm (i) finally curving round to the trapeziometacarpal joint (TM).
- If the thumb is inside the splint, make a second pattern by drawing the outline of the thumb at a distance of 1 cm from its border (j) and overlapping with the first pattern by 3 cm at the root of the finger (i).
- The pattern should be rounded and must not have any angles.

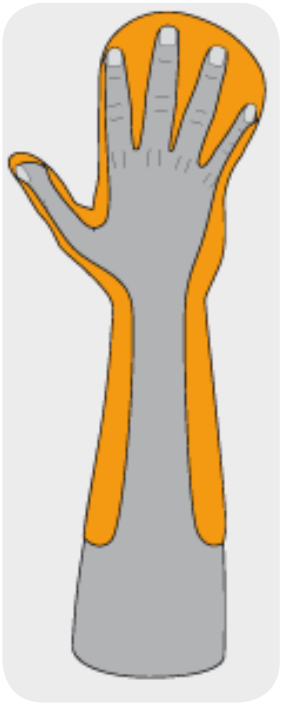
Cut out the paper pattern and try it on the patient's hand; check that the ends match up.

### 7.4.2. Cutting the low-temperature thermoplastic plate

Follow the procedure for cutting the low-temperature thermoplastic plate described in section 1.4.

### 7.4.3. Moulding the low-temperature thermoplastic

#### Palmar shell

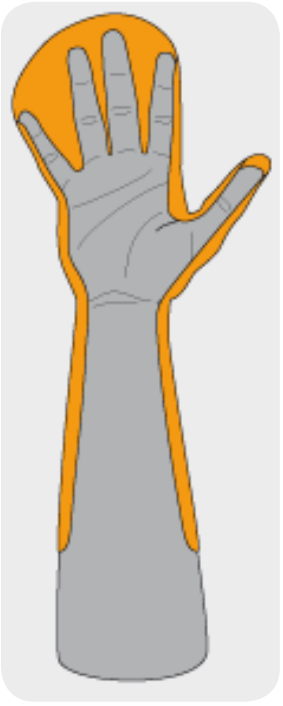


Position the forearm of the patient on its dorsum, the wrist resting on a roll (rolled towel) and in the desired position of immobilization. The fingers should be slightly abducted and the thumb in the correct position.

Heat the plate in a bath at 65°C (C-Lite).

- Mould the thermoplastic around the forearm, hand and thumb.
- Flare the proximal edge.

#### Dorsal shell

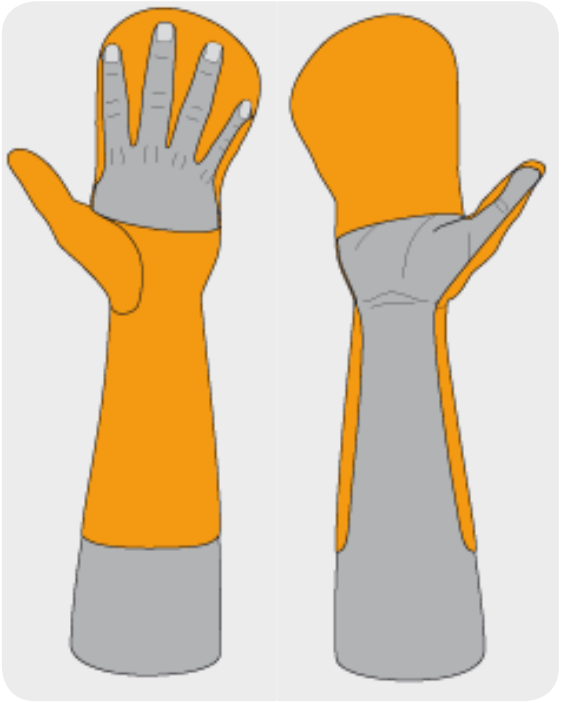


Position the patient's hand raised with the palm facing down, the elbow on the table, the fingers slightly abducted and the wrist and fingers in the desired position of immobilization.

Heat the plate in a bath at 65°C (C-Lite).

- Mould the thermoplastic around the forearm, hand and thumb if included.
- Flare the proximal edge.

**Compound shell**



Position the patient's hand upright with the elbow on the table, the fingers slightly abducted and the wrist and fingers in the desired position of immobilization.

Heat the main plate in a bath at 65°C (C-Lite).

Slide the hand into the slot of the plate as far as the first commissure, leaving the thumb outside.

- Mould the thermoplastic on the dorsum of the forearm and the palmar face of the hand.
- Flare the proximal edge.

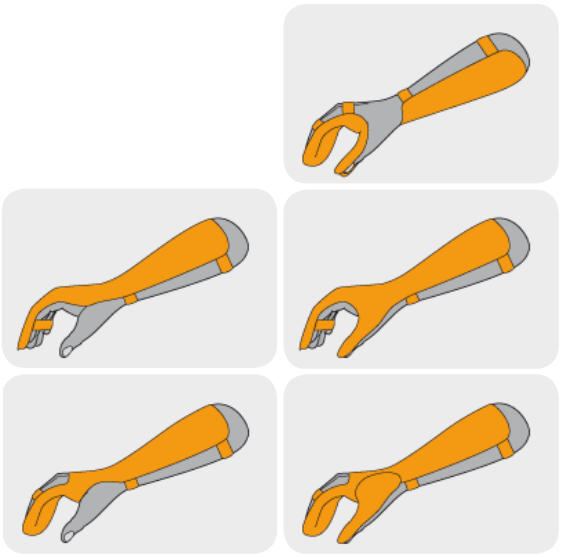
If the thumb is included in the splint:

- Heat the thumb plate in a bath at 65°C (C-Lite).
- Heat the base of the thumb part of the moulded shell with a hot-air gun and reposition the shell on the patient.
- Stick the thumb plate in place and mould the thumb.

### 7.4.4. Preparing the low-temperature thermoplastic shell

If necessary, grind and smooth the trim line.

### 7.5. Making the straps



#### 7.5.1. Simple strap

See section 5.5.1.

#### 7.5.2. Strap with loop

See section 5.5.2.

#### 7.5.3. Positioning the straps

- One forearm strap fixed 10 mm from the proximal edge
- One wrist strap
- One hand strap proximal to the metacarpophalangeal joints of the fingers
- One finger strap at the proximal interphalangeal joints of the fingers
- One thumb strap proximal to the interphalangeal joint

### 7.6. Initial fitting and finishing

Follow the procedure for the initial fitting and finishing described in section 5.6.

# 8 ELBOW AND WRIST IMMOBILIZATION ORTHOSIS

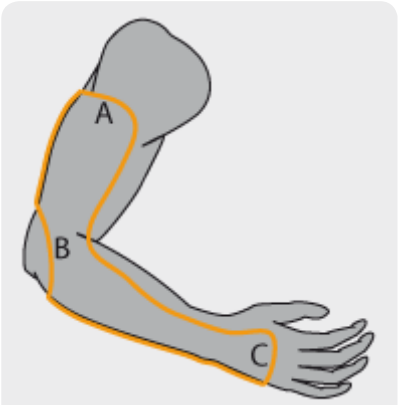
LTT

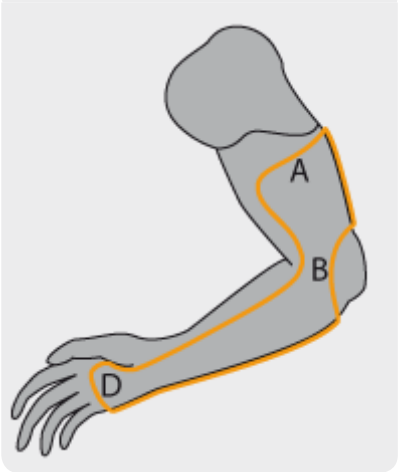
PP

## 8.1. Action

- Motionless stabilization and static posture of the elbow and wrist.
- Immobilization of treatment areas or during rest periods, correction of range of motion deficit or deformity and compensation of motor deficit.

## 8.2. Trim line of the orthosis




Mark the trim line as follows:

**A** The proximal edge starts 2 cm below the axilla and rises over the external face of the arm.

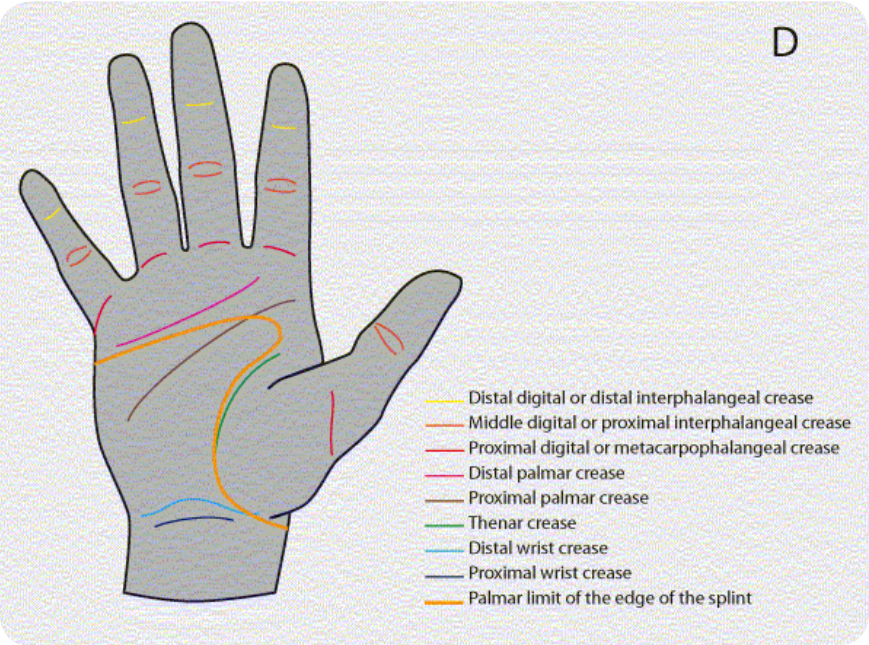
**B** At the elbow, the cut can leave the olecranon and epicondyles free (note that this reduces the firmness and strength of the orthosis).

**C** On the dorsum of the hand, the cut leaves the thenar eminence free and stops proximally to the metacarpal heads.

**D** On the palmar face of the hand, the cut follows the thenar crease and stays proximal to the proximal palmar crease at the 2nd finger and to the distal palmar crease from the 3rd to the 5th finger.

This cut allows free motion of the fingers.
The lower edge can also be cut straight, proximal to the ulnar styloid, thus freeing wrist motion and making a simple elbow immobilization orthosis.

If the splint is made of polypropylene, continue with section 8.3; if it is made of low-temperature thermoplastic, skip to section 8.4.




### 8.3. Polypropylene splint

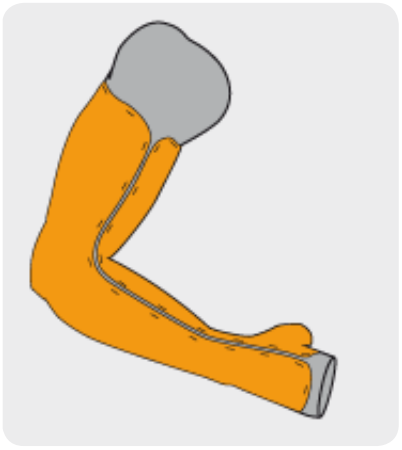
#### 8.3.1. The EVA layer

##### 8.3.1.1. Purpose of the EVA layer

See section 5.3.1.1.

##### 8.3.1.2. Moulding the EVA layer

Position the plaster model with the hand pointing slightly down.



Measurements of the sheet of EVA:

- Width = circumference of the arm
- Length = length of plaster model (arm + forearm + hand)
- Thickness = 6 mm

Heat the EVA at 120° for 3 to 5 minutes.

Drape the EVA manually over the plaster model and hold it in place until completely cool.

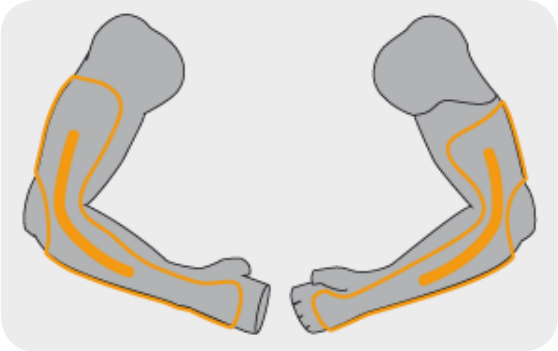
Cut off the surplus.

Staple the EVA onto the biceps on the upper arm and along the radial/dorsal edges of the forearm and hand.

### 8.3.2. Reinforcing the plastic

The elbow orthosis may need reinforcement, particularly at elbow level.

#### Channels in polypropylene



Channels are made in the polypropylene by fixing strips of EVA to the positive before the polypropylene is thermoformed. The presence of channels in the plastic significantly improves its strength.

Cut the strips of EVA:

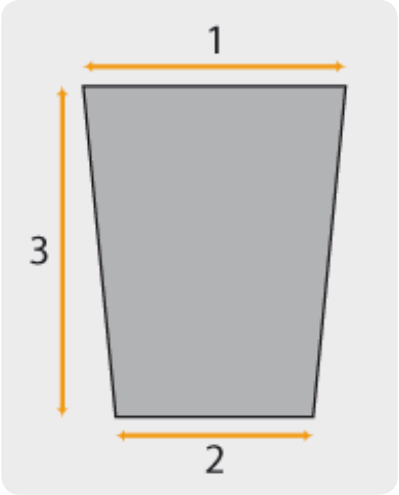
- Thickness = 6 mm
- Width = 7 mm or more
- Length = approx. 15 cm

Grind both distal and proximal ends to gradually reduce the thickness of the EVA.

Pull a stocking over the plaster model.

Glue the strips lightly onto the stocking on either side of the elbow joint keeping well inside the edges.

### 8.3.3. Vacuum-moulding the polypropylene




Pull a stocking over the plaster model, if this has not already been done.

Dust the stocking with talcum powder.

Measurements of the sheet of polypropylene:

**1** Circumference of the upper arm + 10 cm
**2** Circumference of the hand + 10 cm
**3** Length of the plaster model (arm + forearm + hand) + 10 cm

Thickness = 3, 4 or 5 mm depending on the patient's size.

Heat the polypropylene at 180° for 20 to 40 minutes, depending on the thickness of the material and the efficiency of the oven.

Drape the polypropylene over the plaster model and stick it together along the biceps of the arm and along the radial/dorsal edges of the forearm and hand (depending on the casting position).

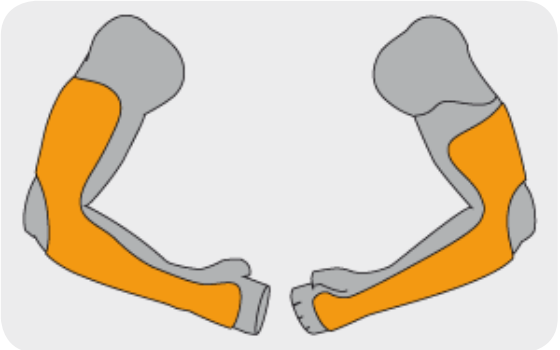
Using a cord or band, tighten the polypropylene around the suction cone.

Open the vacuum valve.

Cut off the surplus plastic while it is still hot.

Keep the vacuum on until the polypropylene cools.

### 8.3.4. Preparing the shell



Draw the trim line on the polypropylene as described in section 8.2.

Cut out the orthosis with an oscillating saw, following the outline.

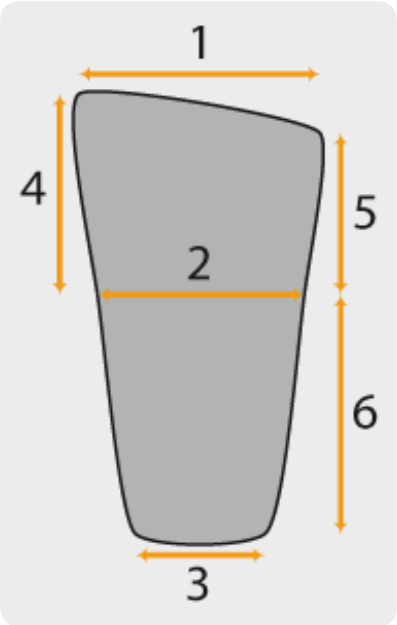
Remove the plastic shell from the plaster model and the stocking from inside the shell.

Grind and smooth the trim line.

If an EVA layer has been moulded, transfer the trim line to the EVA and cut off the surplus.

Then go to section 8.5.

### 8.4. Low-temperature thermoplastic splint




For patients of small size requiring no significant restraint.

#### 8.4.1. Creating a paper pattern

Draw a simplified pattern on a sheet of paper as illustrated:

1. Half the circumference of the upper arm
2. Half the circumference of the elbow
3. Half the circumference of the hand
4. Length of the outside edge of the orthosis on the upper arm
5. Length of the inside edge of the orthosis on the upper arm
6. Length of the forearm and hand

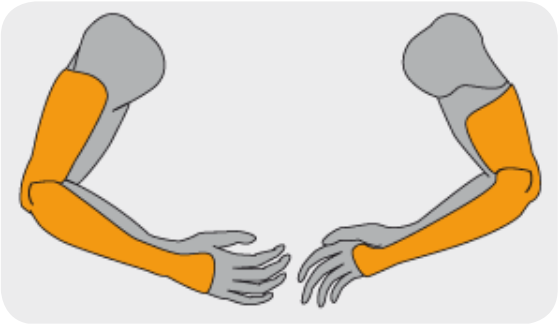
The pattern should be rounded and must not have any angles.

Cut out the paper pattern and try it on the upper limb of the patient; check that the ends match up, especially at the hand and thenar eminence, recutting if necessary.

#### 8.4.2. Cutting the low-temperature thermoplastic plate

Follow the procedure for cutting the low-temperature thermoplastic plate described in section 1.4.

#### 8.4.3. Moulding the low-temperature thermoplastic



Position the patient lying on his back with the upper arm vertical, the elbow and wrist in the desired position of immobilization, and the thumb touching the tip of the 2nd and 3rd fingers.

Heat the plate in a bath at 65°C (C-Lite).

- Mould the thermoplastic around the upper arm and the forearm.
- At the elbow, flatten the two flexion creases on either side (the plastic can be held in place with a rubber band while being progressively positioned).
- At the level of the hand, if necessary roll the plastic back along the distal edge of the thenar eminence.
- Flare the proximal edge of the orthosis.

#### 8.4.4. Preparing the low-temperature thermoplastic shell

If necessary, grind and smooth the trim line.

### 8.5. Making the straps

#### 8.5.1. Simple strap

See section 5.5.1.

#### 8.5.2. Strap with loop

See section 5.5.2.

#### 8.5.3. Positioning the straps

- One arm strap fixed 15 mm from the proximal edge
- Two mid straps fixed 20 mm from the elbow crease on either side
- One wrist strap
- One hand strap fixed distal to the thumb

### 8.6. Initial fitting and finishing

If EVA foam is used, glue it temporarily to the inside of the orthosis.

Perform the initial fitting in accordance with P&O standards.

Modify the plastic as required and smooth the trim line.

If the inside is lined with EVA foam, glue it throughout, cut off the surplus and smooth the trim line.

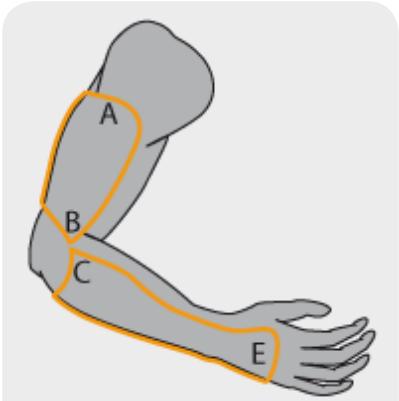
## 9 ARTICULATED FREE-MOTION ELBOW ORTHOSIS ("TAMARACK") WITH WRIST SUPPORT

PP

### 9.1. Action

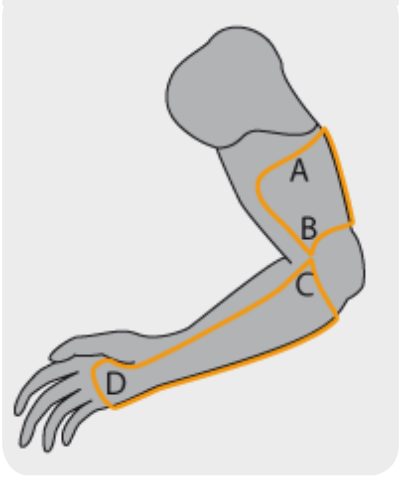
- Free-motion stabilization of the elbow and motionless stabilization of the wrist.
- Treatment and free-motion stabilization.

### 9.2. Trim line of the orthosis




Mark the trim line as follows:

**A** The proximal edge starts 2 cm below the axilla and rises over the external face of the arm.
**B** At the elbow, the cut of the upper part of the orthosis leaves the olecranon and epicondyles free and ends at the centres of the elbow joints.
**C** At the elbow, the cut of the lower part of the orthosis leaves the olecranon and epicondyles free and ends at the centres of the elbow joints.
**D** On the palmar face of the hand, the cut follows the thenar crease and stays proximal to the proximal palmar crease at the 2nd finger and to the distal palmar crease from the 3rd to the 5th finger (see figure D, section 8.2).
**E** On the dorsum of the hand, the cut leaves the thenar eminence free and stops proximally to the metacarpal heads.




This cut allows free motion of the fingers.

The lower edge can also be cut straight, proximal to the ulnar styloid, thus freeing wrist motion and making a simple articulated free-motion elbow orthosis (Tamarack).

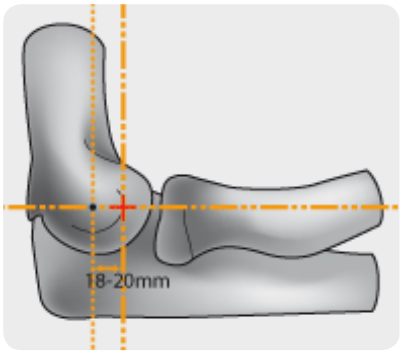
### 9.3. Moulding the EVA layer

Follow the procedure for moulding the EVA layer described in section 8.3.1.

### 9.4. Positioning the "Tamarack" dummies

Nail the "Tamarack" dummies to the positive and centre them correctly.

The mechanical elbow joint centres are located 18-20 mm from the top of the epicondyles along the axis of the forearm toward the hand, with the upper arm flexed at 90°.




### 9.5. Vacuum-moulding the polypropylene

Follow the procedure for vacuum-moulding the polypropylene described in section 8.3.3.

### 9.6. Preparing the polypropylene shells

Draw the trim line on the polypropylene as described in section 9.2.
Following the outline, cut out the orthosis with an oscillating saw, taking care not to cut the "Tamarack" dummies.

Remove the plastic shells from the plaster model and the stocking from inside the shells.
Grind and smooth the trim line.

Mount the "Tamaracks".

If an EVA layer has been moulded, transfer the trim line to the EVA and cut off the surplus.

### 9.7. Making the straps

Follow the procedure for making the straps described in section 8.5.

### 9.8. Initial fitting and finishing

Follow the procedure for the initial fitting and finishing described in section 8.6.

## 10 (SIDE-BAR) HINGED FREE-MOTION ELBOW ORTHOSIS WITH WRIST SUPPORT

PP

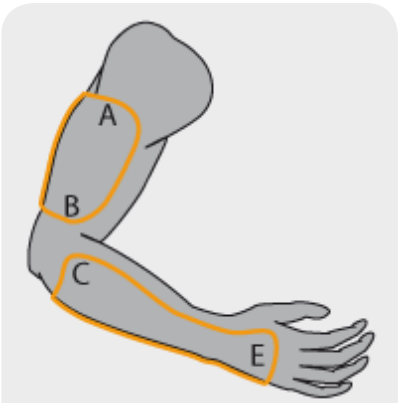
### 10.1. Action

- Mobile stabilization with amplitude limitation of the elbow and motionless stabilization of the wrist.
- Treatment and stabilization with amplitude limitation.

### 10.2. Casting

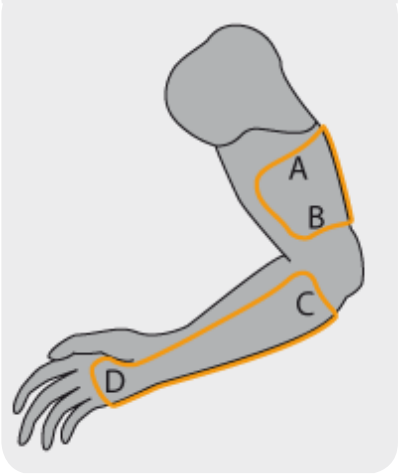
Note that for this type of orthosis it is better to make the cast with the elbow extended as much as is desirable.

### 10.3. Trim line of the orthosis




Mark the trim line as follows:

**A** The proximal edge starts 2 cm below the axilla and rises over the external face of the arm.
**B** At the elbow, the cut of the upper part of the orthosis allows full range of motion of the elbow.
**C** At the elbow, the cut of the lower part of the orthosis allows full range of motion of the elbow.
**D** On the palmar face of the hand, the cut follows the thenar crease and stays proximal to the proximal palmar crease at the second finger and to the distal palmar crease from the 3rd to the 5th finger (see figure D, section 8.2).
**E** On the dorsum of the hand, the cut leaves the thenar eminence free and stops proximally to the metacarpal heads.




This cut allows free motion of the fingers.

The lower edge can also be cut straight, proximal to the ulnar styloid, thus freeing wrist motion and making a simple hinged free-motion elbow orthosis (with side bars).

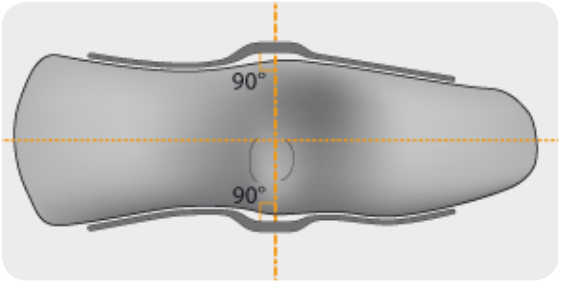
### 10.4. Moulding the EVA layer

Follow the procedure for moulding the EVA layer described in section 8.3.1.

### 10.5. Vacuum-moulding the polypropylene

Follow the procedure for vacuum-moulding the polypropylene described in section 8.3.3.
The centres of the elbow joint (see section 9.4) can be marked by planting two nails in the positive before the polypropylene is thermoformed.

### 10.6. Positioning the side bars




Locate the centres of the mechanical elbow joint and draw the axis connecting them (articular axis).

Cut the side bars to the required length.

Bend the side bars using contouring instruments with the joints centred on the mechanical elbow joint centres. The joint surfaces must be aligned in the sagittal, coronal and transverse plans to ensure the joint is parallel and perpendicular to the articular axis.

Drill the side bars and mark their position in order to fix them on the polypropylene shells.

To make a hinged free-motion elbow orthosis, opt for uprights such as “OCPOKNEE16OFF09”; for a hinged elbow orthosis with position locking, use uprights with multi-position locking hinges.

### 10.7. Preparing the shells

Draw the trim line on the polypropylene as described in section 10.3.

Cut out the orthosis with an oscillating saw, following the outline.

Remove the plastic shells from the plaster model and the stocking from inside the shells.

Grind and smooth the trim line.

Fix the side bars temporarily to the polypropylene shells with M3 screws and nuts.

If an EVA layer has been moulded, transfer the trim line to the EVA and cut off the surplus.

### 10.8. Making the straps

Follow the procedure for making the straps described in section 8.5.

### 10.9. Initial fitting and finishing

If EVA foam is used, glue it temporarily to the inside of the orthosis.

Perform the initial fitting in accordance with P&O standards.

Modify the polypropylene as required and smooth the trim line.

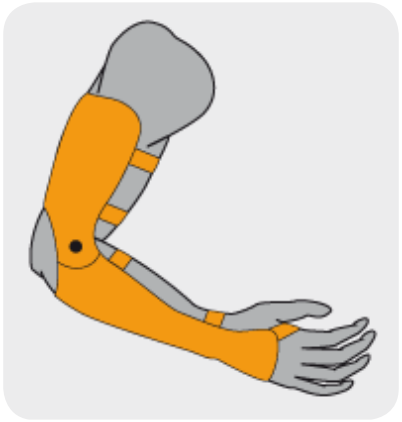
Fix the uprights with copper rivets and check the alignment of the elbow joints again.

If the inside is lined with EVA foam, glue it throughout, cut off the surplus and smooth the trim line.

## 11 OVERLAPPING (LOCKABLE) ARTICULATED ELBOW ORTHOSIS WITH WRIST

PP

### 11.1. Action

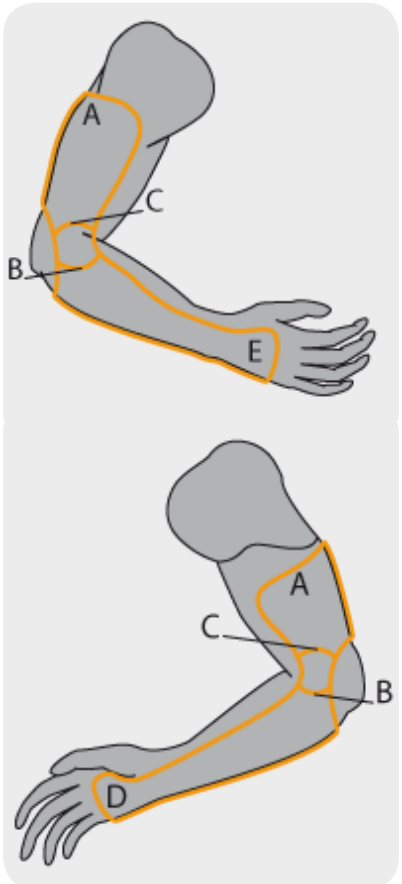


- Motionless stabilization, or mobile stabilization with amplitude limitation, and static posture of the elbow with motionless stabilization of the wrist.
- Immobilization of treatment areas or during rest periods, stabilization with amplitude limitation, correction of range of motion deficit or deformity and compensation of motor deficit.

### 11.2. Rectification of the plaster model

When rectifying the model, make two flat surfaces 6 cm in diameter that are centred on the elbow-joint centres and aligned in the sagittal, coronal and transverse planes to ensure the joint is parallel.

### 11.3. Trim line of the orthosis




Mark the trim line as follows:

- **A** The proximal edge starts 2 cm below the axilla and rises over the external face of the arm.
- **B** At the elbow, the cut of the upper part of the orthosis leaves the olecranon and epicondyles free and ends in a curve about 3 cm below the joint centres.
- **C** At the elbow, the cut of the lower part of the orthosis leaves the olecranon and epicondyles free and ends in a curve about 3 cm above the orthoses joint centres (allowing the two shells to overlap by almost 6 cm).
- **D** On the palmar face of the hand, the cut follows the thenar crease and stays proximal to the proximal palmar crease at the 2nd finger and to the distal palmar crease from the 3rd to the 5th finger (see figure D, section 8.2).
- **E** On the dorsum of the hand, the cut leaves the thenar eminence free and stops proximally to the metacarpal heads.

This cut allows free motion of the fingers.

The lower edge can also be cut straight, proximal to the ulnar styloid, thus freeing wrist motion and making a simple overlapping articulated elbow orthosis.

### 11.4. Moulding the EVA layer

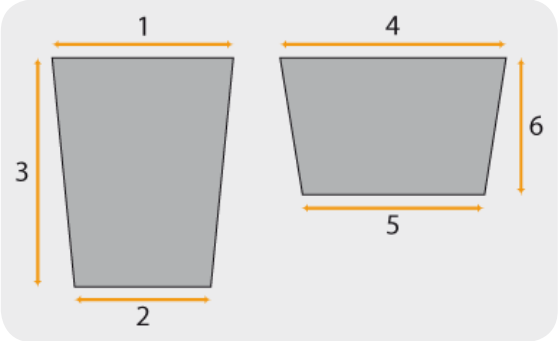
Follow the procedure for moulding the EVA layer described in section 8.3.1.

### 11.5. Vacuum-moulding the polypropylene

Pull a stocking over the plaster model.

Dust the stocking with talcum powder.

Measurements of the two sheets of polypropylene:




1. Circumference of the elbow + 10 cm
2. Circumference of the hand + 10 cm
3. Length of the forearm + hand + 10 cm
4. Circumference of the arm + 10 cm
5. Circumference of the elbow + 10 cm
6. Length of the arm + 10 cm

Thickness = 3, 4 or 5 mm depending on the patient's size.

Heat the polypropylene at 180° for 20 to 40 minutes, depending on the thickness of the material and the efficiency of the oven.

Drape the longer polypropylene plate over the forearm of the plaster model with the distal edge about 3 cm distal to the elbow joint centres, and stick it together along the radial edge or dorsal part (depending on the casting position).

Dust the overlapping area of plastic with talcum powder.

Drape the second polypropylene plate over the upper arm of the plaster model with the proximal edge overlapping the forearm plastic by almost 6 cm, and stick it together along the biceps.

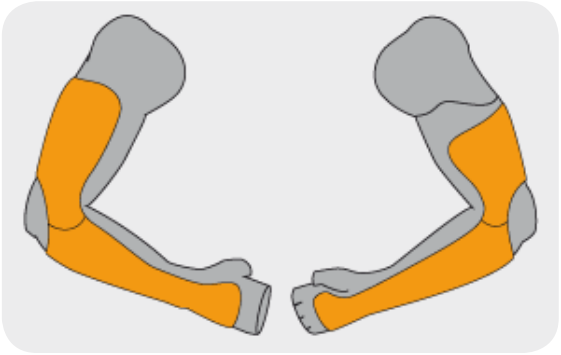
Using a cord or band, tighten the polypropylene around the suction cone.

Open the vacuum valve.

Cut off the surplus plastic while it is still hot.

Keep the vacuum on until the polypropylene cools.

### 11.6. Preparing the polypropylene shells



Draw the trim line on the polypropylene as described in section 11.3.

Following the outline, cut out the orthosis with an oscillating saw, taking care not to cut across the double layer of plastic at the elbow joints.

Remove the plastic shells from the plaster model and the stocking from inside the shells.

Grind and smooth the trim line.

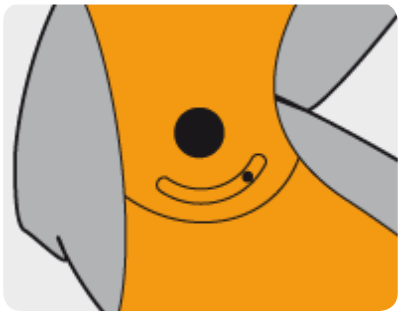
Assemble the two shells with nuts and screws, or T-nuts and washers.

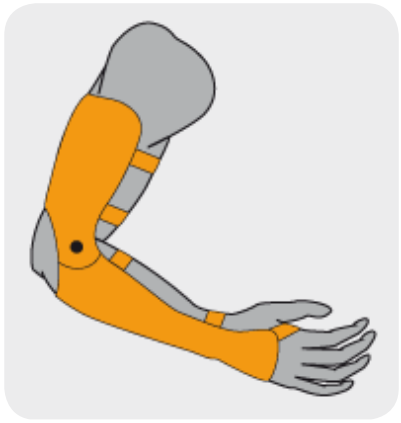
If an EVA layer has been moulded, transfer the trim line to the EVA and cut off the surplus.

### 11.7. Making the straps

Follow the procedure for preparing the straps described in section 8.5.

### 11.8. Initial fitting and finishing



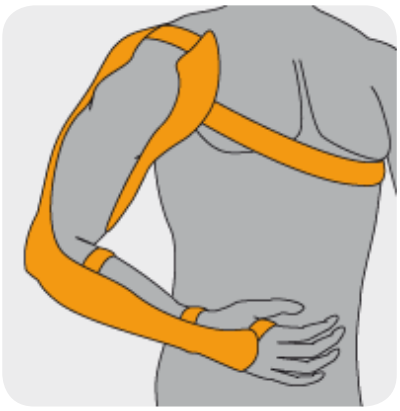


Follow the procedure for the initial fitting and finishing described in section 8.6.

To lock the orthosis, drill the two superimposed plastic shells in the centre of the joint and fix a mounting screw inside the hole with a nut.

(If amplitude is to be limited, make an arcuate slot in the overlap area in the upper shell of the orthosis in the radius of the centre of the mechanical elbow joint. Then fix a tall-head screw in the slot to limit the movement as required.)

# 12 SPIRAL ORTHOSIS



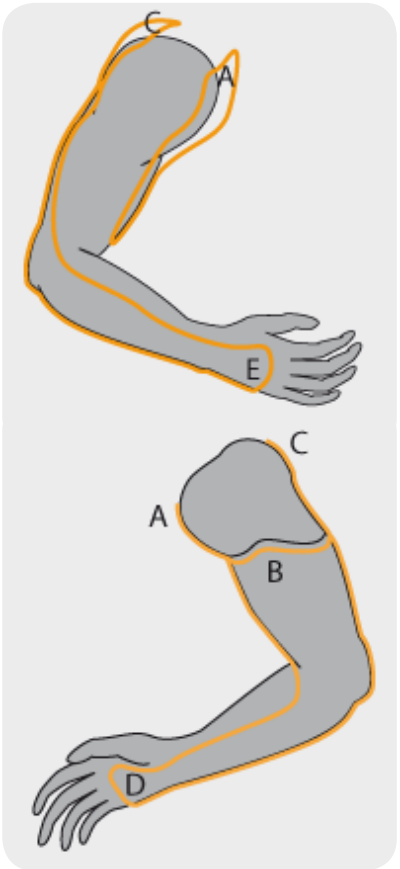

## 12.1. Action

- Motionless stabilization and static posture of the elbow and wrist (if included) or mobile stabilization with amplitude limitation of the elbow if hinged and free-motion stabilization of the shoulder.
- Rest, free stabilization (shoulder coaptation), correction of deformity of the wrist (if included) and compensation of motor deficit (also stabilization with amplitude limitation and correction of range of motion deficit of the elbow if hinged).

## 12.2. Casting

The casting includes the shoulder (from the infraspinous fossa of the scapula to the subclavian chest) with the elbow flexed at 90° and the forearm in neutral position.

## 12.3. Trim line of the orthosis




Mark the trim line as follows:

**A** The proximal anterior edge stops below the clavicle.
**B** The proximal edge at the axillary level is 1 cm below the axilla.
**C** The proximal posterior edge stops below the top of the shoulder.
**D** On the palmar face of the hand, the cut follows the thenar crease and stays proximal to the proximal palmar crease at the 2nd finger and to the distal palmar crease from the 3rd to the 5th finger (see figure D, section 8.2).
**E** On the dorsum of the hand, the cut leaves the thenar eminence free and stops proximally to the metacarpal heads.

This cut allows free motion of the fingers.

The lower edge can also be cut straight, proximal to the ulnar styloid, thus freeing wrist motion if the patient has retained motor potential in the hand.

### 12.4. The EVA layer

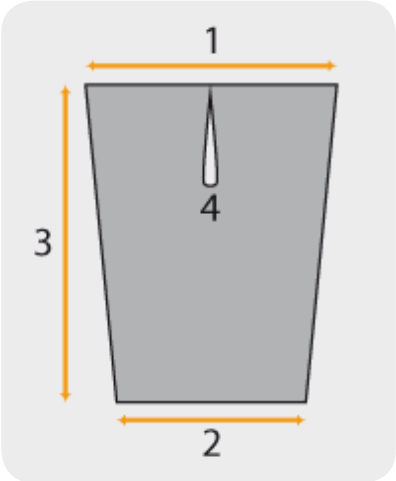
#### 12.4.1. Function of the EVA layer

See section 5.3.1.1.

#### 12.4.2. Moulding the EVA layer

Position the plaster model with the hand pointing slightly down.

Cut the EVA as illustrated to the following measurements:

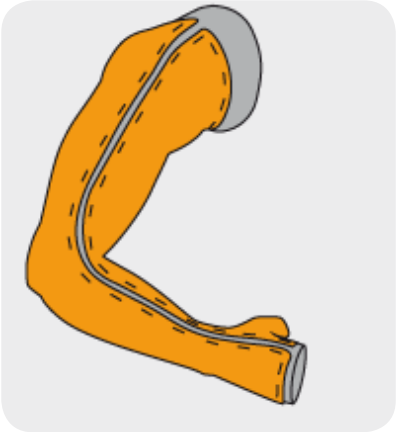



**1** Circumference of the upper arm
**2** Circumference of the hand
**3** Length of the plaster model (shoulder + arm + forearm + hand)
**4** Make a slit about 10 cm long in the middle of the upper part, if possible rounded to prevent the foam from tearing when taut.

Thickness = 6 mm.

Heat the EVA at 120° for 3 to 5 minutes.

Drape the EVA manually over the plaster model:

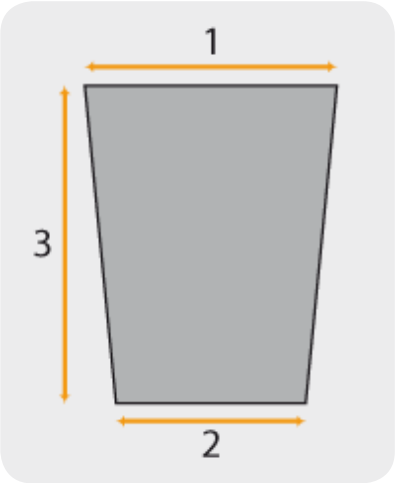


- Slide the EVA onto the model placing the axillary part in the slit and mould the EVA on both sides of the shoulder.
- Mould the arm, closing the EVA on its external face; mould the forearm and hand, closing the EVA on the radial side (pull well at the elbow to avoid creases).
- Hold it in place until completely cool.

Cut off the surplus.

Staple the EVA onto the external face of the upper arm and the radial edge of the forearm and hand.

### 12.5. Vacuum-moulding the polypropylene




Pull a stocking over the plaster model.

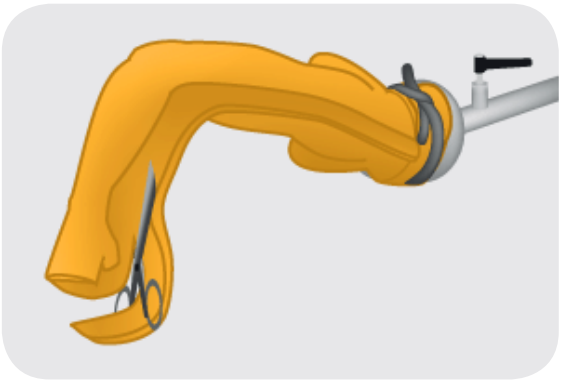
Dust the stocking with talcum powder.

Measurements of the sheet of polypropylene:

**1** Circumference of the shoulder + 10 cm
**2** Circumference of the hand + 10 cm
**3** Length of the plaster model (shoulder + arm + forearm + hand) + 10 cm

Thickness = 3, 4 or 5 mm depending on the patient's size.

Heat the polypropylene at 180° for 20 to 40 minutes, depending on the thickness of the material and the efficiency of the oven.



Drape the polypropylene over the plaster model and stick it together along the external face of the upper arm and the radial edge of the forearm and hand.

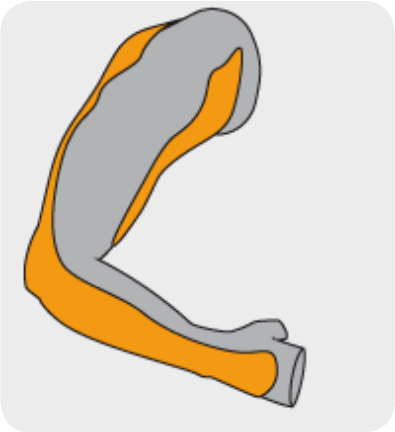
Using a cord or band, tighten the polypropylene around the suction cone.

Open the vacuum valve.

Cut off the surplus plastic while it is still hot.

Keep the vacuum on until the polypropylene cools.

### 12.6. Preparing the polypropylene shell



Follow the procedure for preparing the polypropylene shell described in section 8.3.4.

Note that the method for cutting the shell is described in section 12.3.

### 12.7. Making the straps

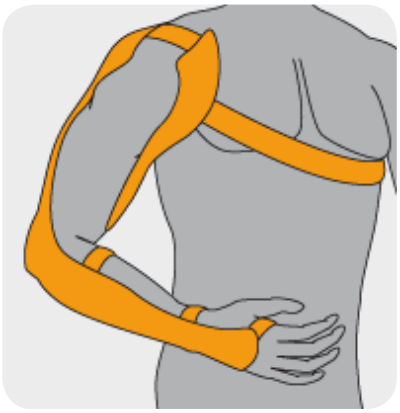
#### 12.7.1. Simple strap

See section 5.5.1.

#### 12.7.2. Strap with loop

See section 5.5.2.

#### 12.7.3. Positioning the straps



- One shoulder strap: fixed strap (originally of leather padded with neoprene), which suspends the orthosis and attaches the anterior to the posterior wing, passing over the shoulder.
- One forearm strap fixed 20 mm distally to the elbow crease
- One wrist strap
- One hand strap fixed distally to the thumb
- One body strap (optional) passing around the body under the other arm from the posterior to the anterior wing, if the stability of the orthosis is insufficient.

### 12.8. Initial fitting and finishing

Follow the procedure for the initial fitting and finishing described in section 8.6.

# 13 THORACOBRACHIAL ORTHOSIS

## 13.1. Action

- Motionless stabilization and static posture of the shoulder, elbow and wrist (if included) or mobile stabilization of the elbow if hinged.
- Immobilization of treatment areas or during rest periods, free stabilization of the elbow if hinged, correction of range of motion deficit or deformity (of the wrist if included) and compensation of motor deficit.

## 13.2. For adults

Note that assembly kits are available from some manufacturers.

PP

## 13.3. For children

### 13.3.1. Casting

Note that for this type of paediatric orthosis the best position is the shoulder at 90° of abduction and 70° of external rotation and the elbow flexed at 90°.

LTT

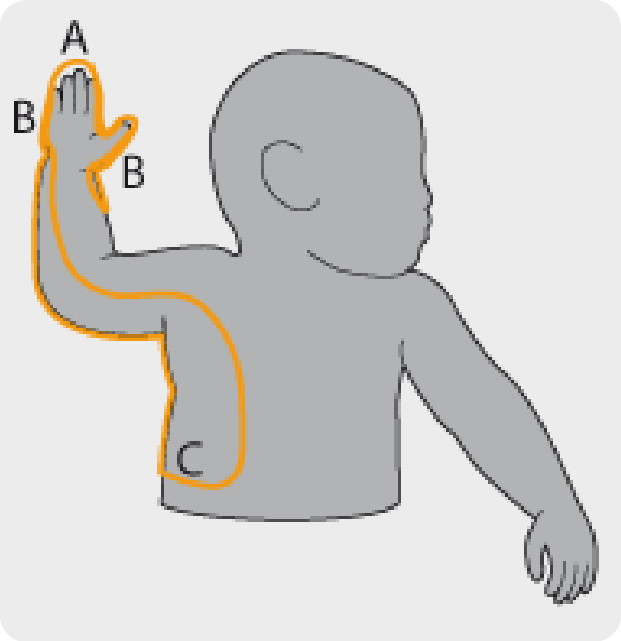
PP

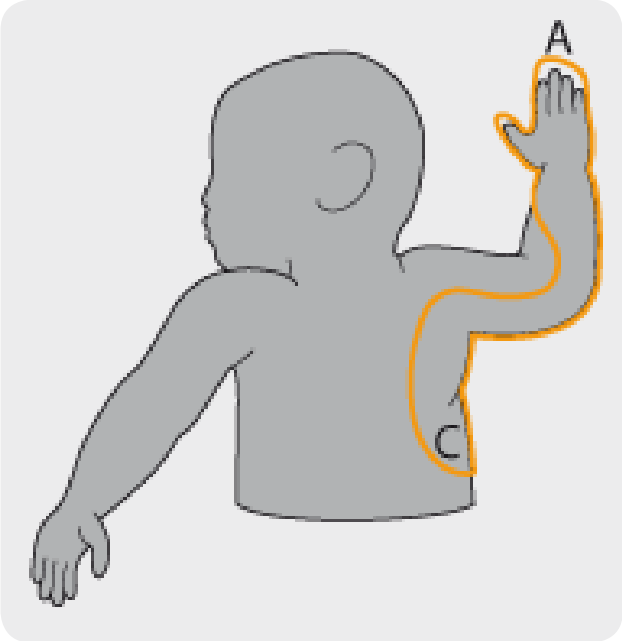
### 13.3.2. Trim line of the orthosis

Mark the trim line as follows:

- **A** The distal edge is 1 cm beyond the fingertips.
- **B** The edge slightly covers the sides of the hand.
- **C** The lower edge is at the waist.

If the cast is made of polypropylene, continue with section 13.3.3; if it is made of low-temperature thermoplastic, skip to section 13.3.4.



### 13.3.3. Polypropylene cast

#### 13.3.3.1. The EVA layer

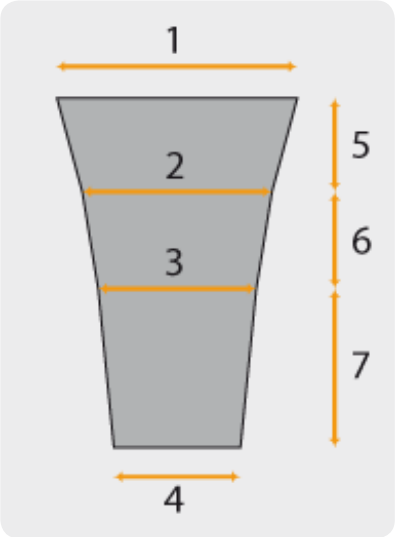
##### 13.3.3.1.1. Purpose of the EVA layer

See section 5.3.1.1.

##### 13.3.3.1.2. Moulding the EVA layer

Position the plaster model with the elbow flexed at 90° and the hand pointing up.

Cut the EVA as illustrated to the following measurements:

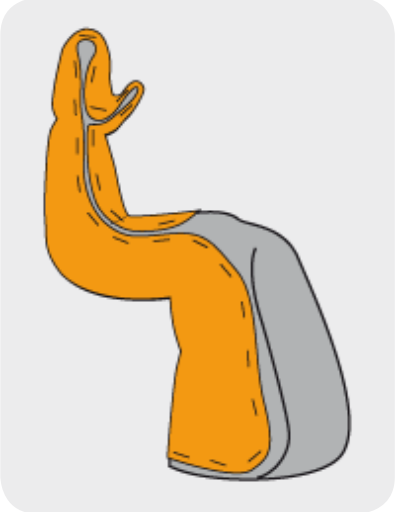



**1** Circumference of the plaster model at the waist level
**2** Circumference of the shoulder
**3** Circumference of the elbow
**4** Circumference of the hand
**5** Length of the torso
**6** Length of the upper arm
**7** Length of the forearm + hand.

Thickness = 6 mm.

Heat the EVA at 120° for 3 to 5 minutes.

Drape the EVA manually over the plaster model:

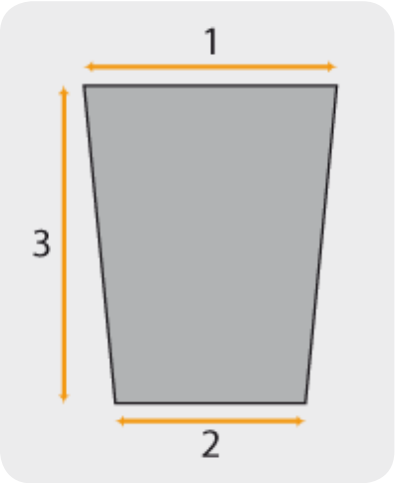


- Mould the EVA on the torso.
- Mould the axilla and arm, closing the EVA on the biceps.
- Mould the forearm and hand closing the EVA on the palmar face.
- Hold the EVA in place until completely cool.

Cut off the surplus.

Staple the EVA onto the anterior and posterior sections of the torso, onto the biceps on the upper arm and onto the palmar face of the forearm and hand.

#### 13.3.3.2. Vacuum-moulding the polypropylene




Pull a stocking over the plaster model.

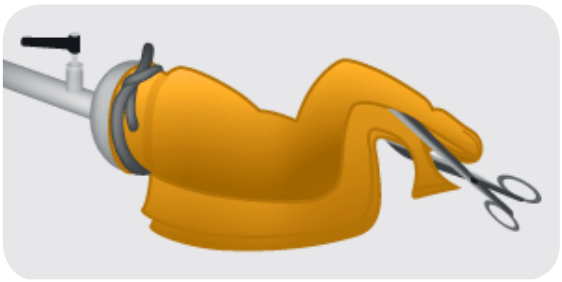
Dust the stocking with talcum powder.

Measurements of the sheet of polypropylene:

1. Circumference at waist level on the plaster model + 10 cm
2. Circumference of the hand + 10 cm
3. Length of the plaster model (torso + arm + forearm + hand) + 10 cm

Thickness = 3 or 4 mm depending on the patient's size.

Heat the polypropylene at 180° for 20 to 35 minutes, depending on the thickness of the material and the efficiency of the oven.



Drape the polypropylene over the plaster model and stick it together along the underside of the torso section and along the biceps on the upper arm and the palmar face of the forearm and hand.

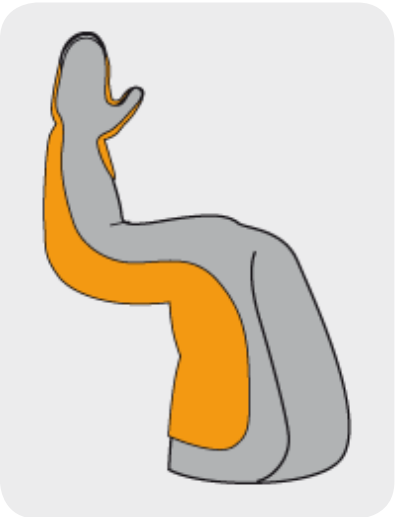
Using a cord or band, tighten the polypropylene around the suction cone.

Open the vacuum valve.

Cut off the surplus plastic while it is still hot.

Keep the vacuum on until the polypropylene cools.

#### 13.3.3.3. Preparing the polypropylene shell

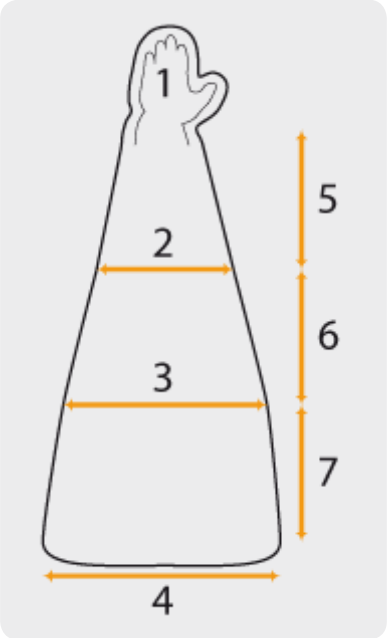


Follow the procedure for preparing the polypropylene shell described in section 8.3.4.

Note that the method for cutting the shell is described in section 13.3.2.

### 13.3.4. Low-temperature thermoplastic splint

#### 13.3.4.1. Creating a paper pattern




Draw a simplified pattern on a sheet of paper as illustrated:

**1** Draw the pattern at a distance of 1 to 2 cm from the outline of the patient's hand
**2** Half the circumference of the elbow
**3** Half the circumference of the shoulder
**4** Half the circumference of the torso (or maximum width of the thermoplastic plate, 15 cm for C-Lite)
**5** Length of the forearm
**6** Length of the arm
**7** Length of the torso

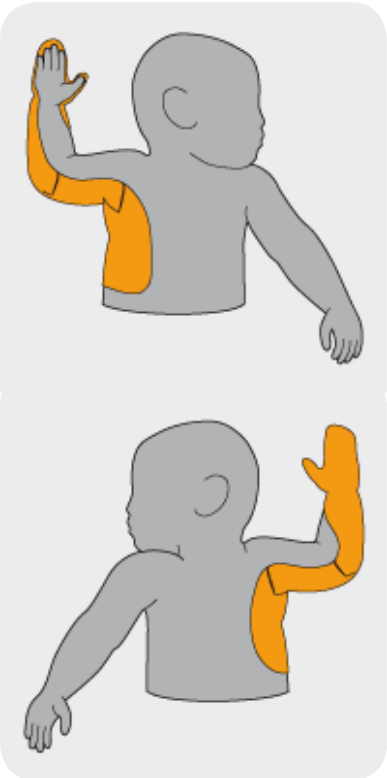
The pattern should be rounded and must not include angles.

Cut out the paper pattern and try it on the upper limb of the patient; check that the ends match up.

#### 13.3.4.2. Cutting the low-temperature thermoplastic plate

Follow the procedure for cutting the low-temperature thermoplastic plate described in section 1.4.

#### 13.3.4.3. Moulding the low-temperature thermoplastic



Position the patient as follows: the head facing away from the limb to be splinted, the forearm vertical, and the shoulder, elbow and wrist in the desired position of immobilization.

Heat the plate in a bath at 65°C (C-Lite).

- Mould the thermoplastic around the torso.
- At the axilla, flatten the two flexion creases on either side of the shoulder.
- Around the arm and forearm, at the elbow, flatten the two flexion creases on either side.
- At the hand (the plastic can be held in place with a rubber band as the orthosis is gradually positioned).
- Flare the lower edge of the orthosis.

#### 13.3.4.4. Preparing the low-temperature thermoplastic shell

If necessary, grind and smooth the trim line.

### 13.3.5. Making the straps

#### 13.3.5.1. Simple strap

See section 5.5.1.

#### 13.3.5.2. Strap with loop

See section 5.5.2.

#### 13.3.5.3. Positioning the straps

- One shoulder strap
- One arm strap proximal to the elbow crease
- One forearm strap (optional), distal to the elbow crease
- One wrist strap
- One hand strap to keep the fingers extended
- One or two body straps circling the torso (provide a protective underflap of 3mm EVA)

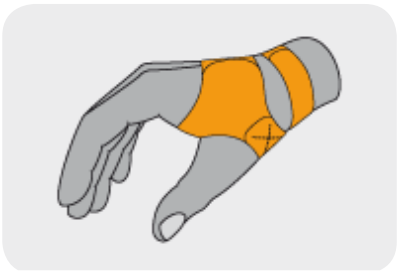
### 13.3.6. Initial fitting and finishing

Follow the procedure for the initial fitting and finishing described in section 8.6.

## 14 WHEELCHAIR PUSHING GLOVE

This type of glove is usually produced in pairs for both hands of the patient.

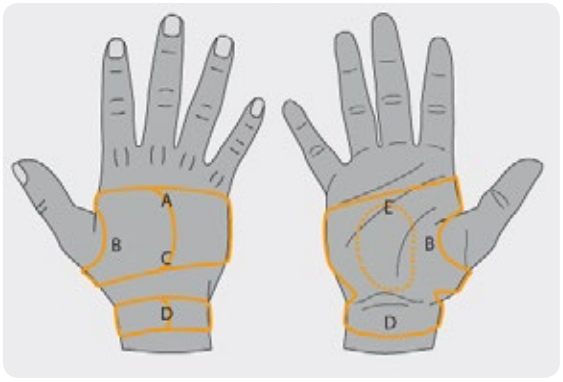
### 14.1. Action



Leather

- Improve adherence of hands on push rings and tyres of wheelchair.
- Slight stabilization of the trapeziometacarpal joint of the thumb.

### 14.2. Trim line of the glove




Mark the trim line as follows:

**A** On the dorsum of the hand, the distal edge is proximal to the metacarpal heads.

**B** At the base of the thumb, the edge is proximal to the metacarpophalangeal joint, in order not to interfere with thumb motion.

**C** On the dorsum of the hand, the proximal edge is distal to the wrist, in order not to interfere with wrist motion.

**D** The proximal part of the glove is attached around the forearm as close as possible to the wrist without interfering with its motion.

**E** On the palmar face of the hand, the distal edge is proximal to the distal palmar crease from the 5th to the 3rd finger and proximal to the proximal palmar crease at the 2nd finger, in order not to interfere with finger motion.

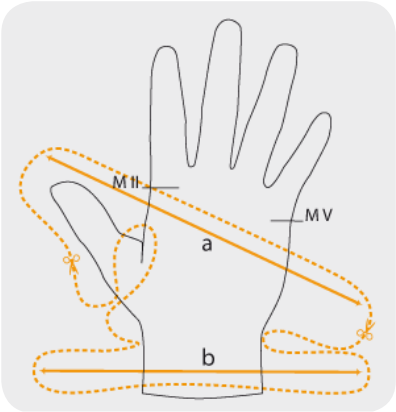
### 14.3. Creating a paper pattern

Position the patient's hand flat on a sheet of paper with the fingers extended and slightly abducted.

Draw the outline of the hand and mark the metacarpal heads of the 2nd and 5th fingers.

Measure the circumference of the wrist and the hand at the level of the metacarpal heads.

Draw the pattern as illustrated:




- The proximal part of the pattern looks like a strip 2-3 cm wide, centred on the wrist, its length equal to 1.25 times the circumference of the wrist (b).
- This proximal part is connected to the distal part of the pattern at the distal level of the wrist over an area whose width is equal to the greatest diameter of the wrist.
- The distal part of the pattern looks like a wide strip centred on the hand. Its ulnar part ends proximally to the head of the 5th metacarpal (M V).
- The radial part of the pattern ends proximally to the head of the 2nd metacarpal (M II) and is perforated by a rounded hole around the base of the thumb.

The pattern should be rounded and must not have any angles.

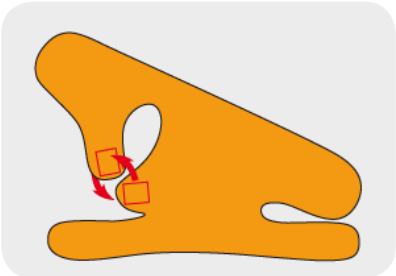
Cut out the paper pattern and try it on the patient's hand; check that the ends match up, especially around the thumb.

### 14.4. Cutting the leather

Draw the pattern on a piece of leather (or thick cloth) and cut it out.

### 14.5. Sewing the glove

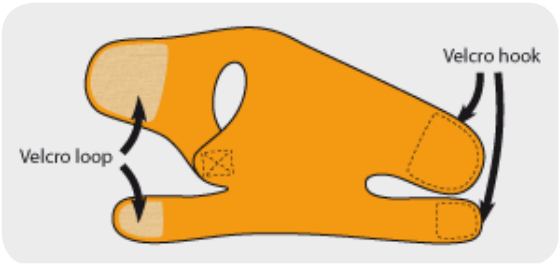
The red squares must be aligned and sewn into place as illustrated.



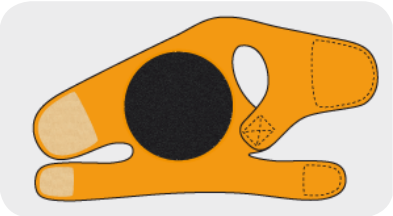
### 14.6. Fixing the velcro

Sew a Velcro hook onto the bottom flaps of the glove, which fold over the back of the hand and remain in contact with the skin, as illustrated.

Sew a Velcro loop onto the top flaps of the glove, which fold over the back of the hand, as illustrated.



### 14.7. Fixing the rubber pimple

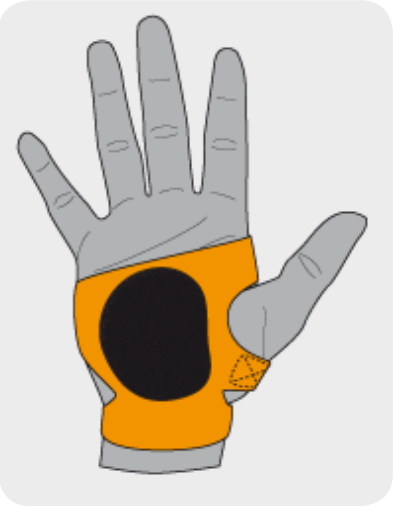


The black rubber pimple, which gives extra grip on the tyres (and push rings) of the wheelchair, is made of the material used for covering table-tennis bats. It can be obtained from sports shops. The rubber should be the type that is backed with fabric, since it lasts longer.

Cut a circle of rubber around 6 cm in diameter.

Glue the rubber pimple onto the outside of the glove, in the middle of the palm, so that it can be removed and replaced easily when it wears out.

### 14.8. Initial fitting and finishing



Try the glove on the patient in accordance with international P&O standards.

Adjust as required until it fits perfectly and the patient is satisfied.

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D. Hohmann, R. Uhlig (eds.), *Orthopädische Technik*, 9. Aufl., Verlag Thieme, 2005

## Key

Key to illustrations:


Polypropylene orthosis


Low-temperature thermoplastic orthosis

**MISSION**

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ICRC

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