Ankle Disarticulation Prosthetics

Course Work Manual

ICRC

(INTERNATIONAL COMMITTEE OF THE RED CROSS)
Aknowledgements

Substantial parts of the information and reference material provided in This Technical Manual for Lower Limb Prosthetics has been compiled from various medical and university sources. Without their long practice, know-how and extensive publications, this manual would simply not exist. We would like to mention in particular:

*Course Work Manual*, Carson Harte and Anne Henriksen, National School of Prosthetics and Orthotics from Phnom Penh, Cambodia:
- Partial foot prosthetics
- Ankle disarticulation prosthetics
- Below knee prosthetics
- Knee disarticulation prosthetics
- Above knee prosthetics
- Hip disarticulation prosthetics.

*Clinical aspects of Lower extremity prosthetics, Trans-tibial, Symes and Partial foot amputations*, The Canadian Association of Prosthetists and Orthotists.

*Traité d'Anatomie Artistique*, Dr. Paul Richer, Inter livres.

*Lower Limb Prosthetics*, 1990 revision, New York University Medical Centre.

*Lower Limb Prosthetics*, 1990 revision Prosthetics and Orthotics, New York University Post Graduate Medical School.
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SECTION - 1

SYMES’ AMPUTATION
The through ankle amputation. (Symes)

Introduction.

The Through ankle amputation was first carried out in 1843 by a Scottish surgeon called Mr. James Symes. The technique still carries his name. The method of surgery remains unchanged and is still widely used today.

The through ankle amputation has a major advantage over other higher levels of amputation, it is End Bearing. That is to say the patient can carry a good partial weight bearing on the end of his stump and in some case, all of his weight. This is a major difference with other BK amputation.

In some instance, it is possible to walk without a prosthesis. The stump is shorter than the original leg but it is still possible to walk even with a limp. Prosthetic treatment can be as simple as building up the end of the stump to make up the shortening or as complicated as building a light weight high performance prosthesis.

Because the major muscles in the stump are no longer used they reduce in size over a short period of time giving the stump a bulbous appearance. While the large distal end and the thin shaft of tibia are unsightly they also give excellent suspension. The prosthesis simply hangs onto the distal end of the stump; therefore no straps are required.
Because the stump is long the lever is long and hence the load on the stump is low. Control and proprioception is greatly increased.

The through ankle amputation is an excellent level of amputation in children. The stump will not grow quite so fast as the sound leg and the stump will appear to shorten as the child grows. This means that as the child develops we retain a good end bearing stump but gain some space to fit in the components of a high performance leg. The cosmesis will also improve as the child grows up.

There are several disadvantages with this level.

Because of the bulbous end the cosmesis is not so good. Because of the long stump, it is difficult to fit a good artificial foot into the space available. Sometimes the surgery can go wrong. This can lead to a painful stump and intolerance to end bearing. In this sort of case we can use the Patella tendon and the tibial flares to partly off load the end of the stump.
SECTION - 2

SYMES' PROSTHESIS

&

COMPONENTS
Rotation about the long axis

The natural triangular shape of the upper end of the stump is emphasized during casting and rectification. The triangular stump keyed into a triangular socket resists rotation.

Suspension

The wide and bulbous stump end means that it is possible to hang the socket onto the end of the stump. This gives good comfortable and secure suspension. The big problem then is gaining access to the socket past the narrow neck.

Stump length.

The long stump gives major problems in that it makes it difficult to fit in a good high performance foot. It is impossible to fit in an ankle mechanism. The foot most commonly used is the low profile SACH foot. The SACH foot gives an acceptable gait. There is a trend towards the use of energy recovery feet such as the Seattle foot or the Quantum foot. The low deck height makes these feet excellent for the limited space available.
Components.

Due to the length of the Symes stump the relevant components to discuss for this amputation are feet and cosmesis. These will be looked at separately.

**Feet**

The Symes stump is always very long, which gives problems in fitting a foot and alignment device. Most prosthetic feet are between 7 to 9 cm high, but it is normal that there only is about 5 cm from the end of the stump to the ground.

Often the socket is bolted or glued directly onto the foot with no easy adjustment possibilities. This will mostly be talked about as a conventional construction.

Some places use special feet and alignment devices which allows small alignment changes to take place during fitting. Such a system will mostly be talked about as a modular construction.

**Conventional prostheses:**

One common conventional construction is the use of a modified SACH foot. This foot has a large wooden keel which is hollowed out so that the end of the socket fits into the hollow space. The Cushion heel is lower than normal, so that a correct height can be obtained, this will cause the problem of a lower shock absorption performance of the foot.

In many places it is also usual to use a normal SACH foot which is cut down to the right height, where after the socket is glued straight on top of it.

With all conventional solutions the major problem is that alignment adjustments are difficult to make.
**Modular prostheses:**

Most of the new energy storing feet such as Quantum, Seattle or Flex foot, are low profile feet, which means the height of the foot is low. This gives excellent opportunities to fit an alignment device between the foot and the socket. A coupling plate will be laminated or draped into the end of the socket and then bolted onto an alignment device on top of the foot. The alignment is done by using a cup and washer device, which gives the possibility to do tilt adjustments (dorsi- and plantar-flexion; in- and eversion; and rotation). This solution gives an excellent prosthesis but unfortunately it is very expensive.

A very good solution used in Cambodia was the specially fabricated Symes foot from VI - Veterans International - together with an ICRC - International committee of Red Cross - PPCAS cup (on top of the foot) and a metal domed washer (inside the socket). This solution also offers a full range of tilt adjustments as outlined above. But the performance of the foot is not as good, because the heel cushion generally is too hard.
Cosmesis.

Cosmesis will never be very good for the Symes amputees because of the large bulbous end. Very often there will be no cosmesis as such in the calf region, and only the "joint" area between the socket and the foot is made stronger and made to look cosmetic. In the following are two suggestions how to make an actual cosmesis.

**Conventional prosthesis**:

The conventional construction can be covered with a second layer of GRP (Glass reinforced plastic). First the ankle and calf regions are built up with a rigid foam filler where after the second layer of laminate is added. This provides the final cosmesis but also adds to the strength of the prosthesis.

**Modular prosthesis**:

The modular leg can be finished with a foam cover, which can be covered again with a plastic / rubber “sleeve”. Or it can be given a rigid polypropylene or GRP skin.
SECTION - 3

PROSTHETIC SOLUTIONS
SOCKET DESIGNS FOR THE SYME’S AMPUTEES

Perhaps the most obvious factor to consider when designing a prosthetic socket for the Syme’s amputees is the distal bulbous of the residual limb. This characteristic will make donning and doffing of the prosthesis impossible (in the majority of cases) unless some modification to the socket is made that will allow passage of the distal end.

1) Traditional Leather Socket

One very early design, although it is now seldom used, consisted of a leather socket that was externally supported by stainless steel uprights positioned both medially and laterally. The uprights arose from a metal plate attached to the upper surface of the prosthetic foot. In order to stabilize the socket further, the equivalent of a calf band was attached to the proximal ends of the uprights. The leather socket was then riveted to the metal framework. Both the flexibility of the leather and the laced anterior opening made it possible to don and doff the prosthesis with minimal effort.

This design has very few advantages. The proximal brim of the prosthesis is considerably lower if compared to most current prostheses fabricated for this level of amputation. This factor creates a number of insufficiencies and problems:

1. It reduces the effective lever arm length. Therefore stump-socket pressures increase.
2. Partial proximal weight bearing is not possible with this design.
3. Rotational stability is somewhat reduced Owing to the absence of prosthetic contact with the femoral condyles.
   Another problem is the unhygienic nature of leather. It is difficult to clean, produces an offensive odour and may contribute to the development of dermatological conditions.
2. Obturator Design

Another solution to the problem of donning and doffing the prosthesis is to remove a portion of the socket wall to form a window or obturator. More often than not the medial aspect of the prosthesis is chosen as the site for the obturator. This placement is logical if you consider two common physical characteristics of the residual limb. One characteristic is the apparent bowing or varus curvature of the atrophied limb, and the other is the prominence of the medial malleolus relative to the long axis of the stump.

If the obturator is placed anywhere else, the result is that the residual limb will have to be displaced unduly with respect to the socket, making application and removal of the prosthesis awkward. A posterior position for the obturator can be chosen, but this may require that the limb be angled posteriorly through the window as the prosthesis is applied. Also, because of the high stress put on the posterior wall of the socket while walking, it does require more reinforcement than the medial one.
A variation of the posterior obturator is the completely removable posterior wall. This type of socket is prescribed if there is not a circumference corresponding to that of the bulbous distal end below the level of the posterior shelf/PTB.

The dimensions of a medial obturator are determined as follows: the width is approximately one-third the measurement of the largest distal circumference, and the length corresponds to the distance between this distal circumference and its proximal equivalent.

If one compares this prosthesis to the traditional leather type that has a lowered proximal socket trim line, one finds that the previously mentioned disadvantages of the latter do not apply.

3. Removable Insert or Segmented Socket

This design incorporates a full pelite liner the thickness of which has been enlarged circumferentially from the widest point of the distal end of the residual limb to a corresponding proximal position. To permit the liner to be donned, it must be split longitudinally the full length of the external pelite build up. Once the liner is in position, the patient can then apply the rigid socket, which has been previously laminated, over the insert. In order to reduce friction between the liner and socket, a nylon stocking can be placed over the liner. The rigid socket will serve to contain the liner and keep it from spreading, thereby ensuring effective suspension of the prosthesis.
A variation in the composition of the insert using different materials is another effective alternative. For example, a thin flexible laminate or thermoplastic could be utilized as the base of the insert with the outer circumferential buildup consisting of Kemblo, rubber or any similar light weight, high density, foamed material. This type of insert is not as flexible as its alvelux equivalent, and therefore multiple longitudinal splits will be required in order that such a liner can be applied. This type of insert may be aptly referred to as a "segmented socket".

Structurally, this prosthetic socket design is somewhat stronger in as much as the tubular rigid laminate remains uninterrupted by an obturator or window. Such a prosthesis tends to withstand the high compressing forces that occur distally and anteriorly during the stance phase of the gait cycle between midstance and toe off much more effectively than any of the obturator variations. This type of prosthesis is appropriate for a residual limb that has a comparatively small, immobile heel pad. If the heel pad is large and such a socket is prescribed, the resulting prosthesis will be bulky and most non cosmetic. An atrophied residual limb with a small heel pad will permit a degree of cosmetic restoration not possible with any of the other prosthetic socket designs, with the exception of the silicone Symes prosthesis (to be discussed).

The application and removal of this type of prosthesis requires that the amputee has sufficient strength and coordination to perform such a task.
4. Silicone Syme’s Prosthesis

This prosthesis incorporates an inner elastic sleeve, or bladder, which permits passage of the bulbous distal end of the Syme’s residual limb. The initial socket layout integrates three separate segments:
1. Rigid laminate proximal brim
2. Elastic sleeve of R.T.V silicone rubber (Dow Corning or Ipocon)
3. Rigid laminate distal cap.

The length of the sleeve corresponds to the distance between the widest point distally and its proximal equivalent. To create an air space behind the sleeve sufficient to allow application and removal of the prosthesis, a rigid plastic lamination is required to bond the proximal with the distal segments. The air space can be created with a sealed cardboard tube or by building up the area overlying the sleeve with beeswax and then draining it once the lamination has cured.

Many of the same criteria used in prescribing the removable insert also apply to the silicone Syme’s prosthesis. Therefore, the advantages and disadvantages of such prescription also apply, i.e. a comparatively large heel pad will produce a non cosmetic result.

Silicone Symes
Sockets in X section
A mobile heel pad may also be a contraindication to the prescription of this socket because it is difficult to control the position of the heel pad when donning the prosthesis. If the pad displaces excessively, it may not be in a position within the socket that is comfortable for weight transmission. This displaced positioning may also create tissue breakdown resulting from tension-producing shear forces.

The silicone Syme’s prosthesis harbours a biomechanical insufficiency that does not plague any of the other prosthetic socket designs if properly fitted. This prosthesis does not control shear forces at the heel pad as effectively as the others because there is little or no stabilization of the residual limb proximal to pad owing to the flexibility of the silicone bladder.

Figures below illustrate two methods of cosmetic restoration for the silicone Syme’s prosthesis and removable insert design if the residual limb is atrophied or the amputee is bilateral lower extremity.

**Cosmetic restoration of the Atrophied Symes Residual Limb**

- Removable insert or silicone Symes prosthesis
- Cosmesis can be accomplished by:
  1) Alvelux or like foam build ups appropriated shaped.
  2) Polyurethane foam (rigid foam) build ups followed by a finishing lamination.
SECTION - 4

BIOMECHANICS
BIOMECHANICS OF THE SYME’S PROSTHESIS
STATIC AND DYNAMIC ALIGNMENT

The major purpose of this segment is to identify the force patterns that occur between the residual limb and the prosthesis at certain critical points in the gait cycle.

**Coronal Plane Alignment**

A mature, atrophied, Syme’s residual limb has an obvious curvature, the concavity of which is medial. The most cosmetic position for the prosthetic foot in relation to the socket is to centre it directly beneath the heel pad. To do so would inevitably create the situation illustrated in figure 4 A. As the amputee shifts his weight toward the prosthetic side at mid-stance, the ground reaction force passes medially relative to the geometric centre of the socket. This causes the prosthesis to rotate in a clockwise direction on the residual limb with resulting forces proximal medial and lateral distal. By displacing the foot somewhat lateral with respect to the socket, this tendency for the prosthesis to rotate on the residual limb is nullified (see figure 4 B). The unfortunate consequence of displacing the prosthetic foot laterally is a compromise in cosmesis.

**The Biomechanical Consequence of Positioning the Prosthetic Foot Medially for Cosmetic Purposes (Coronal Plane, Posterior View)**
You may ask yourself why this tendency for a loss of lateral stability exists. In order to answer your own question, try shifting your weight on to one of your feet so that you begin to fall laterally, outside your base of support. In order to prevent yourself from losing your balance you will invert your ankle. The individual with a Syme’s amputation no longer has voluntary ankle inversion. Thus, the reason for lateral foot displacement is to compensate for this loss of function.

**Sagittal Plane Alignment**

For the purpose of an initial static bench alignment of the socket relative to the foot in the sagittal plane, the prosthesis should be positioned so that the geometric centre of the socket is aligned mid-position of the effective foot length with the socket in approximately 5 degrees of initial flexion (see Figure 4 C)

Let us consider how the prosthesis reacts with respect to the residual limb during the stance phase in the sagittal plane. Figure 4 D clearly illustrates the situation occurring from heel strike to mid-stance. At heel strike, the ground reaction force (GRF) passes posteriorly to the socket’s geometric centre as well as to the anatomical knee joint. The result is that a moment is created on the residual limb by the socket in response to the GRF, causing a rotation of the prosthesis in a clockwise direction (in this particular instance). The forces that occur on the residual limb at this phase of gait are proximal posterior and anterior distal. The GRF also acts on the knee causing it to flex.
The response to this knee flexion should be an eccentric contraction of the quadriceps to permit a controlled transition from heel strike to the foot flat mid-stance position. It is at this point that the knee begins to extend to bring the body’s centre of gravity over the prosthesis in preparation for the commencement of swing phase on the contralateral side. Once the swing phase on the contralateral sound limb is completed, the amputee begins to initiate flexion of the knee on the prosthetic side. Figure 4 E depicts the development of forces proximal anterior and posterior distal in response to a moment causing the prosthesis to rotate in a counter-clockwise direction on the residual limb. This counter-clockwise moment is the result of the GRF passing anterior to the socket’s geometric centre of rotation.

As you can see, the functional loss resulting from Syme’s amputation in normal level walking is not that significant if the amputee wears a properly-fitted and aligned prosthesis. The SACH heel in combination with quadriceps muscle activity will compensate for the lack of controlled plantar flexion normally afforded by eccentric contraction of the pretibial muscle group at heel strike.

Current prosthetic foot designs for Syme’s amputees do not provide any practical push-off capabilities, and since the triceps surae muscles are no longer effective, push-off is compensated by appropriate motion in the knee and hip joints. This compensation is not apparent during normal level walking, but manifests itself if the amputee is involved in sports, particularly when running and/or jumping is required.

Why must the socket trim line extend proximally as superior as the patellar tendon level? For the answer, refer to Figure 4 F.
These two diagrams compare the resulting force magnitude between Syme’s prostheses with differing proximal trim lines. The segment of the gait cycle that has been used to illustrate this point is late stance, but the principle holds true for residual limb/socket forces that result in any plane during any particular point in the stance phase. As the length of the lever arm shortens, the magnitude of the force that develops at either end of the prosthesis increases. Therefore, resulting socket pressures on the residual limb in (II) are much greater than in (I).

The other problem that is evident at this particular phase of gait is the anatomical area over which the anterior proximal socket pressures develop. In (I), the forces are concentrated at the patellar tendon, which is an area that is tolerable to some degree of pressure. However, in (II) the forces are applied over the tibial crest, which is poorly suited to accept such forces, especially if their magnitude is larger. As you can see there is much to be gained by keeping proximal socket trim lines at least as superior as the patellar tendon level.

Fig. 4 F.
Comparison of Proximal Trim Line at Two Different Levels

(I) A Longer Lever decreases the force magnitude exerted by the prosthesis on the residual Limb

(II) The resulting anterior proximal force in (I) is not only smaller than in (II) but is also concentrated in a more anatomically suitable area.
SECTION - 5

CASTING
&
MEASUREMENTS
Ankle disarticulation - Measurements for casting.

Stump measurements:

Stump measurements are taken having the patient standing with weight bearing on the stump. (The pelvis must be level.) It can also be taken with the patient sitting with partial loading on the distal end of the stump.

Diameters:

* Maximum knee tendon level.
* Minimum diameter above Malleoli.
* Maximum diameter at the bulbous end of the stump.

Circumferences:

* Mid patellar tendon level.
* Apex of Fibular head.
* Minimum circumference above Malleoli (taken at same level as the diameter).
* Maximum circumference a bulbous end of stump (taken at same level as diameter).
* Circumferences at shaft of Tibia/Fibula if needed.

Distances/lengths:

* For all circumference measurements the length from the measurement to the end of the stump is also recorded.

* Height from the end of the stump to floor with - patient standing.

Sound leg measurements:

* Length of the foot.
* Heel height of the shoe.
Ankle Disarticulation Prosthetics

Stump measurements

Max. knee diameter
Patella Tendon
Fibular head
Min. Diameter
Max. Diameter
End of stump
Floor
Foot length

MPT
Heel height

Patient name
Prosthetist
Left / Right
Remarks:

Date of casting
Date of fitting
Date of delivery

Foot length

Max.
knee diameter
Patella Tendon
Fibular head
Min. Diameter
Max. Diameter
End of stump
Floor
Casting procedure.

Aim

The aim of taking a plaster cast is to ensure an accurate model of the stump which shows the stump in its load bearing position, or partial weight bearing.

Problems.

1/ Because the stump is bulbous it can be difficult to remove the cast.

2/ The stump must be loaded during casting so the soft tissue on the distal end is deformed into a comfortable position.

Procedure.

1/ The patients personal details and the details of manufacture and construction should be recorded on the measure chart.

2/ Details of the stump and the sound leg should also be recorded.

3/ Special attention should be paid to the diameters and circumferences of the bulbous end of the stump and the narrow part of the stump just above the distal end.

4/ To get the plaster off the patient we will have to cut the plaster. To protect the patient we must place a piece of 1 cm diameter tubing or a strip of lead or plastic under the stump sock. This is placed along the length of the stump usually on the medial side of the tibial crest.

*It is also possible to take the cast with a multi step casting technic, allowing you to get an accurate cast without having to cut or to distort the cast as you are removing it.*

5/ The stump sock is pulled on and the stump marks made. (Figures 5A).
Patella
Patellar tendon (PTB)
Tibial Tuberosity
Tibial tubercle
Crest of Tibia
Medial border of Tibia
Lateral border of Tibia
Head of Fibula
Distal anterior aspect of Tibia
Anterior lateral prominence of tibial condyle
Malleoli (Medial, Lateral)

Fig. 5 A.
Surface Anatomy

Anterior

Lateral

These areas should be marked with indelible pencil prior to negative wrap casting.
6/ An end block is made up. This consists of a block of wood with a layer of 12 mm alvelux on the upper surface. When the patient stands on the block his pelvis should be level.

7/ The distal end of the stump is wrapped in plaster while the patient is sitting. Before the plaster sets he then stands with the end of his stump on the block and bears weight. The plaster is hand moulded and the plaster wrap continued up to the proximal end. The tibial flares and the patella tendon region are hand moulded and shaped to emphasise the triangular shape of the stump. The cast is finished at the level of the mid patella.

8/ When the plaster has set the patient sits down. The cast is cut carefully along the tube or lead strip and then opened enough to allow the stump to be withdrawn. Care must be taken not to damage the cast. The cast is then sealed and built up on the proximal brim and is now ready to be filled.

It must be reminded that this is only one way of taking a cast and probably not the most efficient. The cast can be taken standing up or sitting; with a wide range of partial weight bearing. It can also be taken in one part or in multiple steps, with initial (added directly on the stump) or later (over the positive mould) build up. Just keep in mind that it should be taken with the minimum displacement of the flesh and keep the modification of the cast to a minimum. The two to three part cast with the patient sitting and light loading of the distal end is an excellent alternative that gives great result.
SECTION - 6

RECTIFICATION PROCEDURE
Cast rectification.

After carefully filling and stripping the cast is now ready for rectification.

The purpose of the rectification procedure is to produce a model of the stump that will be used to mould the inside of the socket. The rectification will produce a socket that will off-load the pressure sensitive areas of the stump and will load the pressure tolerant areas of the stump.

To achieve this plaster is removed from the tolerant areas and added in the sensitive areas.

The load tolerant areas in the Through Ankle stump are as follows.

- Distal end pad.
- Tibial Flares.
- Patella Tendon.
- The pressure intolerant areas are.
- Tibial Crest and tuberosity.
- Fibular head.
- Neck of Fibula.
- Patella.
- Medial and Lateral malleoli remnants.

Rectification procedure.

General: Clean up obvious irregularities.
Redress all stump marks.
Check cast measures against patient measures.
Medio-lateral diameter of the knee.

Measure the medial lateral distance across the knee at the widest point and compare the measure taken on the patient. If the cast was well taken, the difference shouldn’t be more than 2 to 3 mm.

If necessary, remove plaster until the measure is approximately 1 to 2 mm close to the patient measure.

**Patellar Tendon**

The rectification of this region is generally the same as the rectification procedure for the BK except that it is a lot less severe. The stump being end bearing much less load is taken proximally.

A patellar tendon indent is made between the thumb marks in the normal way but only to a depth of about 6 to 12 mm according to the weight bearing you want to share between the distal end and the PTB.

**Tibial flare**

Material is removed from the medial tibial flare and in the region of the Tibialis anterior. This is not carried out to produce true load bearing but more so to emphasise the triangular shape of the tibia in cross-section to resist rotation of the socket on the stump. Only 1-2 mm are removed at the deepest point.
**Posterior aspect of the stump.**

The popliteal fossa pressure is not so important since it’s job of holding the patella tendon in contact with the bar is largely redundant. The popliteal fossa should have only a minimal indent. The area of the gastrocnemius should be reduced if the stump is soft and fleshy but should not be reduced if the stump is firm or very bony.

**Fibular Head.**

The Fibular head and neck should be built up in the same way as in the BK cast. Approximately 3 mm should be added at the highest point. The build up should be tapered out at the borders of the head of fibula Anterior, posterior, and proximal. It should be continued down the shaft of the fibula for about 1 cm to relieve the peroneal nerve.

**Tibial Crest and tuberosity.**

Where the tibial crest is prominent build ups of 2-3 mm should be made down the tibial crest. Unless the area of the tuberosity is particularly sensitive to pressure, there should not be any build ups in that proximal area. The build up should start under the tuberosity down to the prominent distal part of the tibia.
Distal end.

This is the major load bearing area and requires the most care.

As the end pad is loaded it will flatten and widen. Since the cast was taken in weight bearing the deformation of the soft material will be already included in the cast.

Sometimes the end pad can move during casting and can appear to be off centre. If the patient has a central end pad and it has shifted then we may have to correct the cast or even recast Yet it is better to make sure that the distal padding doesn’t move during the casting of the stump.

The diameter and the circumference of the cast at the distal end are very important. It is normal that the end pad may be larger on the cast than when measured. Do not reduce the cast back to the measure.

Plaster does not need to be taken off the end pad.

Small build ups are required on the medial and lateral Malleoli and on any sensitive areas or scars. 2-3 mm are quite acceptable as build ups.
**Posterior Trim line.**

The posterior wall follows the same idea as the posterior wall of the BK prosthesis. However since the stump is long we can lower the trim line quite a bit.

It is normal to set the posterior line 2-3 cm, below the level of the mid patella tendon. The limit should be just sufficient enough to allow the patient to kneel comfortably, as for riding a horse or working in the garden.
SECTION - 7

FABRICATION TECHNIC
Manufacture Technique.

Push fit liner.

Principle.

The socket is made in two parts. The outer socket is made in GRP or Polypropylene. Today this is more usually the polypro. The hard socket is shaped as a long cone. It is slightly larger at the proximal end than the distal end. Inside there is a Pelite (alvelux) liner. The inside of the liner is shaped to a rectified cast of the stump, the outside of the liner is cylindrical or some time conical.

The liner has a split or two, running most of it’s length. The patient dons the socket by pushing the stump into the liner. The liner can expand because of the split. The stump and liner are then pushed into the hard socket. The complicated inside shape securely holds the liner onto the stump and friction hold the outer socket securely onto the liner.

Manufacture.

1/ Make up a pelite cone from measurements of the stump. (Refer to the details of the technique in the Below knee manual.)

2/ With the liner moulded and capped in the normal way ( 1 thickness of material on the cap only) carefully measure the diameter of the bulbous end. Move the callipers up to the proximal end and mark the narrowest point on the shank that is equal to the widest part of the bulbous end. This will mark the proximal end of the build up to give a cylindrical outside of the liner. (Check not only the diameter but the circumference also.)

3/ Build up the narrow area between the widest part of the bulbous end and the proximal mark with alvelux. When finished, the outside of the liner should be smooth and uniform in order to be able to move in and out of the socket without too much resistance.
4/ The end of the liner should now be built up using Pelite to hold the form for the alignment coupling. Normal bench alignment should be followed. (See bench alignment section.)

5/ When the alignment device has been positioned the outer socket can be formed either by drape wrap, GRP lamination, or by bubble drape.

6/ The plaster model is chipped out and the socket trimmed and dressed.

7/ The foot is attached to the socket using an alignment bolt and washer.

8/ The leg is now ready for dynamic alignment. The changes possible are Inversion, Eversion, flexion, extension and rotation. Medial and lateral shifts are not usually required since the cosmetic problems it would caused are not acceptable.

9/ After alignment is complete the leg can be finished with a cosmetic cover. This is usually alvelux but can be achieved with a second polypro drape or second lamination. The rigid method means that alignment changes later in the process are more difficult.
SECTION - 8

ALIGNMENTS
**Bench alignment.**

During the bench alignment process we attach the foot to the socket in a position which is generally found to be close to the optimal (best) position for most amputees.

For the normal stump with no instability of the knee joint and without varus/valgus deformities, the foot is placed directly underneath the centre of the stump, when viewed from the front or back.

**Adduction/abduction** angles should be set to match the angles measured during the assessment and casting procedure.

In the case where there for example is a varus deformity of the stump or a tendency to lateral thrust when the patient is walking, the prosthetist may decide to displace the foot a little laterally.

It is important to remember that this will greatly influence the cosmesis which will become poorer.

**Flexion / Extension** angles should be set at the neutral angle. That is the midline of the stump is set at 90 degrees to the top surface of the foot (or the ground).

A plumb line held from the midpoint between the patella tendon bar and the posterior wall should fall approximately 1/3 along the foot from the heel.

The foot should be set at 5 degrees external rotation similar to the BK bench alignment.
Static alignment.

The static alignment procedure is the same as that outlined for the Below Knee amputees. Below is a detailed step by step description:

1) The prosthetist must check the information on the measurement chart, and ask the following questions: - Is this the prosthesis that has been prescribed? Do the measurements of the prosthesis correspond to those taken of the patient?

2) The bench alignment of the prosthesis must be checked. This includes checking adduction / abduction angles, flexion / extension angles, plumb lines and rotation of the foot.

3) The patient is asked to walk on the old leg to show if there are any bad habits or problems that follows the use of this leg.

4) The patient’s stump is examined carefully. Any damage that has been caused by the old prosthesis is noted, and it is assessed whether or not it will prevent the patient from walking on the new prosthesis.

5) If the patient’s stump is healthy the stump sock, liner and prosthesis can be put on. When the liner is put on it is possible to begin assessing the fit of the prosthesis. The split in the liner should not be gaping nor should it be very loose.

6) Now the patient is asked to stand up. It is important that there is something the patient can hold on to, in case the prosthesis is painful or the alignment is very wrong.

7) The fit of the prosthesis is checked by looking at lines, assessing whether the patient is standing with full weight on the prosthesis and asking the patient about pain / comfort.
8) Making sure the patient is standing with equal weight on both legs, the height is checked. The anatomical landmarks used are: Anterior Superior Iliac Spines, Iliac crests, Posterior Superior Iliac Spines and if in doubt - The Spine and shoulders.

9) The general stability of the prosthesis is assessed. Can the patient safely start walking on the leg.

10) Finally the suspension is checked. If any of the above are not found to be satisfactory they will have to be corrected before dynamic alignment begins.

**Dynamic alignment.**

Also the dynamic alignment procedure is very similar to that of the Below Knee Prosthesis. Though the alignment adjustments needed and possible are generally smaller/less. In the following a step by step procedure is described:

1) If the patient is comfortable and the alignment is not too wrong, the patient is allowed to walk for a few minutes.

LOOK FROM THE FRONT AND BACK OF THE PATIENT:

2) The first adjustment to make is to correct the toe in/out position (rotation)

3) If the foot is not flat on the floor so the patient is walking on either the lateral or medial border of the foot, the socket must be tilted into more adduction or abduction.

4) The distance from the floor to the tip of the toes at heel strike is assessed. If it is bigger than the normal side it means the socket is too flexed.
5) There should be no problems with the width of the walking base, unless the stump is very adducted or abducted. It may be considered to place the foot lateral with respect to the end of the socket if the stump has an adduction deformity. But this will affect the cosmesis in a negative way.

LOOK FROM THE SIDE OF THE PATIENT:

6) If point 4 has been carried out correctly, there should be no problems with the flexion / extension of the knee. It should be normal unless the socket has been put too far anterior or posterior on the foot.

7) When the prosthetist is happy with everything above, - check again!

8) Trim lines are checked with the patient sitting. Also check if the patient can take the prosthesis on and off by him / her self.

9) The prosthesis is removed and the patients stump is examined for signs of pressure. Any areas with red marks must be carefully assessed to find out if the socket needs to be adjusted.

10) Before the prosthesis is taken to the workshop for finishing, it is a good idea to check if all measurements needed are written on the chart.
SECTION - 9

FITTING PROBLEMS

&

ADJUSTMENTS
Through ankle, prosthetic problems.

When the patient comes to the prosthetist with a problem, the prosthetist must make a careful assessment. As described in the BK manual the important parts of the patient assessment are:

1) Listen to the patients complaint.

2) Carefully observe the patients gait. To determine whether an alignment error could be the cause of the problems.

3) Examine the stump for signs of unwanted pressure.

4) Compare the measurements of the stump with measurements taken before, and compare the stump shape with the socket shape.

In the following some of the problems that may occur are listed.

1 – PROXIMAL DISCOMFORT.

A) Discomfort at Patellar tendon.

The Patellar tendon bar may be too deep, too wide, positioned in the wrong place or have a wrong shape.

In some cases it will be possible to change the shape of the tendon bar by heating the socket or by grinding away some material. If this is not possible a new socket will have to be made.

It is also possible that the stump sinks too deep in the socket. The reasons could be:
  - The compressing of the alvelux in the patellar tendon area,
  - The shrinking of the stump.

It could also be due because the stump is simply not going deep enough inside the prosthesis.
B) Discomfort at the Fibula head.

In some instances the socket relief for the Head of Fibula is not enough, causing discomfort.

To correct this problem it may be possible to heat the socket and change the shape, or to grind some material away from the inside of the socket.

Just posterior-distal to the Fibular head runs the common peroneal nerve, pressure on this nerve will cause pain.

Pressure on the nerve can also cause what is called referred pain. The patient will complain about pain at the distal part of the stump, but the source of the problem lies proximally with pressure on the common peroneal nerve or on a neuroma.

C) Discomfort in the Popliteal area.

The patient may experience that the top of the socket is too lose. This may be corrected by adding some material to the popliteal area, or by heating this area and compress it a little.

In the case where discomfort is caused by a too high or improperly shaped posterior brim, the brim may be lowered to better allow for the Hamstring tendons (particularly on the medial side.) Or the flare of the brim may be made more generously.

2 – DISTAL DISCOMFORT.

A- Discomfort over Anterior aspect of Tibia.

If the patient complains about pain at the anterior aspect of the stump, it could be because there is too little relief for the bone over this area. To correct this some material is ground away inside the socket. Or a new socket should be made. You can also add some padding on both sides of the tibial crest.
**B) Discomfort at the edges of the distal end.**

In the case where the casting of the patient has been done without weight bearing, a general relief is needed around the edges of the distal end of stump. In some cases this build up is too small and the patient feels pressure on the sides of the stump.

Some material can be ground away from the insides of the socket or a new socket has to be made.

**C) Discomfort under the distal end of the stump.**

Some patients cannot tolerate total weight bearing at the end of the stump. Relief can be provided by adding material to the general proximal weight bearing areas.

In some cases the patient has developed a pressure point or a bone spur under the end of the stump. The point must be accurately located and very localized relief must be made.

**D) Discomfort over the trimmed malleolus.**

The malleolus are very sensitive to pressure so if the patient feels pain here a proper relief must be provided by grinding some material away from the inside of the socket or by making a new socket.

Discomfort at the malleolus can also be caused by general shrinkage of the stump causing a loss of suspension so that the prosthesis is sliding distally on the stump.

This can sometimes be helped by adding some material to the area along the shaft of Tibia and Fibula. Otherwise a new socket must be made.

In very few cases it is possible to relieve the problem of stump shrinkage by adding more stump socks. But mostly this will cause problems at the edges of the stump and at the malleolus.
SECTION - 10

CHECK OUT PROCEDURE
Through ankle, prosthetic check-out.

CHECK-OUT LIST:

1) Is the prosthesis as prescribed? If this is a second check-out, has the new instructions been followed?

2) Can the patient easily put on the prosthesis?

Check with the patient standing.

( for point 3,4,5 and 6 patient should stand with good posture, even weight on both feet and heel centres not more than 15 cm apart. )

3) Is the patient comfortable while standing?

4) Is the anterior-posterior alignment good? (The patient should not feel that the knee is unstable, or that the knee is forced backwards.)

5) Is the medio-lateral alignment good? (The shoe should be flat on the floor and there should be no pressure at the lateral or medial brim of the socket.)

6) Is the prosthesis the correct length?

7) When the patient lifts the leg up a little, there should be no piston action.

8) Are the proximal socket walls the correct height?

9) Are the medial and lateral walls in contact with the epicondyle?

Check with the patient sitting.

10) Can the patient sit comfortably? There should be no pinching of the soft tissues in the popliteal area when the knee is flexed 90 degrees.
11) Is the posterior wall high enough?

12) Do any of the modifications make the patient uncomfortable when sitting?

**Check with the patient walking.**

13) Is the patient walking well on level ground? Indicate below any gait deviations that needs attention.

14) Is piston action between stump and socket minimal?

15) Does the patient go up and down inclines and stairs well?

16) Are the socket and suspension system comfortable?

17) In the case of a socket with a medial panel, does the panel fit properly and is pinching of the patient’s skin avoided?

18) Is the patient able to kneel satisfactorily?

19) Does the prosthesis function quietly?

20) Are size, shape and colour of the prosthesis approximately the same as the sound leg? (With most Through ankle amputees the cosmesis will be a compromise due to the bulbous end.)

21) Does the patient consider the prosthesis satisfactory?

**Check with the prosthesis off the patient.**

22) Is the stump free from abrasion, discoloration and excessive sweating just after the prosthesis is removed?

23) Is weight bearing occurring at the end of the stump? If total end bearing can not be tolerated is weight-bearing distributed over the proper areas of the stump?

24) Is the general workmanship satisfactory?
REFERENCES


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Ankle Disarticulation Prosthetics