VOLUME - 1

THE JAIPUR BELOW KNEE PROSTHESIS HDPE

FABRICATION MANUAL

BY

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PREFACE

The fabrication Manual of Jaipur Below Knee Prosthesis HDPE, a research work of Bhagwan Mahaveer Viklang Sahayata Samiti, is being presented. There has been a long felt need for proper reference material for understanding of the Jaipur Foot/Limb Technique. In the above context, the present series of manuals will go a long way in providing the latest information on the techniques, procedures in fitting and alignment.

The large number of photographs are intended to make understanding of the technique easier. Few of the chapters contained in this manual are from standard text books and other manuals.

It is my proud privilege to present this manual as necessary adjunct to the students learning the Jaipur technique and to all those who have been using it for a long time. It is not intended for general release.

My best wishes to this venture.

B. P. Jain
President
Bhagwan Mahaveer Viklang Sahayata Samiti
India

INTRODUCTION

Bhagwan Mahaveer Viklang Sahayata Samiti (BMVSS) has the privilege of fitting the largest number of artificial limbs to the handicapped in the world. It is an NGO which was set-up and got registered in 1975. Starting in a small way, fitting 59 limbs in 1975, it is now providing more than 16000 artificial limbs in a year. It also provides even larger number of calipers every year. Further other aids and appliances are also given to the handicapped. In last one year alone the total number of the handicapped beneficiaries was around 60,000.

BMVSS in non-religious and non-political body. Besides most of its patients are below poverty line, though affluent people also seek its artificial limbs because of their quality.

However apart from the social input and the quantity, BMVSS has special focus on quality. The effort of BMVSS is to constantly improve the manufacturing standards and processes necessary for Jaipur Foot and the attached sockets including the joints for the above knee limbs. Towards this end the society has been adopting several measures all these years. However these have been partial or product specific. These have also been ad-hoc at times. On the other hand, presently, we are concentrating on more comprehensive approach. Now simultaneously work is going on in developing a new lighter and more durable foot-piece made of special polymers, making sockets of lighter and harder polymers, evolving more functionally effective joints and improving the materials and quality of the suspension systems etc. An equally important aspect is of human resource development. Towards this goal BMVSS is now, instead of imparting training in a sporadic manner to a few technicians, whether its own or of outside organisations of India or abroad, setting-up a full fledged Training Institute for the Jaipur Foot and Limb Technology at Jaipur.

Keeping the importance of training in view, BMVSS has published comprehensive book captioned " Jaipur Artificial Limbs" written by Dr. M. K. Mathur, former professor and Head of Physical medicine and Rehabilitation, SMS Medical College, Jaipur. As part of the same effort, BMVSS is now coming out with the present book titled- "The Jaipur Below Knee Prosthesis HDPE, Fabrication Manual" written by Tarun Kumar Kulshreshtha, Prosthetist & Orthotist who has a long experience of making both western and Jaipur limbs and who has made special efforts in writing this manual in a scientific manner. Hopefully, this would meet a felt need of the technicians and all those interested in Jaipur Foot Technology.

D. R. Mehta
Founder & Chief Patron
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Technical Forward

Amputation is a disability that may affect a person of any age group, of any sex, at any time during his/her life span. There may be a number of reason for amputations which is the loss of the some part of the body. Whatever may be the cause of the amputation, it results in some specific, physical, psychological, and socio-economic problems of unique nature which develop because of permanency, finality, and irrecovability of the loss associated with it. However, this loss can be compensated by the provision of a Prothesis (Artificial Limb) which, with its functions make the amputee mobile, thereby help them to regain their normal life, self-respect, and dignity to a great extent.

India has a very large population of the lower-limb amputees. About 80% of them live in rural areas. The functional, socio-economic and cultural requirements of the Indian amputees are different from the western world. The conventional lower-limb prosthesis has got a foot-ankle assembly which require to be covered and protected with shoes which are expensive and add to the cost of the prostheses. Moreover, the replacement is a costly affair for a poor villager. It was not only the shoes but also the other aspects of the prosthesis which demanded some innovations.

The growing industrialization/urbanization of the third world countries and a global upsurge of civil wars, use of landmines, insurgencies and terrorism demand handling of unprecedented number of amputees who have to be provided with limbs at reasonable cost, in a short time, and which suit with their socio-economic culture. The advantages of the "JAIPUR FOOT and LIMB" has made it the most versatile technology which has, so far, successfully addressed the above problems not only in India but also in many other countries. The main features of the Jaipur Foot/ Limbs are:

1. Jaipur Foot does not require any shoe, amputees can walk barefoot. How ever, shoes can be worn with it
2. It looks like a normal human foot.
3. It is made of waterproof material; amputees can walk in wet and muddy fields.
4. It permits enough dorsiflexion and other movements necessary to adapt itself while walking on uneven surfaces.
5. It is the most cost-effective Foot-pieces available in the world.
6. The Jaipur Prosthesis are light in weight.
7. It is functionally and cosmetically close to human limb.
8. It is a rapid fit limb. A large number of amputees can be provided prosthesis within a very short period of time.
9. It is the most cost-effective prosthesis available in the world.

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ACKNOWLEDGMENT

The opportunity to prepare a new addition of this little manual on the fabrication technique of the "Jaipur Below Knee Prosthesis" provided the occasion to have a new look at the contents in order to make it as acceptable as possible to the students learning this technique and to those who have been using it for quite some time.

I am indeed fortunate and most grateful to Mr. B. P. Jain, President and Mr. D. R. Mehta, Founder and Chief Patron of BMVSS for their motivation and support to me. I am also thankful for the help given to me by a number of persons. It is not possible to name every person who has made contribution. But the following person must be properly acknowledged.

Dr. M. K. Mathur, Consultant, Research, Development and Training, BMVSS, Jaipur India.

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Mr. Surajmal Sharma, Prosthetic technician, BMVSS, New Delhi, India.

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Chapter 1
Useful Anatomical Terminologies

Anatomical position : Reference position of the body permitting description of location and movements. The individual is standing erect.

Head	:	Facing forward.
Arms	:	Parallel to the trunk, straight at the sides.
Hands	:	Positioned so that palms face forward.
Legs	:	Straight.
Feet	:	Parallel to each other.

Anterior	:	Toward the front.
Posterior	:	Toward the back.

Medial	:	Toward the midline of the trunk.
Lateral	:	Away from the midline of the trunk.

Superior	:	Toward the head.
Inferior	:	Away from the head.

Proximal	:	Toward the trunk.
Distal	:	Away from the trunk.

Flex	:	To bend the limb.
Flexor	:	Any muscle which bends the limb.
Flexion	:	Bending the limb.

Extension	:	Straightening the limb.
Extensor	:	Any muscle which extends the limb.
Hyperextension	:	Extending the limb beyond anatomical position.

Abduction	:	Moving the limb away from the body.
Adduction	:	Drawing the limb toward the body.

Dorsiflexion	:	Bending the ankle so the foot points upward.
Plantar flexion	:	Bending the ankle so the foot points downward.
Internal rotation	:	Twisting the limb inward along its long axis.
External rotation	:	Twisting the limb outward along its long axis.
Inversion	:	Movement combining plantar flexion, supination, and adduction.
Eversion	:	Movement combining dorsiflexion, pronation, and abduction.
Circumduction	:	Circular movement combing flexion, abduction, extension, and adduction.

Chapter 2
Important Lower-Limb Landmarks

Bones

1. Iliac Crest : entire length palpable, including anterior superior spine and posterior superior spine; at level of spine.

2. Anterior Superior Iliac Spine : anterior termination of iliac crest; at a level of S1.

3. Posterior Superior Iliac Spine : at base somewhat lateral to the dimple on back. Line joining both posterior superior iliac spines crosses S2 spine, and indicates the sacroiliac joints.

4. Ischial Tuberosity : close to medial termination of gluteal crease; bone on which individual sits; more lateral in women. Flex hip to displace bulk of gluteus maximus.

5. Greater Trochanter : stand or lie with legs well separated to relax tendon of gluteus maximus and tensor fascia latae. Alternate internal and external rotation causes trochanter to roll forward and back ward.

6. Adductor Tubercle : most superior bony landmark on medial surface near knee.

7. *Femoral Epicondyle* : medial epicondyle is 19 mm below the adductor tubercle

8. *Femoral Condyles* : below epicondyles; knee joint axis. Flex knee and follow the joint line as it curves medially and laterally.

9. *Patella :* easily moved from side to side when extensors of the knee are relaxed, as resting the heal on a chair. Apex points downward; base is the superior border.

10. *Medial Tibial Flare* : flat surface on antero-medial aspect just above tibial tubercle.

11. *Medial Tibial Condyle* : follow the medial tibial flare upward onto the medial condyle. Flex the knee and rotate the tibia outward to expose the condyle.

12. *Medial Tibial Plateau* :flex the knee to expose the flat bearing surface of medial tibial condyle plateau is a depression 19 mm below medial femoral epicondyle.

13. *Lateral Tibial Flare* : flat surface on anterolateral aspect of tibia immediately above tibial tubercle, palpable if head of fibula has been removed surgically.

14. *Lateral Tibial Condyle* : approximately on the same level as medial condyle. Lies above and medial to head of fibula. Flex the knee and rotate tibial inward.

15. *Lateral Tibial Plateau* :approximately on the same level as medial plateau, 19 mm below lateral femoral epicondyle.

16. Head of Fibula : place finger behind lateral aspect of knee or trace biceps femoris tendon downward. Head is rounded with blunt apex (styloid process) felt on posterior aspect on same level as tibial tubercle.

17. *Tibial Tubercle (tuberosity)* : on same level as head of fibula, four finger breadths below apex (inferior border) of patella; proximal termination of tibial crest.

18. *Tibial Crest (Shin)* : extends distally from the tibial tubercle along the anterior border of the tibia. Entire length is palpable.

19. *Medial Malleolus* : prominent blunt medial termination of tibia.

20. *Lateral Malleolus* : sharp, triangular, with conspicuous anterior and posterior borders; 19 mm lower and more posterior than medial malleolus.

21. *First Metatarsal* : head is at prominent first metatarsophalangeal joint. Frequent site of bunion enlargement.

22. *Fifth Metatarsal* : projecting base is easily felt about halfway along the lateral border of the foot.

23. *Calcaneus* : the heel bone.

Tendons and Ligaments

Hip

Adductor Longus and gracilis tendon : on medial side of proximal thigh when leg is adducted against resistance.

Femoral Triangle : on proximal antero-medial thigh. Base is formed by inguinal ligament, extending from pubic tubercle to anterior superior iliac spine. Lateral side formed by medial border of sartorius. Medial side is medial border of adductor longus, whose flattened tendon, 19 mm wide, arises from the front of the pubis. Apex is 100 to 150 mm below the inguinal ligament.

Knee

Quadriceps Tendons : mid-anterior thigh at base (superior border) of patella.

Patella Ligament : place thumb firmly on soft tissues about 19 mm directly above tibial tubercle and contract quadriceps by raising right heal 13 mm off floor. Alternate contraction and relaxation of quadriceps is felt as the tension on the ligament changes. Contractions always displace the patella upward.

Semitendinosus Tendon : press back of heel against the leg of a chair. This tendon is round and the lowest and most lateral of the four tendons on the medial side of the knee.

Biceps Femoris Tendon : forms lateral margin of popliteal fossa; inserts into head of fibula. Flex knee against resistance.

Popliteal Fossa : hollow space on back of knee between medial and lateral hamstring tendon, semitendinosus and biceps femoris, respectively. Two heads of gastrocenemius form inferior border.

Chapter 3
Joints of Lower-Limbs and Major Muscles

Hip Joint

	Movement	Muscles
1.	Flexion	Flexors
		Psoas
		Iliacus
		Sartorius
		Rectus Femoris
2.	Extension	Extensors
		Gluteus Maximus
		Hamstrings
3.	Abduction	Abductors
		Gluteus Medius
		Gluteus Minimus
		Tensor Fascia Lata
4.	Adduction	Adductors
		Gracilis
		Adductor Longus
		Adductor Brevis
		Adductor Magnus
5.	External Rotation	External Rotators
		Gluteus maximus
6.	Internal Rotation	Internal Rotators
		Gluteus Minimus

Knee Joint

	Movement	Muscles
1.	Flexion	Flexors
		Sartorius
		Hamstrings
		Gastrocenemius
2.	Extension	Extensors
		Quadriceps

Ankle Joint

1.	Dorsiflexion	Dorsiflexion
		Tibialis anterior
		Extensor hallucis longus
		Extensor digitorum longus
		Peroneus tertius
2.	Planter Flexion	Planter Flexors
		Gastrocenemius
		Soleus
		Flexor hallucis longus
		Flexor digitorum longus

Subtalar Joint

1.	Eversion	Evertors
		Peroneus tertius
		Peroneus longus
		Peroneus brevis
2.	Inversion	Invertors
		Tibialis anterior
		Tibialis posterior

Chapter 4
Important Medical Terminologies

Anatomy:	Anatomy is the study of the structure of the body and of the relationship of its constituent parts to each other.
Physiology:	Physiology is the study of the functions of the normal human body.
Bones:	The bones form the framework of the body known as skeleton, which supports and protect some soft organs. Bones act as levers in movements, and provide surfaces for the attachment of the muscles.
Joints:	The site where two or more bones come together is known as Joint.
Ligaments:	These are the strong cords or bands of tough, white fibers which connect two bones and are found in association with the joints giving stability to them.
Muscles:	The muscles produce movements of various bones at the joint.
Tendons:	Tendons are round or flat band which connects the lower end of the muscle to bones.
Amputation:	Amputation is loss of a part or whole of a limb as a result of injury, disease, or operation.
Stump:	The stump is the residual part of limb after amputation.
Prosthesis:	A Prosthesis is an external mechanical device that replaces lost part of the limb to restore its functions.
Prosthetics:	The science of designing, fabricating, and fitting of a prosthesis is known as Prosthetics.
Prosthetist:	The specialist who designs, fabricate and fit the prosthesis is known as Prosthetist.
Alignment:	Alignment refers to the relative position of the various components of the prosthesis, particularly the positioning of the socket and the foot. In case of Above Knee prosthesis, the alignment of the knee unit is also important.
Socket:	The socket is that in which something can be inserted. In terms of Prosthetics, the stump is inserted in the socket which bears the body weight and transfer it to ground through other components of the prosthesis.

Edema:	Edema is temporary swelling caused in the amputed stump due to trauma, delayed wound healing, or other vascular complications and insufficient distal compression.
Plantigrade:	Neutral position of the foot with respect to leg.
Contracture:	Contractures are caused by muscular imbalance; poor postural habits for long duration
Neuroma:	The cut ends of the nerves form neuromata; which are sensitive and often produce abnormal sensations.
Phantom sensation/pain:	The feeling of presence of the lost limb and pain after the amputation is known as phantom sensation/pain.
Scar:	The scar is the site of healed amputed wound and is an area of vascular insufficiency.
Abrasion:	An abrasion is caused by the friction created between stump and socket due to poor fit and alignment of the prosthesis.
Locomotion:	Locomotion means propulsion of an object. In terms of human body, it means propulsion of the body.
Impairment:	A loss or reduction in physical, anatomical, or psychological function is known as impairment.
Disability:	When impairment interferes with the social, economic, or educational activity, it becomes disability.
Handicap:	If the society has prejudices against the impaired person, it becomes handicap.
Rehabilitation:	Rehabilitation is the restoration of the disabled individual to his optimum potential for physical, mental, vocational, educational, and economic capacity.

Chapter 5
Components and Materials

COMPONENT

The components of the Jaipur Below Knee Prosthesis are Jaipur Foot, Total Contact Socket, Outer Socket(or shank), and Suspension Belt.

1. Jaipur Foot: is made of rubber material, generally, used in the manufacturing of automobile tyres. It looks like a natural human foot; bare foot walking is possible; allows sufficient movements to squat, sit cross-legged, and to walk on uneven surfaces.

2. Total Contact Socket: is made of 10 mm HDPE (High Density Polyethylene) sheet which is thermo formed on a plaster positive mould. It is based on patellar tendon bearing design. Other designs of socket can also be made like patella tendon supracondylar, total surface bearing, etc.

3. Outer Socket or shank : connects the total contact socket proximally and Jaipur Foot distally. It is made of HDPE Pipes and gives the shape of the leg to the prosthesis. Three diameters of HDPE pipes are used in the Jaipur Below Knee prosthesis.

75mm dia. For the outer sockets of children or very thin stumps
90mm dia. Most commonly used size for making BK outer socket
110 mm dia. for the outer socket of very heavy amputees.

4. The Suspension Belts: are made of leather. They are supracondylar type of belts having joints at two places so as to allow the additional range of flexion while squatting. The belt also acts to prevent piston action during swing phase and hyperextension in stance phase of the gait cycle.

MATERIALS

JAIPUR FOOT

SIZE	LENGTH IN Cms.
5	17.50
6	21.50
7	23.50
8	24.50
9	25.50
10	26.50
11	27.00

HDPE PIPE

SKIN COLOUR	75 mm dia.	4 Kg Pressure
	90 mm dia.	4 Kg Pressure
	110 mm dia.	4 Kg. Pressure

HDPE SHEET

THICKNESS	4 mm and 5 mm
LENGTH	2.00 Mtrs.
WIDTH	1.25 Mtrs.

PLASTER OF PARIS

Hospital grade quick setting plaster of paris is required to make positive moulds. Available in 50 Kg and 25 Kg packing.

PLASTER OF PARIS IMPREGNATED BANDAGE

Ordinary cotton bandage (6” X 3 mtr./5mtr.) is impregnated with plaster of paris to take the wrap cast.

STOCKINETTE BK

It has various application during the fabrication of the Jaipur Below Knee Prostheses. Available in 3 1/2", 4" and 4 1/2" in width. The unit of measure is weight.

STEEL SCREWS

8X25 size of steel screw are used to secure the foot-ankle assembly.

PRESS BUTTONS

The Press Buttons are used to attach the side collars of the suspension belt.

THE GLUE

It has number of application from pasting of suspension belt to making of soft inserts.

MANDREL

Specially designed mandrel is used to give initial alignment in the positive mould.

20” long Iron rods having diameter of 3/8” are used to give initial alignment while extending the positive mould.

The Ethaflex sheets are used to make soft inserts. Its thickness is 6 mm and size 40” X 20” .

It is used while thermo forming the HDPE Sheets and pipes.

INDELIBLE AND GLASS MARKING PENCILS

For marking applications.

COTTON BLANKET

Cotton blanket are used when moulding of the HDPE Pipes and sheets is done on the positive mould

Chapter 6
Tools and Equipments

The following tools and equipments are required to run a Jaipur Foot/Limb workshop.

1. Hammers
2. Scissors
3. Screw Drivers
4. Files (rasp - half round and round, smooth - round and half round)
5. Wood chisels - 2" (Flat)
6. Pliers
7. Oven (electric or gas)
8. Jig Saw machine
9. Heat gun
10. Drill Machine
11. Belt Grinder, Stone Grinder.
12. Anvil
13. Vacuum pump with connecting kit.
14. Drill Bits.
15. Buffing wheel (rag wheel)
16. Vice
17. Knife
18. Tri squat or plumb line
19. A-P and M-L Caliper
20. Working bench
21. Measuring tape
22. Centre punch
23. Sheet cutter
24. Hand Drill Machine
25. Alignment Transfer Jig
26. Alignment Coupling, Ankle Adapter and Extension rods

Chapter 7
PTB Socket

The PTB (patellar tendon bearing) total contact socket is used in the Jaipur Below Knee Prosthesis. The main feature of the technique of fitting this socket involves extensive modification of many aspects of the shape of the socket, it mainly derived its name from only one of these features: it is modified to apply the load through the strong, broad, patellar tendon. The modification takes the form of patellar bar which presses in between inferior edge of the patella and tibial tubercle. The counter force is applied by the popliteal area. Care must be taken not to over compress the popliteal vein, common peroneal nerve and tibial nerve. The posterior wall of the PTB socket is in firm contact but is flat. It is necessary to provide relief for hamstring tendons. The mould is also modified to use the flare of the tibial condyles, especially the medial condyle, for support. The crest of the tibia, the head of the fibula, the distal cut end of the tibia and fibula and sometimes a prominent lateral tibial condyle cannot tolerate stress and must be relieved.

Much of the modification of the PTB socket can be achieved at the time of casting stage, by the application of manual pressure as the plaster dries. The patellar ridge is formed by using the thumb and fingers , with counter pressure in the popliteal area. When this pressure is applied, there is natural tendency for the cast to bulge medially and laterally which must be controlled.

The proximal border of the PTB socket is designed to provide medio-lateral stability and suspension by extending the lateral and medial aspects of the socket over the femoral condyles. The maximum height of the proximal border is limited by the need to avoid the socket wall protruding upward above the anterior surface of the thigh when amputee sits. It is important to extend the medial and lateral walls of the socket as far as possible in the case of the short stumps, in order to increase the lever arm available for medio-lateral stability. The anterior wall of the socket usually extends over the lower third of the patella; it is cupped to avoid loading the patella excessively and to provide additional rotational control.

Although a hard socket that has been expertly fitted is usually very satisfactory, there are amputation limbs that benefit from being fitted with soft inserts.

There are several variations in the design of the proximal brim of the below knee prosthetic sockets. These variants are used to provide suspension; such sockets are termed as “PTS” (patella tendon-supracondylar). This design encloses the femoral condyles and sometimes the patella.

A well fitted PTB total contact socket can overcome the problem of the terminal edema .These sockets provide better sensory feedback to the skin of the stump to enable the amputee to know the position of the stump in the space, in spite of the distance from the ground. Although the major weight -bearing area is patellar tendon in a PTB socket, it distributes load evenly and reduces pressure the stump is subjected to.

In short, the design provide a biomechanically efficient system which allows an amputee to walk faster over a longer distance with an almost imperceptible limp.

Chapter 8
Fabrication Technique of Jaipur Below Knee Prosthesis

8.1 Evaluation of the stump

Evaluation of the stump is necessary to determine the factors which may affect the fitting of the prosthesis. It is done by visual inspection and by palpation. The stump is evaluated for joint function, muscle strength, skin condition, scarring and pain. Any information related to these factors is noted and used later on while fabricating the prosthesis.

8.2 Measurements

After evaluating the stump, the measurements of stump and sound limb are taken. The measurements are the most important procedure during the fabrication of a prosthesis , it determines the accuracy of fit and comfort. The measurements are used while modifying the positive mould, to replicate the length of sound limb and to select the appropriate size of Jaipur Foot.

Stump Measurements

The following stump measurements are recorded.

8.2.1. Stump length from head of fibula to distal end of the stump. Head of fibula is easily palpable both on the stump and positive mould. Hence, their are less chances of getting inaccurate stump length. Alternatively, stump length can be measured from inferior edge of patella to distal end of the stump.

8.2.2. Circumference of the stump at mid patellar level, and after every 2” below till distal end of the stump.

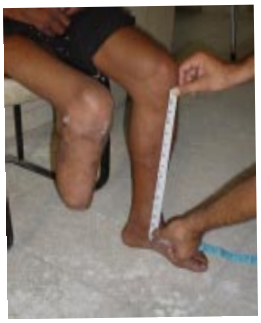
c

8.2.3. A-P dimension: Using a measuring caliper, the Antero-Posterior dimension is recorded from just below the inferior edge of patella to popliteal area. The stump will sink inside the socket if the A-P dimension is greater than actual. If it is less, then the prosthesis user will always complain of uncomfortable pressure on mid patella tendon region and there are chances of compression of popliteal vein, common peroneal nerve and tibial nerve.

8.2.4. M-L dimension: Using the measuring caliper, the Medio-Lateral dimension is recorded from the widest area medio-laterally of the amputed knee joint. The measurements should be checked two-three times as this is an important measurement, accuracy of which provide good medio-lateral stability. The M-L dimension of the positive mould will always be greater than actual since the pressure is applied antero-posteriorly by thumbs and fingers by virtue of which the cast tends to bulge medially and laterally.

The Sound Limb Measurements

The measurements of sound limb are necessary to record as the positive mould is to be replicated as per the length of sound limb. The following measurements are taken with the help of a tape-measure.



8.2.5 Length from middle of patellar tendon to medial malleolus.

8.2.6 Length from tip of head of fibula to floor.

8.2.7 The size of Jaipur Foot.

A Measurement chart should always be suggested to record all these important information and measurements so that the same can be used later on during the fabrication procedure.

8.3 Wrap Cast

After completing the procedure of measurements, the Wrap Cast of the amputee's stump is taken. First of all, the amputee is seated on a firm bench with his/her thigh supported and back of knee appx. 100 mm from the edge of the chair. Then, a moistened cast sock is pulled over the stump. The amputee is instructed to keep his/her stump in an attitude of 5 to 10 degrees of flexion which is maintained throughout the casting procedure.

8.3.1 After this, the following pressure sensitive areas of the stump are marked by using an indelible pencil.

1. outline of patella
2. mid patellar tendon
3. tibial crest
4. medial tibial flare
5. medial border of tibia
6. distal end of tibia

7. head of fibula
8. distal end of fibula if it is prominent
9. any other area which is pressure-sensitive

8.3.2 Two plaster of paris bandages are prepared by simply smearing POP powder on cotton bandages. These bandages are, then, submerged in the water. When the bandages are properly soaked in water, they are taken out and excessive water is squeezed prior to use.

8.3.3 The stump is then wrapped with one of these bandages, lengthwise starting from the superior edge of patella downwards. These bandages are wrapped circumferentially up again covering the femoral condyles, appx. 3" above the mid patellar tendon area. This is done carefully with a firm and even tension. The plaster is worked with the hands, clearly defining bony prominences and features such as medial tibial flare.

8.3.4
As the plaster begins to harden, the thumbs are placed at an angle of 30 to 45 degree to long axis of tibia, on either side of patellar tendon and pressed inwards. The tips of the thumbs locate the patellar tendon, gauging the depth of tissue. And posteriorly, the pads of the fingers are pressed into the popliteal area. Firm pressure is applied with the fingers. The depth of the impression is determined by the firmness of the tissue. The amputee is instructed to remain seated with his/her stump muscles relaxed during the Wrap Casting procedure. When the wrap has hardened completely, it is pulled off the stump.

8.4 Mould Modification



8.4.1 The next step is to fill the wrap cast with plaster of paris paste. The wrap is fixed in the cast holder. Separating agent like vaseline is applied over the mandrel and sliding rod. Then mandrel is fixed in the wall frame and POP paste is poured in the wrap cast. The care should be taken not to make plaster of paris paste too thick or too diluted.

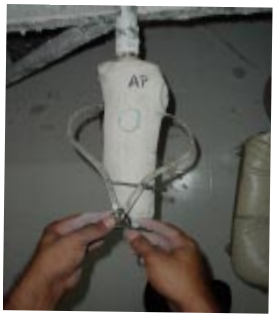
8.4.2 When the plaster is set completely, the plaster of paris bandages are slit open using a knife. Always remember to start cutting from the proximal end of the stump on the middle of anterolateral aspect.

8.4.3 The positive mould of the stump is thus obtained. The pressure sensitive areas which were marked earlier are checked and impressions and markings are reinforced once again. Except these areas, the mould is then smoothened by using a wire mesh and stockinette impressions are removed.

8.4.4 The length of positive mould is checked from head of fibula to distal end of the stump. It is compared with the measurements of stump, any discrepancy is recorded for modification.

8.4.5 Similarly, all circumference are checked and the difference from the actual circumferences of the stump is recorded for modification.

8.4.6 The M-L dimension is checked by using measuring caliper.



8.4.7 The A-P dimension is checked by using measuring caliper. Any difference in both dimensions is recorded. Now, the positive mould is ready for modification.

The objective of modification is to distribute the contact pressure on the pressure tolerant areas and to remove the pressure from the sensitive areas of the stump. Also to ascertain that the measurements of the stumps are confirming to the measurements of corresponding area of the positive mould. The positive mould is modified to distribute even pressure by removing the plaster from the pressure tolerant areas and build-ups are made by adding the plaster to provide reliefs on pressure sensitive areas.

8.4.8 The first step in the modification procedure is to scoop out the plaster from infra patellar region to tubercle of tibia. The thumb impressions taken at the time of wrap cast, should be removed which will determine the depth and width of the channel created. Similarly, the plaster is removed from the popliteal area to the extent of omission of finger impressions. After this, the A-P dimension is checked once again. It should be made sure that the depth and width of the channel created at the mid patellar area should be appx. 1/2" and 1 1/2" respectively and A-P dimension of the positive mould should confirm to the actual A-P dimension of the stump. Next, at least 1/8" to 3/8" of plaster of paris is removed from medial tibial flare. On the lateral side of the positive mould, plaster is removed between 1/8" to 3/8" from 3/4" below the inferior border of fibula to 1" above the distal end of fibula. All the edges are rounded off using a wire mesh, without erasing the markings on the sensitive areas.

8.4.9 After removal of plaster from the positive mould is completed, the build-ups are made on the mould by adding plaster of paris paste on the pressure sensitive areas which were marked earlier at the time of wrap cast. About 1/4" of POP paste is applied over the head of fibula, tibial crest, distal end of the tibia, and any other area where relief from pressure is indicated. Build- ups are also made to accommodate hamstring tendons on the medial and lateral side posteriorly. Also add at least 1/2" of paste at the distal end of the stump. The positive mould is then thoroughly smoothened and finished.

The dimensions of the positive mould are once again checked with the measurements of the amputee's stump.

8.4.10 The length of positive mould form head of fibula to distal end should be 1/2" greater then the actual stump length using Information and Measurement Form.

8.4.11 The A-P dimension of both, the positive mould and the actual, should be the same. If the A-P dimension of the mould is more than actual, then the amputees stump will sink inside the socket. And, if it is less, then the amputee will complain of unbearable pain at the patellar region.

8.4.12 The M-L dimensions of the positive mould and the stump should be the same. Otherwise, any discrepancy in the dimensions would lead to discomfort for the prosthesis user and loss of medio-lateral stability.

8.4.13 The circumferences of the positive mould should be equal to the recorded circumferences of the stump.

8.4.14 After checking each measurement, a sign of ok is marked on the mould, signifying that the desired modification is achieved.

8.5 Fabrication of Soft Insert

The soft insert is not indicated for every patient. However, it is only indicated where local or systematic disease causing sensory deficit or hypoasthesia/hyperasthesia in the stump. Most commonly encountered diseases are diabetes mellitus, leprosy, peroneal nerve palsy, sciatic nerve injury etc. Stumps having bad scars, or skin grafts also require soft insert.

8.5.1 For making the soft inserts, three dimensions are taken: Proximal circumference,

Distal circumference

Length of the positive mould.

8.5.2

The measurements of the positive mould are transferred on the sheet as follows. A vertical line is drawn on the ethaflex sheet across width, which is 5" longer than the length of positi Proximal circumference is added with 1/2", and a line is drawn at the top of and half on the either vertical line. Another horizontal line is dra

distal circumference, at the level marked on the vertical line, equal to the length of the mould from the proximal circumference. Now, the both the ends of proximal circumference and distal circur are met by drawing the lines which extend to further 5", (till the bottom of the vertical line). A third horizontal line is drawn at the bottom of the vertical line.

8.5.3 The sheet is now cut according to the outer lines and its edges are bevelled using a belt grinder, on the opposite sides.

8.5.4 The glue is applied on both ends.

8.5.5 When it is completely dried, both ends are pasted together and pressed by gently hammering the surfaces. Thus, a cone is obtained.

8.5.6 The cone is placed in a preheated oven for 3-5 minutes.

8.5.7 When the sheet becomes malleable, it is pulled over the positive mould and given the shape by hand moulding. Suction apparatus can also be used for moulding the sheet on to the positive mould. The sheet is then, allowed to cool.

8.5.8 To cover the distal end of the soft insert, a cap is made. For making the cap, the tracing of the distal end of the mould is done directly on the ethaflex sheet.

8.5.9 The edges of the cap and of the distal end of the soft insert are bevelled using belt grinder (soft insert remains on the positive mould).

8.5.10 The glue is applied over the bevelled edges .

8.5.11 When it is dried, the cap is pasted on the distal end.

8.5.12 The proximal brim is lined with sheep skin leather in order to protect the soft insert from wear and tear, to increase its life and to give a good cosmetic appearance.

The Soft Insert

8.6 HDPE Socket

8.6.1

Two pieces of HDPE Sheet of the of 15" X 15" having thickness of 5 mm (total thickness of the sheet becomes 10 mm) are fixed in a metal frame, of the same dimensions, with the help of clamps. The sheets are placed on stockinette. The soap stone powder is sprinkled between the sheet and stockinette so that the sheet does not stick with it. Now, this assembly is placed in a preheated oven at about 180 degree of temperature for about 20 minutes.

8.6.2

The mould is covered with single layer of stockinette and fixed in inverted position on the platform of suction apparatus, i.e. the distal end of the mould facing the roofing. At this temperature, the two sheets attain molten state and become single sheet and transparent. If the whole sheet has become transparent, it means it is ready for thermo forming. The sheet is taken out of oven and held over the mould.

8.6.3

Then, the heated sheet is allowed to fall by itself on the positive mould. When the metal frame is in contact with the wooden platform, the suction apparatus is turned on. Great care is taken while operating suction apparatus to achieve suction in a phased manner. If the apparatus is turned to full suction at once, the sheet will burst and suction can not be achieved.

8.6.4

The sheet takes the shape of positive mould by creating vacuum with the help of suction apparatus. The excessive material is cut off by using a sharp knife. When the sheet has cooled down, the plaster of paris is removed from inside of the socket.

8.7 Trimlines

8.7.1 Anteriorly, the trimlines cover lower third of patella, then it extends upward medially and laterally.

8.7.2 Medially and laterally, the trimlines cover the femoral condyles and then start coming down posteriorly (the height of the medial and lateral socket brim is limited to need of avoiding wall protrusion upward when amputee is sitting).

8.7.3 Posteriorly, the trim line is 1/2" lower on the medial side than the lateral side. This is important as two hamstring tendons are inserting on tibia medially as compared to single hamstring tendon insertion on the lateral side. In the middle of posterior aspect, the trim line is 1/2" higher than the patellar tendon so as to give anteriorly directed counter pressure to maintain the patellar tendon on its position. Otherwise, the patellar tendon may sink in the socket.

8.7.4 The HDPE socket is cut according to trim lines drawn by using Zig saw machine. Its rough edges are smoothened using rasp file, smooth file and buff wheel.

8.8 Extension of Socket using Endolite Alignment Transfer System

8.8.1 Next stage in the fabrication procedure is the extension of the socket. Firstly trial of the socket is taken . The amputee is seated and the stump socks is pulled over his/her stump. The HDPE socket is put on the stump. The amputee is asked to flex and extend his/her stump several times in order to ascertain that the trim lines are correct and the amputee is comfortable with the fit of the socket.

8.8.2 Secondly, the amputee is asked to stand up in a frame. Make sure that his/her pelvis are leveled. With the help of trisquat, a line is drawn on centre of the anterior surface of the socket This line describes about the varus (adduction) and valgus (abduction) in the stump and will be used as a guide while extending the positive mould.

8.8.3 A similar line is also drawn on the lateral aspect of the socket. This line shows the amount of flexion in the stump. Both the reference lines will act as guidelines while extending the positive mould.

8.8.4 The Endolite Alignment Transfer System Consists of a Wall Frame, mandrel with sliding rod, and Cast holder. The socket is fixed in the cast holder with its reference lines in vertical position. By dropping plumb line, it is ensured that these lines are vertical. Any inclination can be corrected by loosening the nut in the alignment coupling and adjusting the cast holder accordingly. After adjustments, the nut is tightened

8.8.5 The mandrel is fixed at the upper end of the wall frame. The vaseline is applied over the area which will be in contact with plaster and sliding rod. It is ensured that sliding rod is protruding at least 4" and should touch the bottom of distal end of the inside of the

8.8.6 After this, the POP paste is poured into the socket to fill it completely.

8.8.7 When the plaster is hardened completely, the sliding rod is pressed from above in order to leave a mark on the distal outer surface of the socket. After getting the desired mark, the sliding rod is moved up and a 3/8" hole is made on the outer distal end of the socket.

8.8.8 The socket, with the help of mandrel, is fixed in a inverted position at the lower end of the wall frame. An iron rod (Size: 3/8"X20") is placed in the hole made on the outer distal surface which will serve as the guide for extending the socket.

8.8.9 A cone made of ethaflex sheet, is placed on the socket in such a way that total length of the assembly comes out to be 2" more than the linear distance from the head of fibula to medial malleolus of the sound limb. Care must be taken so that the iron rod remains in the centre of the cone from all sides. Then, the cone is filled with plaster of paris paste. When plaster is hardened, cone is removed and extension is given the shape of the leg.

8.8.10 The extended positive mould with socket

It should be ensured that the diameter of distal end of the mould should match with the diameter of the malleolar region of Jaipur Foot.

8.8 Extension of Socket using Otto Bock Alignment Transfer System

The trial of the patient and the anterior and lateral reference lines are taken as described previously from 8.8.1 to 8.8.3. After getting the reference lines the following procedure is adopted to extend the socket using Otto Bock alignment system.

8.8.4 The socket is fixed with a concave disc with plaster of paris paste. Care is taken to fix the socket on disc with its anterior and lateral reference lines absolutely vertical.

8.8.5 The assembly is fixed on a alignment transfer apparatus. This apparatus helps in aligning the mandrel as per the anterior and lateral reference lines.

8.8.6 Once again, the anterior and lateral reference lines are positioned in absolute vertical position. The mandrel is already in vertical position and is in line with anterior and lateral reference lines. Any angulation can be overcome by screwing and unscrewing the four screws provided with the apparatus.

8.8.7 The socket is then filled with plaster of paris paste.

8.8.8 When the plaster is hardened, a 3/8" hole is made at the distal end of the socket. The assembly is then fixed inverted position in a vice. An iron rod (size: 3/8" X 20") is fixed in that hole which is aligned in line with mandrel. This iron rod is again a guide for extending the positive mould and to reinforce the plaster.

8.8.9 A cone made of ethaflex sheet, is placed on the socket in such a way that total length of the assembly comes out to be 2" more than the linear distance from the head of fibula to medial malleolus of the sound limb. Care must be taken so that the iron rod remains in the centre of the cone from all sides. Then, the cone is filled with plaster of paris paste. When plaster is hardened, cone is removed and extension is given the shape of the leg.

8.8.10 The positive Extended Mould with Socket

It should be ensured that the diameter of distal end of the mould should match with the diameter of the malleolar region of Jaipur Foot.

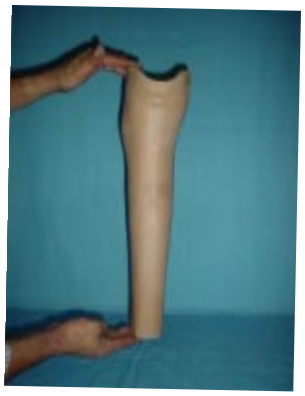
8.9 Fabrication of HDPE Shank

8.9.1 A 24" long HDPE Pipe having diameter of 90 mm is covered with BK Stockinette both from inside and outside. It is important to cover the pipe in this fashion in order to avoid sticking of the same. It is kept in the preheated oven at 180 degree of temperature for about 30 minutes.

8.9.2 When pipe becomes malleable, it is pulled over the positive extended mould.

8.9.3 The heated pipe is then given the shape of the mould by hand moulding. The hands continue working for a few minutes until pipe becomes partially cool. The Extra material is cut off from both ends. When the pipe is completely cooled off, the plaster of paris inside is beaten out either by using a hammer (impact resistance of HDPE does not allow it to break when it is beaten by hammer) or by using chisels.

8.9.4 The cutting and finishing is done as per the trimlines of inner socket. For better smoothness of the edges, it is always suggested to use buff wheels which can be fixed with drill machines.



The HDPE Shank with inner socket inside.

8.10 Trial & Fitting

8.10.1 After making the shank with socket inside, the assembly is now known as double-wall socket. The trial of double-wall socket is taken with amputee is seated on the chair or bench. The socket is pulled on the stump with amputee wearing the stump socks. He/she is asked to flex and extend his/her stump several times. The posterior brim of socket should not be hurting in the popliteal area when it is flexed to maximum extent.

8.10.2 The amputee is then asked to stand erect with the help of supports. A pencil mark is put on the double-wall socket at the level of medial malleolus of the sound limb.

8.10.3 This mark is again checked with recorded measurement of head of fibula to medial malleolus of the sound limb. To avoid any error and to be on the safer side, another mark just 1/2" below the previous mark, should be made. The excess of distal end of the double-wall socket is cut from this second mark.

8.10.4 Approximately, 3" area of distal end of the double -wall socket is heated by Heat Gun. After a few minutes, the area will become malleable and hold the Jaipur Foot when it is cooled down.

8.10.5 The Jaipur Foot is inserted in the heated area of the double-wall socket. This area is massaged properly in order to avoid any wrinkles, which might lead to develop cracks in a later phase while being used by the amputee.

8.10.6 The amputee is made to stand wearing the prosthesis. The rotation of Jaipur Foot is Checked.

8.10.7 The length of the prosthesis is checked by palpating the ASIS. Both the ASIS should be at same level. To be more sure rubber blocks of different thickness can be used beneath the amputed side in case the prosthesis is shorter in length. The rubber blocks are placed under the sound limb if the prosthesis is longer. The adjustments are made accordingly.

8.10.8 After getting the correct length of the prosthesis, the socket-foot assembly is further secured with four screws(size : 8 X 25) on each side of the distal end of the socket. In no case, these screw should be hammered in completely. Rather, a small portion should be hammered and then one drop of feviquick is applied on the threaded portion, and then, the screws should be tightened with a screwdriver.

8.10.9 The one collar of the leather suspension belt is already riveted. The position for other collar is marked on the attachment strap. This is done by placing both the collars on the medial and lateral half of the socket in such a fashion that the movements of the supracondylar strap is not restricted. The location for attaching the loose collar is marked on the attachment strap and at the same time markings are also taken on the socket for pasting the attachment strap on the socket. The loose collar is riveted with attachment strap by press buttons. The marked area on the socket is made rough by rasp file, and glue is applied on it and on the attachment strap of the belt. The glue is then left to dry out. When it is completely dried, the attachment strap is pasted on the socket and pressed with hammer.

Chapter 9
Static & Dynamic Alignment in Jaipur Below Knee Prosthesis

The alignment refers to the relative position of the various components of the prosthesis with respect to each other, particularly, the socket and foot. The alignment of a prosthesis influences the magnitude and distribution of forces applied to the stump by the socket. From the learning of fabrication procedure of Jaipur Below knee Prosthesis so far, it is amply clear that the initial alignment is given at the time of extending the socket by using reference lines. But, still there are some cases where dynamic alignment is required, e.g. abducted or adducted stumps. For dynamic alignment, the equipments and material like an alignment coupling, ankle adapter, extension rods, Jaipur Foot with bolt and alignment transfer apparatus are required. The evaluation of stump determines the requirement of dynamic alignment in the Jaipur Below Knee Prosthesis. The process is as follows.

9.1 By Endolite Alignment Transfer System

The procedure of evaluation, measurements and wrap cast is the same as described in previous chapters from 8.1 to 8.3.

9.1.1 When wrap cast begins to harden, the amputee is made to stand erect with some support, and is seen that his/her ASIS at same level. The anterior reference line is drawn using trisquat. Similarly, a lateral reference line is also drawn on the wrap cast

The wrap cast is then pulled off the stump and anterior and lateral reference lines are further reinforced by indelible pencil.

9.1.2. The wrap cast is fixed in the cast holder which is fixed with the lower end of the wall frame. It is ensured to keep the anterior and lateral reference lines in vertical position. Firstly, the wrap is placed in the sand maintaining the vertical alignment of the reference lines. A plumb line can be dropped to see that the lines are vertical. Any inclination can be corrected by alignment coupling below the sand bucket. The mandrel is applied with the vaseline and inserted from above and fixed with the upper end of the wall frame. After this, the POP paste is filled in the wrap cast.

9.1 By Otto Bock Alignment Transfer System

9.1.1 The anterior and lateral reference lines are drawn in the same manner as described in 9.1.1.

9.1.2 The wrap cast is fixed on a concave disc using plaster of paris paste. Utmost care should be taken to ensure that both the anterior and lateral reference lines are vertical.

9.1.3 Then this assembly is fixed on the alignment transfer apparatus. The mandrel is inserted in the wrap cast from above (vaseline is applied over the mandrel as separating agent).

9.1.4 If the anterior and lateral reference lines are not vertical, they are made vertical with the help of four screws provided in the alignment transfer jig with which the concave disc is attached.

9.1.5 After setting the reference line in absolute vertical position, the wrap is then filled with plaster of paris paste.

9.1.6 When the POP paste is set, the whole assembly is removed from the alignment transfer zig and mould modification is started. After doing the desired modification as described in 8.4, the positive mould is once again fixed in the alignment transfer zig and the anterior and lateral reference lines are remarked on the positive mould. The distal part of the positive mould is additioned with plaster as per following diagrams.

CONDITIONS FOR OPTIMUM ALIGNMENT

9.1.7 The soft insert and HDPE socket are made as described in previous chapters from 8.5 to 8.7.

9.1.8 The Ankle adapter is fixed with Jaipur Foot with bolt. The bolt is kept in vertical position from all sides. The bolt of Jaipur Foot is fully threaded, therefore, the ankle adapter is to be rotated in order to fix it.

9.1.9 The extension rod is fixed with the ankle adapter. The size of the rod will be determined by the measurement from head of fibula to floor less the length of Jaipur Foot,

9.1.10. A hole is made in the centre of distal end of the socket. The alignment coupling is fitted with the socket.

9.1.11. All the components are assembled together. Now the prosthesis is ready for static and dynamic alignment.

9.2 Static Alignment:

The prosthesis is put on the patient, and the static alignment is done.

9.2.1 The length of the prosthesis is checked by asking patient to put on his/her body weight equally on both the sides, and by palpating his/her ASIS. The ASIS should be at the level of an imaginary line across them. Any discrepancy in length can be corrected by replacing the extension rod.

9.2.2 The sole of the Jaipur Foot should be flat on the floor. If it is not flat on the floor, then the nut inside the alignment coupling is loosened and the socket is shifted / tilted on the alignment coupling to achieve the desired result. It is also checked that the bolt of Jaipur Foot is in upright position.

9.3 Dynamic Alignment:

The Gait deviations are seen from front, from behind and from side, when patient is walking. There are always two causes for any gait deviation: prosthetic and amputee's. The prosthetic cause can be corrected by changing alignment known as "dynamic alignment". Whereas, the amputee's cause may be some pathological condition or habit developed after prolonged use of improperly fitted prosthesis. The three important stages of gait cycle are observed.

1. Between heel strike to mid-stance
2. At mid-stance
3. Between mid-stance to toe-off

9.3.1 From heel strike to mid-stance

a. Excessive knee flexion

Prosthetic Causes:

1. Excessive anterior tilt of the socket
2. The Jaipur Foot is fixed in dorsiflexion

Amputee's Cause:

Flexion Contracture at knee

Corrections:

1. The nut inside the alignment coupling is loosened and the socket is tilted posteriorly.
2. The Jaipur foot is removed from ankle adapter and its bolt is corrected to vertical position and reattached to the assembly i.e. it is fixed in plantigrade position.
3. If the flexion contracture is not fixed, the patient is advised to have it corrected by passive stretching under the supervision of a physiotherapist. Fixed contracture needs surgical correction and, hence, the patient should be referred to the surgeon.

b. Insufficient or absent knee flexion

Prosthetic Causes:

1. Excessive posterior tilt of the socket
2. The Jaipur Foot is fixed in planter flexion

Corrections:

1. The nut inside the alignment coupling in loosened and the socket is tilted anteriorly to the desired position.
2. The Jaipur foot is removed from ankle adapter and its bolt is straighten to vertical position i.e. the Jaipur foot is fixed in a plantigrade position.

9.3.2 At mid-stance

a. Excessive lateral thrust

Cause:

Excessive lateral placement of the socket from the weight bearing line.

Correction:

The nut inside the alignment coupling is loosened and the socket is Shifted medially.

b. Pressure on the medial proximal brim

Cause:

Excessive medial placement of the socket.

Correction:

The nut inside the alignment coupling is loosened and the socket is shifted laterally.

c. Lateral bending of trunk

Causes:

1. Prosthesis is short in length than sound limb.
2. Bad gait habit.

Correction:

1. The length of the prosthesis is increased by replacing the extension rod of the correct size.
2. Gait training.

d. Inverted or everted foot (patient walks on the medial or lateral border of the foot)

Cause:

Excessive medial or lateral tilt of the socket.

Correction:

The nut inside the alignment coupling is loosened and the socket is adjusted medially or laterally to the desired position.

9.3.3 Between mid-stance to toe-off

a. Early knee flexion (drop-off)

Causes;

1. The socket is fixed anteriorly from the lateral midline of the stump.

2. The Jaipur foot is fixed in dorsi flexion.

Correction:

1. The socket is shifted posteriorly .
2. The Jaipur foot is removed from the ankle adapter and reattached in a plantigrade position.

b. Delayed knee flexion

causes:

1. The socket is fixed posteriorly from the lateral midline of the stump.
2. Excessive planter flexion of the Jaipur foot.

Corrections;

1. The socket is shifted anteriorly.

2. The Jaipur foot is removed from the ankle adapter and reattached in a plantigrade position.

In Swing Phase

Vaulting

Cause:

The prosthesis is too long.

Correction:

The extension rod is replaced with the rod of correct length.

9.4 Alignment Transfer by using Endolite Alignment Transfer System

9.4.1 After having done the static and dynamic alignment, the Jaipur Foot is removed from the ankle adapter. The Pylon is fixed with the lower part of the wall frame.

9.4.2 The mandrel is inserted from above and fixed with the upper part of the wall frame. Then, POP paste is poured in the socket.

9.4.3 Next, when the plaster has hardened, the assembly is fixed in a inverted position with the lower part of the wall frame. The alignment coupling is removed from the socket.

9.4.4 A nylon rod is attached with the protruding bolt of the alignment coupling. This rod acts as a guide for extending the socket and to hold the plaster.

9.4.5 A cone made of ethaflex sheet, is placed on the socket in such a way that total length of the assembly comes out to be 2" more than the linear distance from the head of fibula to medial malleolus of the sound limb. Care must be taken so that the rod remains in the centre of the cone from all sides. Then, the cone is filled with plaster of paris paste. When plaster is hardened, cone is removed and extension is given the shape of the leg.

9.4 Alignment Transfer by using Otto Bock Alignment Transfer System

9.4.1 After having done the static and dynamic alignment, the Jaipur Foot is removed from the ankle adapter. The whole assembly without Jaipur foot is fixed with the lower part of the transfer apparatus by means of securing ankle adapter with bolt.

9.4.2 The mandrel is inserted in the socket from above which is fixed with the transfer apparatus. The POP paste is poured in the socket.

9.4.3
When the plaster has hardened, the assembly is fixed in a vice in a inverted position and a nylon rod is attached with the protruding bolt with which alignment coupling was attached earlier. A preformed cone made of ethaflex sheet is tied with the socket as described in 9.4.5. Pop paste is poured into the cone from above.

9.4.4 When the plaster is set, the cone is removed and the mould is given the shape of the leg keeping in mind that the diameter of the lower end of the extended mould should be equal to the diameter of the malleolar region of the Jaipur Foot.

The finished extended mould ready for pulling of HDPE pipe covering.

The HDPE pipe is pulled over the extended positive mould as described in 8.9.

The heated pipe is being given the shape of the extended mould.

When the pipe has cooled down completely, the POP is removed from inside and the socket is cut according to the trimlines of the inner socket. It is finished and fitted with Jaipur Foot and leather suspension strap (as per chapter 8.10).

The Jaipur Below Knee Prosthesis

Chapter 10
The Checkout of the Jaipur Below Knee Prosthesis

In checkout procedures, the below knee prosthesis is examined for comfort, stability, alignment and user's ability to use the prosthesis effectively. The general finish and workmanship is also examined. The prosthesis is examined with the patient standing, walking, and with the prosthesis is removed. It is beneficial to record the observation in a checkout form.

1. Is the prothesis as prescribed?
It should be checked that the prosthesis is made as per the prescription. Any deviation from the prescription should be got approved from prescribing authority.

2. Is it easy for the user to don (put on) and doff (put off) the Prosthesis?
The prosthesis user should be able to put on and off the prosthesis by himself/herself.

Check with the patient standing

The amputee should stand erect , as comfortably as possible, bearing his/her weight equally on both feet, with the heel centres not more than 100 mm apart.

3. Is the sole of the Jaipur Foot flat on the floor?
The sole of the Jaipur foot should be flat. This signifies that the amputee is able to bear equal weight on both the legs. Any inclination observed, needs change in the alignment of the prosthesis.

4. Is the prosthesis of correct length?
The prosthetic side should be of the same length as the sound leg. To check the length of the prosthesis, compare the height of iliac crest level; an imaginary line across the crests should be parallel to the ground. ASIS and PSIS can also be used as the reference points. If the reference points are not at same level, immediate conclusion should not be arrived at that the prosthesis is of incorrect length. The apparent discrepancy in length may be due to improper donning of the prosthesis, poor fitting of the socket, poor alignment or due to pelvic drop developed due to some other reasons. After checking all these points, the length of the prosthesis is adjusted.

5. Is the patient free from any pressure in the area of patella tendon or any where else in the stump?
As the patellar tendon is major weight bearing area, sometimes the patient complains of pressure in this area that may be caused by longer length of the prosthesis then the sound leg or smaller A-P dimension. A poor fit socket may cause pressure any where else on the stump. Painful site of the stump, bony prominences, neuromas or any other pressure sensitive area should be taken care at the time of modification of the positive mould. Other wise, the patient may feel unbearable pressure on these areas.

6. Is the patient comfortable while standing with the midlines of the heels not more than 100 mm apart?
The amputee is asked if he/she has any pain or discomfort. Specific location of pain or discomfort should be identified and the reason for that is analyzed.

Check with patient walking

7. Is the patients performance while walking satisfactory?
The amputee is allowed to walk at his/her normal speed. He/she is observed from front, behind and side. Any gait deviation is noted. The cause of deviation is analyzed and corrected.

8. Is the patient go up and down on stairs and inclines satisfactorily?
The amputee's ability to go up and down the stairs and inclines should be carefully analyzed. The attention should be primarily directed to medical-surgical and prosthetic factors. The amputees skill must be judged in relation to his/her total physical condition and age as well as the adequacy of the prosthesis.

9. Does the patient consider the prosthesis satisfactory as to comfort, function and appearance?
The amputee is asked for his/her opinion about the prosthesis. It is tried to obtain his/her views in reference to comfort, stability, effort, and appearance.

10. Is the stump free from abrasion, discoloration, and excessive perspiration immediately after the prosthesis is removed?
The amputee's stump is examined for skin irritation, localized pressure, oedema or any other indication of poor socket fitting. Areas of redness which usually disappear within ten minutes after the removal of the prosthesis are not significant unless accompanied by discomfort. Some redness of the skin on the posterior brim is common. Other area of redness, pallor, bluish colour, coldness or excessive warmth should be noted and cause determined.

If the amputee complains of tightness distally, check for edema of the distal stump. Edema which decreases after the socket is removed suggests poor socket fit. Among the possible causes are tightness of the proximal portion of the socket, piston action, or insufficient contact.

The finish and general workmanship is also checked. Leather work should be of first quality. The socket brim must be adequately flared and all sharp edges removed. A very sharp edge any where on the socket can cause discomfort and lacerate the skin, especially in those amputees, whose skin folds may overlap the socket brim. No cut marks should be left on the brim of the socket. Any cut mark left may lead to development of the cracks within no time. The screws should not be hammered in the socket while fixing the Jaipur foot with the socket. Instead, the one third portion of the screw should be hammered first and then it is tightened with screw driver.

Chapter 11
Your and Your Patient's Responsibilities

For your patient's prosthesis to work at maximum efficiency, you need to give an intimate fit to the socket, maintaining a good alignment. While socket fit and alignment are your responsibility, there is another factor that affect the working of a prosthesis is skin care. Now that you have produced a good prosthesis, you should see that your patient is

1. able to don and doff the prosthesis by himself/herself.
2. able to maintain good standing balance and to transfer body weight from foot to foot.
3. able to walk on plane surfaces at first, then on slopes, uneven and soft grounds.
4. able to climb stairs.
5. able to rise from the floor without anybody's support.
6. able to examine his/her stump after removal of prosthesis.

The patient should be made aware of the most important rule "the communication". It is very important to tell your patient that he/she should inform to you immediately if any thing is wrong during the process of fitment of the prosthesis and learning to use it.

Before your patient leaves your clinic, a few handy tips regarding skin care and general exercises should be given to him/her.

Tell your patient that the care of skin is his/her responsibility. The stump is encased in a somewhat airtight socket which does not breathe and allow the sweat to evaporate. If the sweat is left on the skin and inside the socket, bacteria can grow. And if the skin is broken, infections can occur. To avoid skin problems, ask your patient to follow these simple steps.

1. Every day or more often, the stump should be washed with mild or antibacterial soap and it should be rinsed well.
2. Everyday wash the stump socks with mild or antibacterial soap and rinse them well. It is very necessary to remove every bit of the soap from the socks. The inside of the socket should also be washed and rinsed properly.
3. The stump should not be shaven. Shaving can cause ingrown hairs and often leads to infected hair follicles.
4. Use locally available oils or softening creams when skin is at risk of cracking or peeling.
5. The alcohol-based products should not be used on the stump. They dry out the skin and can cracking or peeling and create a potential site of infection.

6. The thinnest dressing possible should be used if an abrasion needs to be covered. Bulky padding will increase the pressure inside the socket.

7. The soft material should not be added like extra cloth to pad a pressure sore. This will only add more pressure.
8. If the fit of the socket is changed, try to adjust it with increasing or decreasing the layers of stump socks. If problem persists, then he/she should visit you for the needful.
9. Ask your patients to try to maintain their weight.
10. Suggest your patients to visit and seek medical help if problem like rashes, blisters ulcers, or infections local or disseminated occur.

General Exercises

Exercises play an important role in rehabilitation of the amputee. Some of the benefits of exercise include an increase blood flow to the contracting muscles; prevention of tissue adhesion; help in the control of edema; a decrease in residual limb hypersensitivity; an improvement in the muscle power; joint range of motion; and coordination; and development of proprioceptive awareness when using limb sensation. The patient should be told to make a routine of doing the exercises. Active stretching and strengthening exercises of stump and sound limb should be told to him/her.

Chapter 12
Some Common Stump Problems

The Painful Stump

Neuroma

Early after surgery, the divided nerves form neuromata which are sensitive and often produce abnormal sensations in the missing extremities. These symptoms subside with time. If a neuroma becomes adherent to the cut end of a bone, or lies in such a position that it is compressed by the prosthesis socket, it may become a source of continuing pain. Special care must be taken at the time of mould modification to build-up reliefs for such sites.

Phantom Limb

Every new amputee experiences some sensation in an amputed limb. The discomfort from the phantom is short lived and easily controlled with simple medication. In rare cases, a painful sensation persists long after amputation which are characterized by bizarre features: the patient may claim that his/her fingers are tightly clenched, or that there is a flowing pain in the foot. In contrast to the neuroma, the discomfort from a phantom is usually worse without the prosthesis than with one, and is relieved by the use of a prosthesis.

Skin Lesions of the Stump

Lesions of the skin of an amputed stump are almost exclusively the result of poorly fitted and aligned sockets that produce localized areas of pressure on the stump. They are most frequent in individuals with excessively hairy skin, and include blisters, abrasion etc. Nearly all can be corrected by adjustments of the prosthesis socket

Joint Contractures

Frequently, patients arrive with contractures. This is a common feature in old age patients, since positions of flexion provide relief of the pain caused by vascular insufficiency. Some degree of contractures can be accommodated in the prosthesis. The higher degree of contractures need treatment. The method of treatment depends upon the patient's condition and tolerance, and whether the contracture is fixed or not. The patient with higher degrees of contracture which can not be accommodated in the prosthesis, should be referred to a physiotherapist for passive stretching
in non-fixed contractures. The patients should be referred for medical advise in case the contracture is fixed type.

Adherent scar

The amputation limb may have scar areas which may breakdown when subjected to weight-bearing stress. Proper care must be taken to provide prosthesis to such patients having adherent scar on their stumps.

Edema

One must be aware that the fluctuations in amputed limb size may continue for 1 to 2 years after amputation. Proper positioning of the patient in the bed and while sitting, including elevation of the amputed limb as well as active exercises help control edema. The patient should be asked to use an alternative method to control edema when the prosthesis is not in use.

However, with the patient who have been using prothesis for quite some time, the edema is the result of poorly fitted sockets. When the proximal aspect of the socket is too tight and the distal aspect is loose, it results in the terminal edema. The intimate and proper fit of the socket is of great importance to control edema.

Choaking of the Stump

An ill-fitting socket constrict the proximal stump and cause passive venous congestion of the end of the stump. It commonly occurs as the result of shrinkage of the stump permitting it to sink into the socket. The cynosed, pigmented and edematous skin is the characteristic of the Choaking of the stump. More skillful fitting of total contact socket can largely eliminate this problem

Skin Grafts

The skin grafts on the stump are anaesthetic, and break down easily by rubbing against the inside of the socket. However, the skin grafting is done on the stump in order to save considerable amount of stump function of the patient. In such cases, the socket should be provided with soft padding or lining to protect the grafted area from breakdown.

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