Chapter

Prosthetics for Lower Limb Amputation

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Abstract

The Chapter will include a brief note on Amputation, Particularly Lower Limb Amputation (LLA), Levels and Causes of LLA. Importance of Prosthetics for LLA are explained in detail. The types of Prosthesis, Application (Donning & Doffing) of prosthesis are included in this chapter. Diagrammatic representation of the prosthesis are added too. Bio mechanical component is explained in detail within this chapter. The advantages and disadvantages of each and every Lower limb Prosthesis are clearly mentioned. Moreover, the Gait analysis & Training after the application of prosthesis are discussed. The reader will get a complete picture of Prosthetics for Lower limb Amputation by going through this chapter for lower limb prosthesis.

Keywords: lower limb prosthesis, donning & doffing, advantages & disadvantages of prosthesis, materials used for prosthesis, types of prosthesis

1. Introduction

This chapter is written to give information about the basic knowledge about the prosthesis, its types, its application and its advantages. The readers can understand the concept of Prosthesis with respect to biomechanical principles and how the Amputee can adapt himself to the usage of prosthesis with simple explanation. Hence, the chapter gives a overview about the lower limb prosthesis with illustrated pictures for better understanding.

Prosthetics are otherwise known as artificial limbs. They are the device used to replace a missing limb, either upper limb or lower limb. Thereby, the prosthesis are used by a amputee. The amputee by wearing this device, can able to stand walks, maintain balance and regain erect posture. The science of creating artificial body parts is called prosthetics. This prosthesis is designed and manufactured by prosthetist. He also fits the artificial limbs (prosthesis) for people with disabilities especially amputees.

2. Lower limb prostheses

Prostheses is most commonly prescriped for lower limb amputation. Amputation is defined as the removal of the limb through a part of the bone [1] the lower limb amputation is the most common amputation nearly 85 percent of all amputations. The function of lower limb is weight bearing and locomotion. Lower limb

prostheses is used to provide an individual who has an amputated limb with the opportunity to perform functional tasks, particularly ambulation (walking) which may not be possible without the limb.

3. Types of lower limb prostheses

The types of prostheses (**Figure 1**) is determined by an extend of the level of amputation (**Figure 2**). The lower limb amputation are performed at different levels based on that the prostheses are developed. The types of prostheses are

1. Hemipelvectomy prostheses – for hemipelvectomy surgeries

2. Hip disarticulation prostheses – for hip disarticulation

3. Above knee prostheses – Transfemoral/Above knee amputation.

4. Below knee prostheses - Transtibial/below knee amputation. The prosthetic socket encases the residual limb , and is often classified as either “Patellar tendon bearing” - dispersing weight distribution onto several pressure tolerance areas including patellar tendon or “Total surface bearing” creating more equal weight distribution throughout the entire socket.

5. Symes prostheses - Symes amputation/Ankle disarticulation [1]

Figure 1.
Types of Prostheses.

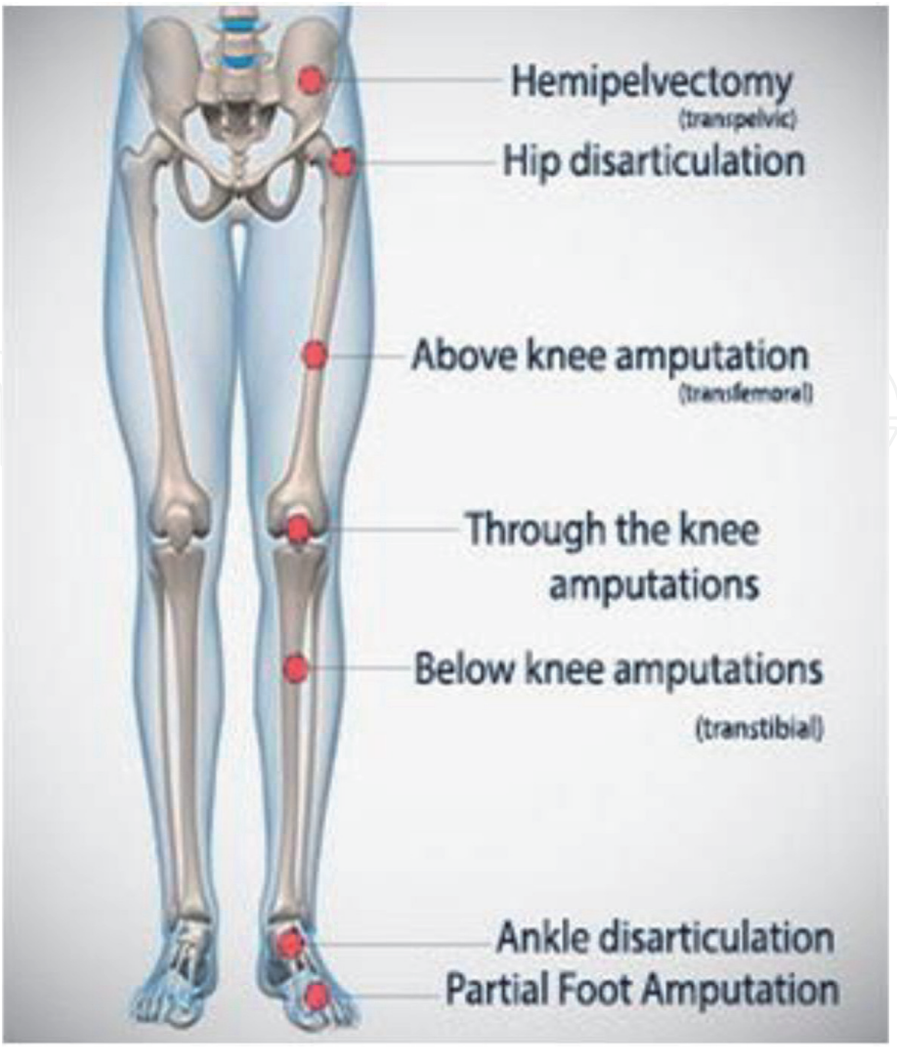

Figure 2.
Levels of amputation.

4. Prosthetic construction design

The prosthetics are designed into two types

i. Endoskeletal prostheses

ii. Exoskeletal prostheses

4.1 Endoskeletal prostheses

Endoskeletal prostheses (**Figure 3**) is a type of prostheses in which the supporting structure is internal it is also called as modular prostheses, it is most commonly used type of prostheses. The endoskeletal prostheses use the human skeleton as the model it has the tube frame provides the weight bearing function and a foam cover gives the prostheses it's near natural appearance [2]. A tube frame is a central part it is called as pylon. The pylon is constructed from Aluminium, Titanium or Stainless steel, it connect proximally socket and distally prosthetic foot. The endoskeletal prostheses includes the joint components to suit the need of the individual amputee.

Advantages of endoskeletal prostheses are

- Changes may be done at any point of time

Figure 3.
Endoskeletal prostheses.

- Light weight and comfortable for weight bearing
- Cosmetically acceptable and it gives the appearance of near to normal
- Suitable for all levels of amputation
- It gives adequate adjustment and good dynamic alignment.

Disadvantages

- Less resistant to external wear
- The foam cover is not last for a longer period and needs to be changed often.

4.2 Exoskeletal prostheses

The exoskeletal prostheses (**Figure 4**) is a type of prostheses in which the supporting structure are on outside. It is also called as conventional or crustacean prostheses. The exoskeletal prostheses has a rigid outer shell as a supporting structure it provides shape and weight bearing function. The weight is beared through

Figure 4.
Exoskeletal prostheses.

the outer shell. It is constructed of wood, or rigid polyurethane covered with a rigid plastic lamination [3].

Advantages of exoskeletal prostheses are

- Lasted for a longer period
- More resistant to external wear
- Cost effective

Disadvantages are

- Heavy & uncomfortable for use
- Fabrication time is longer
- Alignment cannot be changed & couldn't be adjusted
- Not suitable for through knee amputation.

5. Components of lower limb prostheses

The lower limb prostheses has the following components (**Figure 5**)

1. Socket : Is the most important part it is the connection between the stump and the prosthesis. It protects the stump and transmits forces. Contoured sockets

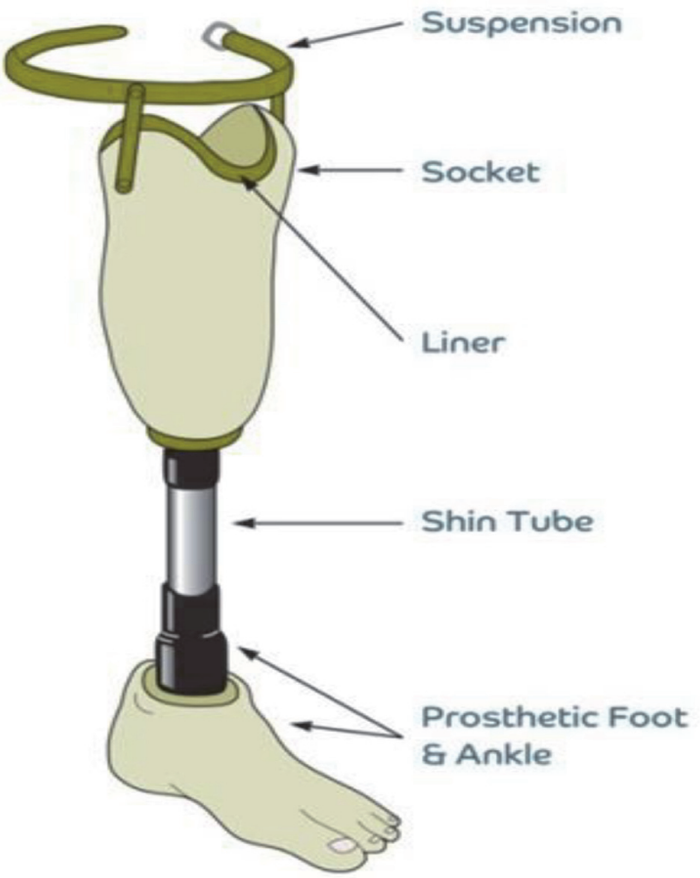

Figure 5.
Components of lower limb prostheses.

fit closer to bone, muscle, soft tissue. It provide support. It can be made of thermoplastic or metal.

2. Suspension : This holds the artificial limb on to stump. Eg. Sleeve, belt, straps, cuffs, suction prostheses.

3. Liner : This is a removable inner socket made of flexible material.

4. Pylon or Shank : This lies between the socket and the prosthetic foot. It is made of strong and lightweight material such as Carbon fibre, Aluminium & Titanium.

5. Prosthetic foot & ankle : Designed to provide support during standing/walking and shock absorption.

6. Description of lower limb prostheses

6.1 Design of prostheses

The prostheses required a high level of customization and represents the interface with the human body or parts of it, the artificial prostheses that have to be designed according to the shape of the specific anatomical area. Considerations taken into account when designing prostheses are basic structure of a lower limb prostheses, materials, weight and mass considerations, power requirements, biomechanics, and tradeoffs in motion and stability.

6.1.1 Temporary prostheses

The temporary prostheses is also called as preparatory prostheses. Temporary prostheses are used for early rehabilitation purpose to speeds the recovery process and it ease the transition into a definitive prostheses. The advantage of the temporary prostheses is it fastened the mobility of the amputee postoperatively, prevents the complications of prolonged bed rest and it promote early discharge from the hospital. It's applied within few days after surgery and limited early gait training is given.

Indications are

- Applied for early rehabilitation
- Unhealed residual limb like Burns, Skin grafts, Open wounds, Infection.
- Dermatological condition
- Painful residual limb
- Fracture healing process

6.1.2 Permanent prostheses

The permanent prosthesis is also called as definitive prostheses. It is applied when the surgical wound is completely healed and the residual limb become shrinken and shaped. The permanent prostheses is changed when the prostheses become excess wear and the atrophy of the residual limb. The permanent prostheses are should be proper fit there by the patient will get proper weight bearing & movement.

6.1.3 Special-use prostheses

The prostheses are specifically designed for certain number of patients will require special-use prostheses and it is designed specifically for sports activities such as running, swimming, or skiing. Special-use prostheses can be valuable to the amputee who wishes to expand his activities and participate in a full range of sports and recreation.

6.2 Materials used

The various materials are used to design the prostheses, the materials should be strong enough, light weight, resistant to thermal conditions, longer durability and biocompatible it should not cause allergic reactions to the body. The materials are

1. Metals: Titanium, Aluminium and stainless steel. The metals are used both in exo & endoskeletal prostheses e.g Socket, Pylon.

2. Plastic: Socket is made of plastic, the thermoplastic materials like polypropylene, polyethylene, polyurethane, acrylic are commonly used. The thermosetting plastic also used for laminated sockets in which the resin is combined with the reinforcing materials like glass fibre, nylon,carban fibre.

3. Wood: Is used in lowerlimb prostheses for foot assembly e.g SACH foot Solid-ankle, cushion-heel (SACH) feet have an interior hardwood heel that provides structural strength to the foot. This heel is bolted to the rest of the prosthesis.

4. Leather: Is used for suspension straps, socket linings.

5. Rubber: The foot in the prostheses made by vulganised rubber

6. Fabric/cotton: Socks is made of cotton. Socks are used as an interface between residual limb & socket and it provides comfort & prevent friction between the residual limb and socket.

7. Fiber reinforcement: Two basic types of high-strength fiber reinforcements are used in prosthetics are glass and carbon. Carbon fibers are more expensive than fiberglass but have superior strength and stiffness. Carbon fibers are generally set in epoxy and can provide a material with a stiffness. In addition to this high strength-to-weight ratio, carbon fiber composites have a fatigue resistance. Prefabricated carbon fiber prosthetic components such as pylon tubes, knee joints, and connectors can significantly reduce the weight of the prosthesis while increasing its strength.

6.3 Function of prostheses

1. To substitute for a lost limb

2. To restore function of Amputee

3. Comfortable ambulation

4. Reduce expenditure of energy

5. Minimizing the shift of the center of gravity of the body during gait.

6.4 Advantages of prostheses

Loss of limb not only causes physical handicap but also leads to Social, Psychological and economic effects on the individual and family. This loss can be overcome to a greater extent by the application of artificial limb which restores the function as well as total body image.

6.5 Disadvantages of prostheses

1. Choke syndrome - caused by obstructed venous outflow due to tight socket leads to red, indurated skin with orange-peel appearance, venous stasis ulcers.

2. Skin problems:

   - Contact dermatitis most commonly caused by liner, socks, and suspension mechanism
   - Cysts
   - Hyperhydrosis

3. Erythema, skin damage – due to shear forces and improperly fit of prostheses.

4. Painful residual limb – due to pressure in the bony prominence.

7. Above knee amputation

Above Knee Amputation (AK Amputation) is Removing the Three Fourth Of The Leg from the body by cutting through femoral muscle and bone. The optimum length of the residual bone is approximately 7.5 – 10cm proximal to the superior border of the patella. With a AK amputation the distal attachments of the femoral muscles are lost, in order to preserve their length and functions myodesis may be performed.

7.1 Indications

Trauma
Malignant Tumors
Diabetic Gangrene
Infections
Peripheral Artery Disease
Burns

7.2 Above knee prosthesis

An above knee prosthesis also known as transfemoral prosthesis. It is custom made for the person who have undergone above knee amputation.

7.3 Components of above knee prosthetics

1. Suspension
2. Cosmesis
3. Socket
4. Knee Joint
5. Shank
6. Foot Ankle Unit

7.3.1 Suspension

Suspension is the part which holds the residual limb into the Socket. Rigid belts or straps can be used as primary suspension which is suspended around the pelvis. This helps the socket on and prevent it from falling off during swing phase. A good suspension will enhance the control of prosthesis, improve energy transfer and decrease discomfort or difficulty during walking. The disadvantages of suspension includes causes pressure around the pelvis, needs good strength and dexterity of hand, moves when sitting, can cause bruising and irritation.

7.3.2 Cosmesis

It is the cosmetic cover that gives a shape and apprearence to the artificial limb. Most of the aritificial limbs are covered with a continous foamtube. This foam tube

is made to match with the remaining limb as close as possible. Later it is covered with stockings.

7.3.3 Socket

The socket for an above knee amputee has two basic categories.

a. ISCHIAL CONTAINMENT SOCKETS: This type of socket have a rigid frame with a flexible inner socket, which holds the pelvis inside the socket.

b. QUADRILATERAL SOCKET: This type of socket provides a shelf for the pelvis to sit on the brim of the socket.

7.3.4 Knee joint

This part is designed to stabilise the individual during standing and walking by transmitting weight throught he prosthesis.it is of two types

a. A SINGLE AXIS: This type enables the individual to bent and straight knee joint in single direction.

b. POLYCENTRIC KNEE: This type allows knee to bend in different directions. this helps in walking on uneven surfaces.

7.3.5 SHANK

This part connects the foot and ankle with the socket. There are two types of shanks.

a. Endoskeletal design: This is lightweighted soft foam gives appearance of skin . It is easily adjustable and compatible with advance technology. But the disadvantage is foam cover is fragile and can be damaged.

b. Exoskeletal design: This type has rigid and durable shell made up of laminated material. This is more durable than endoskeleton .It the ability to transfer weight throught the entire design.

7.3.6 Foot ankle unit

This is the vital part prosthetics to provide support while the individual stands on the prosthesis. The following are the various designs of prosthetic feet.

a. SACH (SOLID ANKLE CUSHION HEEL). It provides a single motion on the joint. This is relatively lightweighted, durable and less expessive.

b. SINGLE AXIS FOOT. This provides up and down movement enhancing knee stability.

c. MULTIAXIS FOOT. This provides increased mobility at the ankle, which helps stabilize the individual on uneven surfaces.

d. DYNAMIC RESPONSE FOOT. This type is more preferable for the individual who can vary in walking speed, change directions quickly and

for long distances.it provides a normal range of motion and more symmetric gait [4].

7.4 Application of prosthesis

7.4.1 Donning the prosthesis

STEP 1- Check for any signs of skin breakdown in residual limb
STEP 2- Open areas should be cleaned and covered with proper gauze bandage
STEP 3- Put on adequate number of socks to fit the residual limb into socket too loose and too tight socks should be avoided.
STEP 4- Clear the wrinkles on the sock to smoothen the surface
STEP 5-Bend the prosthesis knee to 90 degree with the foot flat
STEP 6- Slide the residual limb into the socket and fasten the suspension system loosely.
STEP 7- Stand up holding a stable surface like walker or table
STEP 8- Bring the prosthesis under the hip joint and straighten the prosthenic knee completely
STEP 9- Adjust the residual limb to fit into the socket and finally fasten the suspension system completely.

7.4.2 Doffing the prosthesis

STEP 1- Sit down and remove the suspension system
STEP 2- Remove the socket by slipping it off from the residual limb
STEP3- Check the limb for any signs of skin breakdown [5].

7.4.3 Bilateral above knee amputation prosthesis

It is also known as stubby prosthesis or stubbies. These are specially designed for individual with bilateral above knee amputation and those who are not eligible for full length prosthesis. They are custom fitted and are usually made up of standard sockets, no articulated knee joint with modified rocket bottom foot to prevent them from falling. Stubbies are foreshortened prostheses to bring down the center of gravity and thereby increase the stability. Suspension is achieved through the use of waist belts or pelvic straps. Advantages include stubbies are easy to apply and needs lesser energy expenditure from the patient. Disadvantages include sitting in a chair and stair climbing is difficult. Short canes and crutches are usually needed for the support. Cosmetically unaccepted because of the extreme reduction in height of the patient.

8. Below knee amputation

Below knee amputation (BK) also known as trastibial amputation. It is the surgical removal of foot , ankle and lower third of tibia and fibula. During BK Amputaion fibula is normally 2-3 cm shorter than the tibia to avoid pressure points.

8.1 Indications

Diabetic Foot
Traumatic Injury
Vascular Disease

Malignant Bone Tumors
Congenital Defects

8.2 Complications

Infections
Knee Contracture
Neuroma
Hetertopic Ossification
DVT
Pulmonary Embolism
Phantom Limb Pain

8.3 Below knee prosthesis

Below knee prosthesis also known as transtibialprosthesis. It is custom made for individual who have undergone bk amputation.

8.4 Components of below knee prosthesis

1. Suspension

2. Socket

3. Pylon

4. Ankle And Foot Unit

8.4.1 Suspension

It is the part which holds the residual limb into the socket. Straps are used as support system to hold the socket into place. There are various types of suspension supracondylar cuff most common type, waist belt, cuff strap, thigh corset, vaccum suspension.

8.4.2 Socket

This forms a connection between stump and prosthesis. It protects the stump and transmits the force. There are various types of sockets.

a. Conventional below knee socket

b. Patellar tendon bearing socket

c. Patellar tendon bearing and supracondylar suprapatellar socket

d. Bent knee socket

e. Slip socket

a. Conventional below knee socket: this is custom made for elderly people those with quadriceps weakening. It is fabricated with no pressure over distal tibia,

fibula, head and tibial crest. It has disadvantage of skin irritation and stump chocking by edema.

b. Patellar tendon bearing socket: This is the commonly used socket. It is designed to load the weight in pressure bearing areas like patellor tendon and medial tibial flare. It has got a bar that is built in to patella tendon patella and tibial tubercle. Socket maintained at 5^0 of knee flexion.

c. Patella tendon bearing supracondylar suprapatellar socket: It has anterior trim line to support suprapatellar region. It gives good suspension. It is very much useful for people with short stump and genu recurvatum.

d. Bent knee socket: It is designed for people with fixed flexion deformity. Upto 20^0 of flexion can be accomodated.

e. Slip socket: It has two layers fine leather internally and wooden or plastic socket lines externally. It is also used for short stump.

8.4.3 Pylon or shank

It transfers the body weight from the socket to the foot.
Types of pylon

A. Exoskeletal

B. Endoskeletal

A. Exoskeletal: This is also known as conventinal type. Commonly designed with wood or plastic. The walls of the wooden components are resuced from inside. The exterior provides final shape and cannot be changed nce it is done. Disadvantages-Fabrication time is much longer and does not provide efficient stance phase and swing phase.

B. Endoskeletal: These are light weight and much rom is available when compared with exoskeletal. Cosmetically much accepted. The prostheis has adequate provision foe adjustments to achieve good dynamic alignment. It needs much less time for fabrication.

8.4.4 Ankle and foot unit

An ideal prosthetic foot should perform plantar flexion, dorsiflexion, inversion and eversion. It should stimulate muscle activity and shock absorber. It should provide a stable surface during stance phase.
Types of foot

A. Solid ankle cushion heel (SACH): It is the most common type. It has no articulation presents with solid heel made upof wood or metal , a cushion heel with rubber heel edge which gets compressed during heel strike. It has advantages of less maintenance, durable and light weight.

B. Madras foot: This is modified version of sach. It has space between heel and ground filled with sponge rubber, toes are shaped like normal and rubber sole is provided for bare foot walking.

C. Jaipur foot: It was developed by prof, pk sethi and team at sms medical college, Jaipur. It is modified version of sach in order to make it cheaper and cosmetic. But it has disadvantage it can be used only with shoes because the shapes of toes are not discernible. Advantages: It is cheaper, cosmetically well accepted, waterproof.

8.5 Application of prosthesis

8.5.1 Donning of prostheis

1. Turn the sock inside out
2. Place the end of the sock against residual limb and roll on the sock with no air and wrinkles formed.
3. Adequate number of socks are needed to fit the socket appropriately
4. Place the residual limb inside the socket and try to ensure that the foot is correctly placed.
5. Push the residual limb into the socket .there should be mild resistance while applying prostheis. If there is no resistance then it indicates that less number of socks being used. So ensure adewuate number of socks
6. Check the knee cap in relation with the socket.
7. Buckle the suspension. Keep checking throughout the day for any discomfort or pain.

8.5.2 Doffing the prosthesis

1. Remove the one way valve at the end of the socet and pull the limb out of the socket.
2. Remove the socks and check for any skin irritation or damage [6].

9. Syme's amputation

Syme's amputation (SA) includes ankle disarticulation which is done at the level of the ankle joint in which there is removal of malleoli and the heel pad is protected. It is performed based on indications particularly in pediatric population. SA has the advantage of permitting weight bearing without prosthesis.

Indications:

- Foot trauma
- Diseased tissue/ non-usuable foot
- Infection
- Tumors
- Certain limb deformities which needs excision

9.1 Prosthetic considerations

Syme's level of amputation needs to encompass on several objectives for prosthetic management. It should pay back for the missing foot along with ankle motion which provides propulsive energy during ambulation. Limb length discrepancy (LLD) should be considered before preparing of prosthesis has it needs to suspend during the swing phase of the individual during gait.

Essential socket fit will maintain fat pad beneath the distal end of the tibia and fibula. SA has many functional advantages but when suggested with prosthesis it has various cosmetic limitations depending upon the shape and nature of the limb being treated.

In Biomechanical aspect, the prosthesis must provide comfortable transition, minimize shear and provide comfort for gait.

9.2 Types & parts

Currently four types of basically designed prostheses are used for SA.

The Canadian design or posterior door design, also used for Chopart's amputation is the commonly used prosthesis for individuals with large or bulbous residual limbs. Disadvantages of this prosthesis is heavier in weight when considered as a cosmetic option.

Medial door design (**Figure 6**) is a commonly used prostheis. It has great suspension due to intimate construction nature of the socket. It consists of an expandable door made up of an elastic sleeve which improves cosmesis and helps in donning and doffing process.

An expandable inner liner which is enclosed within the rigid outer shell. It has a hidden-panel expandable wall which is used for small distal ends.

Preparatory prosthesis which consists of a removable foam liner (**Figure 7**) that interfaces with the external socket. This allows or has the ability to modify accordingly further allowing for atrophy during maturation process by using the patellar tendon to assist by unloading the limb. It is lightweight and easily adjustable hence considered as the one with great cosmesis. Proximal region at the level of patella tendon or below can be trimmed as the amputee progresses with limb maturation.

Figure 6.
Medial door design.

Figure 7.
Rigid outer shell.

A modified Jones compression dressing is used postoperatively to control edema and to help shape the stump [7].

10. Rehabilitation

The main aim of rehabilitation followed by a lower limb amputation is to restore daily activities by means of gait. In order to acquire full accomplishment the patient

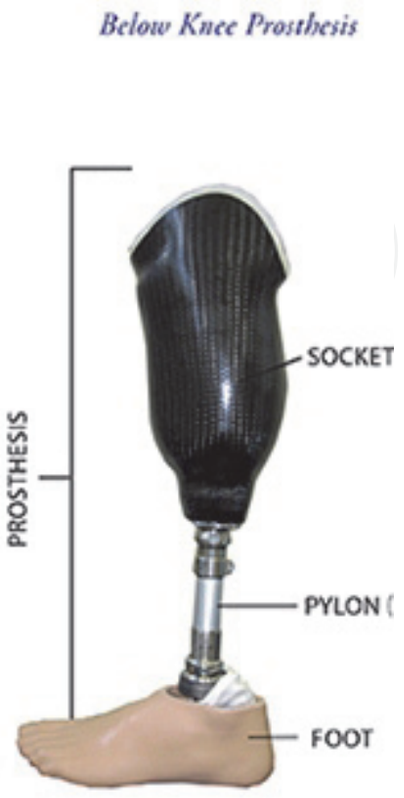

Figure 8.
BK Socket.

must be trained psychologically to obtain physical performances without any hindrance (**Figure 8**).

Donning- Initially the patient is demonstrated with fitting step. Initial fitting refers to the very first time the individual wears the prosthesis and stands, during which; patient should be stable enough to overcome disappointment about amputation and get adjusted to the prosthesis. Any discomfort should be immediately reported to the prosthetist. It is considered as the initial communication between prosthetist and the patient which will be followed by gait training.

Doffing- The patient is likely advised to sit down and remove the socket by slipping it off from the residual limb. After removal instruct the patient to check for any signs of ulcer or skin breakdown [8].

10.1 Prosthetic gait training

1. **Contents of training**: It takes several months so provide the patient with a detailed menu for the entire program from basic to advance. This will anticipate the patient about their progression and helps in self motivation. The menu can be classified into three sections:

   A. *Preparation for prosthetic gait training*

   - Maintain and improve range of motion
   - improve muscle strength
   - balance training along with single leg standing using parallel bars or a walker.

   B. *Basic training for prosthetic gait*

   - Balance and Gait using assistive devices (walker or crutch)
   - gait training within parallel bars.
   - Hygienic management of the prosthesis.

   C. *Advanced training for prosthetic gait*

   - Stairs - Outdoor gait (on rough road, slope)
   - Sports and recreation

2. **Residual limb changes**

   Explain about socket fitting and how it may change as the limb matures. As gait training progresses edema of the residual limb will be reduced, and it may fluctuate between morning and evening. Educating the patients about self management post discharge regarding adjustment of the fitting and maintaining hygiene.

3. **Adjustment of the lower limb prosthesis**

   Instruct patients about the alignment of the prosthesis which varies according to the weight loaded during gait. Educate them to adjust accordingly to avoid pain.

4. **Daily Life after the Gait Acquisition**

Provide the patient with a complete rehabilitation program.

Precautions in daily life

Even though there is a rehabilitation team supporting and encouraging the patient still it is difficult for the patient to overcome certain circumstances. Therefore, it is the patient's capability to withstand and progress further with continuous use of prosthesis by maintain body weight and residual limb related problems.

11. Discussion

All types of prosthesis are well explained with their application and advantages. Each prosthesis has its own uniqueness and the patient will be well rehabilitated with those prosthesis. Not all the patients are permitted into rehabilitation stage. It depends on factors like age, built of the patient, involvement of the limb (bilateral or unilateral), Psychology of the patient, socio-economical status of the patient. A multi- specialist Rehabilitation team has to be set to rehabilitate the Amputee.

11.1 Biomechanical principles of prosthesis and gait in prosthetic leg

The gait cycle which consists of two stages will also be termed as walking cycle. Initial contact is the first step in the starting point and the end point in every gait cycle. A single gait cycle has two phases. The stance phase and the swing phase. The stance phase is the initial step in which the foot contact starts followed by other steps in the ground. The stance phases contribute about 60% of the gait cycle and the swing phase contributes about 40% of the gait cycle. The swing denotes the single leg support in which the foot is off the ground.

The pattern of gait in subjects with prosthesis will present an altered gait pattern. Here the foot contact on the ground and the weight distribution on the foot is the key factor to be noted. The foot contact will occur on the heel in such a way the walking cycle will be as natural as possible. In this situation the sole of the foot will contact the ground and the weight is transmitted to the foot. Thus, the selection of foot component and the knee joint must be proper. This is because this will have an influence on the subject's gait when he turns on to the next phase [9].

During swing phase, the knee function is so important so that the mobility on the knee joint performing both flexion and extension facilitating the foot transition from plantar flexion to dorsiflexion i.e toe elevation. This will prevent the subject from stumbling and subsequent fall.

The residual limb must be placed on the socket which provides rigid and stable attachment to the limb. This aids control over the subject's limb during walking. The prosthesis socket can be divided into 3 parts. The top region of the socket is known as seating face. The central part of the socket is the primary control area. The function of the central part is to ensure correct movement and restrain it in the PA direction during walking. The last part is the distal socket end. This part will transfer only 10% of the subject weight to avoid abnormal weight transfer and this will cause subsequent damage to the soft tissues. The socket must be able to transfer the load thereby it ensures good stability of the subject's gait with better control [10].

During standing, there will be a stretching of gluteus medius muscle. This will maintain the pelvis in a balanced position. For a subject with lower limb amputation this pelvis position is taken care by the prosthetic socket. In a transverse oval socket of transfemoral prosthesis, the pressure on the distal femur end increases and the

body is excessively bending aside to reduce the pressure. It is a non-physiological load transfer, as the load is transferred through the tuberosity of the ischium which reduces the arm of the exerted force and the overturning moments are increased.

If there is any problem in procedure of construction and principles in aligning the prosthesis, there will be an abnormal deviation that may develop during gait. This gait deviations uses more energy expenditure during walking. Once this is practiced as a routine, may result in over use of certain muscle groups which also causes muscle imbalance.

In most cases, the improper construction of the transfemoral prosthesis and transtibial prosthesis includes

1. On circumduction, the foot swings outward which increases resistance to knee flexion with prosthesis. Here the prosthesis knee flexion has been limited for a reason. Thus, the subject has developed the avoidance mechanism.

2. The lateral flexion of the spine, the subject presents a leaning gait with the shoulder depressed towards the affected side. This is due to prosthetic foot is outset greater than 25mm, incorrect prosthesis length, insufficient adduction or amputee sensitivity.

3. Excessive heel raise, where the heel of the prosthetic foot comes up too far and too quickly. This is due to prosthetic knee flexion resistance is inadequate for the patient.

4. Drop off during the late stance, the subject presents excessive knee flexion. This is due to softness of the keel of the prosthetic foot. Also, the toe lever of the foot is too short of the heel height of the shoe is too high.

5. Foot slap, this occurs along with rapid and abnormal plantar flexion movement immediately after heel contact. This is due to insufficient resistance to plantar flexion on the prosthetic foot.

Thus, if there is an improper prosthetic fitting, there will be pain and altered muscle activity during execution of the normal daily activities. This pain may cause lateral asymmetry of the body which is due to incorrect length of the prosthesis or incorrect selection of the prosthetic component. This wrong construction can lead to abnormal force transmission, overloading the various muscles involved and also damage to the soft tissues which may affect the integration of the stump function.

12. Conclusion

Thus, this chapter gives us knowledge about the types, application, advantages, and disadvantages of Prosthesis for lower limb amputation. The biomechanics and Gait through Prosthetic leg is also explained for the readers. There are few limitations in this chapter. The content on latest Prosthetic application through Robotics, Myoelectrical prosthesis are not included in this chapter. Further research has to be done on these contents to include in further revision of the chapter. Thus the chapter is fully concentrated on prosthesis for lower limb amputation with its types and application.

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References

[1] "Text book of Orthopaedics" – JAYPEE BROTHERS, 3rd ed – by JOHN EBNEZAR.

[2] "Therapy for Amputees" – CHURCHILL LIVINGSTONE, 3rd ed by BARBARA ENGSTROM.

[3] "Amputation and Prosthetics – A case study report" – JAYPEE BROTHERS, 2nd ed by BELLA J.MAY.

[4] Ernesto Guerra, Jorge H. Nunez, Judith Sanchez-Raya, Almudena Crespo Fresno 2018.Prosthetic limb options for below and above knee amputations: making the correct choice for the right patient.current trauma reports 4(4):1-9.

[5] Christopher S.Crowel, Kte A, Impastatol, Alex C. Donaghy, Caryn Earl, Janna L.Friendly, Kari A. Keys. Prosthetic and orthotic options for lower extremity amputation and reconstruction. plast Aesthet Res 2019; 6:4 .

[6] Joan E.Edelstein MA, PT, FISPO, CPed -Lower- Limb Prosthetics and Orthotics- Clinical Concepts, Slack incorporated, e book

[7] Orthotics & Prosthetics in Rehabilitation, 4th Edition - Kevin Chui

[8] Article : FOOTCAREMD from American Orthopaedic Foot & Society.

[9] "orthotics and prosthetics rehabilitation" Michelle M. Lusardi, Milagros Jorge 3rdd edition

[10] Bernard O'Keeffe and Shraddha rout et al "Prosthetic rehabilitation in the lower limb" Indian journal of plastic surgery