Prosthesis in Transfemoral amputation
Upon completion of this lecture student will be able to:

- Identify different parts of transfemoral prosthesis.
- Differentiate between Quadrilateral and Ischial Containment Sockets.
- Describe the possible gait deviations in transfemoral prosthesis.
- Differentiate between various type of prosthesis in hip disarticulation.
Principles of Transfemoral Amputation

1. Primary wound healing
2. Preserve as much length as possible
3. Maintain anatomical and mechanical alignment.

- The mechanical axis of lower limb runs from center of head of femur through center of knee and to the mid point of ankle. The anatomical alignment, i.e. femoral shaft-axis is 9° from vertical. In most of transfemoral amputees, the stump is abducted due to over action of gluteus medius and minimus and loss of adductors at the level of insertion (especially adductor magnus accounts for 70% adduction).

- To prevent this complication, the adductors are sutured to the lateral aspect of femur with femur in maximum adduction. In addition quadriceps is sutured posteriorly and fascia lata is also sutured to femur.
With the aid of MRI imaging with three-dimensional graphic reconstruction the amount of atrophy in muscles in stump after 2 years was assessed, it revealed.

1. Muscles that are not sectioned like gluteus medius and minimus, iliopsoas has 30% atrophy.
2. Muscles that lost insertion indirectly like gluteus maximus and tensor fascia lata due to non-attachment of fascia lata showed atrophy of 37 to 47%.
3. Muscles that are sectioned and attached by myoplasty or myodesis atrophied by 40 to 60%.
Difficulties encountered creating an effective prosthesis is due to:

1. Weight bearing area (ischial tuberosity) is proximal to propulsive structure (thigh).

2. Passive mechanical replacement of 2 major joints (knee, ankle) and foot.

3. Limitations in prosthetic technology.
Components of a transfemoral prosthesis- Common types of suspension, socket, knee joint, shank or skin
Two types of sockets commonly used are:

Quadrilateral socket.  
Ischial containment socket.
Quadrilateral Socket.

Developed late in 1950 and is named for its four walls. Distally the socket is contoured for total contact of residual limb.

- **Posterior Wall**
  - It provides the major weight bearing area. It has an ischial seat for ischial tuberosity and glutei muscles which is thicker medially and thin laterally. Internally provides relief for hamstring muscle. Height of posterior wall is at the level of ischial tuberosity.

- **Anterior Wall**
  - It extends five cm above the height of posterior wall with anteromedial inward femoral bulge called scrap's projection. It keeps the ischial tuberosity in situ anterior wall is convex laterally.
Lateral Wall

- Normally, it extends, as high as anterior wall. For short stump it is in trimmed above trochanter to increase stability and control. The wall inclines medially with 10° adduction (normal adduction angle of femur).

Medial Wall

- Medial wall is vertical and parallel to sagittal plane. Relief is given intern adductor longus anteromedially and hamstrings posteromedially.
Ischial Containment Socket

• Developed in early 1990 and shaped differently from quadrilateral socket. The ischium and a part of pubic ramus are enclosed in socket. It contains more area side socket so more area of weight distribution. Narrow mediolateral dimension helps in keeping up ischial tuberosity within posteromedial wall of socket.
• The lateral wall covers trochanter to provide more stability. The distal socket is of total contact socket.
Ischial Containment Socket

*The two types of ischial containment sockets are:*

- **CATCAM** - Contour Adducted Trochanteric Controlled Alignment Method.
- **NSNA** - Normal Shape Normal Alignment.
<table>
<thead>
<tr>
<th>Quadrilateral Socket</th>
<th>Ischial Containment Socket</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quadrilateral with four walls</td>
<td>---------</td>
</tr>
<tr>
<td>Ischial seat for weight bearing</td>
<td>No ischial seat</td>
</tr>
<tr>
<td>Femoral bulge present</td>
<td>No femoral bulge</td>
</tr>
<tr>
<td>Area of weight bearing is less</td>
<td>Area of weight bearing is more</td>
</tr>
<tr>
<td>Long lateromedial dimension</td>
<td>Narrow mediolateral dimension</td>
</tr>
<tr>
<td>Narrow anterioposterior dimension</td>
<td>Long anterioposterior dimension</td>
</tr>
<tr>
<td>Fair pelvic control</td>
<td>Good pelvic control</td>
</tr>
<tr>
<td>Fair rotational stability</td>
<td>Good rotational stability</td>
</tr>
<tr>
<td>Lateral wall normally extends below trochanter except in short stump</td>
<td>Extends above greater trochanter</td>
</tr>
<tr>
<td>Less energy efficient</td>
<td>More energy efficient</td>
</tr>
<tr>
<td>Indicated for standard stumps</td>
<td>It can also be used with short stump and gluteus medius weakness</td>
</tr>
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</table>
Silesian band

- Commonly used. It is a leather belt fixed to the lateral side of socket. It encircles the body and attaches to anterior wall through buckles.

Waist belt

- It provides more hip stability. It is with or without external hip joint. It can be used in patient with hip abductor weakness and short stump.

Suction suspension

- Total suction
- Partial suction
- Hypobraric silicone suspension.
I. Constant friction Knee Joint

• It is a mechanical knee which provides knee stability during stance but no control during swing.

• It is a single axis knee allows flexion and extension.

• To prevent buckling patient should have good hip extensor.

• In case of weakness of hip extensor the axis of knee placed posterior to TKA line.
II. Polycentric Knee Joint

• It allows flexion, extension and some rotation and it gives more knee stability.
• It is indicated in short stumps, aged patient and is hip extensor weakness.

III. Weight Activated Stance Control Knee

• Also called as safety knee.
• The extent of friction depends on extent of weight bearing.
• The friction increases with increased weight bearing.
p-MRS System
(Polycentric - Mechanism of Reaction force Sensing)
IV. Hydraulic/Pneumatic Knee

- They are cadence responsive through cadence dependant resistance.
- Initially these knee units were designed to provide control during swing phase only. Now they are modified to provide both swing and stance control.
  - Mauch S-N-S hydraulic knee where S-N-S is swing N Stance. It has a hydraulic cylinder and a swing adjustment with rod, thus providing swing control and resistance to knee flexion during stance.
  - Endolite pneumatic intelligent prosthesis: It has a computer controlled valve that adjust swing based on cadence.
Views of a Hydraulic Knee Unit
• Both exoskeletal and endoskeletal shank can be used.

• Commonly used is SACH and single axis foot. Young active individual can be given energy storing feet.
Gait Analysis in Transfemoral Amputees

• Both static and dynamic evaluation have to be done.
Before Donning of Prosthesis

- Prosthesis meet specification and prescription.
- Inside of the socket is smoothly finished.
- Joints moving freely.
Sitting with Prosthesis

- Socket is suspended securely.
- Shank equal to opposite side
- Sitting comfortably without pinching.
- Able to lean forward to touch toes.
Standing with Prosthesis

- Socket is fit properly
- Knee is stable on weight bearing
- Pelvis on level both sides
- Socket is in good contact on all side.
- Adductor roll does not get pinched.
- Pressure on pubic ramus.
Walking

• Heel rise adequate to clear ground.
• Prosthetic knee bends smoothly.
• Leg swings forward with adequate knee and hip flexion.
• Knee extends before next heel contact.
• Stride length equal on both sides.
Transfemoral Gait Deviations

I. Heel contact to foot flat
   1. Knee Instability

   ❖ **Prosthetic causes:**
     - If the knee joint is placed anterior to TKA line, the line of body weight will fall behind knee creating flexion moment.
     - Inadequate flexion in socket limiting active hip extension.
     - Too hard heel cushion less shock absorption also producing flexion moment at knee.

   ❖ **Amputee causes:**
     - Hip flexion contracture not accommodated in socket.
     - Hip extensor weakness.
Figure 1.
(a) SACH and (b) Greissinger Plus prosthetic feet: schematic view.
1 = keel, 2 = foot adapter, 3 = heel cushion, 4 = keel, 5 = rocking rubber, 6 = joint retainer.
2. Terminal Impact
   Rapid forward movement of shank that lead to maximum knee extension before heel strike.
   - **Prosthetic causes:**
     - Insufficient knee friction.
   - **Amputee causes:**
     - As habit by assuming to keep knee in full extension before heel strike.

3. Foot Slap
   Forefoot descends too rapidly like slapping the ground.
   - **a. Prosthetic**
     - Plantar flexion resistance is too soft
     - Heel lever arm is too short (end of prosthesis heel to mid point on foot)
   - **Amputee:**
     - Forcibly driving foot into quick flat to assure extension of knee.
II. Midstance

1. Lateral Trunk Bending

All persons with transfemoral prosthesis exhibit some lateral bending from midline to prosthetic side. But excessive bending may be due to:

- **Prosthetic causes:**
  1. Prosthesis too short causes hip drop as well as lateral bending.
  2. Lateral wall is important for mediolateral stability. If lateral wall is fabricated with inadequate adduction angle it leads to lateral bending.
  3. High medial wall causing discomfort so lateral bending to avoid discomfort.

- **Amputee causes:**
  1. Very short stump that fails to provide sufficient lever arm for pelvis.
  2. Painful stump
  3. Weak abductors in the prosthetic side
  4. As a habit pattern.
2. Abducted Gait

- **Prosthetic causes:**
  1. Too long prosthesis
  2. High medial wall pressure on pubic region so keep the prosthesis abducted.
  3. Improper fabrication and not maintaining adduction angle.
  4. Pelvic band too far away from patients body.

- **Amputee causes:**
  1. Abduction contracture
  2. Habit pattern.
3. Excessive Trunk Extension

Hyperextend the trunk from heel strike to midstance.

❖ *Prosthetic causes:*

  1. Insufficient socket flexion leads to lumbar hyperextension.

❖ *Amputee causes:*

  1. Hip flexion contracture
  2. Weak hip extensors
  3. Habit pattern.
III. Midstance to Heel Off

1. Drop Off
   Sudden downward movement of trunk as anterior support is lost prematurely.
   ❖ **Prosthetic:**
     1. Socket placed too far anterior (toe lever arm short)
     2. Toe break placed posteriorly.

2. Inadequate Heel Off
   Heel may not come off floor till the whole body is brought forward.
   ❖ **Prosthetic:** Uneven steps between two legs.
3. Circumduction Gait

The prosthesis swings laterally like an arc during swing phase.

❖ Prosthetic causes:
  1. Too long prosthesis
  2. Difficult knee flexion due to
     • Too much aligned knee (more posterior)
     • Too much friction in knee.

❖ Amputee causes:
  1. Abduction contracture
  2. Not confident of flexing knee
  3. Fear of stubbing the toe.
4. Vaulting

Patient rises on toe of the sound foot to swing the prosthesis through in the little knee flexion.

❖ **Prosthetic causes:**

1. Too long prosthesis.
2. Inadequate suspension.
3. Excessive knee friction.
4. Locked knee.

❖ **Amputee causes:**

1. Socket discomfort
2. Fear of stubbing of toe.
3. Habit pattern.
5. Medial or Lateral Whip

Medial whip is present when heel travels medially on initial flexion at the beginning of swing phase. Lateral whip exists when heel moves laterally.

❖ **Prosthetic causes:**

1. Lateral whip result from excessive internal rotation of prosthetic knee.

2. Medial whip due to excessive external rotation of prosthetic knee.

3. Too light socket

4. Excess valgus, varus in the prosthetic knee.

❖ **Amputee causes:**

1. Applying prosthesis in internal or external rotation.
6. Uneven Arm Swing

Arm on prosthetic side held close to the body rather than freely swinging.

- **Prosthetic causes:**
  1. Improperly fitted socket or unstable knee

- **Amputee causes:**
  1. Improper training
  2. Fear
  3. Habit pattern.

7. Uneven Timing

Steps of unequal duration and length with short stance phase in prosthetic side.

- **Prosthetic causes:**
  1. Improperly fitted socket causing discomfort.
  2. Insufficient knee friction.
Prosthesis in Hip Disarticulation

Amputees with hip disarticulation can be fitted with Three types of prosthesis:

1. Tilting table type
2. Saucer type
3. Canadian type.

All types amputee bears weight through ischial tuberosity and gluteal muscles.
1. **Tilting Table Type**

- It is made of leather or plastic socket that encloses the stump and suspended by a pelvic belt and attached with external hip and knee joint.

2. **Saucer Type**

- It is made of a very shallow saucer like socket over which the ischium, gluteal muscles sits. It has external hip and knee joints which can be locked. Because of shallow socket the stump tends to rotate and lessen the stability.
3. Canadian Type

- It is made of plastic or metal and it encloses ischial tuberosity for weight bearing and iliac crest for stability in swing phase. It has anterior and lateral opening for donning, doffing. Relief is provided for anterior superior iliac spine and posterior inferior iliac spine.

- Mediolateral stability is provided by distal pressure on amputated side and proximal pressure over iliac crest on sound side.

- Anteroposterior stability is achieved by position of hip and knee joint. Hip joint is placed on the anterior part of the socket and anterior to the direction of floor reaction force. The knee is placed posterior to the direction of floor reaction force. This keeps the knee extended.