Principles of prosthetics &orthotics
(UOMU013031)

Lab2

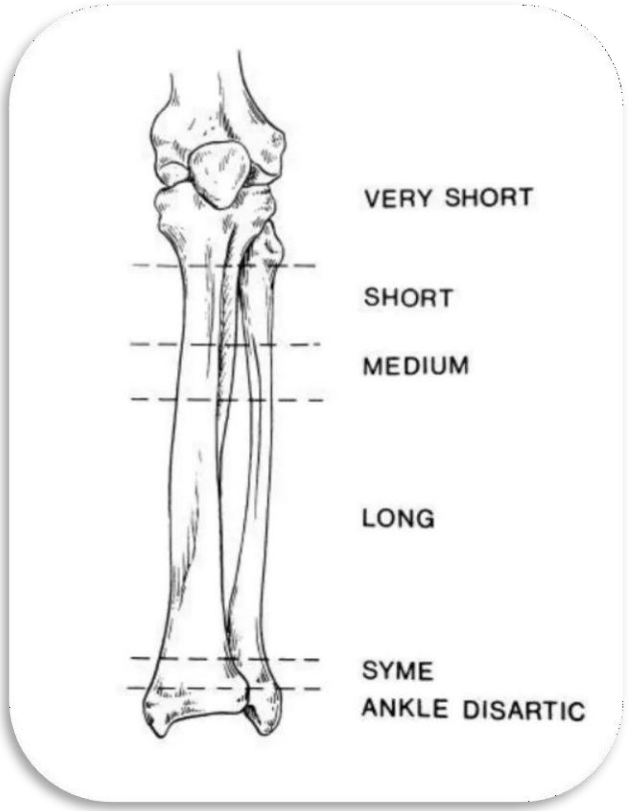
Transtibial Amputation (TT) Basic Principles And Manufacturing Guidelines

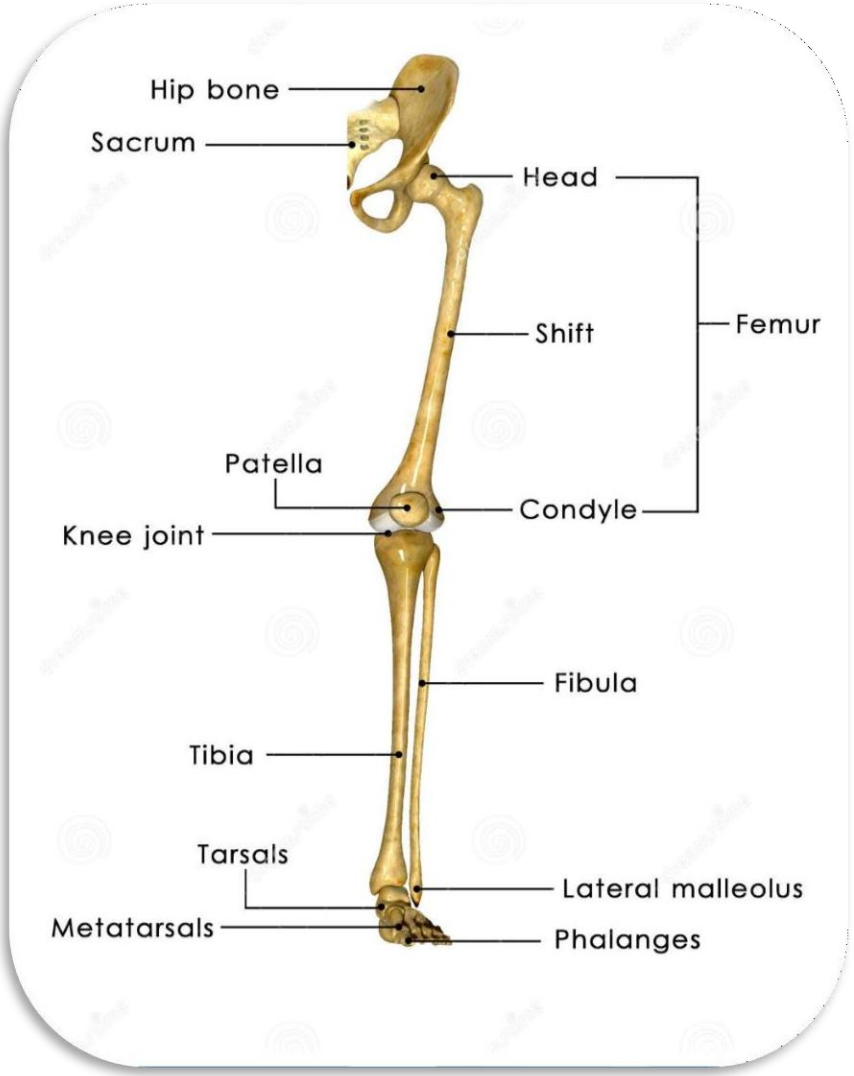
Al-Mustaqbal University College of Engineering & Technology
Department of prosthetics and orthotics engineering
Eng. Aya Talib

Aya.Talib.Hassan@uomus.edu.iq

Transtibial Amputation (TT) /Below knee (BK)
Basic Principles And Manufacturing Guidelines

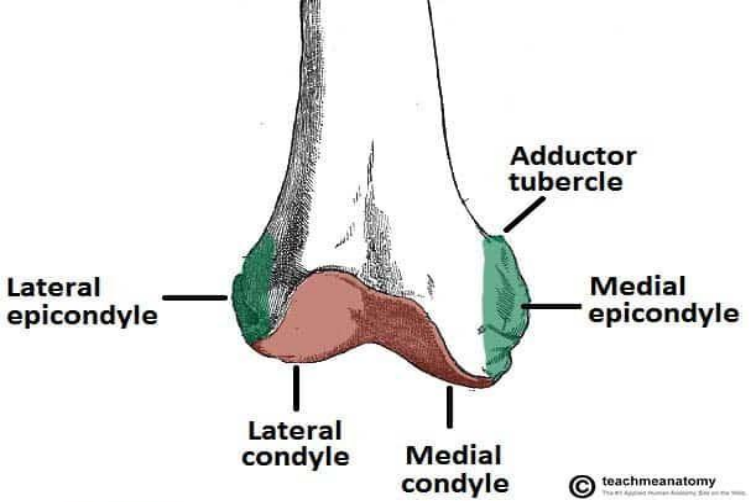
Bone anatomy of the leg vs Bone anatomy of Transtibial Amputation

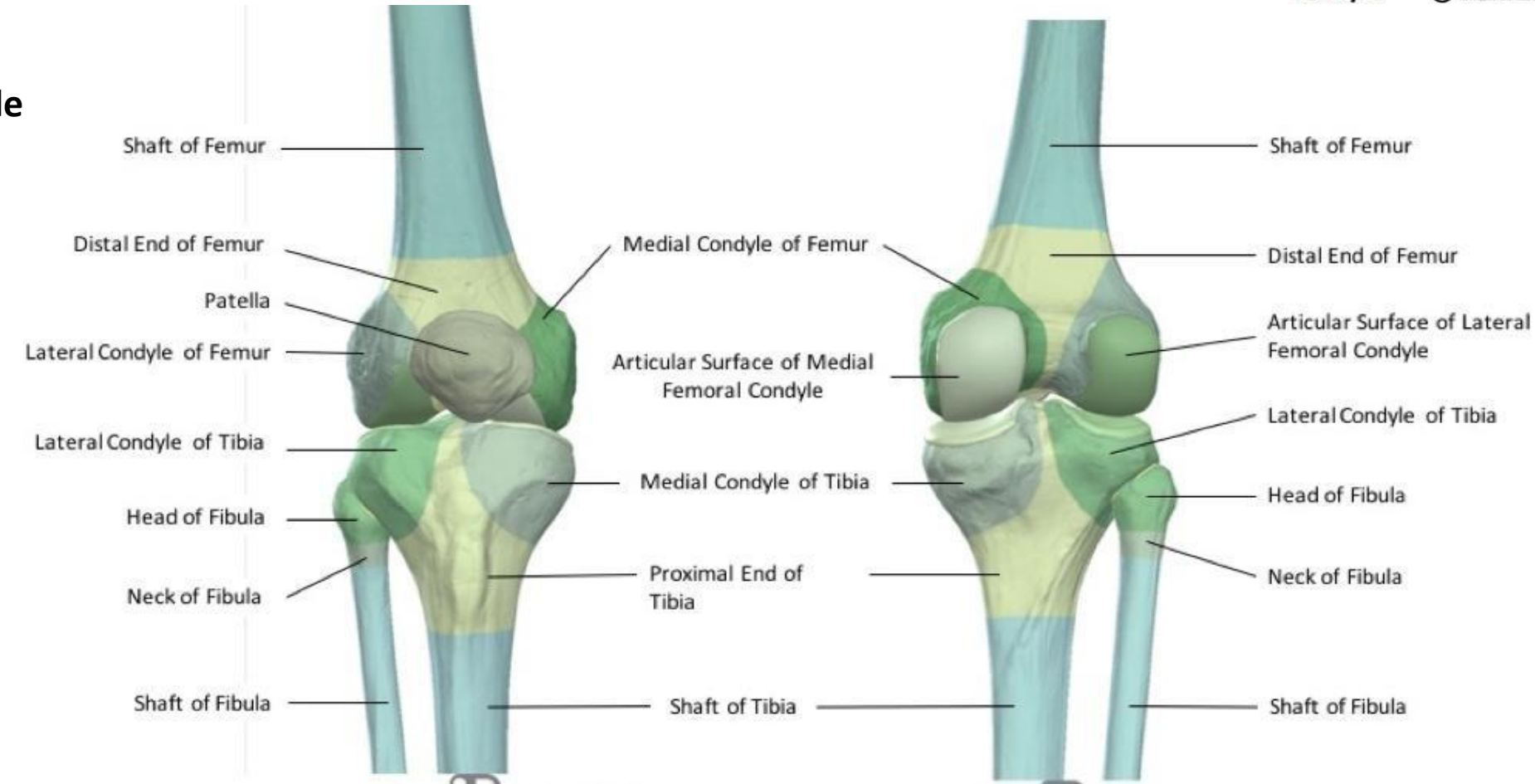




A bony landmark in TT

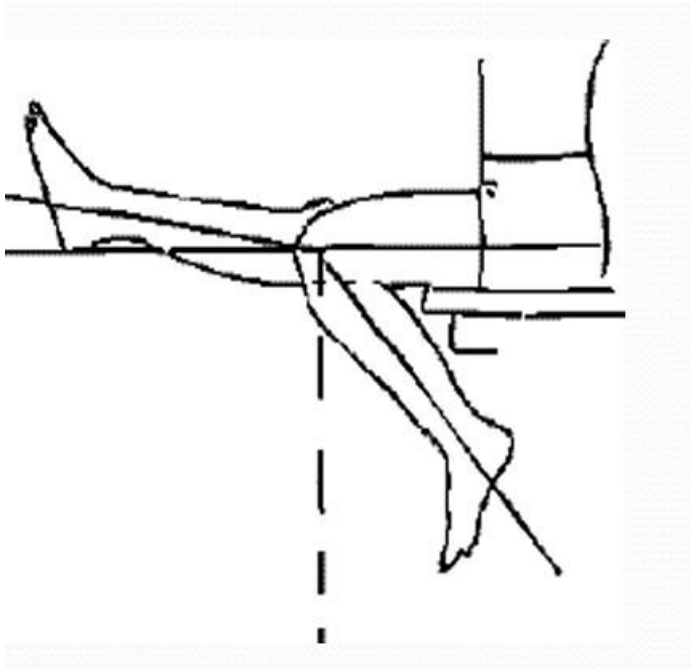
A. Femoral epicondyles
B. Tibial condyles
C. Medial Tibial Plateau
D. Adductor Tubercle
E. Patella
F. Tibial Tuberosity (tubercle
G. Lateral Tibial Tuberosity
H. Head of Fibula
I. Tibial Crest
J. End of Tibia
K. End of Fibula
L. Medial Tibial Flare



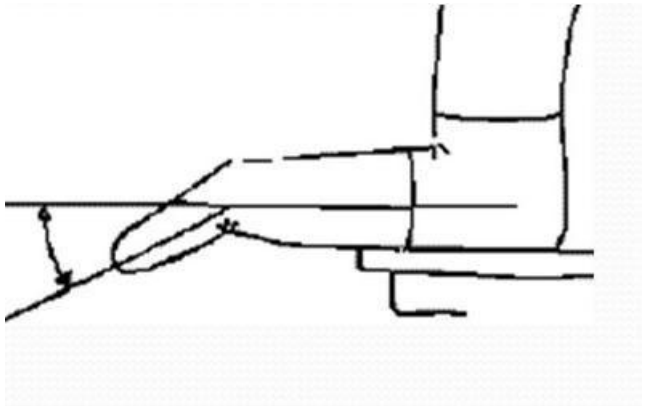


Knee joint

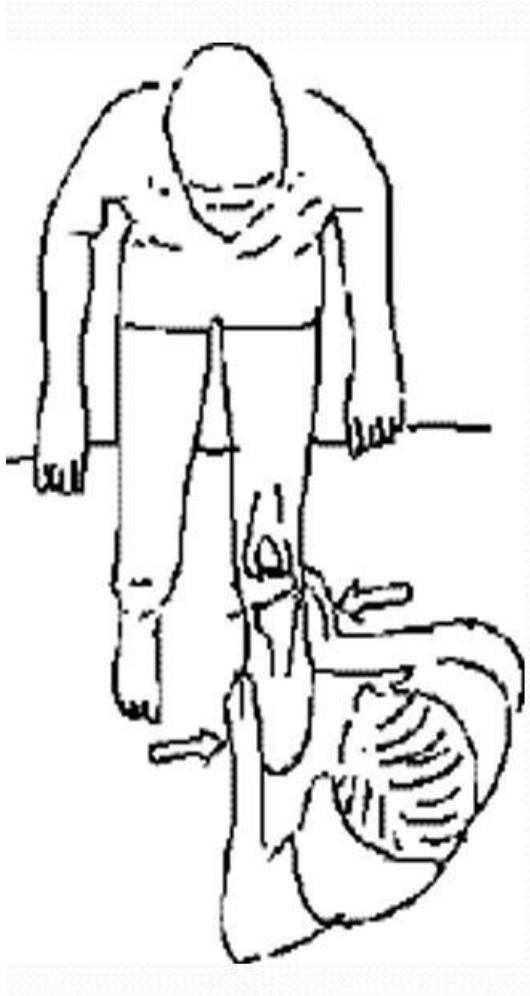
- **RANGE OF MOTION:**
- With the patient sitting on a flat firm surface, check the range of motion of the knee joint.
- Normal range of motion:
- Flexion 130°
- Extension 0 - 10°



The most common problem with knee range of movement is the **knee flexion contracture** (the knee cannot extend fully) A knee flexion contracture is measured by measuring the angle between the midline of the thigh and the midline of the stump

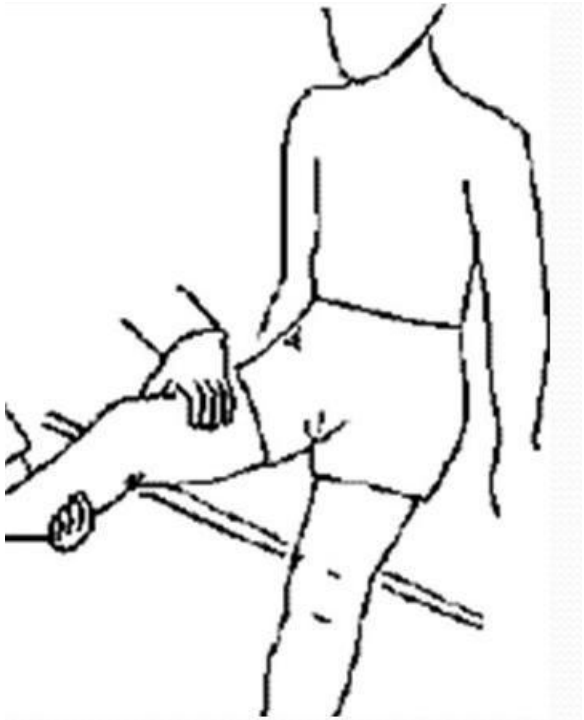


The Medio - Lateral stability (Collateral ligaments) is checked by applying valgus and varus stress to the joint. The patient is sitting with the stump extended



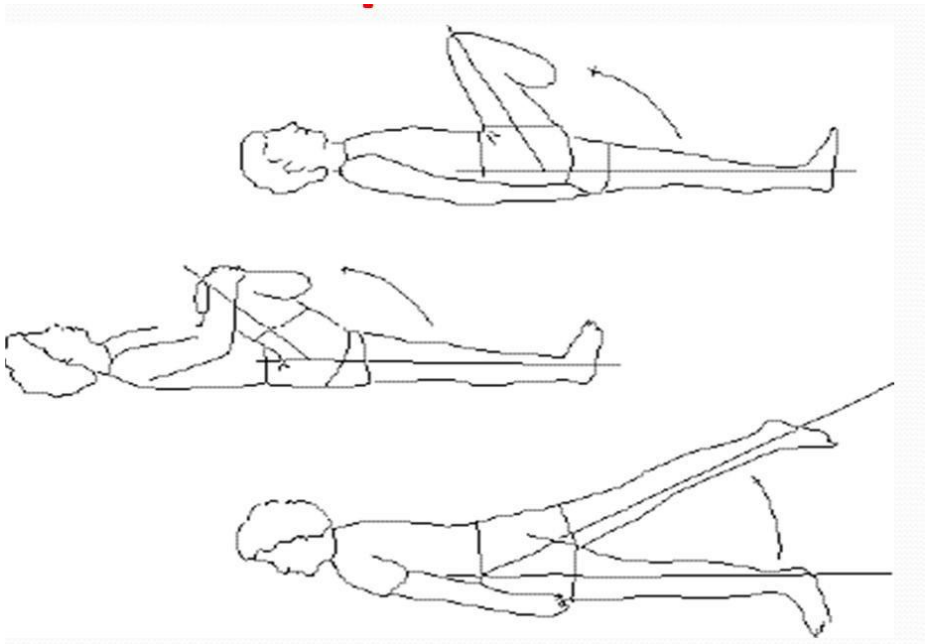
The patient's muscle strength of the knee extensors is checked by asking the patient to extend the knee while the prosthetist is resisting this movement.

The strength of the knee flexor muscles is checked by asking the patient to flex the knee while the prosthetist is resisting this movement.



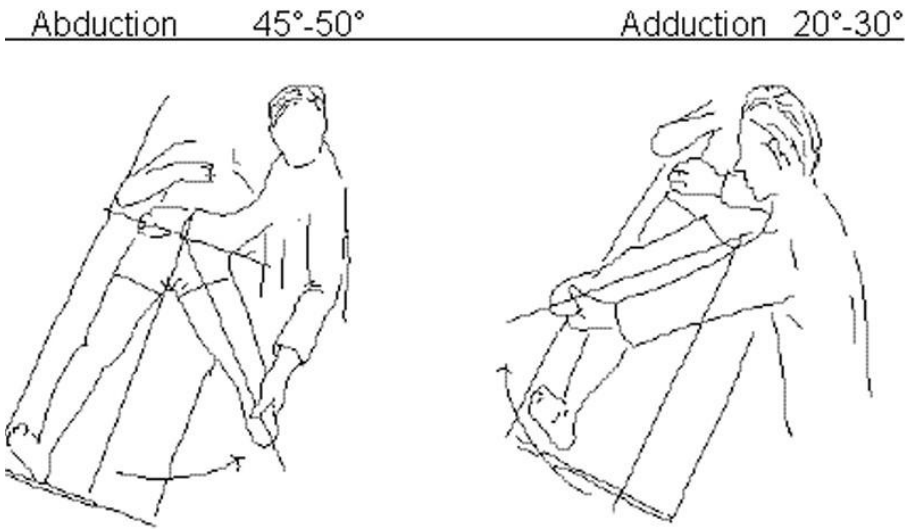
Hip Joint

Let the patient lie on his / her back to test for hip adduction, abduction and flexion



let the patient lie on the front / stomach to test for hip extension

Normal range of motion: Flexion 130°, Extension 30°



The most common problem with the range of movement at the hip joint for amputees is that there is a hip flexion contracture (the hip is "stuck" in some degree of flexion) This can accurately be measured by using the Thomas Test

Steps of the Thomas Test :

1. **Position the patient**: Have the patient lie on their back on an examination table with both legs extended, Hand placed under lumbar spine
2. **Flex one leg**: Bring one knee toward the chest (hip and knee flexed) to flatten the lower back against the table.
3. **Observe the opposite leg**: Keep the other leg extended flat on the table.
4. **Check for leg elevation**: If the extended leg **raises off the table**, it indicates tightness in the hip flexors (positive test), A fixed flexion contracture is characterized by the inability to extend the leg straight without arching the thoracic spine
5. **Further assessment (optional)**: Extend the knee of the flexed leg to differentiate between iliopsoas tightness and rectus femoris tightness.

Positive Test: Extended leg rises off the table.

Negative Test: Extended leg stays flat on the table

Casting Procedure, Modification, and Fabrication Steps for a Prosthetic Socket (TT)

Casting:

Steps of casting

- **Prepare the patient and stump**:
- Position the patient comfortably.
- Apply a **stockinette** to the residual limb.

- **Apply casting material**:
- Use **plaster bandages** or **fiberglass** to wrap around the stump, covering it evenly.
- Dip plaster bandages in water and apply them over the limb, starting from the distal end and working proximally.

- **Shape the mold**:
- Smooth and contour the cast to ensure it's snug**(fit tightly)**, with no wrinkles or air pockets.
- Ensure landmarks (e.g., tibial crest) are accurately captured.

- **Allow the cast to set**:
- Let the cast harden for **15-30 minutes** until it is firm but not fully hardened.

- **Remove the cast**:
- Once set, carefully remove the cast from the stump
- Cut or gently separate the cast if necessary.

- **Refine the mold**:
- Trim and smooth the cast to remove excess material and adjust for accurate anatomical contours.

- **Create the positive model**:
- Fill the cast with **plaster** to create a **positive mold** (replica of the stump "exact copy").

Refining the Positive Model

•A **rasp, surform, or sandpaper** is used to smooth the surface.

•Adjustments are made based on pressure-sensitive and pressure-tolerant areas:

- **Build-up (adding material)** for pressure-sensitive areas (e.g., bony prominences like the tibial crest, and fibular head).
- **Reduction (removing material)** for pressure-tolerant areas (e.g., patellar tendon, medial flare).

Definitive solid Socket Fabrication

Once the test socket is approved, the final socket is made using **lamination** or **advanced materials**.

1.Material Selection

1. **Laminated sockets**: Made from **fiberglass, carbon fiber, or acrylic resins** for durability and lightweight strength.
2. **Thermoplastic sockets**: Made from **polyethylene or polypropylene** for flexibility.

2.Lamination Process (for Composite Sockets)

1. A layer of **nylon, carbon fiber, or fiberglass** is placed over the positive mold.
2. Liquid **resin (acrylic or epoxy)** is applied to harden the structure.
3. The socket is cured, trimmed, and polished for final fitting.

The procedure of the soft socket

1. **Take measurements**:
    1. Measure the **length of the prosthesis**.
    2. Measure the **largest circumference** of the prosthesis.
    3. Measure the **smallest circumference** of the prosthesis.
2. **Prepare the soft material**:
    1. Take a **6mm thick piece of soft material**.
    2. Cut the soft material to match the measurements and the mold shape.
    3. Grind the edges of the material from **different sides**, ensuring the grind does not exceed **1cm**.

3. **Shape the mold**:
    1. Put the cut soft material in the oven for heating.
    2. After heating, remove it from the oven and apply it to the **end of the stump**.
    3. Cut off any excess edges and grind the edges to refine the shape.
    4. Apply glue to the ground edges and leave it to dry.

3. Final shaping:

1. Expose the soft material to heat again and shape it into a **conical shape**.
2. Leave it in the oven for **1 minute** to make it easier to pull over the mold.
3. Wrap the bandage around the mold to help clarify and complete the shape

5. **Create the final cap**:
    1. Take a **square piece of 12mm thick soft material**.
    2. Grind and cut it into a **circular shape**.
    3. Glue the circular piece to the end of the mold.
    4. Place it in the oven.
    5. After heating, stick it to the end of the mold and let it cool.
6. **Final pull**:

    Once the soft socket is complete, pull it off the mold.

Prepare the PVA (Polyvinyl Acetate):

- Wet a towel until it is completely soaked.
- Place PVA inside the towel for 30 minutes to soften and become flexible

Set up the mold:

- Install the mold on the vacuum device.
- Place it on the amputation site and secure it from both the top and bottom to act as a protective layer.

Layering process:

- Apply six layers of Perlon over the mold.
- Place the transformer (carbon or reinforcement material).
- Add another six layers of Perlon.
- Apply a PVA finish, sealing only the bottom end while keeping the top end open.

Prepare the resin mixture:

- Mix laminating resin with a hardening agent in a 2:100 ratio.
- Add special dyes for prosthetics.

Vacuum and resin application:

- Turn on the vacuum device where the mold is installed.
- Pour the resin mixture into the PVA layer.
- Distribute the resin evenly in a thin layer and remove any excess material.
- Allow the materials to fully react and harden.

Final processing:

- Remove the mold from the vacuum system.
- Cut off any excess material.
- Remove the gypsum from the hardened mold.
- Trim and smooth the upper part of the socket.

Final Fitting and Alignment

1. **Socket Attachment to the Prosthesis**
    1. The socket is integrated with **prosthetic components** (pylon, knee, foot).
    2. The alignment is fine-tuned for comfort, stability, and proper gait mechanics.
1. **Patient Testing and Training**
    1. The patient undergoes **gait training** with a prosthetist and physical therapist.
    2. Adjustments are made to improve **weight distribution, comfort, and function**.
3. **Follow-up and Modifications**
    1. The patient returns for periodic check-ups.
    2. Adjustments are made to accommodate **residual limb volume changes** or wear and tear.