ORTHOTICS AND PROSTHETICS

[PT 308]

Dr. AMINU A. IBRAHIM (BPT, MPTh, Ph.D)

LECTURE NOTES FOR 3rD GRADE BPT STUDENTS

SPRING SEMESTER 2024-2025

DEPARTMENT OF PHYSIOTHERAPY, FACULTY OF APPLIED HEALTH SCIENCES

TISHK INTERNATIONAL UNIVERSITY

2024/2025

LECTURE OUTLINE

- Learning objectives
- Prosthesis
  - Definition
  - Function/indication
  - Materials/components
  - Classification/types
- Physiotherapy roles in orthotics and prosthetics
- Ideal orthotics and prosthetics
- Challenges in orthotics and prosthetics
- Review
- Reading resources/additional materials

ORTHOSIS AND PROSTHESIS

COURSE OBJECTIVES

- Define prostheses, including their functions and indications
- Describe the materials/components of prosthesis
- Classify types of prostheses
- Describe the physiotherapist's role in prosthetics

PROSTHETICS

ORTHOTICS AND PROSTHETICS

PROSTHETICS

Definition

- Prosthetics is the science concerned with functional & or cosmetic restoration for all or part of a missing limb.
- **Prostheses = artificial limb**
- Prosthesis: is an artificial device used to replace a missing or non-functional body part, typically a limb.
- Prosthesis can be:
  - Exoprosthesis: common prosthesis used in orthopaedics/physiotherapy
  - Endoprosthesis: Cardiac valve prosthesis, Austin Moore prosthesis

ORTHOTICS AND PROSTHETICS

PROSTHETICS

Function/indications

1. **Traumatic amputation**: due to trauma or accidents,
2. **Surgical amputation**: due to disease e.g. peripheral vascular disease as in diabetes, malignant tumor.
3. **Congenital limb defects**: prosthetics designed for children born without a limb.
4. **Rebuilding or restoring functional movement**: e.g., walking, gripping.

ORTHOTICS AND PROSTHETICS

PROSTHETICS

Materials used in prosthesis

The following are typically used in making an prosthesis

1. Lightweight **carbon fiber**, titanium, silicone, and aluminum.
2. Prosthetic feet often made from flexible materials to simulate natural motion.
3. Custom molds to fit patient anatomy.


Silicone prosthetic foot

Titanium prosthesis

Carbon fiber foot

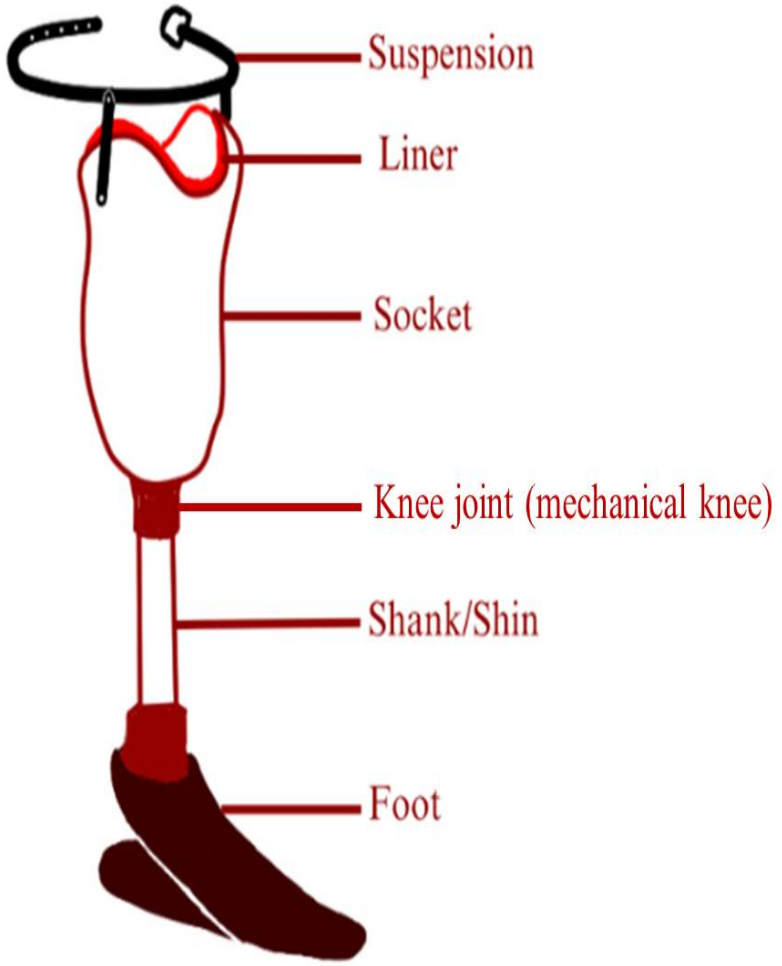
Aluminum prosthesis

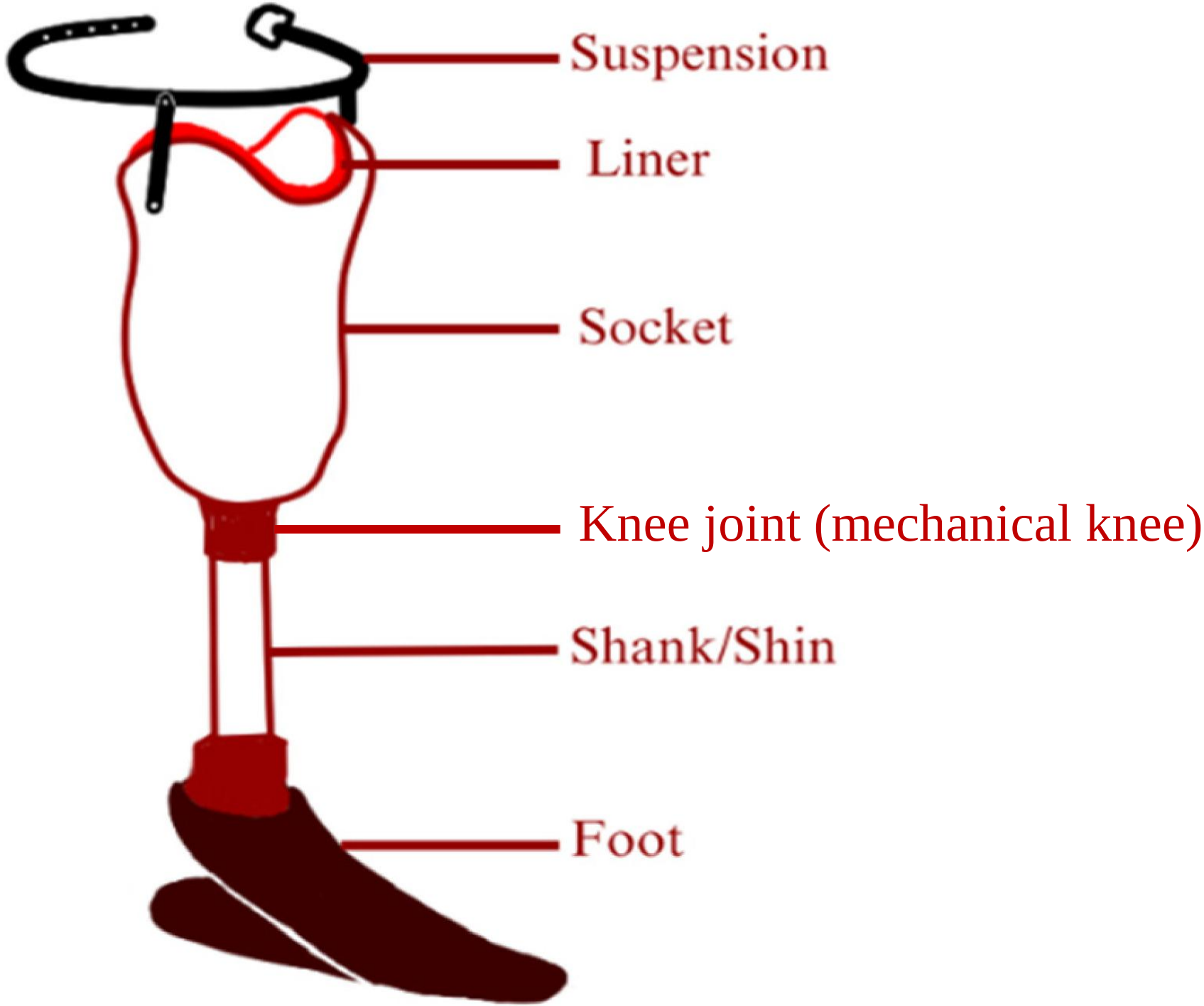
ORTHOTICS AND PROSTHETICS

PROSTHETICS

Component of prosthesis

1. Suspension system: Holds the prosthesis in place.
2. Liner: For cushion & shock absorption.
3. Socket: Interface between the residual limb & the prosthesis.
4. Shank/shin: Connects the socket to the foot or hand.
5. Mechanical joint (for above-limb prostheses) - could be knee or elbow: Provides joint movement for more complex prostheses.
6. Foot/ankle or hand/wrist: Provides functional endpoint (e.g., for walking or grasping).




Suspension
Liner
Socket
Knee joint (mechanical knee)
Shank/Shin
Foot

ORTHOTICS AND PROSTHETICS

PROSTHETICS

Types of prosthesis

1. Upper limb prosthetics
   - Example, below-elbow, above-elbow prostheses
2. Lower limb prosthetics
   - (e.g., below-knee, above-knee prostheses)
3. Cosmetic prosthetics
   - Used primarily for restoring appearance, not functionality.

ORTHOTICS AND PROSTHETICS

PROSTHETICS

Upper limb prosthesis

1. Body-powered prosthetics
2. Myoelectric prosthetics
3. Hybrid prosthesis
4. Cosmetic prosthetics
5. Wrist & elbow prosthesis
6. Terminal devices
7. Shoulder disarticulation prosthesis

ORTHOTICS AND PROSTHETICS

PROSTHETICS

Upper limb prosthesis

Body-powered prosthetics

- Prosthesis controlled by movements of the remaining muscles & joints, such as the shoulder/chest.
- A harness & cable system transfer the movement to operate the prosthetic.
- Reliable, durable, & cost-effective.
- Commonly used for individuals who need functional prostheses but may not need a high level of dexterity.

Prosthesis	Uses
Transhumeral (Above-elbow) prosthesis	For amputation above the elbow
Transradial (Below-elbow) prosthesis	For amputation below the elbow
Partial hand prosthesis	For people who have lost part of their hand, but still retain some function

ORTHOTICS AND PROSTHETICS

PROSTHETICS

Upper limb prosthesis

Transhumeral (Above-elbow) prosthesis

Transradial (Below-elbow) prosthesis

Partial hand prosthesis

ORTHOTICS AND PROSTHETICS

PROSTHETICS

Upper limb prosthesis

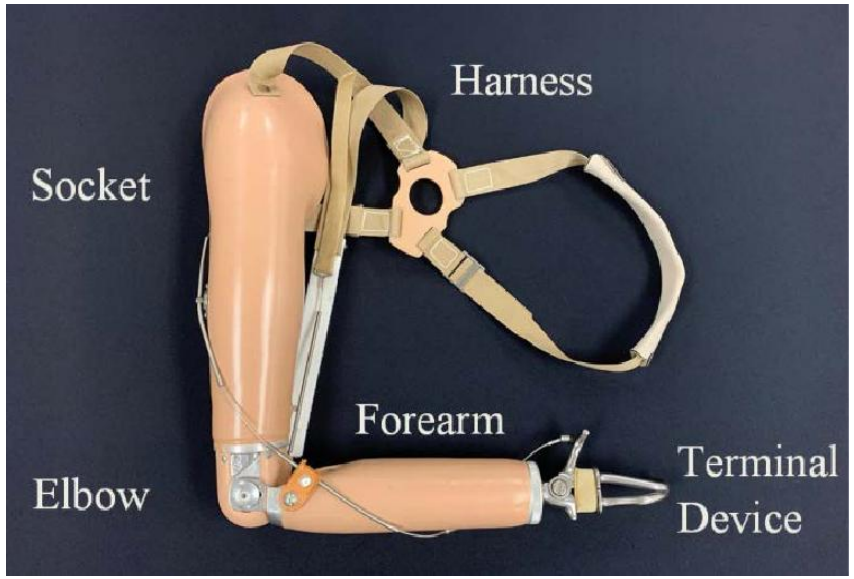
Myoelectric prosthetics

- Prosthesis powered by electrical signals from the user's remaining muscles (usually in the residual limb) & controlled by sensors.
- The signals are processed to move the prosthetic.
- Highly functional with more natural movements & precise control over grip & hand functions.
- Ideal for individuals who need more dexterity.

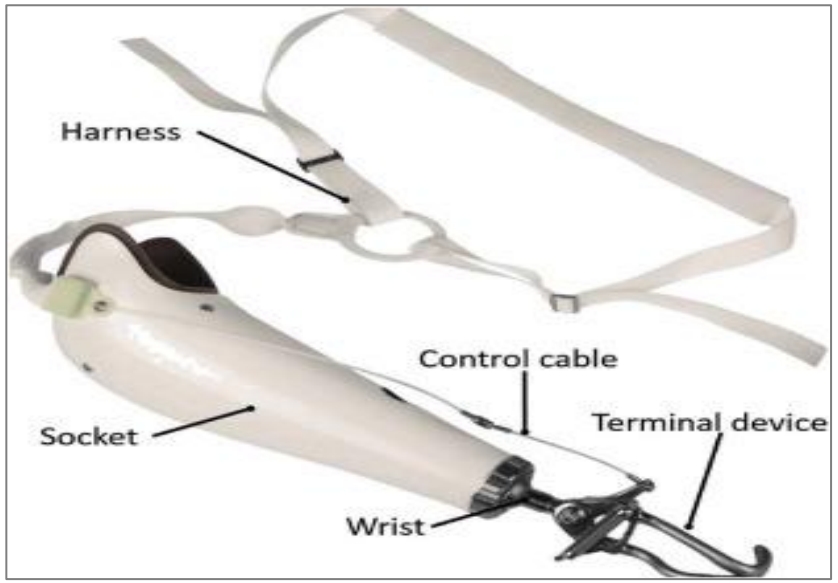
Prosthesis	Uses
Transradial powered prosthesis	For amputation below the elbow
Transhumeral powered prosthesis	For amputation above the elbow
Partial Hand powered Prosthesis	For people who have lost part of their hand, but still retain some function

PROSTHETICS

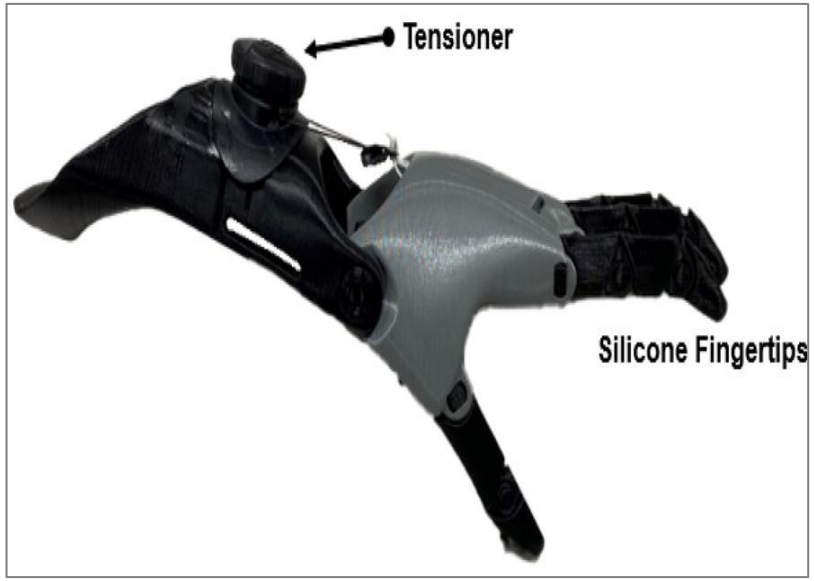
Upper limb prosthesis



Transhumeral powered prosthesis



Transradial powered prosthesis



Partial hand powered prosthesis

ORTHOTICS AND PROSTHETICS

PROSTHETICS

Upper limb prosthesis

Hybrid prosthetics

- Prosthesis that combines both body-powered & myoelectric systems for a more versatile prosthesis.
- Commonly used for individuals who need both active control (myoelectric) & passive control (body-powered) to complete tasks.

ORTHOTICS AND PROSTHETICS

PROSTHETICS

Upper limb prosthesis

Cosmetic prosthetics

- Prosthesis primarily designed for aesthetic purposes, not for functionality.
- Often made to resemble a natural hand or arm.
- Focus on appearance rather than function.

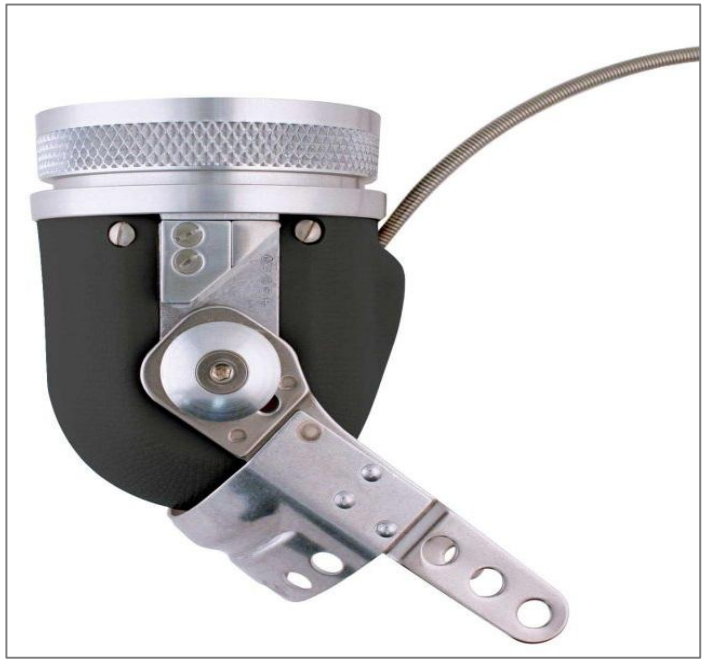
PROSTHETICS

Upper limb prosthesis

Wrist and elbow prosthesis

- Prosthesis components designed to provide movement at the wrist and elbow joints.
- Provide more flexibility in daily tasks & can improve the overall functionality of the upper limb prosthesis.
- Examples **manual/locking elbow & wrist units**

Manual elbow lock



Powered elbow lock

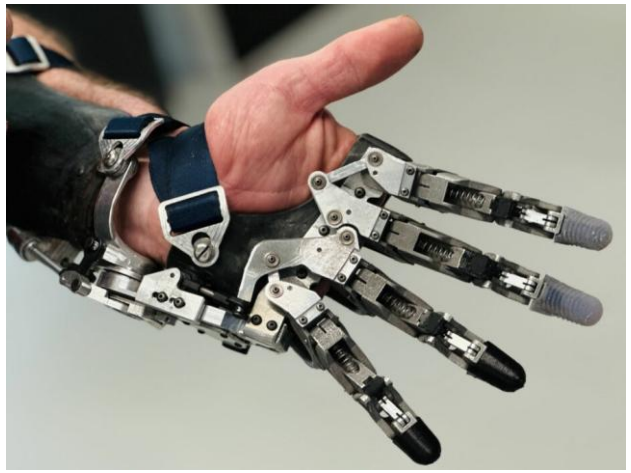
ORTHOTICS AND PROSTHETICS

PROSTHETICS

Upper limb prosthesis

Terminal devices (hand) prosthesis

- Prosthesis components that replace the hand or fingers. They come in various types to perform different tasks.
- Specialized for performing tasks like holding objects, grasping tools, or fine manipulation.
- Examples include **hook or gripper, mechanical hand**



Mechanical hand prosthesis

Hook prosthesis

ORTHOTICS AND PROSTHETICS

PROSTHETICS

Upper limb prosthesis

Shoulder disarticulation prosthesis

- Prosthesis limb designed for individuals who have lost their arm at the shoulder joint.
- replaces the entire arm, including the shoulder and upper arm, offering basic functions like gripping, lifting, & movement.
- Often includes a socket that fits over the remaining shoulder, with a mechanical or myoelectric system for movement control.
- Often customized to suit the individual

Hook prosthesis

ORTHOTICS AND PROSTHETICS

PROSTHETICS

Lower limb prosthesis

1. Above-knee prosthetics
2. Below-knee prosthetics
3. Foot prosthesis

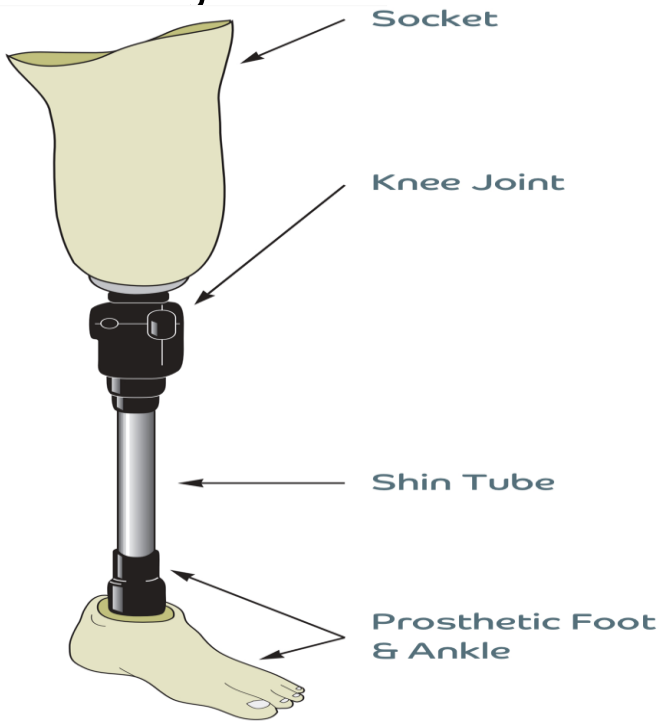
ORTHOTICS AND PROSTHETICS

PROSTHETICS

Lower limb prosthesis

Above-knee prosthesis

- Also known as a transfemoral prosthesis
- Designed for individuals who have undergone an amputation above the knee joint
- Replaces the entire leg below the hip, including the knee



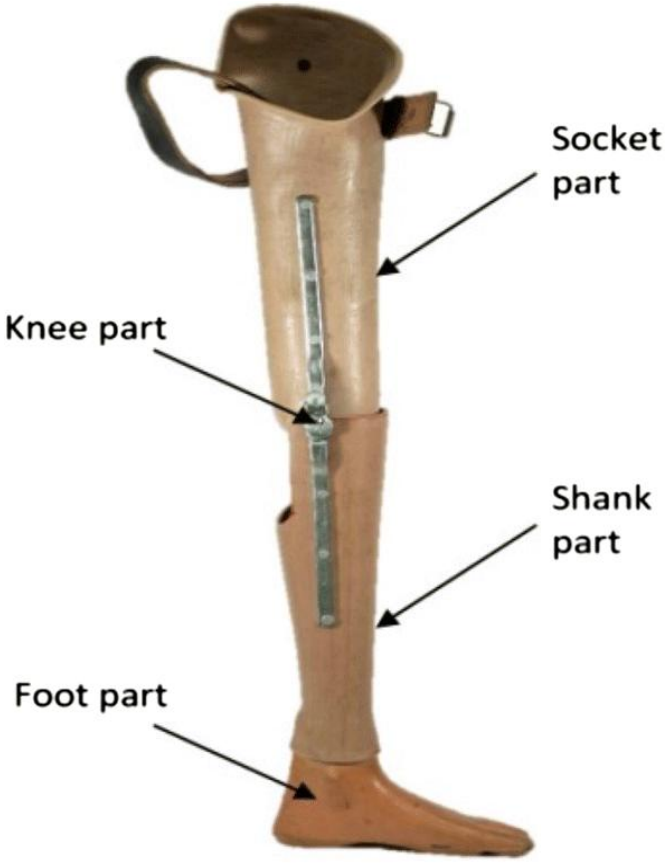
Components of above-knee prosthesis

- Socket
- Knee joint
- Shank/shin
- Foot-ankle unit/assembly

ORTHOTICS AND PROSTHETICS

PROSTHETICS

Lower limb prosthesis



Above knee prostheses

ORTHOTICS AND PROSTHETICS

PROSTHETICS

Lower limb prosthesis

Below-knee prosthesis

- Also known as a transtibial prosthesis
- Designed for individuals who have undergone an amputation below the knee joint
- Replaces the portion of the leg from just below the knee to the foot

Components of above-knee prosthesis

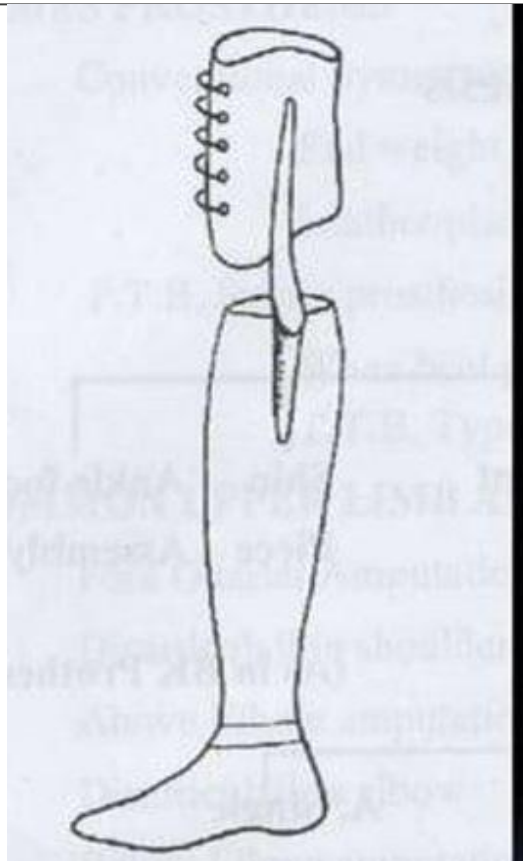
- Socket
- Knee joint
- Shank/shin
- Foot-ankle unit/assembly

ORTHOTICS AND PROSTHETICS

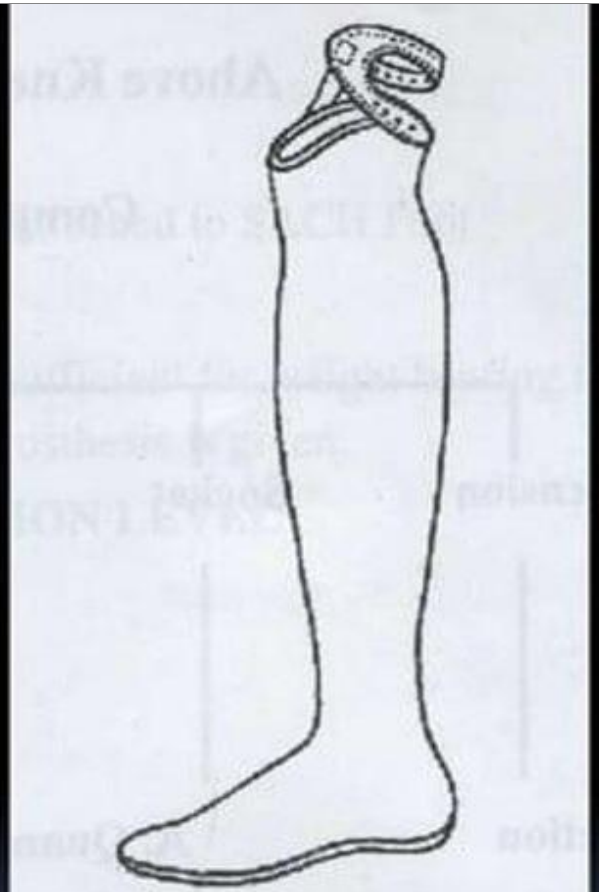
PROSTHETICS

Lower limb prosthesis

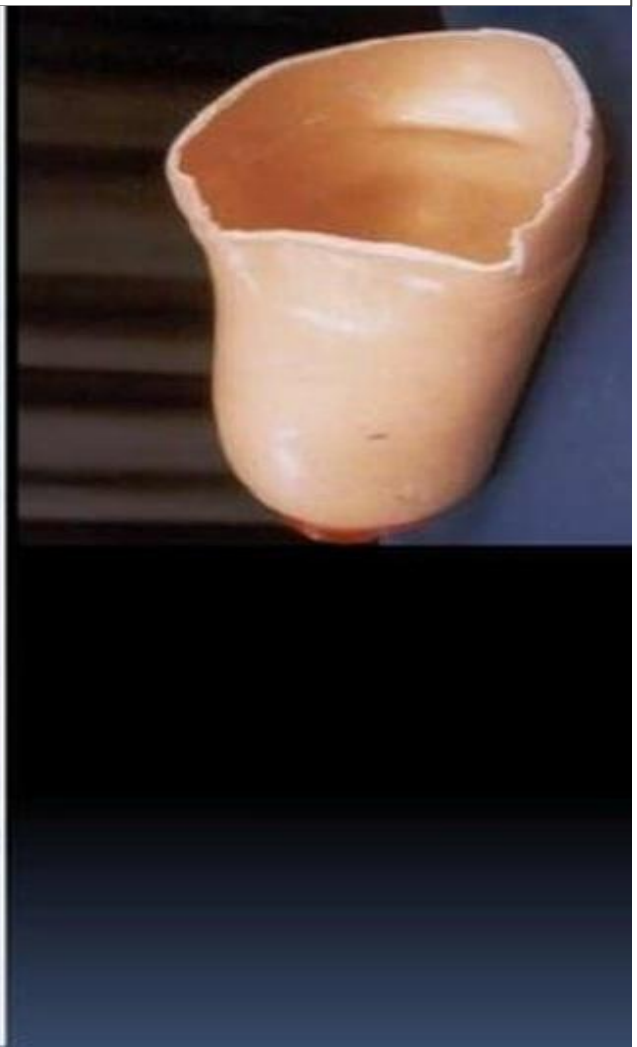
Below-knee prosthesis



B.K. Conventional Prosthesis

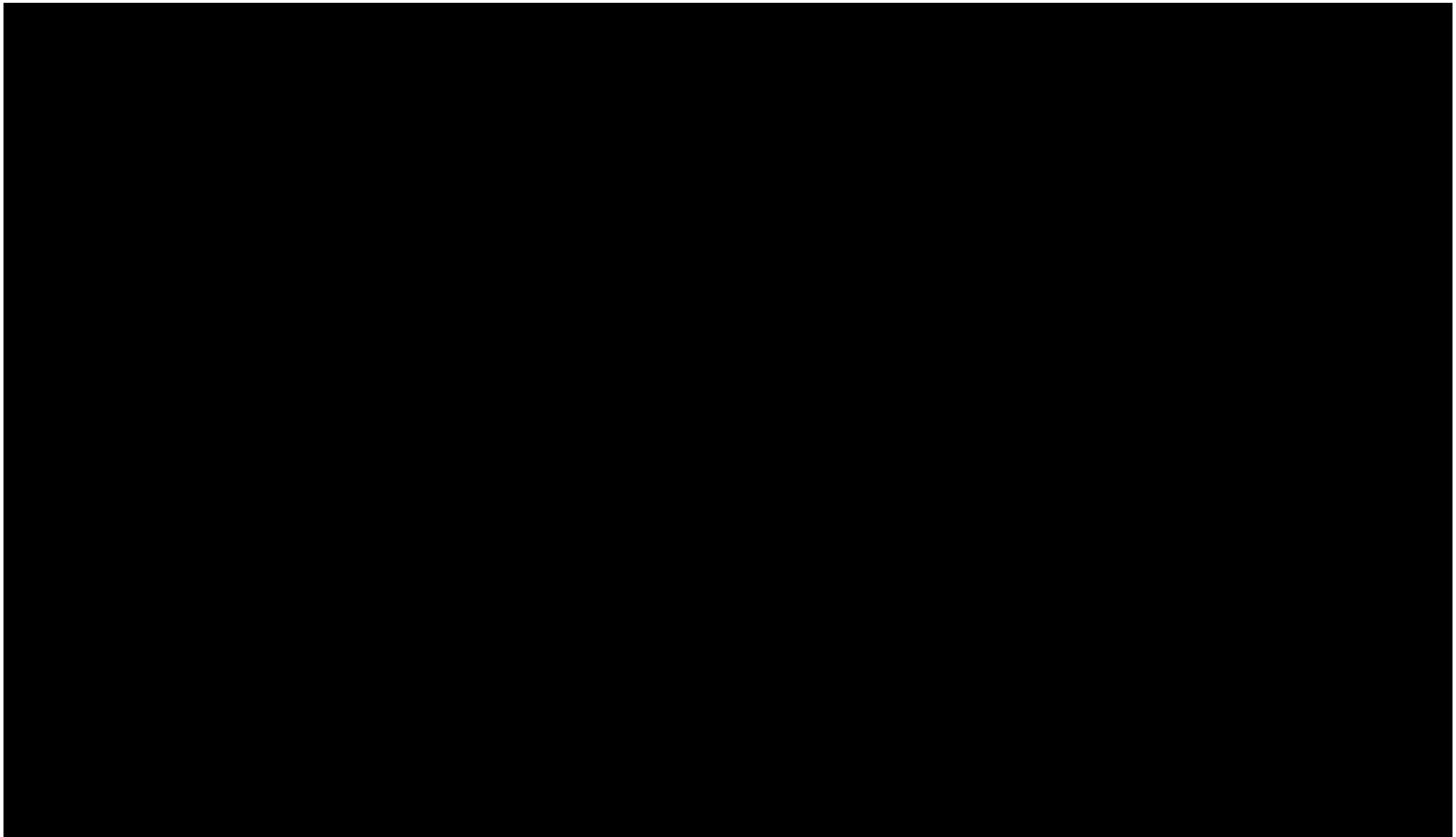


P.T.B. Prosthesis



ORTHOTICS AND PROSTHETICS

Below-knee prosthesis



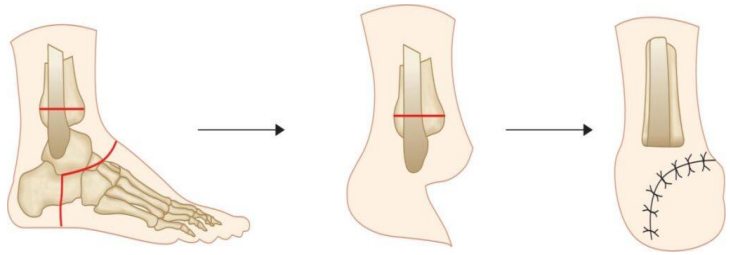
ORTHOTICS AND PROSTHETICS

PROSTHETICS

Lower limb prosthesis

Syme prosthesis

- A type of ankle-level prosthesis designed for individuals who have undergone a Syme amputation
- Syme amputation is where the foot & ankle are removed, but the lower part of the tibia (shin bone) remains intact.



Types of Syme prosthesis

- **Conventional end weight bearing**
  - Leather/plastic attached to solid-ankle-cushion-heel (SACH) foot
- **PTB Syme prosthesis**
  - When heel pad is not sufficient for weight bearing then PTB syme prosthesis is used

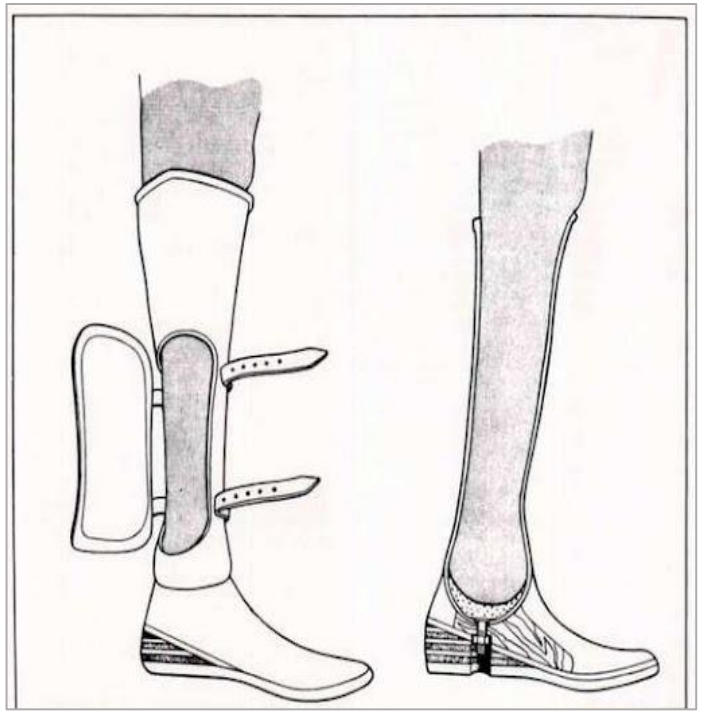
ORTHOTICS AND PROSTHETICS

PROSTHETICS

Lower limb prosthesis

Syme prosthesis

PTB Syme Prosthesis



Conventional end weight-bearing

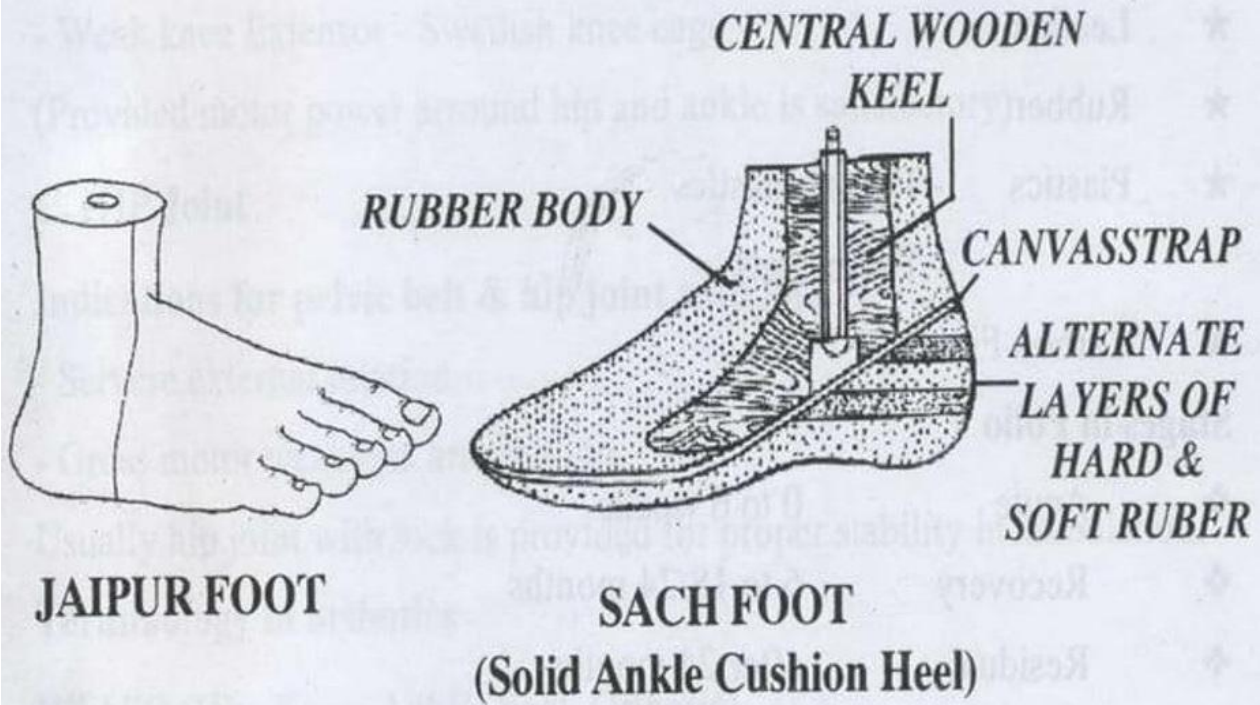
ORTHOTICS AND PROSTHETICS

PROSTHETICS

Lower limb prosthesis

Foot prosthesis

- Solid-ankle-cushion-heel (**SACH**) foot
- Jaipur foot

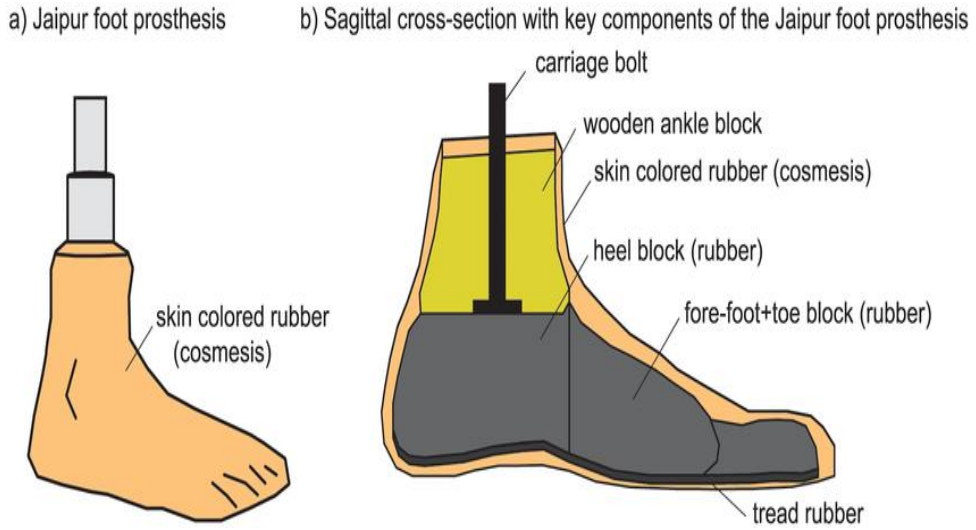


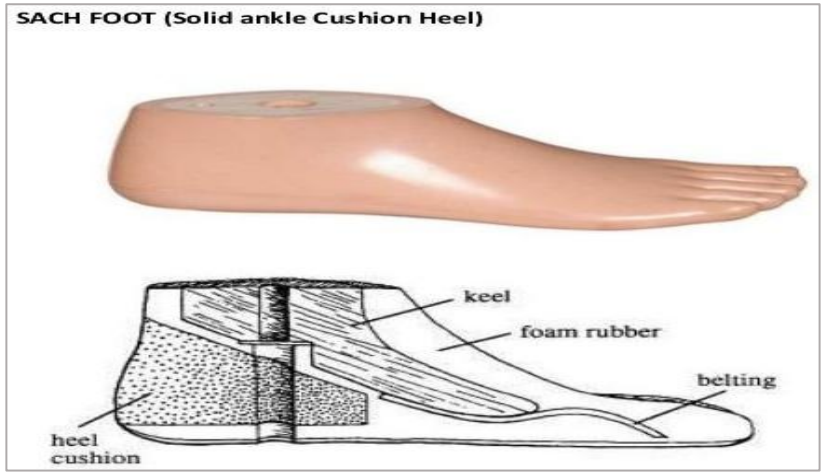
ORTHOTICS AND PROSTHETICS

PROSTHETICS

Lower limb prosthesis

Aspect	Jaipur Foot	SACH Foot
Material	Rubber and wood	Foam and rubber
Flexibility	Highly flexible, suitable for rough terrains	Limited flexibility, stable on flat surfaces
Cost	Low cost, affordable	Higher cost, more advanced
Mobility	Good for walking, squatting, cross-legged sitting	Provides stable support with shock absorption
Usage	Mainly for developing countries	Mostly used in developed countries





ORTHOTICS AND PROSTHETICS

PHYSIOTHERAPY ROLES IN ORTHOTICS AND PROSTHETICS

Pre-operative assessment

- Assess joint mobility (ROM), muscle strength, & balance to determine preoperative function
- Evaluate gait & posture to identify compensatory movements
- Assess pain levels & functional limitations
- Consider psychological readiness for the orthosis/prosthesis use

Pre-operative treatment

1. **ROM/flexibility exercise to prevent contracture**
2. **Strengthening key muscle groups** (e.g. core & residual limb muscles for prosthesis users)
3. **Aerobic exercises to enhance cardiopulmonary endurance for recovery**
4. **Gait training with assistive devices (e.g. crutches, walkers) for post-operative mobility**

ORTHOTICS AND PROSTHETICS

PHYSIOTHERAPY ROLES IN ORTHOTICS AND PROSTHETICS

Pre-operative treatment

5. **Patient education**
   - Explain the surgical process & expected outcomes
   - Teach limb care & skin inspection to prevent ulcers
   - Provide pain management strategies (e.g. TENS, massage)
   - Discuss post-operative rehabilitation & realistic expectations
6. **Collaboration with other health professionals**
   - Work with orthotists, prosthetists, & surgeons to ensure a well-fitted device.
   - Assist in preoperative casting or measurements for orthotic/prosthetic devices.
   - Coordinate with occupational therapists for functional training.

ORTHOTICS AND PROSTHETICS

PHYSIOTHERAPY ROLES IN ORTHOTICS AND PROSTHETICS

Post-operative treatment

1. **Pain and swelling management**
   - Use Ice, compression & elevation (ICE of RISE) to reduce swelling
   - Apply soft tissue manipulation e.g. massage
2. **Gentle mobilization (AROM or PROM) to prevent stiffness**
3. **Wound and skin care**
   - Education on proper wound care to prevent infection
   - Monitor for pressure sores or irritation from orthoses/prostheses
   - Skin desensitization techniques (e.g. tapping, massage) for amputees.

ORTHOTICS AND PROSTHETICS

PHYSIOTHERAPY ROLES IN ORTHOTICS AND PROSTHETICS

Post-operative treatment

4. **Joint mobilization/ROM exercise to prevent joint contractures**
   - **In all joint planes (must be emphasize)**
5. **Muscle strengthening (strength & stability)**

   - Strengthening (activation) of core, glute, hip flexors, add, Abd,
   - <u>Emphasize on residual limb strengthening for amputee</u>
6. **Balance and gait training**
   - Train weight shifting & single-leg balance before using a prosthesis
   - Work on proper foot placement & posture for orthotic users
   - Use parallel bars, walkers, and crutches to assist walking

ORTHOTICS AND PROSTHETICS

PHYSIOTHERAPY ROLES IN ORTHOTICS AND PROSTHETICS

Post-operative treatment

7. **Functional training and orthosis/prosthesis integration**
   - Teaching how to wear & remove (donning & dumping) device properly
   - Training for daily activities like sitting, standing, climbing stairs, etc.
   - Advanced gait training for running or complex movements
8. **Psychological support and motivation**
   - Encourage body confidence & emotional adaptation
   - Work closely with mental health professionals (e.g. psychologists) if needed
9. **Long-term rehabilitation and follow-up**
   - Monitor progress & adjust rehabilitation plans
   - Recommend modifications to orthoses/prostheses if discomfort arises
   - Encourage lifestyle activities to maintain fitness & mobility

ORTHOTICS AND PROSTHETICS

Post-operative treatment (Residual limb management)

ORTHOTICS AND PROSTHETICS

Post-operative treatment (ROM and strengthening (activation) exercises)

ORTHOTICS AND PROSTHETICS

Post-operative treatment (Transfer exercise for unilateral amputation)

ORTHOTICS AND PROSTHETICS

Post-operative treatment (Transfer exercise for bilateral amputation)

ORTHOTICS AND PROSTHETICS

EVALUATION AND SELECTION OF OTHOTICS AND PROSTHETICS

Patient assessment

- Physical examination (strength, ROM, limb length, etc.)
- Functional goals (e.g., walking, running, grasping)
- Psychological considerations (body image, emotional readiness)

Device selection

- Consultation with orthotists & prosthetists.
- Trial fitting & adjustments.
- Functional testing & re-assessment.

ORTHOTICS AND PROSTHETICS

IDEAL ORTHOTICS/PROSTHETICS

An ideal orthosis or prosthesis should be:

1. Functional
2. Fits well & comfort
3. Lightweight design
4. Easy to use
5. Durability & strength
6. Cosmetically acceptable
7. Easily maintained/repaired
8. Adjustable
9. Adaptability to environment & activity
10. Biomechanical efficiency: energy return & correct alignment
11. Stability & Security
12. Technological integration (for advanced prostheses): smart technology & biomechanical sensors

ORTHOTICS AND PROSTHETICS

CHALLENGES IN OTHOTICS AND PROSTHETICS REHABILITATION

1. **Adherence to use**
   - Patient education is key to ensuring proper use & long-term benefits.
2. **Adjustment and maintenance**
   - Devices may require periodic adjustments as the patient's body changes (e.g., muscle atrophy, weight fluctuations).
3. **Psychosocial impact**
   - Support for emotional & psychological well-being is essential for positive rehabilitation outcomes.

REVIEW

OTHER READING SOURCES

TEXT

1. *Shurr, D. G., & Michael, J. W. (Year). Prosthetics and orthotics (2nd ed.). Publisher.*
2. *Chui, K. K., Jorge, M., Yen, S.-C., & Lusardi, M. M. (2019). Orthotics and prosthetics in rehabilitation (4th ed.). Publisher.*
3. *Wilson, A. B. (Ed.). (Year). Orthosis and prosthesis (M. Dolan, Managing Ed.). Editorial board: A. L. Muilenburg, H. F. Gardner, A. Guilford, H. B. Hanger, S. Paul, R. E. Tooms, & W. L. M. Publisher.*

THANKS FOR LISTENING