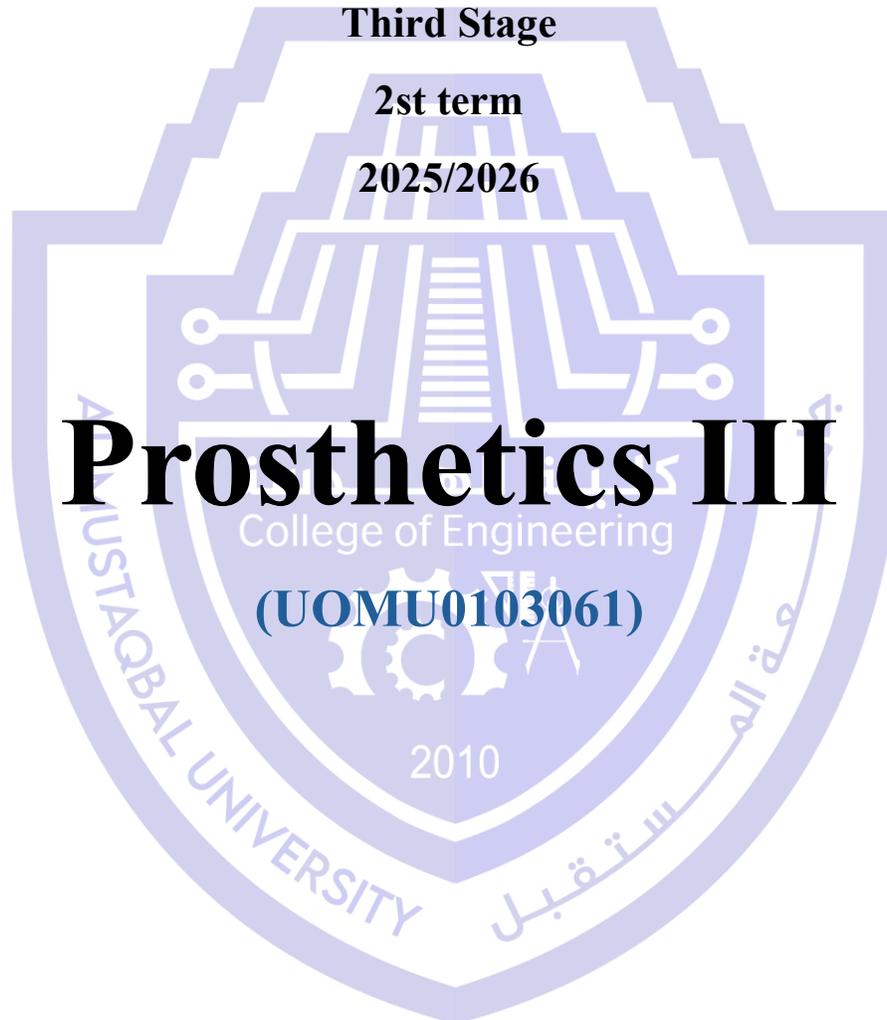




**Al-Mustaqbal University
College of Engineering
Prosthetics and Orthotics Engineering**



Lecture 5

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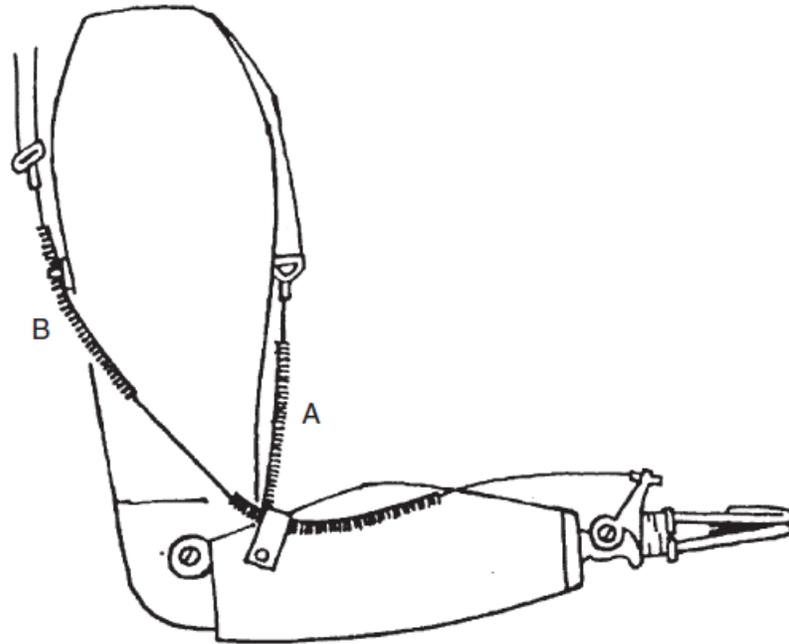
Prosthetic Elbow Mechanisms in Transhumeral Amputations

1. The Dual-Cable System

A. Purpose and Design

Patients with transhumeral amputations typically need a dual-cable system:

- 1 **The anterior cable** Its primary function is to control the locking and unlocking of the elbow mechanism.
- 2 **The other cable** It serves a dual function – controlling the Terminal Device (TD) when the elbow is locked or enabling the movement of the prosthetic forearm when the elbow is unlocked.



B. Harness System

Referring to Figure, a conventional harness system is employed for body-powered bilateral transhumeral prostheses. This includes:

1. **An upper ring** Stabilizing the prostheses on the trunk.
2. **A lower ring** Anchoring the cable control systems.

2. Cable Housing & Positioning

A. The Split-Cable Housing System

The second, longer cable, which attaches to the TD, utilizes a split-cable housing system. It's bifurcated into

- 1 **Proximal housing** This is fastened to the humeral section.
- 2 **Distal housing** Positioned anteriorly to the elbow's center, it's fixed at a specific location and height.

B. Harness Design for Transradial Prostheses

As showcased in Figure , a figure-of-eight harness system is designed for transradial prostheses. This includes distinct components like the axillary loop, anterior support strap, attachment strap for cable control, and the triceps pad.

3. Elbow Mechanisms

A. Locking Positions

The majority of elbow mechanisms feature multiple locking positions. These positions are situated at uniformly spaced intervals, transitioning from full extension to flexion.

B. Activation of Locking Mechanism

Most often, the locking mechanism is actuated using a brisk and powerful shoulder extension coupled with abduction.

4. Control Strategy

- 1 Unlocking and Movement** When the elbow mechanism is locked in a position, a rapid down and back movement stretches the anterior cable, releasing the lock. The subsequent shoulder actions, mainly flexion or scapular abduction, affect the posterior cable, thus repositioning the prosthetic forearm in space.
- 2 Forearm Movement** The anterior positioning of the cable relative to the elbow's rotation axis means that, when the elbow is unlocked, tension applied to this cable induces the forearm to ascend in flexion.
- 3 Lock Re-engagement** Upon reaching the desired inclination, another swift down and back action re-engages the lock. Once the elbow mechanism is secured, cable control shifts to the TD, and subsequent shoulder actions operate the prosthetic hook or hand.

5. Importance of Force Excursion Ratio

The sequential nature of this control strategy mandates a thorough evaluation of the force excursion ratio. A failure to optimize these criteria can lead to incomplete elbow flexion or suboptimal TD control.

Cabling Systems

1. Fundamental Principles

The foundational philosophy when it comes to designing both transradial and transhumeral prostheses is that cables and their housings should follow as direct a path as is practically possible. Why is this essential? The answer lies in the dynamics of movement. When we have a sharp or abrupt radius, it creates an excessive and undue drag as the cable passes through the housing. Remember, the objective is to achieve maximum efficiency. Especially for those patients who might have limited strength or range of motion, the efficiency of the cable system becomes paramount.

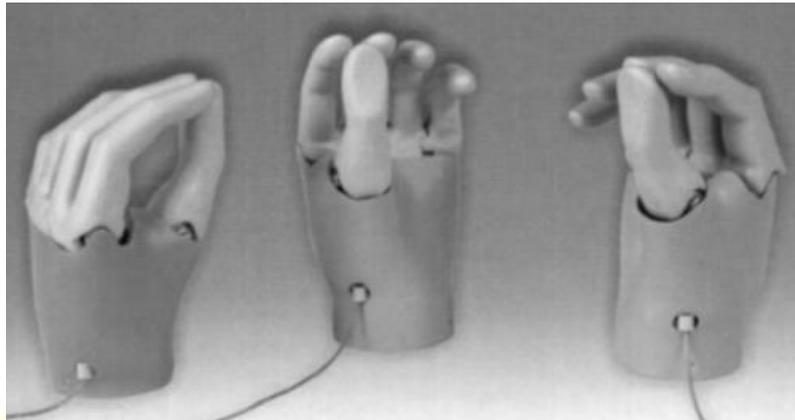
2. Steel Cables

For many decades, steel has been the trusted material for prosthetic cables. It offers strength, durability, and a range of thickness options to cater to diverse user needs. Take, for instance, those engaging in heavy-duty tasks or individuals utilizing prostheses for both their upper extremities. For them, the thicker and more robust steel cables become a suitable choice.

Terminal Devices for Conventional Prostheses

1. Hooks vs. Hands

The primary TDs in conventional prosthetics are dichotomized into either hooks, as visualized in Figure , or prosthetic hands as shown in Figure. Each of these types serves distinct functional needs and are available in two main configurations: voluntary opening and voluntary closing systems.



2. Voluntary Opening Systems

- **Functionality** In voluntary opening devices, the TD is naturally closed. Users open the TD via volitional force applied through cable movement, typically generated by shoulder flexion or abduction. Releasing the cable tension causes the object being grasped to remain secure within the device.
- **Prehensile Force** Figure shows various conventional hooks. For children, we see hooks with thumb posts and coated grip surfaces held closed by rubber bands. The grip strength or prehensile force is mainly dictated by external mechanisms like springs or elastic bands. The challenge lies in optimizing the grip strength. While adding layers of bands or multiple springs increases grip strength, it can't be voluntarily modified, posing issues for objects of varying fragility.

- **Mechanical Concerns** Due to inherent mechanical inefficiency and friction in the cable system, the necessary force to open the TD surpasses the closing force offered by the bands or springs. Striking the right balance between the external mechanism and the user's motor control is paramount.

3. Voluntary Closing Systems

- **Functionality** Contrary to the voluntary opening system, the TD here is normally open. The user closes the TD by applying volitional force through the cable.
- **Advantages** The strength of this system is in its adaptability. Users can adapt the prehensile force to the nature of the object being held, allowing for graded pressure. This system can achieve significant forces, being limited mainly by the user's motor capabilities or any residual limb discomfort.
- **Control Dynamics** Here, users need to consistently maintain power and movement to hold the object securely within the TD.