


Prosthetics
Trans-Tibial Interface Theory Unit
Educational Module
*Module 1 of 2 in this unit***



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Objectives

At the conclusion of this module, you will

- Recall history associated with the PTB interface
- Recall the 3 contemporary trans-tibial interface theories
- Identify load tolerant areas of the trans-tibial residuum
- Identify pressure sensitive areas of the trans-tibial residuum
- Recall fundamental sagittal and frontal plane alignment considerations of the PTB interface
- Identify unique characteristics of the 4 walls of the PTB interface

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Trans-Tibial Interfaces
Three Design Theories

This module on "Trans-Tibial Interface Theories" is the first of two modules in this unit.

- This module will cover the Patella Tendon Bearing Socket theory.
- Module 2 will cover Total Surface Bearing and Hydrostatic Design Theories.
 - A test will accompany the unit.

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Trans-Tibial Interfaces Three Design Theories

1. Patella Tendon Bearing (PTB)
2. Total Surface Bearing (TSB)
3. Hydrostatic Design (HSD)



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Patella Tendon Bearing Design or PTB

History

- Invented in 1950's
- James Foort & Charles Radcliffe
- State of the art was the "plug fit" socket

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Plug Fit

- Typically wood socket lined with leather
- Essentially a cylinder
- No provision for volume change
- Depth of limb engaged in socket was volume dependent
- Depth could change
 - By the day
 - By the hour

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Plug Fit

Schurr and Michael:
state that the plug fit is comparable to a cork in a bottle

- Volume fluctuation would impact fit
- No distal (total) contact
- Lack of distal (total) contact in blue
- Red and blue areas subject to volume fluctuation

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PTB

New Concepts

- Total Contact
- Loading Pressure Tolerant Areas
- Relieving Pressure Sensitive Areas

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PTB: Total Contact

- Total Contact started as a means of decreasing distal edema
- Leaving voids in the interface (as in the plug fit), gave places for fluid to collect
- Distal aspect of transected bones can tolerate gentle quantities of pressure
- Lack of distal contact could lead to *verruose hyperplasia***

Distal end of a transibial residual limb. Note the redness and wart-like appearance due to proximal constriction of the socket.

**See the Dermatology Modules from this project for more on verruose hyperplasia

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PTB-Loading Pressure Tolerant Areas

- It was theorized that certain places on the residual limb would be better at pressure dissipation and thus
- Could tolerate load better than other areas
- These were areas that contained
 - Soft tissue
 - Neurovascular areas
 - Muscular areas

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PTB-Loading Pressure Tolerant Areas

- ➔ Patella Tendon
- ➔ Anterior Muscular Compartment
- ➔ Medial Tibial Flare
- ➔ Lateral Stabilizing bar/ Shaft of Fibula
- ➔ Gastrocnemius muscle bellies
- ➔ Popliteal Fossa
- ➔ Distal end to some extent



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PTB-Relieving Pressure Sensitive Areas

- If soft tissue and vascular areas can tolerate load, then remaining areas must be less tolerant of load.
- This includes areas of
 - Less vasculature
 - Less soft tissue

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PTB-Relieving Pressure Sensitive Areas

- ➔ Patella
- ➔ Lateral Tibial (Gerdy's)Tubercle/Iliotibial Band
- ➔ Fibula Head/Common Peroneal Nerve
- ➔ Tibial Tubercle
- ➔ Tibial Crest
- ➔ Distal cut end of Fibula/Tibia
- ➔ Hamstring Tendons

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PTB- Casting

- Casting or "taking an impression" can be done in 1 or more "stages"
- Many current designs are cast in 1 stage with a circumferential wrapping technique
- The PTB design may be cast in 1 to 3 stages depending on the height of the trimlines or how tall the walls are.
- Each stage serves a different function

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PTB- Casting/ Anterior Panel

- Stage 1- Anterior Panel
- 6-9 layers of plaster are trimmed to fit:
 - From sagittal midline medially to laterally
 - Approximately the joint line (superiorly) to the middle of the distal end of the residuum

Photo courtesy of Otto Bock Healthcare

Red line outlines a typical anterior panel shape

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PTB- Casting/ Anterior Panel

- The anterior panel has several purposes:
 - Pre-relieve the condyles
 - Demarcate
 - The patella tendon
 - Anterior compartment
 - Anterior aspect of the medial tibial flare
 - Tibial crest and tubercle

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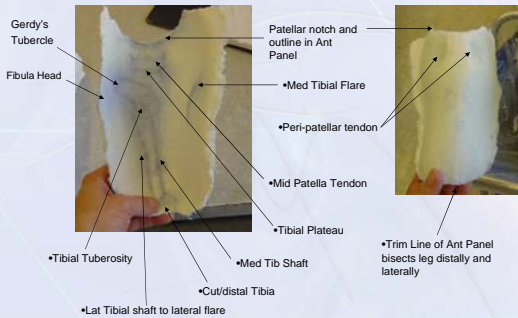
PTB- Casting

- Depicted here are the circumferential wrap removed from the positive model (cut posteriorly)
- The anterior panel has been removed as well
- Note the patellar tendon demarcations and the patellar outline



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PTB-Features and Cast Markings of the Anterior Panel and Residuum



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PTB- Shape (Transverse View)

- Viewed transversely, the PTB interface has a somewhat triangular shape when compared to other, more rounded socket designs.
- "legs" of the triangle are comprised of lines in plane with the following:
 - Popliteal modification (1)
 - Medial tibial flare (2)
 - Anterior muscular compartment (3)



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PTB- Construction/Design

- Generally the PTB socket is designed as either a
 - Thermoplastic or
 - Thermosetting laminated frame
- Generally there are the following four sides or "walls"
 - Anterior
 - Posterior
 - Medial
 - Lateral

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PTB- Anterior Wall

Features of the Anterior Wall:

- Patella Notch/Relief
- Patella Tendon Bar
- Relief for tibial tubercle
- Relief for anterior distal Tibia
- Relief for tibial crest
- Anterior Muscular Compartment
- Medial Tibial Flare (anterior aspect)



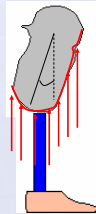
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PTB- Anterior Wall

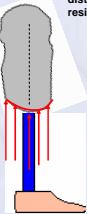
The anterior wall is considered the primary weight bearing surface of the socket

- As more of the anterior wall is exposed with an increased flexion attitude

5-10° of socket flexion exposes more of the anterior wall for weight bearing



0° of socket flexion only permits loading of the distal end of the residuum



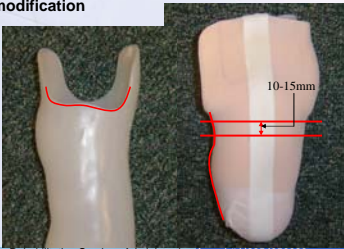
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PTB- Posterior Wall

Features of the posterior wall

- Popliteal modification
 - Deepest point is 12-15mm inferior to MPT level
 - Provides anterior directed counterforce to keep Patella Tendon on Patella Bar which
 - Keeps limb from excessive end bearing
- Gastrocnemius modification
- Hamstring relief

Virtually the entire posterior wall can accommodate reasonable quantities of loading



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PTB- Posterior Wall

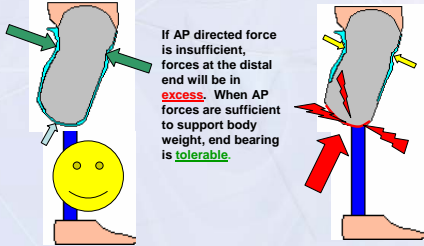
- Hamstring relief can take many shapes.
- Dependent upon:
 - Limb Length
 - Quantity of soft tissue
 - Patient Preference
- Typical shapes are:
 - Straight line sloping distally-medially
 - "W" shape
 - Semi-circular or "arc"-ed for long limbs and Symes



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PTB- Posterior Wall

- Counterforce of the popliteal modification against the patella bar keeps the limb from excess end bearing.
- The anterior to posterior distance (AP) must be appropriate to support body weight during stance



If AP directed force is insufficient, forces at the distal end will be in **excess**. When AP forces are sufficient to support body weight, end bearing is **tolerable**.

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PTB- Trimline Height Medial & Lateral Walls

- The trimlines are the upper most (proximal) aspect of where the socket "ends" or has been cut
- Several options available

MPT

65mm between MPT and trimline is considered starting point for "standard" PTB

Proximal aspect of patella

25mm between proximal aspect of the proximal patella and the trimline is considered starting point for a PTB SC-SP

Also with regard to the trimlines, the patella may be entirely relieved, partially relieved or entirely enclosed.

NOTE:

PTB: patella tendon bearing

PTB SC: patella tendon bearing, supracondylar

PTB SC SP: patella tendon bearing, supracondylar, suprapatellar

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PTB- Trimline Height for Medial & Lateral Walls

- Start with high, supracondylar trimlines
- can be trimmed down to suit the situation
- cannot be lengthened
- Individually specific based on anatomy
- Specific based on suspension mechanism

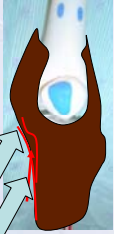
Two cases requiring lower trimlines:

1. PTB with supracondylar cuff strap. Lower, swooped trimlines are needed to prevent the strap from bridging the patella, where suspension is primarily borne. Probably used with a longer limb with good ligamentous stability.
2. PTB with joints and cosset. Lower trimlines are needed to permit inherent pistoning that will occur with this design. This design represents maximal stability offered in a trans-tibial prosthesis without locking the knee joint.

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PTB- Medial Wall

- Weight Bearing Characteristics:
- Broad area for vertical loading (weight bearing) by virtue of
 - Anatomic shape
 - Soft tissue structures in the region




Note the contour of the medial wall. It is well suited for loading.

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PTB- Medial Wall

Features of the Medial Wall:

- Broad area for weight distribution
 - Broad flat bony surface
 - Vast soft tissue including
- **Pes Anserinus group**
- **Popliteus Muscle Insertion**
- **Medial Head of Gastrocnemius**
- **Medial Origin of Soleus**
- **Medial Colateral Ligament**
- Prominent Medial condyle for
 - Suspension
- Frontal plane stability




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PTB- Medial Wall

Alignment and the medial wall

- "Normal" alignment calls for a slight inset of the prosthetic foot
- To induce a varus moment at midstance



~~Valgus Moment~~

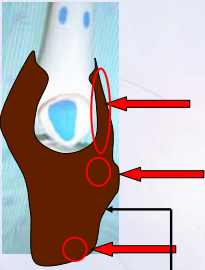
Varus Moment:

1. Narrows the Base of support for improved gait efficiency
2. More closely mimics a normal anatomic gait pattern
3. Loads pressure tolerant structures or, said differently, aids in relieving pressure intolerant structures
4. Appropriately distributes stress to stronger ligaments: i.e. loading the lateral colateral knee ligament versus the medial colateral ligament.

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PTB- Lateral Wall

- Weight Bearing Characteristics:
- Many Sensitive Structures.
- Relief for the following:
 - Iliotibial band
 - Fibula head/Peroneal Nerve
 - Distal, cut end of Fibula
- Design Consideration: A Varus Moment Loads many pressure tolerant structures but has the tendency to load the distal cut end of the femur. Therefore, relief here is very important.



Best location for loading is along the fibula shaft or "lateral stabilizing bar"

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PTB- Lateral Wall

Alignment and the Lateral wall

- REMEMBER: "Normal" alignment calls for a slight inset of the prosthetic foot to induce a **varus** moment at midstance.
- If a Valgus moment is introduced...

~~Valgus Moment~~

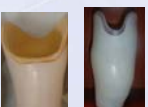
1. A valgus moment will stress the medial colateral ligament of the knee
2. The base of support will be abnormally widened
3. Pressure will be induced at the proximal, lateral aspect of the socket, in the vicinity of the Fibula head. This region tends to be irritable.




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PTB- More Design Choices


- As previously mentioned, the PTB socket may be fabricated as either
 - A thermoplastic or
 - A thermosetting lamination
- The socket too may be fabricated as either a
 - Hard socket or
 - With a soft interface
 - such as Pelite, Bock-Lite, or other soft foams
- These topics are reviewed in greater depth in other modules. Hard socket and soft interface choices will briefly be described here...



Thermoplastic (polypropylene) socket frames. Left socket has a soft, Pelite liner. Right socket has a soft, Bioelastic (thermoplastic) liner.



Laminated (thermosetting) sockets with soft inserts. Left socket has a bioelastic insert and right socket has a Pelite insert.



Cross section of numerous types of gel liners (i.e. silicone, urethane, polymer, etc.). Use of a gel liner creates a soft interface for the residual limb.

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PTB- Hard Socket

- A Hard socket or a socket that lacks a soft insert, will typically utilize prosthetic socks as the interface between the skin and socket.
- Generally, hard sockets are
 - Fit with a 3-6 ply sock fit initially
- Used with those that have
 - Hygiene issues
 - Sensation intact
- Not very accommodating to heavy volume fluctuation



Hard socket with PTB (specific weight bearing) modifications and removable medial brim suspension. Hard socket should be fit with at least 3 plies of socks against the skin.

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PTB- Soft Interface or Insert

- The Soft Insert is more widely used in prosthetics.
- The soft insert
 - May be made of numerous choices of materials
 - Is more accommodating of volume fluctuation
 - Is fit between 0 and 3 ply of prosthetic socks initially
 - May present skin problems if hygiene is an issue
 - Is a better choice if sensory modalities are impaired



Gel liners used as soft inserts. Gel liners can be used without socks.



Soft Inserts shown here. Left is a foam Pelite insert and the remaining 3 at right are Bioelastic thermoplastic.



Transibial prosthesis incorporating a soft, thermoplastic insert in addition to a gel liner for maximal skin protection and adjustability.

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PTB- Benefits & Drawbacks

Benefits

- Still widely used and accepted today
- Time tested and proven
- First design the student prosthetist learns in professional curricula
- Heavily tested on professional licensure & board examinations for several types of professionals
- May be offered as a first option or fall back option

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PTB- Benefits & Drawbacks

Drawbacks

- Pressing more forcefully into muscular and vascular areas has been argued to
 - Limit the ability of muscles to contract
 - Promote atrophy which
 - Leads to characteristic shaping
 - That may result in a residuum that is more difficult to fit later
- It has also been argued that focal loading can overload certain areas making the PTB user more susceptible to skin breakdown

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“Demonstration Project on Prosthetics and Orthotics”

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