



# **Prosthetics I**

## **lab2**

### **transfemoral amputation**

### **Second stage/ 2nd semester**

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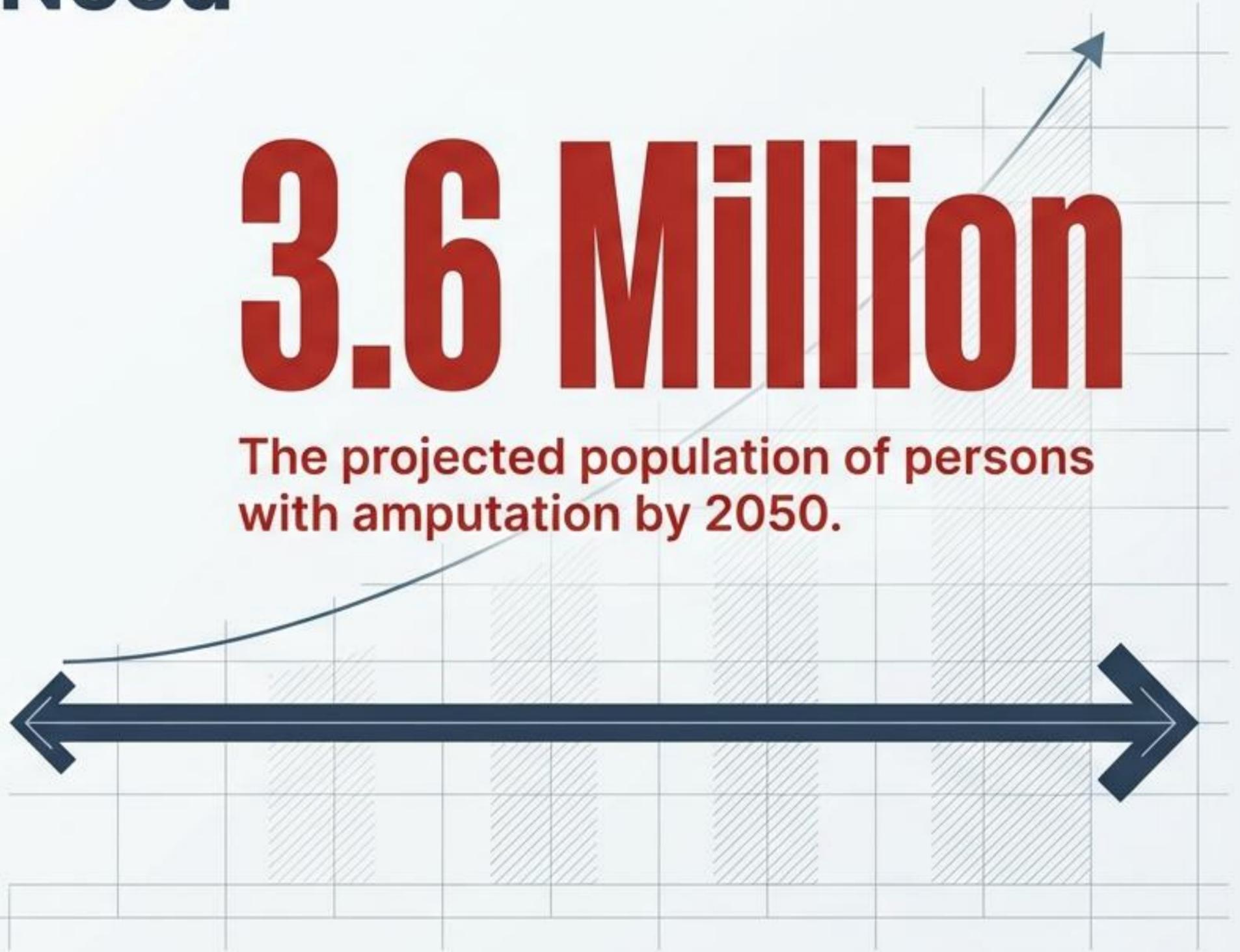
# The Scale of the Need

**2 Million**

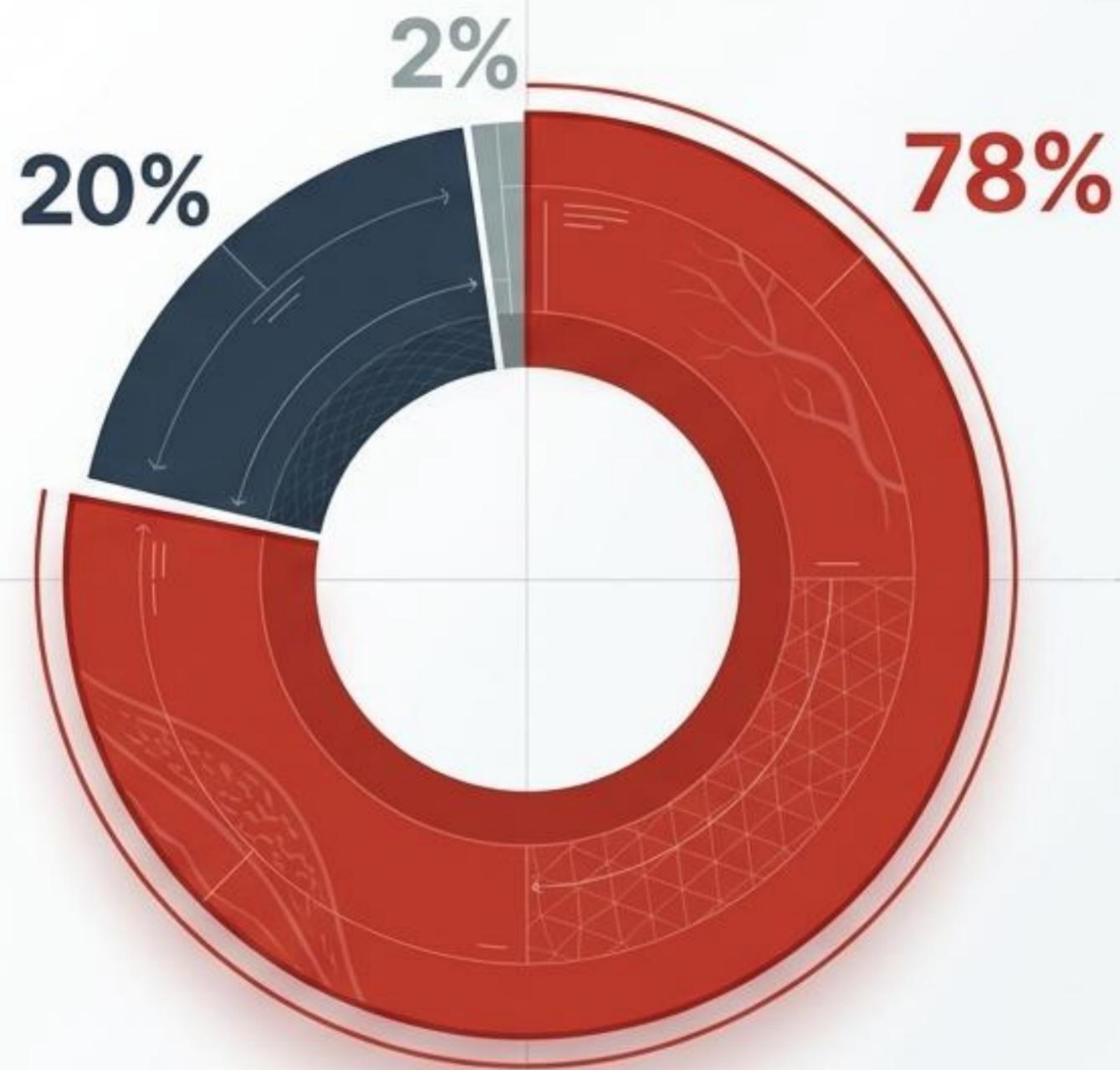
Persons living with amputation in the U.S. today (with 185,000 new procedures annually).

**3.6 Million**

The projected population of persons with amputation by 2050.



# The Root Causes of Limb Loss



## 78% Dysvascular Disease

(Note: Two-thirds of this group have diabetes as a comorbidity).

## 20% Trauma

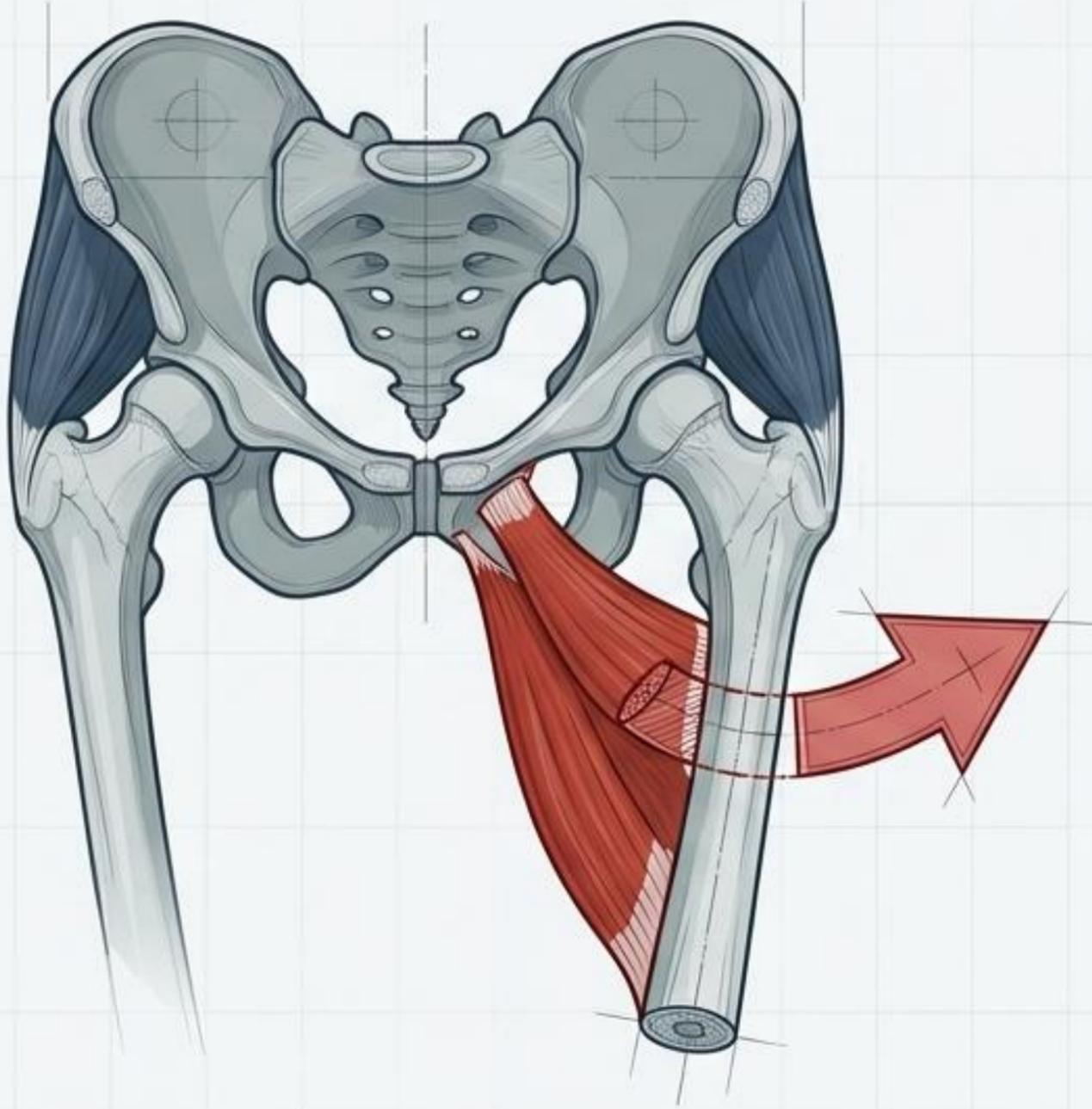
(Skewed heavily towards males under 65).

## 1-2% Cancer.

# The Language of Limb Loss

Correct Usage 	Incorrect Usage 
<p>Prosthesis (the noun/the device, e.g., “fitting a prosthesis”)</p> <p>Prosthetic (the adjective, e.g., “prosthetic knee”)</p>	<p>Never call the device “a prosthetic.”</p>
<p>Person with amputation</p>	<p>Amputee</p>
<p>“Residual limb” or “residuum”</p>	<p>Stump</p>

# The Biomechanical Deficit



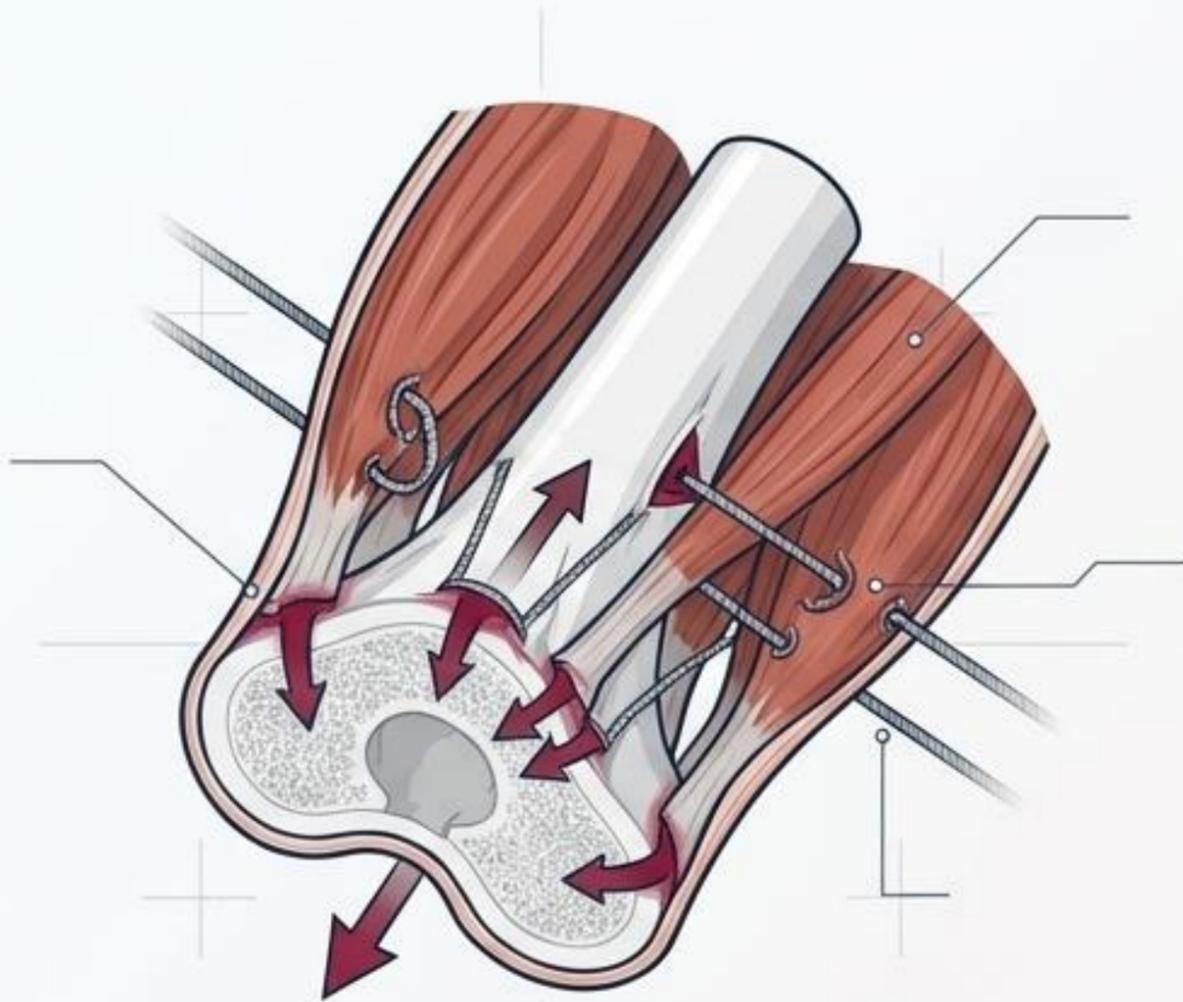
The loss of length equals the loss of adductor strength.

Amputating just **1/3** of the femur length results in a staggering

**70% reduction** in adduction strength.

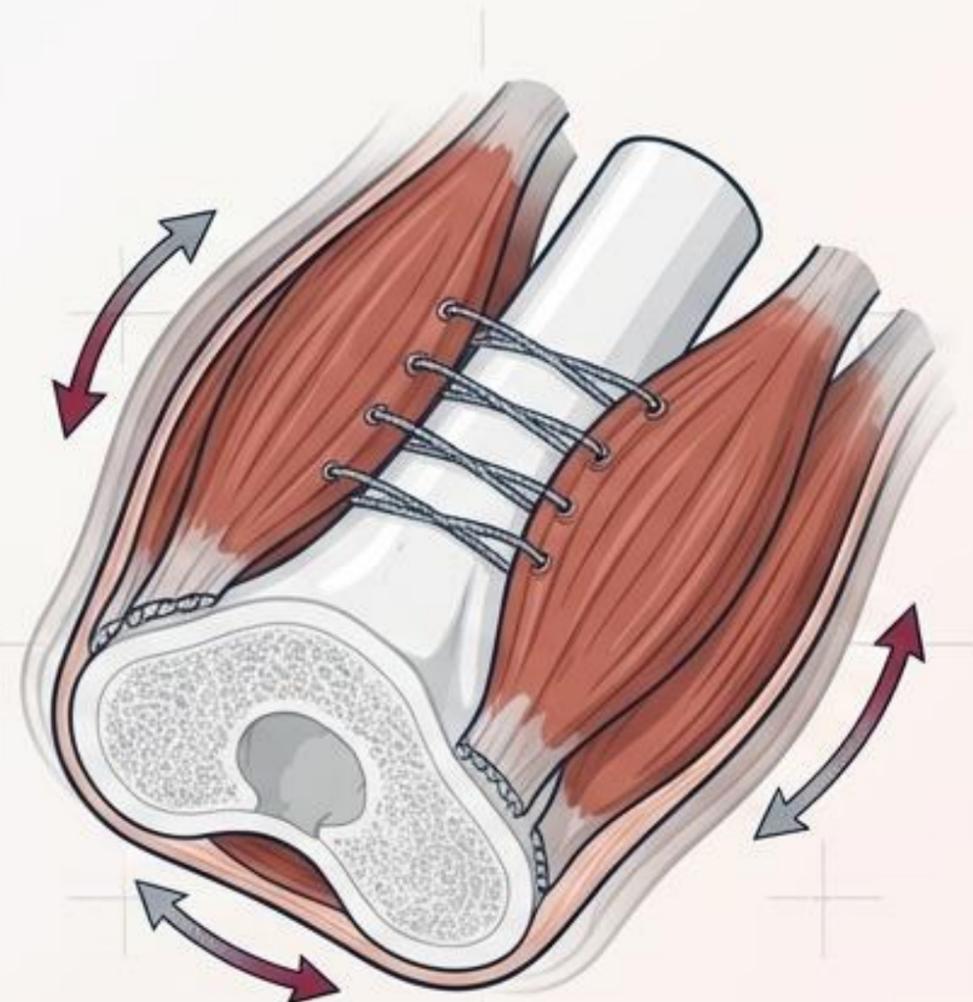
Because the primary abductors remain fully intact, this creates a massive muscular imbalance, driving the femur into abduction.

# The Surgical Foundation



## Myodesis

Anchoring muscle directly to the periosteum and bone. Creates a stable lever acting directly on the skeleton.



## Myoplasty

Suturing muscle to muscle. Creates a moving target inside the socket, altering limb shape between firing and relaxing, complicating the prosthetic fit.

# Stabilizing the Tissue



- Fitted immediately following suture removal.
- Worn **23 hours a day** to provide constant compression.
- The Engineering Goal: Edema reduction and volume stabilization to prevent massive fluid fluctuations when transitioning into a rigid socket.



# Proper shrinker protocol strictly enforces 23-hour compression

# 23 HRS

The **23-Hour Rule**: Shrinkers must be worn 23 hours a day to prevent volume fluctuation before casting. Use a shrinker anytime the prosthesis is not being worn.

**Crucial Warning:** Proximal wrinkles that run circumferentially create a choke point, entirely defeating the shrinker's purpose and damaging the limb.



1. Wait until suture removal. Cover sensitive areas. Roll up like a sock. The proximal medial end must be seated as high as possible into the groin.



2. Attach the waist belt to prevent slipping.



3. Push the bottom ring against the distal limb, reflect the remaining material upward, and smooth entirely.

# The transfemoral rehabilitation timeline spans over six months



**Post-Op**

## **Phase 1: Initial Healing (Weeks to Months)**

- Focus on wound healing and edema control.
- Note: IPOPs (Immediate Post-Operative Prostheses) are extremely rare for transfemoral. Early devices are purely for limb protection, not weight-bearing.

**Preparatory**

## **Phase 2: Preparatory Prosthesis (1 to 6 Months)**

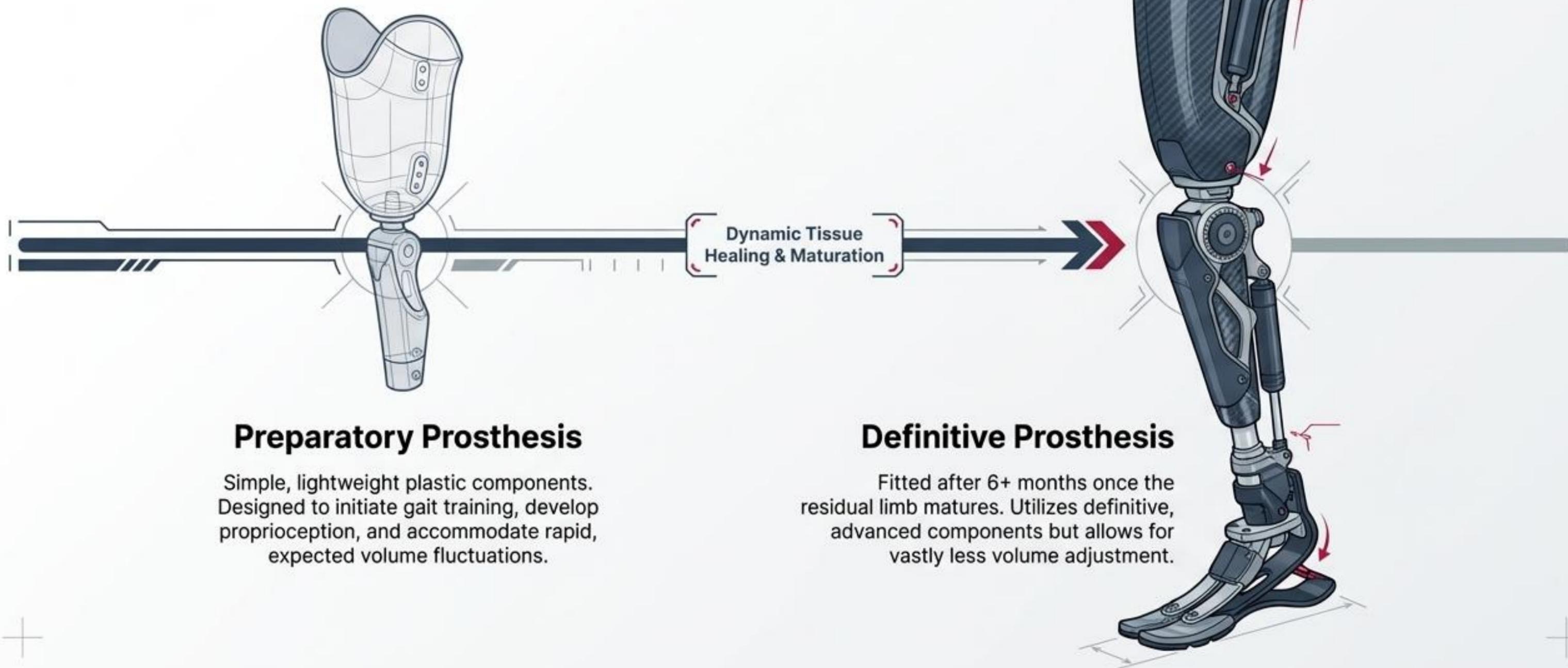
- Simple, lightweight components to initiate gait training and proprioception.
- Accommodates massive expected volume fluctuation. Goal is working up to full-time use.

**Definitive**

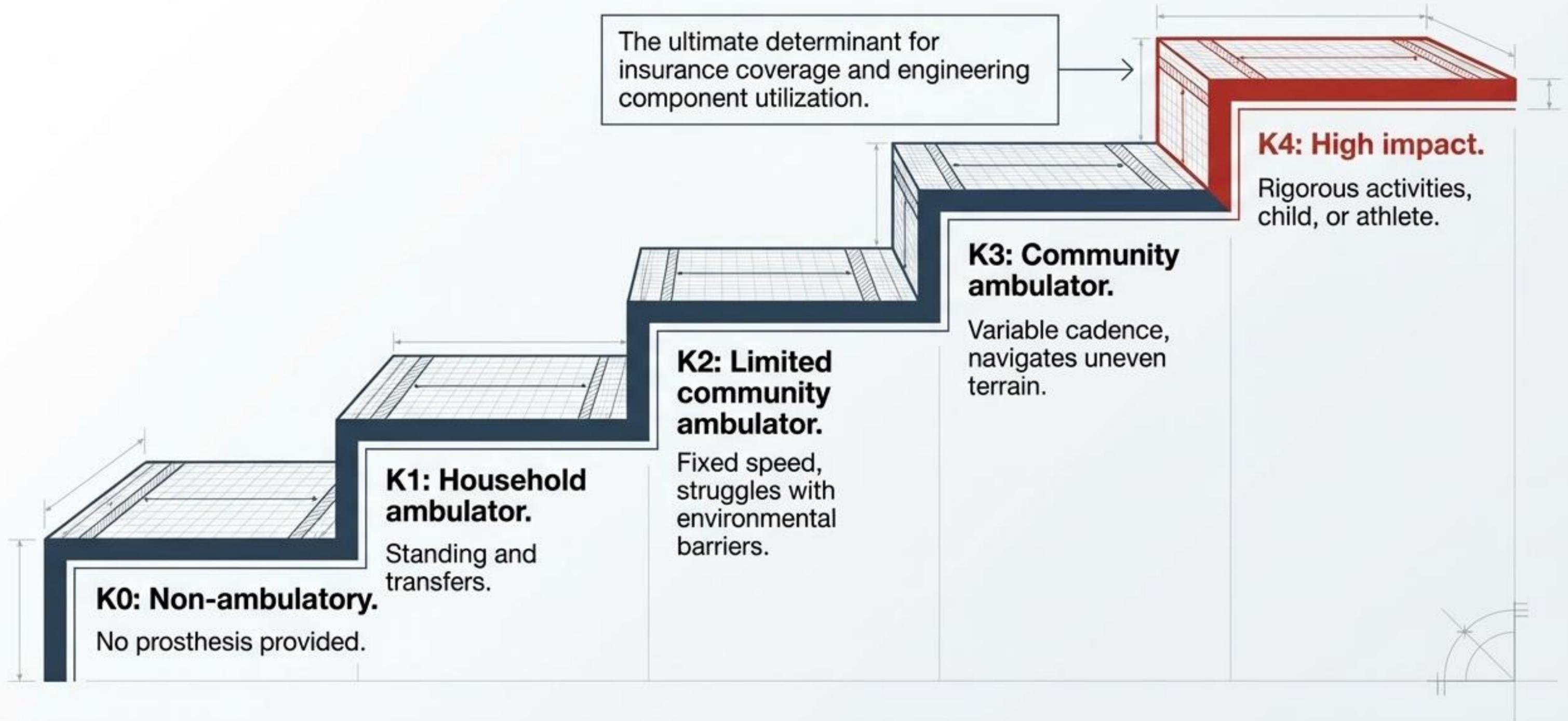
## **Phase 3: Definitive Prosthesis (6+ Months)**

- Fabricated with definitive components once limb volume stabilizes.
- Minimal adjustability compared to preparatory sockets. Expected to last ~5 years.

# The Restorative Timeline



# Defining Potential with K-Levels





**K0**



**K1**



**K2**

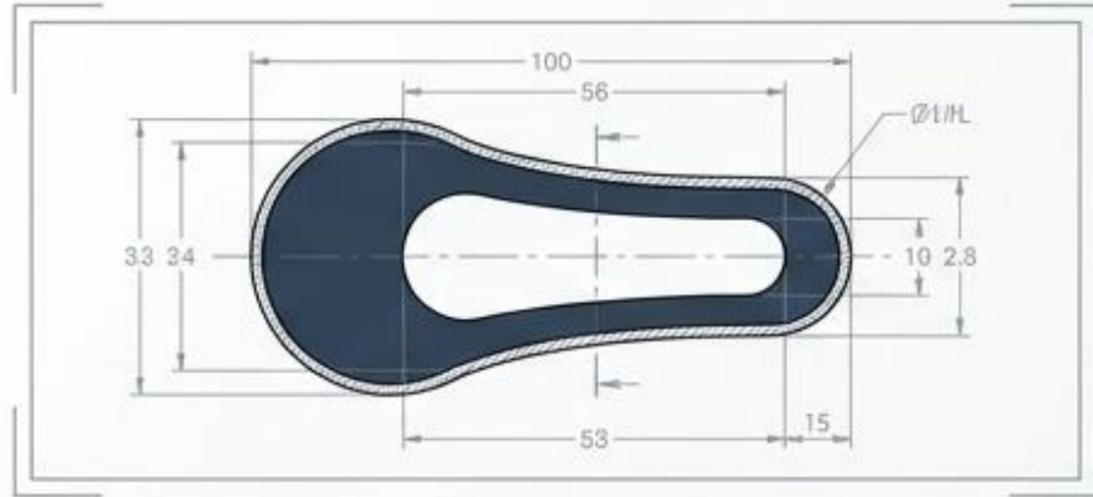


**K3**

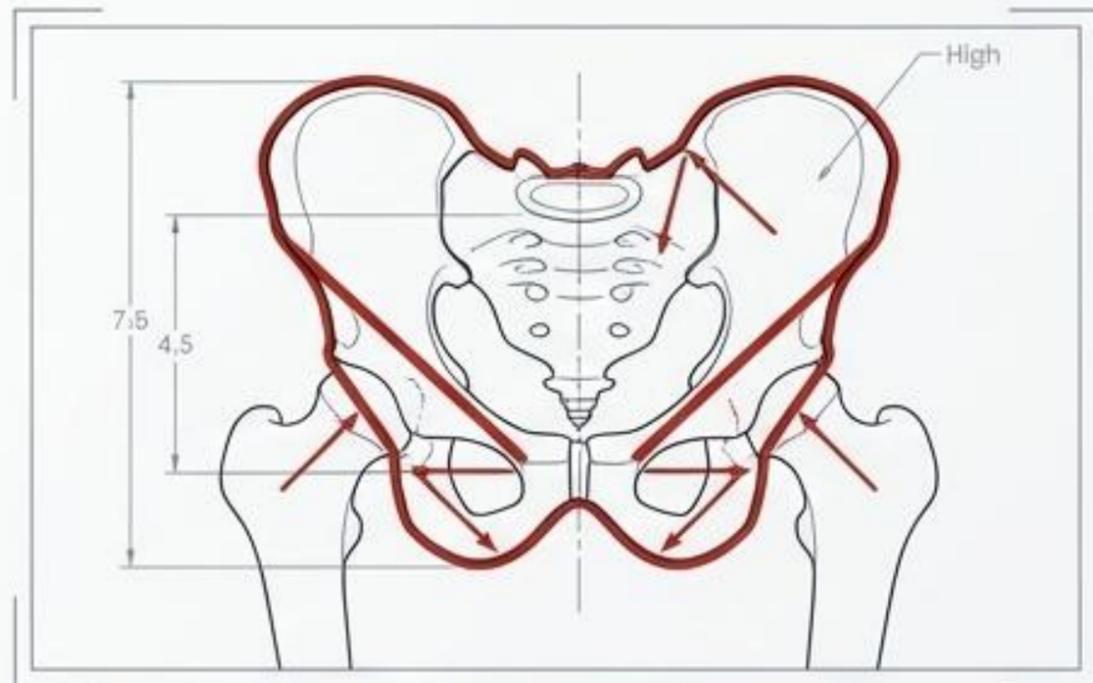


**K4**

# The Critical Interface: Ischial Containment



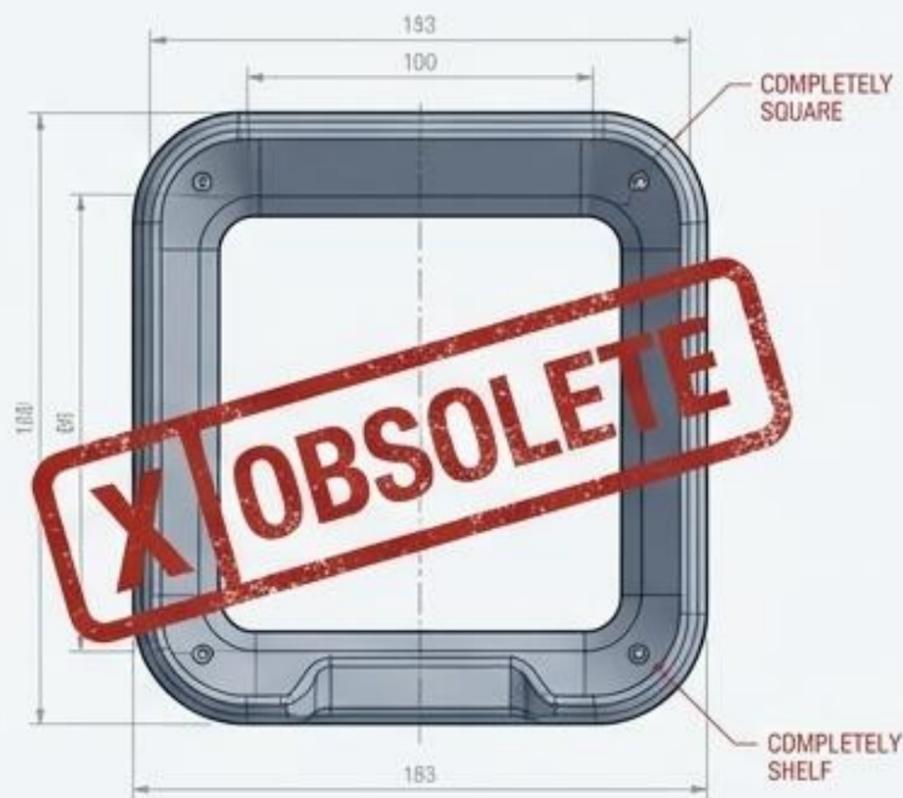
TOP-DOWN VIEW: Narrow ML Shape



ANTERIOR VIEW: Pelvic Lock & Adduction Trap

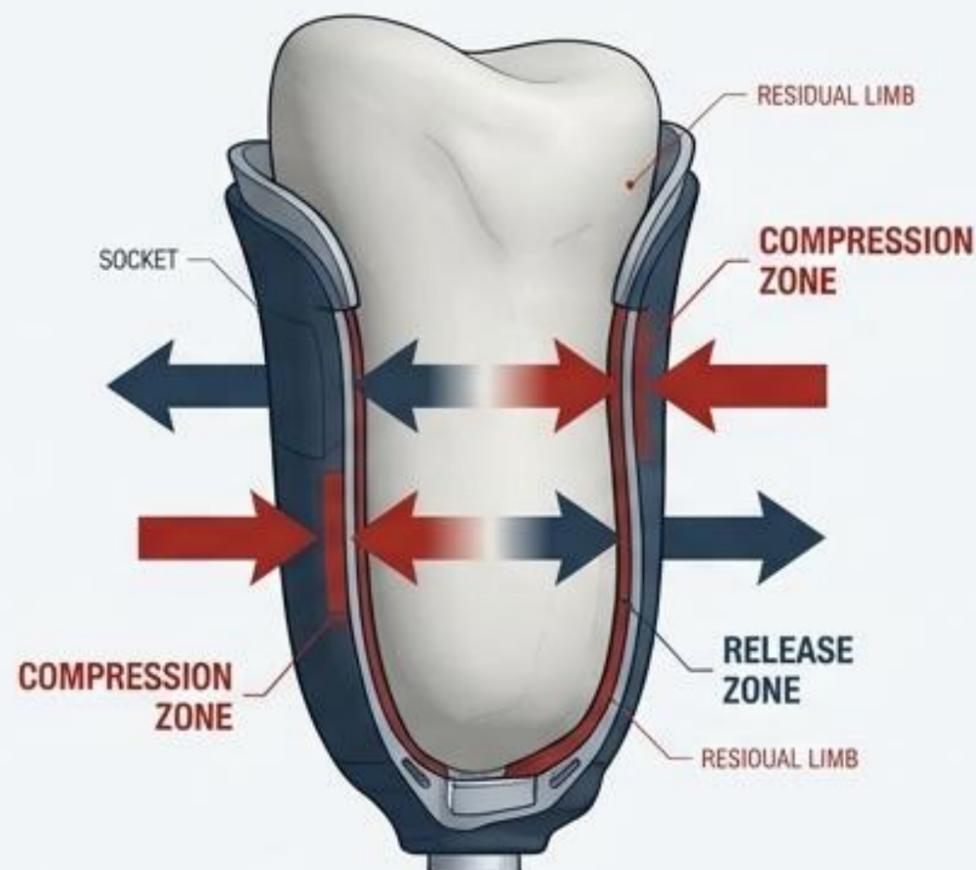
- Achieves a structural 'bony lock' on the ischium and/or ramus.
- Features a narrow mediolateral shape.
- The Engineering Purpose: Provides a distal-lateral force to **mechanically adduct the femur**, directly compensating for the loss of native adductor musculature.

# The Evolution of Comfort: Sub-Ischial Design



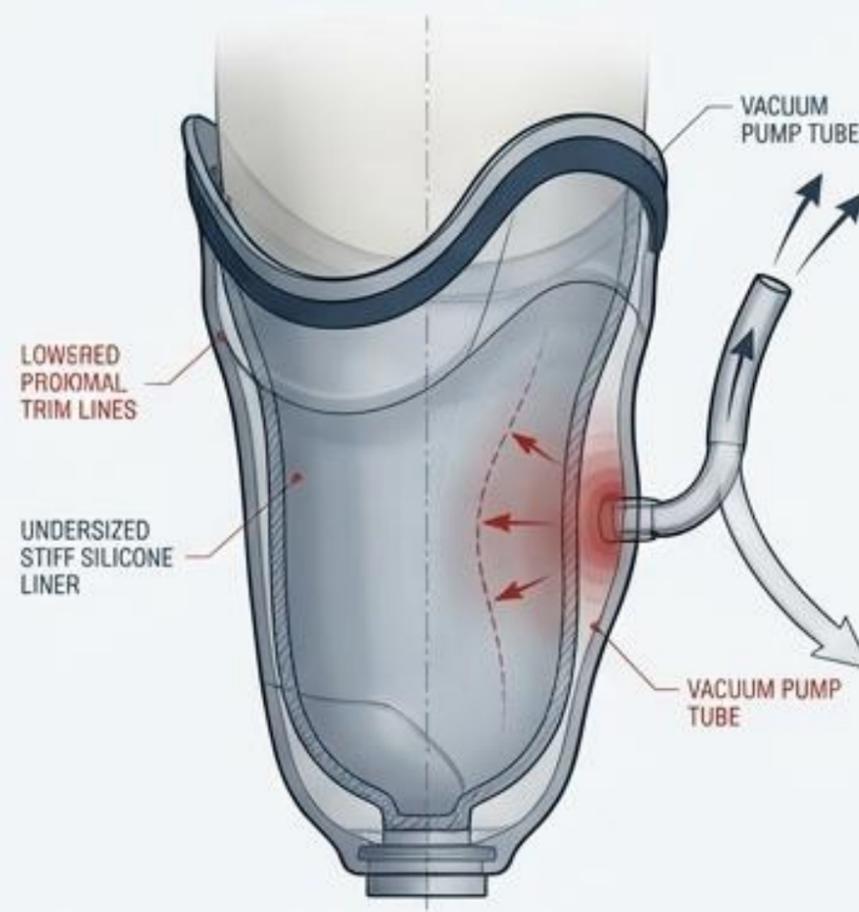
## The Old Standard (Quad)

Utilized a posterior shelf but failed to control femoral abduction.



## Hi-Fi Interface

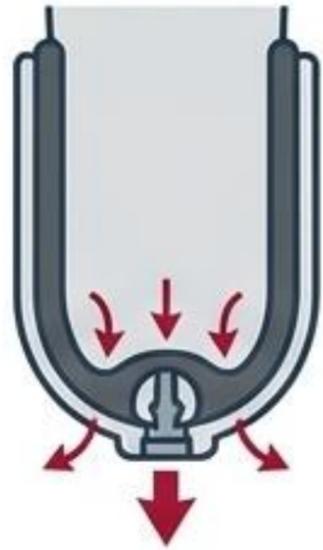
Utilizes diametrically opposed zones of compression and release, running orthogonal to the limb, to aggressively capture the femur.



## NU-Flexiv

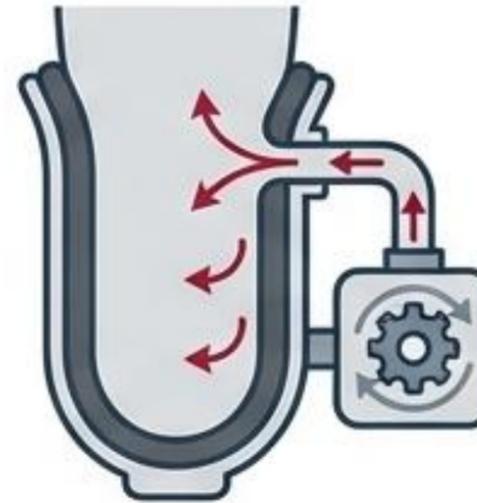
Features lowered, flexible proximal trim lines utilizing an undersized, stiff liner and vacuum distortion to achieve a barrel-shaped tissue lock. Best for longer, firm limbs.

# Defying Gravity: Suspension Systems



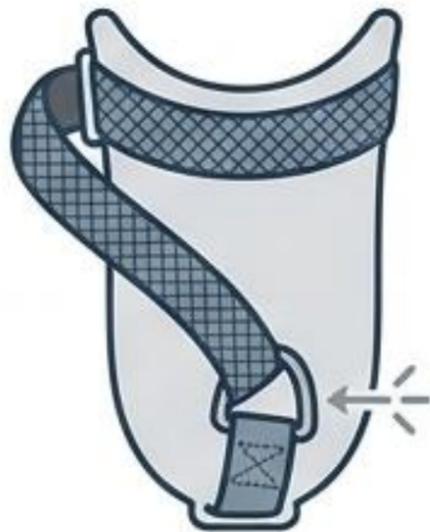
## Suction

Skin-fit or internal sealing ring. Expels air distally to create an internal seal.



## Vacuum

Active mechanical or electronic pump that highly couples the limb to the socket.



## Lanyard

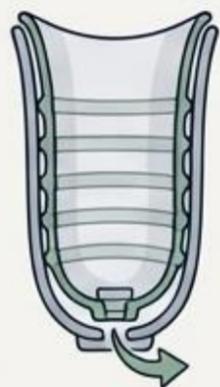
Proximal/lateral locking straps, easier to don than a pin.



## Pin Lock

Rare in transfemoral amputations because the mechanism **elongates the limb**, forcing the prosthetic knee center out of biological alignment.

# Suspension systems must combat the weight of transfemoral hardware



## Internal Sealing Suction

The most common. A sealing ring on the liner presses against the socket, expelling air distally with a one-way valve.



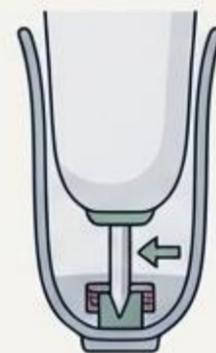
## Skin Fit Suction

No liner used. The limb is pulled directly against the hard socket using an ace wrap or donning bag, sealed at the bottom.



## Lanyard System

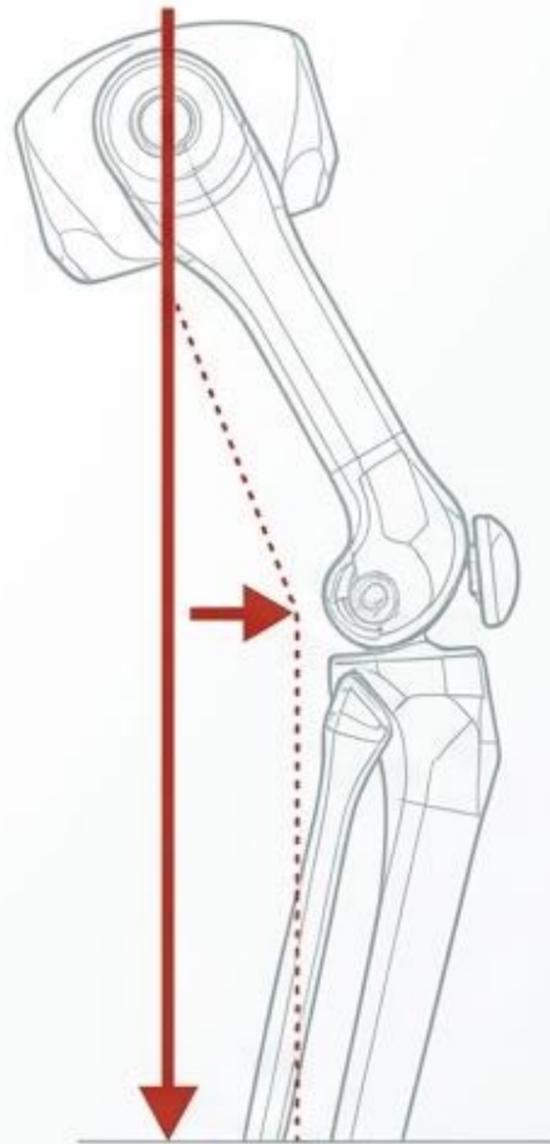
Straps are fed through the distal end and locked externally. Far easier to align than a pin.



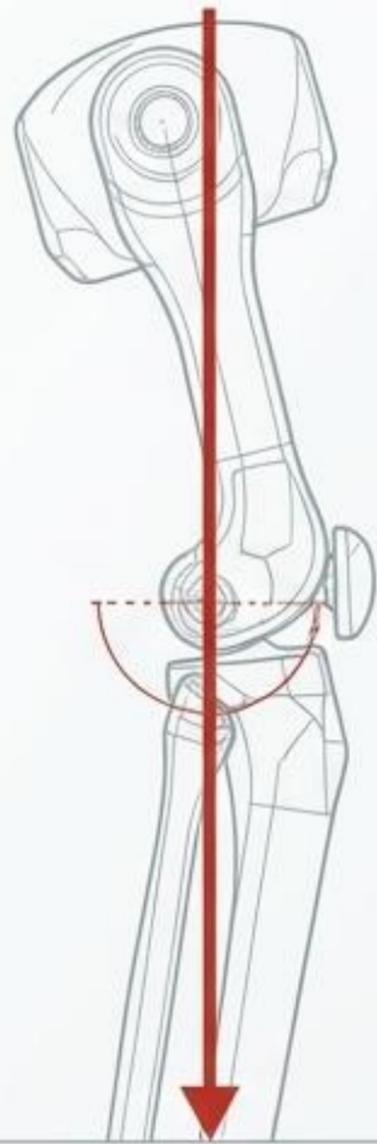
## Pin Lock (Rare for Transfemoral) ⚠️

Highly problematic above the knee. The distal pin elongates the limb, adds bulk, and disrupts the anatomical knee center. Only functional if the patient has a severe flexion contracture.

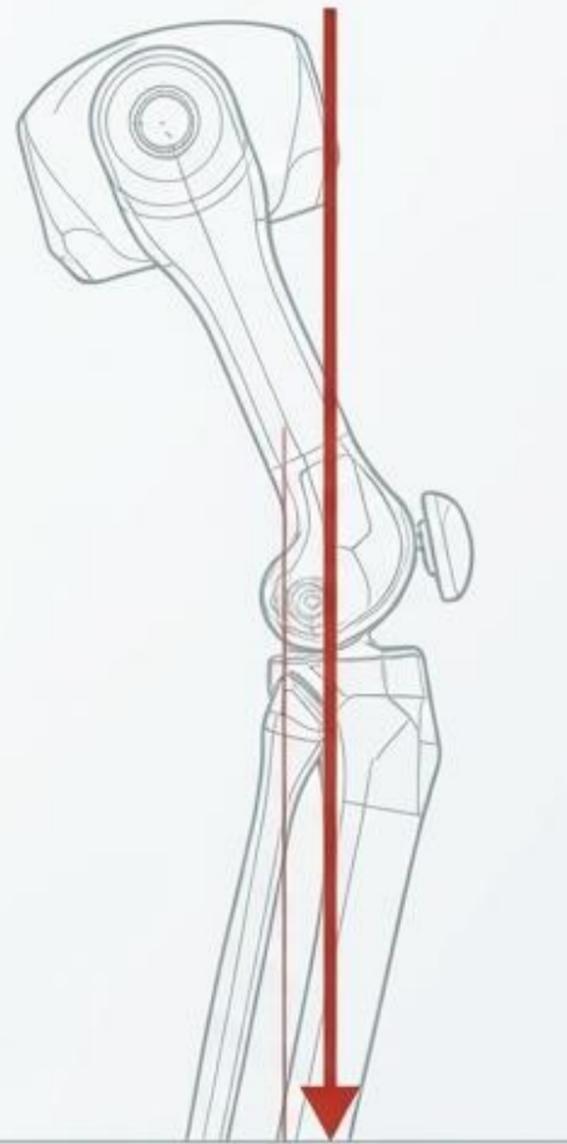
# Restoring Kinematics: The Knee Joint



**Anterior**  
Inherent Stability



**Through Axis**  
Neutral Stability

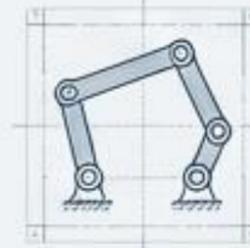


**Posterior**  
User Control  
(Longer Limbs)

## Geometry is Stability

A weight line passing anterior to the knee creates inherent stability; posterior creates instability but yields greater user control for longer limbs.

## Polycentric Knees



Multiple axes of rotation. Mechanically moves the center of rotation proximal and posterior for extreme stability.

## Fluid & Microprocessor (K3/K4)

Provides advanced stumble recovery and accommodates variable cadence through fluid dynamics.

# Aligning the weight line directly manipulates inherent stability



## **Anterior to the Knee (Maximum Stability)**

The physics inherently force the knee into extension. Used for shorter residual limbs lacking muscular control.



## **Through the Knee (Neutral)**

Balances stability with the initiation of swing phase.



## **Posterior to the Knee (Maximum Control)**

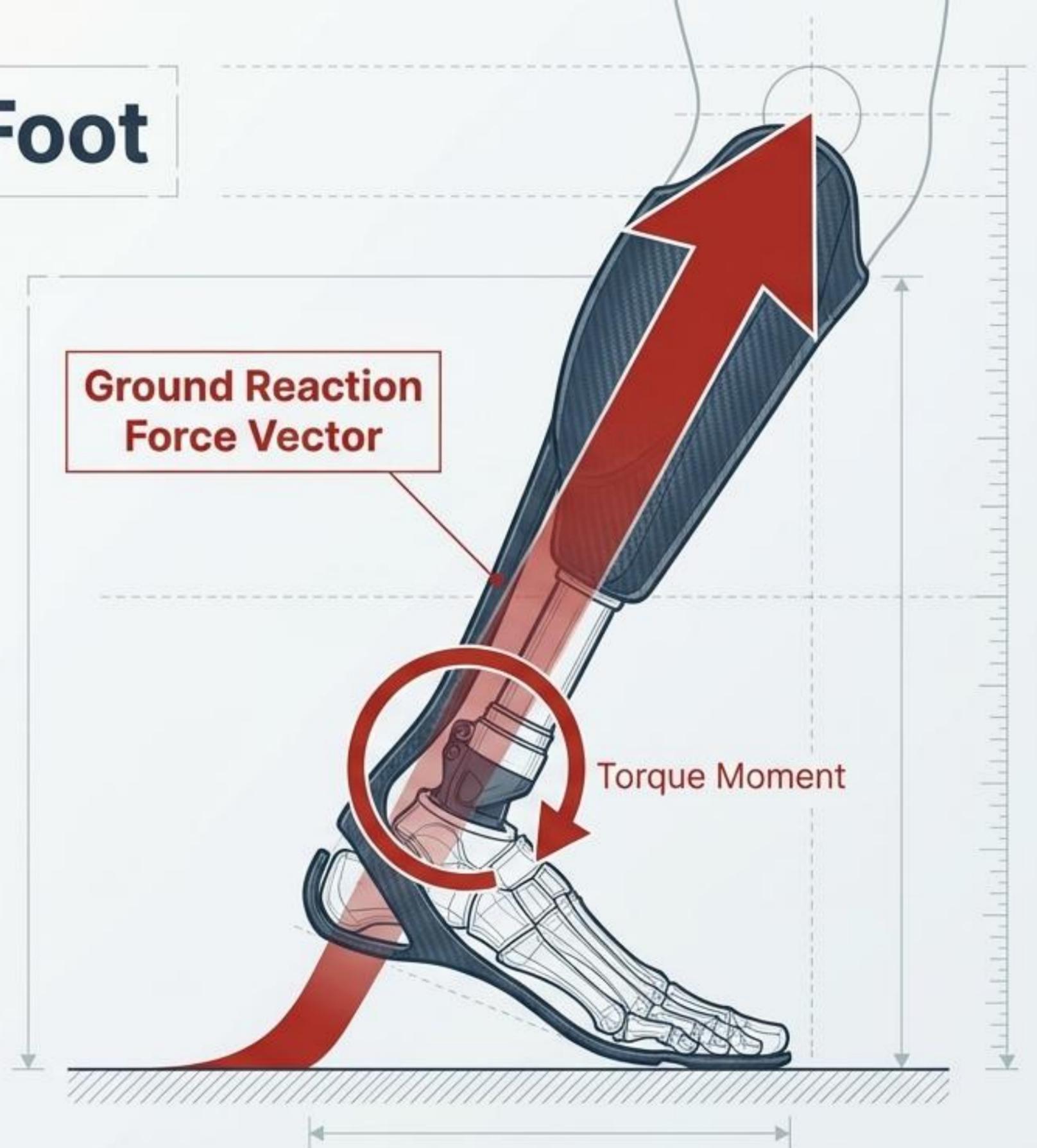
Highly unstable inherently, but gives advanced users with long residual limbs ultimate voluntary control over flexion.

# Ground Reaction: The Foot

**The Ankle-Knee Relationship:**  
The behavior of the foot directly influences knee stability.

- Articulated Ankles: Allow for rapid plantarflexion at heel strike, creating inherent stability at the knee.
- Firm Heels: Induce a rapid flexion moment at the knee, requiring massive user control to prevent buckling.

Component choice balances energy return with required baseline stability.



# The Sum of All Parts

**An effective transfemoral prosthesis is never just a collection of parts.**

- **The socket design must solve the adductor deficit.**
- **The suspension must secure the system against gravity.**
- **The foot's resistance must match the knee's stability requirements.**
- **Engineering and biology must act as a single, integrated biomechanical chain.**

