

# SUSPENSION OPTIONS AND ALIGNMENT

*WillowWood*



# AGENDA

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- Suspension options
- Considerations when choosing suspension
- Axillary componentry
- Alignment
  - Bench
  - TT static and dynamic
  - TF static and dynamic



# CONSIDERATIONS WHEN CHOOSING SUSPENSION

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# CONSIDERATIONS

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- Activities
- Mental acuity
- Hand strength/dexterity
- Clearance
- Limb
- Alignment



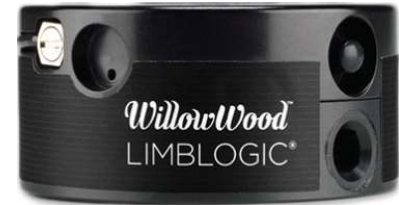
# SUSPENSION OPTIONS

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# SUSPENSION OPTIONS

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- Locks and lanyards
- Suction
- Elevated vacuum



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# LOCKING LINER OPTIONS

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- Pin
- Pull-in
  - Lanyard
  - KISS system



# PIN

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- Styles
- Advantages/disadvantages
- Considerations

# PIN TYPES

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- Shuttle or ratchet
  - Used with shuttle locks
- Clutch or geared
- Smooth



# ADVANTAGES

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- Simple
- Donning and doffing
- Feedback
- No knee sleeves
- Variety
- Volume management control

# DISADVANTAGES

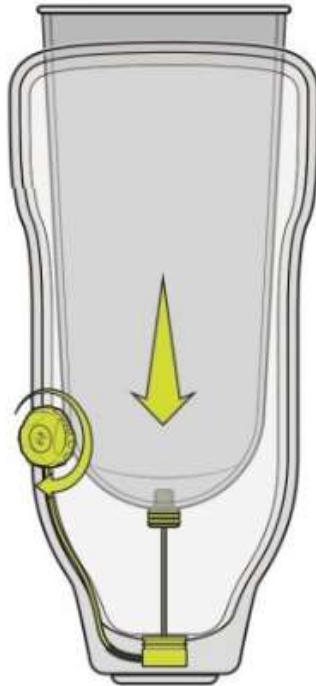
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- Pistoning
- Pin alignment
- Mechanical failures
- Noises
- Cost
- Build height
- Donning and doffing
- Fabrication
- Alignment
- Rotation control

# PULL-IN

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- Lanyards



- KISS



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# ADVANTAGES

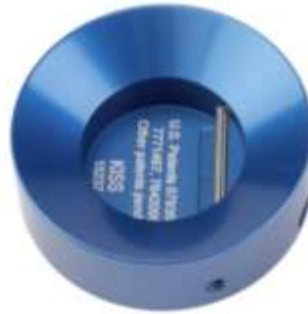
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- Donning
- Rotation control
- Build height
- Alignment flexibility
- Secure
- Minimizes pistoning
- Transfemoral applications

# DISADVANTAGES

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- Dexterity and strength
- Less cosmetic



# CUSHION LINER OPTIONS

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- Passive suction
- Active suction



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PASSIVE VACUUM

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# PASSIVE VACUUM OPTIONS

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- Seal-In liners
- Sleeves
- Expulsion valves



# ADVANTAGES

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- Simple
- Clearance
- Proprioception
- Reduced pistoning
- Limb health

# DISADVANTAGES

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- Sleeves
- Lubricants
- Volume fluctuations





ACTIVE VACUUM

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# TYPES

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- Electrical
- Mechanical



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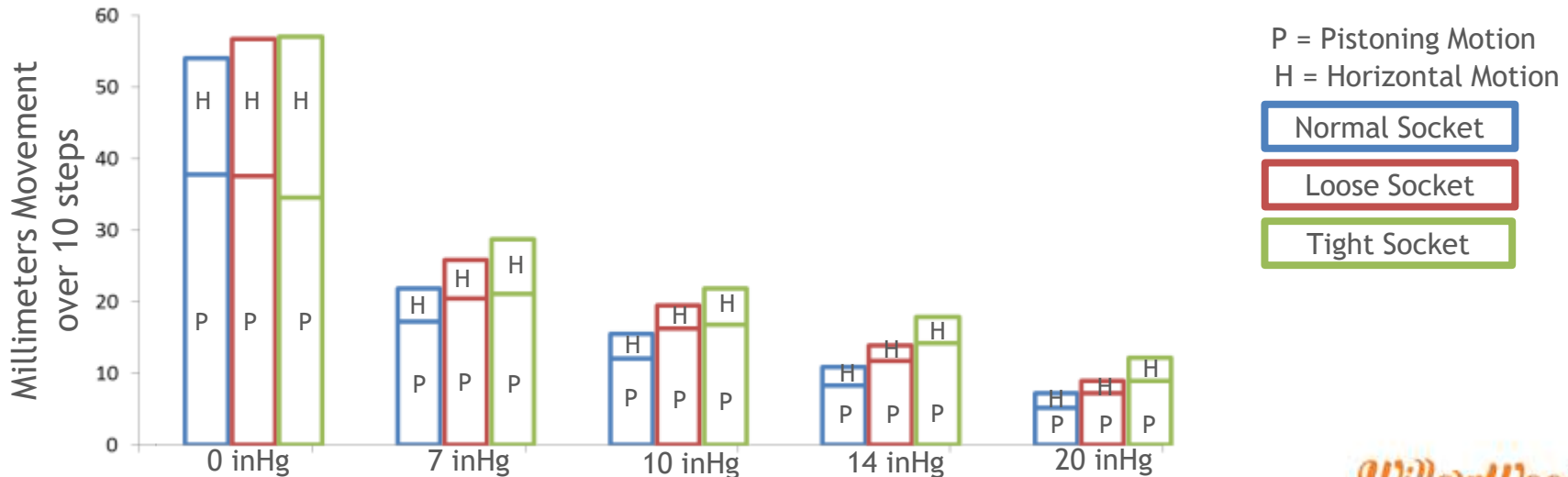
# ADVANTAGES

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- Suspension
  - Better control
    - Better gait
    - Lower energy consumption
- Limb health
- Volume control
- Reduced movement
  - Pistoning
  - Rotation

# GLOBAL FIT CHANGES: INDUCTIVE SENSOR RESULTS

- Socket fit significantly impacted the amount of total motion ( $p=5.3e^{-7}$ )
  - Near significant for pistoning motion ( $p=0.06$ )
  - Significant for horizontal motion ( $p=0.01$ )



# DISADVANTAGES

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- Weight
- Noise
- Clearance
- Volume fluctuations
- Expensive
- Reliability
- Must be recharged
- Sleeves/seals



# AXILIARY COMPONENTRY

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# ACCESSORIES

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- Plates



- Pyramids





# ALIGNMENT CONSIDERATIONS

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# ALIGNMENT GOALS

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- Even weight distribution
- Smooth gait
- Less energy usage
- Realistic appearance



# ALIGNMENT STEPS

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- Evaluation
  - Position of the residual limb
  - Static fitting
- Bench
- Static
- Dynamic

# EVALUATION

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- Mark the natural position of the limb
  - Anterior
  - Lateral
- Positioning of components

# BENCH ALIGNMENT

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- Neutral alignment: all the alignment set screws in neutral
  - Contractures
- Done before the first fitting onto the patient
  - Stable
  - Pylon is vertical
- Socket
  - 5 degrees of flexion
  - 5 degrees of adduction
- Refer to manufacturers' recommendations

# STATIC ALIGNMENT

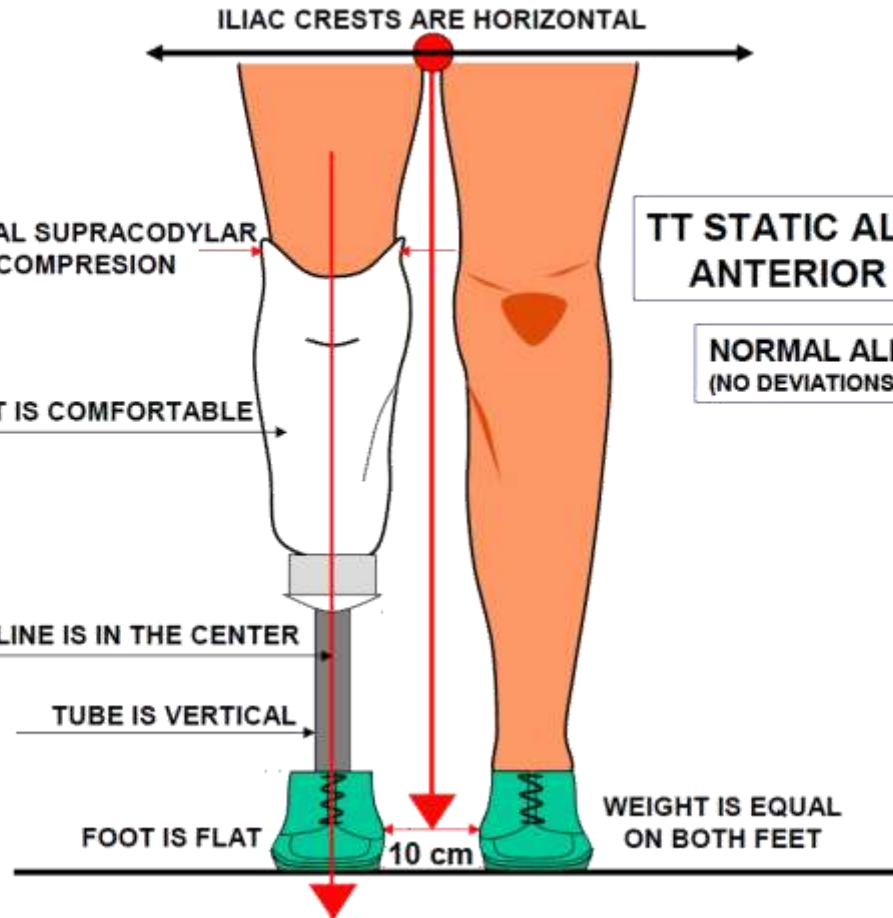
- Stand and balance
  - Ease of standing
- Height
- Comfort
  - High pressure areas
  - Trimlines





TT STATIC

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**NORMAL ALIGNMENT**  
(NO DEVIATIONS OBSERVED)

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## TT STATIC DEVIATION

### PROBLEMS!!!

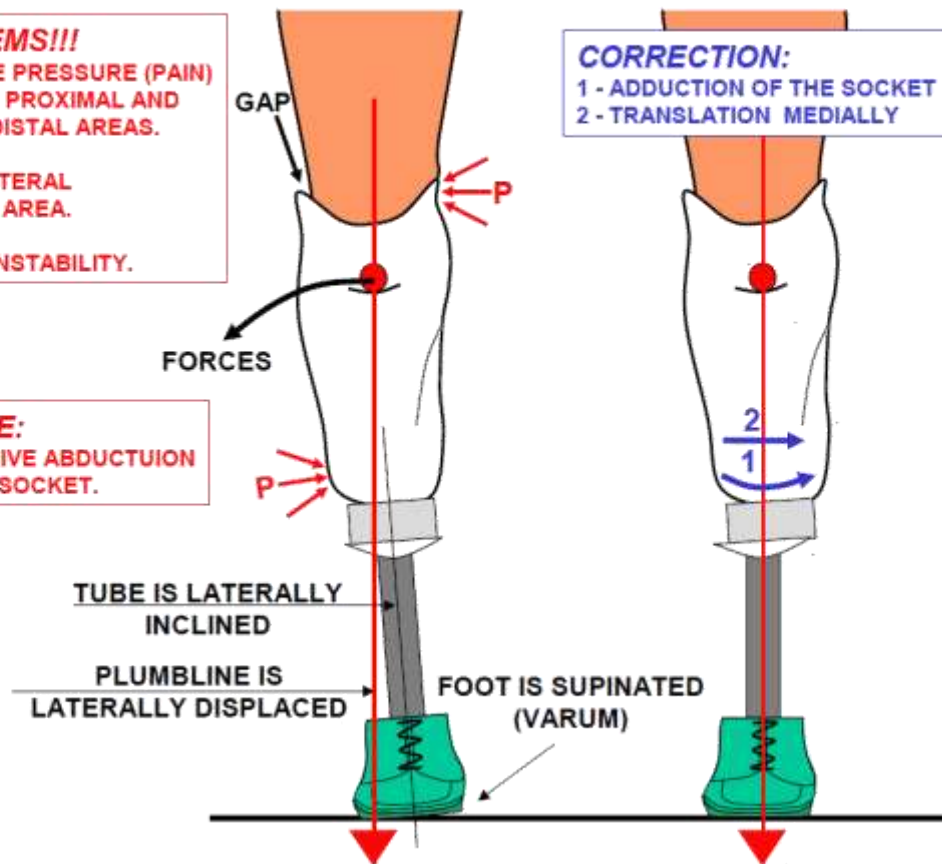
EXCESSIVE PRESSURE (PAIN)  
AT MEDIAL PROXIMAL AND  
LATERAL DISTAL AREAS.

GAP AT LATERAL  
PROXIMAL AREA.

LATERAL INSTABILITY.

### CAUSE:

EXCESSIVE ABDUCTION  
OF THE SOCKET.





## TT STATIC DEVIATION

### PROBLEMS!!!

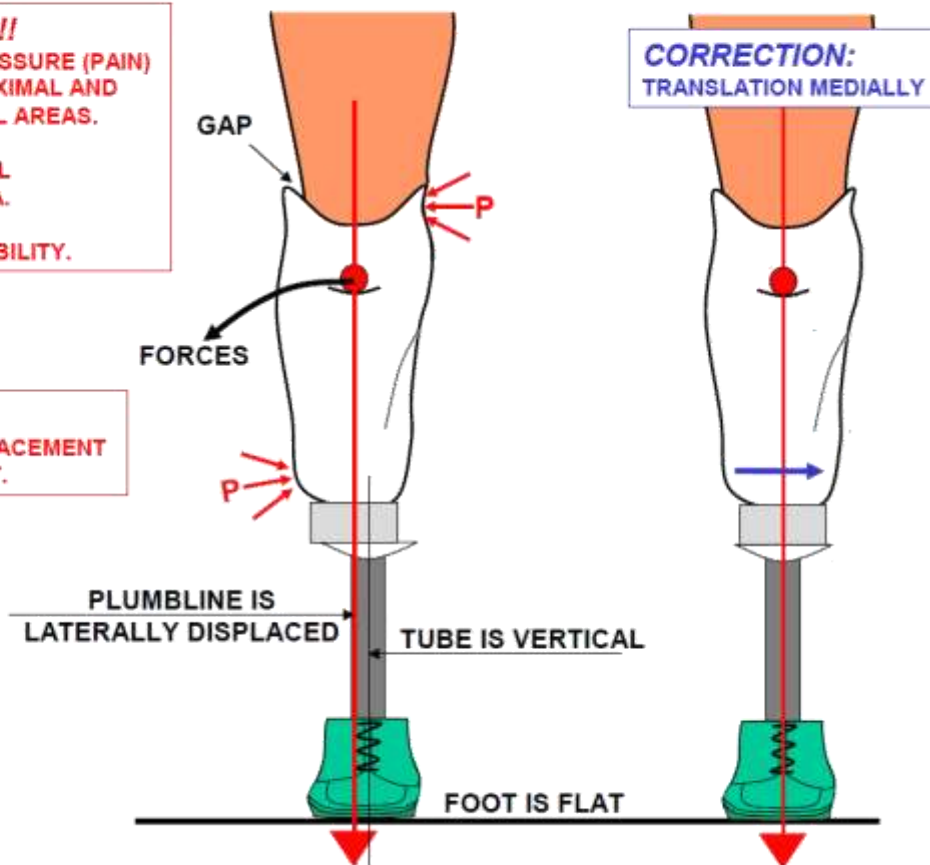
EXCESSIVE PRESSURE (PAIN)  
AT MEDIAL PROXIMAL AND  
LATERAL DISTAL AREAS.

GAP AT LATERAL  
PROXIMAL AREA.

LATERAL INSTABILITY.

### CAUSE:

LATERAL DISPLACEMENT  
OF THE SOCKET.





## TT STATIC DEVIATION

### PROBLEMS!!!

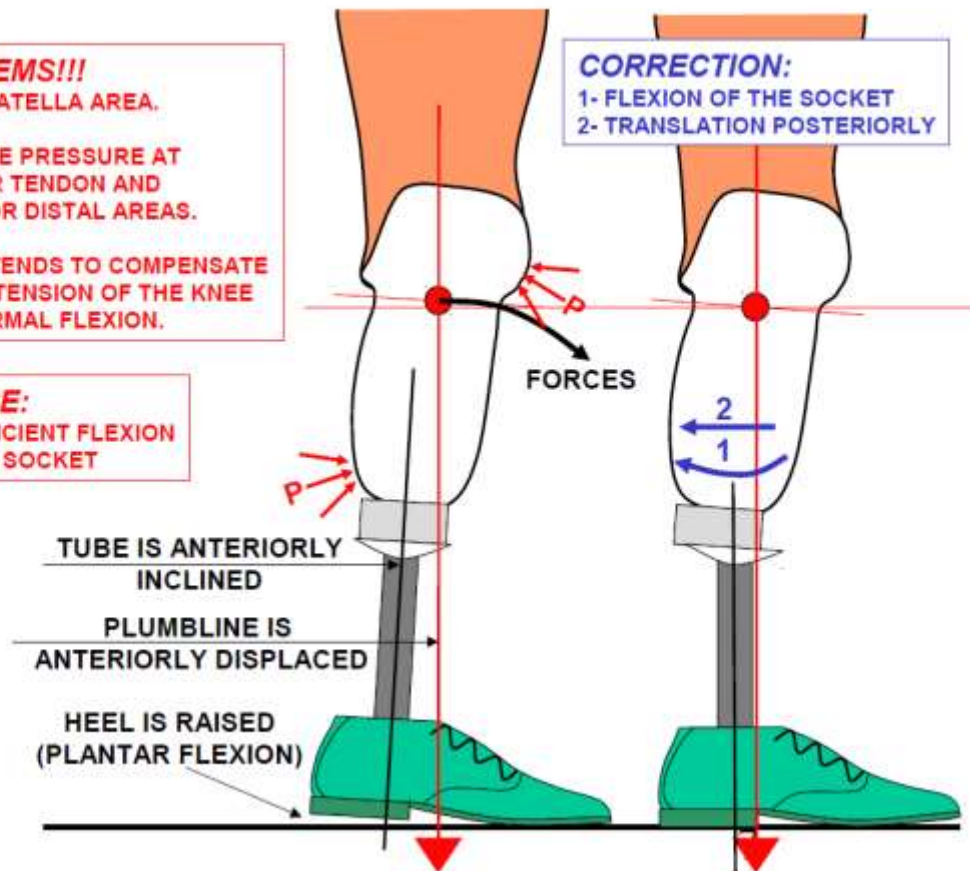
PAIN AT PATELLA AREA.

EXCESSIVE PRESSURE AT  
PATELLAR TENDON AND  
POSTERIOR DISTAL AREAS.

PATIENT TENDS TO COMPENSATE  
HYPEREXTENSION OF THE KNEE  
BY ABNORMAL FLEXION.

### CAUSE:

INSUFFICIENT FLEXION  
OF THE SOCKET





## TT STATIC DEVIATION

### PROBLEMS!!!

EXCESSIVE PRESSURE (PAIN)  
AT POSTERIOR PROXIMAL  
AND ANTERIOR DISTAL AREAS.

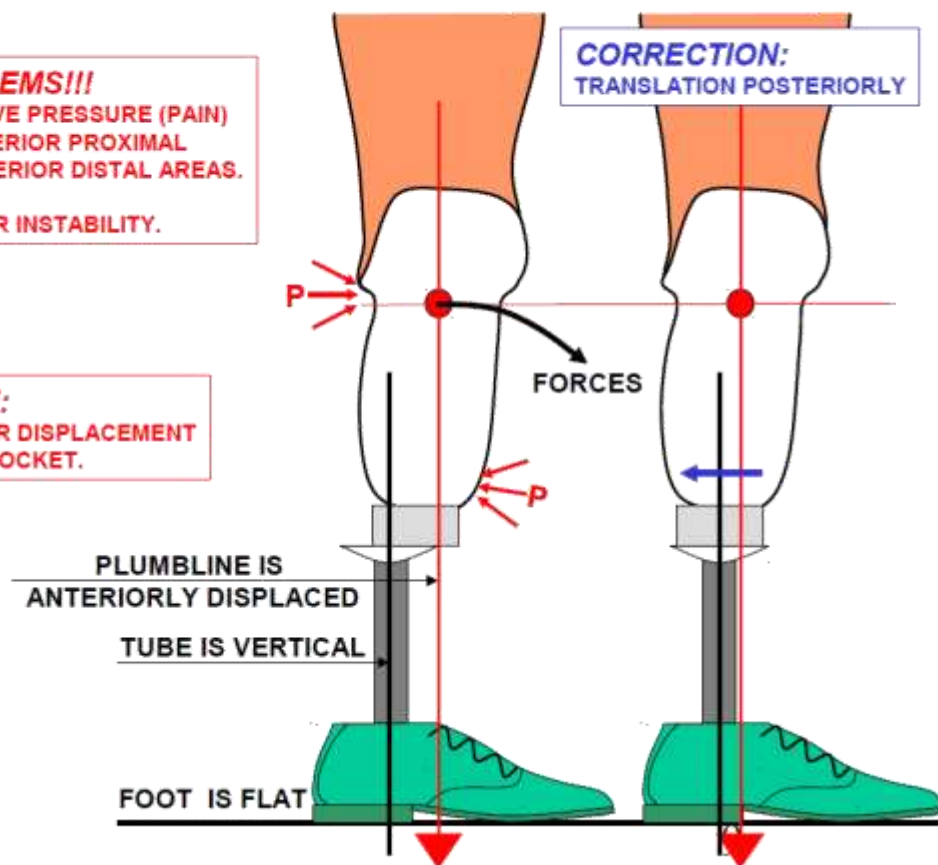
ANTERIOR INSTABILITY.

### CAUSE:

ANTERIOR DISPLACEMENT  
OF THE SOCKET.

### CORRECTION:

TRANSLATION POSTERIORLY



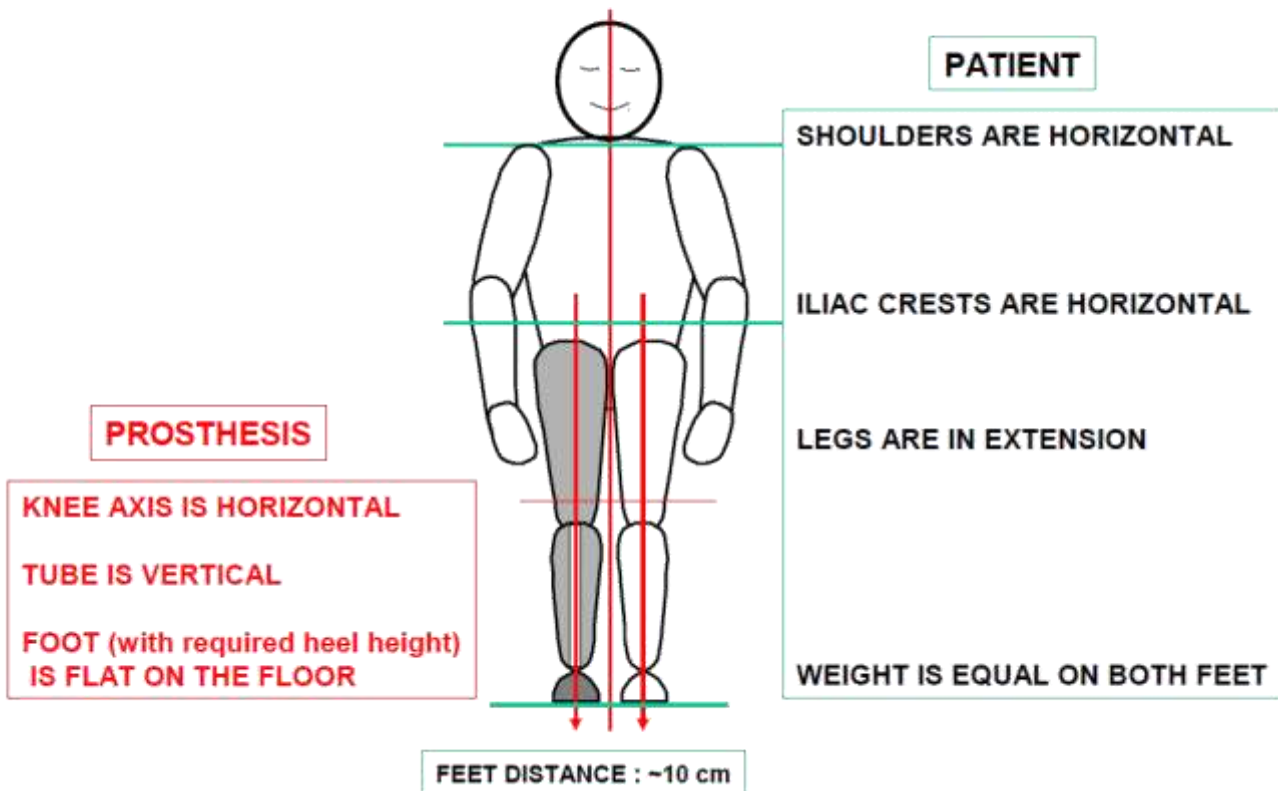


TF STATIC

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## TF STATIC ALIGNMENT: ANTERIOR VIEW





## TF STATIC ALIGNMENT: LATERAL VIEW

### PROSTHESIS

INITIAL FLEXION =  $\sim 5^\circ$

TKA (Trochanter-Knee-Ankle)  
LINE IS 10-15mm ANTERIOR  
FROM KNEE AXIS

TUBE IS VERTICAL

FOOT (with required heel height)  
IS FLAT ON THE FLOOR



### PATIENT

SHOULDERS ARE HORIZONTAL

ILIAC CRESTS ARE HORIZONTAL

LEGS ARE IN EXTENSION

WEIGHT IS EQUAL ON BOTH FEET



## TF STATIC DEVIATION

### PROBLEMS!!!

EXCESSIVE PRESSURE AT THE MEDIAL PROXIMAL AND LATERAL DISTAL AREAS.

GAP AT THE LATERAL PROXIMAL AREA.

LATERAL INSTABILITY.

### CAUSE:

EXCESSIVE ABDUCTION OF THE SOCKET

AXIS IS INCLINED!

PLUMBLINE IS  
LATERALLY DISPLACED!

TUBE IS LATERALLY  
INCLINED!

SOLE IS SUPINATED!

### CORRECTION:

- 1- ADDUCTION OF THE SOCKET
- 2- TRANSLATION Laterally



## TF STATIC DEVIATION

**ISCHIAL SEAT IS  
POSTERIORLY INCLINED!**

**WARNING!!!  
INSUFFICIENT INITIAL  
FLEXION OF THE SOCKET  
(LESS THAN 5°)**

**CORRECTION:**  
1- FLEXION OF THE SOCKET  
2- TRANSLATION ANTERIORLY

Due to this deviation patient flexes his hip  
in order to be able to activate extensor  
muscles. But nevertheless, all phases of  
the gate including stance phase are  
**VERY INSECURE**

- prosthetic knee is always flexed and  
TKA line falls posterior from the knee axis!

**KNEE IS FLEXED !**

**TKA LINE IS POSTERIORLY  
DISPLACED (INSECURE KNEE !)**

**TUBE IS VERTICAL**

**HEEL IS FLAT**

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# DYMANIC ALIGNMENT

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- Evaluation of the user gait
  - Knee is extended at heel strike
  - Knee is flexed between heel strike and foot flat
  - Knee is extended after mid-stance
- Socket comfort
  - Trim lines
  - High pressure areas

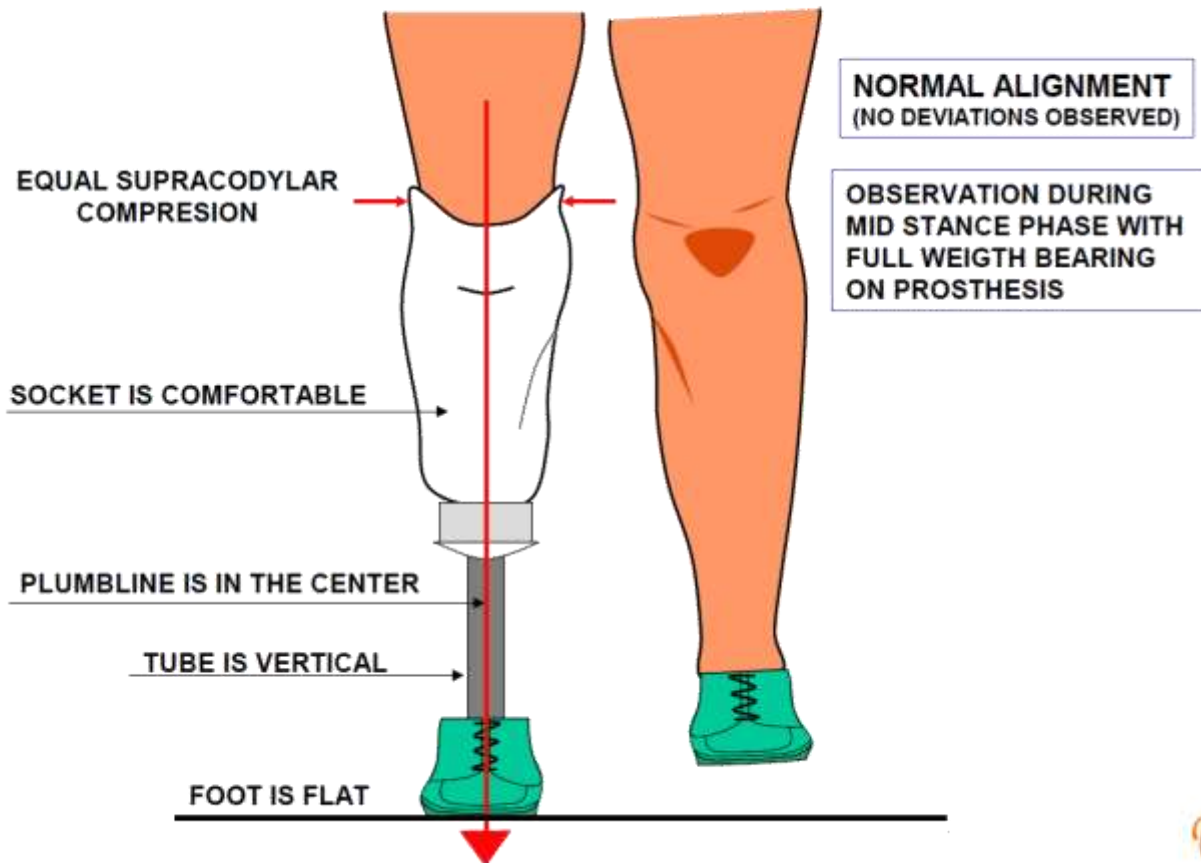


TT DYNAMIC

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## TT DYNAMIC ALIGNMENT: ANTERIOR VIEW





## TT DYNAMIC ALIGNMENT: ANTERIOR VIEW

### PROBLEMS!!!

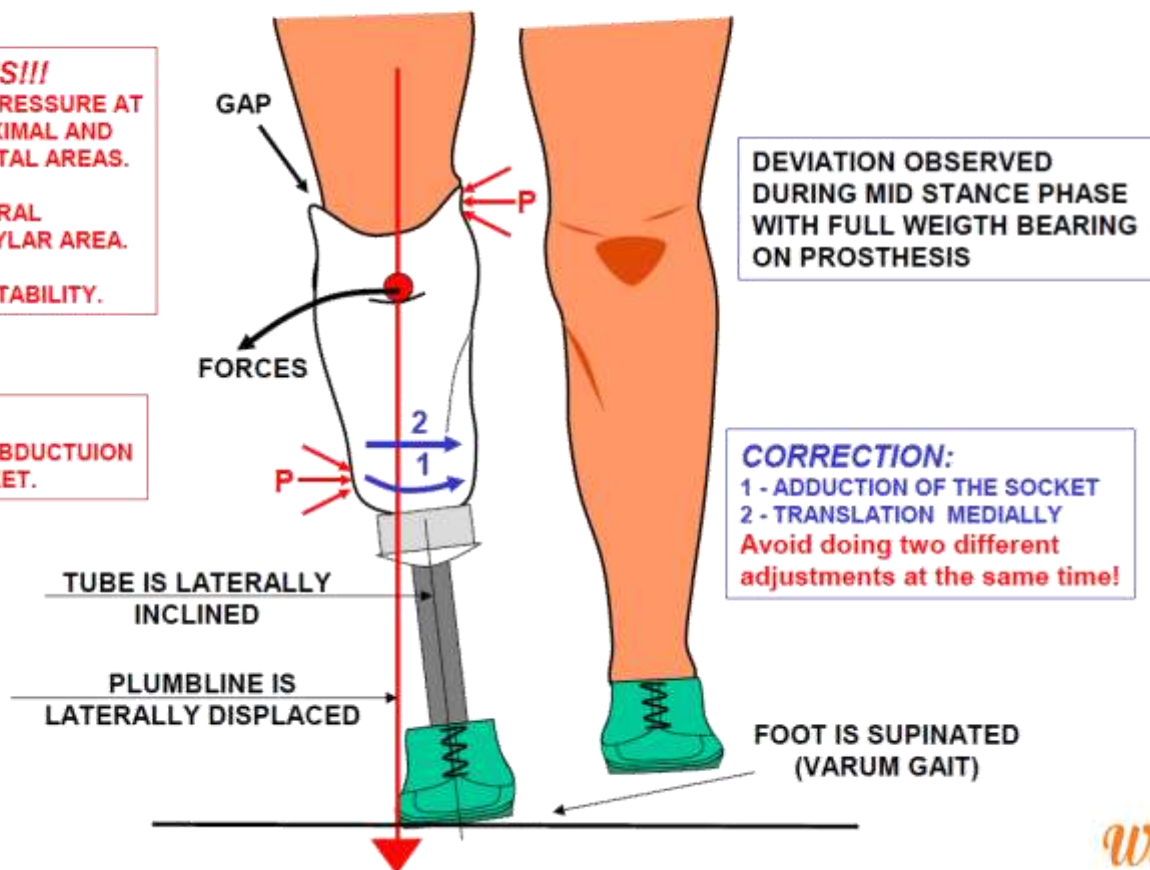
EXCESSIVE PRESSURE AT  
MEDIAL PROXIMAL AND  
LATERAL DISTAL AREAS.

GAP AT LATERAL  
SUPRACONDYLAR AREA.

LATERAL INSTABILITY.

### CAUSE:

EXCESSIVE ABDUCTION  
OF THE SOCKET.





## TT DYNAMIC ALIGNMENT: LATERAL VIEW

### PROBLEMS!!!

RAPID AND PREMATURE KNEE FLEXION.

PREMATURE FOREFOOT CONTACT (SLAP FOOT).

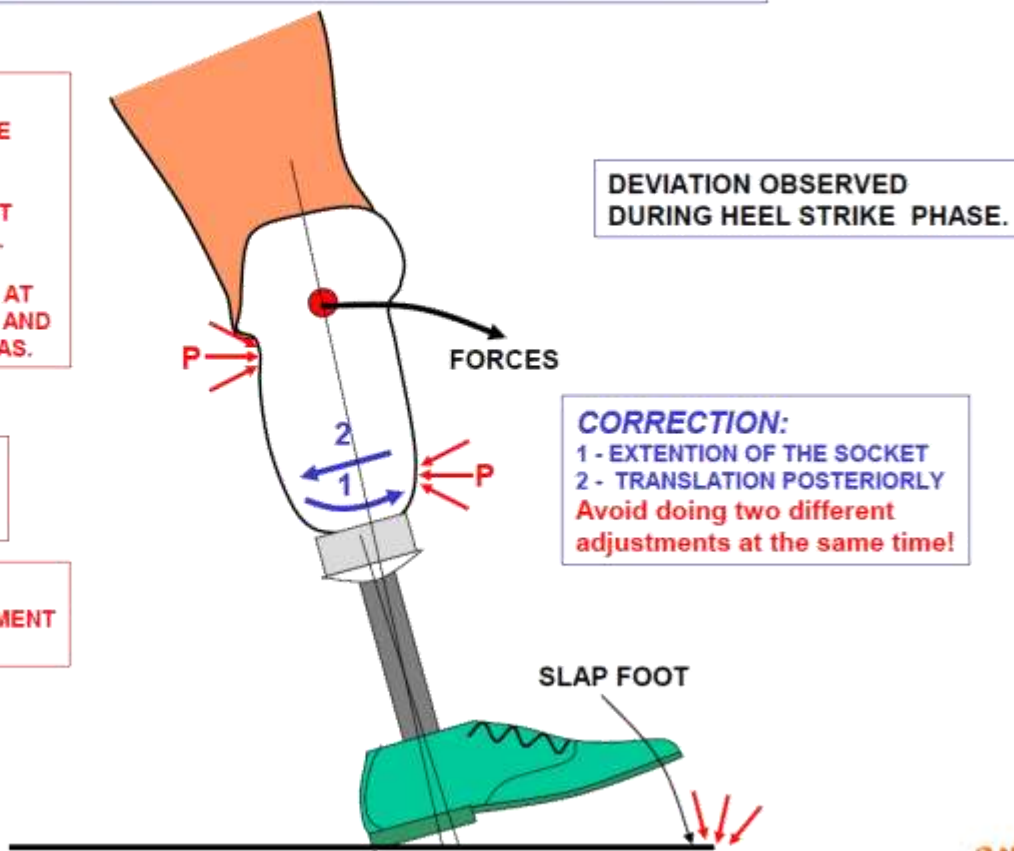
EXCESSIVE PRESSURE AT POSTERIOR PROXIMAL AND ANTERIOR DISTAL AREAS.

### CAUSE 1:

EXCESSIVE FLEXION OF THE SOCKET.

### CAUSE 2:

ANTERIOR DISPLACEMENT OF THE SOCKET .





## TT DYNAMIC ALIGNMENT: LATERAL VIEW

**PROBLEMS!!!**  
HYPEREXTENSION OF KNEE.

PAIN AT PATELLA AREA.

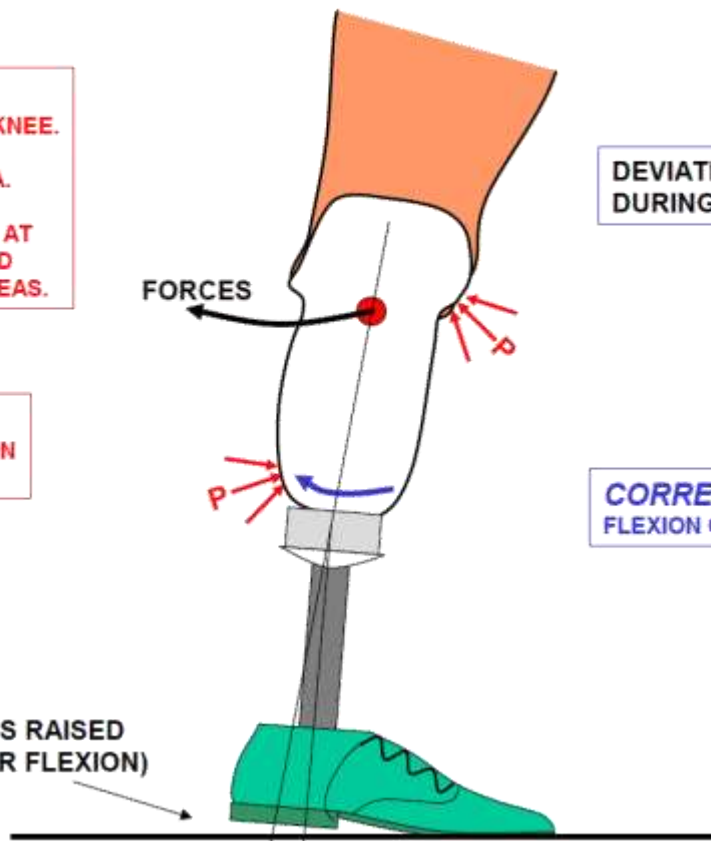
EXCESSIVE PRESSURE AT  
PATELLAR TENDON AND  
POSTERIOR DISTAL AREAS.

**CAUSE :**  
INSUFFICIENT FLEXION  
OF THE SOCKET.

DEVIATION OBSERVED  
DURING MID STANCE PHASE.

**CORRECTION :**  
FLEXION OF THE SOCKET

HEEL IS RAISED  
(PLANTAR FLEXION)





TF DYNAMIC

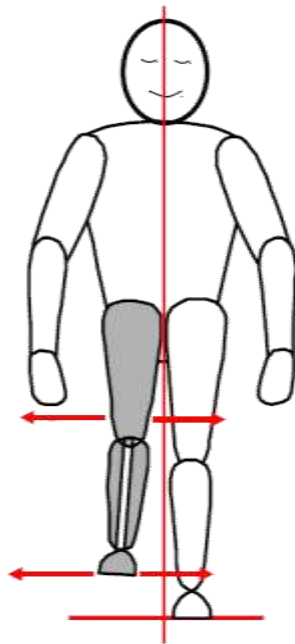
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## SWING PHASE: OSCILLATION OF THE SHIN

### PROSTHESIS

- INCORRECT INITIAL KNEE ROTATION
- INCORRECT SOCKET FITTING
- INCORRECT SOCKET ALIGNMENT
- INSUFFICIENT SUSPENSION OR INCORRECT LOCATION OF THE SILESIA BELT



### PATIENT

- WEAK AND FLASKY STUMP



MID SWING PHASE

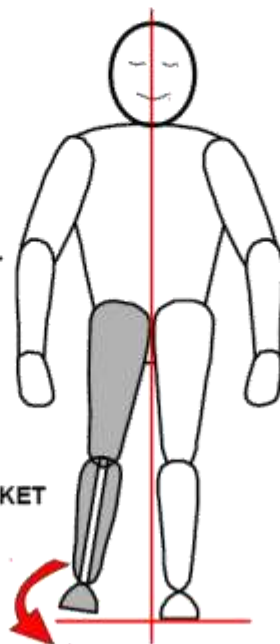
VISIBLE INTERNAL OR EXTERNAL ROTATION OF KNEE



## SWING PHASE: CIRCUMDUCTION

### PROSTHESIS

- PROSTHESIS IS TOO LONG
- EXCESSIVE PLANTAR FLEXION
- INSUFFICIENT SUSPENSION (PISTONING)
- INCORRECT SOCKET FITTING
- EXCESSIVE SUSPENSION OR INCORRECT LOCATION OF THE SILESIA BELT
- INSUFFICIENT ABDUCTION OF THE SOCKET
- MEDIAL SHELF IS TOO HIGH
- ANTERIOR DISPLACEMENT OF THE SOCKET
- EXCESSIVE FRICTION IN KNEE AXIS
- EXCESSIVE STRENGTH OF THE EXTENSION AID



PROSTHESIS CURVES Laterally

### PATIENT

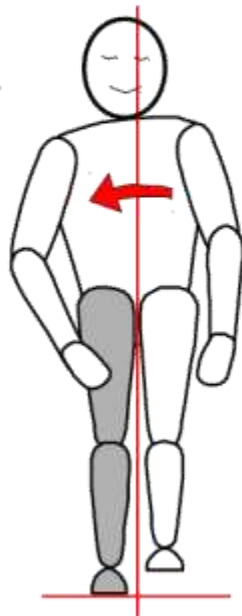
- ABDUCTORS CONTRACTURE
- INSUFFICIENT HIP FLEXION
- WEAK QUADRICEPS MUSCLES
- FEAR OF TOUCHING GROUND
- PAIN IN PERINEAL AREA
- BAD GAIT HABIT



## SWING PHASE: LATERAL TRUNK BENDING

### PROSTHESIS

- PROSTHESIS IS TOO SHORT
- EXCESSIVE ABDUCTION OF THE SOCKET
- INSUFFICIENT LATERAL FEMORAL SUPPORT
- MEDIAL SHELF IS TOO HIGH



### PATIENT

- WEAK ABDUCTOR MUSCLES (TRENDELENBURG SINDROM) OR ABDUCTORS CONTRACTURE
- SHORT STUMP
- HYPER SENSITIVE STUMP
- INSUFFICIENT BALANCE
- BAD GAIT HABIT

LATERAL INCLINATION OF THE TRUNK  
TO THE PROSTHETIC SIDE



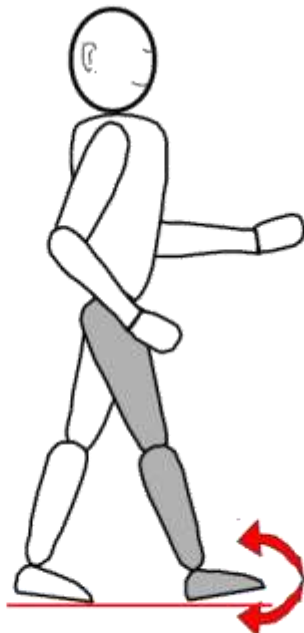
## HEEL CONTACT: OSCILATION OF THE FOOT

### PROSTHESIS

- HARD HEEL CUSHION
- EXCESSIVE EXTERNAL FOOT ROTATION
- INCORRECT SOCKET ALIGNMENT

### PATIENT

- SHORT STUMP
- WEAK AND FLASKY STUMP
- EXCESSIVE HEEL STRIKE



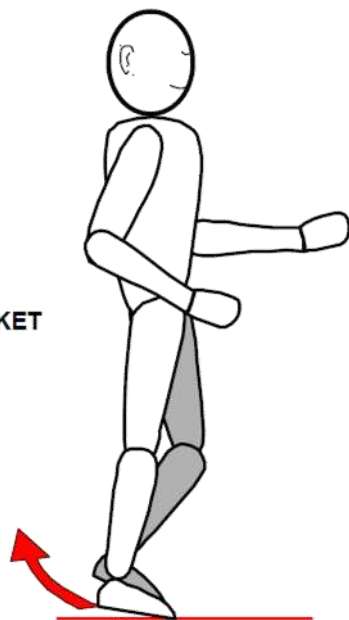
VISIBLE OSCILATION OF THE FOREFOOT



## MID SWING PHASE: VAULTING

### PROSTHESIS

- PROSTHESIS IS TOO LONG
- EXCESSIVE PLANTAR FLEXION
- INSUFFICIENT SUSPENSION (PISTONING)
- INCORRECT SOCKET FITTING
- MEDIAL SHELF IS TOO HIGH
- ANTERIOR DISPLACEMENT OF THE SOCKET
- EXCESSIVE FRICTION IN KNEE AXIS
- EXCESSIVE STRENGTH OF THE EXTENSION AID



### PATIENT

- FEAR OF TOUCHING GROUND
- VERY SENSITIVE OR PAINFUL STUMP
- BAD GAIT HABIT

RAISE OF THE BODY BY EARLY EXCESSIVE PLANTAR FLEXION ON SOUND SIDE

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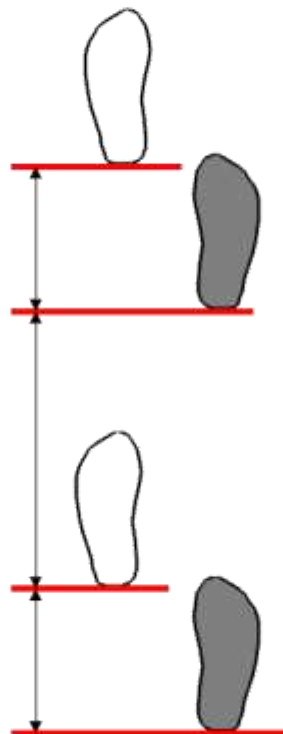
## TRANSVERSAL VIEW: UNEVEN STEP LENGTH

### PROSTHESIS

- INSUFFICIENT FLEXION OF THE SOCKET
- EXCESSIVE PLANTAR FLEXION
- INSUFFICIENT FLEXION OF THE KNEE
- EXCESSIVE STRENGTH OF THE EXTENSION AID

### PATIENT

- SHORT, WEAK OR PAINFUL STUMP
- HIP EXTENSORS CONTRACTURE
- LIMITED HIP FLEXION - EXTENSION
- INSUFFICIENT STABILITY
- PROBLEMS WITH SOUND LEG



SHORT STUMP ON SOUND SIDE

# ACKNOWLEDGMENT FOR ALIGNMENT GRAPHICS

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"Lower Limb Prosthetic Introduction." Physiopedia,.  
29 Jan 2020, 21:10 UTC. 30 Mar 2020, 20:35  
<[https://www.physiopedia.com/index.php?title=Lower\\_Limb\\_Prosthetic\\_Introduction&oldid=229247](https://www.physiopedia.com/index.php?title=Lower_Limb_Prosthetic_Introduction&oldid=229247)>.

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