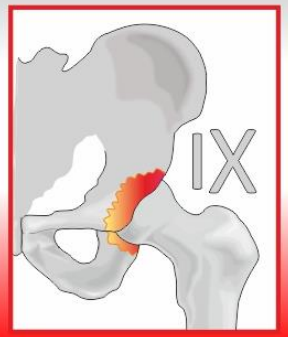

Międzynarodowe Sympozjum

HIP OSTEOARTHRITIS

20 kwietnia 2018, KATOWICE




Biomechanical aspects of leg length inequality in patients with hip arthroplasty.

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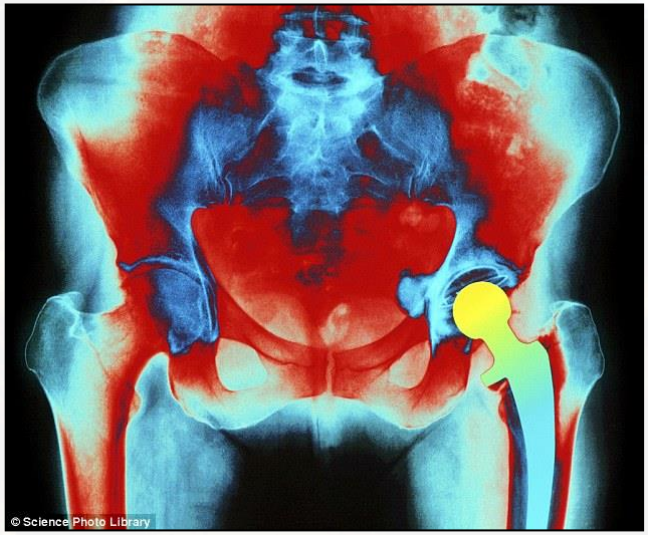
Leg Length Discrepancy

Biomechanics



http://i.dailymail.co.uk/i/pix/2016/08/15/19/31967C1000000578-3741868-image-a-1_1471285262955.jpg

Definition

Anatomical (structural)

- resulting from inequalities in bony structure
  - acetabular side
  - femoral side

Apparent (functional)

- unilateral asymmetry w/o shortening of the osseous components
  - spinal origin (fixed deformity with pelvic obliquity)
  - tightness of the soft tissues about the hip
  - other LLD in the bone segments or joints under the hip

- flexion and adduction contractures - **apparent shortening**
- abduction contractures - **apparent lengthening**

Frequency

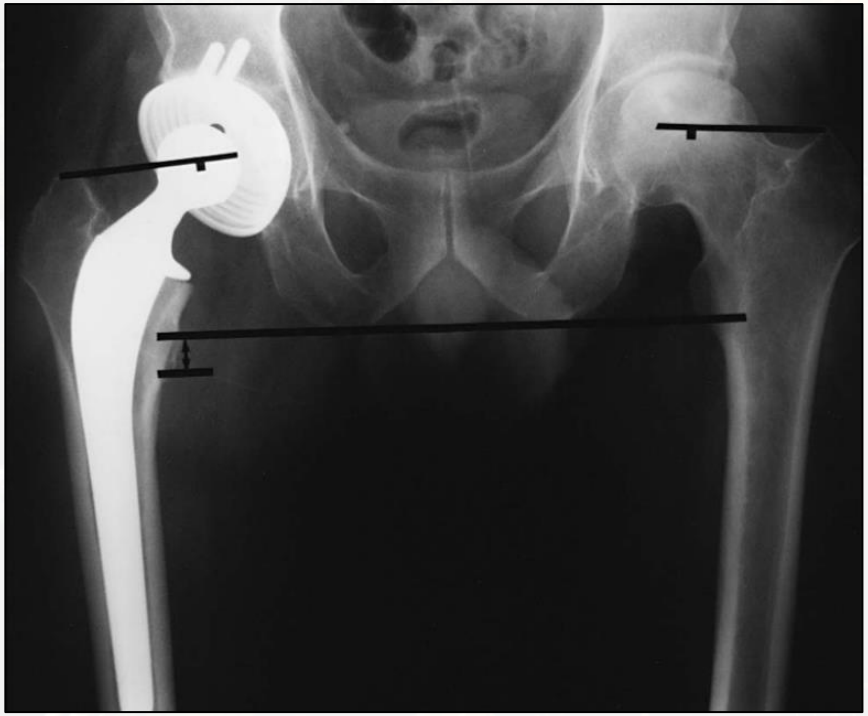
- About 1 in every 3 patients reports a sensation of LLD after THA

- 30% of patients after THR report a perceived limb-length discrepancy
    - 36% of these – radiographically confirmed discrepancy
    - remaining 64% - functional LLD

Causes

Lengthening may result from:

- **insufficient resection** of bone from the femoral neck
- use of a prosthesis with a **neck that is too long**
- **inferior displacement** of the center of rotation of the acetabulum



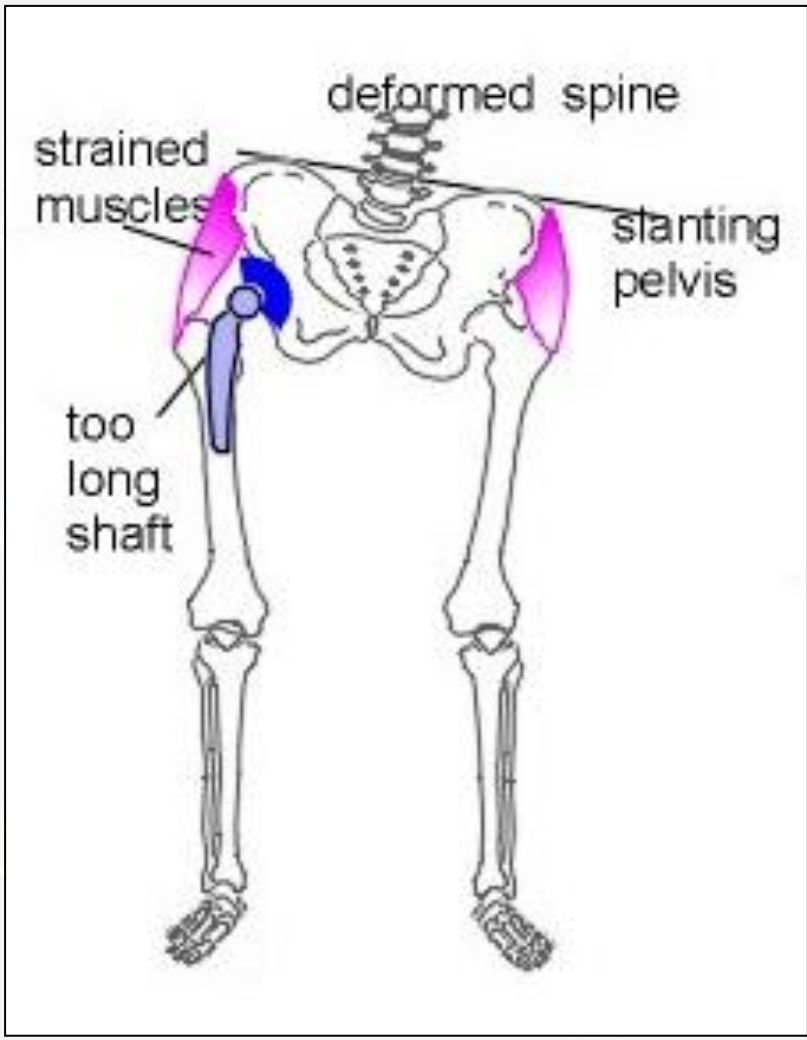
- femoral head – tip of trochanter
- oversized acetabular component – hip center more inferior and overlengthened limb 1 cm

Clinical significance

Not yet well defined - some studies reported minimal functional consequences up to 2 cm

- **> 0.5 - 1 cm**
  - usually well tolerated; may go unnoticed
  - decreased patient satisfaction (technically satisfactory operation)

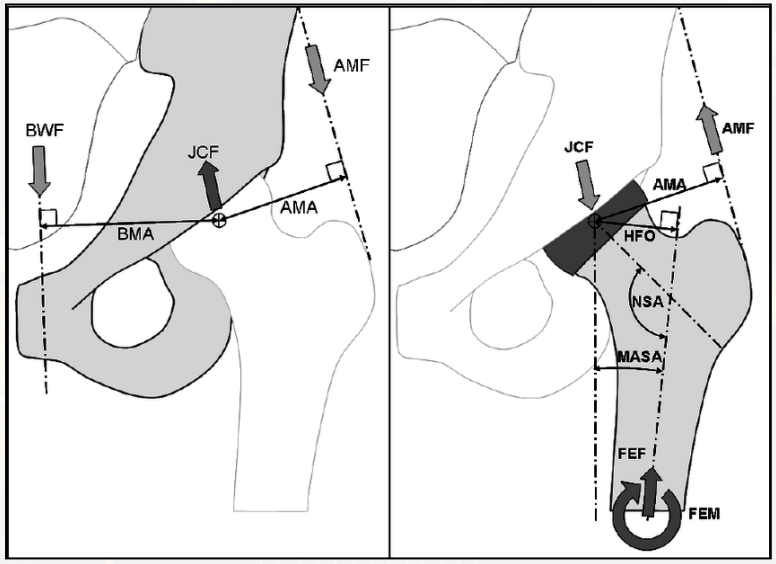
- **> 2.5 cm (symptomatic LLD)**
  - sciatic palsy (> 2.5–4 cm - risk of sciatic nerve injury)
  - limping
  - compensatory pelvic obliquity
  - low back pain
  - increased energy consumption during gait



https://i0.wp.com/www.orthopaedicclinic.com.sg/wp-content/uploads/2012/03/leg-length-discrepancy-back-pain.jpg

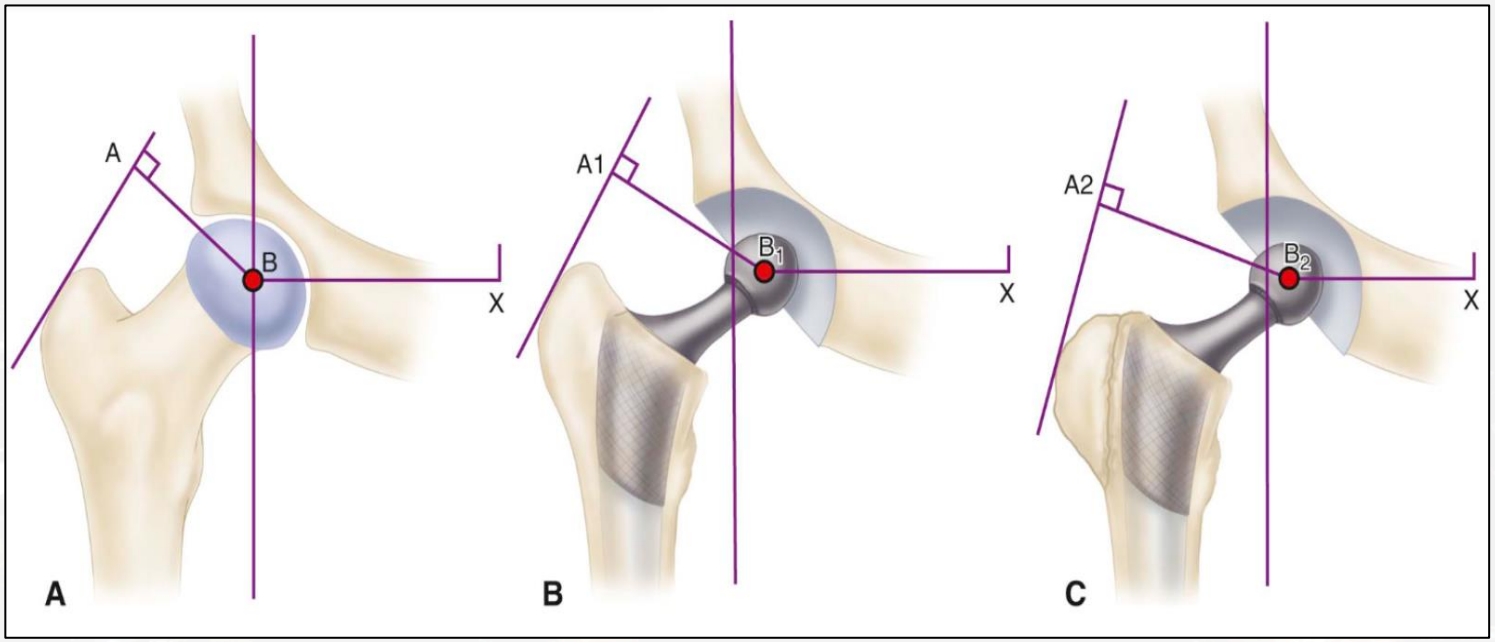
Leg Length Discrepancy

Biomechanics



https://www.researchgate.net/profile/Alex_Dickinson/publication/43245712/figure/fig1/AS:276862103244800@1443020477486/Biomechanical-Measurements-and-Forces-on-Hip.png

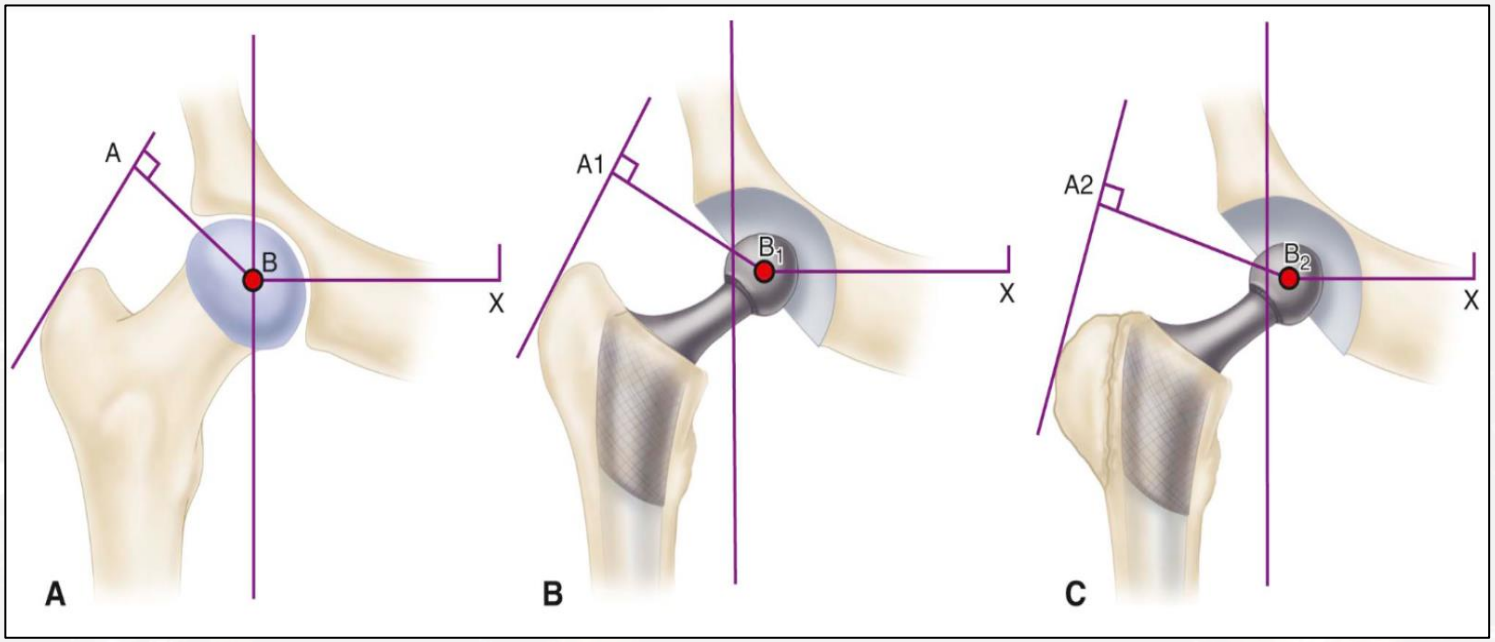
Forces acting on the hip joint



- body weight - load applied to a lever arm B-X
- lever arm B-X – counterbalanced by moment produced by abductors (A)
- abductors (A) – acting on shorter lever arm A-B
- lever arm A-B may be shorter than normal in arthritic joint

- medialization of acetabulum shortens lever arm B-X
- use of high offset neck lengthens lever arm A-B
- lateral and distal reattachment of osteotomized greater trochanter lengthens lever arm A-B further and tightens abductor musculature

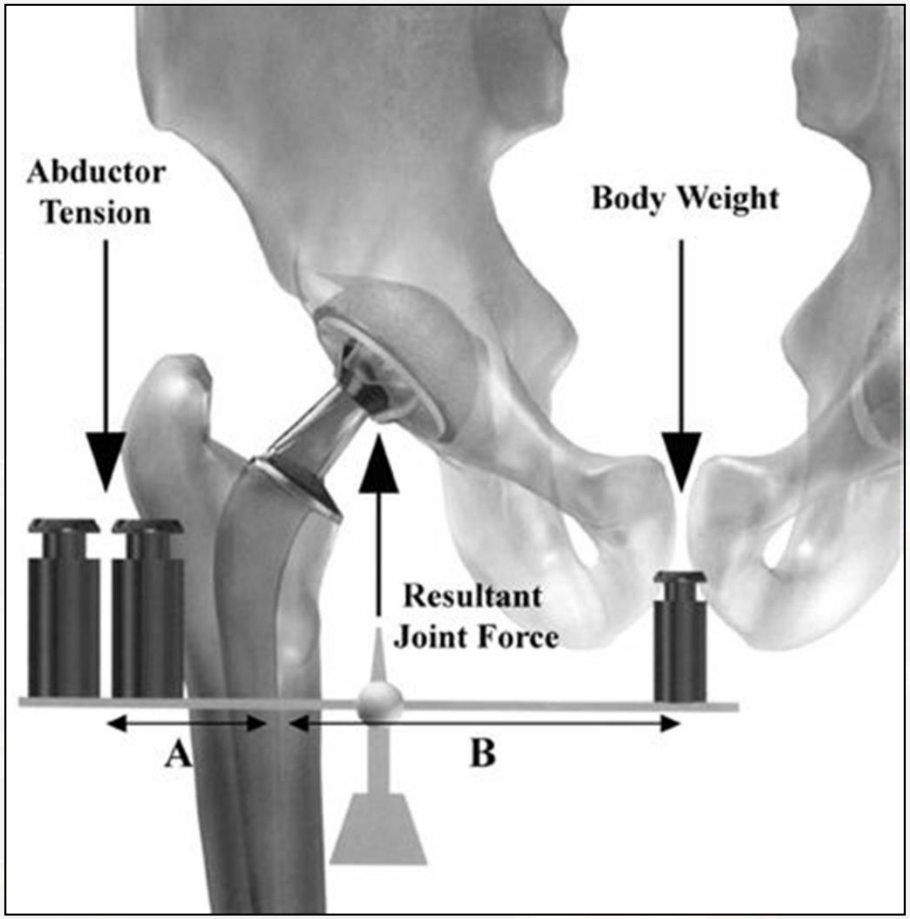
Forces acting on the hip joint



Concept of total hip arthroplasty:

- shorten lever arm B-X (by deepening the acetabulum)
  - preserving subchondral bone
  - deepening acetabulum only as much as necessary
- lengthen lever arm A-B
  - offset of the head to the stem

Forces acting on the hip joint



B:A = 2.5:1

Force of the abductors:

- **2.5 times the body weight** (to maintain the pelvis level, standing on one leg)

Load on the femoral head:

- **three times the body weight** (forces created by the abductors + the body weight)

Forces around the hip joint:

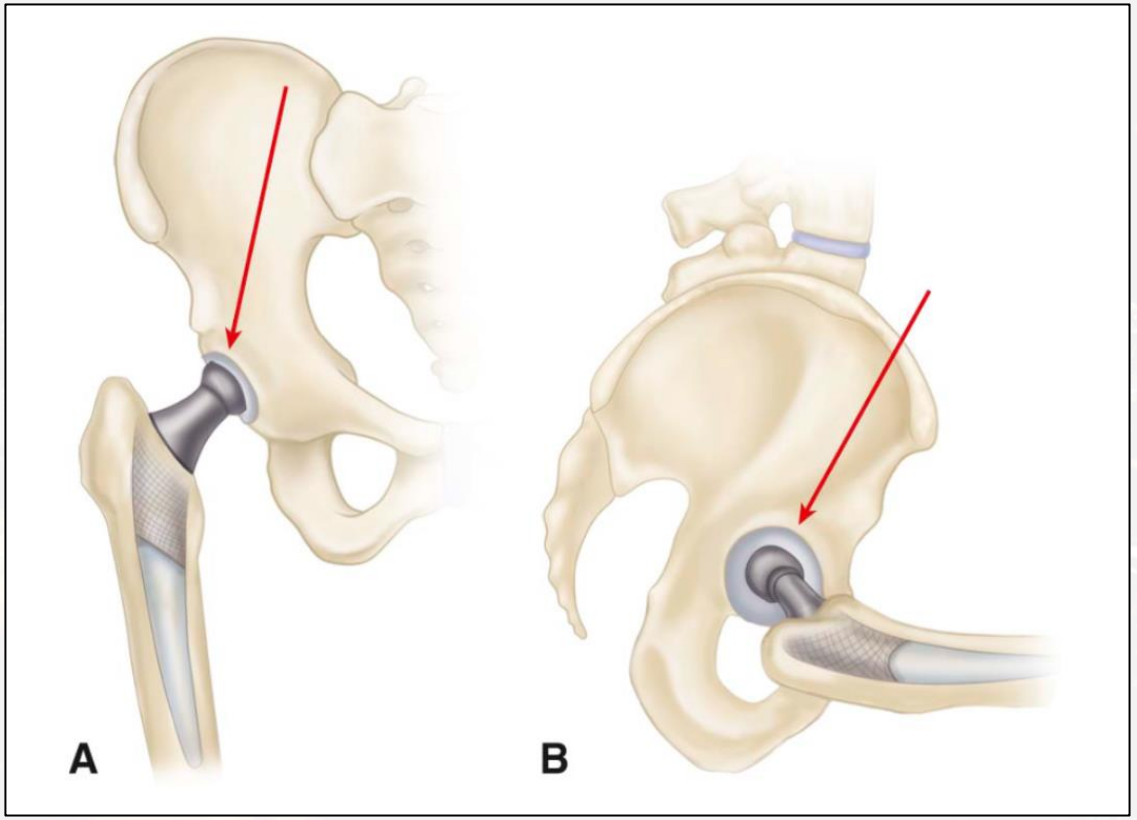
- **2.6 to 3.0 times the body weight** (single-limb stance phase of gait)
- **10 times the body weight** (lifting, running, jumping)

Excess body weight, increased physical activity add significantly to the forces that act to loosen, bend or break the stem of a femoral component.

https://upload.orthobullets.com/topic/9064/images/hip-mechanics.jpg

Forces producing torsion of stem

- in coronal plane – tend to deflect stem medially
- in sagittal plane – tend to deflect stem posteriorly



During the gait cycle, forces are directed against the prosthetic femoral head 15 and 25 degrees anterior to the sagittal plane of the prosthesis.

During stair climbing and straight-leg raising, the force is applied at a point even farther anterior on the head.

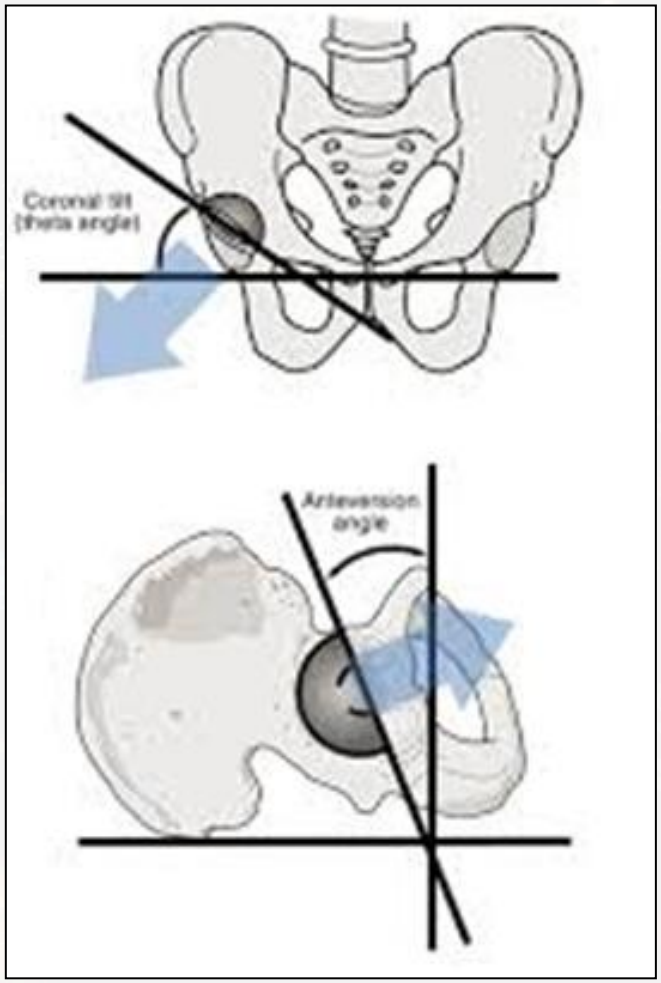
Acetabular component

Important in restoring **leg length**, as well as optimizing the hip **center of rotation** and minimizing **impingement** of the components.

- cup position
- cup **anteversion – 5 to 25°**
- cup tilt (abduction angle; **inclination**) **– 40±10°**

- radiographic landmark:
  - **teardrop** reference point

- intraoperative landmarks:
  - superior, anterior, posterior **rims of the acetabulum**
  - sciatic notch
  - **transverse acetabular ligament**
    - reamer parallel to the TAL – native anteversion
    - component optimally sitting just underneath the TAL - height and depth



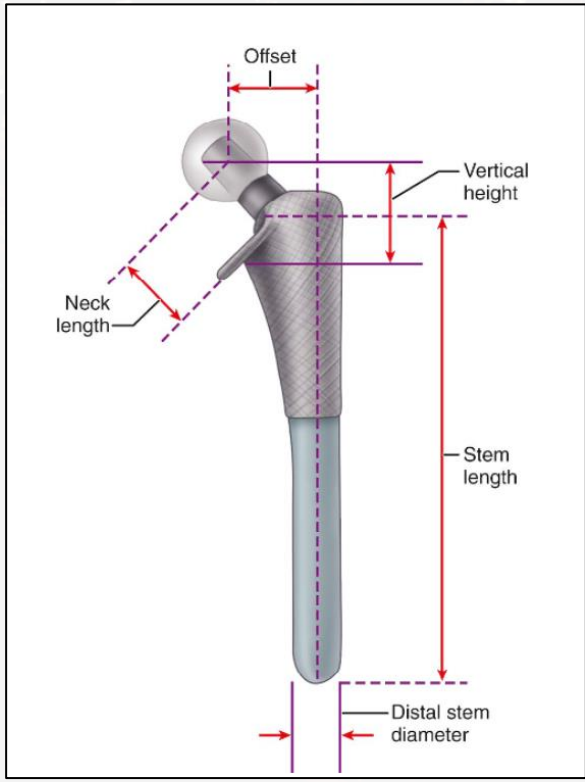
Isolated superior hip center displacement /without lateralization/ - relatively small increases in stresses in the periacetabular bone:

- clinical importance when superior bone stock is deficient

Femoral Components

Goal of a biomechanically stable hip joint

- careful attention to restoration of the normal **center of rotation** of the femoral head (three factors):
  - (1) **vertical height** (vertical offset)
  - (2) **medial offset** (horizontal offset or, simply, offset)
  - (3) **version of the femoral neck** (anterior offset)



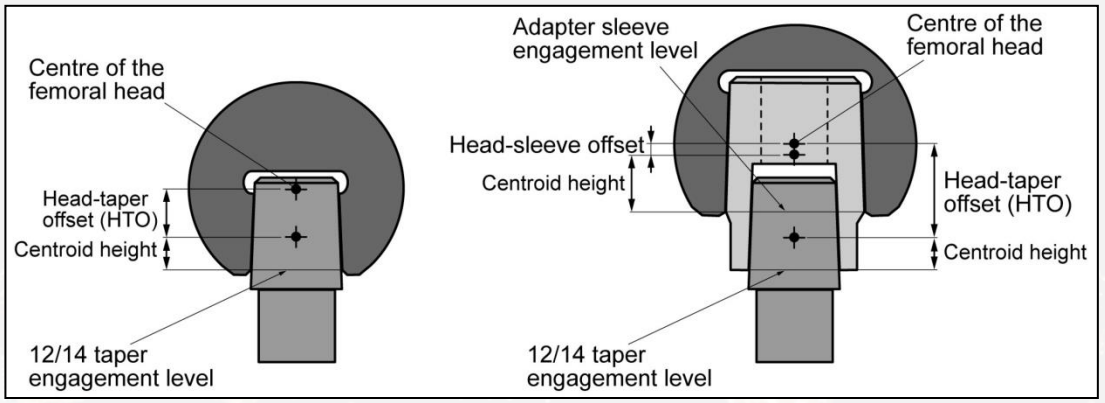
Vertical height (1) and offset (2) increase as the neck is lengthened.

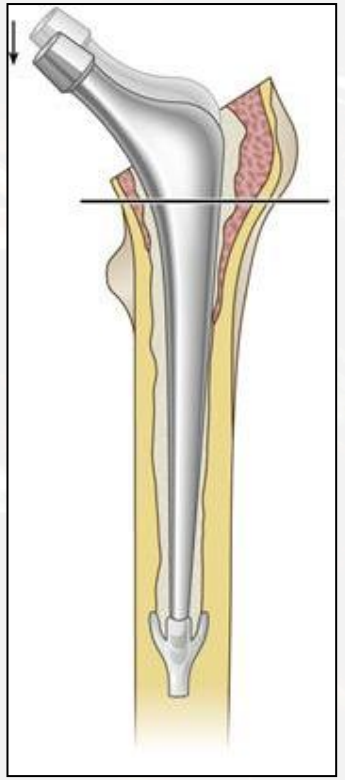
(1) vertical height (vertical offset)

- Determined primarily by:
    - the base **length** of the prosthetic **neck**

    plus

    - the length gained by the **modular head** used





The depth the implant is inserted into the femoral canal alters vertical height:

- when cement is used
    - vertical height – variation in the level of the femoral neck osteotomy
- when a cementless femoral component is used
    - determined more by the fit within the femoral metaphysis than by the level of the neck osteotomy

http://www.mdpi.com/1996-1944/10/7/733/htm
https://musculoskeletalkey.com/cemented-femoral-components/

(2) medial offset (horizontal offset)

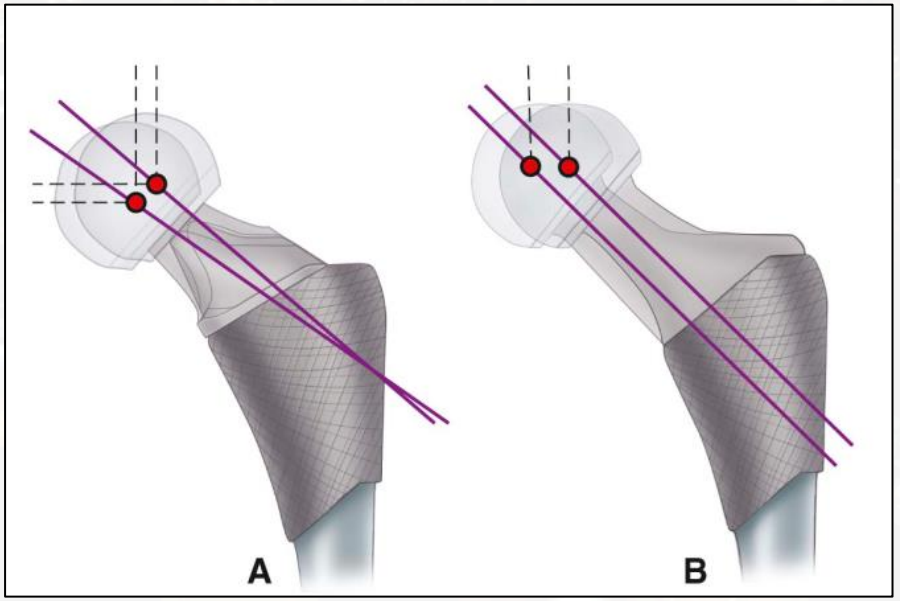
Distance from the center of the femoral head to a line through the axis of the distal part of the stem.

Many components are manufactured with **standard** and **high offset** versions – offset is increased without limb lengthening:

- reduced the neck-stem angle (typically ~127 degrees)

or

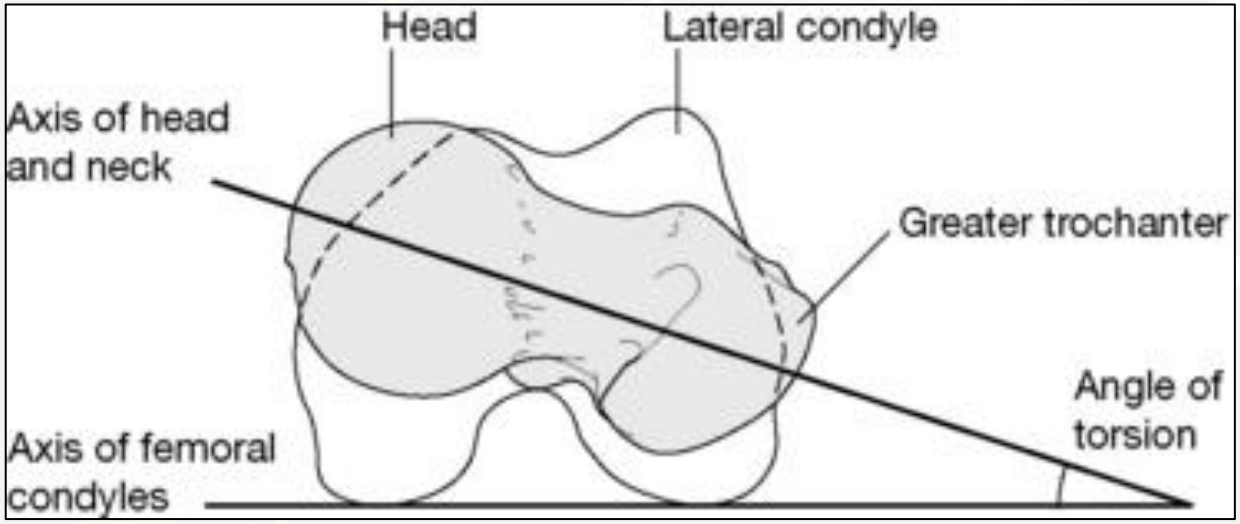
- attached the neck to the stem in a more medial position



(3) version of the femoral neck (anterior offset)

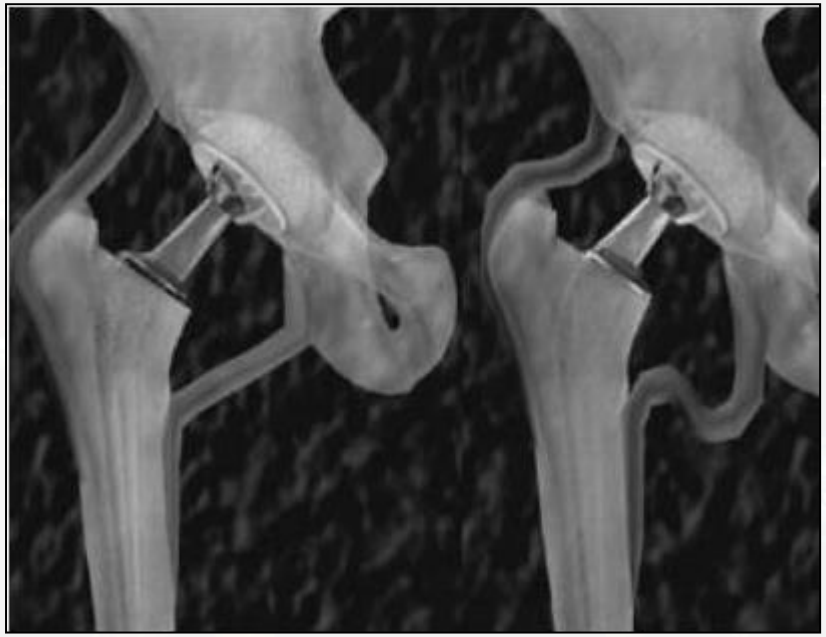
- refers to the orientation of the neck in reference to the coronal plane
  - anteversion or retroversion

- normal femur has **10 to 15 degrees of anteversion** of the femoral neck when the foot faces straight forward



Femoral offset & tissue tension

Reduced femoral offset --> tissue tension has to be restored by inadvertent overlengthening of the limb (height is substituted for offset)



Increasing the offset:

- pain
- stiffness
- functional leg lengthening due to abduction contracture

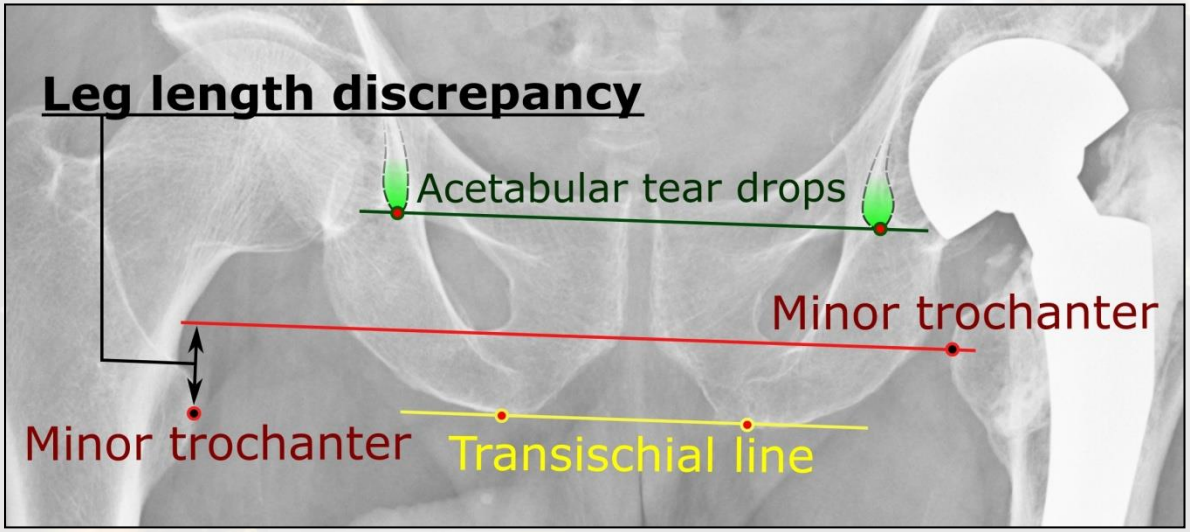
Failure to restore component offset:

- instability
- limp
- excessive wear
- bone impingement
- dislocation

Conclusions (1)

The main objectives THR: pain relief > stability > mobility > equal leg length

- discrepancy is preferable to the risk of recurrent dislocation
- discrepancies of less than 1 cm generally are well tolerated
- the perception of the discrepancy tends to diminish with time
- apparent (functional) leg-length inequality and pelvic obliquity usually respond to physical therapy

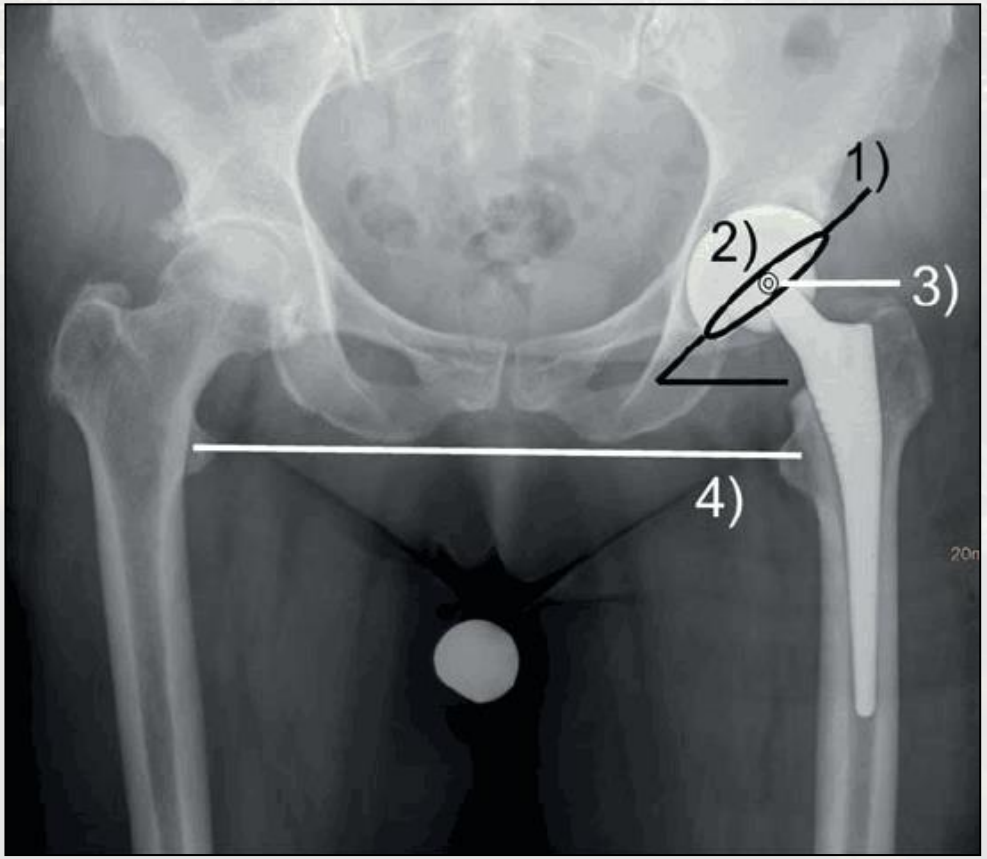


https://upload.wikimedia.org/wikipedia/commons/d/d7/Leg_length_discrepancy_after_hip_replacement.jpg

Conclusions (2)

Arrangements should be made during total hip replacement to achieve:

- restored or slightly medialized initial center of rotation
- accurate femoral offset
- physiological anteversion
- appropriate soft tissue tensioning
- accurate limb length



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Thank you for your attention

Katowice, 19.04.2018