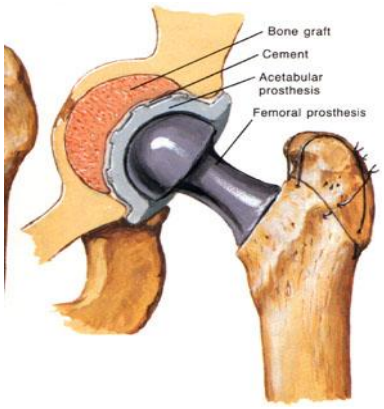
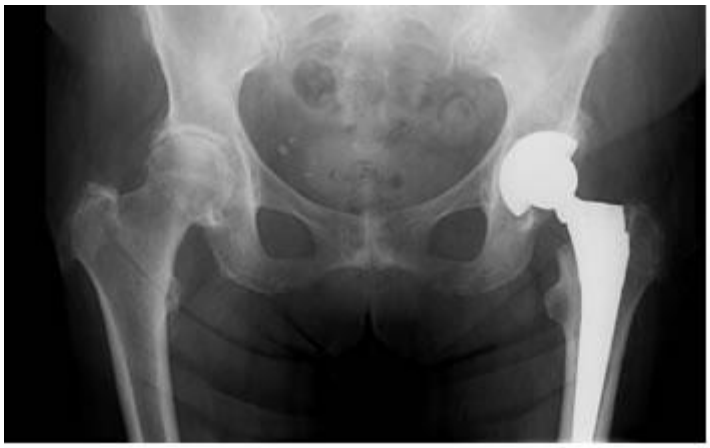
Leg length discrepancy After Total Hip Replacement: Prevalence And impact on functional outcome





Dissertation Submitted for **- M.ch, (Ortho)** ***(USAIM)***

By;

Dr. Vivek Savaskar

M.S. {Orthopaedics}, Orthopaedic Surgeon

Fellow Spine Surgery {ROC}, Member ISAKOS (USA).

To Whom It May Concern

I do hereby declare that all references cited in the Thesis and all the records have been solely prepared by me and it has not been previously accepted by any higher degree. If, somebody has done the same type of study for his own purpose i.e. simply coincidental.

Dr. Vivek N. Savaskar

- M.B;Bch (VMMC, Solapur),
- Master Of Orthopaedic Surgery, (VMMC, Solapur),
- Fellow of Spine Surgery, {Taiwan}.

Introduction

Leg Length Discrepancy after Hip Replacement

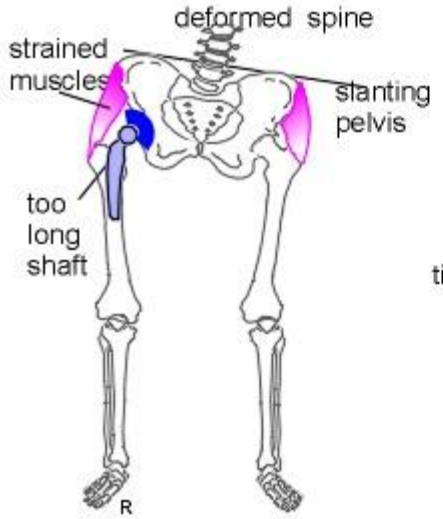
Why Are Leg Lengths Different After Hip Replacement Surgery?

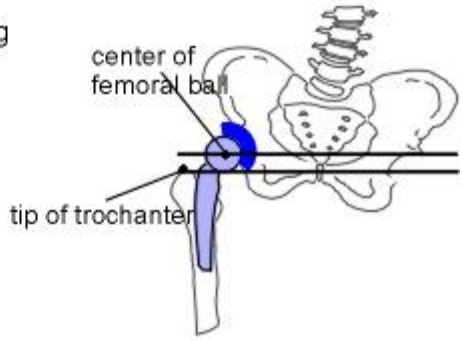
- Hip replacement surgery is performed as a treatment for severe arthritis of the hip joint.
- During a hip replacement surgery, the ball and socket of the joint are replaced with an artificial implant, commonly made of metal and plastic.
- After hip replacement surgery, some patients notice one leg may be longer than the other, most commonly the leg that had surgery.
- Why are leg lengths sometimes different after surgery?

- **Performing Hip Replacement Surgery**

- When a hip replacement surgery is performed, the hip joint is surgically opened. The top of the thigh bone (femur) is removed, and the socket of the pelvis is shaped.
- A metal cup is placed in the opened up socket, and a ball is placed on top of the thigh bone.
- It is important that the new ball-and-socket are stable, meaning they will not dislocate or come out of position.
- In order to prevent dislocation, surgeon may adjust the tension between the ball and socket by placing larger or longer implants in the bone.{AS EXPLAINED IN FOLLOWING FIGURE}

- **Leg Length Discrepancy**





- Exactly how the hip replacement implants are placed, and the size of the implants, will determine the length of the leg after surgery.
- If the hip is felt to be too loose, or unstable and prone to hip dislocation, surgeon may elect to place larger or longer implants in the joint.
- The downside of placing these larger implants is lengthening of the limb.
- Ideally, surgeon wants the leg lengths to end up being symmetric, but that is not always the final result.

- To prevent a post-operative leg length discrepancy, surgeon will template x-rays of your hip with overlay schematics of the hip replacement prosthesis.
- By doing so, surgeon can determine the expected size of implant needed at the time of surgery, and how much bone to remove during the procedure.
- In addition, some surgeons are now using computer-guided systems to help confirm position and size of the hip replacement implants.

- Computer-guided surgery is the operating room equivalent to a GPS system, showing your anatomy on a screen to help guide positioning of the implants.

- When leg lengths are unequal, patients may experience increased pain and muscle fatigue.

- When the leg length is increased by more than a few centimetres, the nerves of the leg may become stretched to the point that patients experiences numbness or pain further down the limb.

Although THR can provide excellent pain relief and restore functional ability for most patients, there are a proportion of patients who experience a poor functional outcome after THR.

As explained above ,one factor that could contribute to a poor outcome after THR is leg length discrepancy (LLD).

Restoration of leg length is important in optimising hip biomechanics and LLD has several consequences for the patient, including back pain and a limp.

Assessment of LLD using radiographs is time consuming and labour intensive, and therefore limits large scale studies of LLD.

However, patients self-report of perceived LLD may be a useful tool to study LLD on a large scale. Therefore, the aim of this postal audit survey was to determine the prevalence of patient-perceived LLD after primary THR and its impact on mid-term functional outcomes.

Material & Methods.

Definition of Leg Length Inequality

Leg length inequality has been described as lengthening or shortening a limb beyond normal anatomy so that the leg is either longer or shorter than the contralateral limb.

This definition assumes that the contralateral limb has no pathology and is normal.

In 1979, Sir John Charnley[1] stated that over lengthening of up to 1 cm can be justified because "…it permits active rehabilitation…and patients very soon become adjusted to 1 cm over-lengthening."

In patients without hip joint deformities, the operative leg is lengthened most often after total hip replacement (THR).

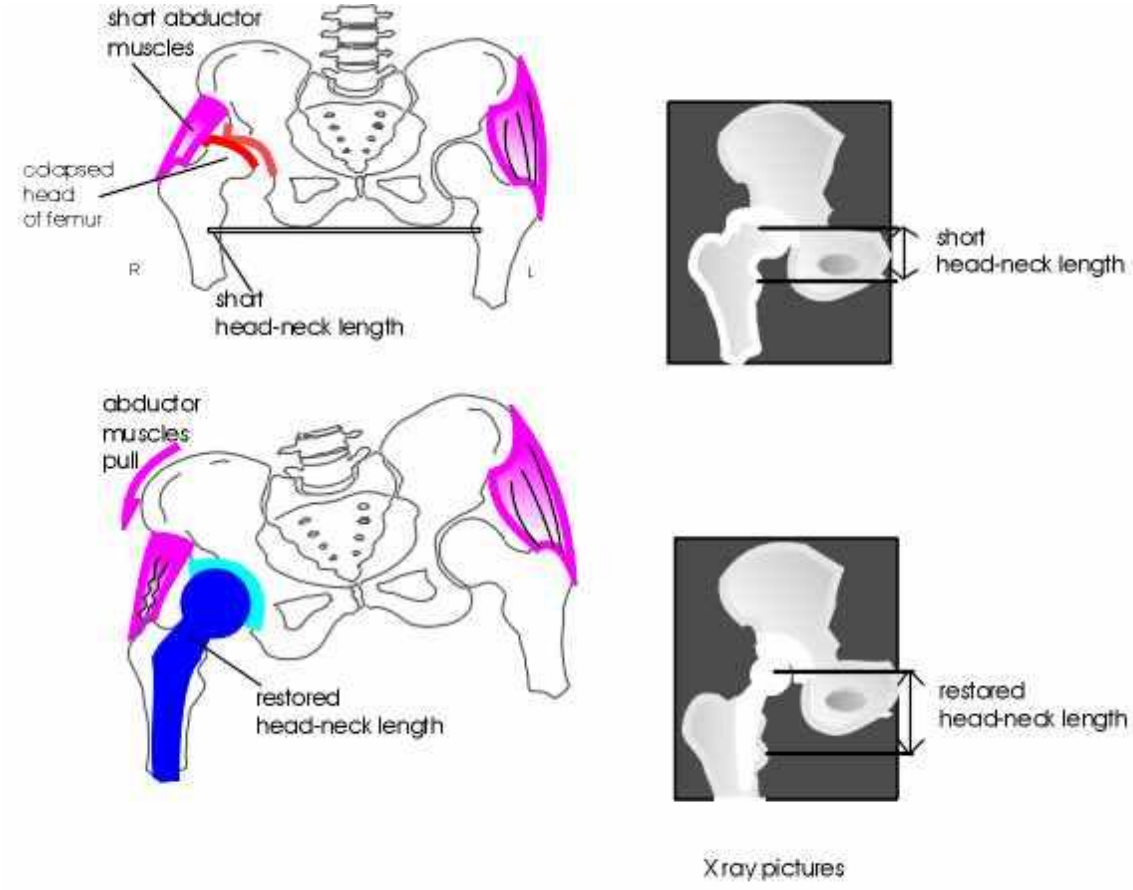
In their study, White and Dougall[2] reported leg length differences within 10 mm in 72% of all patients, with the operative leg longer (>10 mm) in 22% of patients and shorter (>10 mm) in 8% of patients.

Radiographic lengthening or shortening did not correlate with function, comfort, or satisfaction 6 months after the surgery.

When a patient believes that there is leg length inequality, it can be broken down into two components:

- actual or true, or
- Apparent or functional leg length inequality (FLLI).[3]
- Ranawat and Rodriguez[4] thought the actual or FLLI can be attributable to other factors such as tightness of anterolateral soft tissues about the hip and anterior capsule, iliacus, psoas, tensor fascia lata, gluteus medius and minimus, and rectus femoris muscle.

- Functional leg length inequality can be related to degenerative spine disease with scoliosis causing pelvic obliquity.
- Pelvic obliquity results from abduction contracture, which leads to a sensation of lengthening on the affected side.
- Similar lengthening can result from an adduction contracture from the contralateral side.
- In their study, 14% of 100 patients had pelvic obliquity after 1 month.
- All patients had resolution of FLLI between 3 and 6 months. The operative leg lengthened an average of 3.4 mm.
- In a study of 300 total hip arthroplasties, Ranawat and Rodriguez[4] found one persistent FLLI. They also found that high-risk patients are often short, obese women.
- The patient with coxa vara, with or without protrusion, will often experience leg lengthening after total hip arthroplasty, especially if the deformity is bilateral.

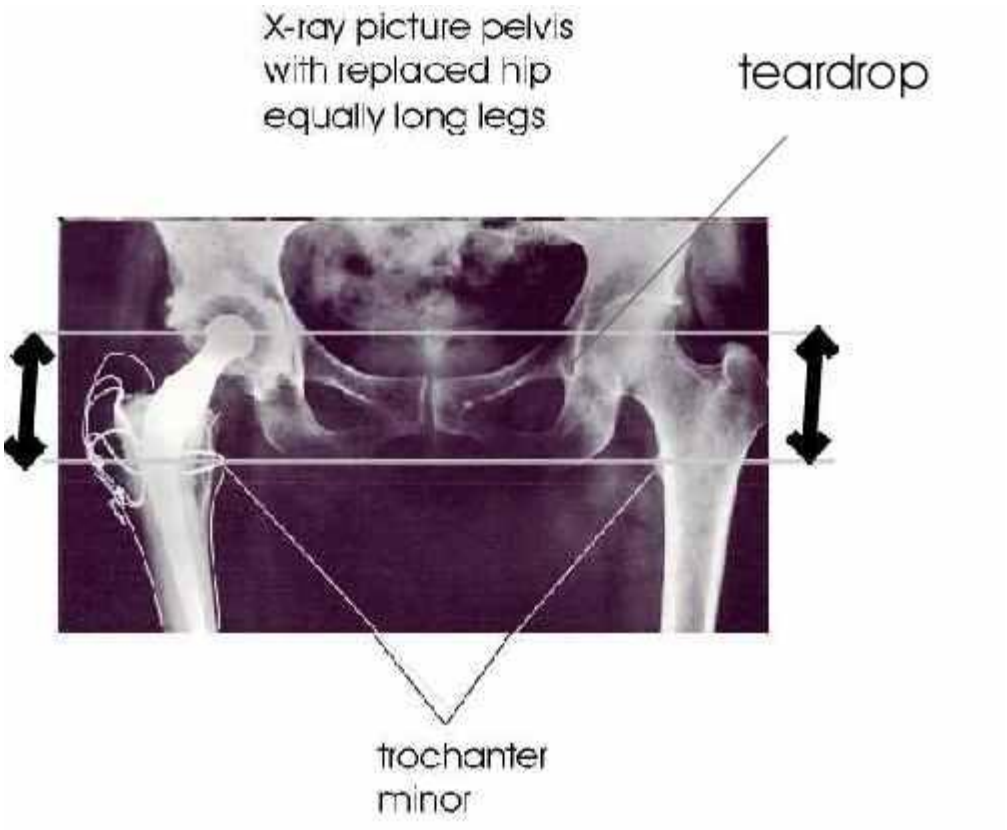


X ray pictures

-

- Woolson et al[5] described a method of leg length equalization for patients undergoing primary THR.
- They achieved this with exact positioning of the femoral neck osteotomy from preoperative templating.
- The same amount of head, neck, and articular cartilage that is removed is replaced with prosthetic implants. The landmark used was the top of the femoral head instead of the lesser trochanter. They found that 97% of the postoperative hips had leg length discrepancy <1 cm, and 86% had a difference <6 mm or 0.25 inch.

- **Measurement fo Lenth.**



The intraoperative goal of a cementless implant is to obtain a stable press-fit to secure biologic fixation. The porous-coated straight stem relies on a combination of distal medullary locking as the primary priority, with proximal press-fit as a second priority. Fixation is achieved with a combination of distal medullary locking as the primary priority and proximal press-fit as a second priority. A straight stem can

sit proud and lengthen the leg if the cortical bone is under-reamed and a slightly oversized stem is impacted into the canal.

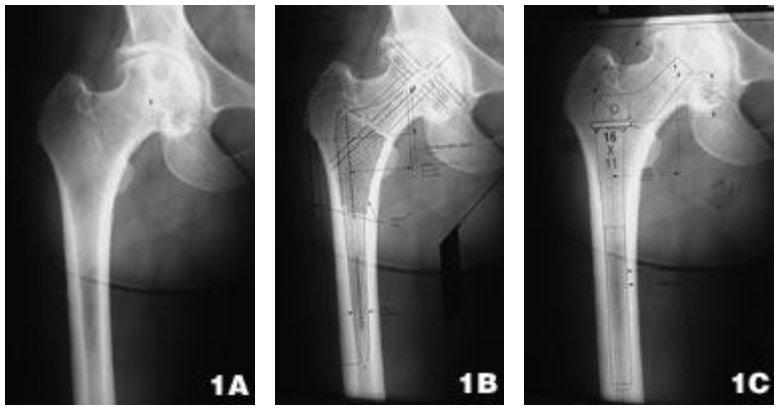


Figure 1: Identification of hip center from acetabular template (A).

Templating with a tapered stem at the level of lesser trochanter (B).

Templating with S-ROM above lesser trochanter (C).

A porous-coated tapered stem relies on a combination of proximal metaphyseal locking as the primary priority, with distal press-fit as a second priority.

The tapered stem can sit proud if the distal implant locks before the proximal metaphysis reaches a press-fit.

In a porous-coated tapered or straight stem, frequent attempts to stabilize with fit and fill are attempted, implying an optimal implant size exists before the hip is even operated upon.

A porous-coated tapered stem allows minimal control of intraoperative leg length with a non-modular stem.

Much literature has been written about intraoperative measurement.[6-10] If the hip is found too long, how easy is it to shorten the limb? With a press-fit stem, a surgeon can cut the neck lower and downsize the

stem, but how does a surgeon manage a canal that has been reamed to the templated size?

A metaphyseal-medullary canal mismatch may occur during preparation.

The Role of Offset

When an implant is used that does not restore the offset between the center of the head and the femoral shaft, a resulting soft tissue laxity that leads to instability may occur.

A surgeon must either length en the leg in the vertical vector by placing a stem proud or add tension by using a longer neck length to lengthen the leg as it restores soft tissue tension.

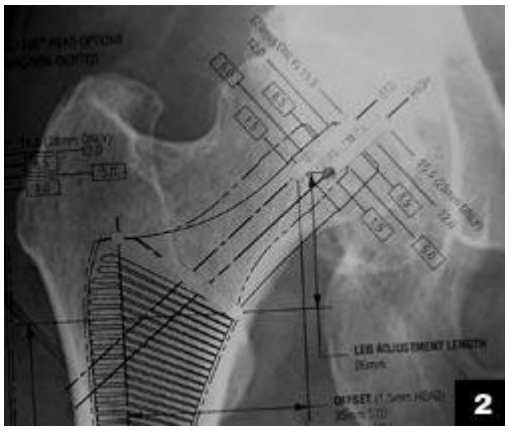
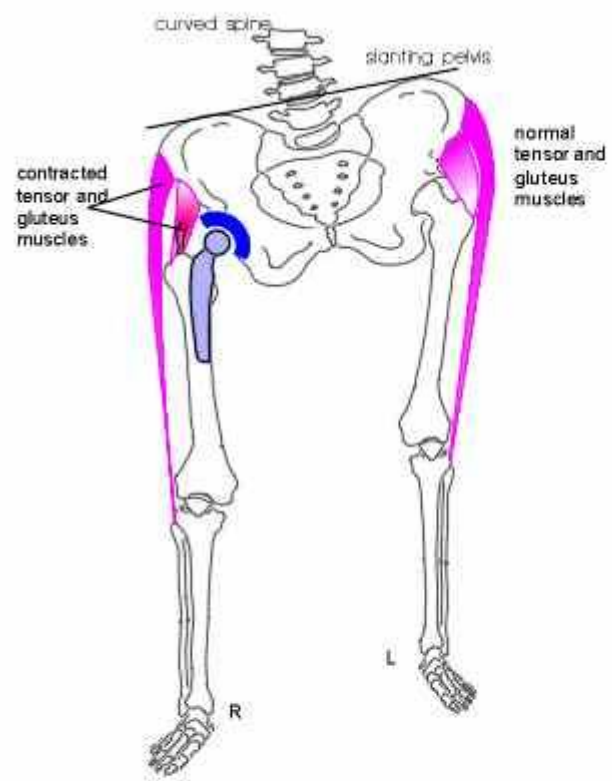


Figure 2: Close up of tapered stem template showing need for neck osteotomy at level of lesser trochanter to maintain leg length.

Charles et al[11] found that if a prosthetic implant system has a single neck-shaft offset, then up to 67% of patients will not have accurate restoration of the biomechanical center of the hip or femoral offset.

Eight neck shaft angles would need to be available to restore the anatomy accurately in only 50% of patients.



Modular Stems

- A modular stem allows control of offset, independent sizing of the distal femoral anatomy, as well as proximal medullary sizing.
- The titanium stem is a fluted design with a coronal slot.
- Its ability to close down in a distal medullary canal prevents the implant from sitting proud.
- Modular stems also have the ability to create a stem with a different proximal and distal sizing, allowing a neck resection closer to the lesser trochanter where a broaching device may cause fracture.
- In addition, medullary canal shape with a cut near the lesser trochanter can rarely be matched with a fixed-tapered stem. This, however, can easily be achieved with an S-ROM stem. The choice of two or more offsets, in addition to independent distal and proximal sizing, allows much closer approximation of normal leg length.

Preoperative Templating and Implant Choice Protocol

The authors compared the restoration of leg length with a 2004 cohort protocol using a porous-tapered stem based on preoperative templating.

The center of the acetabulum was found by templating on the operative side, as well as the nonoperative side. Canal fill and position of the neck osteotomy was determined to restore the center of rotation (Figure 1).

Figure 3: Measuring LFC with a caliper.

The same amount of resected head, neck, and articular cartilage was replaced by prosthetic implants as recommended by Woolson.[5] This required the restoration of offset. If a neck osteotomy at or near the lesser trochanter was required to restore offset, then an S-ROM modular stem was used (Figure 2).

A modular stem was also used in the event that the canal fill of the smallest tapered stem placed the center of rotation of the femoral head proximal to the center of the rotation of the acetabulum. In this situation, a tapered stem would always lengthen the leg.

The postoperative leg lengths of the 2004 cohort in which a modular stem was used as needed to avoid an increase in leg length was com pared to a 2001 cohort in which the tapered stem was used exclusively where priority was given to fit and fill. Prior to and after surgery, length from center (LFC), which is the length from the center of rotation to the top of the lesser trochanter (Figure 3), was measured.

This line was broken into vertical and horizontal vectors to see the vertical length imparted by the surgery (Figure 4).

Outcomes.

1,114 THR patients returned a completed questionnaire, giving a response rate of 73%.

329 patients (30%) reported that they thought their legs were different lengths.

The median OHS for patients with a perceived LLD was 22, which was significantly worse than the OHS of 18 for patients who thought their legs were the same length ($p<0.001$).

Of the 329 patients with a perceived LLD,

- 161 patients (51%) were bothered by the difference,
- 65 patients (20%) thought the discrepancy was sufficient to comment upon and 101 patients (31%) used a shoe raise.
- 31% of patients with LLD limped most or all of the time compared to only 9% of patients without LLD.

•Results

- In the 2001 cohort, tapered stems with fit and fill templating were used. The mean increase of LFC was 9 mm (7 mm leg length). Fourteen percent of the hips did not have restoration of proper offset. Changes in the vertical component of the LFC measurement and offset are presented in Table 1.

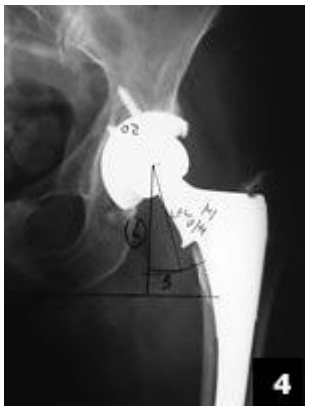


Figure 4: Measuring the vertical vector of LFC.

- In the 2004 cohort, in which exact positioning of the femoral neck osteotomy was calculated by preoperative templating, 25% of the hips were found inappropriate for tapered stems. S-ROMs were used if a tapered stem would length en the leg due to canal fit or a resection close to the lesser trochanter was needed to match the offset. With the standard offset tapered stem, the mean increase of LFC was 6 mm (4 mm leg length). Ten percent of hips did not have restoration of proper offset. With the high offset tapered stem, the mean increase of LFC was 7 mm (5 mm leg length), and 8% of hips did not have restoration of proper offset. When the S-ROM stem with varying offsets was used, the mean increase of LFC was 6 mm (4 mm leg length), and 8% of hips did not have restoration of proper offset. Vertical LFC measurement and offset data are presented in Table 2.
- Only the S-ROM consistently avoided overlengthening in all patients. Patients who were available at follow-up in all groups did not independently offer a complaint of leg length inequality after 1 year.

- Functional leg length inequality is more common than symptomatic actual inequality. Most symptomatic issues resolve at 1 year. It is best to avoid the complication by comprehensive preoperative planning and ensuring intraoperative availability of a range of implant sizes and offsets. Eliminating leg length inequalities with certain anatomies, even in the most experienced hands, may be beyond a surgeon's control.

TABLE 1

2001 Cohort

	Average Increase in Vertical LFC	Cases With Vertical LFC Change >10 mm	Cases With Vertical LFC Change <5 mm	Cases That Did Not Restore Preoperative Offset
Tapered Stems	+7 mm	14%	10%	14%

Abbreviation: LFC=length from center.

-

TABLE 2

2004 Cohort

	Average Increase in Vertical LFC	Cases With Vertical LFC Change >10 mm	Cases With Vertical LFC Change <5 mm	Cases That Did Not Restore Preoperative Offset
Standard Offset	+4 mm	10%	50%	10%
High Offset	+5 mm	10%	44%	8%
Modular S-ROM	+4 mm	0%	70%	8%

Abbreviation: LFC=length from center.

Analysis

1. Postoperative leg length inequality after total hip arthroplasty frequently leads to medical liability issues.

2. No standard exists regarding the acceptable disparity in the postoperative patient.

3. How much disparity is preventable with the available cement less total hip implants?

4. Physical therapists may comment to a patient, “Your leg has been made too long.”

5. Leg-length inequality frequently results from an abduction contracture.

6. Nevertheless, the patient will recall the resounding comment, “your surgeon has made your leg 2 inches longer.”

7. This places the treating physician on the defensive and may lead to a loss of patient trust.

Discussion

- Postoperative leg length inequality after total hip arthroplasty frequently leads to medical liability issues.
- Because no standard exists regarding the acceptable disparity.
- Modular stems allow control of offset, independent sizing of the distal femoral anatomy, as well as proximal medullary sizing.
- The authors compared the restoration of leg length in two cohort protocols.
- In the 2001 cohort, tapered stems were exclusively used, giving priority to fit and fill of the medullary canal.
- In the 2004 cohort, porous-tapered stems, or an S-ROM modular stem (DePuy Orthopaedics Inc., Warsaw, Ind) when needed, were used based on preoperative templating to restore the center of femoral head rotation.
- Prior to and after surgery, length from centre measurements were taken (center of rotation of the femoral head to the top of the lesser trochanter) and the vertical vector to compare the difference in actual leg length.
- In the 2001 cohort, the mean increase of length from centre was 9 mm (7 mm leg length).
- In the 2004 cohort, 25% of the hips were inappropriate for tapered stems. S-ROMs were used because a tapered stem would lengthen the leg.
- In the standard offset tapered stem, the mean increase of length from center was 6 mm (4 mm leg length). In the high offset tapered stem, the mean increase of length from center was 7 mm (5 mm leg length).
- In the S-ROM stem with varying offsets, the mean increase of length from center was 6 mm (4 mm leg length). Only the S-ROM consistently avoids overlengthening in the majority of patients.

Conclusions and Recommendations

In conclusion,

- this study found that the prevalence of perceived LLD at 5–8 years after THR was 30%.

- Of the patients with LLD, over 50% were bothered by the LLD and over a third used a shoe raise to equalise leg lengths.

- Patients with perceived LLD have a significantly poorer self-report functional outcome than those patients without LLD.

- It is therefore important that patients are informed pre-operatively of the high risk of LLD after THR and the associated negative impact this may have on their outcome.

- ***<u>What To Do When Leg Lengths Are Different</u>***

- Surgeon can help you understand why your leg lengths are different.
- In some cases, a leg length difference may have been anticipated, and in others, unexpected.
- The usual treatment of a small leg length discrepancy is with a lift in the shoe of the shorter leg. If the discrepancy is more than about 2 centimetres', then a build-up of the sole of the shoe may be necessary.

Urmila, standing on a 1 1/4 inch lift under the right foot to equalize her leg length discrepancy.

- In larger leg length discrepancies, surgery may be considered to re-size the implants or remove additional bone, but that is usually undertaken only in individuals severely affected. It is important to note that differences in leg length have not been shown to affect how long the hip replacement will last.

References

1. Unequal Leg Length. The leg is too long (usually). Available at: http://www.totaljoints.info/Long_leg_TH.htm. Accessed December 17, 2003.
2. White TO, Dougall TW. Arthroplasty of the hip. Leg length is not important. *J Bone Joint Surg Br*. 2002; 84:335-338.
3. Abraham WD, Dimon JH 3rd. Leg length discrepancy in total hip arthroplasty. *Orthop Clin North Am*. 1992; 23:201-209. Review.
4. Ranawat CS, Rodriguez JA. Functional leg-length inequality following total hip arthroplasty. *J Arthroplasty*. 1997; 12:359-364.
5. Woolson ST, Hartford JM, Sawyer A. Results of a method of leg-length equalization for patients undergoing primary total hip replacement. *J Arthroplasty*. 1999; 14:159-164.
6. Ranawat CS, Rao RR, Rodriguez JA, Bhende HS. Correction of limb-length inequality during total hip arthroplasty. *J Arthroplasty*. 2001; 16:715-720.
7. Bose WJ. Accurate limb-length equalization during total hip arthroplasty. *Orthopedics*. 2000; 23:433-436.
8. Bourne RB, Rorabeck CH. Soft tissue balancing: the hip. *J Arthroplasty*. 2002; 17 (Suppl 1):17-22.
9. Knight JL, Atwater RD. Preoperative planning for total hip arthroplasty. Quantitating its utility and precision. *J Arthroplasty*. 1992; (Suppl 7):403-409.
10. Goodman SB, Huene DS, Imrie S. Preoperative templating for the equalization of leg lengths in total hip arthroplasty. *Contemp Orthop*. 1992; 24:703-710.
11. Charles MN, Bourne RB, Davey JR, et al. Soft-tissue balancing of the hip. The role of femoral offset restoration. *Instr Course Lect*. 2005; 54:131-141.
12. Williams O, Fitzpatrick R, Hajat S, Reeves BC, Stimpson A, Morris RW, et al. Mortality, morbidity, and 1-year outcomes of

primary elective total hip arthroplasty. J Arthroplasty 2002;17:165–71.
13. Williamson JA, Reckling FW. Limb length discrepancy and related problems following total hip joint replacement. Clin Orthop Relat Res 1978:135–8.
14. Friberg O. Clinical symptoms and biomechanics of lumbar spine and hip joint in leg length inequality. Spine 1983;8:643–51.
15. Giles LG, Taylor JR. Low-back pain associated with leg length inequality. Spine 1981;6:510–21.
16. Pritchett JW. Nerve injury and limb lengthening after hip replacement: treatment by shortening. Clin Orthop Relat Res 2004:168–71.