Leg Length Inequality in Total Hip Arthroplasty

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abstract

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 center 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 center 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.

Postoperative leg length inequality after total hip arthroplasty frequently leads to medical liability issues. No standard exists regarding the acceptable disparity in the postoperative patient. How much disparity is preventable with the available cementless total hip implants? Physical therapists may comment to a patient, “Your leg has been made too long.” Leg-length inequality frequently results from an abduction contracture. Nevertheless, the patient will recall the resounding comment, “your surgeon has made your leg 2 inches longer.” This places the treating physician on the defensive and may lead to a loss of patient trust.

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 stated that overlengthening of up to 1 cm can be justified because “...it permits active rehabilitation...and patients very soon become adjusted to 1 cm overlengthening.”

In patients without hip joint deformities, the operative leg is lengthened most often after total hip replacement (THR). In their study, White and Dougall 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). Ranawat and Rodriguez 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,
psosas, tensor fascia lata, glutaeus 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 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.

Woolson et al. 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.

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.

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. 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 lengthen 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. Charles et al. found that if a prosthetic implant 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 ostectomy was determined to restore the center of rotation (Figure 1). The same amount of resected head, neck, and articular cartilage was replaced by prosthetic implants as recommended by Woolson. This required the restoration of offset. If a neck ostectomy 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 compared 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. Lengthen 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 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 anatomicies, even in the most experienced hands, may be beyond a surgeon’s control.

**TABLE 1**

<table>
<thead>
<tr>
<th>2001 Cohort</th>
<th>Cases With Vertical LFC Change &gt;10 mm</th>
<th>Cases With Vertical LFC Change &lt;5 mm</th>
<th>Cases That Did Not Restore Preoperative Offset</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tapered Stems</td>
<td>+7 mm</td>
<td>10%</td>
<td>14%</td>
</tr>
</tbody>
</table>

*Abbreviation: LFC = length from center.*

<table>
<thead>
<tr>
<th>2004 Cohort</th>
<th>Cases With Vertical LFC Change &gt;10 mm</th>
<th>Cases With Vertical LFC Change &lt;5 mm</th>
<th>Cases That Did Not Restore Preoperative Offset</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Offset</td>
<td>+4 mm</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>High Offset</td>
<td>+5 mm</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>Modular S-ROM</td>
<td>+4 mm</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

*Abbreviation: LFC = length from center.*

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

**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). Seventeen 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.

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 lengthen 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 anatomicies, even in the most experienced hands, may be beyond a surgeon’s control.

**REFERENCES**


