Limb-length Discrepancy After Total Hip Arthroplasty: Novel Treatment and Proposed Algorithm for Care

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Abstract: Limb-length discrepancy after total hip arthroplasty (THA) leads to patient dissatisfaction and can be a cause of orthopedic surgery malpractice cases. Nonsurgical and surgical techniques exist to correct limb-length discrepancies. Two limb-lengthening methods were used to correct greater than 2-cm limb-length discrepancies after THA: lengthening over a femoral nail with an external fixator and lengthening with an intramedullary kinetic skeletal distractor. These techniques achieved equal length in less than 4 weeks, with both resulting in a healed distraction gap within 4 months. No patient had loss of proximal or distal joint motion, and mean Harris Hip Score was 90 points at final follow-up. No surgical complications were reported with the intramedullary skeletal kinetic distractor. Limb lengthening using an intramedullary skeletal kinetic distractor is a viable treatment option resulting in reliable lengthening, healing of the distraction gap, and progression to full weight bearing. [Orthopedics. 2014; 37(2):101-106.]

Although high success rates have been reported for total hip arthroplasty (THA), some patients may have limb-length discrepancy postoperatively. Konyves and Bannister reported that more than 60% of patients had measurable lengthening of the treated hip compared with the contralateral side. Patient-reported symptomatic lengthening, which may be a cause of persistent patient dissatisfaction after THA, has been reported to range from 5% to 40% in some studies. The Joint Commission reported that leg-length discrepancies after THA were major adverse events, leading to 4.7% of medical errors. In addition, leg-length discrepancies have been reported to be a leading cause of orthopedic surgery malpractice claims.

Patients must be carefully evaluated both clinically and radiographically when reporting leg-length discrepancy after THA. Often, they may have an “apparent” or “functional” leg-length discrepancy, with minimal or no radiographic evidence despite reporting a longer leg. Also, degenerative conditions leading to spinal deformity or pelvic obliquity may be the cause. When patients have only an apparent lengthening, they may have lower functional and satisfaction scores.

When a radiographic discrepancy is present, complications may include patient dissatisfaction, nerve palsy, low back pain, and altered gait. Small leg-length discrepancies (1 cm or less) are usually well tolerated by patients and may go unnoticed. If these discrepancies are symptomatic, they may be successfully treated in conjunction with physical therapy. Discrepancies between 1 and 2 cm have been shown to affect functional outcome scores. Discrepancies greater than 2 cm may lead to greater patient dissatisfaction, nerve palsy, and back pain. In addition, limb-length discrepancies of 2 cm or greater can lead to gait abnormalities that result in...
increased muscle activity, heart rate, and oxygen consumption. The outcomes of 3 patients who presented with a symptomatic limb-length discrepancy (2.5 cm or greater) are described. Their conditions improved with a shoe lift, but they chose contralateral limb lengthening instead of lifetime wear of an orthotic. An algorithm for the surgical correction of symptomatic limb-length discrepancies after THA is proposed.

**Case Reports**

Three patients who presented with symptomatic limb-length discrepancies of greater than 2.5 cm after THA underwent contralateral femoral distraction osteogenesis. There was no evidence of hip symptomatology, radiographic loosening of any components, or contralateral hip degenerative joint disease at presentation. The first patient underwent external fixation for lengthening over an intramedullary nail. The other 2 patients received totally implantable intramedullary lengthening devices. The goal in all cases was to equalize the limb lengths to within 5 mm of the side that had previously undergone THA.

**Lengthening With Intramedullary Nail/External Fixator**

A 47-year-old woman underwent a left THA for symptomatic unilateral osteoarthritis at another institution. At 1 year postoperatively, she presented with a perceived limb-length discrepancy. She reported that this inhibited her activities of daily living and was causing her emotional distress. On physical examination, there was no pain with range of motion of the hips or knees on either side. Radiographically, the arthroplasty was well positioned with no signs of radioluencies, and her left side was measured to be 2.6 cm longer than her right side. The untreated hip showed no signs of osteoarthritis. The patient was initially treated with a shoe lift, which improved her satisfaction. However, the discrepancy continued to affect her function and she chose surgical correction. Because her hip was asymptomatic and had no signs of loosening on radiographs, revision THA was not considered a viable option. The decision was made to perform distraction osteogenesis to lengthen the untreated femur.

A monolateral external fixator rail system was used for lengthening over an intramedullary nail. The intramedullary nail was inserted in an antegrade manner through the piriformis fossa. When the desired length was achieved, the nail was locked distally and the external fixator removed. The patient was allowed to gradually increase to full weight bearing once the regenerated bone was healed. At 6-month follow-up, she was satisfied with the results and had returned to full activities. The patient tolerated the surgery well, and no major complications were recorded during treatment.

The patient has been followed for 14 years after the contralateral lengthening procedure (15 years since the initial THA). Twelve years after the index THA, revision surgery was performed on the acetabular component for aseptic loosening and osteolysis. She has done well since the latest procedure and has reported no complications related to the distraction osteogenesis.

**Lengthening With Intramedullary Skeletal Kinetic Distractor**

The first patient treated with this technique was a healthy 37-year-old woman with osteoarthritis secondary to left hip dysplasia who underwent THA in 2008 at another institution. Three months postoperatively, she presented for treatment after noting a limb-length discrepancy and new onset of lower back pain. Her medical history was remarkable for tricuspid valve atresia, a mild form of Turner syndrome, and a prior limb-length equalization procedure during adolescence, the exact details of which were unavailable. On physical examination, her left hip abductor muscle was weak, with a score of 2 out of 5 on manual muscle testing (0=no muscle contraction, 5= muscle acts normally, even with maximum resistance applied), and there was an associated adductor muscle contracture. She had no discomfort with any range of motion of her hips or knees on either side. Radiographic evaluation demonstrated a limb-length discrepancy of 2.9 cm, with the treated (left) side being longer.

The patient initially received a shoe lift on the right side, which reduced her back pain, but she remained dissatisfied with the limb-length discrepancy. Because weakness was noted on examination, a left hip abductor mechanism reconstruction with a tibialis anterior tendon allograft was performed, with subsequent improvement of abductor function to 3 out of 5 by 4 months postoperatively. Despite this improvement, gait disturbance and low back pain continued as a result of the limb-length discrepancy. A femoral lengthening was performed on her asymptomatic contralateral (right) side. A 10.7-mm tibial intramedullary skeletal kinetic distractor (ISKD; Orthofix Srl, Bussolengo, Italy) was inserted in an antegrade manner from the greater trochanter entry point. A planned 2.9-cm lengthening was achieved over 3 weeks. The distraction gap healed in 4 months, at which time she had progressed to full weight bearing. No complications of the lengthening procedure were reported. Currently, 30 months after the index THA and 24 months after the limb-lengthening procedure, the patient has no complaints.

The second patient treated with this technique was a 52-year-old woman who had a symptomatic limb-length discrepancy and back discomfort 2 years after THA at another hospital. There were no osteoarthritic changes in the untreated hip. There was no pain with range of motion of the hips or knees on either side. Radiographic evaluation showed that the left side that had undergone
THA was 2.5 cm longer than the right side (Figure 1A). She initially received a shoe lift, which mildly improved her low back pain. However, she felt that the limb-length discrepancy affected her gait and caused pain that decreased her quality of life and affected her ability to perform activities of daily living.

The patient subsequently underwent right femoral lengthening with a tibial ISKD (diameter, 10.7 cm) inserted through the greater trochanter (Figures 1B-1C). Equal length was achieved within 3 weeks, and the distraction gap was fully healed at 4 months, at which time she had progressed to full weight bearing. At 4-month follow-up, she was satisfied with the results and had returned to full activities while walking without a limp (Figure 1D). No complications occurred during the postoperative period. One year later, the lengthening nail was electively removed. At 17-month follow-up, she had no complaints and continued to do well.

**RESULTS**

Three patients who presented with symptomatic limb-length discrepancies of greater than 2.5 cm after THA underwent contralateral femoral distraction osteogenesis. There was no evidence of hip symptomatology, radiographic loosening of any components, or contralateral hip degenerative joint disease at presentation. The first patient received external fixation for lengthening over an intramedullary nail. The other 2 patients received totally implantable intramedullary lengthening devices. The goal in all cases was to equalize the limb lengths to within 5 mm of the side that had previously undergone THA. All patients had union of regenerated bone within 4 months, with no loss of motion of either the proximal or the distal joints (hip or knee). At most recent follow-up, all hardware was intact on radiographic evaluation. There were no neurovascular deficits or signs of infection or evidence of fracture or nonunion. All patients had satisfactory Har-
Treatment algorithm for management of limb-length discrepancy after total hip arthroplasty.

Figure 2: Treatment algorithm for management of limb-length discrepancy after total hip arthroplasty.

...s Hip Scores (100, 88, and 81 points, respectively; mean, 90 points). Within 6 months after the lengthening procedure, they all reported that they were satisfied with their surgical outcomes and had returned to their normal activities with no deficits.

**Discussion**

Symptomatic limb-length discrepancy after THA can be challenging to treat. Discrepancies of less than 1 cm may be successfully treated with physiotherapy or a small shoe lift. Surgical correction should be considered for symptomatic differences of greater than 2 cm. In this case, treatment options include revision arthroplasty when radiographic loosening or hip pain is present, or contralateral THA if symptomatic contralateral degenerative joint disease is present, or limb-length correction. Shortening of the ipsilateral thigh has been reported. To the current authors’ knowledge, this is the first reported series of patients who underwent contralateral lengthening for the treatment of symptomatic leg-length discrepancy after THA.

Although several treatment options have been reported in the literature, there is no standardized treatment algorithm for these patients. Subsequent-ly, on the basis of severity at presentation, the authors propose an algorithm for surgical management of these rare and challenging complications (Figure 2). All of the treatment methods have advantages and disadvantages. Revision of the ipsilateral THA to a shorter construct can result in instability and dislocation. Although this instability can possibly be corrected with the use of a large femoral head or a dual-mobility prosthesis, these procedures should only be considered when there is marked hip pain, radiographic signs of loose components or malpositioning, or osteolysis. If the contralateral hip shows signs of degenerative joint disease and is symptomatic, length can be restored using THA on that side.

If neither of these options is appropriate and the patient has greater than 2 cm of symptomatic limb-length discrepancy, the authors suggest first attempting a shoe lift (internal or external, depending on the degree of discrepancy). For various reasons, including needing to wear shoes full-time or shoe lifts being cosmetically objectionable, this solution may not be permanently acceptable to patients. In these instances, patients have few options. Kasis et al described a patient with a 5-cm limb-length discrepancy who underwent shortening of the ipsilateral femur. A contralateral limb-lengthening osteogenesis was not possible because the contralateral (short) limb had undergone a long-stem revision THA and therefore could not be treated with intramedullary limb lengthening. In addition, because the contralateral limb had undergone multiple procedures, the option of lengthening with an external fixator alone was excluded due to the risk of infection. Nevertheless, after the decision to perform limb-length correction has been reached, shortening is usually not acceptable to patients and should be reserved for those, such as the patient described by Kasis et al, who are not candidates for distraction osteogenesis procedures for lengthening. In addition, shortening would most safely be performed at the distal femur to encourage rapid healing in metaphyseal bone and to avoid the ipsilateral hip prosthesis. However, this can lead to quadriceps muscle weakness.

Limb lengthening is based on the principle of creating a low-energy osteotomy of the long bone and then distracting with either an external fixator or an internal telescopic lengthening nail. This distraction osteogenesis with subsequent consolidation leads to the desired length gain. This technique has been used to manage patients with limb-length discrepancies resulting from infection, trauma, burns, polio, growth plate-related pathologies, or congenital conditions. The quality of life of patients with limb-length discrepancies has been improved with this method. For the first patient in the current series, lengthening over a nail assisted with a temporary monorail external fixator was performed.
this technique, the level of the osteotomy site is chosen based on the length required. The intramedullary rod tip should ideally be at least 10 cm distal to the distraction gap at the end of the lengthening process. It is proximally locked at the initial sitting and the monorail external fixator applied. Care is taken to insert the pins in a collinear manner, perpendicular to the rod. The pins are inserted with a wire followed by a cannulated drill to maintain a clear radiographic space with no contact with the rod. After the desired length is attained, the distal interlocking screws are inserted and the external fixator is removed. The regenerated bone is allowed to consolidate over the locked nail before full weight-bearing activities are allowed. The external fixation time can be reduced by half with this technique.\(^2\)\(^6\) Lengthening over a nail represents improvement over the classic Ilizarov external fixation method, but the ideal lengthening method would eliminate the need for any external fixator.\(^2\)\(^3\)

An intramedullary skeletal kinetic distractor was used for the next 2 patients.\(^2\)\(^9\)\(^3\)\(^0\) This device was developed in the past 10 years and thus was not available when the first of these patients was treated. Multiple drill holes are made at the proposed subtrochanteric osteotomy site. The femur is then reamed to 2 mm greater than the distractor diameter. The distractor is inserted to the level of the drill holes, the osteotomy completed with an osteotome, and the nail passed. Rotational orientation must be maintained while inserting the proximal and distal interlocking screws. The patient is taught how to activate the working mechanism and monitor the pole changes of the magnet with a handheld noninvasive console. The regenerated bone is allowed to consolidate, and the patient is permitted to return to full activities when serial radiographs reveal at least 2 cortices healing. The authors recommend removing the ISKD approximately 1 year after implantation to prevent stress fractures at the tip of the nail. Short nails end up at the middle of the diaphysis. Longer nails, which do not permit adequate rotational activation, may lead to difficult distraction.

These techniques have pitfalls. The intramedullary rod follows the anatomical axis of the femur. After lengthening, the mechanical axis of the entire limb shifts laterally. This effect is minimal in small to moderate lengthenings.\(^2\)\(^3\) Acceptable length gain in the femur can be as much as 5 to 7 cm without typically causing neurovascular problems. The soft tissue may become tight during the process; therefore, the authors advocate prophylactic distal iliotibial band release at the level of the superolateral pole of the patella. The knee should be monitored for contractures, and vigorous physical therapy is required. Weight bearing should be gradually increased once bone healing is seen. This avoids bending forces on the intramedullary skeletal kinetic distractor and prevents the telescopic mechanism from failing. In a large series of 242 cases, Burghardt et al.\(^1\)\(^3\) reported a 6.2% mechanical failure rate with use of an intramedullary skeletal kinetic distractor. The distractor has delicate mechanical parts that may prone to failure from excessive loading prior to full bone healing. Patients should be closely monitored every 7 to 14 days until the desired length is achieved, and then monitored monthly until full healing is seen. Second-generation intramedullary lengthening nails (FITBONE; Wittenstein intens GmbH, Igersheim, Germany; PRECICE; Ellipse Technologies, Inc, Irvine, California) activated by either electrical (FITBONE) or magnetic (PRECICE) motors may provide more accurate control over lengthening rate and rhythm.

**Conclusion**

The authors found distraction osteogenesis for lengthening of the contralateral limb to be a safe and effective treatment for limb-length discrepancies following THA when no other nonsurgical treatment options were successful. All patients were able to return to activities of daily living, no device failures were found, and all patients reported improved satisfaction once their leg-length discrepancy was corrected.

**References**

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