Direct Anterior Total Hip Arthroplasty with Fluoroscopy to Mitigate the Risk of Complications in Patients with Legg–Calve–Perthes Disease

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J Hip Surg

Abstract

A minority of adult patients with childhood Legg–Calve–Perthes disease (LCPD) will develop secondary arthritis with marked leg length discrepancy (LLD) and multiplanar hip deformity. During total hip arthroplasty (THA), these technical challenges increase the perioperative risks of nerve injury, leg length inequality, and implant malposition. The technique of direct anterior total hip arthroplasty (DA-THA) in combination with fluoroscopic imaging was evaluated to mitigate these risks. We performed a retrospective review of 11 DA-THA procedures performed for patients with LCPD. The mean preoperative LLD for the patient cohort was 17 mm (range, 2–54). The mean postoperative LLD was 6 mm (range, 0–28). Acetabular component orientation was precise and accurate with a mean abduction angle of 44 degrees (range, 42–46) and mean anteversion of 20 degrees (range, 16–24). Clinical outcomes demonstrated a mean hip disability and osteoarthritis outcome score for joint replacement (HOOS, Jr) of 94 points. No patients had leg lengthening more than 26 mm and no nerve palsies were identified. We conclude that DA-THA with fluoroscopic guidance may be a valuable method to improve component placement precision and procedural safety in this potentially high-risk patient group.

Keywords

- Legg–Calve–Perthes disease
- total hip replacement
- anterior approach
- fluoroscopy
- nerve palsy
- leg length discrepancy

Legg–Calve–Perthes disease (LCPD or Perthes disease) is a condition of childhood that can have consequences in adulthood. It is most commonly recognized as an idiopathic osteonecrosis of the femoral head, affecting children between the ages of 4 and 10 years. Varied attempts of pediatric intervention with therapy, bracing, or osteotomy are aimed at containment to maintain femoral head sphericity.[1] Once the head has progressed through the stages of fragmentation and reossification, the long-term consequences affecting adulthood become clearer. While most children will achieve favorable outcomes, once the necrosis has resolved, those who acquire more significant deformity may develop secondary arthritis with age.[2,3] The reported prevalence of arthritis is 36% for Stulberg grade 3, 67% for grade 4, and 81% for grade 5.[3] A review of the Stulberg classification system is provided in ►**Table 1**.[3]

Therefore, patients with a radiographic Stulberg grade 3 or higher deformity are far more likely to require total hip arthroplasty (THA).[4] Historical reports of THA for adult patients with childhood Perthes disease demonstrate good clinical survivorship. More recent techniques involving cementless implants report 15-year survivorship of up to 96%.[5] While the outcomes related to implant durability and function in this young, active population have improved,

received
March 31, 2020
accepted after revision
December 10, 2020

Thieme Medical Publishers, Inc.,
333 Seventh Avenue, 18th Floor,
New York, NY 10001, USA

DOI https://doi.org/10.1055/s-0041-1723935.
ISSN 2472-8446.

Table 1 Stulberg classification criteria

Class	Features	Radiographic findings
I	Normal hip joint	Spherical head
II	Spherical congruency Loss of head shape < 2 mm	Spherical head With ≥ 1 abnormality - Coxa magna - Steep acetabulum - Shortened femoral neck
III	Aspherical congruency Loss of head shape > 2 mm	Mushroom- or umbrella-shaped femoral head; not flat With ≥ 1 abnormality - Coxa magna - Steep acetabulum - Shortened femoral neck
IV	Aspherical congruency	Flat femoral head and acetabulum
V	Aspherical incongruency	Flat femoral head, normal neck and acetabulum

Source: Adapted from Stulberg et al.[3]

Fig. 1 Characteristic multiplanar deformity in Stulberg IV hip with femoral head flattening, abnormally steep acetabulum, and leg length discrepancy.

there are still serious concerns related to immediate perioperative complications.

LCPD patients with secondary arthritis exhibit deformity in every key structure affecting arthroplasty: acetabular dysplasia, high hip center, coxa magna, trochanteric overgrowth, coxa breva, and leg length inequality (►**Fig. 1**). Intraoperative challenges related to the characteristic deformity of LCPD introduce the risks of overlengthening, implant malposition, and neurologic injury. The perioperative risk of sciatic nerve injury in patients with LCPD has been reported to be as high as 6% in smaller series and up to 3% more broadly in a meta-analysis, compared with a risk of 0.17% in patients with primary osteoarthritis.[5–7] While the etiology of nerve palsy in these patients is variable, it is likely related to overstretching the nerve during unexpected excessive lengthening.[5]

We routinely perform direct anterior total hip arthroplasty (DA-THA) utilizing intraoperative fluoroscopy. We performed this study to assess whether the use of fluoroscopy would potentially mitigate the risks of implant malposition, leg length inequality, or postoperative nerve injury among patients with LCPD.

Methods and Materials

We retrospectively reviewed a total of 11 THAs in 10 patients with LCPD who underwent DA-THA between 2013 and 2019. Surgery was performed by a single surgeon at a single institution with a minimum of 1-year follow-up. Only patients who had a direct anterior (DA) approach were included. Patients with a history of prior pelvic or femoral osteotomy were not included.

All patients reported a childhood history of LCPD. Charts were reviewed for indications, medical history, and mode of treatment failure. Hospital records were reviewed for complications, reoperations, and readmissions. Outcomes measured were patient-reported hip disability and osteoarthritis outcome score for joint replacement (HOOS, Jr), revision, and death.[8] All patients consented to participate in the database. The study was approved by the Institutional Review Board.

Surgical Technique

The patient was placed on the Hana table in the standard fashion. A DA approach was performed as described by Matta.[9] In more severe deformities with dysplasia, lateral subluxation and coxa breva, fluoroscopy was used prior to incision to locate the appropriate starting point. Dissection was taken to the level of the hip. After capsulotomy, the head was removed in the standard fashion.

Attention was turned to the acetabulum. Preoperative templating was used to locate an acetabular cup position with sufficient bone support and a corrected center of rotation (COR). This location was often inferior and medial to the starting COR and was identified intraoperatively using fluoroscopic guidance when positioning the reamer. A modified medial protrusio technique (MPT) as described by Eskildsen et al was used to create sufficient superolateral coverage for cup stability and ingrowth but without fracturing the medial wall.[10] The technique deepens the reaming directly toward the medial wall, and cup sizing is dependent on the fit between the anterior and posterior columns, to avoid a high hip center and vertical cup placement. Because of the distorted anatomy characteristic of LCPD, the cup was placed under fluoroscopic navigation to enable real-time adjustments to abduction, anteversion, height, depth, and bone coverage. A modular cementless, titanium, hemispherical, acetabular shell (Reflection 3 [Smith & Nephew] prior to 2018; Trident II [Stryker] from 2018) was used with a neutral, highly cross-linked, fixed bearing polyethylene liner to accommodate the largest femoral head.

On the femoral side, the affected hip presented with a widened, flattened head with decreased hip length. Preoperative and intraoperative templating was used to estimate the amount of combined leg length correction from the acetabulum and the head-neck-stem construct. With the trials in place, fluoroscopy was used to identify any increase in hip length beyond the planned correction, and adjustments were made accordingly (►**Fig. 2**). Given the preoperative leg length

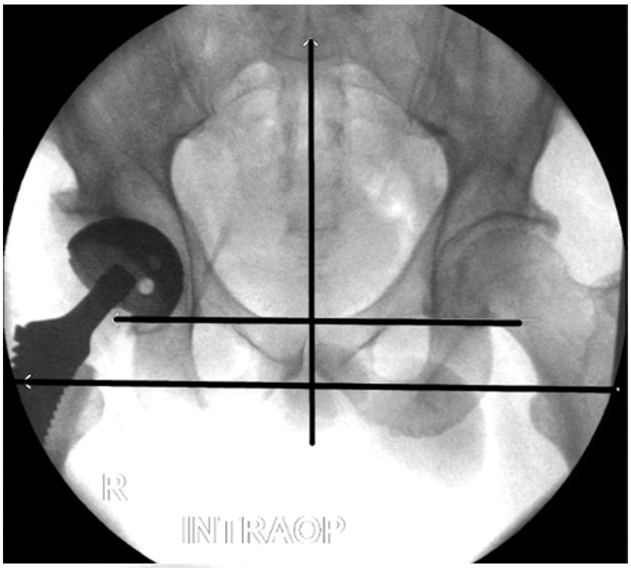

Fig. 2 Intraoperative imaging. The pelvis is leveled with a sacral line bisecting the pubic symphysis. Bilateral hips are in symmetric rotation and abduction. Leg length is measured in relation to the interteardrop line.

inequality, care was taken not to lengthen the hip beyond the contralateral side in an effort to avoid excessive tension on the neurovascular structures. The trials were clinically tested for stability, range of motion, and impingement before the final implants were placed. A standard length cementless titanium stem using a triple taper hydroxyapatite-coated design (Corail [DePuy Synthes]) was used for all patients.

In this series, patients were allowed to progress with weight-bearing as tolerated and without dislocation precautions. Patients were anticoagulated with aspirin for 3 weeks unless stronger anticoagulation was specifically indicated, based on risk stratification, degree of immobility, and prior medical history.

Radiographic Measurement

Preoperative radiographs were reviewed for severity of LCPD and were staged according to the Stulberg classification.[3] Preoperative leg length and inequality were compared with postoperative measurements. Leg length was determined by the vertical distance from a specified point on the lesser trochanter to a horizontal line drawn from the bottom of each radiographic teardrop. Inequality was calculated by the difference in hip lengths between the index side and the contralateral side. Offset was calculated as the horizontal distance from the same point on the lesser trochanters to the most lateral edge of the ischium. Postoperative radiographs were evaluated for cup orientation, amount of lengthening, and postoperative leg length inequality. Anteversion was calculated using the angle of the opening of the ellipse, as calculated by the Radlink software (El Segundo, CA).

Results

The average age of patients at the time of index surgery was 57 years (range, 31 to 81). Patients included eight men and two women. One of the men had bilateral LCPD and underwent staged DA-THA. Using the Stulberg classification, there were two class II, four class III, and five class IV patients.[3] No patient had undergone prior surgical correction.

The mean time to follow-up for surviving patients was 3.3 years (range, 1 to 6). The mean HOOS, Jr was 94 (range, 81–100). At final follow-up, there were no perioperative fractures, nerve injuries, dislocations, infections, readmissions, or revisions. There was one death 28 days after surgery following an uncomplicated hospital course and discharge to home on postoperative day two. The patient was 67 years old with a history of stable coronary artery disease, prior myocardial infarction, and drug misuse. The cause of death was unknown but assumed to be pulmonary embolism, sudden cardiac death, or overdose, according to the primary care doctor.

Radiographic Outcomes

The average acetabular abduction angle was 44 degrees (range, 42 to 46), and the average anteversion was 20 degrees (range 16 to 24). The average amount of preoperative limb length inequality was 17 mm (range, 2 to 54) of shortening. The average amount of postoperative limb length inequality was 6 mm (range, 0 to 28). The average amount of operative limb lengthening was 11 mm (range, 0 to 26). Ten of the patients were lengthened between 0 and 18 mm, and one patient was lengthened 26 mm. This patient started with a 54 mm discrepancy, and it was decided preoperatively to limit the correction to 25 mm as a neuroprotective measure. No hip was lengthened beyond the contralateral side. The average offset preoperatively was 22 mm (range, 19 to 32) with the pelvis level. Postoperatively, the average offset was 20 mm (range, 13 to 28).

Discussion

While modern THA has proven to be an effective and durable treatment for secondary arthritis in LCPD, the immediate perioperative risks of sciatic nerve palsy and excessive leg lengthening remain an ongoing concern. The technical challenges of leg shortening, joint incongruity, and multiplanar deformity create unique risks when placing implants. The purpose of this study was to evaluate the specific technique of DA-THA with fluoroscopy as a tool to decrease the risk of excessive lengthening and consequent nerve injury in this specific patient population.

Patients with LCPD frequently present with a developmental leg length discrepancy (LLD). In the absence of normal skeletal growth, the surrounding neurovascular bundle and soft tissues are developmentally shorter as well. While stretching the tissues beyond their physiological adaptability is to be avoided, the actual amount of lengthening the sciatic nerve can tolerate is unclear. Edwards et al warned of a greater risk beyond 4 cm of lengthening, although complications were noted beyond 2.2 cm.[11]

Whereas there is a 0.17% risk of sciatic injury in THA for osteoarthritis overall, the risk for LCPD patients is substantially higher.[7] Several series have reported rates of perioperative nerve palsy between 3 and 6%.[5,12,13] Using

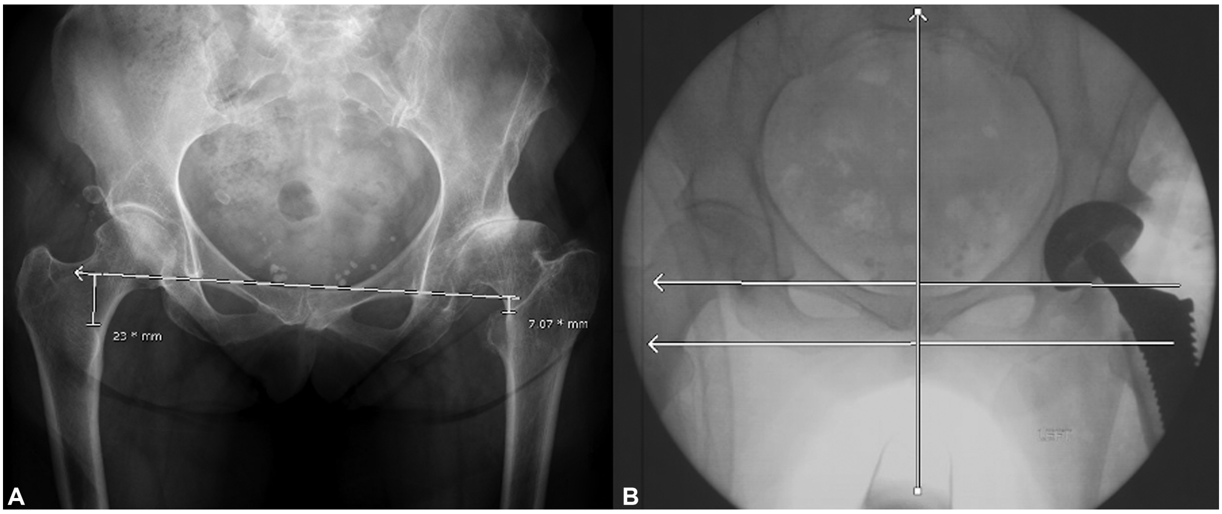

Fig. 3 Confirming cup position and trial implants. (**A**) Preoperative Stulberg IV with 16 mm of shortening and high hip center. (**B**) Intraoperative imaging used to evaluate cup height, depth and orientation and the comparative length of the stem-neck-head construct.

conventional methods without fluoroscopy, Baghdadi et al reported neurological complication in 3 of 99 cases.[13] These three cases were lengthened a mean of 2.2 cm, in contrast to lengthening of 1.4 cm in those without neurologic injury. Luo et al reported sciatic nerve palsy in 2 patients lengthened 3.1 cm and 3.6 cm.[12] Traina et al attributed a neurological complication rate of 6% to excessive limb lengthening.[5] Perhaps because the mean lengthening of our cohort was 11 mm, there were no neurological injuries. Moreover, we intentionally attempted to limit correction to less than 2.5 cm, in order to mitigate the risk of nerve stretch.

Intraoperatively, measuring the exact amount of lengthening in LCPD with conventional methods is challenging. In LCPD, lengthening is related to changes in both the acetabular COR and the head-neck length. Typically, only the change in femoral length can be measured. The change in position of the acetabular COR cannot be measured reliably. Consequently, restoring the appropriate leg length is an estimate based on gross clinical measurements of shuck testing, stability check, and position of the feet.

Adjunctive technologies that provide real-time feedback may reduce the risk of unanticipated lengthening found on the postoperative radiograph. Shah et al used computer navigation in two patients to improve leg length equality.[14] In our series, we found that fluoroscopy offered a reliable way to calculate and confirm hip length. With the trials in place and the hip reduced, fluoroscopy was used to confirm that the hip was not excessively lengthened, and that a paradoxical inequality with the contralateral hip was avoided (►**Fig. 3**). Any radiographic evidence of excessive lengthening was immediately corrected.

Applying this method in our small series, the starting LLD was improved in all cases (►**Fig. 4**). The mean increase in combined hip length was 11 mm (range, 0 to 26). In the one case with a starting LLD of 5.4 cm, we lengthened the leg by 2.6 cm, despite our intention to lengthen less than 2.5 cm. Fortunately, this patient did not have a perioperative nerve complication. Alternatively, patients with a comparably sizable LLD may be reasonable candidates for femoral shortening osteotomy.[15]

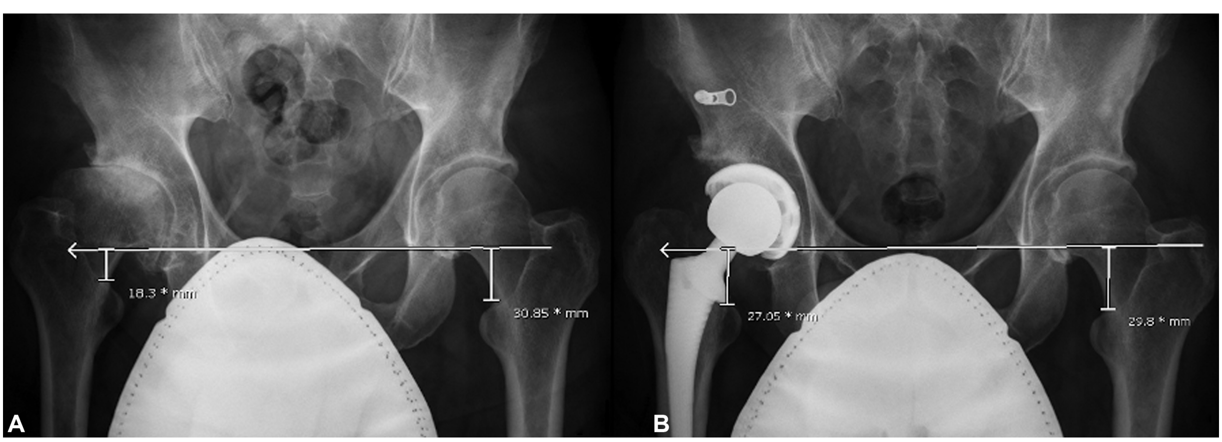

Fig. 4 Managing leg length discrepancy in total hip arthroplasty (THA) for Stulberg IV deformity. (**A**) Preoperatively, right hip with starting deformity of 12 mm shortening, coxa magna, coxa breva and acetabular dysplasia. (**B**) Follow-up radiograph showing cup with restored anatomic center of rotation, femoral offset, and 3 mm of shortening.

In addition to providing valuable information regarding leg length, the use of fluoroscopy ensured both accurate and precise acetabular cup orientation. Patients with Stulberg III class or higher will exhibit changes that distort normal anatomic landmarks. In the acetabulum, for example, a steep slope can lead to an unintentionally high hip center, a shallow base can bias toward vertical cup placement for the concern of coverage, and a developmental retroversion can misrepresent landmarks guiding the degree of cup anteversion. Consequently, Traina et al noted that 6 of 32 cups (19%) fell outside the planned safety zone of 30 to 50 degrees.[5] With the use of fluoroscopy, our cup abduction angle and anteversion had precisely narrow ranges of 4 degrees and 8 degrees, respectively, and were both within the accepted safety zones.

Despite the immediate perioperative risks, patients with LCPD fare well in follow-up. Multiple studies report good clinical outcomes, with mean Harris hip scores (HHS) ranging from 87 to 93 (Traina 87.5, Seufert 93, and Baghdadi 88).[5,13,16] Our study supports these findings.

There are several limitations of this study. It is a single surgeon's small retrospective series. Larger numbers of patients may reveal a complication profile similar to that of other series. A second limitation is the variable preoperative leg length discrepancy among subjects, but this is the nature of this complex condition. Another major limitation is the lack of a control group for comparison. A matched cohort of patients with primary arthritis treated with the DA approach and fluoroscopy could be compared with this series. However, the study would still be substantially undersized to define statistically significant observations and would most likely require a multicentered study to validate major findings. Additionally, patients with primary osteoarthritis do not exhibit the same preoperative deformity or postoperative risk profile as those with LCPD. Another concern is that a minimum 2-year follow-up is more common, but we chose a minimum 1-year follow-up for analysis because the primary endpoints were immediate nerve palsy, cup malposition, and LLD. Finally, with the recent transition to patient-reported outcome using the HOOS Jr score, a preoperative score was not available for comparison.

Conclusion

The sequelae of childhood LCPD may develop into challenging and symptomatic multiplanar deformities many decades later. The characteristic malformations in hips with Stulberg class III and higher changes increase the potential for intraoperative miscalculations and postoperative complications. The historic risks of sciatic nerve injury, LLD, and cup malposition are comparably higher. Modern techniques, as shown in this series, offer the potential to improve these outcomes. While the procedure is not without substantial health risks, a DA-THA with the use of fluoroscopy may guide the surgeon toward safer and more precise reconstructive choices when faced with such difficult anatomy.

Conflicts of Interest
None declared.

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