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Case Report

The Practicality of the Robotic Total Hip Arthroplasty for the Treatment of Complex Bilateral Adult Hip Dysplasia. Technology Makes It Easy

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ABSTRACT

Adult hip dysplasia provides many challenges for joint surgeons. Due to the abnormal bone morphology and altered biomechanics of the hip, surgeons must ensure accurate implant positioning to avoid postoperative complications. We present a 56-year-old female with a history of bilateral Legg-Calve-Perthes disease and subsequent dysplasia who underwent bilateral total hip arthroplasty using robotic navigation. We highlight the utility of robotic navigation in adult hip dysplasia to improve implant positioning and ensure optimal patient outcomes.

Introduction

Adult dysplasia of the hip presents many challenges for total joint arthroplasty in the setting of degenerative joint disease. With abnormal bone morphology, soft-tissue restraints, and a younger patient population, component positioning is imperative to successful outcomes [1–3]. One cause of adult dysplasia is Legg-Calve-Perthes disease, a pediatric disorder characterized by osteonecrosis of the femoral head leading to resorption and subsequent collapse. Consequently, acetabular remodeling secondary to the abnormal joint forces caused by an aspherical femoral head can lead to the late complication of hip dysplasia [4,5]. The Crowe Classification is widely used to stratify the acetabular and femoral variations of adult dysplasia, which serves as a valuable tool in preoperative planning of complex arthroplasty cases. The classification is divided into 4 grades based on the percentage of femoral head subluxation and proximal displacement of the femoral head: group 1, <50% subluxation; group 2, 50%-75% subluxation; group 3, 75%-100%, and group 4, >100% subluxation and proximal displacement of the femoral head divided by the pelvic height [6]. Preoperative radiographs and computed tomography (CT) should be obtained as they aid in identifying leg length discrepancy, locating the hip center, and optimizing implant sizing and alignment.

Over the past decade, there has been expansive use of robotic navigated surgery. Robotic navigation allows surgeons to match the preoperative CT to accurately align the component within the optimal alignments defined by the Lewinnek and Callanan safe zones [7]. Prior studies show that robotic assisted surgeries provide more accurate acetabular cup positioning than conventional surgery [8]. We introduce our case in which robotic technology was used to achieve accurate component alignment and successful postoperative outcome in a patient with adult hip dysplasia secondary to Legg-Calve-Perthes. Written informed consent was obtained for publication of this case report.

Case history

Our case involves a 56-year-old female with a past medical history of hypertension and long-standing bilateral hip pain found to have adult hip dysplasia secondary to Legg-Calve-Perthes disease. At presentation, she had difficulty walking and standing and used a cane or walker. On physical examination, the patient demonstrated limited range of motion in the bilateral hips without

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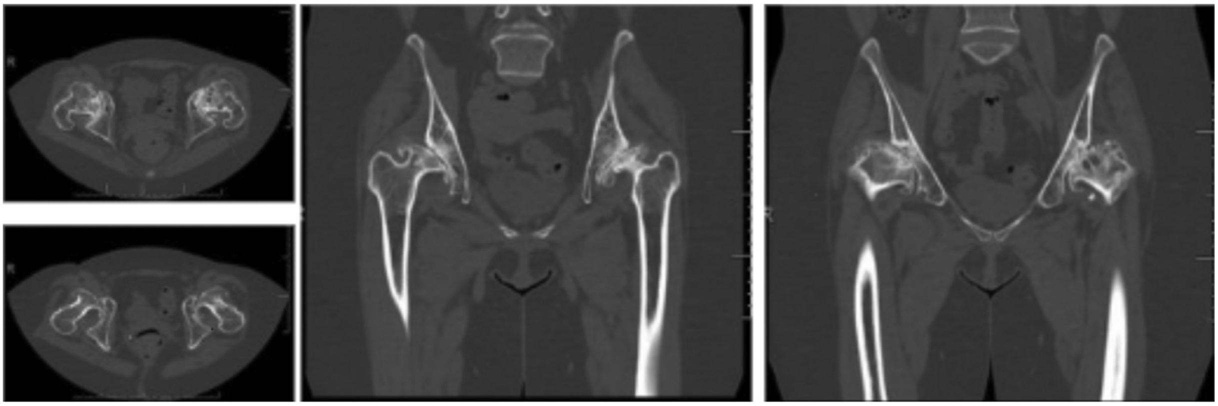

Figure 1. Preoperative computed tomography scans showing Crowe grade 2 adult hip dysplasia.

gross instability or impingement. Radiographs performed at an outside facility showed acetabular dysplasia with subluxation of the femoral head on the acetabulum. Preoperative CT revealed Crowe grade 2 adult hip dysplasia and showed advanced joint space narrowing, coxa magna, coxa vara, and coxa plana (Fig. 1). In the setting of her severe bilateral hip pain and active job, a shared decision was made to perform bilateral total hip arthroplasty (THA). Given this patient's acetabular bone deficiency and the need for accurate component compositing, robotic navigation using the Stryker MAKO system (Kalamazoo, MI) was chosen (Fig. 2). The aforementioned preoperative CT was used for robotic planning.

Operative technique

Upon arrival to the operating room, per our institutions' standard THA protocol, spinal anesthesia was administered by the anesthesia team. The patient then underwent general anesthesia, and an electrocardiogram (EKG) lead was placed along the lateral distal femur bilaterally. The left hip was chosen first, and an incision was made directly over the iliac crest. Two 4.0-mm Steinmann pins (Brasseler USA, Savannah, GA) were placed in the iliac crest. A standard posterior approach was used to gain access to the hip. To achieve initial spatial mapping with the software used, an EKG lead was placed at the lateral knee prior to draping, and a small metal pin was placed in the greater trochanter during the approach, which are both used as "checkpoints". Once the approach is completed, we registered leg lengths using the system-included probe to make contact with the metal tip of the EKG lead and the greater trochanteric checkpoint. Following this step, the external rotators and capsule were taken down as one layer, and the hip was dislocated. Once the femoral neck and head were removed, broaching of the femur was completed. Attention was then turned to the acetabulum. An acetabulum checkpoint (small metal pin) was placed at the 12 o'clock position in the acetabulum. All excess labrum was removed. We then performed a registration using the probe. We mapped the points outside the acetabulum going posterior to anterior and mapped multiple points in the acetabulum. Once we were completed with the registration, the robotic arm was brought into the surgical field, and we reamed directly to the predetermined cup size with the robotic arm. The cup was then placed using the robot arm to ensure we were at about 40° of abduction and 20° of anteversion. A 30-mm screw was then manually placed for additional cup fixation. A single acetabular screw is the standard for the surgeon who performed this procedure to potentially provide an extra layer of protection from cup loosening. The cup was well fixed, so a dual-mobility acetabular liner was placed. The

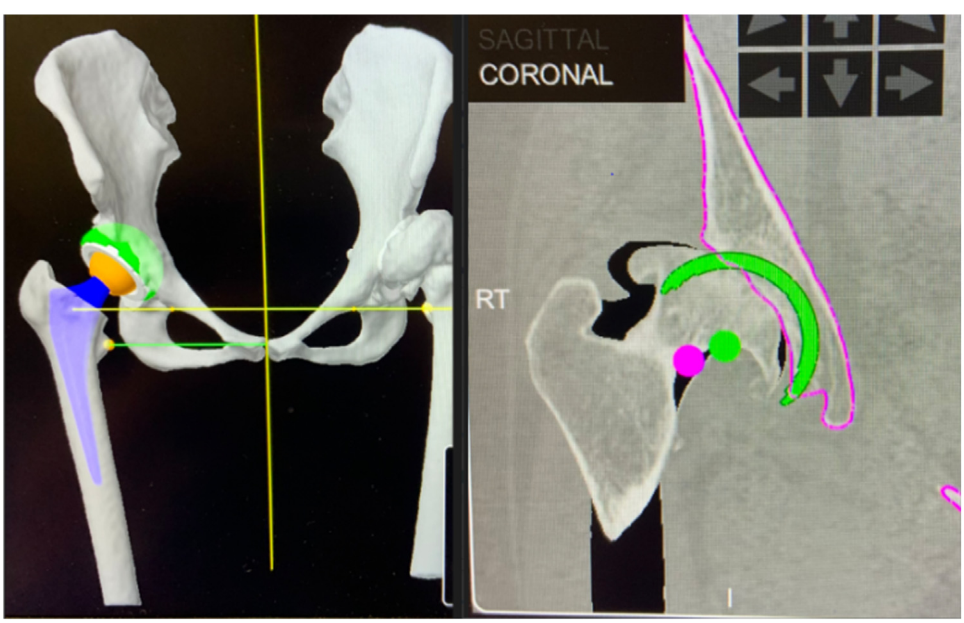

Figure 2. Preoperative planning example of the right hip showing acetabular medialization as well as planned cup abduction and anteversion.

Figure 3. Postoperative-day-1 radiographs showing bilateral total hip arthroplasties in the optimal position.

femoral component was then impacted, and the head was trialed to the appropriate head size, showing excellent stability. Final implants were as follows: Stryker 46 Acetabular Cup, 36 dual-mobility acetabular liner, 36 × 22 head, 0-neck length, #2 femoral stem with a 127° neck angle. Multilayer closure was performed, with staples used for the skin.

The patient was flipped to the left lateral decubitus position and re-prepped and draped in normal sterile fashion. The same procedure as the aforementioned one was performed for the right hip. The cup was placed again using the robot arm to ensure we were at about 40° of abduction and 20° of anteversion. A 30-mm screw was also placed for additional cup fixation. Final implants were as follows: Stryker 46 Acetabular Cup, 36 dual-mobility acetabular liner, 36 × 22 head, +3-neck length, #2 femoral stem with a 127° neck angle. Multilayer closure was performed, with Exofin fusion dressing (Chemence, Atlanta, GA) used for the skin.

There were no complications postoperatively. She was placed on low-dose apixaban for deep vein thrombosis prophylaxis. Immediate postoperative radiographs are seen in Figure 3. She was seen by the physical therapy team for 2 sessions on postoperative day 1, in which she ambulated 200 feet and 150 feet, respectively, both times with a rolling walker. On postoperative day 2, she reported adequate pain control, walked another 150 feet with a rolling walker without assistance, and was discharged to home.

The patient was not readmitted for any reason and has had 4 outpatient follow-up visits. Two-week postoperative images are shown in Figure 4. At her 2-week visit, she reported a pain level of 4 out of 10 and was ambulating with a walker, with no complications. At her 3-month follow-up visit, she reported completing her normal daily activities with little to no difficulty and was ambulating without assistive devices. At 12-month follow-up, she had no complaints and reported increased strength and endurance of her hip at work (Fig. 5). No dislocation events or wound complications were seen.

Discussion

Legg-Calve-Perthes disease has an incidence of 1 in 1000 children and a 5:1 male to female ratio. Bilateral Legg-Calve-Perthes disease occurs in only 12% of affected children [5]. Progression of our patient's bilateral disease led to bilateral coxa magna, vara, and plana, causing subsequent remodeling and acetabular dysplasia bilaterally. Using the Crowe classification, we classified our patient as a grade 2, with 10%-15% proximal migration of the femoral heads compared to pelvic height and 50% subluxation of the femoral heads bilaterally. While bilateral hip arthroplasty is a challenging endeavor for both the surgical team and the patient, there were several reasons why we believed this patient to be appropriate for this procedure. First, our patient reported living an active lifestyle with a job that demanded her to be on her feet for extended periods of time. Given her desire for one hospital stay and a single rehabilitation period, bilateral THA would avoid a second hospital stay and a longer period of work absence. Next, a unilateral THA would cause overcompensation of the contralateral hip, thereby impeding her recovery secondary to increased pain. Finally, studies have shown that single-stage bilateral THA has a lower incidence of systemic complications and lower risk of deep vein thrombosis with no significant differences in pulmonary embolism, cardiovascular complications, or postoperative infections [9].

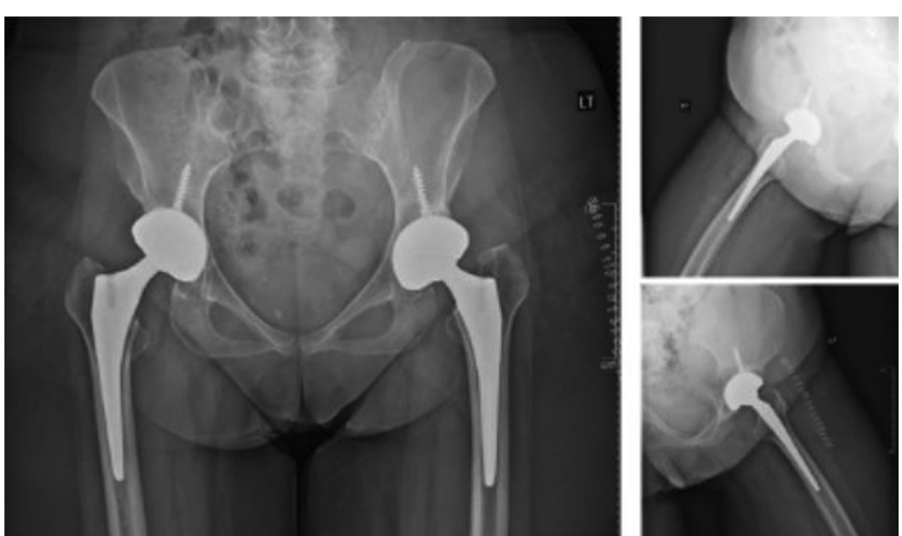

Figure 4. Postoperative 2-week radiographs showing bilateral total hip arthroplasties in optimal position.

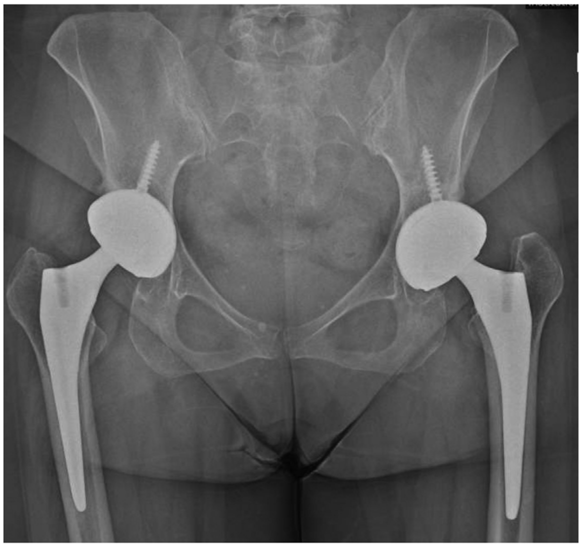

Figure 5. One-year follow-up radiographs showing bilateral total hip arthroplasties in the optimal position with no evidence of hardware failure.

Our preoperative plan was to reconstruct the hip center of rotation at the anatomic center. We decided that to provide the most optimal component alignment and leg lengths, we would use robotic navigation. Studies have shown that surgeons tend to overestimate acetabular cup inclination and underestimate anteversion, leading to increased risk of dislocation, wear, and decreased range of motion [10]. In a matched pair control study, a single surgeon performed 160 THAs that were separated into robotic navigated vs conventional arthroplasty. Results revealed 100% (50/50) of the robotic-assisted THAs were within the safe zone described by Lewinnek et al. (inclination, 30°-50°; anteversion, 5°-25°), while the conventional THAs were within 80% [10]. Ninety-two percent (46/50) of robotic-assisted THAs were within the modified safe zone described by Callanan et al. (inclination, 30°-45°; anteversion, 5°-25°), compared with 62% (31/50) of conventional THAs [11]. By using robotic technology, we registered anatomical checkpoints to ensure proper cup positioning with our planned cup inclination and anteversion of 40° and 20°, respectively. Postoperatively, we achieved 41.4° of inclination and 21.3° of anteversion for the left hip and 39.0° of inclination and 19.5° of anteversion for the right hip. Therefore, with robotics for planning, we were able to remain within the Lewinnek and Callanan safe zones [10–12].

While robotic navigation allowed accurate component positioning, we elected to proceed with dual-mobility implants to provide increased stability without compromising range of motion given the abnormal bone morphology and soft-tissue restraints. Stroh et al. reviewed dislocation rates of dual-mobility implants vs standard components for both primary and revision THAs [13]. Results of the study revealed dislocation rates of 0.1% for primary THAs using dual-mobility implants vs 2%-7% for primary THAs using conventional implants. Revision THAs using dual-mobility implants had a dislocation rate of 3.5%, while the conventional components had a rate of 16% [13].

Summary

Bilateral robotic navigated THA is a viable option for the treatment of hip dysplasia secondary to Legg-Calve-Perthes disease.

Conflicts of interest

The authors declare there are no conflicts of interest.

For full disclosure statements refer to https://doi.org/10.1016/j.artd.2023.101249.

Informed patient consent

The author(s) confirm that written informed consent has been obtained from the involved patient(s) or if appropriate from the parent, guardian, power of attorney of the involved patient(s); and, they have given approval for this information to be published in this case report (series).

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