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Surgical technique

Direct anterior approach total hip arthroplasty for Crowe III and IV dysplasia

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ABSTRACT

High-dislocated hip dysplasia is challenging to treat with total hip arthroplasty via the direct anterior approach (DAA). The DAA has potential advantages including optimizing component positioning, enhanced hip stability, and a more rapid postoperative recovery. We present a surgical technique for DAA total hip arthroplasty for hip dysplasia that includes preoperative planning, soft tissue releases, subtrochanteric osteotomy, component placement, and intraoperative nerve monitoring and imaging. This technique provides detailed technical instructions, specifically including pearls and pitfalls, and complication prevention strategies.

Introduction

Interest in using the direct anterior approach (DAA) in total hip arthroplasty (THA) has been steadily rising in recent years [1]. The DAA is often used for mild pathologies of the hip with less soft tissue contractures, bone defects, articular deformities, and when standard implants can be utilized [2]. High-dislocated developmental dysplasia of the hip (DDH), defined as type III and IV in the Crowe classification, is typically considered a contraindication for DAA due to the considerable challenges caused by multiplanar deformities, complex lumbar-pelvis-hip pathology, advanced reconstruction and correction techniques required, and implant difficulties [3-6].

We present a surgical technique for DAA THA for Crowe type III and IV DDH, which includes preoperative planning, soft tissue release and exposure, acetabular and femoral preparation, subtrochanteric osteotomy, component placement, and reduction technique. We also introduce intraoperative computerized tomography (CT), computer navigation, and nerve monitoring.

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Preoperative planning

Anteroposterior and lateral hip radiographs are templated before surgery for implant size, femoral neck cut, femoral offset, and site of the subtrochanteric osteotomy (STO) when indicated. The acetabular component is placed at the true hip center (anatomic center) regardless of bone defects, which can be addressed with autograft or metal augment. The femoral neck cut is located 5-15 mm above the lesser trochanter level, depending on the preoperative templating.

Anteroposterior and lateral lumbar radiographs, as well as the bending x-ray of the lumbar region, are used to determine the pelvis position in the sagittal plane and the flexibility of the lumbar spine. Standing full-length x-rays are used for STO planning and correcting leg length discrepancy (LLD).

Algorithm for limb length equalization

Many factors can contribute to LLD, including hip dislocation, length of the femur and tibia as many cases have overgrowth, spine-pelvis relationships, intra-articular deformities, extra-articular deformities, and pathologies of the contralateral hip [7]. Although this is a complex interaction of factors, we recommend the four-step algorithm to balance the LLD (Fig. 1a and b).

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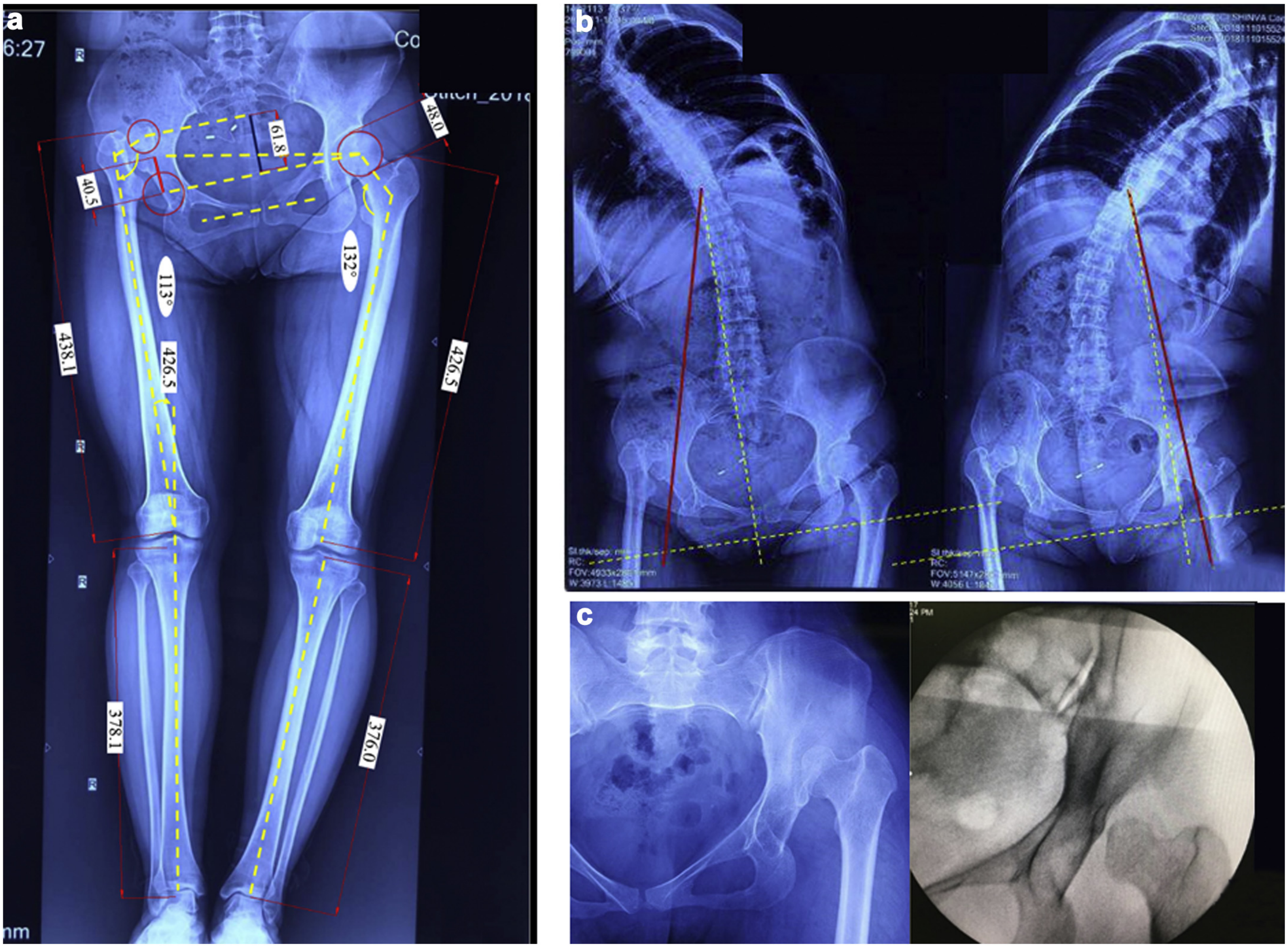

Figure 1. (a) Preoperative planning with stepwise algorithm for limb length equalization. Step 1: Hip reduction would increase the limb length by 61.8 mm. Step 2: The overgrowth of the right femur in anatomical length is 11.6 mm. Step 3: Correction of the pelvic inclination reduced the limb length by 40.5 mm. Step 4: a standard femoral stem (135° in CCD) might mildly increase limb length in cases of coxa vara. Length needed for STO is 9.7 mm. (b) Spinal flexibility and compensation possibility determined by bending radiographs. (c) The reduction height under axial distraction by intraoperative fluoroscopy to estimate the possibility of anatomical reduction, the magnitude of soft tissue release, and need for STO.

Step 1: Determine the dislocation height.
Step 2: Measure the length of the lower limb.
Step 3: Establish the magnitude of the pelvic tilt and lumbar scoliosis.
Step 4: Adjust the length caused by the intra-articular and extra-articular abnormalities.

Positioning and approach

The patients received general anesthesia because of the complex nature of these cases and are positioned supine on a standard operating table. Both lower extremities are prepped and draped to allow for direct comparison of limb lengths intraoperatively and for stability testing. Manual axial traction of the operative hip is used to determine the ability to obtain reduction, the magnitude of soft tissue releases needed, and the need for STO (Fig. 1c).

A standard 8-12 cm incision is made beginning 2 cm lateral to the anterior superior iliac spine and centered over the muscle belly of the tensor fascia latae (TFL) and a standard approach is completed as described in the technique paper by Ong and York et al [2,8].

The femoral neck cut is then completed with the femoral head in the pseudoacetabulum. The cut is performed with a reciprocating saw at about 10 mm proximal to the lesser trochanter based on preoperative templating to allow for proximal stability of the femoral stem. The femoral head is then extracted.

Soft tissue releases

Because chronic dislocation causes soft tissue contractures, adequate release of the soft tissue is crucial to achieve proper joint tension, hip reduction, and limb length equalization. A stepwise procedure including pie-crusting of the adductor tendon, sleeve-like capsulectomy, partial release of psoas tendon and iliotibial band (ITB), release of the reflected head of the femoral rectus, and STO efficiently retunes the soft tissue tension (Fig. 2a).

The tightened fibers of the adductors can be palpated and released with a sterile sharp blade before draping. The ITB release, at the level of 5 cm proximal to the lateral femoral epicondyle, can be performed intraoperatively or postoperatively, according to the reduction requirement and physical examination. For Crowe type IV or posterolateral dislocation, the anterior approach can be extended proximally and the TFL can be sharply released from the iliac crest. The tendinous portion of the TFL is tagged and repaired at the end of the cases.

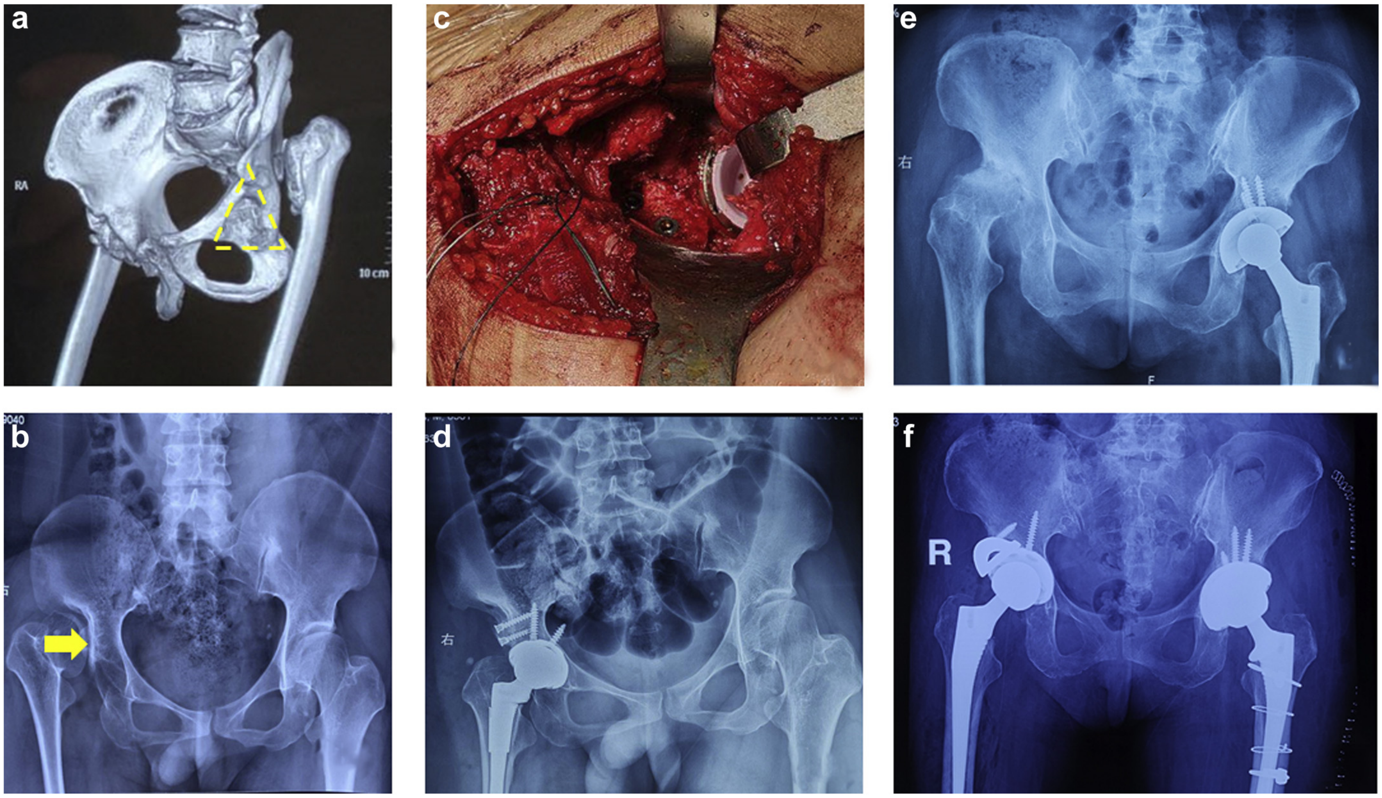

Figure 2. (a) Developmental dysplasia of the acetabulum typically exhibits as a triangle-shaped fossa inferior to the pseudoacetabulum. (b) Sclerotic bone between the false and true acetabulum causes the rotation center to move distally. (c and d) Femoral head autograft bone grafting to address acetabular bone defects. (e and f) Tantalum metal augments to enhance the initial stability and address bone defects.

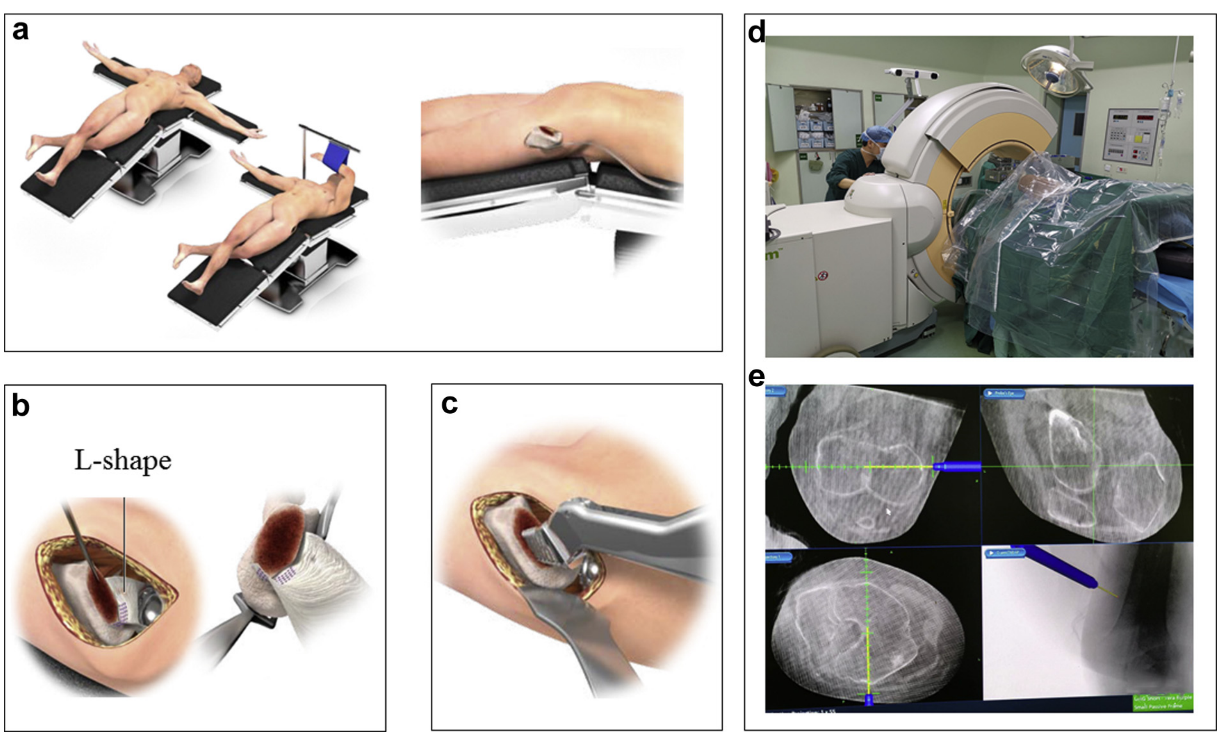

Figure 3. (a) Femoral broaching and reaming can only be initiated when adequate exposure of the proximal femur is achieved. (b) Femoral release of the superomedial capsule attachment at the base of the great trochanter using a reverse "L" manner until the internal side of the great trochanter is visualized. (c) Adequate release is achieved by moving the broach straight into the femoral canal without any obstruction from the iliac crest. (d) Intraoperative CT scanning and navigation to determine the degree of femoral anteversion. (e) The transepicondylar axis of the femoral condyle is used as a reference, and the femoral anteversion is set to be 10°-15°.

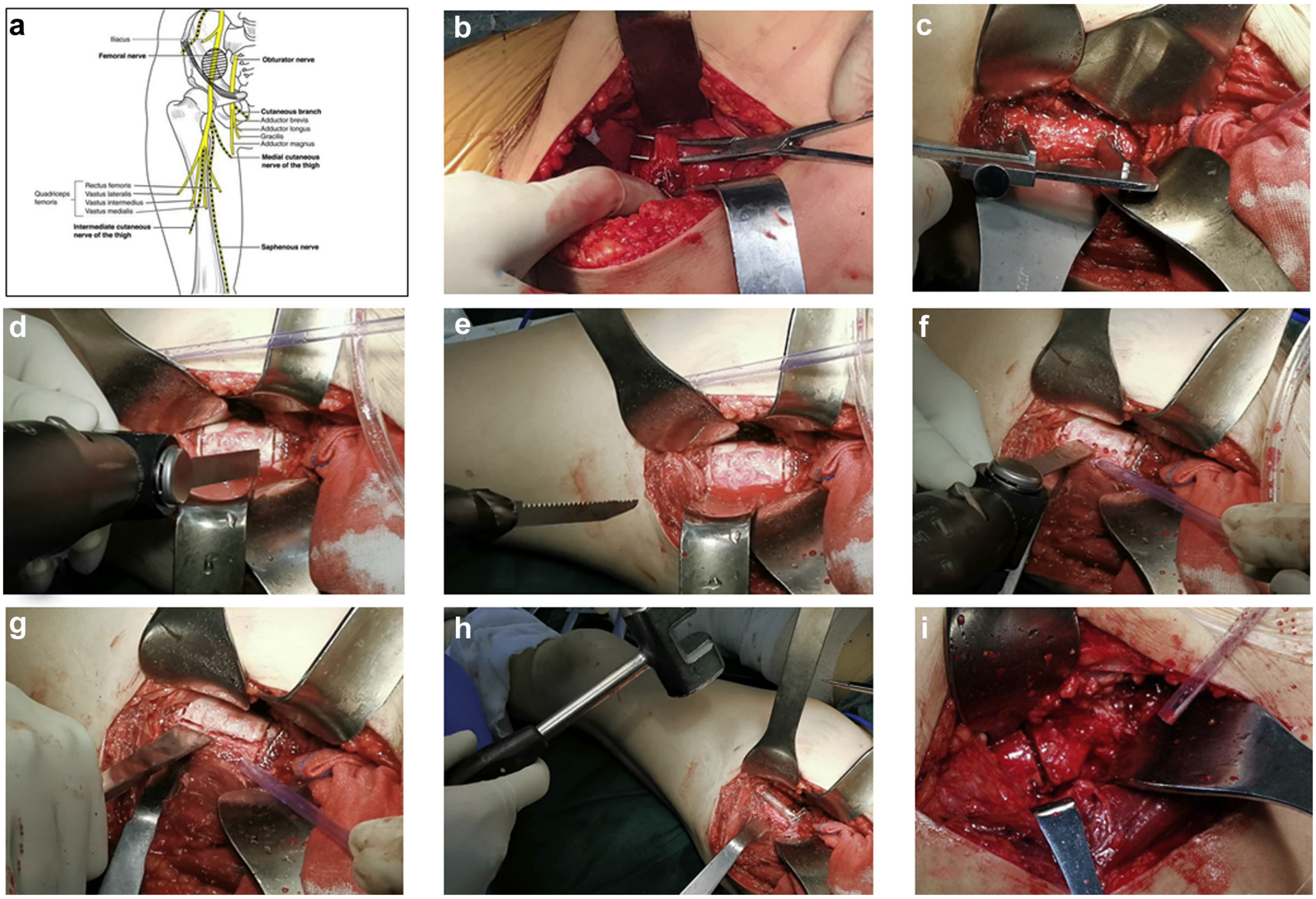

Figure 4. (a and b) The anatomy of the femoral nerve branches to the quadriceps femoris. (c) The osteotomy site is determined and the proximal and distal segments are protected by cerclage wire. (d-g) An osteotomy is performed at the anterior cortex of femur using a suspension saw, at the medial and lateral cortex using a reciprocal saw, and at the posterior cortex by using a 1.5 mm drill and a thin osteotome. (h) The osteotomy should be conducted under direct supervision to prevent damaging the titanium flute of the stem. (i) The final impaction of the femoral stem is completed.

A sleeve-like whole capsulectomy is a key step, which is the removal of all portions of the capsule around the femoral head. The anterior capsule can be removed first by an “H” shaped resection as performed in a standard DAA. Then, the femur is externally rotated to reveal the posterior aspect of the capsule, followed by excisions of the superior, posterior, and inferior capsule.

Preparation of the acetabulum and component placement

After the femoral head has been removed, there are 3 methods for identifying the true acetabulum. The first is to follow the ligamentum teres distally to the cotyloid fossa. The second is to identify the inferior capsule, which may be in line with the transverse ligament. The third is to identify and palpate bony landmarks (anterior and posterior walls of the acetabulum). Typically, there is a triangle-shaped fossa inferior to the pseudoacetabulum, which contains fatty tissue and is the location of the true acetabulum (Fig. 2a).

Two pitfalls should be addressed in restoring the anatomic hip center. One strategy is to avoid lowering of the rotation center by removing the sclerotic bone at the superior margin of the true acetabulum (Fig. 2b). Another strategy is to avoid concentric reaming along the true acetabulum, which may result in anteriorization of the rotation center and iatrogenic pelvic discontinuity. The authors suggest removing the osteophytes and sacrificing a small portion of the posterior wall of the true acetabulum using a sharp thin osteotome before reaming. For most Crowe type III case, the bony coverage is not sufficient for supporting the initial stability of the noncemented shell because of the bone defect located in the superior and posterior aspects of the acetabulum. Thus, the bone defect can be corrected by autografting the femoral head or supporting it with a tantalum metal augment (Fig. 2c-f). For both metal augment and bone grafts, removal of sclerotic bone or cartilage layer on the articulation is necessary to achieve bone integration. The augmentation that is achieved first, followed by implanting a high-porous acetabular shell, would secure sufficient initial stability.

The implantation techniques are similar to those used in traditional anterior approaches [2,3,7]. The cup is placed in 35°-40° of inclination and 10°-15° of anteversion for unilateral DDH, 30°-35° of inclination for bilateral DDH, and in 5°-10° of anteversion from the original pelvis. The inclination and anteversion angles increase with the gradual correction of pelvic tilt and abdominal flexion within 3-9 months after surgery. Computer navigation is recommended when the pelvis is found in extreme tilt or inclination. On this occasion, the proper position of the acetabular shell should be predicted accurately in preoperative planning and be reproduced by navigation (StealthStation 7.0, Medtronic, Minneapolis, MN) intraoperatively.

Femoral preparation and component placement

A standard femoral release and placement of the femoral stem can only begin after adequate exposure of the proximal femur is

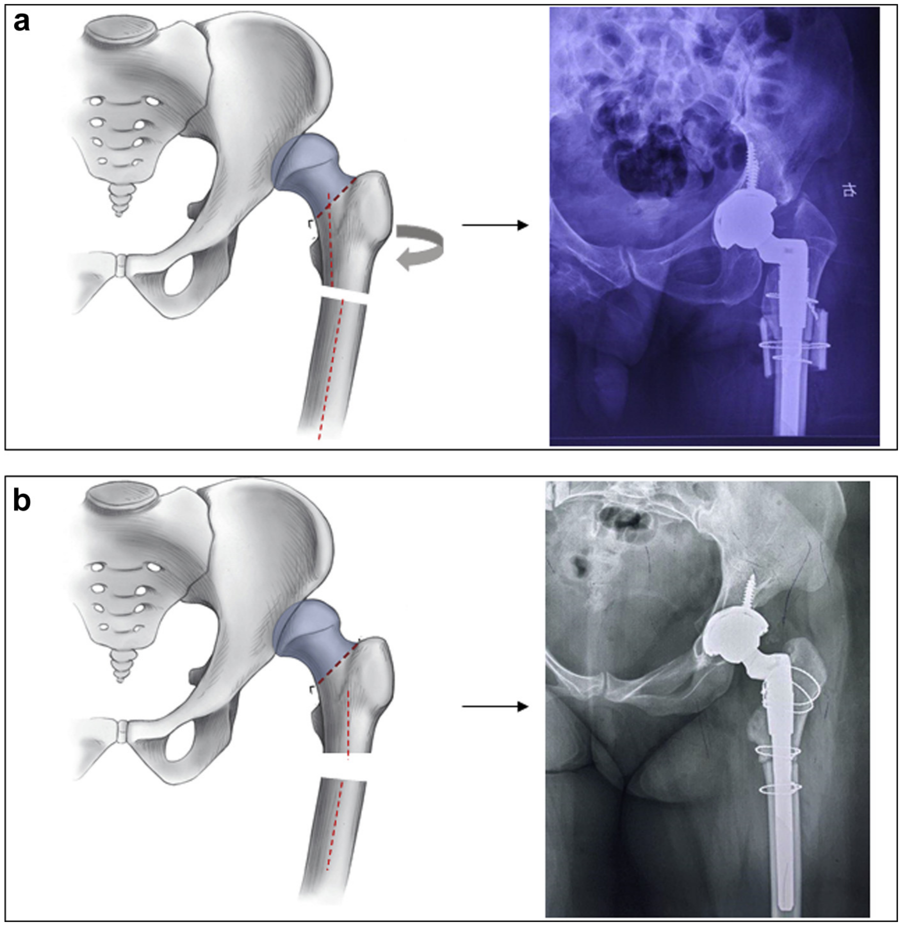

Figure 5. (a) STO can be designed to correct the anteversion by derotating the proximal femur in cases with an increased anteversion deformity of the hip. (b) STO can also be designed to correct the axial deformity of the femoral canal by adjusting the axial alignment using an oblique osteotomy at the proximal femur and a horizontal osteotomy at the distal femur.

achieved (Fig. 3a). Femoral release begins with releasing the superomedial capsule attachment at the base of the greater trochanter using a reverse "L" manner until the internal side of the great trochanter is visualized (Fig. 3b). The release might extend to the piriformis fossa, but not beyond to avoid violating the conjoined tendon. An ideal release is indicated by creating a straight path for the broach into the femoral canal without any obstruction from the iliac crest (Fig. 3c).

A pitfall at this point is the need to determine the femoral anteversion by the bony landmarks around the proximal femur. The authors advise using the transepicondylar axis of the femoral condyles as the reference to set anteversion at 10°-15°. If necessary, a guide wire can be placed along the transepicondylar axis using anteroposterior and lateral views of intraoperative fluoroscopy, or with the assistance of intraoperative CT (O-arm; Medtronic, Minneapolis, MN; Fig. 3d and e).

Standard proximal broaching and distal reaming is performed [6,9]. Successful implantation of a modular femoral prosthesis (S-rom; DePuy, New Brunswick, NJ) requires more elevation and lateral translation of the proximal femur than that of a regular stem. Release of the TFL or partial release of the piriformis is required for some Crowe type IV cases to minimize the intraoperative risks, such as femoral perforation/fracture. It is crucial to be aware of the deformity below the lesser trochanter, including malalignment and inconsistency of the canal.

Subtrochanteric osteotomy

The STO is indicated only for functional equalization of the lower limb, prevention of sciatic nerve injury when the limb is lengthened more than 5 cm, and when nerve monitoring indicates that reduction of the hip results in nerve injury. For very young patients, the above four-step algorithm for limb length equalization is recommended for full recovery of the LLD. But for relatively old patients, the traditional technique depending on the overlap between the proximal and distal femur described by Denial Berry [9] usually works well to achieve the aim of limb length equalization.

In detail, the incision is extended distally 3-5 cm for cases needing an STO. We recommend exposing the osteotomy site by splitting the vastus lateralis as exposure between the interval of vastus lateralis and rectus femoris may increase the risk for nerve injury (Fig. 4a and b).

The osteotomy is performed after placing the final femoral stem, as the distal fragment is difficult to control after the osteotomy. The starting point for the osteotomy is 1.0-1.5 cm distal to the lesser trochanter. The proximal and distal segments of the osteotomy are protected by cerclage wire to prevent fracture. Then, the proximal and distal osteotomies are completed. The anterior cortex of the femur is cut using a suspension saw, the medial and lateral cortices are cut using a reciprocating saw, and the posterior cortex is perforated using a 1.5 mm drill and the cut is completed with a thin osteotome. The bone cut should be made under direct supervision to avoid damaging the stem. Final impaction of the femoral stem is completed. If there is gapping, this can be filled with autogenous morselized bone derived from acetabular reaming (Fig. 4c-i).

The STO functions to shorten the limb but also to correct the anteversion by derotating the proximal femur and adjusting the axial alignment via an oblique osteotomy on the proximal femur and a horizontal osteotomy at the distal femur. The latter 2 methods increase the lever-arm of the abductor complex and further minimize impingement, instability, and limping (Fig. 5a and b).

Reduction

After the femoral head is impacted on the stem, the hip is reduced in standard fashion. Intraoperative nerve monitoring of the femoral and sciatic nerves can be used to detect nerve injury during reduction. An abnormal evoked potential strongly indicates over-lengthening of the nerve and an STO or lowering of the center of rotation should be completed.

Postoperative course

The patients maintain the hip in moderate flexion (40-50 degree) and knee in mild flexion (10-20 degree) to relax the femoral and sciatic nerves and then gradually reach full extension within 24 hours after surgery. For 3 weeks, the patients are protected weight-bearing with crutches. For patients with an STO, they are toe-touch weight-bearing for the first 3 weeks, then transition from partial to full weight-bearing 6 weeks after surgery.

Discussion

Despite a well-documented learning curve for treating DDH via DAA, success still relies on careful preoperative planning and intraoperative implementation [10]. After the surgeon is experienced in performing the DAA in patients with Crowe type I and II DDH, they can consider the DAA for patients with Crowe type III or IV dysplasia. We have illustrated an efficient and reproducible way to ensure favorable surgical performance of the DAA in high-dislocated DDH patients.

Summary

THA via the DAA for Crowe III and IV dysplasia can be achieved via meticulous preoperative planning and surgical technique. Knowledge of techniques for soft tissue releases and exposure, acetabular and femoral preparation, subtrochanteric osteotomy, and reduction are critical. Intraoperative CT, computer navigation, and nerve monitoring are tools the surgeon can use to assist in achieving a favorable outcome.

KEY POINTS

- Correction of LLD using our four-step algorithm would be more accurate for preoperative planning in very young DDH patients.
- A stepwise procedure for retuning soft tissue tension includes pie-crusting of the adductor tendon, sleeve-like capsulectomy, partial release of psoas tendon, reflected head of the femoral rectus and ITB, as well as STO.
- Removing the sclerotic bone at the superior margin of the true acetabulum and sacrificing a small portion of the posterior wall would be helpful to achieve acetabular reconstruction anatomically.
- The modular stem needs more elevation and lateralization of the proximal femur. The femoral anteversion could be referenced by transepicondylar axis determined by intraoperative fluoroscopy or CT.

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Conflict of interest

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