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Management of limb length problems during total hip arthroplasty for patients with developmental dysplasia of the hip

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Abstract

The anatomy of the acetabulum and femur is usually significantly altered in people with developmental dysplasia of the hip and this leads to secondary osteoarthritis of the hip joint. Ideal positioning of implants and reduction of the joint is technically demanding during arthroplasty. Lengthening may result in nerve palsies and therefore procedures may have to be undertaken to shorten the femur. Other complications include dislocation and non-union at the shortening osteotomy site. Thorough preoperative planning and templating is required before surgery to assess the need for shortening. Shortening osteotomies can be performed at the proximal femur, diaphysis or distal femoral levels, with subtrochanteric being the most common level. The procedure should be customised for each patient after extensive planning and detailed counselling.

Key words: Acetabulum; Developmental dysplasia of hip; Femur; Limb length inequality; Sciatic nerve; Shortening

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Introduction

Developmental dysplasia of the hip is a major risk factor for developing secondary osteoarthritis of the hip joint. It is also the most common hip disorder leading to secondary osteoarthritis of the hip joint, as reported by Jacobsen and Sonne-Holm (2005). The incidence of hip dysplasia ranges from 1.7–20% in the general population and hip dysplasia is the leading cause of early onset hip osteoarthritis before the age of 60 years (Murphy et al, 1995). Sewell et al (2009) reported that since the introduction of selective ultrasound screening of hips in babies who are thought to be at high risk of developmental dysplasia of the hip, the UK incidence ranges from 5 to 30 per 1000. Clohisy et al (2011) reported that 48.4% of patients under 50 years old undergoing total hip arthroplasty for osteoarthritis had underlying hip dysplasia as the aetiology of hip osteoarthritis.

The burden of total hip arthroplasty worldwide is increasing, as is the subsequent impact on resources and healthcare costs. Traditionally, the success of total hip and knee arthroplasty has been determined by the measurement of survival. Bayliss et al (2017) reports that in patients aged 50–54 years, the lifetime risk of revision surgeries for total hip arthroplasty is up to 29% compared to around 5% in patients aged 70 years. Younger patients undergoing total hip arthroplasty as a result of developmental dysplasia of the hip leading to osteoarthritis might become a large burden to society in terms of cost and disability.

The anatomy of the dysplastic hip is usually significantly altered. The acetabulum and femur are underdeveloped and the femur is often displaced. Hip biomechanics are altered and there is no ideal stimulation for development of proper acetabulum and proper femoral head. The anatomical pathology in dysplasia is mostly at the acetabular side of the joint. It is more shallow than usual with a thickened medial wall and there is not enough femoro-acetabular coverage. The proximal femur may be hypoplastic with a deformed and high riding femoral head. In a dislocated hip, the femoral head articulates with the iliac bone forming a false acetabulum. The direction of the abductor muscle force vector changes from the usual vertical to horizontal as a result of the high riding trochanter. Hip abductors are usually shortened and contracted. A short femoral neck with increased anteversion, along with a deformed head and altered abductor muscle mechanism, may lead to development of secondary osteoarthritis of the hip joint.

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The most common classification is the Crowe et al (1979) classification with four different degrees of dysplasia. Dysplastic hips are classified based on the amount of subluxation:

1. Group 1 <50% subluxation
2. Group 2 50–75% subluxation
3. Group 3 75–100% subluxation
4. Group 4 >100% subluxation.

Hartofilakidis et al (2008) typing divides developmental dysplasia of the hip into three types, with type A being subluxation, type B being low dislocation and type C being high dislocation of the hip. Depending on the positional correlation between the femoral head and the true and false acetabulum, type C can be subdivided into type C1 (false acetabulum formation) and type C2 (no false acetabulum formation).

During a total hip arthroplasty, the acetabular cup is ideally placed where the centre of the true acetabulum would be. Cup positioning and hip reduction are technically demanding. This can be done by careful soft tissue dissection, capsule release from the proximal femur, release of tight adductors and flexors or pie-crusting of abductors to gain length.

A raised centre of rotation causes a higher joint reaction force. This increases the risk of premature wear, aseptic loosening, and implant failure as reported by Abolghasemian et al (2013). On the other hand, restoring the centre of rotation may cause significant lengthening and require femoral shortening. Edwards et al (1987) reported that lengthening of the leg by more than 4 cm might result in sciatic or femoral nerve palsy. Further, adductor contracture might also compromise reduction of the total hip arthroplasty. Appropriate shortening of the proximal femur avoids these adverse effects. This review highlights the various methods that are useful to manage and avoid complications during total hip arthroplasty in dysplastic hips.

Preoperative planning and investigations

Young patients with limping and postural deformity related to a marked inequality in lower limb length characterises the developmental dysplasia of the patient with a high dislocated hip. In severe cases, limitation of the hip motion may not be obvious as a result of instability. The severity of the pain and the presence of any adjacent joint problems should be investigated, including lumbar spine problems, valgus knee and foot deformity, with callosities under the metatarsal heads as a result of walking on tiptoes. Limb length inequality should be measured and recorded. Wooden blocks under the short leg help to determine the degree of correction of the pelvic obliquity.

Before surgery, bilateral plain radiographs of the anteroposterior and lateral diseased hip joints should be taken to understand the bone condition, acetabular morphology, femoral dislocation distance and shortening. If the height of dislocation is more than 3.5 cm, femoral shortening osteotomy should be considered to help reduce the joint and protect the sciatic nerve.

Careful preoperative templating with more than one prosthesis design is essential to determine which femoral templating design will give the best result. Lateral templating is also important, since proximal femoral deformity may prevent straightforward insertion of the stem. To choose the appropriate hip rotation centre, Crowe et al (1979) recommends use of the contralateral side in unilateral cases and the Ranawat's triangle in bilateral cases.

The required shortening must then be determined. The level of the lesser trochanter is useful, but is not a flawless method; all measurements should be judged against the clinical picture, because pelvic and lumbar deformities, as well as the available femur below the lesser trochanter, may confuse radiographic measuring in a short pelvic view. When using preoperative templating to assess for limb length discrepancy, Meermans et al (2011) recommend using the interteardrop line and the centre of the femoral head. This is because although the lesser trochanter is most frequently used as the femoral landmark, it is not clearly demarcated and could be the subject of error. Rösler and Perka (2000) recommend that the operated limb length should be within 10 mm of the contralateral limb because this does not affect the functional parameters of gait and produces a satisfactory result in most patients. Lewallen (1998) also suggested doing routine computed tomography imaging as a part of the preoperative evaluation.

Techniques

Various techniques have been described to address the issue of femoral lengthening while performing total hip arthroplasty in patients with developmental dysplasia of the hip.

Yoon et al (2013) used a two-stage approach in cases of high dysplastic dislocation. They released the soft tissues only in the first stage and did the implantation and reduction in second stage surgery after 2 weeks of skeleton traction. Even after using this approach, subtrochanteric osteotomy was required in five out of six cases.

After placing the acetabular component in the anatomical position, the femur often becomes too long and needs to be shortened. Thus, shortening femoral osteotomies allow both hip arthroplasty without sciatic nerve stretching and correction of the proximal femoral anteversion. After these procedures are performed, the abductor mechanism of the hip is restored with equal final leg length.

Femoral shortening procedures can be roughly divided according to the level: proximal femur, femoral shaft and distal femoral procedure. The choice of technique depends on the surgeon's preference and expertise. A literature search did not find any study comparing different techniques for femoral osteotomies.

Proximal femoral osteotomies

There are three main types of proximal femoral osteotomies.

Greater trochanteric osteotomies

Trochanteric osteotomies are one of the most commonly performed procedures on the proximal femur during total hip arthroplasty. Charnley (1972) first reported trochanteric osteotomies in total hip arthroplasty. Trochanteric osteotomies have several major advantages. First, they provide excellent visualisation of both femur and acetabulum, that is the whole operating region. Second, by performing trochanteric osteotomy, the abductor mechanism of the hip is preserved and easily repositioned, resulting in a stable hip without the risk of dislocation. The transtrochanteric approach allows performance of corrective osteotomies in areas of femoral metaphysis. However, this approach is still controversial because of unclear conclusions about the relatively high rate (around 6%) of non-union of the greater trochanter after such procedures (Kerboull et al, 2007).

Paavilainen et al (1990) reported a procedure of femoral shortening on the proximal femur during total hip arthroplasty in patients with developmental dysplasia of the hip. This method included a cementless total hip arthroplasty procedure, where the acetabular cup is placed in the anatomical position together with proximal femur shortening osteotomy with distal sliding of the greater trochanter.

Lesser trochanteric osteotomies

A major advantage of lesser trochanteric osteotomies is that the greater trochanter remains intact, which provides better results and potentially lower rates of complications as reported by Bao et al (2013).

Subtrochanteric osteotomies

Shortening procedures performed on the femoral metaphysis (subtrochanteric level) are the most frequently used procedures for femoral shortening in patients with developmental dysplasia of the hip. The extracted femoral head can be morcellised and grafted around the osteotomy site. There is controversy about the type of subtrochanteric osteotomy and prosthetic femoral implant. Transverse osteotomies have been reported by Krych et al (2010) and oblique osteotomies by Yasgur et al (1997). Successful step-cut osteotomies have also been reported by Makita et al (2007), when special requirements are necessary. Metaphyseal shortening can also be done via a lower neck cut at the level or slightly distal to the lesser trochanter as reported by Reikeraas et al (1996) (Figure 1).

The authors have found subtrochanteric osteotomy to be technically easy and have combined it with a trochanteric osteotomy and distal reattachment without any problems of bone union or sciatic nerve palsy.

Subtrochanteric osteotomy requires adapted, graduated postoperative rehabilitation protocols unique to these patients, with weight-bearing as tolerated with two crutches for

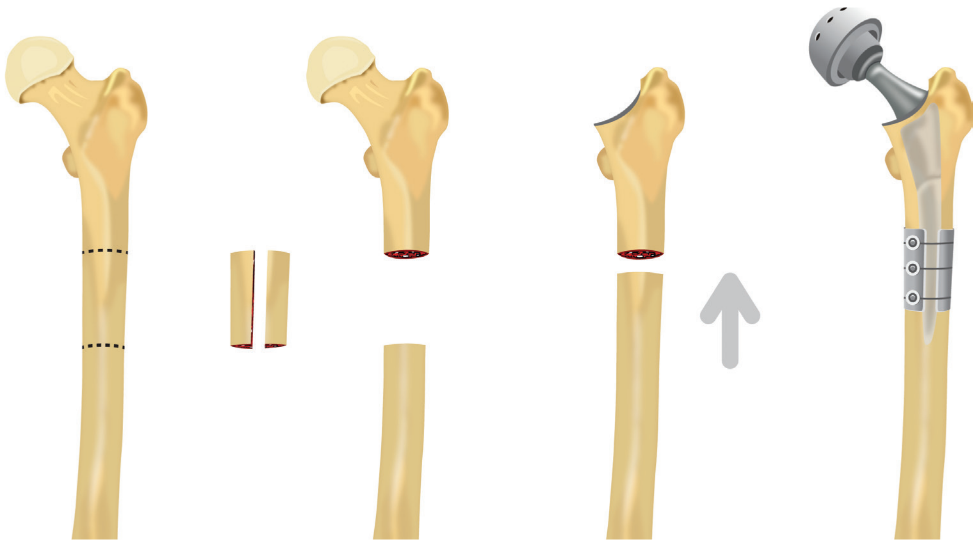

Figure 1. Subtrochanteric osteotomy.

6–12 weeks. The osteotomy has excellent healing, with non-union rates ranging from 0–7% (Bernasek et al, 2007; Krych et al, 2010).

Femoral diaphysis shortening

Very good 5-year follow-up results were reported by Sener et al (2002) on procedures performed on the femoral diaphysis. Here, proximal diaphyseal step-cut shortening osteotomy was performed after femoral reaming. The step-cut was stabilised with two to three cerclage wires with the use of bone grafting. After fixation, intramedullary femoral reaming was continued until satisfactory cortical contact was achieved. Attention was focused on tight contact in the distal fragment of the osteotomised femur (Figure 2).

A very similar method with promising short- to mid-term results for adult patients with Crowe's group IV developmental dysplasia of the hip was reported by Makita et al (2007). Neumann et al (2012) reported the results of a very similar method, but did not use bone grafting techniques at the osteotomy sites.

Distal femoral shortening

This procedure can be performed as an addition to total hip arthroplasty for dysplastic and difficult-to-reduce hips. Koulouvaris et al (2008) used newer technologies, such as customised femoral implants and the use of three-dimensional computed tomography scans, as an important tool in preoperative planning. First, total hip arthroplasty with placement of the acetabulum in the anatomical position is performed. Then a femoral shortening procedure is performed on the distal femur so that the first screw of the plate is more than 2 cm away from the femoral stem. Fixation of the femoral osteotomy was achieved with a titanium limited contact dynamic compression plate (Figure 3).

A major advantage of this technique is the possibility of conjoined correction of the ipsilateral knee valgus deformity. This can be performed simply by changing the shape of osteotomised fragment, allowing regular fixation for valgus osteotomy of the knee. A total of 24 patients were reported in the study, with follow-up period of 4.5 years (Koulouvaris et al, 2008). The authors reported excellent results: only one delayed union was observed, which resulted in malunion after 9 months. The only drawbacks of the distal femoral shortening are a longer incision and additional internal fixation.

Complications and prognosis

Complications are relatively frequent in these patients compared with those undergoing total hip arthroplasty for any other reason. The causes are multifactorial, including abnormal anatomy, the large soft tissue release, osteotomy and abrupt lengthening of the extremity. According to Lewallen (1998), sciatic and femoral nerve palsies are up to ten times more common.

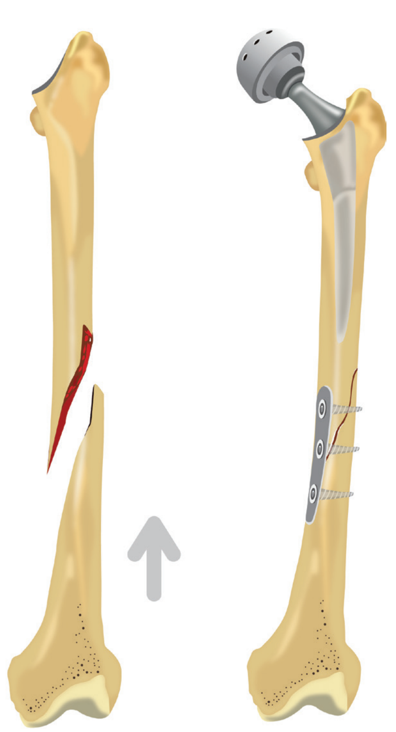

Figure 2. Femoral diaphysis osteotomy.

Figure 3. Distal femoral osteotomy.

Dislocations are reported in between 2.9% and 11% of cases (Cashman et al, 2015). The greatest concern arises when shortening is indicated at surgery. Non-union at the subtrochanteric osteotomy site may occur, and is typically related to inadequate fixation, where rotational stability is a major concern. If using cemented stems, cement extrusion is possible at the site of osteotomy, leading to non-union.

The outcomes for Crowe I and II hips are generally good, and are similar to outcomes seen for total hip arthroplasty in patients without hip dysplasia. The outcome of reconstruction in patients with Crowe IV hips has been reported to show a 75% survivorship rate at 14 years follow up (Bernasek et al, 2007). Improved lasting Harris hip scores have also been reported in a 10-year follow-up study in patients with dysplasia (Biant et al, 2009). However, at 15-year follow up, the need for revision surgery is reported to be 1.5–2.0 times more likely in dysplastic hips than in non-dysplastic hips (Engesæter et al, 2008).

Conclusions

Developmental dysplasia of the hip is a major hip pathology leading to pain, arthritis and hip surgery in young patients. There is no consensus in the literature on what constitutes a 'significant' limb length discrepancy after total hip arthroplasty. In severe cases, a subtrochanteric osteotomy allows for correction of femoral anteversion, assists adaptation of the femoral stem to the distorted proximal femoral metaphysis and overcomes excessive lengthening. Anatomical reconstruction of the hip is required for maintenance of function during the long follow-up periods, with good clinical and radiographical outcomes. Best practice requires careful patient selection and the use of appropriate techniques.

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Conflicts of interest

The authors declare no conflicts of interest.

Key points

- Developmental dysplasia of the hip is a major hip pathology leading to pain, arthritis and hip surgery in young patients.
- Younger patients undergoing total hip arthroplasty as a result of developmental dysplasia of the hip leading to osteoarthritis might become a large burden to society in terms of cost and disability, because of the increased incidence of revision surgeries.
- Acetabular cup positioning and hip reduction are technically demanding in developmental dysplasia of hip because of the altered acetabular anatomy and limb length discrepancies.
- After placing the acetabular component in the anatomical position, osteotomies at the level of proximal femur, femoral shaft or distal femur may be required.
- The operated limb length should be within 10 mm of the contralateral limb so it does not affect the functional parameters of gait and produces a satisfactory result in most patients.

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