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Original Article

Does restoration of hip center with subtrochanteric osteotomy provide preferable outcome for Crowe type III−IV irreducible development dysplasia of the hip??

Tzu-Cheng Yang [a], Cheng-Fong Chen [a,b,*], Shang-Wen Tsai [a,b], Wei-Ming Chen [a,b], Ming-Chau Chang [a,b]

[a] Department of Orthopedics and Traumatology, Taipei Veterans General Hospital, Taipei, Taiwan, ROC
[b] Department of Surgery, School of Medicine, National Yang-Ming University, Taipei, Taiwan, ROC

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Abstract

Background: Subtrochanteric osteotomy and proximal placement of acetabular components are two common procedures used to manage irreducible, high riding developmental dysplasia of the hip (DDH). Some common and specific complications are observed in both procedures. We aimed to compare both the outcomes and complications between these two procedures.
Methods: Twenty-one patients with unilateral, Crowe type III−IV DDH who were seen between 2002 and 2014 were included in this study. Subtrochanteric osteotomy with restoration of the hip center and proximal placement of the acetabular component were performed on 10 and 11 patients, respectively. Harris hip score (HHS) and radiographic images were used for outcome assessment. All patients completed a minimum of 2-year follow-up.
Results: The HHS in patients who had undergone subtrochanteric osteotomy and proximal placement of the acetabular component were 89.4 and 91.9 points, respectively. However, this difference was not significant. There were six complications, including transient sciatic nerve palsy in two patients, nonunion at the junction in two, an intra-operative fracture in one and cup loosening in another. The complication rates in the subtrochanteric osteotomy and proximal placement of the acetabular component group were 30% and 27.5%, respectively.
Conclusion: With regard to both clinical outcomes and complication rates, restoration of the hip center using subtrochanteric osteotomy may provide similar benefits to those patients with proximal placement of the acetabular component in treating Crowe type III−IV DDH.

Keywords: Crowe III−IV DDH; Subtrochanteric osteotomy; Total hip replacement

1. Introduction

Developmental dysplasia of the hip (DDH) is a leading cause of hip arthritis, particularly in young adults. Crowe and colleagues[1] developed a 4-grade system stratifying acetabular deformities by assessing the degree of hip subluxation. A distorted femoral head located in the pseudo-acetabulum and a significant leg length discrepancy (LLD) are classic features in high-grade DDH. Therefore, total hip replacement (THR) performed on patients with Crowe III, IV DDH is a highly complicated surgical procedure requiring sophisticated techniques.

The amount of limb lengthening in high riding DDH determined the position of the acetabular component. Sciatic nerve complications are significantly increased in patients with limb lengthening of 4 cm or more.[2] Consequently, for avoiding

Abbreviations: DDH, developmental dysplasia of the hip; LLD, leg length discrepancy; THR, total hip replacement; HHS, Harris hip score.

Conflicts of interest: The authors declare that they have no conflicts of interest related to the subject matter or materials discussed in this article.

* Corresponding author. Dr. Cheng-Fong Chen, Department of Orthopedics and Traumatology, Taipei Veterans General Hospital, 201, Section 2, Shi-Pai Road, Taipei 112, Taiwan, ROC.

E-mail address: chengfong2751@gmail.com (C.-F. Chen).

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excessive nerve stretching, restoring the hip center is often not accessible in patients with high riding DDH.

Regarding irreducible high riding DDH, some studies that supported proximal placement of the cup had acceptable outcomes.[3−5] However, to minimize the incidence of cup loosening, some authors suggested the implantation of the acetabular component to the anatomical center of rotation.[6−8] Therefore, several types of subtrochanteric femoral shortening osteotomy procedures have been developed to implant the acetabular component to the anatomical center of the hip.[9−15] Nonunion in the osteotomy site appeared to be a common complication of those osteotomy procedures.[10,14,15]

To the best of our knowledge, studies of procedures for subtrochanteric osteotomy and proximal placement of the acetabular component are reported in series. Therefore, we aimed to conduct a comparative study, to compare clinical outcomes and complications between patients with Crowe type III−IV DDH who had undergone subtrochanteric osteotomy, and those who had proximal placement of the acetabular component.

2. Methods

This retrospective study was conducted at a single medical institute from January 2002 to December 2014, and was approved by the Institutional Review Board. Twenty-one patients with unilateral type III−IV DDH that could not be reduced directly to the hip center during surgery were included. Patients with a history of acetabular or hip fracture over the affected limb, poor ambulatory or bedridden status, infection, or bleeding disorders were excluded. In addition, we excluded patients with bilateral hips dysplasia to minimize confounding factors.

All the procedures were performed by one of two senior surgeons experienced in joint replacement surgery. Preoperative images were used to assess the surgical landmark and the distance of lengthening for each included patient. The study protocols were approved by the local ethics committee.

2.1. Study design

The Harris hip score system[16] was applied for evaluating clinical outcome at each visit. For radiographic assessment, the amount of limb lengthening was calculated by comparing the distance from the umbilicus to the medial malleolus before and after surgery with the patient placed on a bed with triple films of the lower extremities.We used the method described by Pierchon et al.[17] to determine the theoretical center of rotation of the hip, using anteroposterior (AP) radiographs.

2.2. Surgical techniques

All patients were lying in the lateral decubitus position accessible to the hip using the standard posterior-lateral approach. A posterior incision was made in a slight curve from the posterior proximity of greater trochanteric tip to the femoral shaft. The short rotator muscle was uncovered by incising the subcutaneous tissue and tensor fascia lata. Detaching the short rotator muscle in association with the inverted L-shaped capsulotomy was performed for accessing the femoral neck and head. The femoral head and neck were preserved as autografts for reinforcing the roof of the original acetabulum if necessary. We assembled the femoral component first with the appropriate femoral reaming. Next, we tried to reduce the femoral head gently to a true acetabular position with traction. In particular, once reduction into the true acetabular position seemed impossible, the surgical plan needed to be modified. Proximal placement of the acetabular componentor subtrochanteric osteotomy was performed to facilitate reduction according to the surgeon's preference.

2.3. Proximal acetabular component placement

Given the difficulty of reduction, proximal placement of the acetabular cup into the superior position with good bone quality was selected. The autograft of the femoral head was fixed with a minimum of two screws on the superolateral active defect for reconstruction. The central reaming was enlarged until a hemispherical bony margin was developed. Once an acceptable cup location was achieved, the final components were implanted (Fig. 1).

2.4. Subtrochanteric osteotomy

While the femoral head was dislocated, the inferior margin of the true acetabulum was identified as the primary landmark. The acetabulum was reamed to a hemispherical bony cavity. Afterward, an appropriately sized cup was selected and placed in the true acetabular center. The subtrochanteric osteotomy was performed beyond 8−10 cm distal to the tip of the greater trochanter. The amount of subtrochanteric shortening required for hip reduction was determined intraoperatively by placing the trial femoral component in the proximal femoral segment accompanied by reducing the proximal segment, and identifying the degree of overlapping proximal and distal femoral fragments by gently pulling the lower limb. The femoral implant was then impacted on the femur across the osteotomy site. Finally, the dynamic compression plate was placed along the lateral side of the femoral shaft and fixed carefully with screws for stabilizing the osteotomy site (Fig. 2).

An intra-operative wakeup test was performed if the lengthening distance was larger than 4 cm in compliance with our previous report.[18] Post-operative aspects of both motor and sensory neural functions were examined immediately after surgery, and at each follow-up appointment to assess the underlying sciatic nerve injury.

2.5. Postoperative rehabilitation protocol

After surgery, toe-touch weight bearing was suggested for 6−8 weeks. Gradually, progressive weight bearing was allowed in accordance with the radiographic evidence of callus formation. Both groups started flexion and extension exercises

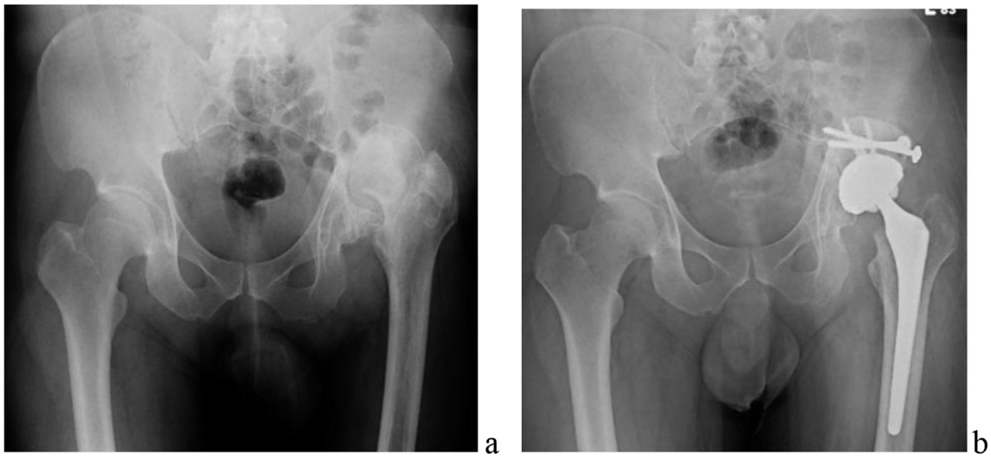

Fig. 1. Proximal acetabular component placement.

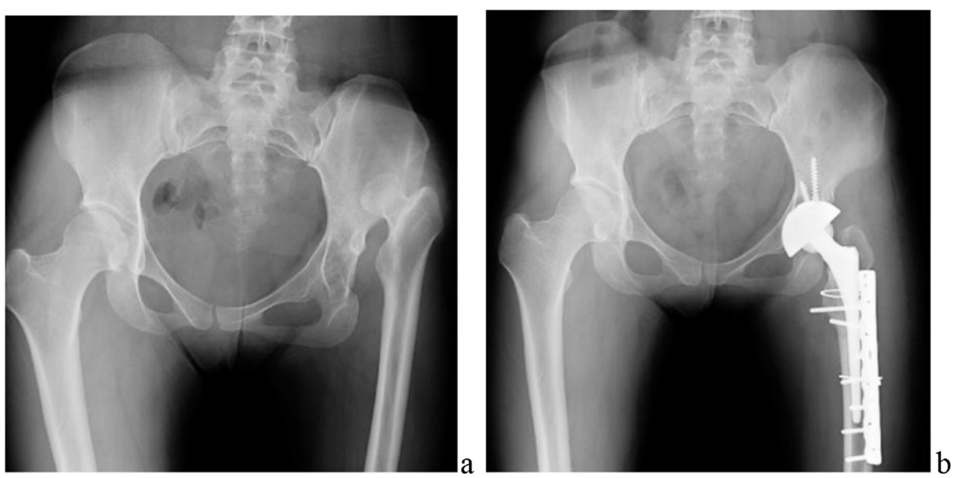

Fig. 2. Subtrochanteric osteotomy.

immediately after surgery. All patients were followed at two weeks, six weeks, three months, six months, one year, and annually thereafter.

2.6. Statistical analysis

Statistical analysis was performed using a Wilcoxon rank-sum test for continuous variables and chi-square test for categorical variables. A P-value less than 0.05 was considered statistically significant.

3. Results

During the period between 2002 and 2014, a total of 24 patients with irreducible high riding DDH undergoing THR were enrolled in this study. Five patients were excluded due to the following the criteria including deaths, being bedridden, and lost to follow-up. Three patients experienced traumatic history over the contralateral lower limb. In the final study cohort, 21 patients with Crowe type III or IV DDH (5 males and 16 females; 9 right and 12 left hips) underwent THR surgery with either subtrochanteric osteotomy or acetabular component proximal placement. Accordingly, both the subtrochanteric osteotomy and the proximal cup placement groups separately included 10 and 11 patients, respectively. In the acetabular component proximal placement group, the autograft bone from the femoral head was used for reconstructing the pseudo-acetabular roof in six patients.

3.1. Clinical results

The average duration of follow-up of the included patients was 6.5 (range 2—13) years. The average preoperative HHS was 49.5 for the subtrochanteric osteotomy group, and 46.3 for the acetabular component proximal placement group ($P = 0.156$). The most recent assessment of average HHS was 89.4 and 91.9, respectively ($P = 0.461$). Both groups revealed a significant difference in the average HHS evaluated at both the preoperative and the last follow-up stages ($P < 0.001$).The average surgical time was 211.3 and 129.8 min for the two groups, respectively, and was significantly longer in the subtrochanteric osteotomy group ($P < 0.001$).

3.2. Radiographic results

The preoperative average LLD was 6.9 cm for the subtrochanteric osteotomy group, and 6.2 cm for the acetabular component proximal placement group ($P = 0.145$). The average postoperative LLD was 3.8 cm and 1.4 cm, respectively ($P = <0.001$). The average limb lengthening was 3.3 cm and 4.1 cm, respectively ($P = 0.279$).The average femoral shaft shortening was 3.3 cm in the subtrochanteric group (Table 1).

3.3. Complications

These two study groups revealed different types of complications despite insignificant statistical differences. The subtrochanteric osteotomy group was associated with two cases of osteotomic site nonunion; furthermore, one was related to infection (Fig. 3).

One aseptic cup loosening was found in a patient who accepted the acetabular component proximal placement procedure without autograft roof reconstruction. Sciatic nerve palsies were found in both groups; however, all of them recovered spontaneously within six months. One case of proximal cup placement suffered an intra-operative lesser trochanteric fracture, which was managed by using a wire loop for fragment fixation (Table 1).

The reoperation rates were 20% and 9% in the subrochanteric osteotomy group and the acetabular component proximal placement group, respectively. The patient who suffered from the osteotomy site aseptic nonunion accepted revision surgery of open reduction and internal fixation with the addition of a broad dynamic compression plate. In contrast, the patient with the osteotomy site infection accepted debridement with antibiotic treatment in the first stage; then, a secondary stage surgery with additional plating fixation was performed when the infection subsided. Otherwise, revision cup placement with allograft augmentation was performed on the patient with cup loosening in the proximal cup placement group.

Table 1
Patients' characteristics.

	Osteotomy (N = 10)	Proximal placement (N = 11)	*P*
Age (y/o)	39.5 ± 11.3	46 ± 10.7	0.193
Sex			0.185
Male	1	4	
Female	9	7	
Crowe type			0.608
Type III	4	4	
Type IV	6	7	
Pre-OP LLD (cm)	6.9 ± 1.2	6.2 ± 1.0	0.145
Post-OP LLD (cm)	3.8 ± 1.4	1.4 ± 1.1	<0.001
Lengthening (cm)	3.3 ± 1.0	4.1 ± 2.0	0.279
Cup inclination (°)	40.5 ± 6.6	45.7 ± 7.7	0.109
Cup diameter (mm)	48.5 ± 1.4	49.1 ± 2.6	0.469
Cup cover (%)	93.5 ± 4.7	93 ± 6.8	0.901
Pre-OP HHS	49.5 ± 6.7	46.3 ± 4.0	0.156
Recent HHS	89.4 ± 6.2	91.9 ± 7.6	0.416
OP time (mins)	211.3 ± 38.1	129.8 ± 32.5	<0.001
Follow-up (years)	5.6 ± 4.1	7.3 ± 3.0	0.277
Complications			0.633
Osteotomy site non-union	2	0	
Sciatic nerve palsy	1	1	
Cup loosening	0	1	
Intra-operative fracture	0	1	
Overall	3	3	

Continuous variables: mean ± standard deviation.
Abbreviations: OP: operative, HHS: Harris hip score, LLD: leg length discrepancy.

4. Discussion

The most important idea of this study is that restoration of the hip center may not be correlated with clinical outcome. In our study, there were comparable clinical outcomes between the two groups.

A surgeon's prior experience plays an important role in the selection of the correct surgical treatment to deal with an obvious LLD. With regard to irreducible high riding DDH, some articles support THR with acetabular component proximal placement to be an acceptable procedure.[3−5] In our study, there were reported preferable clinical outcomes (average postoperative HHS: 91.9) and only one patient needed revision surgery for cup loosening. In contrast with this case of cup loosening complication, all cases with roof reconstruction had no cup failure. This result implies that autograft reconstruction should be considered routinely for the proximal acetabular component position, especially with poor bone stock. Moreover, in our experience, we suggest adequate medialization by keeping the acetabular component in contact with bone least 80%. Another complication of this group is a lesser trochanteric intra-operative fracture, that may be related to the overtraction force for hip center reduction applied when the surgeon attempts to make the rotation center closer to the true acetabular center.

In contrast, others believed that hip center restoration is important due to the higher cup loosening rate.[6] Consequently, the subtrochanteric osteotomy was developed to facilitate hip reduction to the anatomic center and has been reported to have good outcome.[12,15] The procedure of subtrochanteric osteotomy was becoming increasingly popular due to the concept of restoring the hip center with less cup failure complications. Good to excellent clinical outcomes were reported; however, complication rates of 14−43% were observed, including osteotomy site nonunion and femoral component loosening.[11,12,19] Our results demonstrated good clinical outcomes (HHS: 89.4) and show an acceptable complication rate (30%) similar to those of previously published articles.

Osteotomy site nonunion was an underlying complication in association with weak fixation of the osteotomy site. Although some investigations which were in favor of subtrochanteric osteotomy reported higher rates of both union and rare intra-operative fractures,[11,14,19] in this study two patients receiving osteotomy suffered nonunion. Unstable fixation and inadequate early weight bearing lead to osteotomy site nonunion. In our failure case, the osteotomy site was too distal

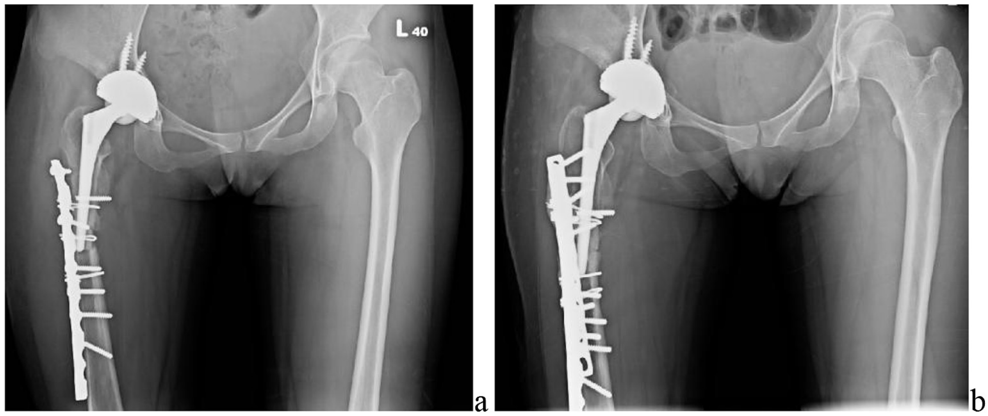

Fig. 3. Septic non-union and revision surgery.

for the stem to bridge it without sufficient length. Therefore, we suggest choosing a stem having an appropriate length, which bridges the osteotomy site by at least 3 cm. Furthermore, a locking plate, bone plate, or wiring was probably required for achieving more rigid fixation. In addition, only one infection case in this study was found in the osteotomy group, that may be related to the longer surgical time and extended surgical wound. Sciatic nerve injury was an important issue of THR for high riding DDH, especially with traction injury. An elevated incidence of nerve palsy following limb lengthening longer than 4 cm has been reported previously.[2] In our institute, a wakeup test was performed following lengthening procedure for assessing the length of an elongated limb. If limb mobilization was impaired, the distance of lengthening was decreased. In both groups, two patients complained of sciatic nerve palsy; however, symptom relief was spontaneous. Reluctant traction with tissue excursion driven should be avoided, and we suggest the post-lengthening wakeup test for routine nerve condition monitoring.

Many patients with bilateral high riding DDH were excluded from our study to promote more accurate outcome assessment. Thus, the major limitation of this study was that the number of patients was relatively small. In an ongoing study, we are dedicated to determining a proper protocol with accurate criteria for assuring the quality of surgery.

In conclusion, the results of this study have suggested that THR with the proximal placement of the acetabular component might be an acceptable surgical procedure for patients with irreducible developmental dysplasia hip, and has the comparable clinical outcome to THR with subtrochanteric osteotomy.

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