ORIGINAL PAPER/PŮVODNÍ PRÁCE

Cementless THA with Femoral Shortening Osteotomy Provides Excellent Results for Patients with Crowe Type IV Hip Dysplasia

Bezcementová TEP kyčle s femorální abreviační osteotomií poskytuje vynikající výsledky u pacientů s dysplazií kyčle typu Crowe IV

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ABSTRACT

Introduction
This study aimed to present the clinical and radiological results and look for complications of total hip arthroplasty (THA) performed with subtrochanteric transverse femoral shortening osteotomy (STFO) for Crowe type IV developmental dysplasia of the hip (DDH).

Material and methods
Ninety-four patients who underwent STFO and THA for Crowe type IV DDH between 2013 and 2018 were retrospectively evaluated. The mean follow-up period of the patients was 40 months (range 25 to 55) and the mean operation time was 58 min (range 52 to 70). We examined the results of routine anteroposterior and lateral hip radiography. The time required for healing of the osteotomy line, preoperative and postoperative Harris Hip Score (HHS), limb length discrepancies, the level of limping and Trendelenburg tests were evaluated for all patients. All complications were noted.

Results
The mean healing time was 5.4 months (range 4 to 10). The preoperative HHS improved from a mean of 52 points (range 42 to 61) to 84 points (range 75 to 96) after the operation ($p < 0.001$). Only two patients had postoperative positive Trendelenburg tests. There were no cases of nonunion or sciatic nerve palsy. An interoperative femoral fracture was observed in one case.

Conclusions
This study demonstrates that excellent clinical outcomes can be achieved with no revisions, no nonunion, and minimal residual limping in patients who undergo shortening with STFO using a Wagner cone for the femur and a primary cup for the acetabulum.

Key words: arthroplasty, hip, developmental dysplasia of the hip, femoral shortening, osteotomy.

INTRODUCTION

Total hip arthroplasty (THA), which is applied in the treatment of developmental dysplasia of the hip (DDH), is a successful method (1). However, compared to other indications, it is a difficult procedure due to the small and narrow femoral canal, acetabulum hypoplasia, increased femoral neck shaft angle, and anteversion (25, 26).

In most cases of Crowe type IV DDH, the true acetabulum is the best place for cup fixation in terms of bone stock and biomechanics (3, 4). Compared to the non-anatomical hip center, the proper anatomical placement of the acetabular component provides a reduced rate of loosening and revision (24).

Especially in cases of high dislocations, reducing the center of rotation to the true acetabulum is challenging for both the acetabulum and the femur, and precision surgery is required. Sometimes this procedure results in high rates of complications such as residual limping, nerve paralysis, and

Table 1. **Demographic information**

NUMBER OF PATIENTS	94
MALE / FEMALE	28 (29.8%) / 66 (70.2%)
MEAN FOLLOW-UP TIME	40 months (range 25 to 55)
MEAN AGE	44 years (range 29 to 80)

dislocation (1, 4, 20). Without femoral shortening osteotomy, excessive lengthening of the limb can lead to nerve paralysis. The best treatment option for correction of the center of rotation of the dislocated hip is considered to be subtrochanteric osteotomy and resection of the bone segment (7, 21).

In this article, we present the clinical and radiographical results and look for the complications of patients who underwent subtrochanteric transverse femoral shortening osteotomy (STFO) using a Wagner cone and primary acetabular cup for the treatment of coxarthrosis in Crowe type IV DDH.

MATERIAL AND METHODS

This study was planned as a retrospective evaluation of the medical data and radiology records of 94 patients with Crowe type IV DDH who were admitted to our clinic between 2013 and 2018 and underwent STFO and cementless THA. The Clinical Researches Ethics Committee of Ankara Yildirim Beyazit University Ethics committee approved this study (Decision number: 2015/183). All the data used in the study were obtained from hospital records. All patients had unilateral dysplasia. Patients were excluded if they had previously undergone multiple operations of the hip to evaluate the outcome of a single type of implant, if they had severe scarring and excessive contraction of the hip due to limited range of motion, or if they had bilateral Crowe type IV dysplasia. Patients with bilateral dysplasia were excluded from the study in order to accurately evaluate clinical results such as limb length discrepancy, limping and Trendelenburg sign. Reviewing the data, pain limiting daily life activities, functional insufficiency, and length differences of legs were identified as indications for arthroplasty.

The mean age of the patients was 44 years (range 29 to 80). Sixty-six female and 28 male patients (see Table 1) were included in this study. The longest follow-up period was 55 months while the shortest follow-up period was 25 months, and the mean follow-up period was 40 months (Table 1). The mean operation time was 58 min (range 52 to 70).

Patients were evaluated clinically and radiologically after surgery in weeks 2, 4, 8, 12, and 24. Additionally, they were evaluated radiographically once a month throughout the first year after the operation. The patients were also evaluated radiologically and clinically at the final follow-up.

In radiological evaluation, anterior-posterior and frog leg lateral hip radiography were used (Figs 1 and 2). Bone fusion of the osteotomy site was evaluated according to the radiological criteria defined by Masonis et al. (13). Additionally, 3D computed tomography (CT) of the pelvis was performed to determine the acetabular structure and bone stock and polyaxial sections (coronal and sagittal) were evaluated in the preoperative planning.

In clinical evaluation, the Harris Hip Score (HHS) (6) was used. Preoperative and postoperative true limb length discrepancy (measured clinically from the anterior superior iliac spine to the medial malleolus) and the level of limping were evaluated. The level of limping was categorized as severe, moderate, mild, or none, as defined by Kim et al. (9). The Trendelenburg sign was also evaluated as a measure of

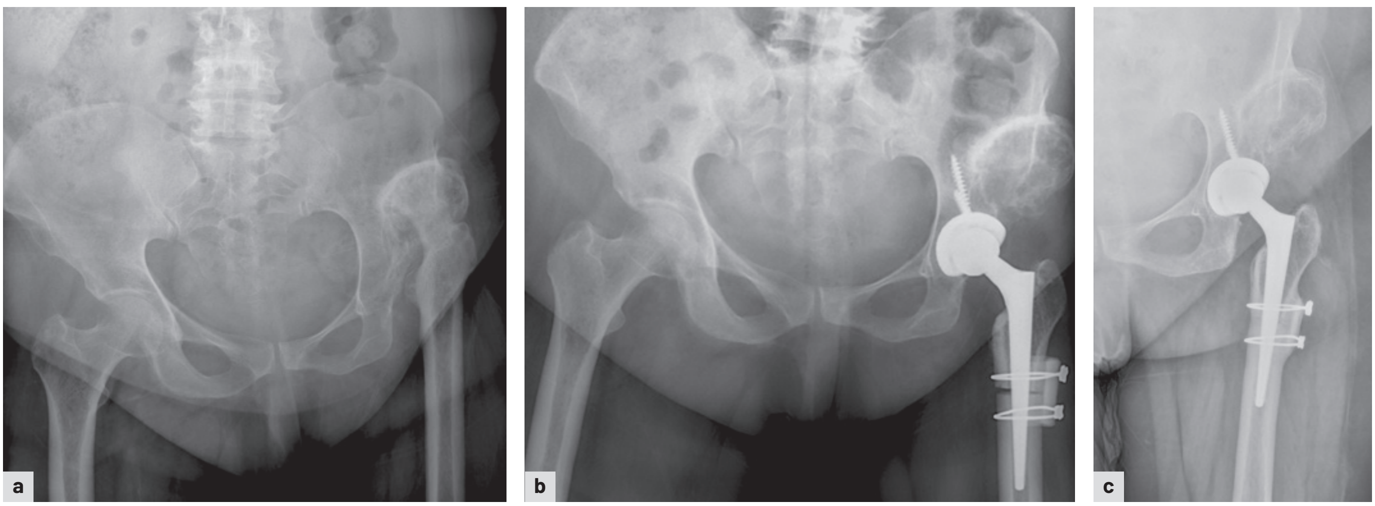
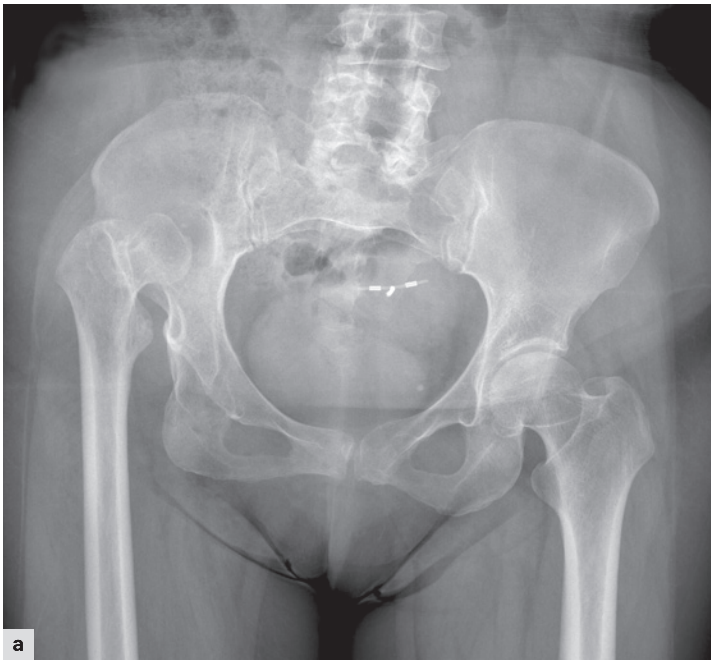


Fig. 1. **Patient 1, with Crowe type IV dysplasia: a – preoperative anteroposterior hip X-ray; b – postoperative hip X-ray; c – postoperative hip X-ray at 8 months (the smallest possible 44-mm acetabular component).**



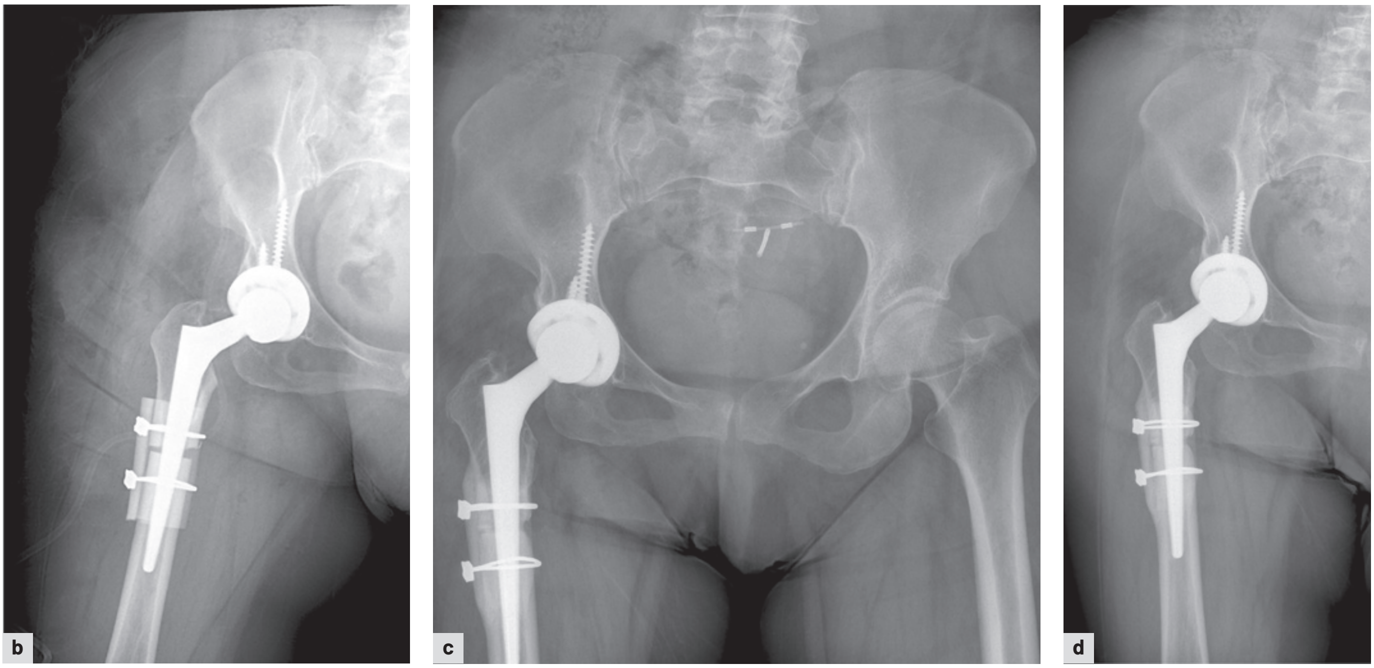


Fig. 2. **Patient 2, with Crowe type IV dysplasia: a – preoperative anteroposterior pelvis X-ray; b – postoperative hip X-ray; c – postoperative pelvis X-ray at 8 months; d – postoperative hip X-ray at 8 months.**

preoperative and postoperative muscle strength. All complications were noted.

The relevant institutional review board approved the research. All patients were informed about the procedures to be applied and signed informed consent forms.

Surgical technique and rehabilitation

In all cases, the surgical team placed the acetabular cup (Trilogy Cup, Zimmer, Warsaw, IN, USA) on the true acetabulum and the same brand of acetabular and femoral implants (Wagner Cone Prosthesis Hip Stem, Zimmer, USA) was used. Applying the same procedure, a single surgeon (author CI) operated on all the patients. All patients received general anesthesia for effective muscle relaxation and early evaluation of sciatic paralysis. The team used a posterior approach for all patients. Cutaneous, subcutaneous, and fascial tissues were exposed. As described in the literature, the gluteal sling was partially relaxed to reduce the risk of sciatic paralysis (8). The external rotators were cut off and preserved for repair. To facilitate limb lengthening, an iliopsoas tenotomy was performed at the level of the trochanter minor insertion. The joint capsule was opened and the femoral neck immediately proximal to the trochanter minor was osteotomized. The capsule was followed and the true acetabulum was reached. The capsule was then excised after the true acetabulum was found. The true acetabulum was exposed by cleaning the surrounding soft tissue and osteophytes. Since bone stock is usually insufficient in the medial wall, the acetabular reamer and acetabulum were prepared without medialization or medial protrusion. The acetabular component was inserted into the prepared acetabulum with a 1-mm press fit. For better fixation, 1–3 screws were inserted to capture the opposite cortex. No other screws were used for additional acetabular stability. For all patients, during the operation, the acetabular prosthesis was covered in the anterior, posterior, and inferior directions. Autografts taken from the femoral head for additional stabilization of the acetabulum (cage, ring, constraint cup) or to support the acetabular roof were not used in any cases.

The planned amount of resection was determined intraoperatively. Femoral reaming was performed based on the proximal alignment of the femoral stem. A transverse osteotomy was then carried out 1–2 cm below the lesser trochanter. A trial femoral component was inserted into the proximal femur and positioned in the acetabulum with the trial femoral head.

To equalize knee levels, the previously osteotomized distal femoral segment was removed. The distal and proximal femoral shafts were aligned and superimposed, and the point where the distal end of the proximal femur would align with the distal segment to achieve equal knee levels was marked. An additional osteotomy was performed at this marked level. The final femoral shortening averaged 4.4 cm (range, 3.2–7.4 cm).

The extracted fragment was divided longitudinally into two parts for use in osteotomy site augmentation in all patients. A reamer was then used to match the distal and proximal medulla for femoral stem implantation. After matching the distal and proximal medullary canal with the reamer, a femoral stem was carefully placed for anteversion, rotation, and stem stability. After the femoral stem was stabilized, the pre-prepared strut femoral grafts from the resected femur bone were fixed with the help of cables to strengthen the fixation. An anti-rotation boot was used at night for 3 weeks to control unwanted and excessive movements.

Table 2. **Clinical results**

LEVEL OF LIMPING	PREOPERATIVE	LAST FOLLOW-UP	P
Severe, n (%)	64 (68.1%)	–	
Moderate, n (%)	27 (28.7%)	1 (1.1%)	
Mild, n (%)	3 (3.1%)	22 (23.4%)	
None, n (%)	–	71 (75.5%)	
TRENDELENBURG SIGN			
Yes, n (%)	94 (100%)	2 (2.1%)	
No, n (%)	–	92 (97.9%)	
Harris Hip Score	52 (range 42 to 61)	84 (range 75 to 96)	< 0.001
Limb length discrepancy (mean cm)	3.4 cm (range 2.2 to 4.7)	1.2 cm (range 0 to 1.8)	
≤ 1 (no. of hips)	–	86	
1–2 (no. of hips)	–	8	
2–3 (no. of hips)	16	–	
3–4 (no. of hips)	72	–	
≥ 4 (no. of hips)	6	–	

Statistical analysis

Data were uploaded to a computer and analyzed using IBM SPSS Statistics 21.0 for Windows (IBM Corp., Armonk, NY, USA). Means were used for descriptive statistics. Paired t-tests were used to compare pre- and postoperative HHS scores. Values of $p < 0.05$ were considered statistically significant.

RESULTS

In this study, all 94 hips had union at the osteotomy site and the mean healing time was 5.4 months (range 4 to 10). The mean preoperative HHS was 52 (range 42 to 61) and the mean postoperative value was 84 (range 75 to 96) ($p < 0.001$). The results of preoperative and postoperative limb length discrepancies (cm), limping levels and Trendelenburg signs are shown in Table 2. Mean limb length discrepancy was 3.4 cm (range 2.2 to 4.7) preoperatively and 1.2 cm (range 0 to 1.8) postoperatively. While 64 patients had severe preoperative limping, none had severe postoperative limping (Table 2). As an early-stage complication, one patient (1%) had a dislocation. This patient underwent closed reduction and was observed 32 months. During follow-up, no further dislocation was recorded. Sciatic palsy was not observed in any cases. One patient (1%) had an intraoperative fracture of the femur. It was fixed with a cable. Since the femoral stem was found to be stable, no extra procedures were performed. No revision or component exchange was required due to the intraoperative femur fracture; thus, the revision-free outcome rate was 100%.

DISCUSSION

The most important finding in this study was that, by performing STFO using a Wagner cone and a primary cup with a posterior approach in cases of Crowe type VI DDH, the rate of complications such as dislocation or nerve damage is minimized and excellent results are obtained. Revision surgery was not performed for any patients in this study.

THA surgery for cases of Crowe type IV DDH is difficult and prone to complications. To minimize these complications, we evaluated patients in the preoperative period using 3D CT in addition to hip X-ray. It is difficult to achieve reduction of the true acetabulum of the hip due to severe soft tissue contractures, abnormalities in neurovascular structures, and limb length discrepancies. Femoral osteotomies facilitate the restoration of the rotation center of the hip and allow for correction of femoral deformities. Although this is an effective approach, it may be accompanied by complications such as nerve injuries or nonunion (2, 5, 14, 27, 28). Reports of osteotomies performed with subtrochanteric femoral surgery via different techniques and distinct types of prostheses have been reported. However, the numbers of cases are low in those reports (8, 18, 21). Different stems were used for the Crowe type IV DDH, such as modular and Zweymüller stems in the femur. Fracture rates have been shown to be high (14). It has also been shown that the use of the Wagner cone stem is simpler and time-saving compared to other stems (14). The present study only used the Wagner cone prosthesis for the femur and primary cups for the acetabulum. All patients underwent STFO. This study included the largest number of cases to date in which the clinical and radiological results of THA with STFO for the treatment of Crowe type IV DDH were evaluated.

One of the most important complications after THA due to Crowe type IV DDH is dislocation. Although it is thought that the posterior approach results in more dislocations due to damage to the posterior tissues, including the external rotator and the joint capsule, many publications have reported no significant differences (12, 23). For instance, one study used a posterior approach without shortening and reported a dislocation rate of 3% for hips with Crowe type III and IV DDH (19). Another study that reported data on shortening femoral osteotomy with a modular stem found the dislocation rate to be approximately 9% (5). In other studies, dislocation rates were reported as 3.8–10.7% in patients with Crowe type IV DDH (16, 22, 28). In the present study, the dislocation rate is reported as 1%. In addition to the importance of the prosthetic position, we believe that the anti-rotation boot that we prescribed for nightly usage for 3 weeks was also effective.

There may be a risk of intraoperative femoral fracture as the femoral medulla is narrow, the anatomy is different, and a cementless femoral prosthesis is used. Some studies have reported intraoperative femoral fracture rates of 6–61.2% (1, 15, 16, 18, 19). Press fit is especially important for patients undergoing subtrochanteric shortening osteotomy. The proximal and distal sides of the osteotomy site can be easily broken during stem placement. In this study, we found that 1 (1%) of the patients had an intraoperative femoral fracture.

Lowering the hip rotation center to the anatomical position provides sufficient bone stock for the acetabular component and stronger muscle strength for the extended abductor arm. Some studies in the literature reported that hip prostheses placed in the anatomical hip rotation center increase the survival rate in the medium and long terms (11, 17). For all the patients in this study, the acetabulum was lowered to its normal location.

The approach in THA, the effectiveness of which has been proven by many surgeons, is the posterolateral approach (10). The direct anterior approach is a surgical approach between the neural interface and the muscle space, which has the advantages of less damage to soft tissues, less bleeding, and rapid healing. However, direct anterior approach has been rarely reported in DDH surgeries. Therefore in this study we preferred to use posterolateral approach in which we are more experienced and which is safer.

The dimensions of the acetabular component and the femoral head are particularly important for stability. It is not possible to place a large acetabular component due to the hypoplastic acetabulum, which is usually found in cases of DDH. We chose to use a 44-mm acetabular component with a 28-mm femoral head for all patients. The acetabular cup was placed in the position that was most covered with bone and would be optimal for stability. Rotational stability was achieved by rotational adjustments in the femoral stem. In the femur, the smallest surgical component that could ensure stability was placed in the distal and proximal parts.

There are many trochanteric femoral osteotomy methods available. This study utilized the subtrochanteric transverse osteotomy method since it is easy to apply. It also allows anteversion management and re-shortening (1). This method, however, has some risks regarding nonunion along the osteotomy line. Previous studies reported nonunion rates ranging from 0% to 2% for osteotomy sites in cases of Crowe type IV (1, 16, 19, 27). In this study, we did not observe nonunion in any cases. We believe that wrapping the excised bone segment with a cable around the osteotomy line increases stability and reduces the risk of nonunion.

Lowering the acetabular component to the anatomical location, even when a femoral shortening osteotomy has been performed, may cause sciatic nerve palsy (19, 28). Some studies have reported that 2.6% to 12% of patients who underwent shortening had sciatic nerve palsy (11, 18). On the contrary, none of the patients in this study had sciatic nerve palsy. Işık et al. showed that sciatic nerve palsy can be prevented by loosening the proximal two-thirds of the gluteal sling to prevent the sciatic nerve from being pinched between the femur and the sling (8). We think that the reason why sciatic nerve palsy was not observed in this study was the partial loosening of the gluteal sling.

While the results of this research are highly significant, the study has some limitations. Major limitations of this study are its retrospective design and the lack of a control group and power analysis. While we have presented results for a mean of 40 months (range 25 to 55), which is also an important contribution to the literature, long-term results would be more valuable. The advantage of this study is that all patients were operated on by the same surgical team and a single type of prosthesis was used.

CONCLUSIONS

In conclusion, this study has presented excellent clinical outcomes with no revisions, no nonunion, and minimal residual limping in patients who underwent shortening with STFO using a Wagner cone on the acetabulum and a primary cup on the femur. ■

Consent to participate: Informed consent forms were obtained from all patients for both their participation in the study and for publications.

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