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Locking Plate Fixation in Subtrochanteric Valgus Osteotomy for Pediatric Coxa Vara: Mid-Term Results

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ABSTRACT

Coxa vara is defined as the cephalomedullary angle below 110 degrees. Femoral valgus osteotomy is performed as the gold standard in the surgical treatment of pediatric coxa vara. Many surgical techniques have been described related to the level and fixation of osteotomy. The aim of this study is to evaluate the radiological and functional outcomes of subtrochanteric valgus osteotomy fixed with a locking plate for pediatric coxa vara.

This study included 23 patients who underwent the same surgical technique. Of these patients, 10 were male and 13 were female. Surgery was performed on the right side of 15 patients and the left side of 8 patients. The functional hip scores of the patients were assessed using preoperative and postoperative IOWA hip scores. Radiographic outcomes were evaluated by measuring preoperative and postoperative Hilgenreiner's epiphyseal angle (HEA) and collodiaphyseal angle (CDA).

The mean age at the time of surgery was found to be 11.35 ± 2.67 years. The mean follow-up duration was determined to be 37,65 ± 12.38 months. No limb-length discrepancy was present in 16 patients in the postoperative period, whereas limb-length discrepancy was encountered in 7 patients. Recurrence was observed in 2 patients. The mean correction of CDA improved from 89.74° to 117.83.8°(t(22)=-12.53, p=0.001). The mean correction of HEA improved from 64.87.2° to 37.48° (t(22)=18.00, p=0.001). The mean IOWA hip score improved from 62.87 to 92.96 (t(22)=18.00, p=0.001) at the last follow-up.

Well-functioning functional and radiological outcomes can be obtained with subtrochanteric valgus osteotomy with locking plate fixation for pediatric coxa vara.

Keywords: Coxa vara, Valgus osteotomy, Locking plate

Introduction

Coxa vara is defined as the cephalomedullary angle below 110 degrees (1). Even though, it is seen depending on many causes, developmental coxa vara is most often encountered. In addition, it may be discovered due to congenital, traumatic or metabolic osseous diseases and monitored on the infectious (inflammatory) or dysplastic basis (2,3,4). Additionally, coxa vara may be encountered as a component of some genetic anomalies (5).

Developmental coxa vara develops due to an ossification defect in the inferomedial femoral neck. Proximal femoral physis becomes vertical, and thereby coxa vara develops. As a consequence, this condition increases physeal shear force and compressive forces in the inferomedial femoral neck (6,7). Congenital coxa vara may be accompanied by proximal femoral insufficiency or a congenitally short femur (8).

The findings of developmental coxa vara are discovered between the start of gait and the 6th year of age. Clinically, pain-free limping and limb-length discrepancy are seen in the patients. The trochanter becomes prominent. Genu valgum and acetabular dysplasia may also be present in these patients. Abduction and internal rotation are limited. Radiological evidence, such as reduced neck-shaft angle and increased HEA (Hilgenreiner's epiphyseal angle), is encountered (9).

Femoral valgus osteotomy is performed as the gold standard in the surgical treatment of pediatric coxa vara. Many surgical techniques have been described related to the level and fixation of osteotomy. Abductor muscle tension and leg length are elevated by increasing the neck-shaft angle with osteotomy. Shear force in the epiphysis

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Fig.1. The preoperative and postoperative radiographs of the patient who underwent valgus osteotomy

is declined, and the limb-length discrepancy is equalized (10).

HEA higher than 60 degrees creates a serious risk for progression and necessitates surgery. Although progression risk in patients with HEA between 45-60 degrees is not clearly known, surgery is recommended for symptomatic cases. Follow-up is recommended for patients with HEA <45 degrees (11).

The aim of this study is to evaluate the radiological and functional outcomes of subtrochanteric valgus osteotomy fixated with locking plate for pediatric coxa vara etiologies.

Materials and Methods

This retrospective study was conducted at Niğde Ömer Halisdemir University, Department of Orthopedics and Traumatology. The study protocol was approved by the Institutional Review Board of the Niğde Ömer Halisdemir University Faculty of Medicine (No:2023/25). The study was conducted in accordance with the criteria of the Declaration of Helsinki.

Patients who were diagnosed with pediatric coxa vara and underwent subtrochanteric valgus osteotomy at Niğde Ömer Halisdemir University Training and Research Hospital between March 2015 and January 2021 were evaluated in this study. The inclusion criteria were as follows: (a) age under 18, (b) subtrochanteric valgus osteotomy with locking plate fixation, (c) available preoperative and postoperative IOWA scores, (d) proper preoperative and postoperative radiographs and orthoradiographs, and (e) application of the same surgical technique. The exclusion criteria were as follows: (a)the patients who did not complete the follow-up process, (b) inappropriate preoperative and postoperative radiographs, (c) missing preoperative and postoperative IOWA scores, and (d) bilateral coxa vara. The study included 23 patients. The follow-up duration of the patients ranged between 18 and 65 months. Of these patients, 10 were male and 13 were female. Surgery was performed on the right side of 15 patients and the left side of 8 patients.

Preoperative and postoperative AP radiographs of the pelvis were evaluated, and measurement was performed using the appropriately taken radiographs. The HE and collodiaphyseal angle (CDA) angles were reviewed preoperatively and postoperatively. The HE and CD angle values measured at the last follow-up were taken into consideration as the postoperative HE and CD angles. All the radiographs were measured by a specialist orthopedic surgeon who performed the surgeries. The preoperative and functional scores after the achievement of union were evaluated using the IOWA hip score. The functional outcomes at the last follow-up were taken into consideration, such as the postoperative IOWA hip score. Postoperative limb-length discrepancy was measured using orthoradiography. All clinical notes, including pain, limping, and complications, were recorded. Gait abnormality and limb-length discrepancy were noted.

Surgical Technique: All surgeries were performed using the same surgical technique. Valgus correction was calculated preoperatively using plain AP radiographs. It was performed under general anaesthesia on the radiolucent operating table. The patient was prepared in the supine position. All the patients were examined.

Table 1: The Measurements of CDA and HEA in the Preoperative and Postoperative Periods and Difference Between the IOWA Hip Scores

	M	p*
Preoperative CDA measurement	89.74	0.001
Postoperative CDA measurement	117.83	
Preoperative HEA measurement	64.87	0.001
Postoperative HEA measurement	37.48	
Preoperative IOWA score	62.87	0.001
Postoperative IOWA score	92.96	

*Paired samples t-test
M: Mean
CDA: Collodiaphyseal angle
HEA: Hilgenreiner's epiphyseal angle

Table 2: The Relationship of IOWA Hip Score, CDA, and HEA Measurements With Shortness In The Postoperative Period

	Shortness	n(total =23)	M	SD	p*
Postoperative IOWA hip score	N/A	16	95.00	4.92	.01
	Present	7	88.29	3.94	
Postoperative CDA measurement	N/A	16	121.63	8.80	.01
	Present	7	109.14	10.69	
Postoperative HEA measurement	N/A	16	34.69	5.40	.01
	Present	7	43.86	9.52	

*: Independent samples t-test
M: Mean
SD: Standard deviation
CDA: Collodiaphyseal angle
HEA: Hilgenreiner's epiphyseal angle

Standard adductor tenotomy. The standard lateral approach was applied (by eliminating the vastus lateralis to the posterior). The osteotomy line was positioned approximately two centimeters below the lesser trochanter and aligned parallel to the Hilgenreiner line under fluoroscopic guidance. Following, the subtrochanteric wedge incision was completed using a K-wire. The femur was brought to abduction, and compression was achieved by closing the wedge incision from the lateral region using a forceps. Following, at least three locked screws were sent to femoral neck over contoured locking plate. Four screws were inserted into the distal osteotomy line. The preoperative and postoperative radiographs of the patient who underwent valgus osteotomy are shown in Figure 1. No hip spica was used in the postoperative period. Full weight bearing was allowed 6-8 weeks after callus formation was maintained.

Statistical Analysis: Statistical analysis was performed using the SPSS Version 25.0 software (IBM Corp., Armonk, NY, USA). For descriptive statistics, mean± standard deviation is given for continuous data that exhibit normal distribution, and median (min-max) values are given for those that do not exhibit normal distribution. The Shapiro-Wilk test was used to determine whether the data were normally distributed. Normal distribution for noncategorical data is evaluated. Because of the retrospective design of the study and a limited number of patients, an a priori test is not used. Paired Samples T Test was used to compare the means of quantitative data in a single group. The Independent Samples t-test technique was used to evaluate the differences between the two groups. A $p<0.05$ value was considered statistically significant.

Results

Surgery was performed for developmental coxa vara, femoral head epiphysis shift, septic arthritis sequela and metabolic etiology in 18, 2, 2 and 1 of the patients, respectively.

The mean age at the time of surgery was found to be 11,35±2.67 years. Mean follow-up duration was

determined to be 37,65 ±12.38 months. The mean time for union was detected to be 81,04 ±11.39 days. No limb-length discrepancy was present in 16 patients in the postoperative period, whereas limb-length discrepancy was encountered in 7 patients. Recurrence was observed in 2 patients. No other serious complication (Avascular necrosis, hip subluxation, etc.) was encountered.

A significant increase was found in the preoperative and postoperative CDA values of the patients. The mean correction of the CDA was improved from 89.74° to 117.83°($t(22)$=-12.53, p=0.001). A significant decline was detected in the preoperative and postoperative Hilgenreiner's epiphyseal angle values of the patients. The mean correction of the HEA was improved from 64.87° to 37.48° ($t(22)$=18.00, p = *0.001*). A significant increase was determined in IOWA hip scores measured in the postoperative period compared with the preoperative period. The mean IOWA hip score was improved from 62.87 to 92.96 ($t(22)$=18.00, p = *0.001*) at the last follow-up. Preoperative and postoperative CDA and HEA measurements and the IOWA hip scores are shown in Table 1.

It was shown that postoperative IOWA hip scores of the patients with postoperative limb-length discrepancy were significantly lower ($t(21)$=3.18, p = *0.01*). It was encountered that postoperative CDA values of the patients with postoperative limb-length discrepancy were significantly lower ($t(21)$=2.93, p = *0.01*). It was ascertained that postoperative HEA values of the patients with postoperative limb-length discrepancy were significantly higher ($t(21)$=-2.96, p=0.01). The relationship between IOWA hip score, CDA, and HEA measurements and shortness in the postoperative period is shown in Table 2.

Discussion

Many surgical techniques have been reported for femoral valgus osteotomy (12,13). However, a consensus on this subject has not yet been established, and a gold standard surgical technique remains to be established. So, the main finding of this study was that plate fixation of subtrochanteric valgus osteotomy with our surgical technique is an applicable choice for different coxa vara etiologies.

Abdelaziz et al. showed that correcting the HEA from a mean of 66.5° to 35.5°, in 26 patients with infantile coxa vara, led to improvements in gait, agility, and the ability to sit cross-legged (14). Elzohairy et al. reported a significant improvement in IOWA scores by correcting the CDA to a mean of 36.2 degrees and the HEA to a mean of 50.4 degrees in 18 patients(15). Similarly, El-sobky et al. corrected the CD angle to 26 degrees and the HE angle to 50 degrees, achieving excellent results in IOWA hip scores (16). In our study, we demonstrated that our surgical technique increased the CD angle to a mean of 28.09 degrees and the HE angle to a mean of 27.39 degrees, while also improving the mean IOWA hip scores from 62.87 to 92.96, consistent with the literature. Therefore, we believe that significant corrections in CD and HE angles play a crucial role in achieving satisfactory functional outcomes.

It is shown that correction of Hilgenreiner's epiphyseal angle is the most crucial part for prevention of recurrence (9,17,18). In a study conducted on 12 patients (20 hips) who underwent valgus osteotomy for coxa vara, recurrence was observed in none of the patients with HEA below 35 degrees and CDA lower than 130 degrees (17). Carroll et al. have observed no recurrence of varus deformity in patients with postoperative HE angles below 38 degrees in their study. Therefore, they have recommended performing overcorrection to the normal value of HE angle (22°). In addition, they could find no significant relationship between postoperative CD angle and favorable clinical results (9). Some authors have noted that favorable short-term results can be obtained with an HE angle below 35 degrees and a CD angle below 120 degrees (19). It has been mentioned in another study that postoperative HEA lower than 38 degrees is critical (20). In our study, we showed that the mean HE angle after osteotomy was 37,48°. However, inconsistent with the literature, recurrence was detected in 2 patients in our study, and undercorrection of HE angle was present in these patients (HE>41°). We conclude, in line with the literature, that performing correction and, if necessary, overcorrection of Hilgenreiner's epiphyseal angle will reduce the risk of recurrence.

In a study evaluating 18 patients, it was demonstrated that all patients had a limb length discrepancy of less than 2 cm following valgus osteotomy and achieved an excellent functional score (10). Another study reported that, with proper correction, limb length discrepancy was less than 1 cm in all patients at the final follow-up (14). Similarly, in our study, although extremity shortening was observed in seven patients at the final follow-up, all cases had a limb length discrepancy of less than 2 cm. Furthermore, we

showed that patients with limb shortening had worse functional outcomes. Therefore, we believe that inadequate correction negatively impacts functional results.

The small number of our study patients, retrospective design of the study and inability to carry out a multiplanar deformity analysis were the important limitations of this study. Additionally, there were some patients in the study who were applied undercorrection and it would be more reasonable to follow-up these patients for a longer period and to evaluate the functional outcomes with respect to recurrence.

It has been stated in a large case series including 32 patients (46 hips) that developmental coxa vara is a three-dimensional deformity and that negative femoral offset and undercorrection in HE angle are the important risk factors for recurrence (21). In our study, although, measurements were performed only on coronal deformity, femoral offset was not evaluated. This is also one of the important limitations of our study.

As a conclusion; well functional and radiological outcomes can be obtained with subtrochanteric valgus osteotomy with locking plate fixation for pediatric coxa vara.

Ethics Committee Approval: The study was approved by Niğde Ömer Halisdemir University Noninterventional Clinical Research

Ethical Committee (Decision no: 25, Date: 2023).

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