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Original Article

Does the Cartilaginous Index Affect Acetabular Development in Developmental Dysplasia of the Hip? A Radiographic Study on Patients with Long-term Follow-up

Kıkırdak Asetabüler Indeksin Kalça Gelişimine Etkisi. Uzun Dönem Takipli Hastalarda Radyolojik Çalışma

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ABSTRACT

Objective: Developmental dysplasia of the hip is one of the most common infantile diseases. Estimating the roles of factors affecting the development of dysplastic hip is essential in determining the treatment outcomes. In this study, we investigated if the cartilaginous acetabular index (CAI), osseous acetabular index, or their difference (delta angle) affect acetabular development in the long- term follow-up.

Method: Thirty-five hips of 30 patients are included in the study. The mean age of the patients was 15.71±6.37 (3-31) months. All patients were treated using a medial approach. The mean follow-up was 149.91±51.43 (60-262) months. Five hips were excluded due to the development of avascular necrosis.

Results: Any statistically significant difference was not found in the evaluation of the correlation between CAI, osseous acetabular index, or delta angle measurements in terms of acetabular development. The acetabular growth in the first year following the reduction was statistically significant ($p<0.001$), while, the acetabular development for the following years were not found to be statistically significant ($p>0.05$).

Conclusion: CAI, osseous acetabular index, and delta angles do not directly affect acetabular development rate. However, most of the acetabular development occurs during the first year after concentric reduction in children younger than 24 months.

Keywords: Acetabular development, dysplasia of the hip, DDH, medial approach, the cartilaginous acetabular index, child

ÖZ

Amaç: Gelişimsel kalça displazisi infant çağının sık görülen hastalıklarındandır. Hastalığın takip ve tedavi sürecinin değerlendirilmesinde, kalça gelişimine etkileyen faktörlerin bilinmesinin önemi büyüktür. Bu çalışmada, başlangıçta ölçülen kıkırdak asetabüler indeks (KAİ) değerinin, hem tek başına hem de asetabüler indeks değeri ile farkının kalça gelişimine etkisi uzun dönem takip edilen hastalarda, radyografik olarak değerlendirildi.

Yöntem: Çalışmaya otuz hastanın otuz beş kalçası dahil edildi. Hastaların ortalama yaşı 15,71±6,37 (3-31) aydı. On üç kalçaya sınırlı medial girişim, 22 kalçaya ise medial girişim uygulandı. Ortalama takip süresi 149,91±51,43 (60-262) aydı. Beş kalça takipler sırasında avasküler nekroz gelişmesi nedeniyle değerlendirme dışı bırakıldı.

Bulgular: Yıllık asetabüler gelişim ile başlangıçta ölçülen KAİ değeri arasında istatistiksel olarak önemli bir ilişki izlenmedi ($p>0,05$). Redüksiyonu takip eden ilk yılın sonunda görülen kalça gelişimi istatistiksel olarak anlamlı saptandı ($p<0,001$). Takip eden yıllardaki asetabüler gelişim istatistiksel olarak anlamlı bulunmadı ($p>0,05$).

Sonuç: KAİ değeri, kalça gelişimini direk olarak etkilememektedir. Bununla birlikte asetabüler gelişim, 24 aydan küçük çocuklarda konsantrik redüksiyonu takip eden ilk yıl içerisinde en yüksek oranda gerçekleşmektedir.

Anahtar kelimeler: Asetabüler gelişim, gelişimsel kalça displazisi, GKD, medial yaklaşım, kıkırdak asetabüler indeks, çocuk

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INTRODUCTION

Although early concentric reduction of the femoral head in the treatment of the developmental dysplasia of the hip (DDH) is an essential factor for acetabular development in infants, higher initial acetabular index (AI) values negatively affect the treatment outcomes [1,2]. Infant acetabulum consists mainly of cartilage tissue. It isn't easy to assess cartilage acetabulum by plain radiographs, and generally, arthrographic imaging, ultrasound, or magnetic resonance imaging (MRI) is being used for this evaluation.

The cartilaginous acetabular index (CAI) can be measured by MRI and arthrographic imaging. Measurement of CAI is also essential for the evaluation of acetabular development [3,4]. The cartilaginous coverage of the acetabulum was also assessed as a predictor of residual hip dysplasia. Many researchers assessed CAI as a potential predictor for decision-making about the need for an acetabuloplasty [4-8].

In the present study, we retrospectively evaluated the development of dysplastic infant hips, which have been treated successfully. We aimed to determine whether the CAI is correlated with acetabular development.

MATERIALS and METHODS

Thirty-five hips of 30 patients treated with the diagnosis of DDH were evaluated retrospectively. Twenty-nine (96.7%) patients were girls and eighteen of the 35 hips were left-sided. Five patients had bilateral DDH. The mean age of the patients was 15.71±6.37 (3-21) months. All patients were treated using a medial approach. The mean follow-up period was 149.91±51.43 (60-262) months.

Our treatment algorithm for DDH is to firstly apply a limited medial approach [9]. Following the skin incision, adductor longus and iliopsoas tenotomies were made. The hip was then reduced, and with one ml contrast material (UROGRAFIN®, Bayer AG Leverkusen/Germany) was injected into the hip joint, and arthrography was performed. According to the arthrographic assessment of Tönnis, the procedure would be completed for type 1 patients who underwent concentric hip reduction. While Type 2 and 3 DDH patients undergo a complete medial approach procedure, including capsulotomy, ligamentum teres excision, transverse acetabular ligament transection, and gentle pulvinar removal [10].

During the postoperative period, hip spica cast was applied for all of the patients with the patient in the 'human position' to be kept for three months and the hips were stabilized in abduction braces with a 90°-100° flexion and 40°-45° abduction for a further three months. Follow-up visits were made at postoperative 6th week, third and sixth months, first-year, then annually. Five hips were excluded from the study during the follow-ups due to the development of avascular necrosis.

On the pre-operatively obtained pelvic anteroposterior radiographs, AI angles were measured (Figure 1). CAI was measured from intraoperatively made artrographic images (Figure 2). The difference between AI and CAI values was accepted as cartilaginous acetabular thickness and described as the "delta angle" for statistical assessment.

Annual measurements were made on the anteroposterior pelvic radiographs for five years. Wiberg's CE angle and Sharp's acetabular angle were measured on the most recent anteroposterior pelvic radiographs of the patients. These measurements were evaluated according to reference values for age and gender [11,12]. The most recent pelvic radiographs of the patients were used for the decision of maturation. Because of the irregularity of the patients' visits during the follow-up period, the acetabular development was assessed only for the first five years.

This study was the research thesis of Mert Filibeli. The study was approved by the University of Health Sciences Turkey, İzmir Tepecik Training and Research Hospital

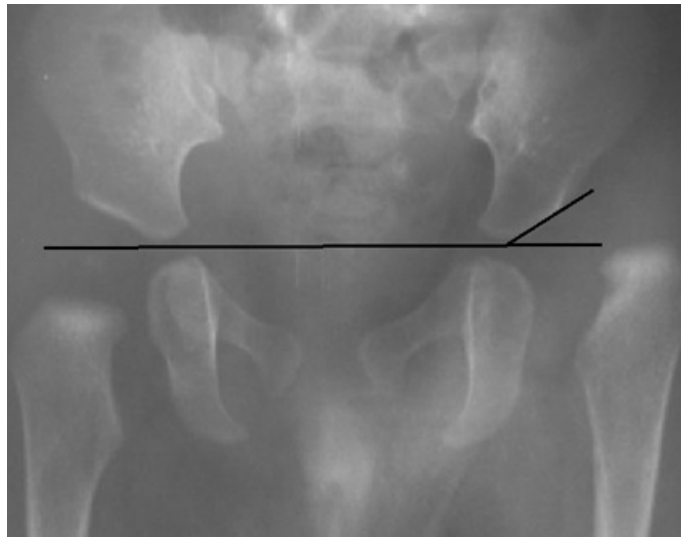

Figure 1. Pre-operative measurements of acetabular indices

Clinical Research Ethics Committee (approval number: 3, date: 05.12.2016).

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics for Windows, ver. 23.0 (IBM Corp, Armonk, New York, USA). The normality of distribution among the groups was assessed using the Shapiro-Wilk test. The p-values greater than 0.05 were accepted as an indication for a normal distribution, and statistical analyses were continued with parametric tests. If the p values were <0.05, non-parametric tests were used for statistical analyses. To compare the improvement of AI values during postoperative years, we used the Bonferroni test. The factors affecting the improvement in acetabular indices progress over the years such as surgical technique, CAI, delta angle were analyzed using covariance analysis (ANCOVA). To conduct an efficient ANCOVA analysis, the patients were divided into groups. According to the surgical technique and labrum status, the patients were divided into two groups as limited and complete medial approach; normal and inverted labrum, respectively. The cut-off value for CAI was accepted as 20° [4], and accordingly patients were divided into two groups. Lastly, the patients were divided into two groups relative to the 30° cut-off value of delta angle.

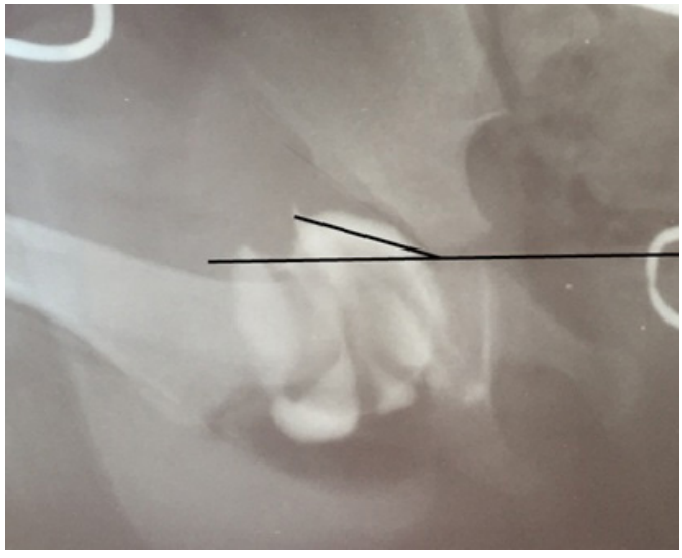

Figure 2. Measurements of the cartilaginous acetabular indices

RESULTS

The mean pre-operative AI angle was 39.2°±4.52 (30-48). The mean CAI, and delta angles were 16.1°±6.94 (4-30), and 23.17°±8.29 (2-40) respectively.

An ANCOVA test was conducted to compare the effects of the CAI, delta angle, labrum status, and surgical technique on the acetabular development in five years while controlling the AI. There was no statistical significance. The F and p values of the analysis are given in Table 1.

No statistically significant difference was found in evaluating the correlation between CAI angle measurements and annual acetabular development (p>0.05).

The mean AI values following reduction are shown in Figure 3.

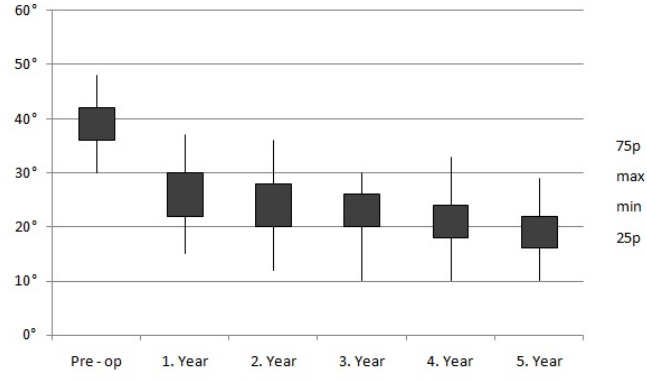

Figure 3. The mean acetabular index values in the first five years

max.: Maximum, min.: Minimum

Table 1. The results of ANCOVA on the acetabular development in five years

	CAI	Delta angle	Surgical technique	Labrum status
1. year	F (1.27)=0.33, p=0.25	F (1.27)=0.07, p=0.79	F (1.27)=0.80, p=0.38	F (1.27)=0.18, p=0.68
2. year	F (1.27)=0.80, p=0.78	F (1.27)=0.28, p=0.60	F (1.27)=0.99, p=0.33	F (1.27)=0.19, p=0.18
3. year	F (1.27)=0.10, p=0.75	F (1.27)=0.00, p=0.99	F (1.27)=0.56, p=0.46	F (1.27)=1.10, p=0.31
4. year	F (1. 27)=0.24, p=0.63	F (1.27)=0.02, p=0.89	F (1.27)=0.10, p=0.75	F (1.27)=1.33, p=0.26
5. year	F (1.27)=0.14, p=0.71	F (1.27)=0.00, p=0.97	F (1.27)=0.20, p=0.66	F (1.27)=1.26, p=0.27

CAI: Cartilaginous acetabular index, ANCOVA: Analyzed using covariance analysis

When the patients' acetabular development in the first five years was compared using multi-directional analysis of variance (Bonferroni), the change over the years was statistically significant (p<0.01) (Table 2).

The multivariate analysis of Bonferroni was used to assess the improvement of the AI over the years. The mean annual differences in acetabular indices in the postoperative first [13.51±5.85 (1-24)], second [2.34±2.76 (0-12)], third [2.11±2.01 (0-8)], fourth [2.11±2.01 (0-8)], ane fifth [1.28±1.58 (0-6)]. The improvement in the first year following the reduction was statistically significant (p<0.001), while the changes between the following years in terms of androgen insensitivity syndrome were not (p>0.05) (Table 3).

No statistically significant difference was found between patients whose age at the operation were younger, and older than 12 months in terms of acetabular development (Table 4).

DISCUSSION

The aim of DDH treatment is to get a concentric and stable reduction of the hip [13-15]. In our study, we evaluated the hips treated with the medial approach

Table 2. The improvement of the acetabular indices over the years (Bonferroni)

	Acetabular index according to years*	Mean difference	Standard error**	p-value	95% CI	
					Bottom	Top
Pre-op	1	12.471*	0.991	0.000	9.334	15.607
	2	14.706*	0.963	0.000	11.658	17.754
	3	16.794*	0.885	0.000	13.993	19.596
	4	18.353*	0.903	0.000	15.494	21.212
	5	19.765*	0.899	0.000	16.921	22.608
1. year	Pre-op	-12.471*	0.991	0.000	-15.607	-9.334
	2	2.235*	0.468	0.001	0.753	3.717
	3	4.324*	0.479	0.000	2.808	5.839
	4	5.882*	0.604	0.000	3.971	7.794
	5	7.294*	0.671	0.000	5.171	9.417
2. year	Pre-op	-14.706*	0.963	0.000	-17.754	-11.658
	1	-2.235*	0.468	0.001	-3.717	-0.753
	3	2.088*	0.349	0.000	0.984	3.193
	4	3.647*	0.506	0.000	2.045	5.249
	5	5.059*	0.562	0.000	3.282	6.836
3. year	Pre-op	-16.794*	0.885	0.000	-19.596	-13.993
	1	-4.324*	0.479	0.000	-5.839	-2.808
	2	-2.088*	0.349	0.000	-3.193	-0.984
	4	1.559*	0.336	0.001	0.497	2.621
	5	2.971*	0.423	0.000	1.631	4.31
4. year	Pre-op	-18.353*	0.903	0.000	-21.212	-15.494
	1	-5.882*	0.604	0.000	-7.794	-3.971
	2	-3.647*	0.506	0.000	-5.249	-2.045
	3	-1.559*	0.336	0.001	-2.621	-0.497
	5	1.412*	0.296	0.001	0.476	2.348
5. year	Pre-op	-19.765*	0.899	0.000	-22.608	-16.921
	1	-7.294*	0.671	0.000	-9.417	-5.171
	2	-5.059*	0.562	0.000	-6.836	-3.282
	3	-2.971*	0.423	0.000	-4.31	-1.631
	4	-1.412*	0.296	0.001	-2.348	-0.476

*Acetabular index according to years. **Standard error, CI: Confidence interval

and ended up with Severin type 1 hips after the follow-up of the patients up to the skeletal maturity. By including only the Severin type 1 hips in the study, we aimed to investigate the factors affecting the acetabular development independent from complicated hips. According to our findings, the acetabular development occurred largely in the first postoperative year following the reduction. There were no statistically significant factors affecting the acetabular development except the concentric reduction.

Some studies have investigated the relationship between the CAI and the acetabuler development. Different cut-off values and age limitations for CAI were suggested to be used for deciding acetabuloplasty [4,7,16,17]. In our study, initial AI or CAI values were of no statistical significance on the acetabular development. However, in our institute, we don't routinely perform MRI or arthrography on patients with DDH for only assessing development at a young age.

As many studies have shown, the acetabulum develops rapidly in the first year following reduction [18-21]. Our results demonstrate statistical significance in the first year's acetabular development. Albeit at a decreasing rate, and without any statistical significance

Table 3. Analysis of the annual differences in acetabular indices (Bonferroni)

	Acetabular development	Mean difference	Standard error	p-value	95% CI	
					Bottom	Top
1. year	2	11.171	1.184	0.000	7.616	14.727
	3	11.400	1.078	0.000	8.164	14.636
	4	12.000	1.021	0.000	8.936	15.064
	5	12.229	1.082	0.000	8.979	15.478
2. year	1	-11.171	1.184	0.000	-14.727	-7.616
	3	0.229	0.661	1.000	-1.756	2.213
	4	0.829	0.573	1.000	-0.892	2.549
	5	1.057	0.502	0.427	-0.450	2.564
3. year	1	-11.400	1.078	0.000	-14.636	-8.164
	2	-0.229	0.661	1.000	-2.213	1.756
	4	0.600	0.453	1.000	-0.760	1.960
	5	0.829	0.441	0.686	-0.494	2.151
4. year	1	-12.000	1.021	0.000	-15.064	-8.936
	2	-0.829	0.573	1.000	-2.549	0.892
	3	-0.600	0.453	1.000	-1.960	0.760
	5	0.229	0.442	1.000	-1.097	1.555
5. year	1	-12.229	1.082	0.000	-15.478	-8.979
	2	-1.057	0.502	0.427	-2.564	0.450
	3	-0.829	0.441	0.686	-2.151	0.494
	4	-0.229	0.442	1.000	-1.555	1.097

CI: Confidence interval

Table 4. Alysis of acetabular development regarding age at the procedure

	<12 months	>12 months	p-value*
1. year	12.66±8.38 (1-24)	13.80±4.87 (4-24)	0.78
2. year	2.88±2.02 (0-7)	2.15±2.98 (0-12)	0.14
3. year	1.88±1.96 (0-5)	2.19±2.05 (0-8)	0.83
4. year	1.77±1.64 (0-4)	1.42±2.06 (0-6)	0.42
5. year	1.88±1.83 (0-6)	1.07±1.46 (0-5)	0.17

*Mann-Whitney U test

acetabular development was maintained over the years. These findings favor Ponseti and Harris's reports related to acetabular development [19,20]. All the AI values at the age of three were <32°, and all the hips completed their normal development, supporting the study of Shin et al. [17].

Ponseti [19] reported that the inverted labrum did not act as an obstacle for the reduction following iliopsoas tenotomy and capsulotomy. On the other hand, Ge et al. [22] evaluated the labrum one year after hip reduction surgeries using magnetic resonance imaging. They reported that the inversion of the anterior part affected the development of the hips, while the inversion of the posterior part affected only the quality of reduction[22]. Contrary to Miyake et al.'s [16] study, labrum status was not associated with the acetabular development in the present research. In our clinic we do not routinely interfere with the labrum during open reduction procedures.

The potential of acetabular development drops after four years of age. The age at the reduction affects the development of hips. Favorable and unfavorable treatment outcomes have been reported in various studies for procedures performed after 12 months of age is [20-32]. The present study reports that the age at the operation did not statistically significantly affect the treatment success rates. The oldest of the patients at the surgery was 31 months of age. We suggest that the medial approach could be an appropriate procedure for patients older than 12 months and as suggested by many authors, we recommend follow-up all the patients up to the skeletal maturity [23-28].

Study Limitations

The number of patients and the measurements made by only one researcher are the main limitations of this study. The most recent pelvic radiographs of the patients have been used for the decision of maturation. Because of the irregularity of the patients' visits during the follow-up period, the acetabular development was assessed only for the first five years. The patients were followed up for almost 13 years which constituted the strength of our study.

CONCLUSION

In conclusion, the results of the present study have shown that concentric and stable reduction are the main factors affecting the development of dysplastic acetabulum. For such hips, acetabular development occurs during the following years at a decreasing rate, and most of the acetabular development is seen in the first year. The CAI should be evaluated carefully as a predictor for the development of infants' dysplastic acetabulum.

Ethics

Ethics Committee Approval: The study was approved by the University of Health Sciences Turkey, İzmir Tepecik Training and Research Hospital Clinical Research Ethics Committee (decision no:3, date: 05.12.2016).

Informed Consent: Since our study had a retrospective design, informed consent was not obtained from the patients.

Peer-review: Externally peer-reviewed.

Author Contributions

Surgical and Medical Practices: H.A., M.F., A.T., Ö.K., Concept: H.A., M.F., A.T., Ö.K., Design: H.A., M.F., A.T., Ö.K., Data Collection and/or Processing: H.A., M.F., A.T., Ö.K., Analysis and/or Interpretation: H.A., M.F., A.T., Ö.K., Literature Search: H.A., M.F., A.T., Ö.K., Writing: H.A., M.F., A.T., Ö.K.

Conflict of Interest: The authors have no conflict of interest to declare.

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REFERENCES

1. Thomas SR, Wedge JH, Salter RB. Outcome at forty-five years after open reduction and innominate osteotomy for late-presenting developmental dislocation of the hip. J Bone Joint Surg Am. 2007;89(11):2341-50. doi: 10.2106/JBJS.F.00857.
2. Terjesen T, Horn J, Gunderson RB. Fifty-year follow-up of late-detected hip dislocation: clinical and radiographic outcomes for seventy-one patients treated with traction to obtain gradual closed reduction. J Bone Joint Surg Am. 2014;96(4):e28. doi: 10.2106/JBJS.M.00397.
3. Li LY, Zhang LJ, Li QW, Zhao Q, Jia JY, Huang T. Development of the osseous and cartilaginous acetabular index in normal children and those with developmental dysplasia of the hip: a cross-sectional study using MRI. J Bone Joint Surg Br. 2012;94(12):1625-31. doi: 10.1302/0301-620X.94B12.29958.
4. Zamzam MM, Kremli MK, Khoshhal KI, Abak AA, Bakarman KA, Alsiddiky AM, et al. Acetabular cartilaginous angle: a new method for predicting acetabular development in developmental dysplasia of the hip in children between 2 and 18 months of age. J Pediatr Orthop. 2008;28(5):518-23. doi: 10.1097/BPO.0b013e31817c4e6d.
5. Merckaert SR, Pierzchala K, Bregou A, Zambelli PY. Residual hip dysplasia in children: osseous and cartilaginous acetabular angles to guide further treatment-a pilot study. 2019;14(1):379. doi: 10.1186/s13018-019-1441-1.
6. Douira-Khomsi W, Smida M, Louati H, Hassine LB, Bouchoucha S, Saied W, al. Magnetic resonance evaluation of acetabular residual

dysplasia in developmental dysplasia of the hip: a preliminary study of 27 patients. J Pediatr Orthop. 2010;30(1):37-43. Epub 2009/12/25. doi: 10.1097/BPO.0b013e3181c877d7.

7. Takeuchi R, Kamada H, Mishima H, Mukai N, Miyakawa S, Ochiai N. Evaluation of the cartilaginous acetabulum by magnetic resonance imaging in developmental dysplasia of the hip. J Pediatr Orthop B. 2014;23(3):237-43. doi: 10.1097/BPB.0000000000000032.
8. Walbron P, Müller F, Mainard-Simard L, Luc A, Journeau P. Bone maturation of MRI residual developmental dysplasia of the hip with discrepancy between osseous and cartilaginous acetabular index. J Pediatr Orthop B. 2019;28(5):419-23. doi: 10.1097/bpb.0000000000000581.
9. Bicimoglu A, Caliskan E. The long-term outcomes of posteromedial limited surgery for developmental dysplasia of the hip: a mean 17.3-year follow-up. J Pediatr Orthop B. 2019;28(2):115-21. doi: 10.1097/bpb.0000000000000555.
10. Biçimoğlu A, Agus H, Omeroglu H, Tümer Y. Six years of experience with a new surgical algorithm in developmental dysplasia of the hip in children under 18 months of age. J Pediatr Orthop. 2003;23(6):693-8.
11. Ozcelik A, Omeroğlu H, Inan U, Ozyurt B, Seber S. Normal values of several acetabular angles on hip radiographs obtained from individuals living in the Eskisehir region. Acta Orthop Traumatol Turc. 2001;36(2):100-5.
12. Ozcelik A, Omeroglu H, Inan U, Seber S. Türk toplumunda çoçuk ve erişkinlerde normal kalçalarında merkez-kenar (CE) açısı değerleri. Eklem Hast Cerrahisi. 2001;12(2):115-9.
13. Yorgancigil H, Aslan A. Comparison of the clinical and radiological outcomes of open reduction via medial and anterior approach in developmental dysplasia of the hip. Eklem Hastalik Cerrahisi. 2016;27(2):74-80. doi: 10.5606/ehc.2016.17.
14. Albinana J, Dolan LA, Spratt KF, Morcuende J, Meyer MD, Weinstein SL. Acetabular dysplasia after treatment for developmental dysplasia of the hip. Implications for secondary procedures. J Bone Joint Surg Br. 2004;86(6):876-86. Doi: 10.1302/0301-620x.86b6.14441.
15. Weinstein SL, Mubarak SJ, Wenger DR. Developmental hip dysplasia and dislocation. J Bone Joint Surg Am. 2003;85(9):1824-32.
16. Miyake T, Tetsunaga T, Endo H, Yamada K, Sanki T, Fujiwara K, et al. Predicting acetabular growth in developmental dysplasia of the hip following open reduction after walking age. J Orthop Sci. 2019;24(2):326-31. doi: 10.1016/j.jos.2018.09.015.
17. Shin CH, Yoo WJ, Park MS, Kim JH, Choi IH, Cho TJ. Acetabular Remodeling and Role of Osteotomy After Closed Reduction of Developmental Dysplasia of the Hip. J Bone Joint Surg Am. 2016;98(11):952-7. doi: 10.2106/JBJS.15.00992.
18. Omeroglu H, Bicimoglu A, Agus H, Tumer Y. Acetabular development in developmental dysplasia of the hip. A radiographic study in anatomically reduced and uncomplicated hips. Bull NYU Hosp Jt Dis. 2007;65(4):276-9.
19. Ponseti IV. Morphology of the acetabulum in congenital dislocation of the hip. Gross, histological and roentgenographic studies. J Bone Joint Surg Am. 1978;60(5):586-99. Available at: https://journals.lww.com/jbjsjournal/Abstract/1978/60050/Morphology_of_the_acetabulum_in_congenital.2.aspx
20. Harris NH, Lloyd-Roberts GC, Gallien R. Acetabular development in congenital dislocation of the hip. With special reference to the indications for acetabuloplasty and pelvic or femoral realignment osteotomy. J Bone Joint Surg Br. 1975;57(1):46-52.
21. Yamamuro T. A radiological study on the development of the hip joint in normal infants. J Jpn Orthop Ass. 1975;49:421-39.
22. Ge Y, Cai H, Wang Z. Quality of reduction and prognosis of developmental dysplasia of the hip: a retrospective study. Hip Int. 2016;26(4):355-9. doi: 10.5301/hipint.5000348.
23. Kotlarsky P, Haber R, Bialik V, Eidelman M. Developmental dysplasia of the hip: What has changed in the last 20 years? World J Orthop. 2015;6(11):886-901. doi: 10.5312/wjo.v6.i11.886.
24. Aronsson DD, Goldberg MJ, Kling Jr TF , Roy DR. Developmental dysplasia of the hip. Pediatrics. 1994;94(2 Pt 1):201-8.
25. Vitale MG, Skaggs DL. Developmental dysplasia of the hip from six months to four years of age. J Am Acad Orthop Surg. 2001;9(6):401-11. doi: 10.5435/00124635-200111000-00005.
26. Pediatrics AAo. Committee on Quality Improvement, Subcommittee on Developmental Dysplasia of the Hip. Clinical practice guideline: early detection of developmental dysplasia of the hip. Pediatrics. 2000;105(4):896-905. Doi: 10.1542/peds.105.4.896
27. Ucar DH, Isiklar ZU, Stanitski CL, Kandemir U, Tumer Y. Open reduction through a medial approach in developmental dislocation of the hip: a follow-up study to skeletal maturity. J Pediatr Orthop. 2004;24(5):493-500.
28. Biçimoglu A, Ağus H, Omeroglu H, Tumer Y. The effects of arthrographically detected femoral head lateralization and soft tissue interposition during closed reduction of developmental dislocation of the hip on mid-term results. Acta Orthop Traumatol Turc. 2004;38(1):1-7.
29. Kiely N, Younis U, Day JB, Meadows TM. The ferguson medial approach for open reduction of developmental dysplasia of the hip. A clinical and radiological review of 49 hips. J Bone Joint Surg Br. 2004;86(3):430-3. doi: 10.1302/0301-620x.86b3.14064
30. Konigsberg DE, Karol LA, Colby S, O'Brien S. Results of medial open reduction of the hip in infants with developmental dislocation of the hip. J Pediatr Orthop. 2003;23(1):1-9.
31. Okano K, Yamada K, Takahashi K, Enomoto H, Osaki M, Shindo H. Long-term outcome of Ludloff's medial approach for open reduction of developmental dislocation of the hip in relation to the age at operation. Int Orthop. 2009;33(5):1391-6. doi: 10.1007/s00264-009-0800-7.
32. Morcuende JA, Meyer MD, Dolan LA, Weinstein SL. Long-term outcome after open reduction through an anteromedial approach for congenital dislocation of the hip. J Bone Joint Surg Am. 1997;79(6):810-7. doi: 10.2106/00004623-199706000-00002.