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Research Article

Center-edge angle values in healthy children between 5 and 14 years old in Turkey

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ABSTRACT

Objective: The aim of this study was to determine the center-edge angle (CEA) values according to age, gender and side in healthy children between 5 and 14 years old in Turkey and to find out the angular limit values for mild and severe dysplasia.

Methods: The data pool that was gathered to investigate the frequency of hip dislocation in children between 6 months and 14 years old in Turkey was used. The data pool consists of pelvis and lower abdomen radiographs obtained for reasons other than hip dysplasia. Lower abdomen/pelvis radiographies of children between 5 and 14 years old were extracted from the data pool and were evaluated. Distribution of CEA values according to age, gender and side was examined. Measurements were performed by a single investigator on computer by using a standard method. Reliability of the measurements was tested by three different investigators on randomly selected films by using the standard method.

Results: CEA values of 3192 hips of 1596 children, who had no hip pathology, were measured. Mean CEA value was found as 26.2°±5.5°. The mean CEA was 26.2°±5.3° in males (%54) and 26.2°±5.7° in females (%46) (p=0.224). Mean values for the right and left hips were 25.7°±5.4° and 26.6°±5.6°, respectively. CEA value of 449 (14%) hips of 333 (20.8%) children was at the limit of mild dysplasia and CEA value of 70 (2.2%) hips of 58 (3.6%) children was at the limit of severe dysplasia. CEA values had increased by age and mild and severe dysplasia limits were determined for every age group.

Conclusion: The mild and severe dysplasia values that are defined according to ages in Turkish population will guide the investigators in the diagnosis, follow-up and treatment planning of developmental dysplasia.

Level of Evidence: Level IV, Diagnostic Study

In the long-term, the early diagnosis and treatment of developmental dysplasia of the hip (DDH) and residual acetabular dysplasia positively affects the development of the hip (1). The diagnosis of DDH in early infancy depends on clinical examination and hip ultrasonography (2). Real-time ultrasonography is an accurate method for imaging the hip during the first few months of life (3). During the first few months of life when the femoral heads are composed entirely of cartilage, radiographs have limited value. The ossification center of the femoral head appears by 4–6 months and radiographs become more reliable (4).

Acetabular index, acetabular angle of Sharp, Smith instability index, Tonnis angle, femur neck-shaft angle, and Wiberg's center-edge angle (CEA) are among the frequently used methods for assessing the development of the hip joint (1). Wiberg defined CEA, and it provides information about the lateral coverage of the femoral head by the acetabulum in the coronal plane (5). While the larger angle values show the deep acetabulum, small-angle values show both the lateral displacement of the femoral head and the shallowness of acetabulum (6). This study aims to determine the normal CEA values in healthy children between 5 and 14 years old in the Turkish population according to their ages, genders, and sides, and to find the angular limit values for mild and severe dysplasia.

Materials and Methods

We used the records from the data pool gathered for the project "Prevalence of untreated hip dislocation at Turkish children aged between

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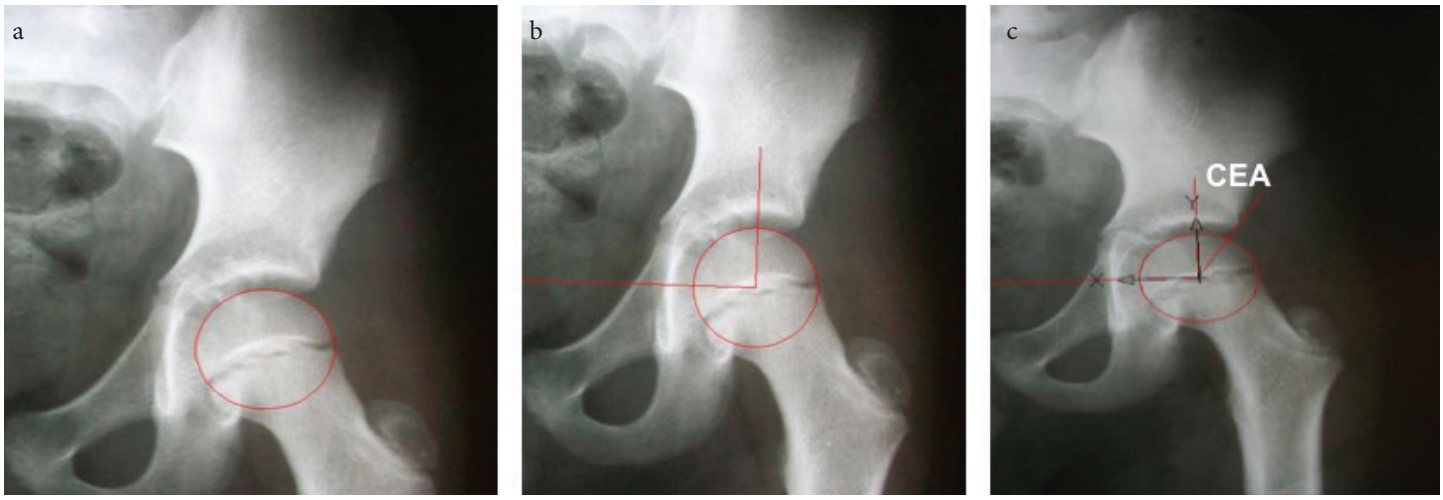

Figure 1. a-c. The measurement technique used to obtain center edge angle (CEA)

6 months and 14 years," which was supported by the Turkish Society of Orthopedics and Traumatology (7). This data pool includes the pelvis and lower abdomen radiographs of patients who were evaluated in emergency departments for non-orthopedic problems and patients examined in orthopedic clinics for non-hip dysplasia-related causes. We assessed the radiographs of 4 956 children from 12 regions and 26 subregions that were defined according to the regional distribution of the country population [developed according to NUTS1 (nomenclature of units for territorial statistics)]. Among these radiographs, 1 655 images of children between 5 and 14 years old were evaluated. Dislocated or subluxated hips were present in 21 children and 38 children were not transferred to the digital environment. The remaining 1 596 x-rays were assessed. A standard method by using the AutoCAD 2010 program performed the measurements. Wiberg's classical method was used as the measurement method (5). First, the concentric circle method determined the center of the femur heads. Second, the plane connecting the center of two femoral heads was defined as the x-plane, and the y-plane that is vertical to the x-plane was found. Finally, the angle between the line formed by combining the central point and the outmost point of the acetabulum and the y-plane was measured. This angle was accepted as the CEA (Figure 1).

We used the Statistical Packages for the Social Sciences version 15 (SPSS Inc., Chicago, IL, USA). The CEA values were reported as mean ± standard deviation. The relation between age and the acetabular index was defined by the Pearson correlation coefficient and linear regression analysis. The index values between 1 standard deviation and 2 standard deviations above mean were taken as mild dysplasia, while the values of more than 2 standard deviations above mean were considered as severe dysplasia. A single orthopedic surgeon performed all the measurements. Three surgeons repeated over 50 randomly selected graphies in one-month intervals and assessed the reliability of the measurements. The mean CEA of the general population was determined. The CEA was also stratified according to age, gender, and laterality.

Results

In our study, measurements were made in a large population and normal and dysplasia limits of childhood CEA values were defined. It was observed that 1 596 patients whose measurements were completed showed a homogenous distribution regarding gender and age. Table 1 shows the distribution of mean CEA values and standard deviations according to age, gender, and sides. Table 2 shows the lower and upper limit values for mild and severe dysplasia. Three orthopedic surgeons made separate measurements over 50 randomly selected 50 graphies, and these measurements were repeated after one month. High conformance is observed between the measurements performed by the surgeon executing the study and two other surgeons (Kappa Coefficient: 0.66–0.74).

Via the measurements, it was determined that from the age of five, the CEA values were higher than 20 degrees and increased with age. Between the ages of five and fourteen, the measurements showed an increasing trend. The CEA values increased with age (Pearson coefficient for right r=0.511, Reflection Equation: CE=22.513+0.424 x age, r=0.596 for left, Regression Equation: CE=22.318+0.534 x years). Accordingly, when the age increases by one unit, the measurement for left increases by 0.534, and for the right it increases by 0.424. Of the 1 596 children who participated in the study, both hips of 1 205 (75.50%) children were at normal limits. At least one hip of 333 (20.86%) children was in mild dysplasia limits, and at least one hip of 58 (3.63%) children was in severe dysplasia limits. Accordingly, it is specified that the CEA values of 449 (14.06%) of 3 192 hips had mild dysplasia and 70 (2.21%) had severe dysplasia. The CEA values increased by age (Figure 2).

Discussion

Treatment in DDH provides a stable, anatomic, and concentric reduction in the hip joint. Early diagnosis and treatment in DDH

Table 1. The mean center edge angles according to gender, age, and side (in degrees)

	Male						Female					
	Right			Left			Right			Left		
Age	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
5	113	24.8	4.5	113	25.4	4.7	105	24.1	4.9	105	24.2	5.2
6	121	25.3	5.4	121	25.3	5.4	116	24.2	5.1	116	25.1	5.3
7	115	25.1	5.1	115	25.8	4.8	112	25.2	5.4	112	26.7	5.4
8	102	25.3	4.8	102	26	5.1	104	25.6	5	104	26.7	5.4
9	123	25.5	4.9	123	26.5	5.2	100	25.9	6	100	27.2	5.4
10	111	26.1	5.4	111	27.1	5.4	78	26.4	5.4	78	27.2	5.4
11	38	26.9	4.7	38	27.6	4.8	30	27.2	5.3	30	28	5.1
12	38	27.6	4.9	38	28	5	25	27.8	4.9	25	28.3	5.2
13	54	28.4	5.1	54	28.6	5.2	31	28.4	5.2	31	28.9	4.9
14	45	28.9	5.2	45	29.1	5.3	35	28.8	5.1	35	29.2	4.8
Total	860	25.8	5.1	860	26.5	5.3	736	25.6	5.6	736	26.7	5.8

N: number; SD: standard deviation

Table 2. Distribution of center edge angle limits for mild and severe dysplasia according to gender, age, and side (in degrees)

	Male						Female					
	Right			Left			Right			Left		
Age	N	Mild	Severe	N	Mild	Severe	N	Mild	Severe	N	Mild	Severe
5	>20	15-20	<15	>20	15-20	<15	>19	14-19	<14	>19	14-19	<14
6	>20	15-20	<15	>20	15-20	<15	>19	14-19	<14	>20	15-20	<15
7	>20	15-20	<15	>21	16-21	<16	>20	15-20	<15	>21	16-21	<16
8	>20	15-20	<15	>21	16-21	<16	>21	16-21	<16	>21	16-21	<16
9	>21	16-21	<16	>22	17-22	<17	>21	16-21	<16	>22	17-22	<17
10	>21	16-21	<16	>22	17-22	<17	>21	16-21	<16	>22	17-22	<17
11	>22	17-22	<17	>22	17-22	<17	>21	16-21	<16	>23	18-23	<18
12	>23	18-23	<18	>23	18-23	<18	>22	17-22	<17	>23	18-23	<18
13	>23	18-23	<18	>23	18-23	<18	>22	17-22	<17	>23	18-23	<18
14	>23	18-23	<18	>23	18-23	<18	>22	17-22	<17	>23	18-23	<18

N: normal

increase the success ratio. The degradation of the load distribution in the hip joint in patients who were not treated or insufficiently treated causes secondary degenerative arthritis that was seen in early ages (8). Clinical examination and imaging methods assist the surgeon in early diagnosis and treatment of residual developmental disorders.

In our study, measurements were taken from a large population, and normal and dysplasia limits of childhood CEA values were defined. The population was selected among 12 regions and 26 subregions defined according to the regional distribution of the country's population. Given this, the selected population reflects the general average of Turkey. The CEA of Wiberg was used in the

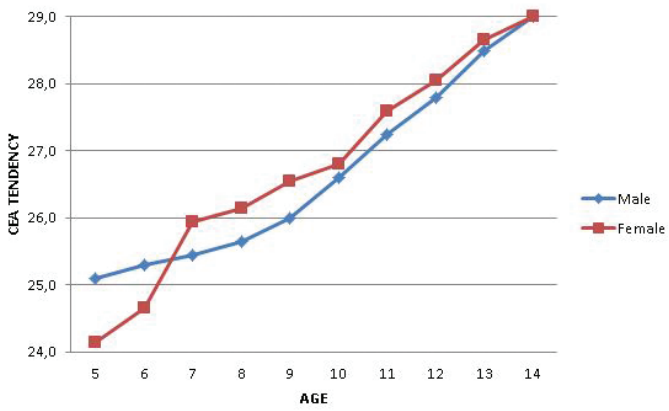

Figure 2. CEA distribution per age and gender

evaluation of acetabular development in the pediatric population along with the acetabular index (5). The current literature lacks high-qualified data regarding the normal values and dysplastic limits for CEA.

The acetabulum remodels, and the deepness increases by loading (8). Given this, it would be inappropriate to use adult CEA values during pediatric and adolescent hip dysplasia assessments. Studies in the literature tend to target the whole population and the obtained data often consist of adult values. In a study performed in a Chinese population, children of 4 years and older were assessed. The mean CEA value between 4 and 9 years old was 23.1° (9). These values are closer to the values obtained in our study.

The CEA values vary between the races (9-14). Thus, it is critical to define the normal and dysplastic values in a selected population. Our study showed that 2.2% of the measured hips were within the severe dysplasia limits. This ratio is compatible with the study in which the acetabular dysplasia ratio was 2.4% in the adult Turkish population between 20 and 79 years old (15). In another study in Turkey, Polat et al. evaluated 1 076 pelvic radiographs between the ages of 18 and 65 (16). Because of pelvic anteroposterior (AP) radiographs, the mean lateral central edge angle (LCEA) was measured as 31.0±6.2° for right hips and 32.1±6.6° for left hips. An interesting result obtained because of the measurements is the difference between the right and left hips. Although there is evidence in the literature that CEA varies according to the side (17), there are also studies showing the opposite (18-20). It was hypothesized that the acetabular depth can change with loading and different loading patterns on the right and left hips could cause different measurements in the CEA (18).

Although the radiographs that were not obtained in the correct planes were excluded from the study, failure to control the patient and the x-ray technician during imaging is one of the limitations of the study. Changes that could occur in the image quality during the digital transfer of the films for measurement purposes could affect the angles measured. Furthermore, although CEA is a reliable radiological variable showing the relationship between the femur head and acetabulum, it should be used with other radiological variables, not only in the diagnosis and follow-up of developmental hip dysplasia.

This study determines the normal and dysplastic limit values for CEA between 5 and 14 years in a large Turkish population. These values will guide the investigators in the diagnosis, follow-up, and treatment planning of developmental dysplasia of the hip.

Ethics Committee Approval: Ethics committee approval was received for this study from the Non-interventional Clinical Research Ethics Board of the Selçuk University (2015/77).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

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