2D/4D Finger Length Ratio in the Screening of Developmental Dysplasia of the Hip

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ABSTRACT

Objective: To investigate whether there is a relationship between the 2nd finger and 4th finger length measurement ratios and developmental dysplasia of the Hip (DDH).

Study Design: Cross-sectional observational study.

Place and Duration of the Study: Department of Orthopaedics and Traumatology, Meram Faculty of Medicine Hospital, Konya, Turkiye, from January 2020 to May 2023.

Methodology: Infants were screened for DDH with Graff method for the ultrasounds of both hips. Lengths of the 2nd and 4th fingers of both hands were measured and recorded. Patients with additional risk factors for developmental dysplasia of the hip (breech birth, family history, oligohydramnios, swaddling) were excluded.

Results: Two hundred and fifty-six babies were screened including 55.1% (n = 141) girls and 44.9% (n = 115) boys. Their mean age was 2.51 ± 0.80 months. The average lengths were 31.73 ± 3.05 mm, for the left 2nd finger and 34.26 ± 3.48 mm for the left 4th finger. In the hip USG measurements, the mean alpha angles were 62.91 ± 3.12° for the right hip and, 63.20 ± 3.55° for the left hip. Eighteen (7%) of babies who underwent hip ultrasound (USG) had unilateral or bilateral DDH. Among these cases, 2.7% (n = 7) had right, 2.3% (n = 6) had left, and 2% (n = 5) had bilateral DDH. There was no statistically significant correlation between the ratios of right 2/4 finger lengths and the right alpha angle (rs = 0.051; p = 0.421). There was a statistically positive and statistically significant correlation between the ratios of left 2/4 finger lengths and the left alpha angle (rs = 0.154; p = 0.013).

Conclusion: Only the left-hand finger ratio among the parameters in the model had a statistically significant effect on DDH. Therefore, the left hand 2D/4D finger length may be of value in screening for DDH.

Key Words: *Developmental dysplasia of the hip, Second to fourth finger digit ratio, Ring finger, Digit ratios.*

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INTRODUCTION

Developmental dysplasia of the hip (DDH) is a dynamic disease in which the normal anatomical relationship of the femoral head and the acetabulum is disrupted during the intrauterine development of the hip joint during the birth and postpartum period.[1] The prevalence of DDH is 0.8-1.6/1000 and 1.6-66/1000 in populations without and with routine ultrasonography (USG) screening, respectively.[2-4] Another important factor is the expertise of the physicians performing the evaluation, reported to be 25/1000 on ultrasound scans, 11.5/1000 on orthopaedic examination, and 8.6/1000 on paediatric examinations.[1,5] The positivity of Ortolani and Barlow tests decreases after the 3rd month due to soft tissue contracture.[6,7]

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DDH is observed unilaterally in 80% of cases, 6 times more common in girls than boys (2.4:1 *vs.* 9.2:1) and more common in the left hip.[8,9] It is thought to be probably related to intrauterine posture.

Subluxation in the pathogenesis of DDH is always accompanied by acetabular dysplasia, manifesting as an unstable, subluxated and dislocated hip joint. Although the underlying etiopathogenesis of DDH has not been adequately clarified, significant risk factors have been identified. First-born girls are at higher risk for DDH. Caucasian, positive family history, oligohydramnios, multiple pregnancy, *inutero* breech position, history of breech presentation at birth, and accompanying deformities, such as pes calcaneovalgus, metatarsus adductus, torticollis, and arson can be counted as other risk factors. The physiological hip position in the newborn is flexion and abduction.[8-10] All factors that force the hip to extension and adduction may pose a risk for DDH.[11]

Fingers have unique morphological features. The most prominent of these is the 2D/4D ratio, which remains constant throughout the life cycle from the 14th week of intrauterine life. Ring (4th finger) and index finger (2nd finger) lengths are thought to be under the influence of prenatal sex hormone levels.[12] The

2D/4D ratio can help in the determination of motor skills in children, and early diagnosis of genetic diseases, autism, schizophrenia, and cardiovascular diseases.[13-17]

Detection of DDH in the advancing time periods may be seen in a group of patients who do not have significant risk factors and who have no problems in the evaluations made by physical examination. This delay is recognised as an important cause of morbidity. Although there are studies that determine the 2D/4D finger length ratio in healthy individuals and the relationship of these results with body components, studies on individuals with DDH are very few. The aim of this study was to assess whether there is a relationship between the 2nd finger and 4th finger length measurement ratios and DDH.

METHODOLOGY

This study included 256 infants who were screened for DDH during January 2020 to May 2023 with the Graff ultrasound imaging method in the Meram Medical Faculty Orthopaedics Clinic, Konya, Turkiye. In addition to the ultrasounds of both hips performed at the mean age of two and three months, the lengths of the 2nd and 4th fingers of both hands were measured and recorded. Patients with additional risk factors for developmental dysplasia of the hip (family history, breech birth, accompanying orthopaedic anomaly or teratological hip dislocation, swaddling, a history of intensive care unit in the neonatal period, oligohydramnios) were excluded from the study. According to the Graph classification system, the files of patients with Stage 2A and above were reviewed and their parents were interviewed.

The data obtained were analysed using the SPSS 27.0 program. The distribution of data by gender was shown as frequency and percentages. Descriptive statistical analysis of all measurements was performed. Number, percentage, mean, and standard deviation for descriptive statistics were stated. Minimum (min.), maximum (max.), mean (mean), and standard deviation (SD) values were given for morphometric parameters. The relationship between the data were investigated by Pearson Correlation Analysis. Statistical significance level was accepted as $p < 0.05$.

RESULTS

The demographic characteristics of the population included in the study are shown in Table I. Two hundred and fifty-six babies were included in the study, 55.1% (n = 141) of the babies were girls and 44.9% (n = 115) were boys. The mean age of the patients was 2.51 ± 0.80 months. While the mean length of the right second finger of the patients was 31.72 ± 3.07 mm, the mean of the right fourth finger length was 34.27 ± 3.48 mm. While the average of the left 2nd finger lengths was 31.73 ± 3.05, the average of the left 4th finger length was 34.26 ± 3.48 mm (Table I).

The 2D/4D finger ratios of the infants included in the study are shown in Table II. The right 2D/4D mean of the babies included in the scan was 0.92 ± 0.03, while the left 2D/4D mean was 0.92 ± 0.03. The mean right second finger length of the girls was 31.48 ± 3.22 mm, while the mean right fourth finger length was 34.12 ± 3.65 mm. While the mean right second finger length of the boys was 32.00 ± 2.85 mm, the mean right fourth finger length was 34.45 ± 3.28 mm. While the average of the left 2nd finger lengths of the girls was 31.51 ± 3.21 mm, the average of the left 4th finger lengths was calculated as 34.12 ± 3.65 mm. While the average left second finger length of the boys was 32.00 ± 2.83 mm, the average left fourth finger length was calculated as 34.42 ± 3.26 mm. While the mean right 2D/4D ratio of female babies was 0.92 ± 0.04, the mean right 2D/4D ratio of male babies was 0.93 ± 0.03 (Table II).

Table I: Parameters in a population of 115 males and 141 females (n= 256).

	Right hand (mm)		Left hand (mm)	
	2D	4D	2D	4D
Female (n=141; 55.1%)	31.48 ± 3.22	34.12 ± 3.65	31.51 ± 3.21	34.12 ± 3.65
Male (n=115; 44.9%)	32.00 ± 2.85	34.45 ± 3.28	32.00 ± 2.83	34.42 ± 3.26
Total	31.72 ± 3.07	34.27 ± 3.48	31.73 ± 3.05	34.26 ± 3.48
Age (Mean±SD)	2.51 ± 0.80 months			

Table II: Mean 2D:4D ratios in a population of 115 males and 141 females (n = 256).

	2D:4D right hand ratio (mm)	2D:4D left hand ratio (mm)
Female (n = 141; 55.1%)	0.92 ± 0.04	0.92 ± 0.04
Male (n = 115; 44.9%)	0.93 ± 0.03	0.93 ± 0.03
Total	0.92 ± 0.03	0.92 ± 0.03

Table III: Comparison with USG measurements of hips and ratios of 2D:4D hand.

	Right DDH	Left DDH
Presence of DDH (7%, n = 18)	7 (2.7%) Double-sided DDH (2%, n = 5)	6 (2%)
	Right hip alpha angle	**Left hip alpha angle**
Female (n = 141; 55.1%)	62.83 ± 3.36°	63.14 ± 3.40°
Male (n = 115; 44.9%)	63.01 ± 2.80°	63.28 ± 3.74°
Total	62.91 ± 3.12°	63.20 ± 3.55°
Comparison of 2D:4D right hand ratio	$r_s = 0.051$; $p = 0.421$	-
Comparison of 2D:4D left hand ratio	-	$r_s = 0.154$; $p = 0.013$

DDH: Developmental dysplasia of the hip.

The comparison of hip USG measurements and finger ratios of the babies included in the study is shown in Table III. In the hip USG measurements of the babies, the mean alpha angles of the right hip were 62.91 ± 3.12°, while the mean of the left hip alpha angles was 63.20 ± 3.55°. In the hip USG measurements of female babies, the mean of right hip alpha angles was 62.83 ± 3.36°, while the mean left hip alpha angle was 63.14 ± 3.40°. While the mean of the right hip USG alpha angles of male babies was 63.01 ± 2.80°, the mean of the left alpha angles was 63.28 ± 3.74°. Additionally, 7% (n = 18) of babies who underwent hip USG had unilateral or bilateral DDH. Specifically, 2.7% (n = 7) had right, 2.3% (n = 6) had left, and 2% (n = 5) had bilateral DDH. There was no statistically significant relationship between the ratio of right 2/4 finger lengths and the right alpha angle (r_s = 0.051; p = 0.421). There was a statistically positive and statistically significant correlation between the ratio of left 2/4 finger lengths and the left alpha angle (r_s = 0.154; p = 0.013, Table III).

DISCUSSION

The diagnosis of developmental dysplasia of the hip is made at the earliest in the third month in most babies. Long-term follow-up, complex treatment options, and complications occur in babies with a late diagnosis of DDH. For these reasons, early diagnosis of DDH is essential. Known risk factors; it is known as family history, breech presentation, swaddling, oligohydramnios, gender, first baby, fetal presentation, maternal age, birth weight, parity, gestational age, and mode of delivery (vaginal / ceasarean section).

There are many studies on DDH risk factors in the literature.[8,9,13-17] In a study by Hassan *et al.*, it was shown that bilateral dysplasia is more common than unilateral dysplasia. However, torticollis and foot deformities were found to be rarely associated with DDH. Asymmetry of skin folds in the groin has been reported to be an important clinical finding associated with DDH for all age groups.[9] In a study by Omeroglu *et al.*, they reported that the risk of DDH significantly increased in infants who have more than one risk factor for DDH.[1] In the present study, unilateral dysplasia was found to be more common than bilateral dysplasia. However, there was a statistically significant relationship between the ratio of left hand 2D/4D finger lengths and DDH. Therefore, the authors think that the left hand 2D/4D finger length value may be a risk factor for DDH.

Female child is reported as an important risk factor in DDH in studies in the literature.[8,9] In a study of Hassan *et al*. they reported that 84.1% of females in the study had DDH0.[7] In a study by Xiao *et al.* they reported that of the 204 patients diagnosed with DDH, 184 were females.[18] In a study by Alanazi *et al*., they reported that of the 412 patients diagnosed with DDH, 290 (70.4%) were females.[18] In a study by Bakti *et al*., they reported that of the 948 patients diagnosed with DDH, 686 (72.4%) were females.[19] Compared to the previous studies in the literature, in this study, it was found that the rate of women was less and 141 of 256 DDH patients were women (55.1%).

The finger length ratio (2D/4D) is used as a biomarker for exposure to prenatal sex steroids.[14] The 2D/4D ratio was found to be 0.96 in boys and 1 in girls.[13] Putz *et al*. reported in their study that the 2D:4D ratio of men was lower than that of women, and the difference between the genders was statistically significant.[20] Manning *et al*. reported that the 2D:4D ratio was higher in women than in men, but this difference was significant only in the right hand.[14] In this study, this rate was equal 0.93 ± 0.03 for the right and left sides in boys. For female babies, it was found equal for the right and left sides. Contrary to the literature, the rate in boys was found to be higher in the present measurements.

It is known that testosterone causes more elongation of the 4th finger, and estrogen causes more elongation of the 2nd finger. If the 2D/4D ratio is high, it has been observed that women are exposed to high estrogen in the first trimester, and there is an increased risk of high fertility, fertility and breast cancer after delivery.[14] A decrease in the 2D/4D ratio in men indicates high fetal testosterone exposure. In the follow-up of these babies, life-long reproductive success known as the hypermuscular triad, high aggression, an increase in the desire to turn to homosexuality, and an increase in music and sports success are observed.[14] Left hand 2D/4D ratio is directly proportional to height in boys and inversely proportional to height in girls. An increase in the 2D/4D ratio in men has been associated with an increased risk of early heart disease.[15] Since differences in the 2D/4D ratio cause character and morphological distinctions. The authors evaluated this ratio in terms of DDH risk and found a statistically significant relationship between the ratio of left hand 2D/4D finger lengths and DDH.

This study has some limitations. First of all, the retrospective nature of the study design limits the generalisation of the results. Another issue is that USG evaluations and DDH follow-ups were performed by different orthopaedic specialists by different physicians.

CONCLUSION

In the regression analysis created with the ratio of age, gender, right and left hand 2D/4D finger lengths, only the ratio of left hand 2D/4D finger lengths from the parameters in the model had a statistically significant effect on DDH. Therefore, left hand 2D/4D finger length value may be a risk factor or screening parameter for DDH.

ETHICAL APPROVAL:

An approval was obtained from Necmettin Erbakan University, Meram Medical Faculty Ethics Committee. This

article does not contain any studies with animal subjects. Written informed consent was obtained from a legally authorised representative(s) for anonymised patient information to be published in this article.

PATIENTS' CONSENT:
Patients' consent was not obtained as the study was designed on retrospective pathology archive preparations.

COMPETING INTEREST:
The authors declared no conflict of interest.

AUTHORS' CONTRIBUTION:
IHK, ND: Conception and design of the work, acquistion, analysis, interpretation of data for the work, drafting the work, and revising it critically for important intellectual content. Both authors agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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