Original Article

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Evaluation of the Relationship Between Delivery Type and Craniofacial Morphology and Condylar Symmetry

Doğum Tipiyle Kraniyofasiyal Morfoloji ve Kondiler Simetri Arasındaki İlişkinin Değerlendirilmesi

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ABSTRACT

Objective: To assess the effects of delivery types on growth patterns and mandibular asymmetry.

Methods: One hundred six patients were divided into two groups as those who were born via normal delivery and via cesarean delivery. Skeletal growth patterns were measured on cephalograms using NemoCeph software (Nemotec, Madrid, Spain). The condylar, ramal and total asymmetry indexes were calculated on panoramic radiographs using the ImageJ software (ImageJ software, 1.37, National Institutes of Health, Bethesda, Maryland, USA). The mothers of the patients were also asked to respond to questions on their childbirth experiences and the infancy stages of their children.

Results: There was no statistically significant difference between the groups in terms of their skeletal, dental and soft tissue parameters on their cephalometric images ($p>0.05$). While there was a significant difference in the asymmetry index scores of the normal delivery group based on their Co-Sg distance values, there was a significant difference in the index scores of the cesarean delivery group based on their Sg-Go distance values ($p<0.05$). No statistically significant difference was observed between the asymmetry index values of the two groups ($p>0.05$). A significant correlation was observed between the gestational weeks of the patients at birth and their total asymmetry scores ($p<0.05$).

Conclusion: Types of delivery did not affect growth patterns significantly. However, more asymmetric condyles were observed in the normal delivery group, and more ramus asymmetries were observed in cesarean delivery group. There was also a relationship between preterm birth and mandibular asymmetry.

Keywords: Normal delivery, cesarean delivery, asymmetry, radiographic analysis

ÖZ

Amaç: Doğum yöntemlerinin büyüme paternleri ve mandibuler asimetri üzerindeki etkilerini değerlendirmektir.

Yöntemler: Yüz altı hasta normal doğum ve sezaryen doğum olarak iki gruba ayrıldı. İskelet büyüme modelleri, NemoCeph yazılımı (Nemotec, Madrid, İspanya) kullanılarak sefalogramlarda ölçüldü. ImageJ yazılımı (ImageJ yazılımı, 1,37, National Institutes of Health, Bethesda, Maryland, ABD) kullanılarak panoramik radyografilerde kondiler, ramal ve toplam asimetri indeksleri hesaplandı. Hastaların annelerinden doğum deneyimlerine ve çocuklarının bebeklik dönemlerine ilişkin soruları da yanıtlamaları istendi.

Bulgular: Gruplar arasında sefalometrik radyograflarda iskelet, diş ve yumuşak doku parametreleri açısından istatistiksel olarak anlamlı fark yoktu ($p>0,05$). Co-Sg mesafesi değerlerine göre normal doğum yapan grubun asimetri indeks puanlarında anlamlı fark bulunurken, sezaryen ile doğum yapan grubun Sg-Go mesafesi değerlerine göre indeks puanlarında anlamlı fark vardı ($p<0,05$). İki grubun asimetri indeks değerleri arasında istatistiksel olarak anlamlı bir fark gözlenmedi ($p>0,05$). Hastaların doğum anındaki gebelik haftaları ile toplam asimetri skorları arasında anlamlı bir korelasyon gözlendi ($p<0,05$).

Sonuç: Doğum şekli büyüme paternlerini önemli ölçüde etkilememiştir. Ancak normal doğum grubunda daha fazla asimetrik kondil, sezaryen doğum grubunda daha fazla ramus asimetrisi gözlendi. Erken doğum ile çene asimetrisi arasında da bir ilişki bulunmuştur.

Anahtar Sözcükler: Normal doğum, sezaryen doğum, asimetri, radyografik analiz

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Introduction

Malocclusions may cause social and health problems at any age (1). Several theories have been proposed on the formation of malocclusions. The most widely agreed upon theory is the functional matrix theory, which argues that bone develops in response to changes in functional matrices (2).

Moss reported that the coronoid process does not develop after the unilateral resection of the temporal muscle because it is dependent on the demands of the functional matrix (temporalis muscle) of the coronoid (skeletal unit) (2).

Face remodeling and growth are also linked to the development of neurocrania. Most of the maturation process of the brain occurs in the first 2 years of life. During this time, deviations in the maturation process may lead to abnormal skeletal patterns. Another theory associated with this condition is the osteopathic theory. The osteopathic theory specifies neuromuscular and joint dynamics for the primary movements of cranial respiration and the formation of surrounding facial structures (3).

In their study that was conducted with the participation of 1,250 children, Frymann (4) observed that osteopathic birth trauma created cranial dynamics that caused complications such as abnormal craniofacial shapes and abnormal neuromotor development in the future. In their study, it was shown that osteopathic disorders of the occipital condyle were observed quite frequently. This is because the 12th cranial nerve, which innervates the lingual muscles, is located in the condylar canal (5). It is assumed that birth trauma may cause orthodontic problems in two ways: the formation of irregular facial structures as a result of cranial growth and changes in sucking-swallowing patterns (4).

There are a few studies investigating the effects of birth trauma on dental malocclusions using the Angle classification. To better understand the links between the osteopathic theory and dental occlusion, Cattaneo et al. (3) reported that precise and more accurate evaluations are necessary. Schoenwetter (6) stated that there might be shape changes in the maxilla since premaxillary compression occurs in normal birth, and they believed that two children born by cesarean section had symmetrical narrow maxillae, and the pressure the fetus was exposed to before birth caused the deformity.

Irma et al. (7) found that birth by cesarean delivery seemed to be slightly protective against the risk of malocclusions.

While some studies have focused on dental occlusions, no studies exist on the cephalometric assessment of skeletal and soft tissue growth models and mandibular asymmetries. The aim of this study was to determine whether type of delivery influenced skeletal and soft tissue growth patterns and mandibular condylar asymmetry status.

Our null hypothesis was that there would be no difference in the asymmetry index between the two methods.

Methods

This study was approved by the Ethics Committee of the Bezmialem Vakıf University (12/2019). Informed consent was received from the patients for their orthodontic treatments.

For the study, 372 patients who were admitted to Bezmialem Vakıf University for orthodontic treatment were selected. The following inclusion and exclusion criteria were considered before the examinations of the radiographic images of patients.

Inclusion criteria: (1) Having been born via spontaneous vaginal delivery or cesarean delivery, (2) having good-quality radiographic records before orthodontic treatment, and (3) being in the 6th cervical vertebral maturation stage.

Exclusion criteria: (1) Having been born via forceps-assisted vaginal delivery, (2) having been born before 32 weeks of gestation, (3) being a cleft lip and palate patient, (4) history of orthognathic surgery, (5) systemic or metabolic diseases, and (6) history of facial trauma.

After applying the inclusion criteria, 108 patients (38 males, 70 females) were included in this study. The patients were divided into two groups as the normal delivery group (36 females, 18 males; mean age: 14.21±2.27 years) and the cesarean delivery group (34 females, 20 males; mean age: 14.16±2.19 years).

The mothers of the patients who were included in the study were asked to respond to questions on their childbirth experiences such as the gestational week of childbirth, duration of labor, the birth order of the child included in the study (first child vs. other), status of breastfeeding in the first 6 months, duration of breastfeeding, use of an infant bottle/pacifier, duration of using an infant bottle/pacifier, and timing and form of introduction to solid food (Table 1).

Cephalometric Analyses

Lateral cephalometric images were taken using the same device (Planmeca ProMax, Helsinki, Finland) and with the same standardized method. All measurements were performed by the same researcher (İ.E.M.) using the NemoCeph program (Nemotec, Madrid, Spain). Skeletal, vertical, dental, and soft tissue measurements were performed in this study. The included measurements are shown in (Figure 1).

Vertical Condylar Symmetry Evaluations

Digital panoramic radiographs (Planmeca Promax Digital Panoramic X-ray Unit, Planmeca Inc, Helsinki, Finland) taken before the orthodontic treatments of the patients were used for the condylar asymmetry measurements. The ImageJ software (ImageJ software, 1.37, National Institutes of Health, Bethesda, Maryland, USA) was used for the measurement of the distance between the Condylion (Co) and Sigmoid Notch (Sg) (condylar height), between the Sg and Gonion (Go) (ramal height), and between the Co and Go (total height) to evaluate condylar asymmetry (Figure 2). The scale settings were calibrated after importing the radiographic images, and the linear distances between the examined points were measured in pixels.

Table 1. Comparison of the mothers' birth experiences between cesarean and normal birth groups

	Normal delivery		Cesarean delivery		
	Mean	SD	Mean	SD	p-value
Week of birth	37.41	2.15	36.57	3.60	0.1
Duration of the labour (hours)	4.8	1.9	-	-	0.1
Solid food time (months)	7.83	4.18	6.83	2.66	0.1
Breastfeeding time (months)	15.07	8.05	13.11	9.16	0.2
Pacifier/bottle time (months)	9.30	9.18	12.69	10.73	0.08
Nutrition for the first 6 months	n	%	n	%	
Breast milk	46.00	85.2%	34.00	0.63	
Formula	4.00	7.4%	10.00	18.5%	
Both	4.00	7.4%	10.00	18.5%	
Type of nutrition					
Bottle	5.00	9.3%	14.00	25.9%	
Breast feeding	44.00	81.5%	32.00	59.3%	
Both	5.00	9.3%	8.00	14.8%	
Which solid food					
Yogurt	12.00	22.2%	17.00	31.5%	
Soup	12.00	22.2%	14.00	25.9%	
Formula	8.00	14.8%	2.00	3.7%	
Fruit puree	32.00	40.7%	21.00	38.9%	
Using of pacifier/bottle					
None	22.00	40.7%	16.00	29.6%	
Pacifier	17.00	31.5%	10.00	18.5%	
Bottle	12.00	22.2%	17.00	31.5%	
Both	3.00	5.6%	11.00	20.4%	
Child order					
First	23.00	42.6%	28.00	51.9%	
Subsequent	31.00	57.4%	26.00	48.1%	

Independent t-test was used, SD: Standard deviation, n: Number of samples

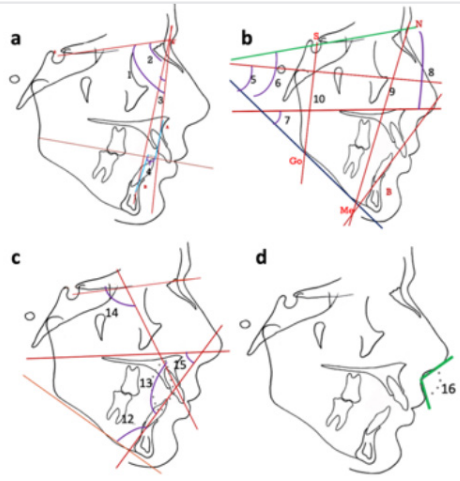

Figure 1. Cephalometric variables, a; 1. SNA°, 2. SNB°, 3. ANB°, 4. Wits appraisal; b; 5. FMA°, 6. MP-SN°, 7. PP-MP°, 8. SN-PP°, 9. Anterior facial height (Na-Memm), 10. Posterior facial height (S-Gomm), 11. Jarabak ratio (ratio of posterior facial height to anterior facial height), c ° 12. IMPA°, 13. interincisal angle (U1-L1°), 14. U1-SN° (long axis of U1 to sella-nasion plane) 15. U1-PP° (long axis of U1 to palatal plane), d; 16. Nasolabial angle

We calculated the asymmetry index with the formula (Asymmetry index = (right-left)/(right + left) x100) used by Lim et al. (8).

Statistical Analysis

The radiographic images of 25 patients were randomly selected after 2 weeks and re-analyzed to assess intra-examiner agreement. The intraclass correlation coefficient (ICC) was used to assess intra-observer reliability. The mean intra-observer ICC was 0.964 (0.932-0.996), which indicated a high level of agreement between the two measurements.

The SPSS package program (version 15.0; SPSS, Chicago, IL) was used for the statistical analyses. The data were tested for normal distribution by using the Shapiro-Wilk test. T-tests and the Mann-Whitney U test were performed to identify differences between groups. Pearson's correlation tests were performed to analyze the relationships between the asymmetry index scores of the patients and their gestational week at birth and feeding and sucking patterns. The level of statistical significance was set at $p<0.05$.

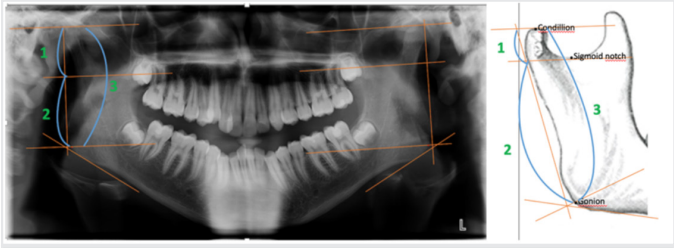

Figure 2. 1; The linear distance between Condyle (Co) and Sigmoid notch (Sg) points, 2; the linear distance between Sigmoid notch (Sg) and Gonion (Go) points, 3; the linear distance between Condilion (Co) and Gonion (Go) points

Results

Table 1 presents the data on the demographic characteristics of the participants. There was no statistically significant difference between the normal delivery and cesarean delivery groups in terms of their demographic characteristics.

There was no statistically significant difference between the normal and cesarean delivery groups in terms of their sagittal, vertical, dental, and soft tissue measurements on cephalometric radiographs (Table 2 and $p>0.05$).

The intra-group comparison in the normal delivery group showed a statistically significant difference in the asymmetry index scores based on the Co-Sg length ($p<0.05$ and Table 3).

The intra-group comparisons in the cesarean delivery group showed a statistically significant difference in the asymmetry index scores based on the Sg-Go length values ($p<0.05$ and Table 3).

Table 2. Comparison of the skeletal, dental and soft tissue cephalometric measurements between groups

	Normal delivery		Cesarean delivery		
	Mean	SD	Mean	SD	P value
SNA°	77.78	4.86	78.22	4.01	0.61
SNB°	74.88	4.56	75.83	4.31	0.27
ANB°	2.88	2.58	2.38	3.48	0.78
NA (mm)	-3.02	3.94	-1.83	4.13	0.13
N-POG (mm)	-9.23	8.47	-6.47	7.33	0.07
Witts(mm)	0.88	3.77	0.16	4.62	0.38
SN-MP°	36.97	8.88	36.57	6.71	0.32
SN°-PP°	9.53	5.01	9.64	4.36	0.42
PP°-MP°	29.53	6.27	28.66	6.46	0.39
U1-SN°	101.41	9.34	99.83	8.16	0.35
U1-PP°	110.31	8.01	107.10	15.65	0.37
U1-NA (mm)	4.55	3.29	3.57	2.82	0.10
U1-NA°	23.64	8.47	21.82	7.56	0.24
IMPA°	90.61	7.17	90.55	6.95	0.96
L1-NB (mm)	4.26	2.31	4.32	2.32	0.89
L1-NB °	23.23	6.52	23.00	6.24	0.85
U1-L1°	130.26	11.67	132.97	10.42	0.41
Nasolabial angle°	113.80	18.32	114.41	15.36	0.84
Upper lip (mm)	-3.65	2.84	-3.56	2.86	0.88
Lower lip (mm)	-1.23	2.59	-1.84	2.96	0.25

Independent t-test was used, SD: Standard deviation

Total asymmetry index indicated a statistically significant difference for both groups (p<0.05 and Table 3).

The inter-group comparisons indicated no statistically significant differences in the asymmetry index scores between the groups based on their Co-Sg, Sg-Go, and Co-Go lengths (p>0.05 and Table 4).

A significant negative correlation was observed between the gestational weeks of the patients at birth and their total asymmetry index scores (p<0.05 and Table 5). On the other hand, no significant correlation was found between the total asymmetry index scores of the patients and other characteristics of them presented in Table 5 (p>0.05).

Discussion

Abnormal muscle tone may restrict the protective effect of the uterus on the head of the fetus during vaginal delivery, and the compression of the head by the pelvic bones of the mother may result in abnormal cranial development (9). Frymann (4) reported that in cases of vaginal delivery, the duration of the labor should be between 6 and 12 hours to consider the delivery as a normal delivery. The author classified longer or shorter vaginal deliveries as non-normal vaginal deliveries (slow and quick deliveries). This categorization was based fundamentally on the duration of labor as evidence of force applied on the cranium of the infant (4). A higher force on the baby's skull in a non-normal delivery causes occipital condylar dysfunction, which negatively affects the function of the XII pair of the cranial nerves (hypoglossal nerves). The hypoglossal nerve functionally facilitates the motor innervation and posture of the tongue (3,4,10), and the function of the tongue affects the development of craniofacial structures, and accordingly, the formation of malocclusions (11). Another concern is the recent significant increase in the number of cesarean deliveries due to the preferences of mothers and healthcare practitioners. The worldwide cesarean section rate is about 15% in general, even reaching 35-45% in some countries, according to the World Health Organization (12-14). The Turkish Society of Obstetrics and Gynecology reported the cesarean section rate as 5.7% in 1988, 21% in 1998, and over 45% in 2010. Turkey is one of the countries with the highest cesarean section rates in the world, at a current rate of 53.2% (15,16).

It has been reported in the literature that there are some advantages and disadvantages of normal or cesarean deliveries

Table 3. Intra-group comparison of asymmetry index in normal and cesarean delivery groups

	Normal delivery			Cesarean delivery		
	Mean	SD	P value	Mean	SD	P value
Right Co-Sg	127.04	36.02	**0.01**	132.26	38.21	NS
Left Co-Sg	120.82	35.72		130.67	40.60	
Right Sg-Go	221.59	67.97	NS	235.96	62.60	**0.03**
Left Sg-Go	218.75	64.88		230.55	62.97	
Right Co-Go	348.60	90.44	**<0.001**	368.40	84.14	**0.02**
Left Co-Go	339.83	87.95		359.77	86.95	

The value of Co-Go represents the total asymmetry index. Wilcoxon signed-rank test was used, SD: Standard deviation, bold font indicates statistical significance

Table 4. Inter-group comparison of asymmetry index

	Normal delivery		Cesarean delivery		
	Mean	SD	Mean	SD	P-value
Co-Sg	6.06	4.67	6.05	5.14	0.95
Sg-Go	3.09	2.72	3.19	2.39	0.47
Co-Go	2.03	1.46	2.81	3.22	0.32

Mann-Whitney U test was used, SD: Standard deviation

Table 5. Correlation between demographic features and asymmetry indexes

	Co-Sg		Sg-Go		Co-Go	
	r	P value	r	P value	r	P value
Week of birth	0.06	0.51	-0.01	0.88	-0.20	**0.03**
Solid food time (months)	-0.10	0.29	0.09	0.34	0.10	0.31
Duration of the labour (hours)	0.10	0.30	0.03	0.79	0.17	0.09
Breastfeeding time (months)	-0.01	0.92	0.10	0.30	-0.06	0.54
Pacifier/bottle time (months)	-0.17	0.08	0.11	0.27	0.15	0.13

Pearson correlation test was used, r: Correlation coefficient, bold font indicates statistical significance

for both the mother and the infant. Although each procedure carries its own risks for systemic condition and malocclusion development, both methods are routinely performed in clinical obstetrics. While genetic factors are highly effective in the development of malocclusions, it is also known that gestational week at birth, parental age, birth order, birth weight, characteristics of pregnancy, and type of delivery also play a critical role in the etiology of malocclusions (2). Therefore, the aim of this study was to compare cephalometric parameters and facial symmetry characteristics between individuals who were born via cesarean delivery and those born via normal delivery.

To eliminate the possible effects of differential jaw growth and occlusal changes from primary to permanent dentition on the results, patients who completed pubertal growth were included in this study (14,17-19). No statistically significant differences in sex and age were observed between the normal delivery and cesarean delivery groups.

Cattaneo et al. (3) and Zhou et al. (20) reported that children born via normal delivery had lower rates of malocclusions than those born via cesarean delivery. On the other hand, Irma et al. (9) reported that cesarean delivery had slightly protective effects against the risk of malocclusion development. In our study, no significant difference was found between the groups in terms of their cephalometric values. Cattaneo et al. (3) defined deliveries lasting 6-12 hours as normal deliveries in their study. On the other hand, Zhou et al. (20) did not define a specified duration of delivery considered natural. This difference in findings may be attributed to the fact that the births of the patients in the normal delivery group took shorter (4.8±1.9 hours) as the mothers of most of these patients were multiparous. Another possible explanation might be that patients with severe skeletal malocclusions requiring orthognathic surgery in which genetic factors were significantly effective were excluded from this study.

We used panoramic radiographs to examine Co-Sg, Sg-Go, Co-Go distances, and asymmetry index values. Many studies have reported that panoramic radiographs give reliable results in the measurement of condylar asymmetry and condylar height (21-23). No statistically significant differences in condylar asymmetry, ramal asymmetry, or total asymmetry index values were found between the groups in this study. On the other hand, we found a statistically significant difference between the right and left sides in terms of condylar height in the normal delivery group, as well as a significant difference in terms of ramus height in the cesarian delivery group. However, a statistically significant difference was observed in total asymmetry index for both groups. Therefore, the null hypothesis was rejected. A relationship between labor and delivery stress and orthodontic malocclusions was reported (3). This was because asymmetric mechanical forces could induce deviations in the craniofacial bones by the accumulation of stress in the mandibular condyles and the inability to tolerate this stress due to the articulation of the condyle with the skull base (3,4,25). Therefore, this condylar asymmetry could be attributed to the maxillofacial trauma caused by muscular and positional push and pull forces applied to the craniofacial structure during vaginal deliveries (24, 25).

The difference in the position of the mandible between normal and cesarean delivery depending on the way the head is delivered, the localization of the forces that the baby is exposed to during two different types of birth, and the difference in the extension and flexion of the head may have led to this finding.

The condylar asymmetry index values of both groups were similar when compared based on the 3% threshold value proposed by Habets et al. (26) However, to the best of our current knowledge, the present study is the first to investigate the relationship between mandibular asymmetry and type of delivery. It is difficult to compare our findings to those of previous studies evaluating condylar asymmetry, as there have been no studies investigating mandibular vertical asymmetry in cases of different type of delivery. Thus, further studies are needed in this field.

Zhou et al. (20) reported that breastfed children had lower risk levels in terms of malocclusion development. In this study, the majority of the patients in both groups had mixed breast and bottle feeding in the first 6 months. Moreover, the groups had similar results in terms of the duration of breastfeeding, the duration of using an infant bottle/pacifier, and the timing and type of introduction to solid food. Prolonged breastfeeding is one of the factors that prevent malocclusions by restricting bottle-feeding and non-nutritive habits (27,28). One of the possible explanations for the absence of a significant difference between the groups in terms of malocclusions may also be the similar feeding habits of the two groups.

Moreover, in this study while no significant correlations were found between the duration of breastfeeding, the duration of using an infant bottle/pacifier, and the timing of introduction to solid food in the groups and their mandibular asymmetry index scores, a significant negative correlation was identified between gestational week at birth and mandibular asymmetry index scores. It has been reported in the literature that the development of malocclusions is associated with preterm birth (15,29).

Pogliani et al. (30) stated that the risk of plagiocephaly was high in preterm children, and accordingly, the possibility of mandibular asymmetry development was high. On the other hand, the specific mechanism that can explain this association remains unclear (15).

Study Limitations

Finally, this study had several limitations. In this study, data were collected using retrospective questionnaires applied to the mothers of the patients who might not be able to remember every detail of their pregnancy and childbirth correctly (recall bias). Individual variations may also make it difficult to determine the relationship between the variables in prenatal and infantile periods and orthodontic malocclusions. Therefore, further prospective controlled studies with larger sample sizes are needed to determine whether perinatal and infantile variables may increase the risk of malocclusions.

Conclusion

Keeping in mind the limitations of this study, it was concluded that;

- Type of delivery had no significant effect on skeletal, dental, and soft tissue cephalometric parameters.

- The patients born via vaginal delivery tended to have a higher prevalence of condylar asymmetry, whereas those born via caesarean section tended to have a higher prevalence of ramal asymmetry.

- A statistically significant relationship was observed between preterm birth and mandibular asymmetry.

Ethics

Ethics Committee Approval: Ethical approval was obtained from the Research Ethics Committee of Bezmialem Vakıf University (protocol no: 54022451-050.05.04).

Informed Consent: The informed consent forms were obtained from individuals included.

Peer-review: Externally peer reviewed.

Authorship Contributions

Surgical and Medical Practices: İ.E.M., E.D.Ş., Concept: İ.E.M., E.D.Ş., Design: İ.E.M., E.D.Ş., Data Collection or Processing: İ.E.M., E.D.Ş., Analysis or Interpretation: İ.E.M., E.D.Ş., Literature Search: İ.E.M., E.D.Ş., Writing: İ.E.M.

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References

1. Goymen M, Topcuoglu T, Aktan AM, Isman O. Cephalometric comparison of cesarean and normal births. Eur J Dent 2016;10:199-202.
2. Moss ML, Salentijn L. The primary role of functional matrices in facial growth. Am J Orthod Dentofacial Orthop 1969;55:566-77.
3. Cattaneo R, Monaco A, Streni O, Serafino V, Giannoni M. Birth delivery trauma and malocclusion. J Clin Pediatr Dent 2005;29:185-8.
4. Frymann V. Relation of disturbances of craniosacral mechanisms to symptomatology of the newborn: study of 1,250 infants. J Am Osteo Ass 1966;65:1059-75.
5. Aiello I, Serra G, Traina G, Tugnoli V. Entrapment of the suprascapular nerve at the spinoglenoid notch. Ann Neurol 1982;12:314-6.
6. Schoenwetter RF. A possible relationship between certain malocclusions and difficult or instrument deliveries. Angle Orthod 1974;44:336-40.
7. Irma C, Eleonora O, Chiara M, Stefano N, Davide P, Annalisa M. Malocclusion and perinatal factors: a retrospective study. Int J Clin Exp Med 2016;9:22758-63.
8. Lim Y-S, Chung D-H, Lee J-W, Lee S-M. Reliability and validity of mandibular posterior vertical asymmetry index in panoramic radiography compared with cone-beam computed tomography. Am J Orthod Dentofacial Orthop 2018;153:558-67.
9. Irma C, Eleonora O, Chiara M, Stefano N, Davide P, Annalisa M. Malocclusion and perinatal factors: a retrospective study. Int J Clin Exp Med 2016;9:22758-63.
10. Frymann VM. A study of the rhythmic motions of the living cranium. J Am Osteo Ass 1971; 70: 928-45.
11. Garliner D. The importance of oro-facial muscle function and dysfunction in the treatment of various occlusal problems. J Orofac Orthop 1986;47:215-20.
12. MacDorman MF, Declercq E, Menacker F, Malloy MH. Neonatal mortality for primary cesarean and vaginal births to low-risk women: Application of an "intention-to-treat" model. Birth 2008;35:3-8.
13. Chen MM, Hancock H. Women's knowledge of options for birth after Caesarean Section. Women Birth 2012;25:E19-E26.
14. Goumalatsos G, Varma R. Vaginal birth after Caesarean section: a practical evidence-based approach. Obs Gyn Rep Med 2009;19:178-86.
15. Amaral CC, da Costa VPP, Azevedo MS, Pinheiro RT, Demarco FF, Goettems ML. Perinatal health and malocclusions in preschool children: findings from a cohort of adolescent mothers in Southern Brazil. Am J Orthod Dentofac Orthop 2017;152:613-21.
16. Tontus HO, Nebioglu S. Improving the caesarean decision by robson classification: a population-based study by 5,323,500 livebirth data. Ann Glob Health 2020;86:101.
17. Mew JR. The postural basis of malocclusion: a philosophical overview. Am J Orthod Dentofacial Orthop 2004;126:729-38.
18. Carlson DS. Theories of craniofacial growth in the postgenomic era. Semin Orthod 2005; 11: 172–83.
19. Rapeepattana S, Thearmontree A, Suntornlohanakul S. Etiology of malocclusion and dominant orthodontic problems in mixed dentition: A cross-sectional study in a group of Thai children aged 8–9 years. J Int Soc Prev Community Dent 2019;9:383-9.
20. Zhou Z, Liu F, Shen S, Shang L, Shang L, Wang X. Prevalence of and factors affecting malocclusion in primary dentition among children in Xi'an, China. BMC Oral Health 2016;16:1-11.
21. Laster W, Ludlow J, Bailey L, Hershey HG. Accuracy of measurements of mandibular anatomy and prediction of asymmetry in panoramic radiographic images. Dentomaxillofac Radiol. 2005;34:343-9.
22. Lemos AD, Katz CRT, Heimer MV, Rosenblatt A. Mandibular asymmetry: A proposal of radiographic analysis with public domain software. Dental Press J Orthod 2014;19:52-8.
23. Momjian A, Courvoisier D, Kiliaridis S, Scolozzi P. Reliability of computational measurement of the condyles on digital panoramic radiographs. Dentomaxillofac Radiol 2011;40:444-50.
24. Harila-Kaera V, Grön M, Heikkinen T, Alvesalo L. Sagittal occlusal relationships and asymmetry in prematurely born children. Eur J Orthod 2002;24:615-25.
25. Pirttiniemi PM. Associations of mandibular and facial asymmetries—a review. Am J Orthod Dentofacial Orthop 1994;106:191-200.

26. Habets L, Bezuur J, Naeiji M, Hansson T. The Orthopantomogram®, an aid in diagnosis of temporomandibular joint problems. II. The vertical symmetry 1988;15:465-71.

27. Peres KG, Cascaes AM, Peres MA, Demarco FF, Santos IS, Matijasevich A, et al. Exclusive breastfeeding and risk of dental malocclusion. Pediatrics 2015;136:E60-E7.

28. Feldens CA, Vitolo MR, Rauber F, Cruz LN, Hilgert JB. Risk factors for discontinuing breastfeeding in southern Brazil: a survival analysis. Matern Child Health J 2012;16:1257-65.

29. Rythén M, Thilander B, Robertson A. Dento-alveolar characteristics in adolescents born extremely preterm. Eur J Dent 2013;35:475-82.

30. Pogliani L, Mameli C, Fabiano V, Zuccotti GV. Positional plagiocephaly: what the pediatrician needs to know. A review. Childs Nerv Syst 2011;27:1867-76.