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Biological predictors of mandibular asymmetries in children with mixed dentition

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Objectives: The objective was to investigate the severity of skeletal mandibular asymmetry in children with mixed dentition and other factors associated with asymmetry. **Method:** The study was cross sectional, with stratified sampling according to malocclusion type consisting of 205 subjects with mixed dentition (median 10, interquartile range 9–11 years). There were 59 subjects presenting Class II/1, 77 Class II/2, and 69 Class III. The mandibular asymmetry has been estimated from orthopantomograms using the Habets' method and the dental maturation by Demirjian's method. The sagittal skeletal relationship and facial growth pattern were assessed from lateral cephalograms. **Results:** Asymmetries in general, were not rare and were more present in the condylar height rather than in the height of the ramus. The highest severity of condylar asymmetry was in Class II/2 subjects (median of asymmetry index 7.3; 64% subjects exhibiting moderate and severe asymmetry), while the Class III subjects exhibited the highest severity of both ramus and total height asymmetry (2.1; 13% and 2.0; 15%, respectively). Multiple logistic regression unveiled male gender as the only predictor of moderate or significant overall asymmetry. Dental age, the difference between dental and chronological age, and facial growth pattern were not significant predictors of asymmetries. **Discussion:** Overall, asymmetries in mixed dentition cannot be considered rare; however, no strong relationships between asymmetry and observed biological factors were found.

Keywords: Mandibular asymmetry, condylar asymmetry, asymmetry index, panoramic radiography, angle class

Introduction

Facial symmetry can be defined by the position of points on both sides of the face in comparison to the medio-sagittal plane. Although a lot of faces may appear well balanced and symmetrical on clinical observation, radiographic analyses indicate the presence of asymmetry as a common characteristic of all faces.[1–4] It is debatable when to declare asymmetry "normal" or "abnormal."[5,6] Some research suggested that, in the case of minor asymmetries, the right side of the face is usually wider in comparison to the left side, and the chin is moved to the left.[6] Also, asymmetry often involves the lower third of the face, which can be explained by a longer period of mandibular growth.[7]

Mandibular asymmetry plays an important role in determining facial appearance and functioning of the masticatory system. It is caused by many factors: developmental, pathological, functional, and traumatic.[1,6] Some important morphological and functional causes of mandibular asymmetries include a constricted airway due to enlarged tonsils, adenoids, or allergies with impaired breathing; a constricted maxilla, forced bite, mandibular shifts to one side and unilateral crossbite, muscular activity, parafunctional habits like thumb and pacifier sucking, reverse swallowing, and oral breathing.[8–12]

Early diagnosis of asymmetry is important to identify the causes of asymmetry for better treatment options and prevention of its consequences.[1,13,14] Orthopantomograms (OPG), posterior–anterior cephalograms, and computerized tomography (CT) scans are methods of choice for diagnosing asymmetries. Although, a less sophisticated method, detection of asymmetries on OPG is still widely used and has advantages over CT, primarily in reduced ionizing radiation.[15–18]

Several techniques for measuring the asymmetry on OPG have been developed.[19–22] Asymmetries are more likely to appear in patients with Class II and III malocclusions, although they may be present in individuals with normal occlusion.[5] Furthermore, mandibular asymmetry could represent a risk factor for temporomandibular

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disorders.[19,23] Interceptive treatment, such as the elimination of the airway problems and parafunctions, grinding of primary teeth, and maxillary transversal expansion in lateral crossbite cases and functional mandibular shift, can be beneficial in the primary dentition, creating optimal conditions for normal occlusal development, skeletal growth, and improved facial symmetry.[24–26]

The aim of this study was to investigate the severity of skeletal mandibular asymmetry in children with mixed dentition and to explore the association with biological factors: sagittal skeletal relation, gender, chronological age, dental maturity, difference between chronological and dental age, type of dentition, and rotational pattern of facial growth. The hypothesis of this study is that asymmetries are more pronounced in Class III boys, and the least in Class II/1 girls and that asymmetries increase with increasing chronological and dental age, accelerated dental maturation, and the tendency of the horizontal growth pattern. The authors assumed that the sagittal skeletal relation and the accelerated dental maturation are the most significant predictors of mandibular asymmetry.

Materials and methods

The study was cross sectional with stratified sampling according to malocclusion type, consisting of 205 subjects with mixed dentition referred for orthodontics at the University Dental Clinic for consultation (median age 10, interquartile range 9–11 years). There were 57% girls, 28% in early mixed dentition, 59 subjects presenting Class II/1, 77 Class II/2, and 69 Class III. The mandibular asymmetry was estimated on OPG using the Habets' method.[22] In brief, condylar height was measured as a distance between the most cranial and the most lateral point of the condyle on the ramus tangent, while ramus height presented distance between the most lateral point of the condyle and ramus on the ramus tangent. Asymmetry index was calculated by the following formula: Asymmetry index $= \left| \frac{RIGHT-LEFT\ STRUCTURE}{RIGHT+LEFT\ STRUCTURE} \right| \times 100$. The above-mentioned heights were measured in mm, while asymmetry index is a ratio with a measure scale from 0 to 100%.

The severity of the asymmetry was classified as insignificant (0–2.99% of asymmetry index, AI), slight (3–4.99%), moderate (5–9.99%), and severe (≥10%).[27]

Dental maturation has been estimated from OPG using the Demirjian's method.[28] The difference between dental and chronological age was used as a measure of decelerated, balanced or accelerated dental maturation. Lateral cephalograms were used to assess skeletal sagittal relations as well as rotational pattern of facial growth, which was estimated using Jarabak's ratio of posterior and anterior facial height (S-Go: N-Me).[29]

The study was approved by the local ethics committee.

In the statistical analysis, normality of distribution of data was checked by the Kolmogorov-Smirnov test and homogeneity of variances by the Levene's test. The Kruskal-Wallis test and Mann-Whitney test with Bonferroni correction for multiple comparisons were used to compare the asymmetry, differences between dental and chronological maturity, and rotational pattern of facial growth between the sagittal classes groups. Effect size was quantified by the formula $r = z/\sqrt{N}$.[30] The frequencies were compared using χ^2 test, and the effect size was quantified by Cramer's V.

Spearman correlation was used to evaluate correlation between variables of asymmetry, pattern of facial growth, maturity, and gender.

Multiple logistic regression was used to estimate predictors of moderate or severe asymmetry. For that purpose, the asymmetry index was dichotomized: 0 = insignificant or slight asymmetry (≤4.99%), and 1 = moderate or severe asymmetry (≥5%). All analyses were performed using commercial software SPSS 11.5 (SPSS Inc., Chicago, USA).

Results

The distribution of subjects by class, difference between dental and chronological age, growth pattern, and by asymmetries is presented in Table 1. Genders were equally allocated within the Angle class groups. Subjects with Class II/1 had accelerated dental maturation, while subjects with Class II/2 and Class III had decelerated dental maturation in relation to their chronological age ($p < 0.001$). The difference between Class II/1 and II/2 accounts for 4.4% of variability, while between Class II/1 and III for 9% of variability (Table 1).

When observing the facial growth pattern, assessed by Jarabak's ratio, the interquartile ranges suggest subjects with Class II/1 and III demonstrate a tendency for a vertical growth pattern in comparison to those with Class II/2 ($p = 0.014$, Table 1). The difference in Jarabak's ratios between Class II/2 and Class II/1 as well as Class II/2 and Class III accounts for 4.4% of variability ($p = 0.014$ and $p = 0.012$).

Asymmetries were more often present in condylar height rather than in the height of ramus, but there was no significant difference between malocclusion groups (Figure 1, Table 1), genders, or types of dentition (early vs. late mixed dentition). As can be seen in Figure 1, overall, only one third of children exhibited severe condylar asymmetry. A higher severity of condylar asymmetry can be noticed in Class II/2 compared with Class III and Class II/1 (Table 1). The moderate and severe asymmetry in Class II/2 was 64%, while in Class III and Class II/1 it was 53 and 56%, respectively (Figure 1). Observing the total ramus height, less asymmetry was recorded in children

Table 1. Subjects distribution by class, difference between dental and chronological age, growth pattern and by asymmetries. AQ7

Variable	Angle class	Median	Interquartile range		*p**
			25 centile	75 centile	
Difference between dental and chronological age	II/1	0.5[a]	–0.3	1.3	<0.001
	II/2	–0.6[b]	–1.5	0.8	
	III	–0.4[b]	–1.0	0.7	
Rotational pattern of facial growth (Jarabak's ratio)	II/1	64.0[a]	61.5	66.0	0.014
	II/2	65.0[b]	62.9	68.1	
	III	64.7[a]	61.3	66.6	
Index of condylar asymmetry	II/1	6.5	2.3	13.6	0.849
	II/2	7.3	3.5	10.4	
	III	5.8	3.0	10.7	
Index of ramus asymmetry	II/1	2.0	0.9	3.7	0.829
	II/2	2.0	0.9	3.4	
	III	2.1	0.9	3.9	
Index of total ramus asymmetry	II/1	1.4	0.8	2.7	0.196
	II/2	1.7	0.8	2.6	
	III	2.0	0.9	3.7	

**Kruskal-Wallis test.*
Note: Classes which do not share the same superscript letters are statistically significantly different.

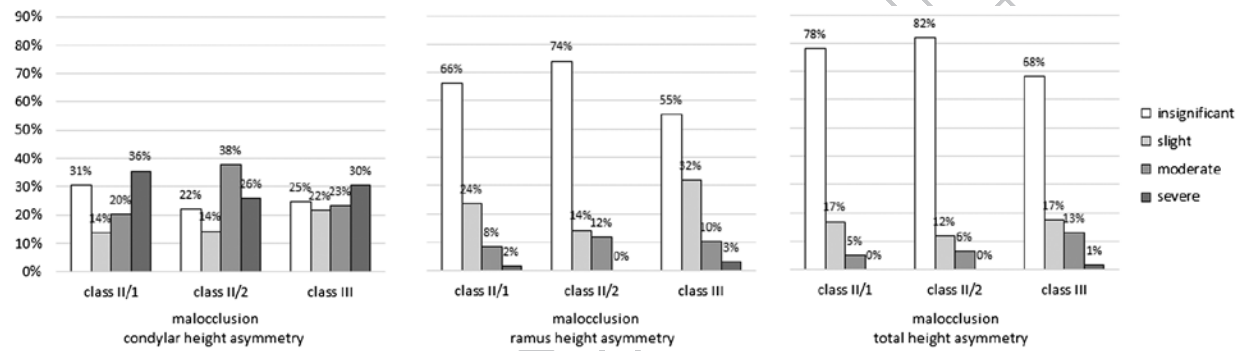

Figure 1. Distribution of asymmetry intensity levels within the malocclusion groups.

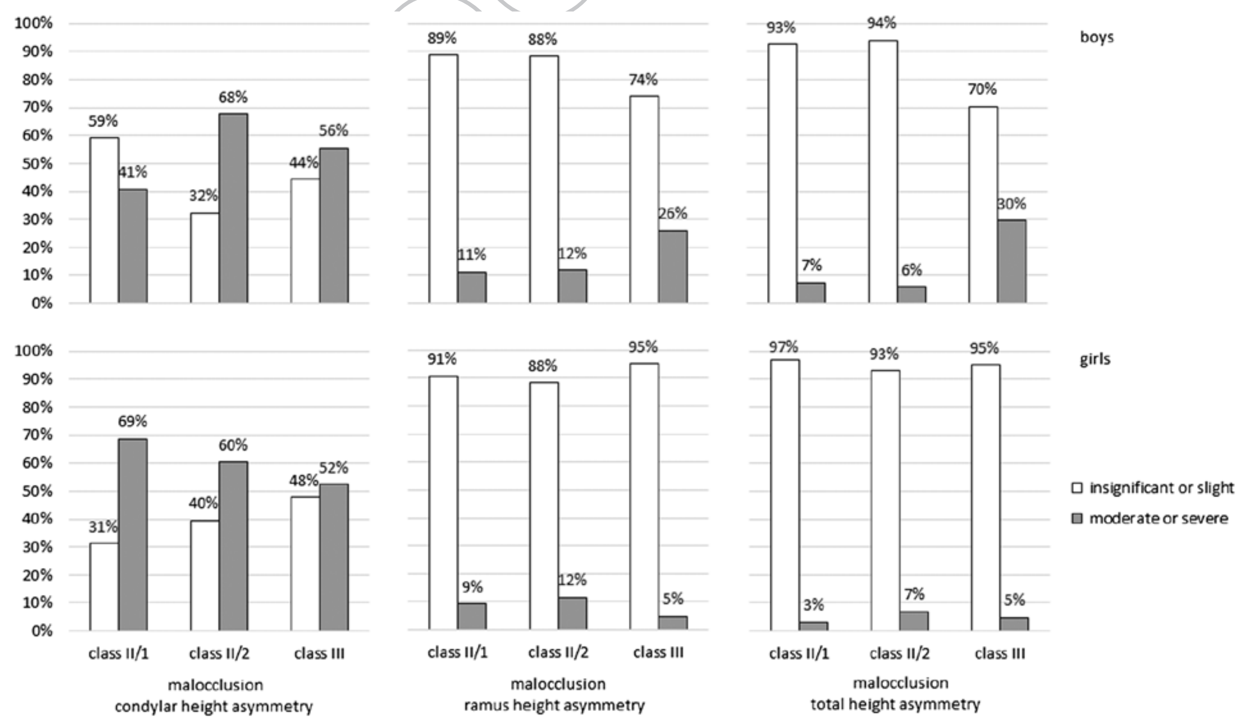

Figure 2. Distribution of the asymmetry intensity between malocclusion types and gender.

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Table 2. Spearman correlations between measures of asymmetry and hypothetical biological predictors.

		The index of condylar asymmetry	The intensity of condylar asymmetry	The index of ramus asymmetry	The intensity of ramus asymmetry	The index of total asymmetry	The intensity of total asymmetry
The index of condylar asymmetry	*r*	1	0.965	0.140	0.218	0.106	0.096
	p		<0.001	0.045	0.002	0.130	0.169
The intensity of condylar asymmetry	*r*	0.965	1	0.161	0.231	0.125	0.114
	p	<0.001		0.021	0.001	0.075	0.104
The index of ramus asymmetry	*r*	0.14	0.161	1	0.841	0.749	0.628
	p	0.045	0.021		<0.001	<0.001	<0.001
The intensity of ramus asymmetry	*r*	0.218	0.231	0.841	1	0.691	0.702
	p	0.002	0.001	<0.001		<0.001	<0.001
The index of total asymmetry	*r*	0.106	0.125	0.749	0.691	1	0.745
	p	0.130	0.075	<0.001	<0.001		<0.001
The intensity of total asymmetry	*r*	0.096	0.114	0.628	0.702	0.745	1
	p	0.169	0.104	<0.001	<0.001	<0.001	
Chronological age	*r*	0.004	0.014	–0.008	0.032	–0.014	0.008
	p	0.956	0.838	0.904	0.648	0.842	0.911
Dental age	*r*	–0.033	–0.005	–0.006	0.039	–0.042	<0.001
	p	0.635	0.938	0.927	0.582	0.553	0.999
The difference between dental and chronological age	*r*	–0.028	0.009	–0.006	0.051	–0.05	–0.013
	p	0.687	0.897	0.929	0.465	0.478	0.848
Type of dentition (1 = early. 2 = late mixed dentition)	*r*	0.004	–0.003	–0.027	–0.025	0.016	0.038
	p	0.954	0.961	0.701	0.717	0.816	0.587
Gender (1 = male. 2 = female)	*r*	–0.006	0.004	0.006	–0.002	–0.049	–0.065
	p	0.929	0.951	0.929	0.972	0.485	0.353
Pattern of facial growth (Jarabak's ratio)	*r*	0.149	0.150	–0.006	–0.016	–0.026	–0.133
	p	0.033	0.032	0.928	0.822	0.713	0.057

Note: r = correlation coefficient, p = level of statistical significance.

with Class II/2 (6%), than in those with Class III (15%; Figure 1).

When the combination of gender and class were taken into consideration, and when severity was dichotomized into two categories, significant differences in severity were only present for the asymmetry of the total ramus height where boys of Class III more often had moderate or severe asymmetry compared to the boys of other classes with a small effect size ($r = 0.311$, $p = 0.014$, Figure 2).

The difference between genders was significant for the asymmetry in the condylar height in Class II/1, where girls more often had moderate or severe asymmetry compared to boys (69 vs. 41%, $p = 0.038$, $r = 0.281$). Boys of Class III were more likely to have moderate or severe ramus asymmetry than girls of the same class (26 vs. 5%, $p = 0.023$, $r = -0.307$), and moderate or severe asymmetries of the total ramus height were present more often in male subjects (30 vs. 5%, $p = 0.011$, $r = -0.345$). Gender accounts for a small part of the variability in the asymmetry, 8–12%.

Condylar asymmetry did not correlate with the ramus or the total asymmetry, while ramus asymmetry correlated with total asymmetry (Table 2). The correlation was stronger for the ordinal severity scale ($r = 0.702$, $p < 0.001$) than for the continuous index scale ($r = 0.557$, $p < 0.001$).

Correlation between asymmetry and assessed biological predictors such as dental age, chronological age, the differences between dental and chronological age, type of dentition, gender, and the pattern of facial growth was not proven (Table 2).

Multiple logistic regression models, used to estimate predictors of moderate or severe asymmetry, showed that by controlling for other biological predictors, only the male gender was a predictor of moderate or significant

Table 3. Multiple logistic regressions for estimation of biological predictors of moderate or severe asymmetry.

Asymmetry	Predictor	B	SE	Sig.	OR	95% CI	
Condyle asymmetry*	Dental age	–0.063	0.085	0.463	0.939	0.795	1.110
	The difference between dental and chronological age	0.074	0.118	0.533	1.076	0.854	1.356
	Class III (ref)			0.725			
	Class II/1	0.164	0.382	0.667	1.179	0.558	2.490
	Class II/2	0.279	0.35	0.426	1.322	0.665	2.625
	Gender M	0.318	0.3	0.289	1.374	0.763	2.475
	Jarabak's ratio	0.083	0.038	0.029	1.087	1.008	1.171
	Constant	–4.730	2.525	0.061	0.009		
Ramus asymmetry**	Dental age	0.058	0.122	0.633	1.06	0.834	1.347
	The difference between dental and chronological age	0.083	0.175	0.635	1.086	0.772	1.530
	Class III (ref)			0.685			
	Class II/1	–0.483	0.589	0.412	0.617	0.194	1.957
	Class II/2	–0.041	0.525	0.937	0.959	0.343	2.686
	Gender M	–0.832	0.455	0.068	0.435	0.178	1.062
	Jarabak's ratio	–0.054	0.058	0.348	0.947	0.846	1.061
	Constant	1.442	3.793	0.704	4.228		
Total asymmetry***	Dental age	0.058	0.138	0.672	1.060	0.809	1.390
	The difference between dental and chronological age	0.041	0.191	0.829	1.042	0.717	1.516
	Class III (ref)			0.124			
	Class II/1	–1.419	0.732	0.052	0.242	0.058	1.015
	Class II/2	–0.711	0.612	0.245	0.491	0.148	1.630
	Gender M	–1.412	0.561	0.012	0.244	0.081	0.731
	Jarabak's ratio	–0.137	0.07	0.051	0.872	0.759	1.001
	Constant	7.061	4.613	0.126	1166.13		

*Negelkerke pseudo R2 = 0.049; p = 0.271.
**Negelkerke pseudo R2 = 0.044; p = 0.581.
***Negelkerke pseudo R2 = 0.143; p = 0.035.

overall asymmetry (Table 3). Regression models for condylar asymmetry and ramus height asymmetry were not significant, that is, it did not detect significant predictors (Table 3).

Discussion

The present study did not prove a strong relation between asymmetry and explored biological predictors of dental age, chronological age, the difference between dental and chronological age, type of dentition, gender, and rotational pattern of facial growth; however, a few tendencies were observed. Asymmetries were more often present in condylar than in the ramus height. Class II/2 children had the strongest condylar asymmetry, but it appears to be compensated with ramus height, while condylar asymmetries in Class III intensify with asymmetry of ramus height.

Asymmetry may, to some extent, be related to gender. Girls with Class II/1 were more likely to have moderate or severe asymmetry of the condylar height compared to the boys, and moderate or severe ramus asymmetry and asymmetry of the total ramus height in Class III were more often found in male rather than in female subjects. When controlling for all other predictors, male gender appears to be the predictor of moderate or significant overall asymmetry. These results could indicate that women have better compensation mechanisms of condylar asymmetry by modifying the ramus height. Another possibility is that this compensation occurs earlier in females because of earlier maturation of girls. Previous studies demonstrated a significant condylar asymmetry in Class II/1 when compared to normal occlusion, Class II/2 and Class III; however, the relation to gender is still ambiguous.[3,4]

The reason for higher severity of condylar asymmetry recorded in Class II/2 compared with Class III may be due to condylar morphology. Class II/2 usually has a tall and narrow condyle, while the condyle in Class III is generally wide, short, and squat.[31–33] Because of the difference in condylar height, the asymmetry of a high and narrow condyle might be more noticeable. Another possibility is that on a higher condyle, typical for Class II/2, the asymmetry could be more easily and more precisely measured and recorded.

The pattern of facial growth could also be considered as one of the factors of successful asymmetry compensation. Comparing Class II/2 and Class III, it can be seen that Class II/2 has a conspicuous horizontal growth pattern and a higher ramus, while Class III has a tendency towards a vertical growth pattern as an attempt to compensate bite by posterior rotation of the mandible and a shorter ramus.[34,35] There is a probability that the higher length of the ramus can easily compensate asymmetry coming from the condyle. This certainly supports the fact that Class II/2 has a less conspicuous total ramus asymmetry compared to Class III.

Numerous factors, such as gender, age, facial growth pattern, functional and pathological alteration, dental occlusion changes, and muscular activity, may reconfigure and remodel temporomandibular joint surfaces and also influence the development of mandibular asymmetry.[31,33,36] As condylar cartilage is an area with the strongest growth potential on the mandible, injuries during the developmental stages can disrupt the mandibular growth potential by displacing the mandible towards the injured side and cause condylar asymmetry.[3,4] However, recent studies suggested that the condyle has a great capacity for regeneration, and it is considered that the changes in the further mandibular growth occur in only 25% of children.[37]

OPG has its advantages, since it is possible to see joints, teeth and parts of the jaw with only one exposure; therefore, the subjects are exposed to lower radiation in comparison to CT.[38] Although there is a question of its credibility because of the magnification effect, most authors proved that even greater changes in the head position cannot affect the results of vertical measurements.[4,21,39] The asymmetry due to incorrect positioning is not greater than 6%, and the difference between the right and the left condyle greater than 6% indicates a condylar asymmetry.[22]

Conclusion

In conclusion, by controlling for biological factors: dental age, the difference between dental and chronological age, type of dentition, and facial growth pattern, only male gender emerges as a predictor of moderate or significant AQ3 overall asymmetry. This may be because of the better compensation ability of females or it may be related to the earlier maturation of girls.

AQ4 Disclosure statement

No potential conflict of interest was reported by the authors.

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References

1 Chia MSY, Naini FB, Gill DS. The aetiology, diagnosis and management of mandibular asymmetry. Ortho Update. 2008;1(2):44–52.
2 Peck S, Peck L, Kataja M. Skeletal asymmetry in esthetically pleasing faces. Angle Orthod. 1990;61(1):43–48.
3 Sezgin OS, Celenik P, Arici S. Mandibular asymmetry in different occlusion patterns, A radiological evaluation. Angle Orthod. 2007;77(5):803–807.
4 Bajracharya M, Mishra P, Bhattarai P, Parajuli U, Shrestha R, Poudel KR. A radiographic evaluation of mandibular asymmetry in class II division 1 malocclusion pattern. Nepal J Orthod. 2012;2(1):16–20.
5 Cheong YW, Lo LJ. Facial asymmetry: etiology, evaluation, and management. Chang Gung Med J. 2011;34(4):341–351.
6 Bishara SE, Burkey PS, Kharouf JG. Dental and facial asymmetries: a review. Angle Orthod. 1994;64(2):89–98.
7 Primozic J, Perinetti G, Richmond S, Ovsenik M. Three-dimensional evaluation of facial asymmetry in association with unilateral functional crossbite in the primary, early, and late mixed dentition phases. Angle Orthod. 2013;83(2):253–258.
8 Ovsenik M. Incorrect orofacial functions until 5 years of age and their association with posterior crossbite. Am J Orthod Dentofacial Orthop. 2009;136(3):375–381.
9 Raoul G, Rowlerson A, Sciote J, Codaccioni E, Stevens L, Maurage CA, et al. Masseter myosin heavy chain composition varies with mandibular asymmetry. J Craniofac Surg. 2011;22(3):1093–1098.
10 Mahony D, Karsten A, Linder-Aronson S. Effects of adenoidectomy and changed mode of breathing on incisor and molar dentoalveolar heights and anterior face heights. Aust Orthod J. 2004;20(2):93–98.
11 Lessa FC, Enoki C, Feres MF, Valera FC, Lima WT, Matsumoto MA. Breathing mode influence in craniofacial development. Braz J Otorhinolaryngol. 2005;71(2):156–160.
12 Kwak YY, Jang I, Choi DS, Cha BK. Functional evaluation of orthopedic and orthodontic treatment in a patient with unilateral posterior crossbite and facial asymmetry. Korean J Orthod. 2014;44(3):143–153.
13 Kasimoglu Y, Tuna EB, Rahimi B, Marsan G, Gencay K. Condylar asymmetry in different occlusion types. 2015;33(1):10–14.
14 Malandris M, Mahoney EK. Aetiology, diagnosis and treatment of posterior cross-bites in the primary dentition. Int J Paediatr Dent. 2004;14(3):155–166.
15 Damstra J, Fourie Z, Ren Y. Evaluation and comparison of postero-anterior cephalograms and cone-beam computed tomography images for the detection of mandibular asymmetry. Eur J Orthod. 2013;35(1):45–50.
16 Silvestrini-Biavati F, Ugolini A, Laffi N, Canevello C, Silvestrini-Biavati A. Early diagnostic evaluation of mandibular symmetry using orthopantomogram. Indian J Dent Res. 2014;25(2):154–159.
17 Lemos AD, Katz CR, Heimer MV, Rosenblatt A. Mandibular asymmetry: a proposal of radiographic analysis with public domain software. Dental Press J Orthod. 2014;19(3):52–58.
18 Kurt G, Uysal T, Sisman Y, Ramoglu SI. Mandibular asymmetry in class ii subdivision malocclusion. s. 2008;s78(1):32–37. AQ6
19 Yanez-Vico RM, Iglesias-Linares A, Torres-Lagares D, Gutierrez-Perez JL, Solano-Reina E. Association between condylar asymmetry and temporo- mandibular disorders using 3D-CT. Med Oral Patol Oral Cir Bucal. 2012;17(4):e852–e858.
20 Fuentes R, Engelke W, Bustos L, Oporto G, Borie E, Sandoval P, et al. Reliability of two techniques for measuring condylar asymmetry with x-rays. Int J Morphol. 2011;29(3):694–701.
21 Sadat-Khonsari R, Fenske C, Behfar L, Bauss O. Panoramic radiography: effects of head alignment on the vertical dimension of the mandibular ramus and condyle region. Eur J Orthod. 2012;34(2):164–169.
22 Habets LL, Bezuur JN, Naeiji M, Hansson TL. The orthopantomogram, an aid in diagnosis of temporomandibular joint problems. II. The vertical symmetry. J Oral Rehabil. 1988;15(5):465–471.
23 Iturriaga V, Navarro P, Cantin M, Fuentes R. Prevalence of Vertical Condilar Asymmetry of the Temporomandibular Joint in Patients with Signs and Symptoms of Temporomandibular Disorders. Int J Morphol. 2012;30(1):315–321.
24 Primozic J, Richmond S, Kau CH, Zhurov A, Ovsenik M. Three-dimensional evaluation of early crossbite correction: a longitudinal study. Eur J Orthod. 2013;35(1):7–13.
25 Flores-Mir C. Grinding is effective in early orthodontic treatment of unilateral posterior crossbite. Evid Based Dent. 2005;6(1):24.
26 Lippold C, Stamm T, Meyer U, Végh A, Moiseenko T, Danesh G. Early treatment of posterior crossbite–a randomised clinical trial. Trials. 2013;14(1):20.
27 Ramirez-Yanez GO, Stewart A, Franken E, Campos K. Prevalence of mandibular asymmetries in growing patients. Eur J Orthod. 2011;33(3):236–242.
28 Demirjian A, Goldstein H, Tanner JM. A new system of dental age assessment. Hum Biol. 1973;45(2):211–227.
29 Muretic Z, Lapter-Varga M. New parameters for roentgencephalometric analysis “Zagreb 82 MOD”. Acta Stomatol Croat. 2004;38(2):169–172.
30 Rosenthal R. Meta-analytic procedures for social research. Newbury Park (CA): Sage; 1991. p. 19.

31 Saccucci M, D'Attilio M, Rodolfino D, Festa F, Polimeni A, Tecco S. Condylar volume and condylar area in class I, class II and class III young adult subjects. Head Face Med. 2012;8:34.

32 Akahane Y, Deguchi T, Hunt NP. Morphology of the Temporomandibular Joint in Skeletal Class III Symmetrical and Asymmetrical Cases: a Study by Cephalometric Laminography. J Orthod. 2001;28(2):119–128.

33 Arieta-Miranda JM, Silva-Valencia M, Flores-Mir C, Paredes-Sampen NA, Arriola-Guillen L. Spatial analysis of condyle position according to sagittal skeletal relationship, assessed by cone beam computed tomography. Prog Orthod. 2013;14:36.

34 Brezniak N, Arad A, Heller M, Dinbar A, Dinte A, Wasserstein A. Pathognomonic cephalometric characteristics of angle class II division 2 malocclusion. Angle Orthod. 2002;72(3):251–257.

35 Guyer EC, Ellis EE 3rd, McNamara JA Jr, Behrents RG. Components of class III malocclusion in juveniles and adolescents. Angle Orthod. 1986;56(1):7–30.

36 Ueki K, Nakagawa K, Marukawa K, Takatsuka S, Yamamoto E. The relationship between temporomandibular joint disc morphology and stress angulation in skeletal Class III patients. Eur J Orthod. 2005;27(5):501–506.

37 Proffit WR, Vig KWL, Dann C IV. Who seeks surgical-orthodontic treatment? The characteristics of patients evaluated in the UNC dentofacial clinic. Int J Adult Orthod Orthogn Surg. 1990;5(3):153–160.

38 Roberts JA, Drage NA, Davies J, Thomas DW. Effective dose from cone beam CT examinations in dentistry. Br J Radiol. 2009;82(973):35–40.

39 Boratto R, Gambardella U, Micheletti P, Pagliani L, Preda L, Hansson TL. Condylar-mandibular asymmetry, a reality. Bull Group Int Rech Sci Stomatol Odontol. 2002;44(2):52–56.