Rev Estomatol. 2025; 33(2):e15011. DOI: 10.25100/re.v33i2.15011

ORIGINAL ARTICLE

Prevalence and Morphological Patterns of Mandibular Asymmetries in a Mexican Population: A CBCT-Based Analysis

Andrea Celeste López Martínez [1] | Alan Martínez Zumarán [1] | Adriana Torre Delgadillo [1] | Leticia Ramírez Martínez [1] | Marco Felipe Salas Orozco [2]

Institutional Affiliation

[1] Autonomous University of San Luis Potosí, Faculty of Stomatology, Specialty in Orthodontics and Dentomaxillofacial Orthopedics, San Luis Potosí, México.
[2] Autonomous University of San Luis Potosí, Faculty of Stomatology, Clinical Research Laboratory, San Luis Potosí, México.

Citation:
López Martínez A.C., Martínez Zumarán A., Torre Delgadillo A., Ramírez Martínez L., Salas Orozco M.C. Prevalence and morphological patterns of mandibular asymmetries in a mexican population: A CBCT-Base Analysis. *Rev Estomatol.* 2025; 33(2):e15011. DOI: 10.25100/re.v33i2.15011

Received: 09th September 2025
Evaluated: 10th September 2025
Accepted: 20th September 2025
Published: 24th September 2025

Corresponding author: Marco Felipe Salas Orozco. Av. Dr. Manuel Nava No. 2, Zona Universitaria, Facultad de estomatología, 78290 San Luis Potosí, S.L.P, México. Telephone / Mobile: +52 4448111193 Email: marco.salas@uaslp.mx

Keywords: Mandibular asymmetry; cone-beam computed tomography; craniofacial morphology; hemimandibular elongation; glenoid fossa asymmetry.

ABSTRACT

Objective: To evaluate the prevalence, severity, and morphological classifications of mandibular asymmetries in a Mexican population using cone-beam computed tomography (CBCT).
Materials and methods: A cross-sectional study was conducted involving 231 patients aged 9–65 years from the orthodontic clinic at Universidad Autónoma de San Luis Potosí. Mandibular asymmetry was assessed using CBCT scans, categorized by the deviation of the mandibular symphysis (DMS) as mild (0–2 mm), moderate (2.1–5 mm), or severe (>5 mm). Severe asymmetries were further classified according to Obwegeser and Makek's system. Descriptive and inferential statistics were used to analyze differences in condylar and mandibular dimensions.
Results: Among 231 participants, 18 cases (7.8%) presented with severe mandibular asymmetry. Asymmetry of the glenoid fossa (AGF) was the most common classification (38.89%), followed by hemimandibular elongation (HE) at 27.78%. Severe deviations predominantly occurred on the right side (61.11%). No statistically significant differences were observed between male and female participants in terms of asymmetry type or severity.
Conclusion: CBCT imaging provides detailed visualization for detecting and classifying mandibular asymmetries. AGF and HE were the most frequent morphological types in this Mexican population, with a predominance of right-sided deviation. These findings underscore the need for population-specific diagnostic protocols and highlight the clinical value of 3D imaging in asymmetry evaluation.

CLINICAL RELEVANCE

The identification of morphological patterns of mandibular asymmetry through CBCT enhances clinicians' ability to make precise, case-specific treatment plans. Recognizing prevalent deviations—such as glenoid fossa asymmetry and hemimandibular elongation—supports better interdisciplinary coordination between orthodontists and maxillofacial surgeons. This study's population-based data provides essential parameters for differential diagnosis, helping clinicians distinguish between functional and structural asymmetries. The findings promote early diagnosis and more predictable outcomes in asymmetry management.

Introduction

Facial symmetry is a defining feature of both human aesthetics and functional balance, playing a pivotal role in physical appearance and interpersonal perception. The lower third of the face, dominated by the mandible, holds particular importance as its growth and morphology significantly influence facial harmony.[1] Mandibular symmetry contributes to balanced occlusion, phonetics, and mastication, while deviations from this symmetry often result in functional impairments and aesthetic concerns.[2] Minor asymmetries are common and often imperceptible; however, pronounced deviations can lead to malocclusions, temporomandibular joint (TMJ) disorders, and psychosocial distress in affected individuals.[3] Approximately 74% of facial asymmetries involve the lower third of the face, compared to 36% in the middle and only 5% in the upper facial third. The increased prevalence in the lower third is partly due to the mandible's prolonged growth period and its susceptibility to postnatal influences such as trauma, infection, and functional imbalances.[4]

Mandibular asymmetries arise from various congenital, developmental, or acquired factors. Genetic syndromes such as hemifacial microsomia,[5] or conditions like hemimandibular hyperplasia can cause pronounced asymmetries.[6] Developmental anomalies, such as condylar hyperplasia or hypoplasia, disrupt normal mandibular growth patterns, leading to skeletal discrepancies.[7] Functional factors, including parafunctional habits or TMJ disorders, may also contribute to these deviations.[8] Acquired conditions, such as trauma, infections, or surgical interventions, further compound the complexity of diagnosing and managing mandibular asymmetries.[9] Despite their multifactorial nature, the clinical implications are universally significant, impacting both form and function. Patients with mandibular asymmetries often experience difficulty with mastication, speech, and social interactions due to perceived or actual aesthetic deficits.

The advent of advanced imaging technologies, particularly cone-beam computed tomography (CBCT), has greatly improved the ability to diagnose and classify mandibular asymmetries. Unlike conventional two-dimensional radiography, CBCT provides detailed three-dimensional representations of craniofacial structures, enabling precise identification of deviations in condylar morphology, ramus height, mandibular length, and chin position. These insights are invaluable for planning orthodontic and orthognathic treatments tailored to the patient's specific needs.[10] However, the literature reveals notable gaps in the epidemiological understanding of mandibular asymmetries, particularly within specific populations. While numerous studies have documented the prevalence and characteristics of mandibular asymmetries in Caucasian and Asian cohorts, there is limited data on the Mexican population, which possesses distinct genetic and environmental influences.[11]

Moreover, the classification of mandibular asymmetries varies widely across studies, leading to inconsistencies in diagnostic criteria and treatment approaches. For example, some studies focus on unilateral elongation or shortening of the mandibular ramus, while others emphasize deviations in condylar height or mandibular body length. These discrepancies hinder the establishment of standardized protocols for diagnosis and management.[12] Additionally, there is a lack of consensus on what constitutes a clinically significant asymmetry. Some researchers consider deviations exceeding 2 mm from the facial midline as noteworthy, while others use a threshold of 5 mm or more.[3]

The objective of this study was to evaluate the prevalence, severity, and morphological characteristics of mandibular asymmetries in a Mexican population using cone-beam computed tomography (CBCT), with the aim of identifying the most common patterns of asymmetry, assessing their relationship to demographic factors such as gender.

Materials and methods

This cross-sectional study was conducted at the Orthodontic Clinic of the Universidad Autónoma de San Luis Potosí (UASLP) to analyze the prevalence and morphological characteristics of mandibular asymmetries using cone-beam computed tomography (CBCT).

The study included a total of 231 patients selected through simple random sampling from a population of 578 active patients. Participants included males and females aged 9 to 65 years. Inclusion criteria required complete and high-quality CBCT records taken at the UASLP radiology unit. Exclusion criteria eliminated patients with prior orthognathic or temporomandibular joint (TMJ) surgeries and craniofacial trauma. Mandibular asymmetry was categorized based on the deviation of the mandibular symphysis (DMS):

- **Mild Asymmetry:** DSM deviation between 0 and 2 mm.

- **Moderate Asymmetry:** DSM deviation between 2.1 and 5 mm.
- **Severe Asymmetry:** DSM deviation greater than 5 mm.

These classifications were based on clinical guidelines and supported by prior literature on mandibular asymmetry evaluation.

Severe mandibular asymmetries, defined as deviations exceeding 5 mm, were further categorized based on their etiology and morphological characteristics according to the classification system proposed by Obwegeser and Makek (1986)[13] and by López et al. (2019)[14] in their tomographic three-dimensional reconstruction study:

- **Hemimandibular Elongation (HE):** Characterized by horizontal mandibular deviations and increased condylar length on the affected side.
- **Hemimandibular Hyperplasia (HH):** Associated with vertical asymmetries, elongated ramus, and increased vertical dimension on the affected side.
- **Hybrid Form (Hyperplasia and Elongation) (HF):** Severe three-dimensional asymmetry involving vertical and horizontal deviations.
- **Asymmetric Mandibular Prognathism (AMP):** Bilateral Class III malocclusion with midline deviations following mandibular overgrowth.
- **Functional Laterognathism (FL):** Mandibular deviations due to occlusal interferences without anatomical alterations.
- **Asymmetry of the Glenoid Fossa** (AGF)**:** Deviations caused by morphological changes in the TMJ's glenoid cavity.
- **Unilateral Condylar Resorption:** A progressive condition characterized by the loss of bone in one mandibular condyle, leading to facial asymmetry, malocclusion, and functional impairments.
- **Solitary Condylar Hyperplasia** (SCH)**:** Excessive unilateral growth of the mandibular condyle, leading to facial asymmetry and occlusal discrepancies.
- **Primary Condylar Hypoplasia** (PCH)**:** Congenital underdevelopment of the mandibular condyle, resulting in mandibular asymmetry and functional limitations.
- **Secondary Condylar Hypoplasia** (SecCH)**:** Acquired underdevelopment of the mandibular condyle due to trauma, infection, or systemic conditions affecting growth.

The characteristics of the mandible in the severe asymmetry group that were analyzed in the study were as follows:

- **Glenoid Fossa Height (GFH)**: In the coronal section, the deepest part of the glenoid fossa is measured relative to the plane passing through the base of the sella turcica.
- **Condylar Length (CL):** In the sagittal section of the CBCT, the measurement is taken from the highest point of the condylar head to the deepest part of the sigmoid notch.
- **Mandibular Ramus Length (MRL):** In the sagittal view of the CBCT, a line is drawn from the deepest part of the sigmoid notch to the antegonial point.
- **Mandibular Ramus Width (MRW):** In the sagittal view of the CBCT, the distance between the deepest point of the anterior contour of the mandibular ramus and its posterior border is measured.
- **Mandibular Body Length (MBL):** In the sagittal view of the CBCT, the distance is measured along a line drawn from the gonion to the pogonion (bony landmarks).
- **Mandibular Symphysis Deviation (MSD):** In the frontal view of the CBCT, the distance is measured from the midpoint of the menton to a line passing through the crista galli and perpendicular to the bizygomatic line.
- **Laterognathia (Direction of Deviation, LD):** The side to which the chin is deviated is observed, indicating whether it is deviated to the left or right.

To ensure reliability, two experienced orthodontists were calibrated using a subset of 20 CBCT scans. Measurements were repeated after a two-week interval to assess intra- and inter-examiner reliability, yielding intraclass correlation coefficients (ICCs) greater than 0.90, indicating excellent agreement. Scans were also categorized by gender to evaluate differences in the prevalence and types of asymmetries.

This study complied with all ethical standards outlined by the Declaration of Helsinki and the guidelines established by NOM-004-SSA3-2012. The study protocol was approved by the Ethics Committee of the Faculty of Stomatology at UASLP under Registration Number CEI-FE-009-023. Patient confidentiality was maintained throughout the study, with all data anonymized prior to analysis.

Statistical analyses were performed using SPSS software version 27.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics, including mean, standard deviation, and frequency distribution, were used to summarize the data. Inferential statistics included Chi-square tests to compare the prevalence of asymmetries, and one-way ANOVA to compare morphological deviations across groups. A significance level of $p<0.05$ was used for all statistical tests.

Results

The descriptive statistics for the age distribution in the study population reveal a total of 231 participants, with 145 females (62.77%) and 86 males (37.23%). The mean age for females was 21.30 years, with a standard deviation of 10.66 years, and an age range from 9 to 65 years. In contrast, males had a mean age of 18.64 years, a standard deviation of 6.79 years, and an age range from 11 to 55 years.

The descriptive analysis of mandibular deviation severity reveals that 119 cases were categorized as mild asymmetry, with a mean deviation of 0.97 mm (SD = 0.58). For moderate asymmetry, 94 cases were identified, with a mean deviation of 3.29 mm (SD = 0.84). Severe asymmetry was observed in 18 cases, with a mean deviation of 6.65 mm (SD = 1.45) (Table 1). The Dunn post-hoc test results indicate significant differences in mandibular asymmetry severity among the three groups.

Table 1: Descriptive Statistics of Mandibular Symphysis Deviation (DSM)

Mandibular Symphysis Deviation (mm)				
	Mild asymmetry	Moderate asymmetry	Severe asymmtry	*p*
n	119	94	18	
Mean	0.97	3.29	6.65	
Standard Deviation	0.58	0.84	1.45	<0.001
Minimum	0.00	2.03	5.19	
Maximum	2.00	5.00	9.69	

The Chi-square test indicated no statistically significant association between sex and type of asymmetry (*p*=0.54). The table 2 provides an overview of the frequency and percentage of mandibular deviations categorized by asymmetry type and overall distribution. When considering the overall distribution across all cases, deviations to the left side were slightly more common, with 117 cases (50.65%), compared to 114 cases (49.35%) deviating to the right. These findings suggest that while the left side shows a higher overall deviation frequency, the severity of asymmetry influences the predominance of deviation direction, particularly for more severe cases, where right-sided deviations are more frequent. The Chi-square test (*p*=0.46) indicates no statistically significant association between the side of deviation (left or right) and the type of asymmetry.

Table 2: Frequency and Distribution of Deviation Sides by Asymmetry Type

Type of Asymmetry	Side of Deviation	F (%)
Mild asymmetry	Left	64 (53.78%)
	Right	55 (46.22%)
	Total	119 (100%)
Moderate asymmetry	Left	46 (48.94%)
	Right	48 (51.06%)
	Total	94 (100%)
Severe asymmetry	Left	7 (38.89%)
	Right	11 (61.11%)
	Total	18 (100%)
Overall	Left	117 (50.65%)
	Right	114 (49.35%)
	Total	231 (100%)

The most frequent mandibular asymmetry classification was Asymmetry of the Glenoid Fossa (AGF), accounting for 38.89% of cases (7 out of 18). Hemimandibular Elongation (HE) was the second most common, observed in 27.78% of cases (5 out of 18). Asymmetric Mandibular Prognathism (AMP) represented 11.11% of the cases (2 out of 18), while Secondary Condylar Hypoplasia (SecCH), Condylar Hypoplasia (CH), and Hemimandibular Hyperplasia (HH) were each identified in 5.56% of the cases (1 out of 18 each) (Table 3).

Table 3. Morphological Characteristics of Severe Mandibular Asymmetry Classifications

Clasifiaction	Sex	HG F-R	HG F-L	C L-R	C L-L	MR L-R	MR L-L	WM R-R	WM R-L	MB L-R	MB L-L	MSD	LD
HE	M	6.66	7.82	19.98	23.61	46.91	48.35	32.14	31.56	88.58	85.21	7.9	R
HE	F	12.74	5.21	14.85	17.04	45.17	49.22	26.93	29.82	78.53	80.39	5.36	R
HE	F	4.61	1.78	24.44	21.01	42.76	41.56	30.77	30.17	69.87	76.88	6.41	L
HE	M	12.28	11.05	23.79	18.67	50.35	51.66	34.44	31.17	88.32	86.46	9.69	L
HE	F	8.81	8.03	16.24	19.27	41.98	39.67	28.38	30.11	79.65	78.37	5.4	R
AGF	F	9.04	3.59	23.26	24.87	54.44	54.15	32.43	34.17	94.37	93.95	7.24	R
AGF	F	2.38	9.96	17.34	13.22	42.89	36.52	26.12	21.87	64.93	71.5	8.61	L
AGF	F	2.32	14.5	13.9	13.86	49.46	44.21	27.48	28.72	81.61	79.3	6.4	L
AGF	F	11.27	15.67	14.6	13.54	48.89	47.72	28.21	28.41	70.97	70.19	5	R
AGF	M	11.42	19.51	18.73	17.03	49.49	47.2	31.36	72.79	78	78.67	5.65	R
AGF	F	4.4	7.63	15.05	16.75	47.49	48.93	26.64	27.8	74.94	75.18	5.2	R
AGF	M	6.01	11.08	16.97	17.05	53.86	48.79	25.1	29.05	85.03	82.97	6.86	R
AGF	F	11	7.43	17.18	16.86	45.27	47.08	25.92	25.74	73.05	75.4	5.19	L
AMP	F	10.91	11.06	14.37	16.19	46.97	46.33	27.98	27.05	83.25	78.43	6.47	R
AMP	F	14.91	15.5	14.74	15.59	51.54	49.8	28.38	29.5	72.84	78.46	5.5	L
SecCH	M	11.7	9.26	15.15	20.63	44.4	51.49	38.81	35.91	88.76	88.85	8.66	R

CH	F	2.32	7.53	20.52	16.75	47.49	46.62	28.67	26.64	78.82	80.64	5.21	L
HH	M	10.95	9.78	17.68	21.81	45.46	51.83	40.25	36.77	89.52	91.52	8.52	R

Discussion

Mandibular asymmetry is highlighted as a multifactorial condition influenced by genetic, environmental, and developmental factors. The role of genetic contributors such as PITX2, ACTN3, ENPP1, and ESR1 genes has been moderately supported in recent studies. Variants in PITX2, a key regulator in craniofacial development, are linked to mandibular malformations, with moderate evidence confirming its role in asymmetry. Similarly, ACTN3 is associated with craniofacial skeletal patterns and mandibular asymmetry, supported by findings in both clinical and animal studies. ENPP1 has shown potential links with mandibular condyle variations, though findings remain inconclusive. The impact of ESR1, limited to a single study, suggests a potential influence on craniofacial dimensions but requires further validation.[15]

Mandibular asymmetries, arising from etiological factors such as trauma, condylar hyperplasia, or functional deviations, often manifest as chin deviation, occlusal disturbances, or skeletal discrepancies. The diagnosis is pivotal, facilitated by a combination of clinical evaluation, radiographic imaging, and dental records. Advanced tools like cone-beam computed tomography (CBCT) enable a detailed assessment of bony structures, providing a robust framework for planning interventions. Management strategies depend on the severity and underlying cause of the asymmetry, ranging from conservative approaches, such as orthodontics and physiotherapy, to surgical solutions like high condylectomy or orthognathic surgery for severe cases. Notably, advancements in diagnostic imaging and surgical techniques have enhanced treatment precision, allowing for individualized interventions that address both functional and aesthetic concerns.[4]

Our research categorized asymmetries by severity, Evangelista et al. evaluated them in relation to unilateral crossbite and skeletal Class I malocclusion, reporting slightly greater asymmetries in adults. Our study, focusing on a Mexican population, identified a 7.8% prevalence of severe mandibular asymmetries, with right-sided deviations predominating in severe cases (61.11%), whereas Evangelista et al. found small yet statistically significant asymmetries in patients with unilateral posterior crossbite, particularly in mandibular ramus height (mean difference of 2.0 mm, $p<0.05$). The significant differences in condylar length and ramus height reported by Evangelista et al. are consistent with the morphological deviations observed in hemimandibular elongation and hyperplasia in our study.[16]

Thiesen et al. reported a higher prevalence (17.6%) and emphasized the relationship between gnathion displacement (>4 mm) and maxillary asymmetry (OR = 4.93, $p<0.001$). These differences may result from variations in classification criteria, and both studies observed laterality in mandibular asymmetries. Our findings showed a predominance of right-sided deviations in severe cases (61.11%), while Thiesen et al. identified left-sided deviations as significantly associated with severe asymmetry (OR = 2.09, $p < 0.05$). These differences may be attributed to population-specific factors or differences in measurement approaches. Our study measured condylar length, ramus height, mandibular body length, and symphysis deviation, revealing mean deviations of 6.65 mm in severe cases, whereas Thiesen et al. emphasized angular and linear measurements, such as ramus height asymmetry (mean difference = 3.2 mm, $p < 0.05$), and highlighted maxillary contributions to mandibular asymmetry.[17]

In our study, asymmetries were categorized based on mandibular symphysis deviation into mild, moderate, and severe, with severe asymmetries accounting for 7.8% of cases. In contrast, Bakri et al. employed the asymmetry index (AI) to classify deviations as light, moderate, or severe, finding severe asymmetry in 23.71% of cases across linear dimensions. These differences highlight variability in diagnostic criteria and thresholds, influenced by methodological choices and population characteristics. Regarding laterality, our study found a predominance of right-sided deviations in severe cases, with 61.11% involving the right side and no significant gender differences ($p = 0.54$). Conversely, Bakri et al. reported a higher prevalence of left-sided deviations in younger children. Bakri et al. relied on orthopantomograms (OPG), a cost-effective and widely available method particularly suited for pediatric populations. While practical, OPG presents limitations in vertical measurement accuracy, which may impact the precision of asymmetry evaluations.[18]

In our study, severe mandibular asymmetries were observed in 7.8% of the cases, with Asymmetry of the Glenoid Fossa, which accounted for the largest proportion (38.89%), followed by Hemimandibular Elongation at 27.78%. Conversely, López et al. identified a much higher prevalence of HE (47.1%), making it the most common etiology in their sample of facial asymmetry patients, while AMP represented 26.4%. These discrepancies may result from differences in population demographics and inclusion criteria; our study involved a broad age range (9–65 years) in a Mexican population, while López et al. focused on a younger cohort (median age 18) with more pronounced developmental asymmetries.[14] In this study, mandibular asymmetries were categorized as mild, moderate, or severe based on mandibular symphysis deviation, with severe asymmetries comprising 7.8% of cases. Conversely, López et al. classified asymmetries into six etiological categories, with hemimandibular elongation (HE) being the most common (47.1%). This aligns with our finding that HE was among the predominant severe asymmetries, although our classification emphasized severity rather than etiology. Key morphological parameters, such as condylar length and mandibular ramus length, showed significant asymmetries in both studies. Our study highlighted that severe asymmetry predominantly exhibited right-sided deviations (61.11%), whereas López et al. reported left-sided deviations in 64.2% of their cases.[14]

Ramirez-Yañez et al. reported significant asymmetries in ramus height (RH) and corpus length (CL) using panoramic radiographs. They utilized an asymmetry index (AI) to quantify severity and classified more than half of their sample as exhibiting moderate-to-severe asymmetries. Similarly, our results showed comparable classifications derived from CBCT measurements.[19] Miresmaeili et al. explored mandibular asymmetry in young adults with unilateral posterior crossbite (UPCB) using CBCT, reporting that UPCB patients exhibited significant deviations toward the crossbite side, particularly in condylar width ($p = 0.029$) and corpus length ($p = 0.014$). Our findings similarly revealed mandibular asymmetries, particularly in ramus and corpus dimensions. However, we observed a right-sided predominance, whereas Miresmaeili et al. emphasized asymmetries linked to functional shifts in chewing patterns caused by crossbites.[20] In Vespasiano et al.'s cohort, 9.8% of the included mandibles exhibited significant asymmetry (≥3% asymmetry index), with the greatest deviations observed in ramus height. Similarly, our study identified the ramus as a primary region of asymmetry. However, the prevalence of significant asymmetries was higher in our findings, likely reflecting variations in sample composition and age-related factors.[21]

Hikosaka et al. employed CBCT imaging to evaluate mandibular asymmetry, focusing on morphological differences between the deviated (Dev) and non-deviated (N-Dev) sides. Hikosaka et al. reported that mandibular asymmetry does not exhibit significant variations based on sex or ethnicity. This aligns with our observations, where no substantial sex-related differences emerged in the asymmetry patterns.[22] Hlatcu et al. found that condylar asymmetry indices (CAI) exceeded 3% in most cases, with males showing significantly higher values than females ($p = 0.023$). Similarly, we identified higher right-sided deviations in severe asymmetry cases (61.11%) but observed no significant gender differences ($p = 0.54$).[23]

Conclusion

This study emphasizes the clinical significance of mandibular asymmetries, which impact both function and aesthetics, highlighting the value of CBCT in their precise diagnosis and morphological classification. Severe asymmetries were identified in 7.8% of the Mexican population studied, with Asymmetry of the Glenoid Fossa and Hemimandibular Elongation being the most prevalent patterns, predominantly exhibiting right-sided deviations. The absence of significant gender differences and the observed variability in asymmetry patterns compared to other populations underline the influence of genetic and environmental factors. These findings reinforce the need for standardized diagnostic criteria and multidisciplinary approaches to optimize treatment outcomes and address the specific needs of diverse populations.

Declaration of conflict of interest

The authors declare no conflicts of interest related to financial interests, consulting fees, patents, or provision of study materials. All evaluations and analyses were conducted independently, and no support was received from commercial entities.

Sources of funding

This study received no external funding. All research activities were supported through institutional resources from the Clinical Research Laboratory, Faculty of Stomatology, Universidad Autónoma de San Luis Potosí.

References

1. Zhu Y, Fu X, Zhang L, Zheng S, Wen A, Xiao N, et al. A mathematical algorithm of the facial symmetry plane: Application to mandibular deformity 3D facial data. J Anat. 2022;240(3):556-66. Doi: https://doi.org/10.1111/joa.13564

2. Xie Y, Zeng R, Yan J, Yan T, Tan J. Introducing surface-to-surface matching technique to evaluate mandibular symmetry: a retrospective study. Heliyon. 2022;8(7). Doi: https://doi.org/10.1016/j.heliyon.2022.e09914

3. Ng WH, Goh BT, Lim AAT, Tan MH. Mandibular asymmetry: Is there a difference in the bone and soft tissue thickness between both sides? Oral Surg Oral Med Oral Pathol Oral Radiol. 2022;134(6):e299-306. Doi: https://doi.org/10.1016/j.oooo.2022.05.010

4. Iyer J, Hariharan A, Cao UMN, Tran SD. Acquired facial, maxillofacial, and oral asymmetries-a review highlighting diagnosis and management. Symmetry. 2021;13(9):1661. Doi: https://doi.org/10.3390/sym13091661

5. Atiba PM, Omotoso BR, Madaree A, Lazarus L. Hemifacial microsomia: a scoping review on progressive facial asymmetry due to mandibular deformity. Oral Maxillofac Surg. 2024;1-15. Doi: https://doi.org/10.1007/s10006-024-01276-5

6. Almeida LE, Zammuto S, Lopez DF. Evaluating Surgical Approaches for Hemimandibular Hyperplasia Associated with Osteochondroma: A Systematic Literature Review. J Clin Med. 2024;13(22):6988. Doi: https://doi.org/10.3390/jcm13226988

7. Prasad B. Condylar hyperplasia: A road not taken. J Indian Soc Pedod Prev Dent. 2024;42.

8. Šimunović L, Lapter Varga M, Negovetić Vranić D, Čuković-Bagić I, Bergman L, Meštrović S. The Role of Malocclusion and Oral Parafunctions in Predicting Signs and Symptoms of Temporomandibular Disorders-A Cross-Sectional Study. Dent J. 2024;12(7):213. Doi: https://doi.org/10.3390/dj12070213

9. Chia MS, Naini FB, Gill DS. The aetiology, diagnosis and management of mandibular asymmetry. Orthod Update. 2008;1(2):44-52. Doi: https://doi.org/10.12968/ortu.2008.1.2.44

10. La Rosa S, Leonardi R, Ronsivalle V, Cicciù M, Giudice AL. Radiographic and diagnostic approaches for mandibular asymmetries in orthodontic practice: A narrative review. 2024

11. Marques FBC, de Lima LS, Oliveira PLE, Magno MB, Ferreira DMTP, de Castro ACR, et al. Are temporomandibular disorders associated with facial asymmetry? A systematic review and meta-analysis. Orthod Craniofac Res. 2021;24(1):1-16. Doi: https://doi.org/10.1111/ocr.12404

12. Leung M, Leung Y. Three-dimensional evaluation of mandibular asymmetry: a new classification and three-dimensional cephalometric analysis. Int J Oral Maxillofac Surg. 2018;47(8):1043-51. Doi: https://doi.org/10.1016/j.ijom.2018.03.021

13. Obwegeser HL, Makek MS. Hemimandibular hyperplasia-hemimandibular elongation. J Maxillofac Surg. 1986;14:183-208. Doi: https://doi.org/10.1016/S0301-0503(86)80290-9

14. López DF, Botero JR, Muñoz JM, Cárdenas-Perilla R, Moreno M. Are there mandibular morphological differences in the various facial asymmetry etiologies? A tomographic three-dimensional reconstruction study. J Oral Maxillofac Surg. 2019;77(11):2324-38. Doi: https://doi.org/10.1016/j.joms.2019.05.020

15. Babczyńska A, Kawala B, Sarul M. Genetic factors that affect asymmetric mandibular growth-A systematic review. Symmetry. 2022;14(3):490. Doi: https://doi.org/10.3390/sym14030490

16. Evangelista K, Valladares-Neto J, Silva MAG, Cevidanes LHS, de Oliveira Ruellas AC. Three-dimensional assessment of mandibular asymmetry in skeletal Class I and unilateral crossbite malocclusion in 3 different age groups. Am J Orthod Dentofacial Orthop. 2020;158(2):209-20. Doi: https://doi.org/10.1016/j.ajodo.2019.08.010

17. Thiesen G, Gribel BF, Freitas MPM, Oliver DR, Kim KB. Mandibular asymmetries and associated factors in orthodontic and orthognathic surgery patients. Angle Orthod. 2018;88(5):545-51. Doi: https://doi.org/10.2319/111517-785.1

18. Bakri MMH, Vishvnathaiah S, Bakmani HF, Hakami AJ, Zaidan MS, Dighriri MA, et al. Prevalence of Mandibular Asymmetries in the Pediatric Population of Jazan: A Radiographic Analytical Study. Heliyon. 2024. Doi: https://doi.org/10.2139/ssrn.4661737

19. Ramirez-Yañez GO, Stewart A, Franken E, Campos K. Prevalence of mandibular asymmetries in growing patients. Eur J Orthod. 2011;33(3):236-42. Doi: https://doi.org/10.1093/ejo/cjq057

20. Miresmaeili A, Salehisaheb H, Farhadian M, Borjali M. Mandibular asymmetry in young adult patients with unilateral posterior crossbite: A controlled retrospective CBCT study. Int Orthod. 2021;19(3):433-44. Doi: https://doi.org/10.1016/j.ortho.2021.05.003

21. Vespasiano V, Klop C, Mulder CS, Koolstra JH, Lobé NH, Beenen LFM, et al. Normal variation of mandibular asymmetry in children. Orthod Craniofac Res. 2023;26(3):524-30. Doi: https://doi.org/10.1111/ocr.12639

22. Hikosaka Y, Koizumi S, Kim YI, Adel M, Nadim M, Hikita Y, et al. Comparison of mandibular volume and linear measurements in patients with mandibular asymmetry. Diagnostics. 2023;13(7):1331. Doi: https://doi.org/10.3390/diagnostics13071331

23. Hlatcu AR, Galan E, Milicescu Jr Ștefan, Teodorescu E, Ionescu E. An Evaluation of the Ramus Mandibular Asymmetry on the Panoramic Radiography. Appl Sci. 2023;13(13):7645. Doi: https://doi.org/10.3390/app13137645