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Cephalometric Evaluation of Mandibular Symphysis Dimensions in Patients with Different Jaw Relations in the Vertical Dimension of the Face

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ABSTRACT

Background and Objective: Symphysis morphology serves as a valuable diagnostic and treatment-planning tool in orthodontics, and its morphology determines the position of the mandibular incisor during orthodontic treatment and orthognathic surgery. The aim of the present study was to perform a cephalometric evaluation of the dimensions of the mandibular symphysis in patients with different vertical jaw relations.

Methods: In the present analytical study, 180 standard lateral cephalometric radiographs of patients prior to the initiation of orthodontic treatment, with a normal anteroposterior pattern (skeletal Class I), were evaluated. Patients were categorized into three equal-sized groups according to the mandibular growth pattern: normal vertical pattern, long vertical pattern, and short vertical pattern. Ten linear parameters and six angular measurements related to symphysis dimensions were measured and compared.

Findings: Of the total 180 radiographs studied, 140 (77.77%) belonged to women and 40 (22.23%) to men. In the comparison of linear parameter measurements, the values of Id-B (7.01±2.07 mm) and Id-Me (28.48±3.31 mm) in the long vertical pattern group, as well as Pog-Me (9.71±2.23 mm) and Go-Gn (72.61±4.69 mm) in the normal vertical pattern group, were statistically greater than those in the other two groups. In the analysis of angular parameters among the three groups, significant differences were observed in B-B1-Gn (p=0.007), Id-B/Go-Me (p=0.040), and IMPA (p=0.001).

Conclusion: The results of the study demonstrated that individuals with a long vertical pattern exhibit a greater overall symphysis length, while IMPA is significantly reduced in this group. The present study underscores the importance of conducting an analysis for each individual patient, thereby enabling the formulation of an appropriate diagnosis and treatment plan and the prevention of complex problems.

Keywords: *Mandibular Symphysis, Lateral Cephalometry, Morphology.*

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Introduction

The face functions as a communication tool for us, and the facial profile is an important factor in evaluating facial balance and harmony. The chin, although constituting only a small component of the face, plays a significant role in the facial profile (1). For this reason, in orthodontic treatments and orthognathic surgeries that focus on the middle and lower regions of the face, the shape and thickness of the chin are influential factors in diagnosis and treatment planning (1). Accordingly, the mandibular symphysis, being a part of the chin (2), can also exert a significant influence on treatment planning.

The mandibular symphysis, as a valuable diagnostic tool, can serve as a reference for measuring esthetic goals, particularly in the lower third of the face, and its morphology can determine the position of the lower incisors during orthodontic treatment and orthognathic surgery (3). For example, individuals with a wide symphysis can likely be treated through protrusion of the anterior incisors and are less likely to undergo extraction-based treatment. In contrast, patients with a long and narrow symphysis are more likely to undergo orthodontic treatment with tooth extraction to compensate for longitudinal discrepancy (2). Furthermore, in implant treatment, preoperative evaluation of the symphysis can prevent complications such as cortical bone perforation or hemorrhage due to vascular trauma (1), and it can serve as a source for harvesting autogenous bone for bone grafting during implant placement in other areas of the mouth (4).

Another application of analyzing and better understanding the mandibular symphysis is the use of the constancy of the internal cortical structure of the lower border of the symphysis for superimposition and prediction of the mandibular growth pattern (5, 6). To evaluate the mandibular symphysis, numerous factors, including neuromuscular functional balance, masseter muscle thickness (7), mandibular plane angle (8), overbite (9), vertical jaw relation (10), lower incisor inclination (11), occlusal force deficiency and its recovery (12), heredity, and anterior facial dimensions, can contribute to its morphology (3, 13). Additionally, skeletal classification (1) and the direction of mandibular vertical growth (3) have also been considered as influential factors.

Various radiographs are recognized as one of the tools for examining the mandibular symphysis, and by performing cephalometric analyses on them, it is possible to understand the relationship between different skeletal factors and mandibular symphysis morphology. One of these radiographs is lateral cephalometry, which, since its introduction, has become a standard tool in orthodontic evaluations and treatment planning and has been routinely and widely accepted (14).

Various studies have investigated the relationship between symphysis dimensions and morphology and bone thickness in different vertical and horizontal jaw discrepancies; however, many confounding factors, including differences in growth pattern, were not taken into account (6, 15, 16), and these studies examined symphysis dimensions in both vertical and horizontal dimensions simultaneously. For this reason, the results obtained by them could be affected by confounding factors, and their scientific validity may be questioned. Therefore, the aim of the present study is to perform a cephalometric evaluation of symphysis dimensions in patients with different vertical relations and normal horizontal relation.

Methods

This analytical study, which was approved by the Ethics Committee of Babol University of Medical Sciences under code IR.MUBABOL.HRI.REC.1402.129, was conducted at the School of Dentistry of Babol University of Medical Sciences. In this study, lateral cephalometric radiographs of patients who had referred to the school for orthodontic treatment, and whose radiographs had been taken before the initiation of

treatment, were used. The selected samples were in the age range of 18 to 35 years and had a normal sagittal pattern relation (Cl I), such that they were selected in three vertical groups: Normodivergent (normal vertical pattern), Hypodivergent (short vertical pattern), and Hyperdivergent (long vertical pattern), with an equal sample size of 60 per group and a total of 180 samples. This sample size was determined at a 95% confidence level and 80% test power with a standardized effect size of 0.5 in the measured parameters among the vertical groups. Patients with a history of orthodontic treatment, jaw surgery, a history of trauma to dentofacial structures in the anterior mandibular region, periodontal problems, supernumerary, missing, and impacted teeth, genetic anomalies, neurological disorders, syndromes, and dentoskeletal asymmetries, as well as all radiographs of inadequate quality, were excluded from the study. All radiographs used in this study were recorded in the Natural Head Position (NHP) with the head in a resting position. All demographic information of the samples, such as age and sex, was also recorded.

Since only individuals whose anteroposterior jaw relation fell within the normal range were included in the study, the ANB angle was measured in all radiographs in order to assess the sagittal jaw relations of the patients; if its value was not within the range of 0 to 4 degrees, the individual was excluded from the study. Patients were divided into three groups according to the vertical jaw conditions and the mandibular vertical growth pattern, determined through tracing of lateral cephalometric radiographs and with the aid of the standard Tweed ranges: Group 1 (Normodivergent), patients with an FMA angle between 22 and 28 degrees; Group 2 (Hypodivergent), patients with an FMA angle less than 22 degrees; and Group 3 (Hyperdivergent), patients with an FMA angle greater than 28 degrees.

Cephalogram measurements and linear parameters of the mandibular symphysis: In all patients, lateral cephalometric radiographs prepared in the NHP position were used. Lateral cephalograms were traced manually in a dark room using matte acetate tracing paper attached to the radiograph. Ten linear measurements and six angular measurements were considered according to the cephalometric landmarks of the mandibular symphysis and other cephalometric landmarks (Figure 1).

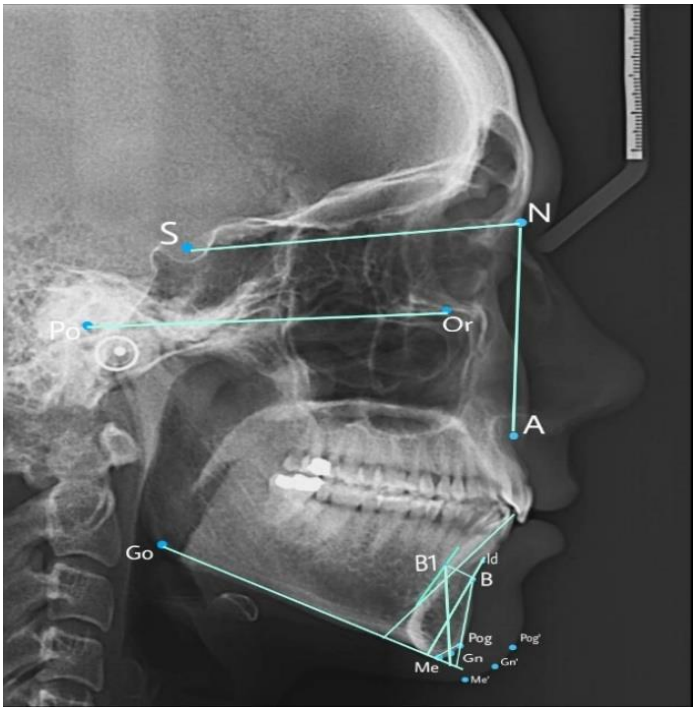


Figure 1. Method of measuring parameters related to the mandibular symphysis

Definitions of the linear parameters of the mandibular symphysis: **1) Id-B: the linear distance from Id to point B, representing the dentoalveolar length of the mandibular symphysis. 2) B-Pog: the linear distance from point B to Pog, representing the skeletal length of the mandibular symphysis. 3) Pog-Me: the linear distance from Pog to Me, representing the length of the chin. 4) Id-Me: the linear distance from Id to Me, representing the total length of the mandibular symphysis. 5) Perpendicular distance from Pog to the B-Me line: the perpendicular distance from Pog to the line connecting point B to Me, representing the anterior prominence of the mandibular symphysis. 6) Pog-Pog´: the linear distance from the hard tissue Pog to the soft tissue Pog. 7) Gn-Gn´: the linear distance from the hard tissue Gn to the soft tissue Gn. 8) Me-Me´: the linear distance from the hard tissue Me to the soft tissue Me. 9) GoMe: the distance between the Gonion point and the most inferior point of the mandibular symphysis (Me). 10) Go-Gn: the linear distance from Go to Gn. Definitions of the angular parameters of the mandibular symphysis: 1) B-B1-Gn: the angle between points B, B1, and Gn, which represents an indirect reflection of the vertical dimension of the mandibular symphysis. 2) Id-B-Pog: the angle between points Id, B, and Pog, which reflects the concavity of the mandibular symphysis. 3) B-Pog-Me: the angle between points B, Pog, and Me, which reflects the convexity of the mandibular symphysis. 4) Id-B/GoMe: the angle between the line connecting Id to B and the mandibular plane, which reflects the slope of the alveolar portion of the mandibular symphysis in relation to the mandibular plane. 5) B-Pog/GoMe: the angle between the line connecting point B to Pog and the mandibular plane, which reflects the slope of the skeletal portion of the mandibular symphysis in relation to the mandibular plane. 6) IMPA: the angle of the lower incisors to the mandibular plane.**

The obtained data were entered into SPSS software version 23 for Windows. For the preliminary assessment of the sample, a set of 20 cases was evaluated for intra-observer reproducibility in the cephalometric analyses, performed twice consecutively using the Pearson correlation coefficient, and the findings showed a correlation above 89% between the first and second measurements. In the descriptive analysis, the cephalometric indices in the three vertical groups, Normodivergent, Hyperdivergent, and Hypodivergent, were expressed as mean and standard deviation. The means of the cephalometric indices in the three vertical groups were compared using one-way ANOVA, and a value of $p \leq 0.05$ was considered significant. Multiple post hoc pairwise comparisons among the different vertical groups were also performed using the Tukey method.

Results

Of the total of 180 radiographs studied, 140 (77.77%) belonged to women and 40 (22.23%) to men. The mean age of the study participants was 22.40±4.80 years. The mean SNA of the participants was 81.35±6.65 degrees, the SNB index was 78.83±6.97 degrees, and the mean ANB was 2.56±1.20 degrees. The descriptive characteristics, including sex, age, and other cephalometric features of the patients with the vertical skeletal relations Hypodivergent, Normodivergent, and Hyperdivergent, are presented separately in Table 1.

In comparing the measurements of linear parameters among the different vertical skeletal patterns, significant differences were observed in the parameters Id-B (indicating the dentoalveolar length of the mandibular symphysis), Pog-Me (indicating the length of the chin), Id-Me (indicating the total length of the mandibular symphysis), and Go-Gn ($p \leq 0.05$). Among these, the values of Id-B and Id-Me in the Hyperdivergent group, and Pog-Me and Go-Gn in the Normodivergent group, were statistically greater than those of the other two groups (Table 2).

Upon examination of the angular parameters, it became evident that significant differences were observed in B-B1-Gn (an indirect reflection of the vertical dimension of the mandibular symphysis), Id-B/Go-Me, and IMPA (indicating the angle between the mandibular incisor and the mandibular plane).

Table 1. Cephalometric and demographic characteristics of the study participants according to the vertical skeletal pattern

Vertical skeletal pattern Variables	Hypodivergent (n=60)	Normodivergent (n=60)	Hyperdivergent (n=60)
Age (years), Mean±SD	23.41±5.27	22.00±4.33	21.80±4.66
Sex, Number(%)			
Male	14(23.3)	13(21.7)	13(21.7)
Female	46(76.7)	47(78.3)	47(78.3)
SNA (degrees), Mean±SD	80.36±3.22	80.85±2.95	82.85±10.57
SNB (degrees), Mean±SD	77.86±3.31	78.20±2.76	80.45±11.17
ANB (degrees), Mean±SD	2.50±1.25	2.65±1.21	2.53±1.14
FMA (degrees), Mean±SD	19.88±1.92	25.68±1.78	33.28±4.12
Jarabak Index (%), Mean±SD	69.41±2.69	64.02±0.98	59.12±2.28

Table 2. Association between the linear and angular measurements of the mandibular symphysis and the different vertical skeletal patterns

Vertical skeletal pattern Variables	Hypodivergent (n=60) Mean±SD	Normodivergent (n=60) Mean±SD	Hyperdivergent (n=60) Mean±SD	p-value
Id-B (mm)	5.69±1.49	6.53±2.26	7.01±2.07	0.001*
B-Pog (mm)	14.41±2.43	14.27±3.07	14.46±3.16	0.935
Pog-Me (mm)	8.52±2.18	9.71±2.23	8.54±2.26	0.005*
Id-Me (mm)	26.64±2.93	28.40±2.53	28.48±3.31	0.001*
Pog-Pog' (mm)	11.31±1.93	11.24±2.16	10.69±2.61	0.263
Pog to B-Me (mm)	4.51±1.05	4.67±0.97	4.46±1.07	0.532
Gn-Gn' (mm)	9.94±2.23	9.35±2.64	8.97±2.82	0.122
Me-Me' (mm)	8.92±2.27	8.44±2.04	8.43±2.21	0.370
Go-Me (mm)	66.94±4.68	68.83±4.28	67.58±5.79	0.109
Go-Gn (mm)	70.24±4.81	72.61±4.69	70.91±5.72	0.034*
B-B1-Gn (degrees)	49.20±5.65	48.95±6.63	52.48±7.76	0.007*
Id-B-Pog (degrees)	151.03±9.58	148.91±7.20	151.68±8.32	0.174
B-Pog-Me (degrees)	131.00±7.61	131.46±8.82	132.43±9.09	0.645
B-Pog/Go-Me (degrees)	63.31±6.91	62.31±6.11	60.58±6.45	0.069
Id-B/Go-Me (degrees)	91.81±9.27	92.48±6.71	88.75±9.31	0.040*
IMPA (degrees)	98.01±6.29	96.21±5.48	92.01±9.02	0.001*

*$p \leq 0.05$

In the pairwise comparison between the Hypodivergent and Normodivergent groups, the parameters Id-Me, Pog-Me, and Go-Gn were statistically significant. In the comparison between the Hypodivergent and Hyperdivergent groups, other mandibular parameters, including Id-B, IMPA, and Id-Me, as well as B-B1-Gn, demonstrated significant differences. Finally, in the comparison between the Normodivergent and Hyperdivergent groups, statistically significant differences were observed in the parameters Pog-Me, B-B1-Gn, Id-B/Go-Me, and IMPA (Table 3).

Table 3. Results of the Tukey post hoc pairwise multiple comparisons for the measured parameters among the different vertical groups

Cervical relations / Parameters	p-value Hypodivergent vs Normodivergent	Hypodivergent vs Hyperdivergent	Normodivergent vs Hyperdivergent
Id-B	0.055	0.001*	0.373
B-Pog	0.961	0.996	0.934
Pog-Me	0.011*	1.000	0.013*
Id-Me	0.003*	0.002*	0.989
Pog-Pog'	0.981	0.292	0.387
Pog to B-Me	0.677	0.974	0.536
Gn-Gn'	0.428	0.105	0.704
Me-Me'	0.445	0.436	1.000
Go-Me	0.096	0.760	0.355
Go-Gn	0.032*	0.756	0.163
B-B1-Gn	0.977	0.023*	0.013*
Id-B-Pog	0.356	0.906	0.173
B-Pog-Me	0.952	0.629	0.809
B-Pog/Go-Me	0.677	0.058	0.312
Id-B/Go-Me	0.904	0.122	0.046*
IMPA	0.349	0.001*	0.004*

*$p \leq 0.05$

Discussion

The findings of the present study demonstrated that the mean Id-Me and Id-B in Hyperdivergent individuals are significantly greater than in Hypodivergent individuals. Furthermore, the B-B1-Gn angle in Hyperdivergent individuals is greater than in the other two vertical jaw pattern groups. These findings indicate that symphysis length is dependent on the vertical jaw pattern, and that Hyperdivergent individuals possess a longer symphysis compared with normal or Hypodivergent individuals. This finding of ours is consistent with the results obtained in the study by Jain et al. (15). In addition, other studies (16, 17) have also confirmed that individuals with a small facial angle and a short face have a symphysis with a lower height, whereas in patients with a larger facial angle and a long face, the opposite is true, and their symphysis is longer.

Among the findings obtained by the present study, the anterior prominence of the mandibular symphysis (Pog to B-Me) did not exhibit a significant difference among individuals with different jaw patterns, a finding that is also consistent with the study by Linjawi et al. (6). However, in contrast to our findings, Ahn et al. (2) concluded that symphysis width and thickness have a significant relationship with vertical parameters. Furthermore, in another study (16), a considerable relationship was reported between the vertical dimensions of the symphysis and its width, and it was concluded that symphysis width in Hyperdivergent individuals is less than in individuals with a normal or Hypodivergent pattern, which is not consistent with the results of our study. This difference in results may be because, in their study, individuals with different vertical and sagittal skeletal patterns were included, and neither of these two patterns was

held constant. In contrast, given the fact that the vertical and horizontal dimensions of the face can influence each other, in the present study we included only individuals with Class I sagittal relations and different vertical facial heights. Based on the results of this study, chin length in Normodivergent individuals is greater than in Hyperdivergent and Hypodivergent individuals, which is indicated by the increase in the mean value of the Pog-Me parameter in normal individuals, and this is consistent with the results obtained in the study by Linjawi et al. (6). Furthermore, upon examination of the angle of the lower incisor relative to the mandibular plane (IMPA), the results showed that in individuals with a Hyperdivergent jaw pattern, this angle is significantly reduced compared with normal and Hypodivergent individuals. This finding is consistent with the results obtained in other studies (15, 18) and may be due to the increased forces exerted by the lips and soft tissue as a result of the increased facial height and the compensatory rotation of the mandible in these individuals (19).

In comparison with the results of the present study, Gómez et al. (1) investigated the relationship between symphysis convexity and concavity and jaw patterns by measuring the B-Pog-Me and Id-B-Pog angles, and their results showed that symphysis convexity is considerably greater in individuals with a Hyperdivergent vertical pattern than in individuals with a normal or Hypodivergent pattern, a finding that is contrary to the results obtained by the present study. They also found a significant relationship when examining the simultaneous effect of vertical pattern and skeletal class on jaw concavity; however, when they examined symphysis concavity and jaw vertical pattern alone, no effective relationship was demonstrated, which is in agreement with our results.

Some experts have pointed to the equal influence of soft and hard tissue in creating the chin form; therefore, three linear measurements that included points from both soft and hard tissue were examined in the present study, but no statistically significant relationship was obtained. In another study (1), the relationship between more hard and soft tissue parameters was investigated, and despite finding a weak relationship among some of them, it was concluded that the soft tissue profile in the chin region is not directly influenced by the underlying hard tissue. The present study also faced limitations that, if addressed in future studies, could influence the interpretation of the obtained data. For example, the unequal distribution of the number of women and men in the different jaw groups, and the generally lower number of men, could lead to natural differences in symphysis morphology and affect our results; therefore, generalizing the results to men should be analyzed with caution.

Another limitation is the random error in the measurement of parameters related to the mandibular symphysis. However, since these measurements are indistinguishable with respect to linear vertical conditions and the vertical pattern of the mandible, this does not create a relationship with the effect size observed in the vertical groups. Nevertheless, random measurement error may reduce the power of the statistical tests and reduce the effect size of the parameters related to the mandibular symphysis in the compared groups. However, in the present study, in the assessment of measurement reproducibility in the preliminary sample, a high correlation coefficient was observed, which indicates high reproducibility in the measurement of the intended parameters.

According to the obtained data, individuals with a long facial vertical pattern showed a longer overall symphysis length, and at the same time, IMPA was significantly decreased in this group. This study demonstrates to us the importance of performing a complete analysis for each patient, because an appropriate diagnosis and treatment plan must be provided by taking into consideration the morphology of the chin and symphysis, and complex problems that can arise due to inadequate examination of the symphysis region can be prevented.

Conflicts of Interest: There are no conflicts of interest in the present study.

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