[DOR: 20.1001.1.23222913.2019.8.4.8.4]

Original article

Cephalometric Association of Mandibular Size/Length to the Natural Head Position

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Abstract:

Introduction: to determine the head posture in anterior-posterior skeletal malocclusion caused by mandibular growth problems.

Methods: In this analytical study, Lateral cephalometric images were taken from 66 patients and categorized into three classes of malocclusion, including classes I (n=22), II (n=25) and III (n=19). The collected data was analyzed by SPSS17 software using ANOVA, independent t-test and Kruskal-Wallis. This study was done in orthodontics department of Dental School, Shahid Sadoughi University of Medical Sciences, Yazd, in 2017.

Findings: The craniocervical angles were significantly lower in men than women ($P < 0.05$). The OPT/CVT angle, which represents cervical curvature, was significantly lower in men than women ($P = 0.001$). Regarding to gender and type of malocclusion, craniovertical and craniohorizontal angles were significantly lower in classes II and III male patients than those in class I ($P<0.05$).

Conclusion: class II men had a tendency to move up their head. On the other hand, class III male patients turned their head and neck upward despite the forward position of the mandible. The mandibular length may have more effect on the patient's head position than neck position.

Keywords: Malocclusion, Cephalometry, Facial, Cranium, Head-Down Tilt.

Introduction:

Everybody has a certain and reproducible head position of his or her own. Natural head position (NHP) is a standard position in which head has a vertical position so that a person can look at a distant point at the same level with his or her eyes. Long-term stability of NHP has been investigated in some studies. Cooke reported the stability of NHP after five years (1). Also, Peng and Cooke reported the stability of NHP even fifteen years after initial radiography (2).

Studies have shown that the head and neck positions are associated with different physical factors such as age, gender, ethnic, and facial morphology (mandibular divergence) (3-6). Moreover, other factors affecting the head posture include airway, temporomandibular disorders (7) and bruxism(8). If cephalometric images are located in NHP, the head position changes can be measured in different malocclusions. If head is bent downward or upward, the angle between sella-nasion 1 line and true vertical line would change (9).

Some studies have shown that class II patients tend to turn their head slightly up. On the other hand, class III patients tend to turn their head slightly down (10,11). This relationship can be important for determining the jaw displacement in orthognathic surgeries (12). The NHP changes following orthognathic surgeries. The study of Dohyun Cho et al. on patients with class III skeletal malocclusion showed that patients turned their head up following orthognathic surgery (13). Also, Xiaozhen Lin and Sean P. Edwards reported a significant relationship between mandibular position change following surgery and NHP change in patients with mandibular hypoplasia (14).

Head and neck positions can also be associated with malocclusion. In this regard, Beni Solow and Liselotte Sonnesen reported that craniocervical angle was 3-5 ° larger in patients lacking more than 2 mm space in the anterior part of mandibular and maxillary arch than those who had no crowding (15). Further, Simona Tecco et al. evaluated the cervical spine position following FR-2 treatment and showed that following functional treatment in class II patients, cervical lordosis angle (CVT/EVT) increased with anterior displacement of mandible, which was probably due to posterior slope of upper cervical spine (CVT/VER and OPT/VER) and extension of head (head down tilt) on cervical spine. Moreover, they showed that increase of this angle can be associated with mandibular growth and increased length of maxillary base (16).

The studies conducted on the relationship between NHP and various malocclusions have only investigated the type of malocclusion and treatment (12,17), while various factors can be involved in malocclusion. This study was aimed to investigate cephalometric association of mandibular size/length and natural head position.

Methods:

Participants and design:

In this analytical study, samples were collected from lateral cephalometric radiographs taken from NHP of patients referring to the orthodontics department of Dental School, Shahid Sadoughi University of Medical Sciences, Yazd, Iran.

The inclusion criteria of patients based on their radiographs were as follows:

1. Presence of permanent dentition. 2. Absence of any syndrome and cleft lip or plate. 3. Presence of malocclusion caused by mandibular growth disorder; e.g. class III malocclusion due to mandibular excess and class II malocclusion due to mandibular deficiency. 4. Presence of the first four vertical vertebrae in the image. We tried to include the images having the sixth vertebra, but due to limited number of patients, the first four vertebrae were considered for the analysis, and cervical lordosis index was assessed only in patients whose six vertebrae were present in images. 5. No history of

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orthodontic treatment or maxillofacial surgery.

The exclusion criteria was:

Poor quality radiographs were excluded from the study.

The lateral cephalometric images were divided into three classes, including classes I, II and III malocclusion based on the ANB angle (normal range of 2-3 °) and the Wits angle (normal range of 0-1 mm). Based on the Schwartz index (SeN+3mm=body length), the mandibular body length was calculated ideally and compared with patient's mandibular body length. In class II malocclusion, if the mandibular body length was less than the obtained number, it was considered mandibular deficiency, and if it was equal to or more than the calculated length, it was not included in the study2, 3Also in patients with class III malocclusion, if the mandibular body length was larger than the obtained number, it was considered mandibular excess, and if it was equal or less than the ideal size, it was not included in the study. Also in patients with class I malocclusion, only those whose mandibular body length was equal to the ideal number were included in the study. All measurements were performed by a trained researcher. Finally, 22 class I, 52 class II and 19 class III patients were included in the study.

A total of 13 reference points (Table 1), including 9 points on the skull and 4 points on the spine were marked on tracing paper by a sharp pencil. Two true vertical and horizontal planes were used in this study so that the shadow of the chain hung in the cephalometric image was considered a true vertical line, and true horizontal line was obtained by drawing a line perpendicular to the vertical line (Table 2). In addition, palatal, SN and mandibular planes were drawn, and cervicohorizontal, cervical curvature, craniovertical and craniocervical angles were measured (Figure 1).

All measurements were performed manually by one researcher, and re-measured one week later by the same researcher and the mean of each index was considered.

The data obtained from cephalometric tracing entered SPSS-17 software. The angles studied in the three malocclusion classes were tested by Kolmogorov-Smirnov test. All data were distributed normal. Hence, ANOVA test and Tukey test was used for pair comparisons. Further, independent t-test was used to compare the mean angles in both genders irrespective of the type of malocclusion.

Findings:

Sixty-six lateral cephalometric radiographs taken from patients referring to the orthodontics department of dental school were investigated. Out of 66 participants, 20 (30%) were male and 46 (70%) female. Also, 22 samples were of class I type, 25 (37.8%) class II and 19 (28.7%) class III.

As shown in Table 3, independent t-test showed that SN/CVT, NL/CVT and ML/CVT angles were significantly smaller in men than women ($p<0.05$). Moreover, CVT/HOR angle was significantly smaller in men than women ($p<0.05$). On the other hand, OPT/CVT angle, which indicates cervical spine curvature, was significantly smaller in men than women ($p<0.05$).

The differences between the study groups were tested by ANOVA test, and none of the variables were statistically significant (Table 4). From craniovertical angles in men in three malocclusion classes, the means of SN/VER and ML/VER angles showed statistically significant differences (p=0.0.19 and p=0.001, respectively). Further, the mean SN/VERT angle in lateral cephalometric radiographs was significantly lower in class II than class I patients (p=0.019) and lower in class III than class I patients (p=0.037). Moreover, mean ML/VER angle in lateral cephalometric radiographs was significantly lower in class II than class I patients (p=0.041) and lower in class III than class I patients (p=0.001) (Table 5).

Discussion:

Nowadays, the interaction of forehead and neck position in facial balance and beauty as well as overall convexity and concavity of individual profile is quite evident to everyone; however, this has been disregarded in many common facial analyses. Some studies have reported that the anterior-posterior position of forehead and neck affects the aesthetic profile of people with different jaw relations (20).

Since the head and neck position in different malocclusions affects the facial appearance and can encourage many patients to undergo orthodontic treatments or surgeries, a number of studies have investigated this issue. Hence, the present study aimed to investigate the head position in anterior-posterior skeletal malocclusions caused by mandibular growth disorders and to determine whether the patients' mandibular length affected their head and neck position.

ANB angle is the most common measurement to evaluate anterior-posterior disorders of the jaws. However, rotation of jaws clockwise and counterclockwise relative to the reference lines within skull like SN affects the ANB angle. On the other hand, Witt's evaluation of jaw disorders shows displacement of jaws relative to one another, but this evaluation is largely dependent on the correct position of occlusal plane. Therefore, this study used both methods to assess the anterior-posterior skeletal disorders and to classify patients.

Some studies have only explored this issue in one gender (male or female). For example, D'Attilio et al. (7) analyzed cervical lordosis angle in women. Some other studies found no difference between the two genders (15). In the present study, the given variable was investigated both in general and by gender.

Further, in some studies the samples were very young and patients were in mixed dentition period. For instance, in the study of Simona Tecco et al. (17), the mean age of samples was 8.4 years at baseline and 10.3 years at the end of the study. In the current study, patients who were in permanent dentition period were investigated. The mean age of patients was 15 years, so they had a better understanding and showed more cooperation to be in NHP during radiography. Moreover, based on Scammon's graph and mandibular growth compliance with general growth of body, since the basis of classification of

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malocclusion in the present study was mandibular length, an attempt was made to select the samples with a higher mean age so that a large portion of mandibular growth would be completed in these patients.

In this study, first a general comparison was made between men and women irrespective of the type of malocclusion. The findings showed that some craniocervical and craniohorizontal angles were significantly smaller in men than women; i.e. men generally tended to turn their head down more than women. Also, OPT/CVT angle, which is indicative of the cervical spine curvature, was significantly smaller in men than women. Thus, men held their cervical spine more upright than women. However, by considering the type of malocclusion in patients, classes II and III male patients tended to move their head up more than those of class I; whereas, no significant difference was found between groups regarding the angles studied in women.

On the other hand, the mean difference of craniovertical angles was higher in class III patients than class II ones, i.e. class III patients turned their head up more than class II ones. However, standard deviation showed more dispersion in class III patients than others, which indicates more variation of head position in class III patients than others. Further, the results of Jan A. V. Huggare and Michael S. Cooke (21) showed that although there was a strong relationship between the height of atlas posterior appendage and mandibular growth orientation in both genders, it was only seen between craniovertical angles and mandibular growth orientation in men not in women, confirming the results of the present study.

According to Arntsen and Sonnesen (22), some studies have reported an association between head position and class II malocclusion, as upright head position and spinal extension (head down tilt) have been found to be more prevalent in patients with class II malocclusion. However, some studies conducted in Iran, including the study of Hedayati et al. (12) found no significant difference between class II patients and controls regarding their head position.

In the present study, although no significant difference was seen in overall comparison of groups, craniovertical angles as indicator of spatial head position of patients, were significantly smaller in class II patients than class I male ones. These results show that class II male patients turned their head slightly upward compared to those of class I. It can be argued that class II patients probably tend to move their head a little up to achieve more beautiful appearance and easier respiration. Moreover, some angles determining the head position in space (SN/VER, ML/VER, OPT/HOR and CVT/HOR) were significantly smaller in class III patients than class I male ones, indicating that these patients turned their head slightly up compared to the controls. However, there was no statistically significant difference between classes II and III patients in ML/VER angle.

Accordingly, tendency of class III patients to keep their head up may be due to their higher self-confidence owing to look taller and having a bigger body. Hence, despite the protruded jaw in these patients, they may turn their head upward because of the psychological factors that may affect their behavior and posture.

This study showed no significant difference in craniocervical angles, as indicator of head position of patients, both in total samples and in each gender. Since in this study there was a significantly strong difference between different male groups in craniovertical angles, mandibular length probably affected patient head position rather than their neck position.

Conclusion:

Irrespective of the type of malocclusion, men generally tended to hold their head more downward and their cervical spine more upright than women. Meanwhile, class II male patients tended to turn their head a little up to attain a more beautiful appearance and easier respiration. On the other hand, class III male patients, despite their protruded jaw, turned their head slightly up to have higher self-confidence as a result of being taller and having a larger body. Furthermore, since there was only a significant difference in head position angles after considering the type of malocclusion, it can be concluded that longer mandibular length probably affects the patients' head position rather than their neck position**.**

Limitation

In this study, two-dimensional lateral cephalometric radiographs were used. Hence, the reference points present in a three-dimensional image cannot be determined in a two-dimensional image. Therefore, future studies are recommended to use more reliable images like CBCT.

Suggestions

The more the number of samples, the higher the accuracy of results would be. Hence, due to some differences between the results of this study and others, further studies are required in different societies and with a larger sample size. Additionally, future studies can investigate other factors such as age and stature that can affect head and neck position of patients.

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Tables and Charts:

Table 1. Definition of the Cephalometric Landmarks Used in the Study

1	Anterior Nasal Spine (ANS)	The most anterior point of the tip of the anterior nasal spine
2	Gonion (Go)	The most posterior and lowest point on mandibular angle, which is made from the bisector of tangent lines on posterior border of the ramus and the lower border of the mandible.
3	Gnathion (Gn)	The most anterior and lowest point on chin symphysis.
4	Nasion (N)	The most anterior point at frontonasal suture at midsagittal plane.
5	Posterior Nasal Spine (PNS)	Intersection of the continuation of the anterior wall of the pterygomaxillary fissure and the nasal floor
6	Subspinale	the most posterior point at midfacial concavity between prosthion and ANS.
7	Supramental e	The most posterior point at midfacial mandibular concavity, located between the highest point of alveolar bone under mandibular incisors and Pog.
8	Sella	Midpoint of sella turcica
9	Functional occlusal plane	The contact point of distal cusps of first molars and contact point of first premolars to draw occlusal plane
10	CV2sp	The uppermost and most posterior point on odontoid appendage of second cervical vertebra.
11	CV2ip	the lowest and most posterior point on the corpus of second cervical vertebra
12	CV4ip	The lowest and most posterior point on the corpus of fourth cervical vertebra.
13	CV6ip	the lowest and most posterior point on the corpus of sixth cervical vertebra

Table 2. Definition of Assessed Cephalometric Indices

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1	Craniovertical angles	SN/VER, Nassal line (NL)/VER and Mandibular line (ML)/VER angles. For example, SN/VER angle is an angle made from SN and VER lines
2	Craniohorizontal angles	OPT/HOR and CVT/HOR angles
3	Craniovertical angles	SN/OPT, SN/CVT, NL/OPT, NL/CVT and ML/CVT angles
4	Cervical lordosis angle	An angle made from EVT and CVT lines.
5	Cervical curvature	An angle made from OPT and CVT lines (20).
6	Occlusal plane	A line connecting the distal cusps of maxillary and mandibular first molar to the cusps of maxillary and mandibular first premolar.
7	OPT	a line connecting CV2sp and CV2ip
8	CVT	a line connecting CV2sp and CV4ip
9	EVT	a line connecting CV4ip and CV6ip
10	True vertical line	An external reference line usually characterized by a suspending chain in the air which is drawn on the film during exposure.
11	True horizontal line	a reference line out of skull obtained by drawing a line perpendicular to the true vertical line

Table 3. Means of Studied Angles Based on Gender**.**

Angle (degree)	Study groups				P-Value
	Female n=46		Male n=20		
	S.D	Mean	S.D	Mean	
SN/VER	5.61	83.19	5.59	84.50	0.388
NL/VER	5.15	91.02	6.43	92.05	0.492
ML/VER	5.67	119.67	7.74	120.2	0.758

SN/OPT	1.17	99.32	6.73	95.45	0.173
SN/CVT	1.11	105.35	6.15	98.60	0.014
NL/OPT	1.02	92.41	7.55	88.80	0.162
NL/CVT	8.80	98.15	7.08	91.10	0.002
ML/CVT	8.09	69.13	5.52	63.05	0.003
OPT/HOR	8.62	92.78	8.25	89.65	0.174
CVT/HOR	7.35	98.74	7.25	92.95	0.004
OPT/CVT	3.12	6.04	2.68	3.30	0.001
CVT/EVT	9.71	11.38	1.40	17	0.335

Table 4: Means of studied angles by Based on Malocclusion Types

Angle (degree)	**Study groups**						**P-Value**
	Class I n=22		Class II n=25		Class III n=19		
	S.D	Mean	S.D	Mean	S.D	Mean	
SN/VER	5.91	84.54	5.34	83.40	5.66	82.74	0.580
NL/VER	5.10	91.95	5.02	91.56	6.71	90.31	0.626
ML/VER	7.07	120.41	5.22	120.84	6.58	117.84	0.262
SN/OPT	10.69	97.27	8.75	100.88	12.25	95.58	0.233
N/CVTS	9.41	102.95	8.74	106.40	2.45	99.63	0.097
NL/OPT	10.58	90.32	9.33	92.72	9.03	90.63	0.655
NL/CVT	8.83	95.86	8.53	97.84	9.31	93.79	0.329
ML/CVT	7.77	67.23	7.49	68.32	8.71	66.00	0.633
OPT/HOR	10.19	91.59	7.53	93.44	7.84	90.00	0.420

CVT/HOR	7.47	97.54	7.07	98.96	8.24	93.74	0.077
OPT/CVT	3.97	5.59	3.11	5.52	2.31	4.37	0.408
CVT/EVT	12.44	15.12	9.59	12.58	2.08	3.64	0.274

Table 5: Means of studied angles among the men

Angle (degree)	**Study group**						**P-value**
	Class I n=4		Class II n=6		Class III n=10		
	S.D	Mean	S.D	Mean	S.D	Mean	
SN/VER	1.82	91	2.23	81.83	6.11	83.50	0.019
NL/VER	2.99	98.75	2.59	90.50	7.45	90.30	0.057
ML/VER	2.52	130.50	3.67	121.50	6.48	115.30	0
SN/OPT	1.82	98	5.74	99.17	7.24	92.20	0.088
SN/CVT	2.08	99.50	4.41	102.50	6.99	95.90	0.105
NL/OPT	1.91	90.50	6.56	90.33	9.46	87.20	0.662
NL/CVT	0	92	5.43	93.67	8.98	89.20	0.479
ML/CVT	3.41	61.50	4.37	62.50	6.90	64	0.737
OPT/HOR	2.64	99.50	7.39	90.33	6.83	85.30	0.006
CVT/HOR	3.40	100.75	5.54	93.50	7.04	89.50	0.021
OPT/CVT	1.50	1.25	3.12	3.17	2.48	4.20	0.178

Table 6: Means of studied angles among the women

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Angle (degree)	Study group						P-value
	Class I n=18		Class II n=19		Class III n=9		
	S.D	Mean	S.D	Mean	S.D	Mean	
SN/VER	5.54	83.11	5.96	83.89	5.35	81.89	0.684
NL/VER	4.16	90.44	5.60	91.90	6.22	90.33	0.637
ML/VER	5.60	118.17	5.69	120.63	5.77	120.67	0.36
SN/OPT	11.85	97.11	9.58	101.42	15.77	99.33	0.547
SN/CVT	10.25	103.72	9.47	107.63	16.03	103.78	0.519
NL/OPT	11.74	90.28	10.08	93.47	7.19	94.44	0.523
NL/CVT	9.60	68.50	9.01	70.15	7.01	68.22	0.684
ML/CVT	7.94	89.83	7.39	94.42	10.33	95.22	0.775
OPT/HOR	10.44	89.83	7.50	94.42	5.24	95.22	0.174
CVT/HOR	7.99	96.83	6.72	100.68	7.04	98.44	0.285
OPT/CVT	3.70	6.55	2.78	6.26	2.24	4.55	0.275
CVT/EVT	12.44	15.12	6.87	10.16	0.71	2.50	0.23

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