

Changes in Hyoid Bone Position after Orthodontic Treatment of Patients with Mandibular Deviation

Q Yang^{1, 2}, CHL Wang³, C Fan², J Chen²

ABSTRACT

Objectives: The aim of this study was to observe the influence of orthodontic treatment on the hyoid position of patients with different vertical skeletal craniofacial patterns of mandibular deviations.

Methods: A total of 60 patients with mandibular deviations, including 30 males and 30 females with a mean age of 15.4 years, were recruited. They were equally divided into average angle, high angle, and low angle groups, with a 1:1 gender ratio. Their hyoid position was measured before and after orthodontic treatment. The data were analysed using paired t-tests and analysis of variance (ANOVA).

Results: After treatment, the hyoid body in the high angle group presented significant forward and upward movements ($p = 0.012$ and $p = 0.005$). The hyoid body in the low angle group exhibited significant forward movement ($p = 0.048$) and a significant increase in the hyoid inclination ($p = 0.00$). In the average angle group, the hyoid body significantly moved downward ($p = 0.031$) and the thyrohyoid moved upward ($p = 0.046$). The ANOVA showed that orthodontic treatment significantly influenced the vertical position and inclination degree of the hyoid ($F = 6.37$, $p = 0.003$; $F = 6.204$, $p = 0.004$; and $F = 3.393$, $p = 0.025$). The average angle group displayed significant differences in these indices compared with the high angle and low angle groups. Orthodontic treatment significantly influenced the mandibular plane angle in the high angle group ($p = 0.012$).

Conclusion: Orthodontic treatment influences the hyoid position of patients with different vertical skeletal craniofacial patterns of mandibular deviations by varying degrees.

Keywords: Hyoid bone position, jaw dysplasia, orthodontic treatment

Cambios en la Posición del Hueso Hioides después del Tratamiento Ortodóntico de Pacientes con Desviación Mandibular

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RESUMEN

Objetivos: El objetivo de este estudio fue observar la influencia del tratamiento ortodóntico en la posición hioidea de pacientes con diferentes patrones craneofaciales esqueléticos verticales de desviaciones mandibulares.

Métodos: Se reclutaron un total de 60 pacientes con desviaciones mandibulares, incluyendo 30 hombres y 30 mujeres con una edad media de 15.4 años. Los pacientes fueron divididos a partes iguales en grupos de ángulo promedio, ángulo alto, y ángulo bajo, con una proporción de género de 1:1. Su posición hioidea fue medida antes y después del tratamiento ortodóntico. Los datos se analizaron mediante pruebas t pareadas y análisis de varianza (ANOVA).

Resultados: Luego del tratamiento, el cuerpo del hioides en el grupo de ángulo alto presentó movimientos significativos hacia adelante y hacia arriba ($p = 0.012$ y $p = 0.005$). El cuerpo del hioides en el grupo de bajo ángulo exhibió avance significativo ($p = 0.048$) y un aumento significativo en la inclinación del hioides ($p = 0.00$). En el grupo de ángulo promedio, el cuerpo del hioides se movió significativamente hacia abajo ($p = 0.031$) y el tirohioideo se movió hacia arriba ($p = 0.046$). El

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análisis de ANOVA mostró que el tratamiento ortodóntico influye significativamente sobre el grado de inclinación y posición vertical del hioides ($F = 6.37$, $p = 0.003$; $F = 6.204$, $p = 0.004$ y $F = 3.393$, $p = 0.025$). El grupo de ángulo promedio mostró diferencias significativas en estos índices en comparación con los grupos de ángulo bajo y ángulo alto. El tratamiento ortodóntico influyó significativamente en el ángulo del plano de la mandíbula en el grupo de alto ángulo ($p = 0.012$).

Conclusión: *El tratamiento ortodóntico influye en la posición hioidea de pacientes con diferentes patrones craneofaciales esqueléticos verticales de desviaciones mandibulares de diversos grados.*

Palabras clave: Posición del hueso hioides, displasia de la mandíbula, tratamiento ortodóntico

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INTRODUCTION

Mandibular articulation deviation refers to asymmetry of the mandible relative to the median sagittal plane of the skull. It is a common clinical type of malocclusion that can lead to mandibular movement abnormality, occlusion disorder, periodontal injury, and temporomandibular joint disease (1). Mandibular deviations can affect maxillofacial features and cervical posture, and they are correlated with functional abnormalities of the facial and neck (cervical) muscles (2). In clinical practice, orthognathic surgery is the most effective therapeutic method for severe mandibular deviation, whereas camouflaged orthodontic treatment is more easily accepted among patients with mild or moderate mandibular deviation. Although both orthognathic and orthodontic treatment methods modify the occlusion or tongue position of patients, this occlusion will inevitably influence the stomatognathic system (3). The position of the hyoid, which is always abnormal among patients with mandibular deviation, is easily influenced by the positions of the tongue, the mandible, and the suprahyoid and infrahyoid muscle groups; furthermore, patients with different vertical skeletal craniofacial patterns of mandibular deviations have varying degrees of differences in hyoid position (4, 5). The effects of orthodontic treatment on the hyoid position of patients with different vertical skeletal craniofacial patterns of mandibular deviations have not been reported in literature.

In the current study, the hyoid positions before and after orthodontic treatment of patients with different vertical skeletal craniofacial patterns of mandibular deviation were measured using the WinCeph 8.0 cephalometric analysis system. These measurements were then compared statistically.

SUBJECTS AND METHODS

A total of 60 patients with mandibular deviation who received orthodontic treatment at the Affiliated Hospital of Medical College, Qingdao University between 2006 and 2010 were enrolled in the study. The subjects included 30 males and 30 females with ages ranging from 11 years to 16 years, with an average of 15.4 years. The selection criteria included the following: 1) mandibular articulation deviation, with the chin deviating by 2 mm to 5 mm from the facial median line according to skull X-rays; 2) permanent tooth

occlusion with a centred upper median line, but with a deviated lower median line (above 2 mm), and without tooth alignment deficiency, according to clinical examination; 3) no history of orthodontic treatment, facial trauma, or temporomandibular arthrosis, as well as no tonsillar hypertrophy and 4) a willingness to improve facial features through orthodontic treatment alone.

All enrolled patients signed an informed consent form. All procedures were in accordance with the Declaration of Helsinki and were approved by the Ethics Committee of Qingdao University Medical College, China.

After treatment, the chin deviations in all the patients improved. The deviation of the lower median line from the upper median line was reduced to less than 1 mm, and the overjet and overbite of the anterior teeth became normal. Differences and changes in the molar relation as well as any sagittal skeletal craniofacial deviations were excluded from consideration.

Cephalometric analysis

A cephalometric radiographer was used. The linear amplification ratio was set to 9%, which was not corrected during the whole procedure. Each patient was seated upright with a straight back, and the position of the head was strictly fixed, with the eye-ear plane parallel to the floor. The lips were closed naturally with a centric dental occlusion. Radiographs of the lateral projection of the cranium were taken before and after the orthodontic treatment for each patient. The angle of the mandibular plane was measured using the WinCeph version 8.0 cephalometric analysis system. Based on the different mandibular plane angles, the patients were divided into the average angle (Group 1), high angle (Group 2), and low angle (Group 3) groups, with 10 males and 10 females in each group.

Seven measurement marking points and three reference planes were determined in cephalometric analysis (Figs. 1 and 2). The measurements were based on the method by Jena and Duggal (5). The lines passing the points S and PTR, vertical to the FH plane, were taken as the two vertical reference planes, whereas the horizontal line passing the point C₃C was considered the horizontal reference plane. These reference planes were used to evaluate the horizontal

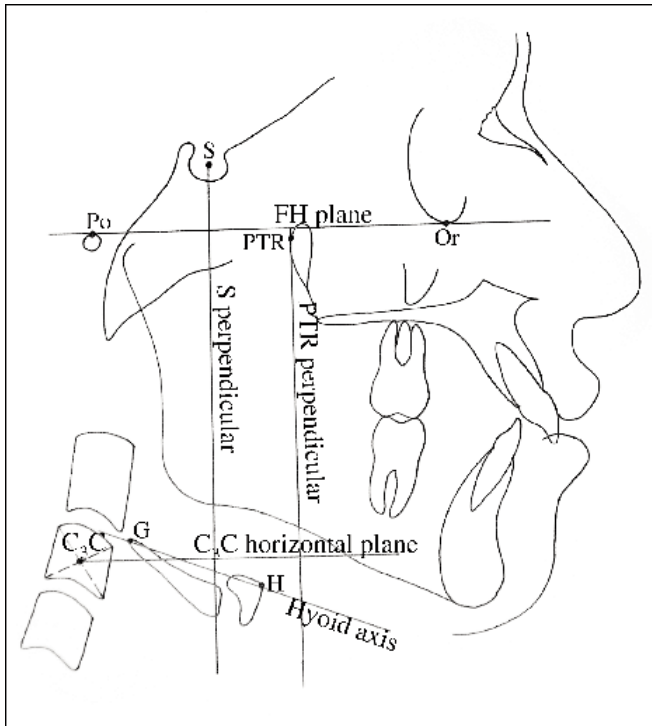


Fig. 1: Cephalometric marking points and planes. Point S is the sella turcica, Po is the porion, Or is the orbitale, PTR is the most posterior point of the pterygomaxillary fissure, C₃C is the central point of the third cervical vertebra, H is the most anterior point of the hyoid body, and G is the most posterior point of the thyrohyal; FH plane is the line passing Po and Or, S-per is the S-passing line vertical to the FH plane, PTR-per is the PTR-passing line vertical to the FH plane, C₃C plane is the C₃C-passing horizontal line vertical to the S-per line, and Hyoid axis is the line through H and G.

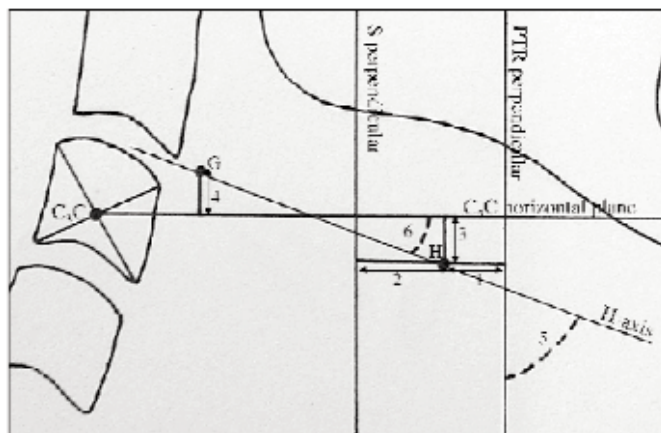


Fig. 2: Line distances and angles for hyoid position change measuring. 1, the distance between H and PTR-per; 2, the distance between H and S-per; 3, the distance between H and the C₃C horizontal line; 4, the distance between G and the C₃C horizontal line; 5, the included angle between the H axis and PTR-per and 6, the included angle between the H axis and the C₃C horizontal line.

and vertical movements in hyoid position. The respective vertical distances between point H and the S reference plane, as well as the PTR reference planes were used to evaluate the

anteroposterior movement of the hyoid position. The vertical distances from the points H and G to the C₃C plane were used to evaluate the vertical movement of the hyoid position. The included angles between the H axis and the PTR plane (Angle 1), as well as between the H axis and the C₃C plane (Angle 2), were used to evaluate possible changes in the inclination of the hyoid body. The marking points and reference planes in the present study are all located around the hyoid, thereby avoiding inaccurate measurements of the changes in hyoid position caused by excessively far distances between the measurement points and the hyoid, as in other measurement methods.

Statistical analysis

All cephalometric data were measured thrice by the same physician, and the mean values were obtained. The data were then analysed using SPSS version 18.0 statistical software. A paired *t*-test was performed to compare the measurements before and after orthodontic treatment in each group, and one-factor analysis of variance (ANOVA) was performed for comparisons among groups.

RESULTS

Post-treatment changes in hyoid position

The results are summarized in Table 1. The high angle group showed the most obvious anteroposterior movement in hyoid position among the three groups after orthodontic treatment. In this group, a significant forward movement was observed after treatment compared with that before treatment ($p = 0.012$). The hyoid position in the low angle group was more anterior than those in the other two groups, both before and after orthodontic treatment. After treatment, a significant forward movement was also observed in this group ($p = 0.048$).

Point H in the high angle group showed a significant upward movement after treatment ($p = 0.05$), but such a significant change was not observed in the height of point G. In contrast, the average angle group showed a significant downward movement in point H ($p = 0.031$), as well as a significant upward movement in point G after treatment ($p = 0.046$), but did not show a significant change in the inclination of the hyoid body.

The low angle group showed the largest increase in the inclination of the hyoid body after treatment ($p = 0.00$).

The ANOVA shows that the influence of orthodontic treatment on the height of point H of the hyoid ($F = 6.37, p = 0.003$), angle 1 ($F = 6.204, p = 0.004$), and angle 2 ($F = 3.393, p = 0.025$) was significant. The average angle group showed significant differences in the three indices compared with those in the high angle and low angle groups. However, no significant differences were observed between the high angle groups and the low angle group.

Post-treatment changes in mandibular plane angle

Orthodontic treatment significantly influenced the mandibular plane angle of the high angle group ($p = 0.012$). The

Table 1: Change of hyoid bone position before and after orthodontic treatment

Item	Group	$\bar{x} \pm S$		D-value	t	p	F	p	Comparison among groups		
		Before treatment	After treatment						I vs II	I vs III	II vs III
H-PTR (mm)	1	-2.92 ± 5.842	-1.78 ± 4.742	-1.140 ± 6.343	-0.804	0.432	0.551	0.579			
	2	-6.25 ± 5.364	-3.58 ± 5.305	-2.675 ± 4.332	-2.761	0.012					
	3	2.65 ± 3.756	4.18 ± 4.243	-1.525 ± 3.230	-2.111	0.048					
H-Sper (mm)	1	13.15 ± 6.829	15.550 ± 8.0261	-2.4000 ± 8.9008	-1.206	0.243	0.091	0.914			
	2	-7.39 ± 7.245	-5.550 ± 6.9261	-1.8400 ± 5.8792	-1.400	0.178					
	3	14.98 ± 4.315	16.450 ± 5.1348	-1.4750 ± 5.4784	-1.204	0.243					
H-C ₃ Chor (mm)	1	-10.525 ± 8.6772	-14.750 ± 6.6698	4.2250 ± 8.0857	2.337	0.031	6.370	0.003	*	*	
	2	-9.045 ± 5.9554	-6.050 ± 4.0357	-2.9950 ± 4.2483	-3.153	0.005					
	3	-14.350 ± 5.5396	-13.600 ± 5.2855	-0.7500 ± 6.7209	-0.499	0.623					
G-C ₃ Chor (mm)	1	-2.45 ± 5.765	0.46 ± 4.036	-2.910 ± 6.103	-2.132	0.046	2.099	0.132			
	2	-2.36 ± 5.703	-2.05 ± 2.915	-0.315 ± 4.092	-0.344	0.734					
	3	-3.30 ± 4.476	-3.30 ± 4.228	.000 ± 4.347	0.000	1.000					
Haxis-PTR (mm)	1	70.15 ± 4.921	72.10 ± 6.480	-1.950 ± 6.393	-1.364	0.188	6.204	0.004	*	*	
	2	73.35 ± 4.870	71.65 ± 7.177	1.700 ± 4.162	1.826	0.084					
	3	69.80 ± 5.977	66.85 ± 5.566	2.950 ± 2.121	6.221	0.000					
Haxis-C ₃ Chor (mm)	1	19.58 ± 5.022	17.90 ± 6.480	1.675 ± 7.859	0.953	0.353	3.939	0.025	*	*	
	2	16.65 ± 4.870	18.35 ± 7.177	-1.700 ± 4.162	-1.826	0.084					
	3	20.20 ± 5.977	23.05 ± 5.472	-2.850 ± 2.272	-5.611	0.000					

Table 2: Post-treatment changes in mandibular plane angle

Group	$\bar{x} \pm S$		D-value	p
	Before treatment	After treatment		
1	31.1750 ± 3.00559	31.2000 ± 3.19704	-0.02500 ± 0.81878	0.893
2	38.6200 ± 2.58713	35.7250 ± 3.57250	2.89500 ± 4.64809	0.012
3	21.5500 ± 2.37808	21.6000 ± 2.13739	-0.05000 ± 0.48395	0.649

results obtained from the paired *t*-tests are summarized in Table 2.

DISCUSSION

Mandibular deviation should be treated as early as possible. Orthodontic treatment stops the progression of early mandibular deviations induced by abnormal muscular activities, tooth malposition, occlusal interference, and so on to prevent the formation of bone deformities. In the present study, the subjects were selected according to a gender ratio of 1:1 to exclude the influence of sex on the obtained results because the hyoid position in males is more likely to move forward with age compared with females (6).

Both the lateral and individual tooth crossbite occlusions can cause lateral tooth dysfunction. This condition can further lead to weaker muscular strength on the ipsilateral side compared with the contralateral side. After the mandibular deviation was improved and a new occlusal relation was established through orthodontic or orthognathic treatment, the motor function of the related perioral muscle groups changes, resulting in a change in hyoid position, which is greatly influenced by the perihyoid muscles and the

mandibular position (7–9). Similarly, the hyoid position can also change after the mandibular sagittal and vertical positions change. Conducted mandibular forward protrusion influences hyoid position and the size of the pharyngeal airway by varying degrees (10), whereas protruded mandibular withdrawal through orthognathic treatment causes backward movement of the hyoid (11).

The low angle group presented the most anterior and the lowest hyoid position both before and after treatment. Orthodontic treatment had the most obvious influence on hyoid inclination in this group. A clockwise rotation of the hyoid was observed after treatment, but significant changes in its general height and anteroposterior position were not observed. Jena and Duggal (5) also found that patients with low-angle mandibular deviation have more anterior hyoid positions than other patients. Therefore, the high incidence of severe obstructive sleep apnea syndrome among Class II brachyfacial patients is likely correlated with a relatively posterior hyoid position. The clockwise rotation of the hyoid position in the low angle group may be correlated with the pulling effect of the suprahyoid muscle groups after deviation correlation or improvement. This change is related to the heavy muscle tension among low-angle patients (12, 13).

In this study, the high angle group presented the most posterior hyoid position before and after treatment. After the treatment, the hyoid position showed forward and upward movements, and the mandibular plane angle was significantly reduced ($p = 0.012$). These results indicate that a change in the mandibular plane angle influences hyoid position. This study also demonstrates that orthodontic treatment has a relatively small influence on hyoid position in the low angle group. After treatment, the hyoid body in the low angle group moved downward whereas the thyrohyoid moved upward, showing a general downward movement. These results indicate that changes in hyoid position are correlated with vertical skeletal craniofacial deviations. In this study, all the selected subjects were past the tooth growth and development stage. Therefore, only camouflaged orthodontic treatment was performed for them. Consequently, their pre-existing bone deformities remained after treatment. However, as the treatment progresses, adaptive rebuilding can still be performed on the alveolar bone and muscle nerves, thereby changing the hyoid position as well as the different types of malocclusions (14–16).

In summary, the hyoid positions among different types of vertical craniofacial deviations differ significantly. Orthodontic treatment has different degrees of influence on hyoid position, to which patients with exceedingly high or exceedingly low mandibular plane angles are more susceptible. Changes in the hyoid position influence the area and morphology of the pharyngeal airway (17–20), but the influence remains to be explored.

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