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Evaluation of Head and Cervical Spine Posture after Therapy with Maxillary Protraction Appliances

Evaluación de la Postura de la Cabeza y la Columna Cervical Después de la Terapia con Aparatos de Protracción Maxilar

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SUMMARY: The objective of this study was to evaluate the changes of head and cervical spine posture of skeletal class malocclusion in adolescent with maxillary protraction. Thirty cases of skeletal class malocclusion were randomly selected from the Stomatological Hospital of Shanxi Medical University. High-quality lateral cephalograms were collected including pre- and posttreatment to compare the changes of head and cervical spine posture. Data were processed using SPSS 26.0 statistical software. The paired-t test was used to compare pre- and posttreatment mean angular measurements. A significant difference in the SNA($p<0.001$), SNB($p<0.01$), and ANB($p<0.001$) between T1 and T2 showed an improvement in the sagittal relationships. A significant change was observed in middle cervical spine posture, while upper cervical spine posture variables showed no significant difference after treatment. Skeletal class with maxillary protraction appliance not only led to the improvement of sagittal relationship, but also changed the middle cervical spine posture.

KEY WORDS: Head posture; Cervical spine posture; Skeletal class; Maxillary protraction; Cephalometric measurements.

INTRODUCTION

The formation of malocclusion is affected by many factors, such as evolution, heredity and environment, which can lead to the development of craniofacial malformations. Craniofacial structure and cervical spine are adjacent structures, morphologically and functionally related, being mutually influenced by their growth patterns (Anshuka *et al*., 2020). Since the 1970s, many scholars have begun to systematically study the relationship between craniocervical posture and craniomaxillofacial morphology. Evidence suggests a relationship between head position and dentofacial morphology (Solow & Tallgren, 1976; Liu *et al*., 2016). There is a certain correlation between cervical spine posture and craniofacial morphology, and different cervical spine postures are associated with sagittal growth of the maxilla and mandible, especially with the direction of facial growth Sonnesen, 2012. Head posture extension showed head anteversion, and head posture flexion showed headretroversion (Soytarhan & Aras, 1990). Different head posture and cervical spine posture tend to present with different craniofacial morphological characteristics. In general, those with extended head posture have smaller posterior height, larger anterior cranial base angle, larger mandibular angle, larger intersection angle between mandibular plane and palatal plane and anterior cranial base plane, and relatively receding mandible, while those with flexed head posture have opposite posterior height, smaller anterior cranial base angle, and relatively protruding mandible (Solow & Tallgren, 1977). This relationship has been explained by the hypothesis of soft tissue stretching, which states that a head extension leads to a passive stretching of soft tissues generating a dorsal direction force, which does not allow the normal component of head growth in a forward direction (Solow & Kreiborg, 1977).

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D'Attilio *et al*. (2005) found children in skeletal class III showed a significantly lower cervical lordosis angle than the children in skeletal class I and skeletal class II. Maxillary protraction is a common clinical treatment for skeletal class III malocclusion and has a definite effect in promoting maxillary development. Some studies have been done previously to evaluate whether the Twin Block appliance and Forsus appliance used for alteration of Class II malocclusion had any effect on the cervical spine posture (Kamal & Fida, 2019; Malik *et al*., 2022). However, when it comes to the maxillary protraction, there are no studies available to assess its effects on cervical spine posture. Hence, the present study was undertaken to investigate whether the treatment of skeletal class ? malocclusion with the maxillary protraction appliance produces any changes in the cervical spine posture in children.

MATERIAL AND METHOD

Materials selection. Thirty patients with skeletal class III malocclusion, aged 6-12 years with an average age of 9.12 ± 1.36 years, were selected from Shanxi Medical University stomatological hospital from 2016 to 2022, 15 male and 15 female patients were treated with maxillary protraction. Inclusion criteria: (1) good general condition, no other systemic diseases; (2) no previous orthodontic treatment; (3) pubertal stage of development (CVS2–CVS3 in cervical vertebral maturation); (4) Concave type; skeletal Class III malocclusion; (5) informed consent of parents.

Experimental method. All patients were treated with maxillary protraction device, and the appropriate model was selected according to the head circumference of the patients; the protraction direction was 15 ° ~ 30 ° angle to the plane, in order to avoid the rotation of the palatal plane counterclockwise, the force of the line as far as possible through the center of the nasal maxillary complex, so that the maxillary movement of the overall movement to prevent the phenomenon of jaw opening, and the bilateral force application direction was parallel; it was worn for more than 12 hours every day; the initial force value was about 200 g, which reduces the damage caused by adverse gravity on the muscles and joints, While improving patient comfort and appliance retention performance, reducing the appliance off rate, and then the force value was appropriately adjusted according to the clinical situation. The appliance should be removed after reaching the normal occlusion, and patients then underwent a post treatment cephalogram.

A retrospective cohort was conducted with the use of pre– (T1) and post– (T2) maxillary protraction therapy cephalograms of orthodonticallytreated patients. The radiographs were taken with head positioning X-ray camera (Siemens, Germany), and lateral cephalometric radiographs were taken of the participants in natural head position (NHP). Cephalograms were traced manually with a 0.5-mm lead pencil on acetate sheets on an illuminator. Angular readings were measured with the help of a protractor. In total, 11 angular variables were measured for cephalometric radiogram assessment. Reference lines used for cephalometric analysis are shown in Figure 1 and Table I.

Statistical analysis. To test the internal reliability of the measurements, the authors repeated all lateral cephalometric radiographs three times. Intraclass correlation coefficients showed high correlation between the two readings (Table II). Data were tested for normal distribution using the

Table II. Internal reliability of the measurements.

Parameters	Value	ICC
SNA	77.12	0.980
SNB	79.14	0.967
ANB	-2.00	0.824
SN-MP	34.50	0.953
SN-OPT	93.87	0.985
PP-OPT	85.42	0.979
MP-OPT	59.50	0.962
SN-CVT	100.32	0.938
PP-CVT	92.00	0.974
MP-CVT	65.12	0.997
OPT-CVT	6.66	0.952

Table I. Reference lines used for cephalometric analysis.

Cephalometric reference lines	Description	Characterization of reference lines
SN	Nasion-sella line	Line through Nasion and Sella points
NA		
NB		
PP	Nasal line	Line through anterior and posterior nasal spines
MP	Mandibular line	Tangent to the lower border of the mandible through Menton point
CVT	Cervical tangent	Posterior tangent to the most posterior and inferior point on the corpus of the fourth and sixth cervical vertebra
OPT	Odontoid process tangent	Posterior tangent to the odontoid process through the most posterior and inferior point on the corpus of the second cervical vertebra

Shapiro-Wilk test, which showed a normal distribution. The paired-t test was used to compare pre- and post-treatment mean angular measurements. $P < 0.05$ was considered statistically significant.

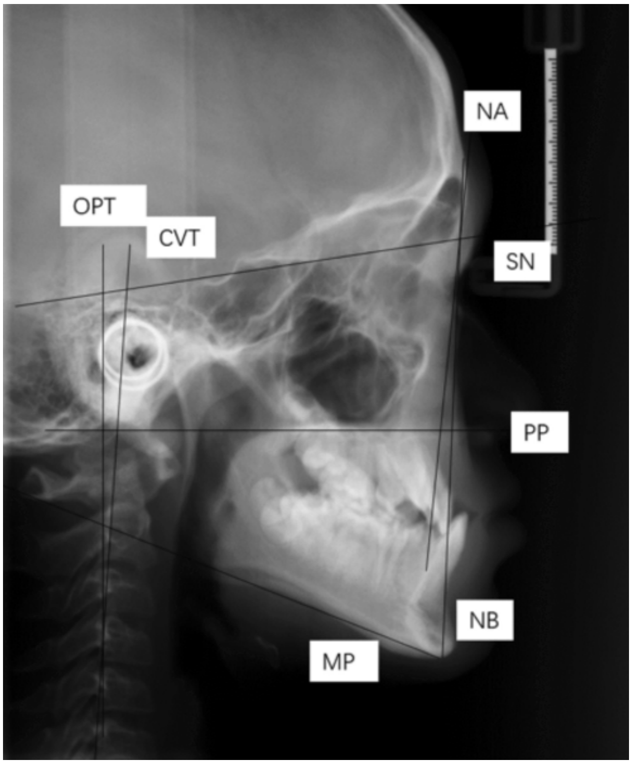

Fig. 1. Reference lines used for cephalometric analysis.

RESULTS

The change in the T1 and T2 values were presented in Table III. The T1 and T2 sagittal values, such as SNA (P<0.001),SNB (P<0.01) and ANB (P<0.001), showed a significant difference. The increase of SN-MP was observed in the vertical dimension.

A statistically significant change was observed in SN/ cerebral vertebrae tangent (CVT) angle (P < 0.001), PP/ CVT angle (P < 0.01) and MP/ CVT angle (P < 0.05) in the middle cervical spine posture, statistically significant increase in cervical curvature angle (OPT/CVT) was found after the treatment (P = 0.043). While upper cervical spine posture variables (SN-OPT (P = 0.186), PP-OPT (P = 0.090), MP-OPT (P = 0.086)) showed no significant difference after treatment.

DISCUSSION

This study was conducted to determine the change of the head and cervical spine postures between subjects with skeletal class. Skeletal class malocclusion can affect the function and facial esthetics of patients and cause a great challenge to the orthodontist during orthodontic treatment. There are numerous management strategies for skeletal class malocclusion.

Many researchers have identified the relationship between craniofacial morphology and cervical spine postures (D'Attilio *et al*., 2005; Sandoval *et al*., 2021). Head and neck posture is associated with many factors, including age, sex, and facial morphological features, such as mandibular deviation (Hellsing *et al*., 1987). In addition, functional factors such as obstructive sleep apnea syndrome (OSAS), temporomandibular disorders can also affect head and neck postures (Rai *et al*., 2020; Almaan *et al*., 2022). Maxillary protraction is a common clinical treatment for skeletal class III malocclusion, suitable for maxillary hypoplasia, maxillary retrusion of the patients, can promote the growth and development of the maxilla. It not only has a definite effect in promoting maxillary development, but provides a more favorable environment for the normal development of the maxilla and mandible (Cordasco *et al*., 2014; Ngan & Moon,

Table III. Evaluation of cephalometric parameters between pre (T1)-and posttreatment (T2).

Cephalometric parameters	Pretreatment		Posttreatment		Paired t-test	p
	Mean	SD	Mean	SD		
SNA	77.32	3.01	79.08	2.84	4.08	0.000***
SNB	79.25	3.39	78.40	2.90	2.61	0.009**
ANB	-1.94	2.58	0.67	1.55	-7.08	0.000***
SN-MP	34.67	5.10	35.71	4.15	-2.06	0.064
SN-OPT	93.96	7.96	96.09	7.98	-1.42	0.186
PP-OPT	85.36	8.55	88.09	8.14	-1.87	0.090
MP-OPT	59.50	5.96	59.81	6.97	-0.18	0.86
SN-CVT	100.36	10.76	107.00	9.17	-4.67	0.001***
PP-CVT	92.09	11.18	98.18	8.52	-3.33	0.008**
MP-CVT	65.09	10.00	69.54	8.15	-2.31	0.044*
OPT-CVT	6.72	7.39	10.27	6.82	-2.32	0.043*

2015). A significant difference in the SNA, SNB and ANB angles in T1 and T2 showed an improvement in the sagittal relationships in this study, indicating the dentoalveolar and hard tissues changes caused by the Maxillary protraction appliance.

Some previous studies on cervical spine posture have suggested that the inclination of the cervical spine is related to sex and usually shows a relatively straightened cervical spine in males, while it shows a larger curvature in females (Solow & Tallgren, 1971; Visscher *et al*., 1998). However, Makofsy *et al*. (1991) later concluded that sex and age had no significant effect on cervical spine posture. In our study, the male to female ratio was 1:1, so the mean value of cephalometric measurements of all samples in this experiment could represent the mean value of males and females. Therefore, in this study, the samples were not grouped by sex.

In this study, regarding the head and cervical assessments, the results showed that a statistically significant change was observed in SN/ CVT angle, PP/ CVT angle and MP/ CVT angle in the middle cervical spine posture, while upper cervical spine posture variables showed no significant difference after treatment. According to previous study, in class III individuals, decreased craniocervical angel and craniovertebral angles, craniocervical flexion, and a posterior inclination of the cervical spine have been observed (Liu *et al*., 2016). Compared to the head and cervical postures of pretreatment, post-treatment presented significant larger SN/ CVT angle, PP/ CVT angle, MP/ CVT angle and OPT/ CVT angle. Although other cephalometric parameters have not statistically significant, they followed consistent trend. As the sagittal position of the maxilla and mandible changes, the inclination of the cervical spine causes corresponding changes. In summary, skeletal class individuals showed larger craniocervical and craniovertebral angles, craniocervical extension, and anterior inclination of the cervical spine after treatment. This result could not be compared with other studies as this is the first study to have explored the effects of maxillary protraction appliance on cervical spine posture.

It is noteworthy that there are several limitations in this study. Because control group without maxillary protraction was not set up, the change in cervical spine posture may be a result of the patient's own growth and development. Many researchers have studied the effects of Twin block functional appliances on cervical posture previously. Smailiene˙ *et al*. (2017) found certain changes in body posture following orthodontic treatment, since the changes were noticed in both Twin block and control groups, the researchers concluded that the changes in cervical spine posture were unconnected to orthodontic treatment and improvement in occlusion but were an assertion of physiological growth. However, a study by Kamal & Fida (2019) found that the increase in the SN-OPT angle of the control group without Twin block which indicates a change in the upper cervical posture making it more forwardly inclined with a retrognathic mandible. Compared to the control group, the decrease in the SN-OPT angle shows that there is an uprighting and development of a natural curvature of the spine with Twin block. Thus, these subjects would definitely have a greater physiologic change in their cervical posture to prevent further development of malocclusion. Although the results showed changes in middle cervical spine posture, the interpretation of this result should be cautious and more studies are needed to support this result.

CONCLUSIONS

From this study, we can conclude the following: 1. The maxillary protraction improves the sagittal relationships between the maxilla and mandible. 2. Skeletal class individuals showed larger craniocervical and craniovertebral angles, craniocervical extension, and anterior inclination of the cervical spine after maxillary protraction treatment.

Pay attention to the change of cervical spine posture in patients with sagittal dysplasia. Poor cervical spine posture may be the physiological compensatory mechanism caused by malocclusion. Early correction of sagittal dysfunction can improve the poor cervical spine posture and achieve balance of bone, muscle and nervous system to facilitate the correction of malocclusion and long-term stability maintenance.

LIU, T.; ZHANG, Z. Y.; CAO, Y. X.; KYUNG, H. M.; BING, L. & WU, X. P. Evaluación de la postura de la cabeza y la columna cervical después de la terapia con aparatos de protracción maxilar. *Int. J. Morphol., 41(3)*:889-893, 2023.

RESUMEN: El objetivo de este estudio fue evaluar los cambios en la postura de la cabeza y la columna cervical debido a la maloclusión clase esquelética en adolescentes con protracción maxilar. Treinta casos de maloclusión de clase esquelética fueron seleccionados al azar del Hospital Estomatológico de la Universidad Médica de Shanxi. Se recogieron cefalogramas laterales de alta calidad, incluidos el tratamiento previo y posterior, para comparar los cambios en la postura de la cabeza y la columna cervical. Los datos se procesaron con el software estadístico SPSS 26.0. Se utilizó la prueba t pareada para comparar las medidas angulares medias antes y después del tratamiento. Una diferencia significativa en SNA ($p < 0{,}001$), SNB ($p < 0{,}01$) y ANB ($p < 0{,}001$) entre T1 y T2 mostró una mejora en las relaciones sagitales. Se observó un cambio significativo en la postura de la columna cervical media, mientras que las variables de postura de la columna cervical superior no mostraron diferencias significativas después del tratamiento. La clase esquelética con aparato de protracción maxilar no solo condujo a la mejora de la relación sagital, sino que también cambió la postura de la columna cervical media.

PALABRAS CLAVE: Postura de la cabeza; Postura de la columna cervical; Clase esquelética; protracción maxilar; Mediciones cefalométricas.

REFERENCES

Almaan, O.; Kui, A.; Duncea, I.; Manea, A. & Buduru, S. Temporomandibular joint disk displacements in class II malocclusion and cervical spine alterations: systematic review and report of a hypodivergent case with mri bone and soft tissue changes. *Life, 12(6)*:908, 2022.

Anshuka, A.; Shenoy, U.; Banerjee, S.; Wajekar, P. & Vasvani, V. Assessment and comparison of the head posture and craniofacial growth in vertical dimension - A cephalometric study. *J. Evol. Med. Dent. Sci., 15(9)*:1276-80, 2020.

Cordasco, G.; Matarese, G.; Rustico, L.; Fastuca, S.; Caprioglio, A.; Lindauer, S. J. & Nucera, R. Efficacy of orthopedic treatment with protraction facemask on skeletal Class III malocclusion: a systematic review and meta-analysis. *Orthod. Craniofac. Res., 17(3)*:133-43, 2014.

D'Attilio, M.; Caputi, S.; Epifania, E.; Festa, F. & Tecco, S. Evaluation of cervical posture of children in skeletal class I, II, and III. *Cranio, 23(3)*:219-28, 2005.

Hellsing, E.; McWilliam, J.; Reigo, T. & Spangfort, E. The relationship between craniofacial morphology, head posture and spinal curvature in 8, 11 and 15-year-old children. *Eur. J. Orthod., 9(1)*:254-64, 1987.

Kamal, A. T. & Fida, M. Evaluation of cervical spine posture after functional therapy with twin-block appliances: A retrospective cohort study. *Am. J. Orthod. Dentofacial Orthop., 155(5)*:656-61, 2019.

Liu, Y.; Sun, X.; Chen, Y.; Hu, M.; Hou, X. & Liu, C. Relationships of sagittal skeletal discrepancy, natural head position, and craniocervical posture in young Chinese children. *Cranio, 34(3)*:155-62, 2016.

Makofsky, H. W.; Sexton, T. R.; Diamond, D. Z. & Sexton, M. T. The effect of head posture on muscle contact position using the T-Scan system of occlusal analysis. *Cranio, 9(4)*:316-21, 1991.

Malik, N.; Fernandes, B. A.; Ramamurthy, P. H.; Anjum, S.; Prakash, A. & Sinha, A. Cephalometric evaluation of the cervical spine posture following fixed functional therapy with Forsus™ appliance. *J. Indian Soc. Pedod. Prev. Dent., 40(1)*:81-5, 2022.

Ngan, P. & Moon, W. Evolution of Class III treatment in orthodontics. *Am. J. Orthod. Dentofacial Orthop., 148(1)*:22-36, 2015.

Rai, D.; Navit, P.; Singh, R.; Grover, N.; Navit, S. & Khan, S. A. Effect of obstructive sleep apnea on condylar malformation, vertebral column, and head posture: a cephalometric evaluation. *Int. J. Clin. Pediatr. Dent., 13(Suppl. 1)*:S64-S68, 2020.

Sandoval, C.; Díaz, A. & Manríquez, G. Relationship between craniocervical posture and skeletal class: A statistical multivariate approach for studying Class II and Class III malocclusions. *Cranio, 39(2)*:133-40, 2021.

Smailiene˙, D.; Intiene˙, A.; Dobradziejute˙, I. & Kusˇleika, G. Effect of treatment with twin-block appliances on body posture in class II malocclusion subjects: a prospective clinical study. *Med. Sci. Monit., 23*:343-52, 2017.

Solow, B. & Kreiborg, S. Soft-tissue stretching: a possible control factor in craniofacial morphogenesis. *Eur. J. Oral Sci., 85(6)*:505-7, 1977.

Solow, B. & Tallgren, A. Dentoalveolar morphology in relation to craniocervical posture. *Angle Orthod., 47(3)*:157-64, 1977.

Solow, B. & Tallgren, A. Head posture and craniofacial morphology. *Am. J. Phys. Anthropol., 44(3)*:417-35, 1976.

Solow, B. & Tallgren, A. Natural head position in standing subjects. *Acta Odontol. Scand., 29(5)*:591-607, 1971.

Sonnesen, L. Cervical vertebral column morphology associated with head posture and craniofacial morphology. *Semin. Orthod., 18(2)*:118-25, 2012.

Soytarhan, A. & Aras, A . Evaluation of the head posture in orthodontic malocclusions. *Turk. Ortodonti Derg., 3(1)*:102-6, 1990.

Visscher, C. M.; de Boer, W. & Naeije, M. The relationship between posture and curvature of the cervical spine. *J. Manipulative Physiol. Ther., 21(6)*:388-91, 1998.

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