

THE BIOMECHANICAL RELATION BETWEEN INCISOR AND CONDYLAR GUIDANCES IN DEEP BITE CASES

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ABSTRACT

The aim of this study was to investigate the biomechanical relationship between the condylar and anterior guidances of patients with symptomatic temporomandibular disorders before and after orthodontic treatment. For this purpose, a four-bar link system was described for use on lateral cephalometric radiographs taken before and after treatment. A computer program was developed utilizing the lengths of the bar links of this four-bar link system on the cephalometric films. The link measurements were entered into the computer program which subsequently calculated the rotations of the mandible and the condyle during the mandibular movement. Three subjects with class II malocclusion and deep bite were selected from patients with temporomandibular pain dysfunction for this investigation. All subjects were treated by intrusion and protrusion of incisors. The rotations of mandible and condyle of these three subjects decreased and temporomandibular joint pains of the subjects were greatly diminished by treatment. In this study, it is observed that anterior guidance and condylar path are dependent on each other.

Key words: Anterior Guidance, Condylar Guidance, Mandibular Protrusive Movement.

ÖZET: Bu çalışmada temporomandibular eklem rahatsızlığı ve semptomatik ağrı şikayeti bulunan 3 bireyin ortodontik tedavi öncesi ve sonrası anterior ve kondiler rehberlik arasındaki biyomekanik ilişkileri gösterilmiştir. Ortodontik tedavi öncesi ve

sonrası alınan sefolometrik filmler üzerinde four-bar link sistemi oluşturulmuştur. Sefolometrik film üzerinde oluşturulan bu four-bar link sistemi yardımıyla elde edilen ölçümler için bir bilgisayar programı yazılmıştır. Bu vaka raporunda TME ağrı şikayeti bulunan deep bite ve Class II malokluzyonlu 3 bireyinde kesicilerde intruzyon ve protruzyon ile tedavi edilmiştir. Tedavi sonunda bu üç bireyinde mandibular ve kondiler hareket açıları azalmış ve TME ağrı şikayetleri önemli düzeyde azalmıştır. Bu vaka raporunda, anterior rehberlik ile kondilin çizdiği yol birbiri ile ilişkili olduğu tespit edilmiştir.

Anahtar kelimeler : Anterior Rehberlik, Kondiler Rehberlik, Mandibular protruziv hareket.

INTRODUCTION

The etiology, diagnosis and treatment of temporomandibular joint (TMJ) pain and dysfunction are controversial subjects. Multifactorial etiology has been suggested. Clinical examination often reveals a dental feature such as deep bite, skeletal abnormalities, dental occlusal observations, which is thought to be the "cause" of the patient's pain¹.

One of the goals of orthodontic treatment is the establishment of harmony between occlusal function and the TMJ. Many investigators think occlusion plays a primary role^{2,3,4,5,6,7}. However other findings indicate that occlusion⁸ or orthodontic treatment^{9,10} has no correlation with the incidence of temporomandibular disorders.

There are varying opinions regarding the contribution of occlusion (malocclusion) to

the development of mandibular dysfunction and further the contribution of occlusal alterations (orthodontic and restorative) to the development of pain and dysfunction¹. Presently there are no studies, which suggest that, orthodontic or restorative treatment either prevents or promotes the development of symptoms¹. It has been suggested that excessive horizontal and vertical overlap of the anterior dentition "predisposes" an individual to the development of mandibular dysfunction¹. Some authors^{11,12} demonstrated no relationship between deep bites and condyle position but other authors⁶ suggested that a steep incisal guidance can lead to abnormal movements and that the deep bite can cause posterior condylar displacement, disk laxity, TMJ clicking and pain.

Temporomandibular joint and anterior teeth determine the movement patterns of mandible. To ensure the health of dynamic and static occlusions, temporomandibular joint and anterior teeth, which are called posterior and anterior guidance, must be in harmony⁷.

In early years anterior guidance was discussed independently or dependently of the condylar path. Many authors^{13,14,15,16} found that anterior guidance was correlated with the condylar path. Kubein-Meesenburg¹⁸ showed a biomechanical correlation between anterior and posterior guidance in Class I

malocclusion. They found that patients with TMJ disorders have an increase in the angle of condylar movements compared to normal occlusions without subjective symptom of pain and objective symptom of clicking.

This case report shows the biomechanical relationship between condylar and anterior guidances in the treatment of subjects with deep bite malocclusions.

METHOD

In three subjects, upper incisors were intruded with approach of Burstone segmental arch technique. The patients were treated for six months. The lateral cephalometric radiographs were taken before and after treatment.

In this study dental parameters were measured according to a coordinate system. In the coordinate system which is related to the cranial base, CT_x is a horizontal reference line through point C (the most anterior point of the cribriform plate at the junction with the nasal bone) and point T (the most superior point of the anterior wall of the sella turcica at the junction with the tuberculum sella). CT_y is a line perpendicular to the CT plane at the point T and used as the vertical reference line (Figure 1).

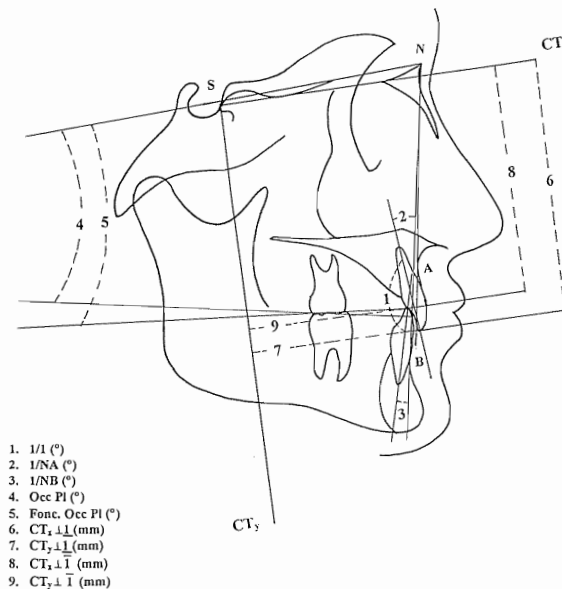


Figure 1. Angular and linear measurements used in the present study.

THE BIOMECHANICAL RELATION BETWEEN INCISOR

In this article, the motion of the mandible is modeled following the approach used in Kubein's study¹⁸. Referring to Figure 2, point D represents the guiding point on the mandibular incisors which glides along the palatal concavity of the maxillary incisors.. This concavity can be mathematically described¹⁸ by a catenary, which can be closely approximated¹⁸ by a circle with radius R_1 . The hinge axis C, on the other hand, moves on an approximate circle (with radius R_2) during the protrusive movement. Under these conditions, the described motion of the lower jaw may be modeled by the, so-called, four bar mechanism shown in Figure 3. In this figure, A represents the fixed point on the lower jaw, which corresponds to the center of the curvature of the palatal concavity of maxillary incisors. B is also a fixed point on the upper jaw that corresponds to the center of curvature of the hinge axis, C. Therefore, AB represents the fixed link of the four bar which corresponds to the upper jaw. The coupler link DC, on the other hand, represents the motion of the lower jaw. In Figure 3, the angles θ_2 , θ_3 and θ_4 represent the positions of lower incisal edge, mandible and condyle, respectively. Initial values of these angles, $(\theta_2)_{ini}$, $(\theta_3)_{ini}$ and $(\theta_4)_{ini}$ show the positions at

the centric relation and, final values, $(\theta_2)_{fin}$, $(\theta_3)_{fin}$ and $(\theta_4)_{fin}$, give the positions after the protrusive movement. $\Delta\theta_2$, $\Delta\theta_3$, and $\Delta\theta_4$ angles represent the differences between initial and final values and give the rotation of lower incisal edge, mandible and condyle, respectively. In this study, $\Delta\theta_2$, which also represent the protrusive motion, is taken at 45° .

$AD = R_1$, $BC = R_2$, $CD = L_{MD}$ and $AB = L_{MX}$ will clearly be different for each patient. In this article, these dimensions are determined by taking measurements from the cephalometric radiographs of the patients. The initial inclination of the posterior guidance¹⁸, α (see Figure 3) is also an angular measurement from the lateral cephalograms of the patients. Once the dimensions of the four bar and α is known, one can determine the initial value of the angle θ_2 , $(\theta_2)_{ini}$, (that corresponds to the position of the four bar described by the angle α) by using the following procedure. Referring to Figure 3, cosine theorem for triangle DCB yields

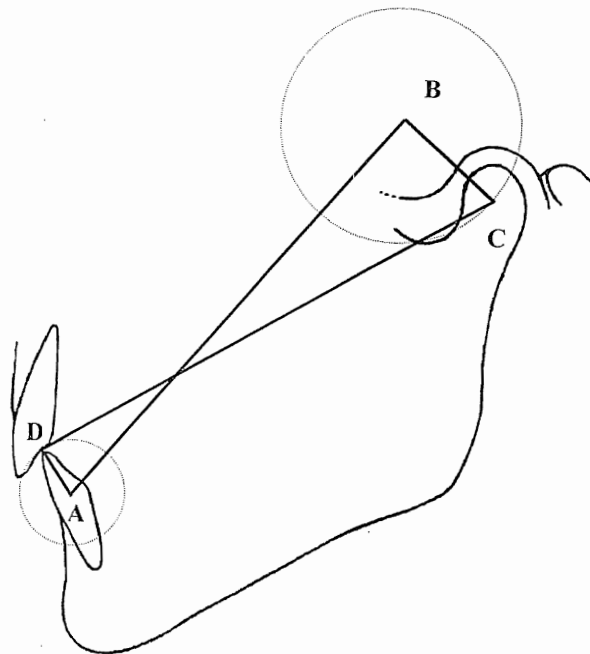


Figure 2. Four bar modeling of the motion of the mandible.

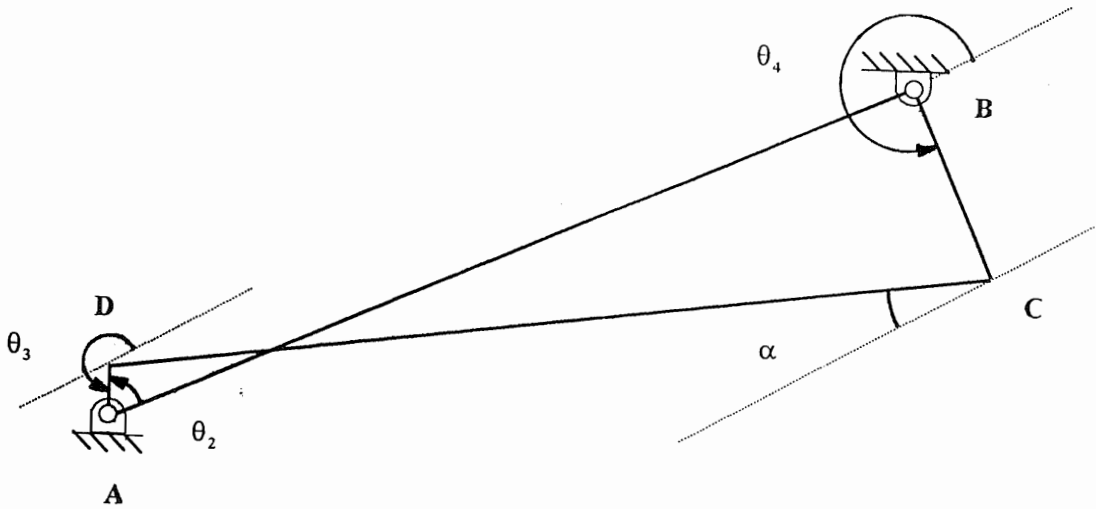


Figure 3. The notation used in the four bar model.

$$DB^2 = L_{MD}^2 + R_2^2 - 2L_{MD}R_2\cos(\pi/2 - \alpha) \quad (1)$$

Cosine theorem for triangle ADB, on the other hand, will yield

$$DB^2 = L_{MX}^2 + R_1^2 - 2L_{MX}R_1\cos(\theta_2)_{ini} \quad (2)$$

Eliminating DB from equations (1) and (2) and solving $(\theta_2)_{ini}$ from the resulting equation, one obtains

$$(\theta_2)_{ini} = \text{Cos}^{-1} \left[\frac{R_1^2 + L_{MX}^2 - L_{MD}^2 - R_2^2 + 2L_{MD}R_2\cos(\pi/2 - \alpha)}{2R_1L_{MX}} \right] \quad (3)$$

For the four bar mechanism shown in Figure 3, when the dimensions and the value of θ_2 are given, the values of the angles θ_3 and θ_4 can be determined via the so-called position analysis of the mechanism. The first step of the position analysis is to write down the loop closure equations. For the four bar shown in Figure 3, these equations are given by

$$L_{MD} \cos\theta_3 = L_{MX} + R_2 \cos\theta_4 - R_1 \cos\theta_2 \quad (4)$$

$$L_{MD} \sin\theta_3 = R_2 \sin\theta_4 - R_1 \sin\theta_2 \quad (5)$$

Equations (4) and (5) represent two nonlinear equations involving the unknowns θ_3 and θ_4 . Subsequent to the squaring, then adding of these equations and adding them up, one may eliminate the unknown θ_3 , yielding

$$(-2R_1R_2\sin\theta_2)\sin\theta_4 + (2L_{MX}R_2 - 2R_1R_2\cos\theta_2)\cos\theta_4 + (L_{MX}^2 - L_{MD}^2 + R_1^2 + R_2^2 - 2L_{MX}R_1\cos\theta_2) = 0 \quad (6)$$

Now, by using the half tangent identities

$$\sin\theta_4 = \frac{2x_4}{1+x_4^2} \quad (7)$$

$$\cos\theta_4 = \frac{1-x_4^2}{1+x_4^2} \quad (8)$$

equation (6) may be transformed into a quadratic equation in x_4 , where $x_4 \equiv \tan(\theta_4/2)$. In general, the quadratic formula will yield two distinct solutions for x_4 , corresponding to two θ_4 values. Corresponding to each θ_4 value, a unique θ_3 value may then be obtained via equations (4) and (5). The two solutions thus obtained for the θ_4, θ_3 pair are said to signify the two different closures, or assembly configurations, of the four bar. Clearly, the correct solution is the one that corresponds to the assembly configuration shown in Figure 3.

Using the procedure described above, the position analysis of the four bar depicted in Figure 3 has been performed for $(\theta_2)_{ini} \leq \theta_2 \leq (\theta_2)_{ini} + \pi/4$ for each of the patients. Note that the selected motion range for θ_2 , [i.e., $(\theta_2)_{ini} \leq \theta_2 \leq (\theta_2)_{ini} + \pi/4$] is assumed to represent the part of the motion where there exists contact between the mandibular incisors and the palatal concavity of maxillary incisors.

CASE REPORTS

Case 1

A 26-year-old female patient reported that she had been feeling severe pain in the temporomandibular joint and experienced limited of mandibular movement. This patient

presented with a Class II division 2 dental malocclusion. The patient used a stabilization appliance before her orthodontic treatment. After 3 months of this therapy, the symptoms had lessened. The upper incisors were protruded during the orthodontic treatment using the Burstone segmental arch treatment technique. Lateral cephalometric radiographs were taken before and after treatment period of six months (Table I).

The angles, which show the initial and final positions of the rotations of the mandible and condyle before treatment, are shown in Table II. The angle of condyle position, $(\theta_4)_{ini}$, decreased from -71.16° to -79.80° after treatment. On the other hand, the condyle rotation (magnitude of the angle $\Delta\theta_4$), $|\Delta\theta_4|$, decreased from 11.85° to 11.16° at the end of treatment.

The changes of the condylar angles and mandible positions in protrusive movement are given as a function of lower incisal edge position in Figures 4 and 5 before treatment and in Figures 6 and 7 after treatment.

Table I. The values of dental parameters measured in degrees before and after treatment in Case 1.

	1/1(°)	1/NA(°)	1/NB(°)	OP(°)	FOP(°)	CT _x ⊥I(mm)	CT _y ⊥I(mm)	CT _x ⊥Ī(mm)	CT _y ⊥Ī(mm)
before	163	13	2	14	14.5	77	56.5	71.5	53
after	141	33	6	10	13.5	74.5	58	70	52

Table II. The angles (degrees) of position and rotation of the lower incisal edge, mandible and the condyle in Case 1.

	(θ ₂) _{mi}	(θ ₂) _{fm}	(θ ₃) _{mi}	(θ ₃) _{fm}	Δθ ₃	(θ ₄) _{mi}	(θ ₄) _{fm}	Δθ ₄
before	78.84	123.84	-12.16	-12.22	0.06	-71.16	-83.02	11.85
after	79.2	124.2	-12.85	-12.58	0.27	-79.8	-91.0	11.16

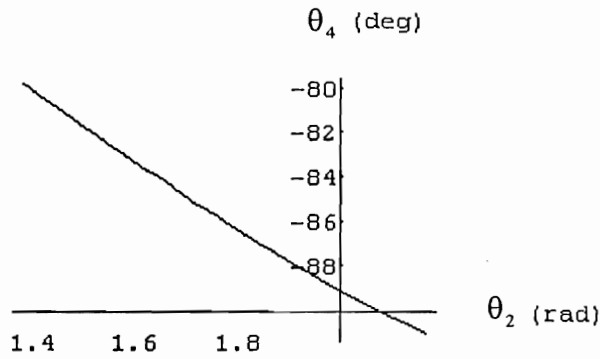


Figure 4. The relation between condyle and lower incisal edge positions in protrusive movement before treatment for Case 1.

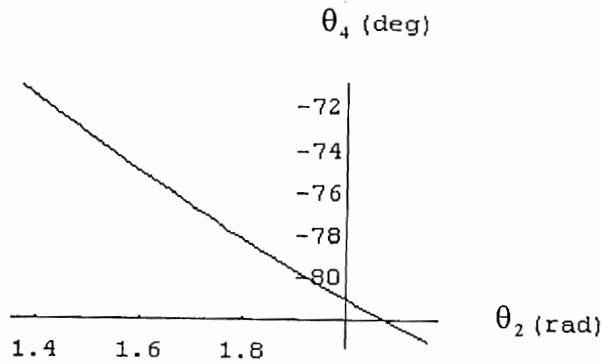


Figure 5. The relation between condyle and lower incisal edge positions in protrusive movement after treatment for Case 1.

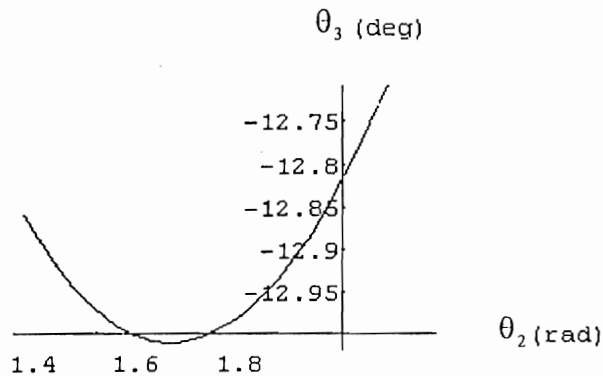


Figure 6. The relation between mandible and lower incisal edge positions in protrusive movement before treatment for Case 1.

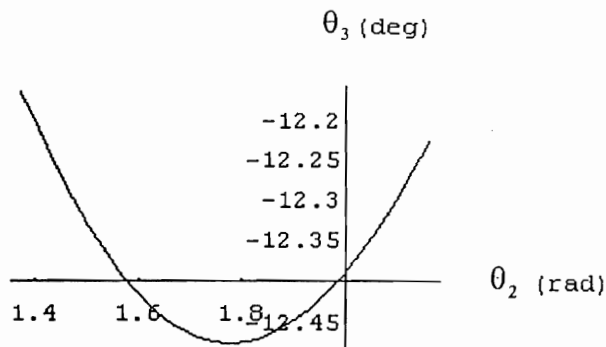


Figure 7. The relation between mandible and lower incisal edge positions in protrusive movement after treatment for Case 1.

Case 2

A 25-years-old female subject with deep bite malocclusion and anterior disk displacement complained of severely aching on temporomandibular joint region. This patient also had Class II division 2 malocclusion. The patient had used a stabilization appliance before orthodontic treatment for 3 months. At the end of this therapy, the symptoms had lessened. During the active orthodontic treatment, which took six months to complete, the upper incisors were protruded and intruded with Burstone's segmental arch technique. The lateral

cephalometric radiographs were taken before and after treatment (Table III).

The angles, which show the initial and final positions as well as rotations of mandible and condyle before treatment, are shown Table IV. The condylar rotation, $|\Delta\theta_1|$, decreased from 13.39° to 12.19° at the end of treatment.

The changes of the condylar and mandibular positions in protrusive movement are given as a function of lower incisal edge position in Figures 8 and 9 before treatment and in Figures 10 and 11 after treatment.

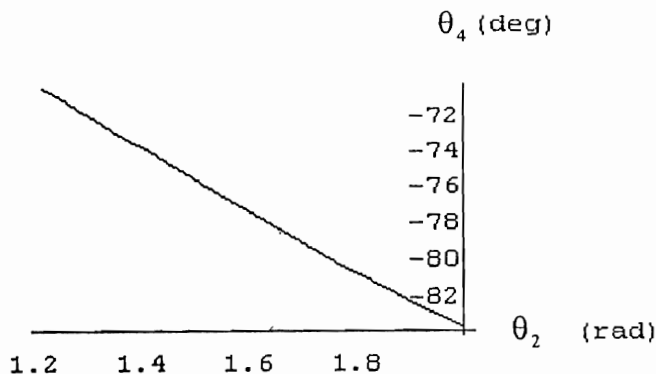


Figure 8. The relation between condyle and lower incisal edge positions in protrusive movement before treatment for Case 2.

Table III. The values of dental parameters measured in degrees before and after treatment in Case 2.

	1/1(°)	1/NA(°)	1/NB(°)	OP(°)	FOP(°)	CT _x ⊥1(mm)	CT _y ⊥1(mm)	CT _x ⊥ \bar{I} (mm)	CT _y ⊥ \bar{I} (mm)
before	161	3	18	22.5	22	84	48	77	45
after	132	16	27	22	22	84.5	51	79.5	48

Table IV. The angles (degrees) of position and rotation of the lower incisal edge, mandible and the condyle in Case 2.

	(θ_2) _{ini}	(θ_2) _{fin}	(θ_3) _{ini}	(θ_3) _{fin}	$\Delta\theta_3$	(θ_4) _{ini}	(θ_4) _{fin}	$\Delta\theta_4$
before	69.82	114.82	-11.50	-11.92	0.42	-70.50	-83.89	13.39
after	84.24	129.24	-11.52	-11.39	0.13	-70.52	-82.71	12.19

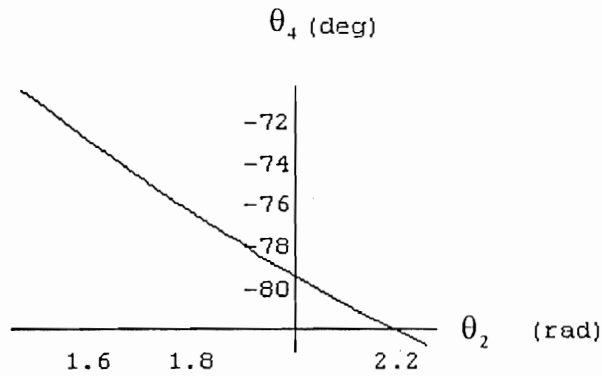


Figure 9. The relation between condyle and lower incisal edge positions in protrusive movement after treatment for Case 2.

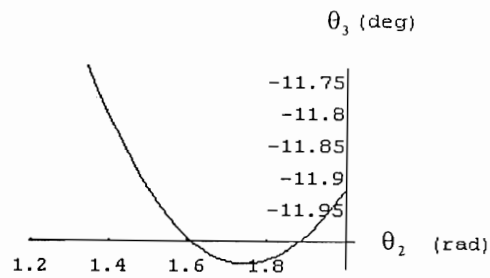


Figure 10. The relation between mandible and lower incisal edge positions in protrusive movement before treatment for Case 2.

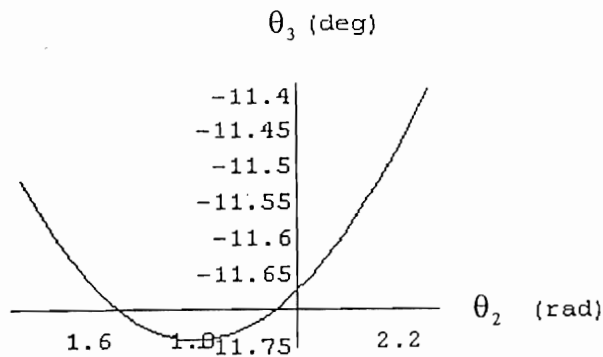


Figure 11. The relation between mandible and lower incisal edge positions in protrusive movement after treatment for Case 2.

Case 3

A 23-years-old male subject with a Class II division 2 deep bite malocclusion and anterior disk displacement, complained of severe aches and sounds in the temporomandibular joint region. After 3 months of a stabilization appliance therapy prior to orthodontic treatment, the symptoms had lessened. The upper incisors were protruded and intruded with the Burstone segmental arch technique. The treatment lasted for six months. The lateral cephalometric radiographs were taken before and after treatment (Table V).

The angles, which show initial and final positions and rotations of the mandible and condyle before treatment, are shown Table VI. The angle of condylar position, $(\theta_4)_{ini}$, decreased from -69.25° to -81.84° after treatment. On the other hand, condyle rotation, $|\Delta\theta_4|$, decreased from 12.41° to 10.88° at the end of treatment.

The changes of the angles of condylar and mandibular positions in protrusive movement are given as a function of lower incisal edge position in Figures 12 and 13 before treatment and in Figures 14 and 15 after treatment.

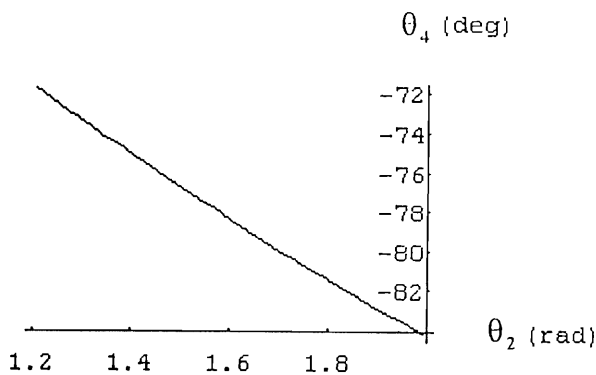


Figure 12. The relation between condyle and lower incisal edge positions in protrusive movement before treatment for Case 3.

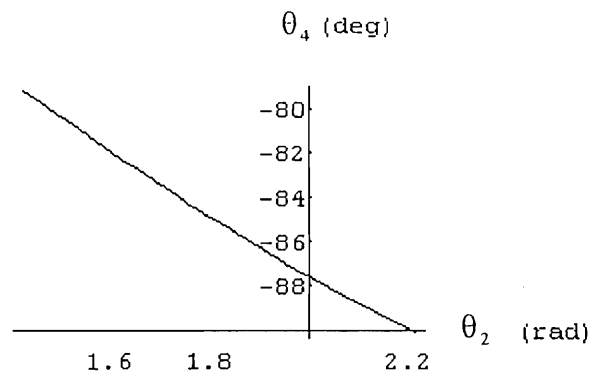


Figure 13. The relation between condyle and lower incisal edge positions in protrusive movement after treatment for Case 3.

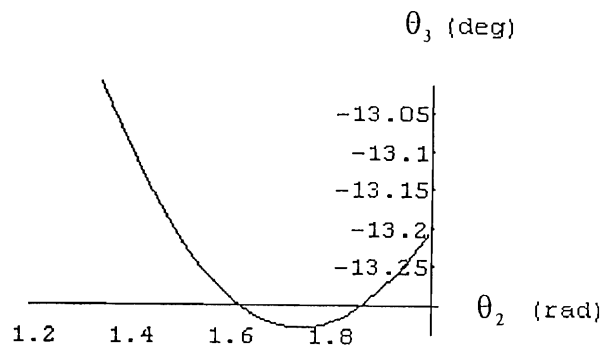


Figure 14. The relation between mandible and lower incisal edge positions in protrusive movement before treatment for Case 3.

Table V. The values of dental parameters measured in degrees before and after treatment in Case 3.

	1/1(°)	1/NA(°)	1/NB(°)	OP(°)	FOP(°)	CT _x ⊥I(mm)	CT _y ⊥I(mm)	CT _x ⊥Ī(mm)	CT _y ⊥Ī(mm)
before	151	15	12	10.5	10.5	90	63	82	61
after	143	23	13	12	12	86.5	68	82	62

Table VI. The angles (degrees) of position and rotation of the lower incisal edge, mandible and the condyle in Case3.

	(θ ₂) _{mi}	(θ ₂) _{fm}	(θ ₃) _{mi}	(θ ₃) _{fm}	Δθ ₃	(θ ₄) _{mi}	(θ ₄) _{fm}	Δθ ₄
before	69.25	114.25	-12.78	-13.21	0.42	-71.78	-84.19	12.41
after	81.84	126.84	-13.14	-12.79	0.84	-79.15	-90.02	10.88

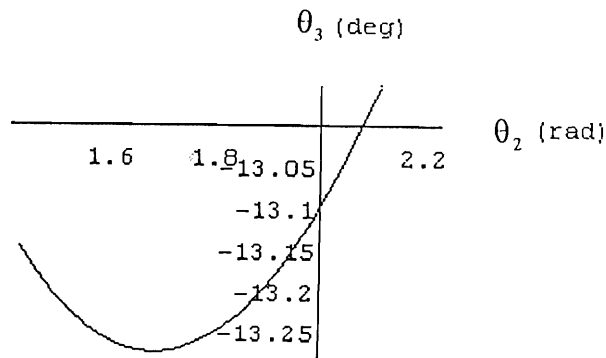


Figure 15. The relation between mandible and lower incisal edge positions in protrusive movement after treatment for Case 3

CONCLUSION

This case reports of these deep bite malocclusions show upper incisor intrusion and protrusion. The TMJ symptoms had decreased in the all the subjects following the orthodontic treatment. The biomechanical relationship between condylar path and anterior guidance of the subjects has been investigated by using a four bar link system model. The following results have been obtained following the completion of the orthodontic treatment (i) the change of incisor position affected the angle of the condylar rotation, (ii) the condylar rotation decreased for the same protrusive movement following treatment compared to the beginning of treatment. Hence it can be concluded that anterior guidance and condylar path are dependent of each other.

REFERENCES

1. Tallents R H, Catania J, Sommers E. Temporomandibular joint findings in pediatric populations and young adults: a critical review. *The Angle Orthod* 1990;61:7-15
2. McLaughlin R P. Malocclusion and the temporomandibular joint. An historical

perspective. *The Angle Orthod* 1988;58:185-191.

3. Morowa A P, Loos P J, Easton J W. Temporomandibular joint dysfunction in children and adolescents: incidence, diagnosis, and treatment. *Quintessence Int* 1985;11:771-777.
4. Perry H T. Mandibular function: An orthodontic responsibility. *Am J Orthod* 1975;67:316-323.
5. Roth R H. Temporomandibular pain-dysfunction and occlusal relationships. *Angle Orthod* 1973; 43:136 -153.
6. Thompson J R. Abnormal function of the Temporomandibular joints and related musculature Part II. Orthodontic implication *The Angle Orthod* 1986;56:181-192.
7. Ramfjord S P, Ash M M. *Occlusion 2nd ed.* Philadelphia: W.B.Saunders Co. 1971: 129-130.
8. Egermark-Eriksson I, Carlsson G E, Magnusson T. A long-term epidemiologic study of the relationship between occlusal factors and mandibular dysfunction in children and adolescents. *J Dent Res* 1987;66:67-71.
9. Sadowsky C, Polson A M. Temporomandibular disorders and functional occlusion after orthodontic treatment: results of two long-term studies. *Am J Orthod* 1984;86:386-390.

10. Reynders R M. Orthodontic and temporomandibular disorders. A review of the literature.(1966-1988) Am J Orthod Dentofac Orthop 1990;97:463-471.
11. Alexander S R, Moore R N, DuBois L M. Mandibular condyle position: Comparison of articular mountings and magnetic resonance imaging. Am J Orthod Dentofac Orthop. 1993;104:230-239.
12. Gianelly A A, Petras J C Boffa J. Condylar position and Class II deep-bite no-overjet malocclusion. Am J Orthod Dentofac Orthop 1989;96:428-432.
13. Okeson J P. Management of temporomandibular disorders and occlusion. St. Lois: Mosby, 1989:124,147.
14. Kantona T R. A mathematical model of mandibular protrusion. J Prosthet.Dent. 1991;66:699-705.
15. Kohno S, Nakano M. The measurement and development of anterior guidance. J Prosthet Dent 1987;57:620-625.
16. Takayama H, Hobo S. Kinematical and experimental analyses of the mandibular

movement for clinical application. Int J Systemics 1984;2:229-304.

17. Ogawa T, Koyano K, Suetsugu T. The influence of anterior guidance and condylar guidance on mandibular protrusive movement. J Oral Rehabil 1997;24:303-309.
18. Kubein-Meesenburg D, Nagerl H, Klam B. The biomechanical relation between incisal and condylar guidance in man. J Biomechanics 1988;12:997-1009.

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