

Original Article

Rotation coordinating device for improving condylar guidance settings of nonarcon articulators: Part I

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ABSTRACT

Background: Setting of condylar inclination is inaccurate in nonarcon articulators because of alteration of the angle between the upper member and condylar track. This article presents a device which can be attached to a nonarcon articulator to rectify errors related to alterations of maxillary occlusal plane-horizontal condylar guidance relation in nonarcon articulators.

Materials and Methods: The device provides tight connection of condylar axis to condylar track by mechanical interdigitation of fragments which are placed on condylar axis and condylar track. Condylar track rotates coordinated with condylar axis. Fragments consist of medial fragments placed on medial surface of articular fossa analogs, lateral fragments placed on lateral surface of articular fossa analogs, and condylar axis fragments placed on condylar axis. The device can be used during condylar inclination adjustment by interocclusal records, changing vertical dimension of occlusion, and occlusal adjustment of restorations. Initial evaluation of the device was performed during an opening hinge movement in a single experiment. The angle between condylar track and the upper member of the articulator was determined by calculation before and after applying hinge movement and with and without the device.

Results: When the device was not used, the postexperimental condylar inclination was 7.31° higher than preexperimental value. Using the device, discrepancy reached 2.17°.

Conclusion: Using this device may lead to more accurate condylar inclination adjustment which is followed by more accurate prosthetic teeth.

Key Words: Articulator, mandibular condylar, jaw relation records, occlusal adjustment, vertical dimension of occlusion

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INTRODUCTION

Occlusal surface of any restoration must not exhibit any interference with mandibular movements.^[1] Horizontal condylar guidance is the posterior determinant of mandibular movements.^[2] Accurate estimation of condylar guidance leads to an increased success rate for prosthetic procedures and reduces clinical errors.^[3,4]

Articulator is an instrument representing the temporomandibular joints and jaws, to which casts may be attached to simulate mandibular movements.^[5] Two major types of articulators have been introduced: arcon and nonarcon. The angle between maxillary occlusal plane and condylar track of an arcon articulator is fixed, but in nonarcon types,

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afore-mentioned angle is not fixed.^[6] Angulation undergoes changing when intentional or unintentional hinge movements are applied on the nonarcon articulator, but correct angulation is maintained in arcon types.

It is mentioned in the literature that certain errors occur in cast restorations using nonarcon articulators^[6] and arcon articulators are widely used for cast restorations because of more accuracy.^[7] Studies were conducted to compare condylar guidance angles obtained from nonarcon articulators with angles from arcon types. Condylar guidance angles were relatively similar in some^[8-10] and also significantly different in others.^[11,12]

Although there are controversies, it seems that using a mechanism that is based on the coordinated movement of condylar track and maxillary member may be beneficial. This article introduces a supplementary device for a nonarcon articulator to prevent changes in angle between maxillary occlusal plane and condylar track during condylar guidance adjustment, alterations of vertical dimension of occlusion (VDO) and occlusal adjustment of restorations.

MATERIALS AND METHODS

Mechanism of function

The device provides mechanical integration between condylar axis and condylar track to transmit rotations of condylar axis to condylar track. This is achieved by tight connection of condylar axis to condylar track by mechanical interdigitation of fragments which are placed on condylar axis and condylar track. Condylar track rotates coordinated with condylar axis by same degree and direction. Therefore, occlusal plane-condylar track angle is maintained [Figure 1].

Fragments

Six bilateral fragments are shown in Figure 2 part a to d for Dentatus ARH (Sweden) articulator. Fragments include (1) condylar axis fragments that are placed on the condylar axis. (2) Lateral fragments which are placed on the lateral surfaces of the mechanical fossa. (3) Medial fragments which are placed on the medial surfaces of the mechanical fossa.

Condylar axis fragments

These are two similar pieces on the left and right side of the condylar axis. Each fragment consists of two parts: a rectangular process in the lateral end and a hollow cylindrical portion. Thicker part (medial

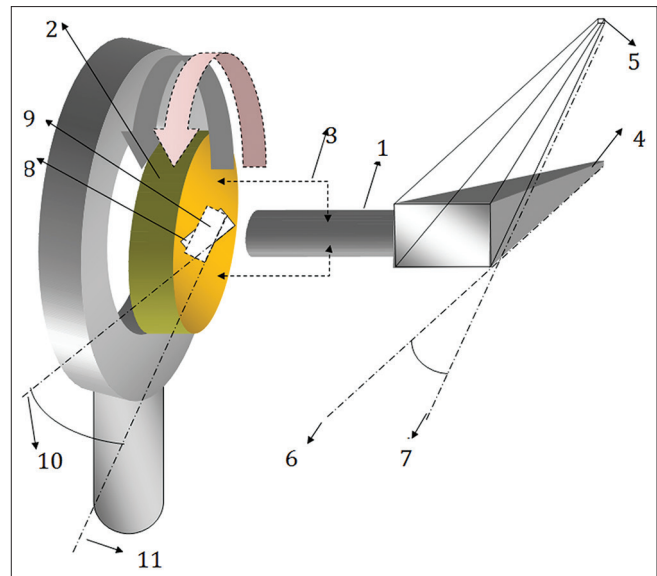


Figure 1: Posterior schematic view of articulator is shown. Angulations of condylar track and upper member change coordinately and equally via tight connection of condylar axis to condylar track; so the angle between them will be maintained. (1) Condylar axis. (2) Condylar track. (3) Tight connection between condylar track and condylar axis. (4) Upper member before hinge movement. (5) Upper member after hinge movement. (6) Upper member plane before hinge movement. (7) Upper member plane after hinge movement. (8) Slot of condylar track before hinge movement. (9) Slot of condylar track after hinge movement. (10) Condylar track plane before hinge movement. (11) Condylar track plane after hinge movement.

portion) of condylar axis is completely fitted in the cylindrical part. The rectangular process is fitted in a lengthwise slot prepared in medial fragments. Two screws are placed in respective holes to fix the fragment to the condylar axis tightly by frictional retention [Figure 2a and b].

Lateral fragments

These are two mirror-image fragments which are placed on the lateral surface of the left and right mechanical fossae. Each fragment is connected to the respective medial fragment by three screws to form an assembly that surrounds the mechanical fossa [Figures 2a, c and 3]. Five screws in respective holes touch the central part of the mechanical fossae (condylar tracks) tightly. It should be mentioned that no hole is prepared on the articulator for the screws.

Medial fragments

These are two similar pieces placed on medial surfaces of the left and right mechanical fossae. Each fragment is connected to the respective lateral fragment by three screws. Four holes are prepared

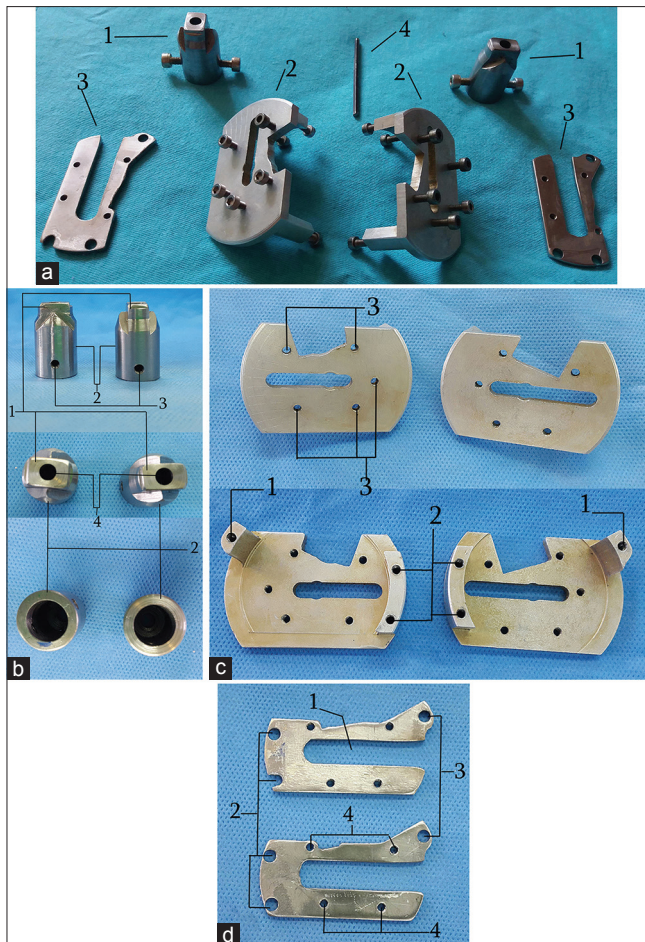


Figure 2: (a) (1) condylar axis fragment, (2) lateral fragment, (3) medial fragment, and (4) Allen wrench for screws. (b) Condylar axis fragment from three aspects (1) rectangular process, (2) cylindrical portion, (3) hole for screw, and (4) hole for passage of condylar axis. (c) Lateral fragments. Up: Lateral aspect. Down: Medial aspect. (1 and 2) Holes for screws to connect medial fragment to lateral fragment and (3) hole for screw to fix the fragment to articular fossa. (d) Medial fragments (1) Lengthwise slot, (2 and 3) hole for screw to connect medial fragment to lateral fragment, and (4) hole for screw to increase retention.

in the fragment for additional screws which touch central part of mechanical fossae (condylar tracks) to provide better retention if needed. A lengthwise slot is prepared on each fragment to interdigitate with the rectangular process of respective condylar axis fragment for providing mechanical integration between condylar axis and condylar track. The lengthwise slot is prepared in a length which allows the upper member to move back and forth unrestrictedly when the fragments are completely interdigitated [Figures 2a, d, 3 and 4].

The condylar track must be connected tightly to the assembly which surrounds the mechanical fossa.

Tight connection to the condylar track is provided by cooperation of three components (1) Screws which are placed on the lateral surfaces of the mechanical fossae. (2) Lateral surfaces of the medial fragments. (3) Screws which connect medial and lateral fragments. Peripheral (fixed) part of the mechanical fossa and also condylar track (central part of fossa) are covered by the assembly of medial and lateral fragments [Figure 4]. However, the assembly is attached to the condylar track (central part of fossa) only because of very thin relief area which is prepared between fragments and peripheral parts of the mechanical fossa.

Applications

The device can be used in situations where the angle between maxillary occlusal plane and condylar guidance changes. Aforementioned situations include adjustment of horizontal condylar guidance through protrusive interocclusal records, alteration of vertical dimension and occlusal adjustment of artificial teeth.

Complete interdigitation between medial fragments and condylar axis fragments cannot be achieved when the progressive side shift angles are not on zero. The complete device exhibits interferences with lateral movements. Hence, lateral and medial fragments are mounted on the articulator when needed and then must be removed. Condylar axis fragments are mounted on the articulator permanently. When the device is not in use, they should be fixed at the most medial position while the rectangular processes stand vertically for preventing interferences with progressive side shift angles adjustment and lateral movements [Figure 5].

Condylar guidance adjustment through protrusive interocclusal records

- (1) Mount the casts by conventional procedures.
- (2) Set the progressive side shift angles on zero.
- (3) Determine horizontal condylar guidance by protrusive interocclusal record.
- (4) Tighten the screws of the condylar track.
- (5) Move medial and lateral fragments to the place and then, tighten the screws to form the assembly surrounding the mechanical fossa. A completely opened position of the articulator makes mounting procedure more convenient.
- (6) Adapt the maxillary member on the record again.
- (7) Loosen screws on the condylar axis fragments and move the fragments laterally until rectangular processes are fitted in the lengthwise slots of the medial fragments completely [Figure 4]. Tighten the screws of the fragments.
- (8) Loosen the screws of condylar track.
- (9) Remove the record and return the maxillary

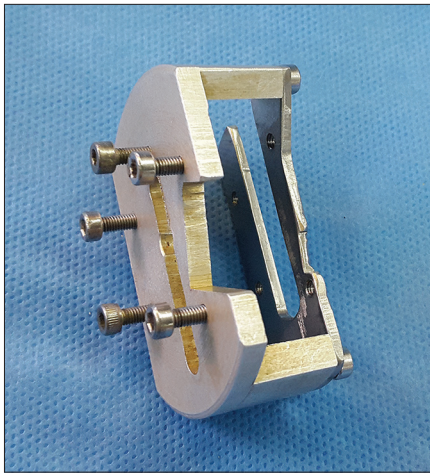


Figure 3: Each assembly consists of medial and lateral fragment. Practically, fragments are assembled on the articulator and this picture is shown for better comprehension.

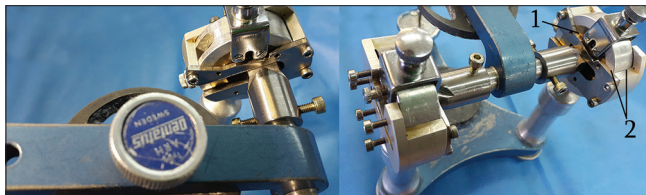


Figure 4: Right: The Assemblies are mounted on the condylar tracks. Condylar axis fragments are interdigitated with lengthwise slots. Central part (1) of the articular fossa analogue (condylar track) as well as peripheral fix part (2) is covered by device. Left: Backward movement of maxillary member is seen in the picture while fragments are interdigitated.

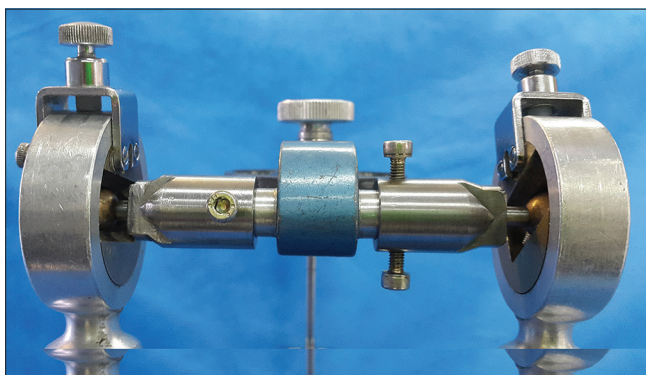


Figure 5: Fragments are mounted on the articulator at as medial as possible position with a vertical direction for rectangular processes.

member to centric position. The condylar guidance is automatically reestablished in correct relation to the maxillary occlusal plane. At this time, an increase is seen in the number on condylar inclination gradation. (10) Tighten the screws of the condylar track and remove fragments except the condylar axis fragments.

Vertical dimension changing

(1) Save the progressive side shift angles and set them on zero. (2) Assemble the device on the articulator. (3) Loosen the screws of the condylar track. (4) Establish the desirable amount of change in VDO. (5) Tighten the screws of the condylar track. The condylar guidance is automatically reestablished in correct relation to the maxillary occlusal plane. When the VDO is increased, the number on condylar inclination gradation decreases and when the VDO is decreased, an increase is seen in the number of condylar inclination. (6) Disassemble the device. (7) Reset the progressive side shift angles to the previous values.

Protrusive occlusal adjustment

(1) Save the progressive side shift angles and set them on zero. (2) Mount the device on the articulator. (3) Loosen the screws of the condylar track. (4) Conduct conventional protrusive adjustment procedure. Condylar guidance is readjusted automatically when inadvertent hinge movements are involved in the simulated protrusive jaw movements. The lengthwise slots prepared in the medial fragments allow free protrusive movements of the upper member of the articulator [Figure 4]. (5) Tighten the screws of condylar tracks. (6) Remove the fragments. (7) Reset the progressive side shift angles to the previous values.

Initial evaluation

At this time, a single experimentation was conducted for initial evaluation of the device. Realistic and practical evaluations are needed for ensuring the reliability of the device functionality.

Two far away arbitrary points selected and marked on a supposed horizontal plane on the lateral surface of the upper member of the articulator assisting a height gauge (Height Gauge, 12×0.0001 Inch; Diamond Brand, China) while the incisal pin number was on zero. Two arbitrary points located on the lateral surface of the right condylar track close to inferior border of track slot were marked by same procedure while the condylar inclination was set on zero. Distances between points on condylar track and upper member were measured by micrometer (Eline GL45512 Stainless Vernier Caliper). Then, condylar inclination was set on an arbitrary angle and heights of points measured assisting the height gauge. The device was mounted, and then an arbitrary opening movement applied on the system. Upper member was stabilized in the position by the incisal pin. Device was removed

and heights were measured [Figure 6a-e]. Angulations of condylar track and upper member were calculated by the following formulas: HC_p : Height of posterior point on condylar track. HC_A : Height of anterior point on condylar track. S_c : subtraction of the heights of points on condylar track. HU_p : Height of posterior point on upper member. HU_A : Height of anterior point on upper member. S_u : subtraction of the heights of the

points on the upper member $D =$ Distance between points located on each articulator component).

$$HC_p - HC_A = S_c$$

$$HU_p - HU_A = S_u$$

$$\text{Arcsin} \frac{S}{D} = I$$

$$I_c + I_u = I_{c-u}$$

I_c and I_u indicate inclination of condylar track and upper member toward horizontal reference respectively. I_{c-u} indicates condylar inclination (the angle between the upper member and the condylar track).

RESULTS

Results for parameters before and after hinge movement, with and without using the device are shown in Table 1. To determine I_{c-u} that is related to condition in which the device is not used, secondary I_u was subtracted from primary I_c . When “The rotation coordinating device” was not used, the postexperimental condylar inclination (65.19°) was 7.31° higher than preexperimental condylar inclination (57.88°). Using the device, discrepancy between pre and postexperimental inclinations was decreased by 5.21° and reached 2.17° . There was 9.48° of difference between the postexperimental angle obtained using the device (55.71°), and the angle obtained without using the device.

DISCUSSION

The angle between maxillary occlusal plane and condylar path of nonarcon articulators changes due to intentional or unintentional hinge movements at such situations are as follows.

Condylar inclination adjustment through interocclusal records

The interocclusal records are 3–5 mm

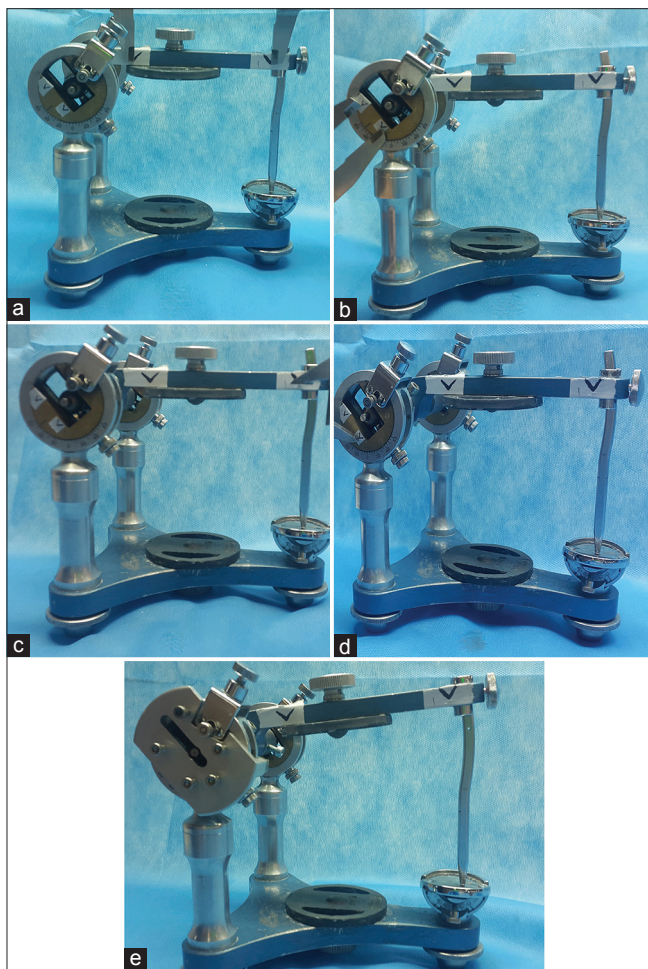


Figure 6: Points on the upper member and condylar track are indicated by arrow tips. (a and b) Distances between points on the upper member and the condylar track were measured. (c and d) Heights of four points were measured. (e) Hinge movement was applied.

Table 1: Measured and calculated values which used for mathematical evaluation

Parameter	HC_p (mm)	HC_A (mm)	HU_p (mm)	HU_A (mm)	S_c (mm)	S_u (mm)	I_c (°)	I_u (°)	I_{c-u} (°)
Before	129.56	113.36	134.74	135.26	16.20	0.52	57.53	0.35	57.88
After	127.40	113.12	137.66	149.00	14.28	11.34	48.05	7.66	BD: 55.71 WD: 65.19

After hinge movement, there is a difference of 9.48° between the angle obtained by using the device and the angle obtained without using the device. “BD” refers to I_{c-u} values obtained using the device. “WD” refers to I_{c-u} values obtained without using the device. Measured values of parameter “D” were 85.00 mm for points on the upper member and 19.20 mm for points on condylar track. HC_p : Height of posterior point on condylar track; HC_A : Height of anterior point on condylar track; HU_p : Height of posterior point on upper member; HU_A : Height of anterior point on upper member; S_c : Subtraction of the heights of points on condylar track; S_u : Subtraction of the heights of the points on the upper member. I_c : Inclination of the condylar track toward horizontal plane. I_u : Indicates of the upper member toward horizontal plane. I_{c-u} : Condylar inclination (the angle between the upper member and the condylar track).

thick.^[7] Following the interocclusal record removal, hinge (closing) movement is incorporated in the movement of the maxillary part back to the first position. Condylar inclination decreases when the teeth are closed together on the nonarcon articulator.^[7]

Vertical dimension of occlusion changing

VDO may be changed necessarily after condylar guidance adjustment. A hinge movement must be applied on the maxillary part for changing VDO. Change in VDO alters the angle between the maxillary occlusal plane and condylar track in nonarcon articulators.^[11]

Occlusal adjustment of artificial teeth

Occlusal adjustment of prosthetic teeth on the articulator is established through simulating eccentric movements. During lateral and protrusive movements, the relationship between maxillary occlusal plane and condylar guidance would change in nonarcon articulators.^[13] Inadvertent hinge movements during eccentric movements are the reason. This leads to inaccurate occlusal adjustment.

Inaccurate condylar guidance adjustment due to nonarcon design leads to inaccurate simulation of jaw movements followed by inaccurate prosthetic teeth. There are some solutions: Shillingburg proposes a difference of approximately 8° between the condylar inclination at the open and the closed positions of the articulator.^[7] Hence, after record removal, the condylar inclination should be set on an angle 8° steeper than determined angle. Naturally, this number is approximate and some degrees of inaccuracy occur. It is proposed in the literature that if VDO is being changed or if interocclusal records have to be taken in some opening of the jaw, arcon articulator should be used.^[14] Centric position may be less maintainable using arcon articulators.^[7]

The brief examination of the device showed that alteration of condylar inclination may be reduced using the device. When the device was used, the condylar inclination alteration was reduced from 7.31° to 2.17°. It should be noted that postexperimental result obtained by using the device was lower than preexperimental interestingly value. Logically, the opening applied movement has tendency to increase the angle between the upper member and the condylar track. On the other hand, mechanism of the device function does not provide rotation of condylar track more than condylar axis, so lower value of postexperimental condylar inclination is interpreted as a result of measurement errors.

We believe that introduced device is a highly effective device to prevent changing the angle between maxillary occlusal plane and previously adjusted condylar guidance in nonarcon articulators and leads to more accurate simulation of jaw movements which is followed by more accurate restorations. The practical effectiveness of the device will be evaluated in the future.

During lateral movements, change in correct angulation occurs in nonarcon articulators,^[15] but this device does not support lateral interocclusal records and lateral occlusal adjustment.

CONCLUSION

We explained a device to prevent changing the angle between maxillary occlusal plane and condylar guidance in nonarcon articulators; so using this device may lead to more accurate simulation of jaw movements which is followed by more accurate prosthetic teeth.

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Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

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