A comparison between arbitrary and kinematic mandibular hinge axis location in full mouth rehabilitation patients (An in vivo study)

Ma'an R. Zakaria, B.D.S., M.S., Ph.D. (1)
Hussain F. Al-Huwaizi, B.D.S., M.Sc., Ph.D. (1)
Widad A. Alnakkash, B.D.S., M.Sc. (2)

ABSTRACT
Background: Casts are often transferred to the adjustable articulator by arbitrary means because the method of locating the mandibular terminal hinge axis is thought to be complicated and time-consuming. The aim of this study was to compare between the arbitrary and kinematic location of the hinge axis in full mouth rehabilitation patients.

Materials and methods: Arbitrary hinge axis was marked at eleven mm from the superior border of the tragus of the ear on both sides of fifty full mouth rehabilitation patients. Terminal hinge axis of each patient was located using the TMJ kinematic hinge axis locator. Position differences between the arbitrary and terminal hinge axes were recorded.

Results: Results indicated that 28% of the patients possessed terminal hinge axes located in an anterior-inferior position to their arbitrary hinge axes from the superior border of the tragus of the ear.

Conclusion: Careful location of the terminal hinge axis as the posterior reference point instead of depending upon an arbitrary marking is recommended to avoid potential sources of error in mounting casts on the adjustable articulator thus preventing statistically different articulator settings.

Key words: Arbitrary, Terminal, Hinge axis.

INTRODUCTION
The hinge axis is an imaginary line that passes horizontally through the rotation centers of both condyles to the right and left when the condyles are in their most distal, unstrained, retruded positions in their respective fossae. It is a position where the condyles can demonstrate pure rotary motion around the horizontal axis of rotation during opening and closing movements of the mandible, thus the name hinge axis, or terminal hinge axis (1). The hinge axis is a fixed anatomic and geometric reference axis that can be relocated repeatedly by mechanical methods. This point is stable in a healthy, physiologically functioning adult joint and can be used as a reference point with accuracy for mounting casts or measuring jaw movement (2). Centric relation is the starting position for all mandibular movements. The position of condyle in centric relation to the maxilla is required to orient the upper cast to the condylar elements, i.e. the condylar axis of the articulator. Face-bow essentially records the positional relation of the maxilla to the condyles in centric relation and later transfers this relation to the articulator so that the maxillary cast is mounted in the same spatial relationship as seen in the mouth (3).

There are two types of face-bows, the kinematic (the actual) axis face-bow and the arbitrary (average) axis face-bow. The kinematic face-bow records the exact axes (centers of condylar rotation) which occur during the hinge movement of the mandible which is essential in transferring information from the patient to the fully adjustable articulator. With the semi-adjustable articulator, an arbitrary condylar hinge axis is utilized for the face-bow transfer to relate the approximate condylar axis to the maxilla (4). If the location of the axis of rotation in relation to the cusp tip differs from the articulator to the patient, the radius of the arc of movement of the cusp tip may be different or the center of rotation may be displaced, and an error will exist. Differences between that radius of movement on the articulator and that in the patient’s mouth can affect the placement of cusps, ridges, and other features of the occlusal surface. For maximum accuracy, the distance between the hinge axis and the tooth being restored should be transferred from the patient to the articulator by the use of a face-bow. If the casts are mounted so that the articulator closes around a different hinge axis than does the patient’s mandible, when the interocclusal record is removed, the teeth will come together in a position on the instrument that is different from that in the mouth. This may occur when no face-bow is used or if only an approximate hinge axis is employed (5).

(1) Professor, Department of Conservative Dentistry, College of Dentistry, University of Baghdad.
(2) Professor, Department of Prosthetic Dentistry, College of Dentistry, University of Baghdad.
MATERIALS AND METHODS

Fifty asymptomatic adult patients (25 females and 25 males) aged 30 to 65 years who required extensive occlusal rehabilitation treatment (patients with either generalized loss of incisal and occlusal morphology due to attrition and faceting of teeth, extensive defective restorations, or multiple missing teeth, associated with moderate or severe OVD collapse) participated in this study. Full mouth rehabilitation patients were recruited from patients seeking fixed prosthodontic work at the Department of Conservative Dentistry, College of Dentistry, University of Baghdad. The criteria for patients’ selection concentrated on the status of being healthy with no oral pathology or history of TMJ pain or dysfunction. Full series of periapical x-rays and a panoramic radiograph were taken for each patient.

Arbitrary mandibular hinge axis location was achieved by placing the index finger tip over the TMJ area and asking the patient to open wide so that when the condyle translated forward, the finger tip dropped into the depression where the condyle was. The patient was asked to close and as the condyle translated back, its position was located by the finger tip. The procedure was repeated to feel the condyle rotation and locate the axis within an average of 2 mm or less since the axis generally occurs near the center of the depression felt by the finger tip. When that point was located, it was marked as a dot by an indelible pencil (6). A measurement method was applied by placing a ruler on an imaginary line running from the patient’s superior border of the tragus to the outer canthus of the eye. The arbitrary axis was marked on the skin at eleven mm anterior to the tragus (4).

Terminal mandibular hinge axis location was performed by using the TMJ kinematic face-bow (TMJ Instrument Co. Inc, USA) following the manufacturer’s instructions. Hinge axis flags were positioned like a pair of glasses on the patient with its nose piece resting on the patient’s nose bridge. Set screws were tightened after positioning the metal flags accurately on the arbitrary hinge axis skin marks. Self adhesive graph paper grids were pressed on the flags for locating the hinge axis. The set screws allowed the flag assembly to adapt to various face sizes (Figure1). Mixed Silicone heavy body impression material was placed inside the universal clutch to secure it on the patient’s mandibular teeth followed by attaching the kinematic face-bow assembly to the universal clutch fork. Applying mild pressure with the thumb to the patient’s chin and angles of the mandible using the rest of fingers to prevent translation, the patient was asked to open and close the mouth in a hinge movement with observing, on one side, the direction and magnitude of the stylus arc against the flag as the mandible moves down. Adjustments were made by the micro-adjustment screws of the kinematic face-bow to allow for superior/inferior adjustments of the side arms until the stylus didn’t translate when the mandible was arced indicating the pure rotational axis of the condyle. The procedure was repeated on the other side of the patient (Figure 2). When the axis locator pin of the stylus achieved a pure rotational movement, the location of the pin point was marked on the flags’ graph paper grids on both sides. When the axis was located, the flags were removed, styli moved out to mark its tip with graphite pencil and with holding the supported mandible in terminal hinge position, each stylus was moved toward the skin to mark it. The kinematic face-bow assembly was detached from the universal clutch which was taken out of the patient’s mouth. The terminal hinge axis point was darkened with a red pen.

RESULTS

Concerning the location of the kinematic hinge axis from the tragus of the ear in relation to the arbitrary hinge axis, the anterior-inferior position was the highest (16%) among female patients followed by the anterior-superior position (12%) while in the male group, the posterior-superior, anterior-inferior, and the similar locations were the highest (12%) (Table 1 and Figure 3). As a total percentage for both sexes, the kinematic terminal hinge axis lied in an anterior-inferior position to the arbitrary hinge axis in 14 of the patients (28%), Figure 4.

DISCUSSION

It has been concluded that an arbitrary axis recording technique would lie within 5 mm of the kinematic axis in 98% of a patient population (7). That finding was corroborated by Cheong (8) who reported 88% correlation in another population sample. Choi et al. (9) considered that important describing the kinematic-axis location as time-consuming and of a complex nature. Our results proved the opposite since locating the terminal hinge axis with the TMJ kinematic face-bow showed that in only one patient (2%), the arbitrary hinge axis lied 5 mm from the kinematic hinge axis and the rest lied less than that. Our results went along with those of Catic and Naeije (10) who found significant differences in the axis location of both groups and its repeatability. Our findings
also coincided with Naeije\(^{(11)}\) findings that there is considerable variation in morphological features of the condyle and thus the location of a particular reference point in relation to the actual condyle may vary among individuals. On the other hand, our findings didn't coincide with those of Tokiwa et al.\(^{(12)}\) who found that the mean location of hinge axis point was 12.9 mm anterior of the porion and 5.3 mm inferior to the Frankfort horizontal plane, and the kinematic axis point was situated in 12.8 mm anterior and 0.1 mm inferior. The cause of the difference could be related to that they investigated eighteen Japanese women only whom their kinematic and hinge axes points were determined using an optoelectronic jaw-tracking system. The effect of the hinge axis on articulation is very closely allied to centric relation which can't exist without the other. The hinge axis can be located only in the terminal hinge position which is an important part of centric relation. The opening and closing components of centric relation relate to locating and stabilizing the terminal hinge action at a convenient level of vertical dimension. If one accurately locates the centers of lateral motion but errs in the location of the hinge axis, the articulation will be out of harmony. The arcs of vertical rotation in the eccentric relations will not be harmonious with the patient's arcs, and lateral stresses will be created. In other words, failure to make use of the hinge axis in an articulation will have the same effect as "missing the bite". The forces of articulation will be in a lateral pattern and destructive. Emphasizing that the maxillary cast can be oriented on the articulator as the patient's maxillae was to the TMJs necessitated transferring the position of the horizontal axis from the patient to the articulator\(^{(13)}\). However, potential differences between arbitrary and kinematic axes necessitate the use of the latter as posterior reference point\(^{(14)}\). Utilizing the kinematic hinge axis locator in our study has supported those clues. It has been reported that since the kinematic center is not an anatomical point which can be recognized on a radiograph which has been considered as a disadvantage; therefore its location must be performed either with a kinematic hinge axis locator or calculated from a 6-degree-of-freedom kinematic data collected during symmetrical jaw movements\(^{(11)}\).

In our study, the mandibular kinematic center of rotation for each patient was located with the TMJ kinematic hinge axis locator.

In conclusion, careful location of the terminal hinge axis as the posterior reference point instead of depending upon an arbitrary marking is recommended to avoid potential sources of error in mounting casts on the adjustable articulator thus preventing statistically different articulator settings especially in complicated occlusal rehabilitation cases.

REFERENCES

Table 1: Descriptive statistics of the location of Kinematic Hinge Axis (KHA) from tragus of the ear in relation to Arbitrary Hinge Axis

<table>
<thead>
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<th>KHA Position</th>
<th>Female</th>
<th>Male</th>
<th>Total</th>
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<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
</tr>
<tr>
<td>Ant. sup.</td>
<td>6</td>
<td>12</td>
<td>5</td>
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<tr>
<td>Post. sup.</td>
<td>2</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Ant. inf.</td>
<td>8</td>
<td>16</td>
<td>6</td>
</tr>
<tr>
<td>Post. inf.</td>
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<td>2</td>
</tr>
<tr>
<td>Same</td>
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</tr>
<tr>
<td>Total</td>
<td>25</td>
<td>50</td>
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</table>

Figure 1: Hinge axis flags in place.

Figure 2: Locating the terminal hinge axis.

Figure 3: Location of Kinematic Hinge Axis from tragus of the ear in relation to Arbitrary Hinge Axis.

Figure 4: Marking the terminal hinge axis on the patient’s skin which was located in an anterior-superior position to the arbitrary axis, pointed to by the pen.