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Review Article

Hinge Axis–A journey from Past to Present

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ABSTRACT

The idea of hinge rotation as related to functional jaw movements has become a bitterly contested tenet in dental literature. Indeed, the validity of rotational axes is still being contemplated in various articles published recently. The first actual kinematic location was done under the leadership of Dr. B.B.Mc Collum through the California Gnathological Society and its credit for the idea was given to Dr. Robert Harlan. Various schools of thought exists on the existence and the necessity to locate hinge axis especially in the field of dental practice when restoring lost natural teeth. So let's explore and identify the significance of hinge or the transverse axis and the various methods to locate the same

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INTRODUCTION

The idea of hinge rotation as related to functional jaw movements has become a bitterly contested tenet in dental literature. Indeed, the validity of rotational axes is still being contemplated in various articles published recently.[1]

Axis rotation is based on the principles of mechanics and it refers to *kinematics*-the mechanics that deals with the possible motions of material body. Since the jaw also has a rotational component of motion it is subjected to the same kinematic law of any rotating object. It is a known fact that any object capable of rotation must do so around a *theoretical or imaginary axis.* This axis will pass through the exact center of the rotating object. This axis still remains a mathematical entity and are being utilized as a control center for rotational movement[1] We know that the mandible rotates about three different rotational axes. These are the horizontal, vertical, and saggital axes. The only axis in mandible, about which pure rotational movement takes place, is the horizontal axis. This axis is called the hinge axis of the mandible. The horizontal hinge axis is an imaginary line connecting the two centers of rotation in each mandibular condyle

During the opening movement of mandible the distance between the incisors is shown to be 20 mm while both condyles remain in their most posterior positions. This movement is known as the terminal hinge opening and closure.[2] The *Terminal Hinge Position* (THP) can be considered the relation of the mandible to the maxillae that results when the mandible makes a rotary opening or closing movement in its most posterior position, i.e., a border movement[3]

DEFINE TO DISTINGUISH

Synonyms: transverse horizontal axis, transverse hinge axis, kinematic axis. An imaginary line around which the mandible may rotate within the saggital plane[4]

Hinge axis -Dated back

The first actual kinematic location was done under the leadership of Dr. B.B.Mc Collum through the California Gnathological Society and its credit for the idea was given to Dr. Robert Harlan.[5] The first location employed a modified Snow facebow and it was performed for 8hrs. New devices and concepts have evolved from this above mentioned mechanism and its attendant theories.

The written history of mandibular hinge axis goes back into the first edition of *Gray's Anatomy.*[6] According to Gray and followers the mandible moves on a hinge and forward and lateral movements of the condyle takes place in the glenoid fossa during movement.

Bonwill in 1860 assumed that the forward movement of mandible was on a straight line in a forward direction. According to him the distance from the centre of each condyle to the median incisal point of the lower teeth was 10 cm. this was used as a standard for mounting casts in the articulator developed by Bonwill. But the drawback was that the level where the occlusal plane should be oriented was not mentioned.[6]

Balkwill of England, in 1865 identified the sliding action of the joint. He stated that the mandible moves on an axis that passes through both the condyles. He described Balkwill's angle which was the angle between the inclination of Bonwill's triangle to the plane of occlusion. According to Balkwill the size of this angle varied from 22 to 30 degrees, with an average of 26 degrees.[7] He also mentioned that the variations in Balkwill's angle influenced the cusp angulation and the sagittal inclination of cuspless posterior teeth in complete dentures. However the world gave no attention to his works and his articles was stored on the shelf of London library.

In 1899, *Snow* recognized the importance of hinge axis and he contributed a facebow to transfer the axis to the articulator. *Campion* in 1905 also recognized the importance of locating hinge axis and emphasized that, in mounting casts on an articulator, the axis of the articulator shaft should coincide with the mandibular transverse hinge axis of the patient.[8]

In 1921 *Mc Collum and Stuart* became convinced that transverse axis in the condylar region about which sagittal plane rotational movements could occur with constancy was recordable.[1] The scientific basis and the practical method for locating hinge axis came through the work of Mc Collum and Stuart in 1921 and the Gnathological Society of California and was based on the earlier studies of Balkwill, Bennet and Campion.

Trapazanno and Lazari[9] showed that more than one terminal hinge axis existed. They used two ipsilateral styli from the same anterior clutch supported rod. After many investigations and studies they concluded that:

1. The presence of multiple hinge axis has been established
2. The technique or recording terminal hinge axis requires two operators
3. Relaxation of the patient during making of terminal hinge axes is essential

4. Because of the presence of multiple hinge axes points,increasing or decreasing the vertical dimension on the articulator is contraindicated unless a new interocclusal record is made on the patient at the desired vertical dimension
5. The concept that only one terminal hinge axes exist is fallacious.

Biological Significance of Hinge Axis Location[10]

In order to understand the biological significance of hinge axis location, let us consider a fully dentulous and a fully edentulous condition. In the fully dentulous condition with full complement of teeth the maximum intercuspation position is a position in where in the maxillary and mandibular teeth and in complete intercuspation. This may or may not coincide with the centric relation position. This maximum intercuspation position is mainly guided by the proprioceptive signals which are present in the periodontal ligament of the teeth. The signals guide the mandible during closing movement. Whereas in case of fully edentulous condition these proprioceptive signals in periodontal ligament are absent hence the guidance mechanism is lost.

It is said that there are certain proprioceptive receptors present in the capsule of tempero mandibular joint. These signals are activated only when the condyle is in the centric relation position or the hinge position. These signals when activated can guide the mandible during opening and closing movement. It is for this reason that the hinge axis determination is essential. The capsular proprioceptors which were of only protective functional value takes over as a guiding principle and the patient will be able to make repeated opening and closing movements and follow the same occlusal pattern.

Schools of Thought[11]

From the earlier experiments on hinge axis there evolved four schools of thought:

1. Absolute location of hinge axis
2. Arbitrary location of hinge axis
3. Non-believers in hinge axis
4. Split axis rotation

Absolute Location of Hinge Axis

This group believes in the existence and transverse hinge axis and also believes that it can be recorded accurately. They came up with the following conclusions:

1. With the use of face-bow the articulator axis can be related to the maxillary cast in the same way as the anatomic axis is related to human maxilla.
2. The mandibular hinge axis and maxillary hinge axis are coincided using a centric relation record.
3. In doing so the path of closure of mandible and the articulator will be the same
4. This helps in placement of cusps in a way that it does not collide during border movements
5. The hinge axis is a component of every masticatory movement. This entity cannot be disregarded
6. The hinge axis relationships between the articulator and the jaw must be the same. Otherwise the mechanical reproduction of jaw motions on the articulator is impossible.

Arbitrary Location of Hinge Axis

This group believes that accurate location of hinge axis would be of very little value and proposes the effortless and arbitrary location is sufficient. Craddock states "But the search for the axis, in addition to being troublesome, is of no more than academic interest, for it will never be found to lie more than a few millimeters distant from the assumed center in the condyle itself". But according to group 1, this group fails to recognize that if the hinge axis of the patient and the articulator are not coinciding the path of closure will not be the same.

Non Believers

The third group believes that hinge axis is theoretical and not practical. It is not possible to locate hinge axis with accuracy. According to Lauritzen and Wolford if the terminal hinge position could be located consistently within a radius of 1mm, this would be more acceptable than a location with a variance of a 2 mm radius. Actually, neither one is accurate, but the first is certainly more accurate than the second. It is because the sense of perception and delicacy of touch different for different individuals. Boucher commented, "The test seems to be one of the accuracy of the machine work on the instrument rather than one of the validity of a hinge axis registration."

Split Axis Group

These were called the Transograph men. They believed that each condyle rotated independently of each other. Slavens states "by definition, an axis is always a line, never a point. Again, by definition, an axis is invariably perpendicular to the path or plane of rotation it controls. This means that the transverse axis of each joint is a line and both of these are perpendicular to the same plane of opening and closing rotation"

Methods to locate hinge axis

The two popular methods of locating hinge axis are:

1. The arbitrary method
2. The kinematic method

Arbitrary Method

Also called the Anatomic method of locating hinge axis. Most commonly used method especially in complete dentures because of the ease of technique. The proponents of group 2 school of thought proposed the arbitrary methods to locate hinge axis. Various anatomic landmarks were used to locate hinge axis arbitrarily. According to them this method provided enough accuracy for restoration of mouth, if occlusal vertical dimension is not going to be altered to a significant extent.

Various hinge axis points proposed by the proponents of this group are as follows:[12]

1. *Denar*–12 mm anterior to posterior border of the tragus and 5 mm inferior to the line extending from the superior border of the tragus to the outer canthus of the eye.
2. *TSN*–12 mm anterior to centre of the external auditory meatus on the Frankfort plane
3. *Lauritzen and Bodner*–12 mm anterior to the centre of external acoustic meatus and 2 mm inferior to the porion–canthus line
4. *Whip Mix*–according to the design of their ear-bow, in antero posterior direction at anterior wall of external acoustic meatus and in the superior-inferior direction approximately at the level of most prominent point of posterior border of tragus
5. *Prothero*–on line from superior margin of the external acoustic meatus to outer canthus of the eye intersecting with line 13 mm anterior to anterior edge of external acoustic meatus according to Richley's condyle marker
6. *Brandrup-Wognsen*–12 mm anterior to most prominent point of posterior border of tragus
7. *Beyron*–13 mm anterior to posterior margin of tragus on line from the centre of tragus to the outer canthus of the eye
8. *Gysi*–13 mm anterior to anterior margin of external acoustic meatus on line from superior margin of external acoustic meatus to outer canthus of eye
9. *Bergstrom*–10 mm anterior to centre of spherical insert of his face bow and 7 mm below Frankfort plane

10. *Schallorn*–13 mm from the posterior margin of the tragus to the canthus.

Beck in a study compared the arbitrary points of Gysi, Beyron and Bergstrom in 12 subjects. He found Bergstom's point to be the closest with 4.1 mm from the kinematic axis, Beyron's point the next which was 5.7 mm from the kinematic axis and Gysi's 10.7 mm from the kinematic point.[13]

Kinematic method[14]

The kinematic method is not the commonly used method of locating hinge axis because of the complexity in procedure. It is used only in fixed prosthesis warranting a reorganized approach. The device consists of the following parts:

1. Clutch/ bite fork
2. Cross bar and stud
3. Axis indicator
4. Graph pad
5. Universal clamp/ screws

The recording is started with the patient seated in upright position away from the back or head rest. The clutch is attached to the mandibular teeth or the occlusion rim. It is stabilized to teeth using impression compound. The graph pad is positioned over the condyle. The cross bar is attached to the clutch by means of universal clamp. The axis indicator is attached to the assembly and positioned over the graph pad over the condyle. The axis indicators are adjusted such that when the patient opens and closes the mouth the indicator no longer moves in an arc, rather it rotates on a single point. The graph background is removed and that point is marked on skin. The assembly is then removed.

According to Irwing. M. Sheppard, the insertion of clutches alters the closed position of the condyles in most of the joints. In some instances it can also limit condylar movement.[15]

CONCLUSION

The existence of hinge axis still remains a dilemma for many clinicians. The importance of location is still not clearly understood. This concept requires further studies in detail as there are a lot of controversies. This article would pay way for further research into the existence and the necessity of hinge axis.

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