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A Conception versus Contention of Mandibular Axis

Research Article

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Abstract

The mandibular axis is considered to be the axis along which the temporomandibular joint(mandibular condyle) in its terminal, and the retruded position has a purely rotational movement without any translation. Its significance in prosthodontics has been associated with the centric relation position and the fabrication of prosthesis with regards to this position. Its role during functional mandibular movements has therefore been questioned. This has led to various schools of thought on the presence/absence, location, and the number of the hinge axis with proponents for and against this. This review article aims to discuss the concepts and controversies surrounding the hinge axis and the current clinical significance of this concept.

Keywords: Hinge Axis; Terminal Hinge Axis; Centric Relation; Temporomandibular Joint; Condylar Rotation.

Introduction

The temporomandibular joint (TMJ) is a complex joint in the head and neck region with the two articular surfaces being formed by the temporal bone and the mandible. The articular eminence and anterior mandibular fossa of the temporal bone form the superior articular surface and the mandibular condyle forms the inferior articular surface. The articular surfaces have a fibrocartilaginous covering.[1]

The TMJ being aginglymodiarthrodial joint (gliding hinge), is the only one of its type in the body differing in its form and function from other joints. Effectively the meniscus or articular disc separates it into two joints. The gliding movement takes place in the superior compartment, above the meniscus while the hinge movement takes place in the inferior compartment, below the meniscus. The center of rotation of the condyle and the articular disc coincides such that the meniscus moves along with thecondyle as it traverses anteriorly, posteriorly, or laterally.[2]

The opening and closing movement of the mandible is always a combination of the gliding and hinge factors making the understanding of mandibular dynamics confusing. The only position in which the condyle can have a pure rotational or hinge movement is when the condyle is as far as it can go by its muscular power into the glenoid fossa. This is a repeatable and reproducible position that can be achieved by training the patient andused to determine thecentric relation.[1, 2]

Any three-dimensional object that moves in a coordinated rotational path of motion, which is part of a circle or ellipse, has an axis of rotation and the motion is perpendicular to this axis. (Weinberg, 1959). The imaginary line or axis around which the condyles have pure rotational or hinge motion without translation is known as the hinge axis.[3]

In a three-dimensional view, there are different axes of rotation of the mandibular condyles based on the plane from which it is viewed and the movement of the condyle is perpendicular to the axis of rotation. In the vertical or sagittal plane, the axis which passes through both condyles is associated with rotation of the mandible and is termed the transverse hinge axis. Rotation in the

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transverse or horizontal plane and is by the working side condyle and is along the physiologic vertical axis of rotation. The sagittal axis goes through the working side condyle and rotation along this axis is by the balancing condyle with rotation in the frontal plane.[4]

Multiple authors have defined the hinge axis. According to GPT -9, the Transverse horizontal axis is defined as an imaginary line around which the mandible may rotate within the sagittal plane. Boucher defined it as "An imaginary line between the mandibular condyles around which the mandible can rotate without translatory movement" while Heartwell defines it as "an imaginary line around which the condyles can rotate without translation. The opening axis is an imaginary line around which the condyles may rotate during the opening & closing movements of the mandible." "The hinge position or the terminal hinge position is that position of the mandible from which or in which pure hinge movement of a variably wide range is possible" as described by Sicher.[9]

If the path of motion of a body, in this case, the mandibular condyle, is part of a circle, the axis of rotation itself is not moving. This is observed clinically when it is closing as if on a hinge such as during minimal mouth opening. If the path of motion is an ellipse, then the axis itself moves i.e., when the condyles are translating such as in the wide opening of the mouth. No purpose is served by recording this translatory axis or position without first locating the terminal hinge position which is considered the "starting point".[3]

Hinge Axis And Centric Relation

The loss of teeth in a patient leads to the loss of periodontal proprioception and thereby the loss of the guiding signals to the mandibular musculature during the closure of the jaw.

The pattern of proprioceptive stimuli must be reestablished by teaching the patient to move the mandibleas posteriorly as possible, into a repeatable border position. This is done when the centric relation is recorded as it is assumed that in the retruded position (terminal hinge position) the anteroposterior relation of the mandible to maxilla is the same as the centric relation.[1]

Movement from the terminal hinge positionis always less than the maximal mouth opening and is a conditioned response. As discussed previously this position is significant because it is a learnable, repeatable, and recordable position.

The extent of hinge movement, while the condyles are in this position, is approximately 12 to 15 degrees from maximum intercuspation or approximately 19 to 20 mm between the upper and lower incisal edges. The condyles occupy a definite position in the mandibularfossae during these terminal hinge movements. [1]

The chewing cycle cannot occur in centric relation but when the bolus is being prepared for swallowing, maceration of it by the teeth needs a strong muscular force. The condyles, at this point, traverse the path that the fossa anatomy dictates (upward and backward) and try to seat themselves as far as they will go by these muscular forces into the glenoid fossa. The intervention of teeth at this point such as any premature contacts will generate a lateral force proportional to the muscular force and the extent to which the mandible is out of centric. [5]

Excessive pressure on the borders of the disc which are innervated can also lead to pain in case of eccentric condylar-disc relation. It can also lead to muscular spasms due to the excess proprioceptive stimulation by the PDL and TMJ.

Clinical Significance

As stated by Cohen recording the hinge axis can help to mount study casts to determine if the patient's centric relation is coinciding with centric occlusion. Working casts can be mounted in the best relationship for the teeth or the denture bases. Since the hinge is a fixed component of every closing position of the mandible, it is necessary to reproduce it on the appropriate instrument if the occlusion is to be rehabilitated. It is possible to increase or decrease the vertical dimension on the instrument without disturbing centric relation.[1]

Weinberg on the other hand stated that the recording of the hinge axis only helps in orienting the maxilla and determine the static starting point for functional mandibular movements.

He emphasized that recording this axis or position does not help in recording either the condylar movements or centric relation.3

There has been much criticism concerning this trained hinge movement as patient function during opening is usually accompanied by condylar translation as well; therefore it can be used only to determine the starting point of mandibular opening and not the path of the condyle. [3]

Locating The Hinge Axis [6]

- Arbitrary hinge axis location by the use of arbitrary face bows.
- Location of true hinge axis with kinematic face bows

CONTROVERSIES [7]

❖ Existence and accurate location of Hinge axis.
❖ A single or Multiple hinge axis exists.
❖ Clinical usefulness regarding the location of the hinge axis.
❖ Whether an arbitrary point can be substituted for a kinematic axis (Gordon, 1984).

Sloane (1952), Granger (1952), Thompson (1954), Kornfeld (1955), Aull (1963) suggested that there existed only one hinge axis. However, other authors argued the presence of multiple axes. Kurth and Feinstein (1951) said that multiple points may act as hinge points and Beck (1959), Trapozzano, and Lazzari (1967) claimed the presence of multiple hinge axis.[7, 8]

The proponents of Gnathology, claimed there was one transverse hinge axis for both condyles that could be determined accurately. The proponents of Transographics, on the other hand, claimed that there is a different transverse hinge axis for each condyle which could only be recorded by a transograph.[7]

Still, others claimedthe impossibility of exact duplication of movements of the mandible and instead to make use of an articulator, that utilizes a face bow transfer and several average values to replicate excursive movements.[7]

Schools Of Thought

Absolute Location of the Hinge Axis [2]

This school of thought is based on the philosophy that there is a definite transverse axis that can be located accurately. This can be done with a face bow and is used to mimic the relation of the maxillary cast to the articulator and its transverse similar to how the maxillae are related to the mandibular condyles and the teminal axis. [McCollum (1955), Lucia (1960)][3]

This will also lead to a similar path of closure intraorally and on the articulator. Some articulators such as Gnathoscope, Hanau, Gnatholator House, Dentatus, Terrell, and Bergstrom Arcon used this priniciple.[10]

Granger (1954) The mandible is capable of an infinite variety of paths of movement; one condyle could be undergoing only rotational movement while the other condyle was both rotating and gliding, or both could be rotating and gliding simultaneously. The split hinge rotation was discarded as the condyles were positioned in centric relation only when the mandible was in the most retruded or backward position. Successful treatment depended upon the correct orientation of the teeth to each other and the hinge-axis.[11, 12]

The study by Aull in 1963 is representative of the design of single-axis "proof". His design employed 4 styli from one mandibular clutch supporting rod. The proof was demonstrated by the fact that all 4 points located (2 on each side) lay in a straight line and therefore, both condyles must have a common collinear axis.8, 13 Also supported by Brotman (1960), Cohen (1961), Weinberg.[1, 3, 5]

The theory was criticized as they concluded the articulators were designed based on imaginary lines drawing the same midpoint on either side. However, the claim was discarded as mandibular anatomical apparatus are bilaterally asymmetrical in size and shape. As the condyles do not lie in a common plane of orientation with a single possessing of the intercondylar shaft.[2, 13]

True Hinge Axis Location

Kinematic facebow uses the terminal hinge axis and inferior orbital rim as reference points.The area of the true hinge axis is located by palpating the subject's condyles during the opening and closing of the mandible.The kinematic method is not the commonly used method of locating hinge axis because of the complexity of the procedure. It is used only in fixed prostheses warranting a reorganized approach.[1]

The hinge bow or kinematic facebow is used to locate the true hinge axis. A clutch and assembly which has two adjustable pins near the condyles are attached to mandibular teeth. The patient opens and closes in a trained (unstrained) rotational path of motion and when this path of motion is part of a circle (if the condyles do not translate), the pin assembly can be manipulated and adjusted for only rotatory movement. A graph paper is then placed [5, 14]

ADVANTAGES[7]

- The hinge axis location is exact. This leads to decreased chair sie time required for trimming.
- Occlusal discrepancies are well visualized, corrected, and kept to a minimum especially in cases of full mouth rehabilitation, thus increasing the prognosis and patient comfort.

DISADVANTAGES[7]

- Patient comfort is compromised while recording because of the armamentarium used.
- The insertion of clutches might lead to altered position of condyle which might interfere with the absolute location.
- It is technique sensitive and warrants remaking.
- It can be used only with a fully adjustable articulator.
- The procedure is time-consuming

Arbitrary Hinge Axis Location

The Arbitrary Hinge Axis location is also known as Anatomic technique of locating the position of hinge axis. It is the most commonly used method especially in complete dentures because of the ease of technique. Proponents of this theory said that the determination of the true hinge axis is not essential when one looks at the effort required to find it. This method in conjunction described adequate accuracy for rehabilitation of the oral cavity, without hampering the vertical dimension at occlusion significantly.

The hinge axis was pinpointed arbitrarily based on anatomical marker. Scallhorn found that the hinge axis points were located 13 mm anterior to the distal marginal border of the tragus muscle on the line between tragus – distal orbital line angle within a 5 mm radius of the kinematically located axis in 95% of the individuals.[15]

Beyron found that approximately 87% of the located points were within a 5 mm radius of the arbitrary points.Lauritizen and Bodner found only 33% of the true axis points to be located within a 5 mm radius of the arbitrary points.[16] Teteruck and Lundeen found similar results.Walker found that 20% of the true axis points were located within 5 mm from the arbitrarily selected point.[17]

Palik, Nelson, and White found that the earpiece face-bow related the maxillary cast to the hinge axis only 50% of the time. 92% of the time the arbitrary axis was located anterior to the terminal hinge axis.

According to Weinberg (1959), the anatomic transverse hinge axis location and the subsequent face bow transfer within a 5 mm error is a practical and dependable method for orientating the maxillary cast. Inter-occlusal centric relation records that limit the interocclusal opening to 6 mm at the incisors produce a negligible error (0.1044 mm at the incisors).

Based on these different authors suggested the use of various anatomical landmarks as posterior reference points to locate the hinge axis arbitrarily with facebows. These reference points include:[18]

➢ Bergstrom's point - A point 11 mm anterior to the center of a spherical insert for the auditory meatus and 7 mm below the Frankfort horizontal plane.

➢ Beyron's point - A point 13 mm anterior to the posterior margin of the tragus of the ear on a line from the center of the tragus to the outer canthus of the eye.

➢ Gysi point -10mm anterior to posterior margin of tragus on a line from the center of tragus to the outer canthus of the eye

Advantages

- Less time-consuming procedure.
- The technique is very simple to practice.
- The uncomplicated procedure leads to a reduction in errors in location.
- Records almost 5mm around the absolute location by kinematic hinge axis.
- Can be used with a semi-adjustable articulator.

DISADVANTAGES

As it isn't an absolute location, a 5mm error around this true hinge axis might lead to an array of occlusal discrepancies, which tend to considerably increase the chairside time.

Beck (1957) made a comparison of four axes of rotation:[19]

- Bergstrom's axis: 10 mm anterior to the center of the auditory meatus and 7 mm below Frankfort plane.
- Arbitrary axis is given by Gysi: lies online from upper border of external auditory meatus to canthus of the eye, and 13 mm ant of margin of the meatus.
- Arbitrary axis is given by Beyron: 13 mm anterior to posterior Margin of tragus, on the tragus-canthus line.
- The kinematic axis is given by McCollum

Within radius of 5 mm, the Bergstrom point is the most favorable with the kinematic points,

Next came Beyron's axis points, whereas from the kinematic points, the Gysi point showed a rather greater deviation from the true hinge axis.

This theory received considerable critics owing to the failure to recognize that in case the hinge axis of the articulator and patient don't coincide, then the path of closure wouldn't be the same.[2]

Split Axis Rotation

Proponents of this school of thought follow the 'Transographic theory' proposed by Page. The supporters believe in the 'Split axes where each condyle rotates independently of each other. Owing to the asymmetry present in the mandible the axes are not bilaterally symmetrical and the terminal hinge position mark on either side of the face is slightly higher than its position on the other side, thus concluding that there cannot be a common axis.[20, 21]

There have been two axes that are parallel to one another with both axes at right angles to opening and closing movements of the mandible. Owing to the irregular morphology of the condyles they do not have a commonpoint of rotation. Frank in his study of condylar positions using Roentgenographic reports, concluded that no one condyle was placed in symmetry to its opponent.[20]

Harry Page brought a big challenge to the traditional concept of only one inter condylar axis proposing his transographic concept. He hypothesized that every condyle has its axis of rotation and that there exists two, noncolinear, mutually independent axes. Page stated that such independence from the mutual axis is allowable anatomically and mechanically possible which can be attributed to the flexibility of the mandible.[22]

Critics say that unidirectional movement in a single plane can only have one rotational axis as the concept of having two axial centers for the same direction and plane seem contradictory.

Considering the anatomy and physiology of the TMJ , the vertical height of the translating condyle would have to change in case the presence of two independent axes should be considered acceptable.[2, 13]

Non-Believers in Transverse Axis Location

Proponents of this theory stated that the concept of transverse axis is only theoretical and not practical as the location of the transverse hinge axis with accuracy is impossible.[25]

Bohr and Posselt were unable to record the hinge axis on a modified Hanau H articulator without any errors. Errors estimated to 1-1.5 at an opening of 10-15 degrees.

Authors like Beck suggested that the opening and closing movements of an articulator cannot be replicate the actual movement of a mandible, as the articulator moves only along a single axis

In 1962, Shanahan postulated that the artificially produced jaw movements, an axis of the mandible, position of the jaw are not physiologic. No evidence of rotation about a single mandibular axis in the condylar region along with translation anteriorly was found in these studies of the masticating movements as well as opening and closing movements.[23]

Kurth and Feinstein in 1951 mathematically investigated the determination of the hinge-axis concluding that owing to all the variables like anatomy, physiology, the ability of the patient to follow instructions, operator's prejudice, and perception, it was less likely that the location of the hinge-axis could be accurate.[24]

The critics of this group claimed that the primary motion is purely rotational along with some amount oftranslation, thus adding up to a common center of rotation. The repeatability of this motion makes it a reliable orientation point. [24]

Conclusion

Despite the numerous studies on the hinge axis, its concept is one of the most discussed controversies in the literature. The varying schools of thought with regards to its existence and its actual location often generate doubt regarding the application of this concept in clinical practice.

As Cohen correctly stated that the accurate value of an individual's work can only be measured in terms of fineness that is reflected in our practice of dentistry rather than which school of thought do we prefer over the other.

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