



ISSN: 0976-3376

Available Online at <http://www.journalajst.com>

ASIAN JOURNAL OF
SCIENCE AND TECHNOLOGY

Asian Journal of Science and Technology
Vol. 10, Issue, 04, pp.9639-9641, April, 2019

REVIEW ARTICLE

HINGE AXIS: CONCEPTS, THEORIES AND CLINICAL SIGNIFICANCE - A REVIEW

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ARTICLE INFO

Article History:

Received 17th January, 2019

Received in revised form

24th February, 2019

Accepted 20th March, 2019

Published online 30th April, 2019

Key words:

Hinge Axis, Arbitrary, Absolute, Split axis, Transographics.

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Citation: Dr. Dipankar Pal, 2019. "Hinge Axis: concepts, theories and clinical significance - A review", *Asian Journal of Science and Technology*, 10, (04), 9639-9641.

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ABSTRACT

The hinge axis is an imaginary line around which the condyles can rotate without translation. Terminal hinge position is the most retruded hinge position and it is significant because it is a learnable, repeatable and recordable position that coincides with the position of centric relation. There are many schools of thought regarding hinge axis. The proponents of Gnathology say that there is one transverse hinge axis common to both condyles which can be accurately located. The proponents of transographics claim that each condyle has a different transverse hinge axis and that a transograph is the only instrument that can duplicate this. Still others claim that an exact duplication of jaw movement is not possible on any machine. The aim of this article is to throw light on concepts, various theories and rationale of hinge axis.

INTRODUCTION

The subject of occlusion and mandibular movements has been studied for many years. Though not thoroughly understood, its significance to all aspects of dentistry is widely accepted. One pertinent aspect of the subject which has led to much discussion, arguments and confusion is the theory of hinge axis. We know that all the elements of the stomatognathic system (i.e. muscles, teeth and condyles) must work in harmony along with coordination of the neuromuscular system guided by proprioceptors for successful function of the masticatory system. Any dysfunction among any one of these elements will lead to symptomatic changes in the weakest member. In pursuit of this aim, the management and establishment of proper maxillomandibular relationships is of virtual importance. The first step in establishing correct jaw relationship is the face bow transfer. The only axis about which mandibular movement takes place in a pure form is the horizontal or hinge axis of the mandible. This axis therefore has an immense importance in orienting the jaws in proper relationship.

Definition: Boucher has defined hinge axis as "an imaginary line between the mandibular condyles around which the mandible can rotate without translatory movement". According to Sicher, "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".

History and development of the hinge axis concept: The written story of the mandibular hinge axis goes back into the

first edition of Gray's anatomy. Gray and those following him recognised that the mandible moves on a hinge as well as by the forward and lateral movement of the condyles in the glenoid fossa. The temporomandibular orientation was called a "ginglymo-arthroidal" joint by Gray. Until the time of Bonwill, American dentists treated the joint as if it had only hinge action. This is evidenced by the hinge-like articulators they invented and patented during that period. Balkwell of England, in 1824, called attention to the sliding actions of the joint. However dentists nowhere in the world paid heed to his proposal. Bonwill assumed that the forward motion of the joint was on a straight line in a forward direction. This idea held precedence for 40 years, until Walker proved that the motion was forward and downward. Snow recognised the importance of hinge axis to other jaw motions and he contrived the face bow for transferring this axis to a mounting instrument. (Campion, 1902, 1905) stated that there was no axis but the movements were a complex one, consisting first of rotation and secondly of a forward and downward one. He probably produced the first graphic records of mandibular movements on a patient. (Bennett, 1908) was of the opinion that there was no single fixed rotation since centre of rotation constantly shifted for movements in a sagittal plane. Mandible was capable of two independent movements, angular rotation and translatory movements. He probably produced the first graphic records of mandibular movements on a patient. (Gysi, 1920) stated that natural condyles are not considered as true rotation points but as fixed guides of mandible. "The mandible opens, closes and rotates on another rotational centre which has no influence in the setting up of the teeth on articulators. Therefore need not be considered in the construction of an articulator". (Needles, 1923) agreed with Bennett and

supported that there is both hinge and sliding parameters. There is no fixed centre of rotation in the temporomandibular joint and there is instant and constant shifting of rotational centres. (Wadsworth, 1925) gave an anatomist's conclusion in stating that the first movement is around a transverse axis passing through the condyles which remain seated in the fossae. The second movement occurs on articular eminence. (Hall, 1929) concluded that "the condyle is not the centre of rotation". (McCollum, 1939) was considered a leading advocate of the hinge axis theory. He confirmed definite opening and closing axis by using face bow minimising the use of external landmarks. Rotation occurs during 0.5 inch at incisors for most people although some can open even 1 inch. (Stuart, 1939) completed the work of McCollum in reproducing the movements on articulator in duplicating the jaw movements. Both of them were considered as pioneers of gnathology. According to (McLean, 1944), "the diagnosis of pathological occlusion depended on the fact that the final phase of jaw closure was a pure hinge movement". (Lauritzen, 1951) thought that articulation would be understood more easily if the TMJ was regarded as two separate joints. The only movement which could take place in the 'menisco-condylar' part of the joint while opening and closing is a purely rotational movement. In all patients, the anterior teeth could be separated by at least 12mm in the rotational hinge relation. (Posselt, 1952) concluded that hinge opening is obtained if patient is in passive or trained active motion. He could not prove that this movement was habitual. According to him, hinge axis opening was around 1.9cm. (Kornfield & Granger 1955) stated that the only position at which it was possible to locate and reproduce hinge axis was at centric relation. (Trapozzano, 1955) stated that hinge axis represented a border movement that could be recorded repeatedly with unfailing accuracy. (Weinberg, 1959) conceptualised hinge axis based on asymmetry of condyles. Off-centre opening and closing movements were perpendicular to hinge axis and he concluded that movement in one direction in one plane can have only one axis of rotation.

Theories of hinge axis: (Aull, 1963) classified theories of hinge axis based upon four schools of thought. They are;

- a. The absolute location of the hinge axis school
- b. The arbitrary location of the hinge axis school
- c. The non-believers of transverse axis location school
- d. The split hinge axis school (Collinear – non collinear controversy)

A. Absolute location of the hinge axis: Believers of this school were of the opinion that there is a definite transverse axis and it should be located as accurately as possible. With the aid of the face bow, it is possible to relate the maxillary cast to the transverse axis of the articulator in the same relationship as the maxillae are related to the anatomic mandibular axis of the condyles. The mandibular hinge axis is coincided with and related to the maxillary hinge axis by means of a centric relation record. The path of closure on the terminal hinge will therefore be the same on the articulator as it is in the mouth. The cusps of the teeth should be so arranged that they will coincide during this border mandibular movement.

B. Arbitrary location of the axis: Followers of this school stated that the value of actually locating the exact hinge axis is not worth the effort. In relation to this, Craddock stated that "

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 millimetres distant from the assumed centre in the condyle itself". This may be determined by simple palpation or by following the convention of measuring a distance of about 1cm anteriorly along a line drawn from the upper free margin of the tragus of the ear to the corner of the eye.

C. Non believers of the transverse axis location: According to this group, it is impossible to locate the terminal hinge position with accuracy. (Kurth and Feinstein), using a Hanau articulator, concluded that the axis location could be limited to 2mm radius, when opening was restricted to 3/4th inch. They concluded that with all the variables which operated in the determination of the hinge point such as perception, anatomy, physiology, the ability of the patient to follow instructions, it was unlikely that the hinge axis could be located accurately. (Borgh and Posselt) found the accuracy of location to be within 1.5mm when there is a 10 degree opening and within 1mm when the arc of movement was increased to 15 degrees. On the other hand, Lauritzen and Wolford were able to locate the axis within 0.2mm radius in 95% cases with a 10 degree arc of movement. (Trapozzano and Lazzari) found that in 37.2% of the subjects, more than one condylar hinge axis points were located on either one or both sides of the face. They concluded that findings indicate that, since multiple condylar hinge axis points were located, the high degree of infallibility attributed to hinge axis points may be seriously questioned.

D. Split axis rotation: (The collinear – non collinear controversy): A major challenge to the traditional concept of a single intercondylar axis was hurled by Harry Page in his proposal of the transographic concepts. He postulated the existence of two mutually independent non collinear axes or simply that each condyle had its own axis of rotation. Page theorised that since the mandible is flexible, such independence from a mutual axis is mechanically possible and anatomically allowable. Since the mandible is not bilaterally symmetrical and the terminal hinge position mark on one side of the face is usually a little higher than on the other side, it would follow that there cannot be a common axis. There must be two axes parallel to each other with both axes at right angles to the opening and closing movements of the mandible. Slavens stated, "By definition, an axis is always a line never a point". Again, by definition, an axis is invariably perpendicular to the same plane of opening and closing rotation, they are parallel to each other even though asymmetrically positioned, and by definition, parallel lines never meet. So again, the single, intercondylar transverse axis is proved to be impossibility.

The advocates of this concept developed an articulator called a 'transograph'. This articulator tried to overcome the problem of irregular condyles which made it impossible for the various individual axes to be constant even in simple rotation. This instrument made use of a transverse split hinge axis. On the subject of transographics or the two transverse hinge axis theory, Weinberg pointed out that much of the concept was based on the asymmetry of the condyles. However, he pointed out that 'off-centre' opening and closing movements of the mandible were still perpendicular to the transverse hinge axis. He concluded that marked "off-centre" opening was due to pathologic unilateral condylar limitation of movement.

Clinical Significance of Hinge-axis determination: By placing the condyles in the centric relation position, which is a posterior mandibular border position, we can make the hinge axis a constant point to both the maxilla and mandible. The maxilla is therefore oriented spatially in the articulator in the same position as it occurs in the patients head. Each tooth is on a different arc of closure depending on its distance from the rotational centre. The rotational centre can be thought of as centre of a number of circles. Each circle is larger as its radius from the common centre is longer. Each tooth, then on its arc from the common centre will travel a different path to meet its antagonist because of the size of the corresponding segment of the arc of the circle on which it is closing. For the teeth to meet properly, each tooth and its corresponding arc that varies with the size of the circle segment it is on must be located at the exact distance from the centre of rotation on the articulator as it is in the mouth. By properly relating the maxilla and the mandible with interocclusal record, the accurate arc of rotation for any given tooth can be established.

Summary and Conclusion

To sum up, we can derive to a conclusion that, unless the actual kinematic hinge axis point is transferred to the articulator, there will be some error in the size of the closing circle and we will have different approaching axes as the teeth meet each other. If the teeth don't meet in the same arc on the articulator as in the mouth, we are going to have premature contacts. Studies by Weinberg have demonstrated that if we can locate an axis point within a 5mm range of the actual centre of rotation of the patient and transfer this to an instrument, we will only have 0.2mm error in incline contacts around the molar area. Placement of the tragus-canthus line at the superior border of the tragus of the ear will contribute to greater inaccuracy in most patients. The largest percentage of true axis locations will be inferior to the tragus-canthus line at the superior border of the tragus of the ear. In the final analysis, the true value of our individual work can be measured only by the degree of fineness with which we practice the art of dentistry rather than the particular school of thought to which we adhere.

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