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RESEARCH ARTICLE

HINGE AXIS RECORDING "THE ESSENTIAL NEED IN PROSTHODONTICS"

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ABSTRACT

Battered Precision is the key to prosthodontics and it is thus imperative that restorations are made as accurately as possible. This is best achieved by the use of hinge axis concept and thus it should be incorporated into routine clinical practice to achieve optimum results. The transverse hinge axis in dentisry has always been a subject of controversy with its existence itself and existence of single or multiple hinge axes. The presence or absence of a hinge axis of the mandible is of prime importance in clinical phases of dentistry and can be located with any degree of accuracy. Most of the transographs concept is based on the asymmetry of the condyles. The anatomic condylar asymmetry, as well as the observation that the mandible may open or close at a slight angle to an arbitrary vertical plane of the face has lead page to theorize that there are two transverse hinge axis, one for each condyle. Hinge axis record reveals that translatory and rotational components in varying proportions affect the path and location of the condyle in movement. In order to program a dental articulator to duplicate the hinge opening and closure of the mandible, it is necessary to make a hinge axis record and transfer this information to the articulator. The transverse hinge axis point may be located most precisely by a kinematic process, or its location may be estimated by some arbitrary method. The following methods are explained in sequence.

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INTRODUCTION

The written story of the mandibular hinge axis goes back into the first edition of Gray's *Anatomy*. Gray and those following him recognized that the mandible moves on a hinge as well as by means of the forward and lateral movements of the condyles in the glenoid fossae. The temporomandibular articulation was called "ginglymo-arthroidal joint" by Gray (Mc Collum, 1960). The temporomandibular articulation is a complex joint in which two basic movements of the mandible can be distinguished.

- Rotary or hinge like movement taking place between the articular disc and condyle in the lower compartment of the temporomandibular articulation.
- Translatory or sliding movement between the temporal bone and articular disc in the upper compartment of the temporomandibular articulation (Standard, 1955).

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Prior to the 1920s, Snow, Gysi and others were aware of the existence and importance of an opening and closing axis. Yet their methods were not advanced enough to exactly pinpoint the location of the hinge axis. This led them to believe that change in vertical dimension was a chair side procedure. The first actual kinematic location was evolved through the California Gnathological Society under the leadership of Dr. B.B. McCollum (Mc Collum, 1960) and the credit for the idea of the mechanical location of an axis goes to Dr Robert Harlan. The Glossary of Prosthodontic Terms defines Hinge axis as an imaginary line passing through the two mandibular condyles and around which the mandible can rotate without translatory motion. According to Heartwell: Hinge axis is 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.

Description of transverse hinge axis

The physiological transverse hinge axis is located by a series of controlled opening and closing movements of the jaws when the mandible is held in its most retruded position relative to the maxillae. These mandibular movements are called *terminal*

hinge movements (Zarb, 2009). Any three dimensional object that move in a coordinated rotational path of motion, which is part of a circle or ellipse, has an axis of rotation (Weinberg, 1959).

Clinical use of the transverse hinge axis: The terminal hinge movement is used only to locate the starting point of the mandibular opening and not the condylar path itself. The transverse hinge axis plus one anterior point serves to locate the maxilla in space. Thus, the location of the transverse hinge axis serves only to orient the maxilla and to record the static starting point for functional mandibular movements. It does not record centric relation to condylar movements. The transverse hinge axis can be recorded physiologically by the use of a gnathoscope but the face bow mountings record it as an anatomic average within 5mm of error. Intraoral eccentric records are used with the Hanau type of adjustable articulator to estimate the functional condylar movements concerned with cuspal occlusion. The Gnatho- scope records condylar movements by means of extraoral records with extreme accuracy. Moving condyles are used in both methods without any trained hinge motion to obtain condylar path recordings. The transverse hinge axis has always been a subject of controversy with its existence itself and existence of single or multiple hinge axes. Most of the transographs concept is based on the asymmetry of the condyles. The anatomic condylar asymmetry, as well as the observation that the mandible may open or close at a slight angle to an arbitrary vertical plane of the face has lead page to theorize that there are two transverse hinge axis, one for each condyle.

The slightly off centric opening and closing movements of the mandible are still perpendicular to the transverse hinge axis. The movement is off centric only when we compare the opening and closing motion to our arbitrary orientation of the patient. The 'off-centric motion' is perpendicular to the transverse hinge axis and will deviate from the arbitrary vertical plane to the degree of deviation of the transverse hinge axis. Movement in one direction in a plane can have only one axis of rotation. Two axial centers of rotation for the same plane and direction of movement is a self-contradictory statement. If the mandible were rotating about one axis, translation would have to occur in the other hinge axis. Physiologically, two independent hinge axes would require the translating condyle to change its vertical height when this condyle serves as the hinge axis, the opposite condyle will then translate with a change in its vertical height. The capsular ligament will not tolerate this degree of vertical movement. Second, the disc is non-vascular and firm in the central portion, allowing close contact with the temporomandibular fossa. An increase in vertical height of the condyle would be injurious. If the transverse axial center of motion shifts from one condyle to other as claimed by transographics, no co-ordinated opening and closing motion would be seen clinically. Instead, the pattern of mandibular movement would change as the axial center shifts from side to side. In normal opening and closing movements (up to 35mm) the motion follows a co-ordinated rotational path (Weinberg, 1959).

Biological Significance of Hinge Axis: In order to understand the biological significance of hinge axis location. A fully dentulous and a fully edentulous condition is considered. 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 are 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 temporo 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 (Sicher, 1956).

Rationale of Hinge Axis

The presence or absence of a hinge axis of the mandible is of prime importance in clinical phases of dentistry and can be located with any degree of accuracy (Kurth, 1951). Hinge axis record reveals that translatory and rotational components in varying proportions affect the path and location of the condyle in movement (Levao, 1955). The location of the transverse hinge axis serves only to orientate the maxillae and to record the static starting point for functional mandibular movements. It does not record centric relation or condylar movements. Intraoral eccentric records are used with adjustable articulator to estimate the functional condylar movements concerned with cuspal occlusion (Renner, 1979).

Chair-side and laboratory procedures could be considerably shortened if an accurate hinge axis could be located and transferred to an adjustable articulator for edentulous patients. Record of hinge axis can be used to:

- Alter the vertical dimension of occlusion on the articulator.
- Obtain the centric relation records and verify them at the try-in at an altered vertical dimension of occlusion.
- Minimize the remounting procedures to perfect the occlusal scheme.
- Safely use a cusp-form (anatomic) posterior tooth where indicated with minimal occlusal adjustments.
- Develop an occlusion which would preserve and restore oral function (Kurth, 1951).
- The anatomic or the kinematic hinge axis face-bow transfer is the first step in recording the relationship of the maxillary arch to the condylar paths. Once the maxillary cast is oriented on the articulator, the centric relation record completes the static, or starting, relationship between the maxillae and the condyles in the temporomandibular fossae (Weinberg, 1961).

Different theories of transverse hinge axis

From early experiments there have evolved four main schools of thought regarding the horizontal axis. They are as follows.

Group I: Absolute location of the axis

There are those who believe that there is a definite transverse axis and it should be located as accurately as possible.

McCollum, Stuart & Lucia believe that the hinge axis is a component of every masticatory movement and cannot be disregarded. The investigators who endorsed this concept have established a repeatable point of reorientation from which the above information and relationships may be obtained.

Group II: Arbitrary location of the axis

The second group includes those who believe that the arbitrary location is not worth the added effect. Craddock for one stated that the search for the axis, in addition to being troublesome, is of no more than academic interest. Though, this group believed in location of the axis.

Group III*: *Nonbelievers in the transverse axis locations

The third group who believes it is impossible to locate the terminal hinge position with accuracy.

Group IV: Split axis rotation

These are believers of the Transographic theory. They believe in the "split axis" with which each condyle rotates independently of the 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. That 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. The significance of the fact that these two transverse axes are never symmetrically positioned in the same head. Being perpendicular to the same plane of rotation, they are parallel to each other even though asymmetrically positioned and, by definition parallel lines never meet" (Sharma, 2012; Aull, 1963 and Rathee, 2014).

Controversies Regarding Hinge Axis

- Existence and accurate location of Hinge axis.
- Single or Mutiple hinge axis exists.
- Clinical usefulness regarding location of hinge axis.
- Wheather an arbritrary point can be satisfactorily substituted for a kinematic axis (Gordon, 1984).

Single Axis or Multiple

During 1950, Dr. William Bransted, Dr. Raymond Gravy and Dr. Robert Okey conducted an experiment and concluded the presence of a single axis. Dr. Arne Lauritzen., working with a study group in 1957, repeated the same experiment and arrived at the same conclusion. Woelfel, Hickey and Rinear (1957) gave electromyographic evidence supporting the mandibular hinge axis theory. The results indicated that the neuromuscular system is so arranged that the hinge movement of the mandible is possible. When the bony structure of the temporomandibular joint and shape of the meniscus will permit, the neuromuscular system is such that a significant amount of hinge movement can be accomplished. However, for most individuals this is not the normal opening pattern (Weinberg, 1959). In 1959 the committee of the greater New York academy of prosthodontics repeated this experiment and concluded that there was only one transverse axis through both condyles. Later Lucia also conducted extensive experiments and concluded the presence of a single axis.

McCollum And Stuart stated that only when a single THA exists, can the CR registrations be made at an increased VD of occlusion (Weinberg, 1963). Transographics and Gnathology confirmed the validity of existence of 2 materially independent, non-collinear hinge axes and their recordings clinically (Brekke, 1959). Trapozanno & Lazzari support this theory. Later Wienberg conducted experiments to support this Transographic theory. They concluded that multiple axes exist and their presence opens the Field for interesting conjecture (Weinberg, 1959). Aull discussed the impossibility of the presence of a split HA, or of a different HA for each condyle acting simultaneously (Aull, 1963). Harry page in his experimentation in 1979 also supported the above views.

The hinge axis and its practical application in the determination of centric relation

To secure a centric inter-occlusal record, we attempt to "freeze" the terminal hinge closure at a convenient vertical opening. Without the hinge axis, we would be unable to secure an accurate centric inter-occlusal record because to obtain such a record the recording medium must not be penetrated by the teeth or the occlusion rims. In order to avoid penetration (at least in dentulous cases), we must obtain our centric interocclusal record in an open relationship, and if we were not in the same arcs of closure, our efforts would be useless. It is impossible to check a centric inter-occlusal record without an axis mounting (Lucia, 1964). Cohen (1960) described an instrument called the 'Hinge axis trainer' to train patients to open and close the mandible in a hinge manner, the position of the condyle when this movement occurred was not a retruded position or a forced position but a position when the condyles were sealed in the glenoid fossa as far posterior as they would go by their own muscular power. This position was centric relation. Cohen further stated that once the hinge-axis points had been located and marked permanently it was never necessary to repeat the procedure since the anatomic structures they represented never changed during life.

The following benefits were derived from a hinge-axis record:

- Study models could be mounted to determine if the patients own centric occlusion was in harmony with centric relation.
- Working models could be mounted in the best relationship for the teeth or denture bases.
- The vertical dimension could be increased or decreased on the instrument without disturbing centric relation.

Location of the hinge axis

The first actual kinematic location was evolved through the California Gnathologic society under the leadership of McCollum and credit for the idea of the mechanical location of an axis was given to Dr. Robert Harlan. The transverse axis of rotation can be located by use of an instrument called the 'Face-Bow'.

Definition (GPT-7): A caliper-like instrument used to record the spatial relationship of the maxillary arch to some anatomic reference point or points and then transfer the relationship to the articulator (Zarb, 2009).

According to Heartwell: Face bow is a caliper like device used to record the relationship of maxilla to the temperomandibular joint (Heartwell, 1992).

Indications of Face Bow

When disharmonies in occlusion resulting from failure to use the face bow are analyzed, it can be concluded that the face bow should be used when: Cusp teeth are used. Balanced occlusion in the centric positions is desired. A definite cusp fossa or cusp tip to tip incline relation is desired. When interocclusal check records are used for verification of jaw positions and when the occlusal vertical dimension is subjected to change and alterations of tooth occlusal surfaces are necessary to accommodate the change and to diagnose existing occlusion in patients mouth.

Contraindications face Bow

When monoplane teeth are arranged on a plane in occlusal balance and the mandible is in most retruded relation to the maxilla at an acceptable vertical dimension of jaw separation. When no alterations of the occluding necessitate change in the vertical dimension. When there is no need to record inter occlusal check records and when articulators are not designed to accept facebow transfer.

Advantages of Using Face-Bow

Face bow permits more accurate use of lateral rotation points for the arrangement of teeth. It aids in securing the anteroposterior cast position with relation to the condyles of the mandible. It registers the horizontal relationship of the casts quite accurately and assists in correctly locating the incisal plane. It is also an aid in the vertical positioning of the casts on the articulator (Lazzari, 1955).

Techniques for locating the hinge axis

It is the same for dentulous and edentulous patients but methods for attaching clutch to the mandible are different. Clutch is a mechanical device made to be rigidly attached to the mandibular teeth on mandibular residual ridge to which a hinge axis bow is attached.

Patient variables affecting terminal hinge axis location:

- Condyle asymmetry.
- Inability to locate a true hinge axis: In any system of kinematic axis location an essential prerequisite is the attachment of the clutch to the mandibular teeth. An anterior cross bar which holds the styli is anchored to this clutch. These styli can only locate the arc center of the rigid components of the combined mechanism. If it is an arc there is one arc center. If it is not a pure arc, then a moving centric exists and no 'true' hinge axis can really be found.
- Emotional condition of the patient.
- Occlusal interference which can cause incoordination of masticatory muscles and muscle splitting.

Different methods have been used to locate and transfer the hinge axis to the articulator which can be divided into three groups- arbitrary group, kinematic group and modified techniques. These are briefly discussed below.

Arbitrary methods of hinge axis location- In this method arbitrary posterior reference points based on average, anatomic landmarks are used. They are easy to use compared to trial-and-error method of locating the kinematic axis. It has been demonstrated mathematically that location of an arbitrary axis point ± 5 mm anterior-posterior to the kinematic axis will result in negligible error (0.2 mm) on the nonworking side when a 3-mm– thick centric relation record is used (Nagy, 2002).

Various arbitrary posterior reference points used are

11 to 13 mm anterior to the upper one-third of the tragus of the ear on a line extending to the outer canthus of the eye, given by Henderson et al. in 1973. 13 mm anterior to the posterior margin of the center of the tragus of the ear on a line extending to the corner of the eye, given by Osborne et al. in 1968. 10 mm anterior to the center of a spherical insert for the external auditory meatus and 7 mm below the Frankfort horizontal plane. Palpation. This method was applied as described by Dawson. From a position behind the patient, the index finger was placed over the joint area, and the patient was asked to open widely. As the condyle translated forward, the fingertip was dropped into the depression left by the protruded condyle. Gysi point located 13 mm in front of the most upper part of the external auditory meatus on a line passing to the ectocanthion.

The Lauritzen- Bodner axis determined by the use of specially constructed disks 10 mm in diameter and a plastic ruler. This point is located 12 mm anterior and 2 mm below the porion (Sharma, 2012 and Abdal-Hadi, 1989). Dubey et al (2013) (Dubey, 2013) studied the proximity of four arbitrary hinge reference points- Beyron's , Bergstrom's, Gysi's And Hobo Point to kinematic hinge axis point located through customized kinematic hinge axis locator and concluded that the Beyron's point is closest to the true hinge axis as compared to the Bergstrom's, Gysi's and Hobo's point and there is collinearity in Beyron's point. Placement of points on the Tragus-Canthus line at the superior border of the Tragus of the ear as is the case with Gysi's point, as well as with FH line in case of Hobo's point, will contribute to greater inaccuracy in most of the patients.

Advantages of Arbitrary Method of Locating Hinge Axis

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

Disadvantages of Arbitrary Method

Because it is not an absolute location, even an error of 5mm around true hinge axis might lead to occlusal discrepancies, which increases the chair side time.

Kinematic Method

Hinge axis locator and kinematic face-bow is the most accurate method of mounting for Kinematic method. Kinematic face-bow 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 opening and closing of the mandible. 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:

- Clutch/ bite fork
- Cross bar and stud
- Axis indicator
- Graph pad
- 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. A hinge axis flagging device, worn like a pair of glasses and secured posteriorly by a head strap, is adjusted to the subject. The subject is then positioned at approximately a 45- to 60-degree angle from horizontal. After a clutch tray is rigidly affixed to the mandibular teeth the Hanau kinematic face-bow is firmly attached to the clutch stem. The condylar pointers are provisionally positioned, and the subject is instructed to open and close within a limited range of approximately 1 cm. During these movements, the subject is maintained in centric relation with light but continuous hand pressure. The condylar pointers are adjusted until they are directly perpendicular to the hinge axis and rotated without translatory movement. With the mandible maintained in centric relation, the axis points are tattooed on the skin and the hinge axis locating equipment is then removed. A bite fork is adapted to the occlusal surfaces of the maxillary teeth with black modelling compound in cake form. The modeling compound is cooled and trimmed to leave only a light index of the cusp tips. The maxillary cast is positioned in the modeling compound index to ensure accuracy of fit. The bite fork is used for both kinematic and arbitrary face-bow recordings. The bite fork is placed in the mouth and the kinematic face-bow is firmly attached. The condylar pointers are adjusted to the terminal hinge axis points with the patient in the same postural position.

The orbital pointer is positioned at the inferior orbital foramen, previously identified by palpation. The kinematic facebow is then carefully transferred to the articulator. The face-bow is positioned to relate each condylar pointer accurately to the corresponding apparatus on the articulator. The orbital pointer is positioned by adjusting the cast-supporting device attached to the base of the articulator. The maxillary cast is seated and secured in the compound index and mounted to the articulator (Palik, 1985).

Advantages of Kinematic Technique

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

Disadvantages of Kinematic Technique

- 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.

Modified Techniques

This group includes techniques used to locate arbitrary and kinematic hinge axis by making some modifications in conventional methods.

- Loma-linda hinge axis recording device and method.
- Buhnergraph intraoral method.
- Technique using geometric principle to locate hinge axis.
- Abdal-Hadi's technique of locating arbitrary hinge axis.

Loma-linda hinge axis recording device and method

The opponents of use of a kinematic hinge-axis location for edentulous patients point to its unreliability because of the resiliency of the oral mucosa, the added weight of the recording clutch which tends to shift the denture base, and the time-consuming nature of the procedure. To eliminate some of these disadvantages, a modification of the Loma Linda hinge-axis recording device and face-bows for use on edentulous patients are developed.

Modification of the hinge-axis locator

- Cut two parallel channels down the length of a clear Lucite plastic blank to accommodate the hinge-axis recorder and flags.
- Modify a set of lower edentulous impression trays with cold-curing acrylic resin to accommodate the modified Lucite blank.
- Cut a pair of hollow tubes, four in all, 1/2 inch in length.
- Perforate each of the aluminum trays, and shorten the handle.
- Fix the Lucite blank and hollow tubes to the trays with a mix of cold-curing acrylic resin. The resin is allowed to harden, chemically locking the Lucite to the tray as a new handle and mechanically locking the tubes as stabilizers for a circum- mandibular elastic effect. The acrylic resin covers all external portions of the edentulous trays and is smoothed and contoured to eliminate all sharp and rough edges. A series of lower impression trays can thus be modified to make clutches for use with the Loma Linda hinge-axis locator (Palik, 1979)

Buhnergraph intraoral method

It is the technique used to record terminal hinge axis, with the help of an instrument made by the dentist called Buhnergraph. It is named after Dr. W. A. Buhner of Daytona Beach, Florida, who has helped with its design and machine work. Long (1970)[26] used an intraoral device to locate the transverse hinge axis and he used a Buhnergraph to verify the records. He encountered errors in either location or its transfer to the articulator, which he corrected by moving the recording shaft to the Buhnergraph and until the records made by it coincides.

The key to the success of this technique lies in the accurate location of centric relation at 2 different degrees of jaw separation. Centric relation can be located by many techniques but there is some variability. Buhnergraph instrument consists of a U-shaped piece of aluminum which is attached to the underside of the lower member of a Whip Mix articulator. On each side is attached an adjustable arm containing a pointed shaft which moves in and out. Casts are mounted on the articulator with the maxillary cast preferably related to the terminal hinge axis and the mandibular cast related to the maxillary cast by means of a tentative centric relation record. The pointed shafts are adjusted to fit into the recess on each lateral face of the condylar guide housing. These recesses mark the center of rotation of the articulator. A piece of graph paper is now fastened to the lateral face of each condylar guide housing and the horizontal graph lines are made parallel to the upper member of the articulator. With the removal of the condylar elements, the instrument ceases to be an articulator and becomes a Buhnergraph. The tentative centric relation registration record is placed between the casts and the relationship is carefully stabilized.

Technique using geometric principle to locate hinge axis

Gunderson and Parker presented a technique that uses geometric principles to locate the mandibular transverse horizontal axis (hinge axis). This technique is a rapid method for locating the mandibular transverse horizontal axis of a patient with accuracy. It does not use an arbitrary posterior reference point, which introduces unnecessary errors where maximum precision is indicated. In addition it is a technique useful in teaching the concept of hinge rotation to the student of mandibular movement.

1. A millimeter graph paper is attached to the facial sidearm of a hinge axis locator positioned over the site of the temporomandibular joint.
2. A clutch is rigidly attached to the mandibular teeth and a microadjustable axis location assembly is placed over the millimeter grid.
3. A graphic stylus is inserted in place of the axis locator pin and positioned in the anterior region of the graph paper.
4. A series of arcs are scribed by gently guiding the patient in repeated retruded (hinge) opening movements and adjusting the mandibular sidearm to position the stylus in a series of positions located on the grid.
5. The procedure is repeated in an area of the grid inferior to the temporomandibular joint.
6. One or more of the arcs are selected from the anterior and inferior groupings. A line is scribed perpendicular to a tangent of each of these arcs (or center of the chord of each arc). The point where these lines intersect is the center of rotation, or the hinge axis reference point.
7. An alternative technique is to identify a horizontal and vertical grid line that is perpendicular to a scribed arc from the anterior and inferior groups. The intersection of these grid lines also identifies the center of rotation and quickly locates a reference point for the mandibular transverse horizontal axis.
8. Once the intersecting point has been located, the graphic stylus is replaced with an axis locator pin. The locator pin is positioned precisely over the marked grid point and locked in place. The hinge axis may be verified with conventional arcing techniques.
9. The grid is removed and the hinge axis point is transferred to the patient as a posterior reference point for subsequent procedures.
10. The procedure is repeated on the opposite side. Two reference points, once located, provide an accurate determination of the mandibular transverse horizontal axis (Gunderson, 1987).

Abdal-Hadi's technique of locating arbitrary hinge axis

Abdal-Hadi's method is based on the high correlation between the width profile of the face and the X coordinate of the kinematic point. Thus, the use of the linear regression formula permits prediction of the anterioposterior site of the kinematic point. This equation is Y = 9.5 c 0.95 (X) where Y represents the width profile of the face measured from the ectocanthion to the center of the external auditory meatus and X is equal to the anterioposterior position of the kinematic point. A constant distance equal to 0.5 mm was used above the line passing from the center of the external auditory meatus to the canthus to locate the superioinferior position of the proposed method. The proposed arbitrary method of recording the hinge axis based on the correlation between the profile width of the face and the kinematic axis was compared with three commonly used arbitrary methods. Furthermore, this method clearly illustrated that its highest concentration was in the posteriosuperior quarter around the true axis. The proposed technique was found to be more accurate than the other techniques (Abdal-Hadi, 1989).

Hatzi and Maya (2001) studied the accuracy of articulator interchangeability and hinge axis reproducibility in Whip Mix, Girrbach Artex and KaVo articulator system and found that none of the system was to be exact duplicate of one another. The Whip Mix followed by KaVo articulator showed greater deviation while the Artex articulator provided the most consistent in hinge axis repeatibilty and and in articulator interchangeability.

Marking The Axis Location On The Patient

When we are satisfied that we have located these points on the axis, the marking medium, such as an indelible pencil, is rubbed on the end of the stylus. We make sure the patient is in the terminal hinge position and then have him move his head out of the headrest, making sure that he does not also move out of the terminal hinge position. The stylus is gently pushed against his face to transfer the point to the skin. These marks are made permanent by using a special needle and a little pink marking dye -sulfide of mercury. Gordon has presented an alternate technique for recording the located axis point by non-tattooing method[9].

Conclusion

The hinge axis concept still controversial inspite years of study. The various schools of thought regarding its existence and location often leads to doubt regarding its application in everyday clinical practice. Various studies have shown that an arbitrary location of the hinge axis is an acceptable alternative to its accurate location. With the availability of easy to use ear piece facebows location and transfer of hinge axis to the articulator is an easy and quick procedure. Precision is the key to prosthodontics and it is thus imperative that restorations are made as accurately as possible. This is best achieved by the use of hinge axis concept and thus it should be incorporated into routine clinical practice to achieve optimum results.

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