

DYNAMISM IN ANTERIOR POINT OF REFERENCE: A POTENTIAL SOURCE OF ERROR!

Veena Hegde¹, Gurkaran Preet Singh², Prerna Jain³

1. Professor and former Head of the Department, Department of Prosthodontics and Crown & Bridge, Manipal College of, Dental Sciences, Manipal, Karnatak, India

2. Consultant Prosthodontist, Max Super Speciality Hospital, Phase VI, Mohali, Punjab, India.

3. Assistant Professor, Department of Orthodontics, Gian Sagar Institute of Dental Sciences, Banur, Punjab, India

ABSTRACT:

Oral rehabilitation involves fabrication of restorations or prostheses in harmony with the functional movements of the mandible to ensure physiologic acceptance. Location of the transverse horizontal axis is essential to correctly relate the mandible to the maxillae. Consequently, relationship of the maxillary dental cast to the articulator's hinge axis should be as precise as the relationship between the maxillae and the mandibular hinge axis. Facebow records accurately capture this relationship for transfer to the articulator. Additionally, superior/inferior position of the horizontal ear-bow needs to be determined using a third point of reference in order to successfully orient the maxillary cast three-dimensionally on the articulator. However, errors in the selection of this reference horizontal can result in substantial errors in the final occlusion of the prosthesis and also result in unnatural axial inclination of the maxillary anterior teeth. This review paper aims to throw valuable light on this contentious issue. It is an attempt to apprise the reader of various anterior reference points documented in the literature and the significance of the anterior point from an esthetic standpoint.

Key-words: Dental Articulators, Dental Models, Dental Occlusion, Jaw Relation Record/methods, Mandibular condyle, Dental esthetics



INTRODUCTION:

Accurate positioning of the maxillary cast on an articulator has long been a challenging task in prosthodontic practice. The maxillary arch has a definite three-dimensional relationship to the paths of the advancing condyles and a kinematic or an arbitrary face bow transfer is regarded as the primary step in recording the above mentioned relationship. Broadly speaking, a facebow registers in 3 planes, namely, antero-posterior, lateral and vertical planes, the position of the maxilla in relation to 2 fixed points on the cranium. The fixed points being glenoid fossa bilaterally and establishes the same relationship between the maxillary cast

and the mechanical hinge of the instrument. In doing so, we also require a constant third point of reference which will constitute horizontal reference plane through this point and two posterior points located on the transverse hinge axis. Use of a facebow also helps in orientation of the cast in relation to axes of movements which is of great significance as maxillae constitute an asymmetrical body, rather than a finite point.

Several investigators have recognized the significance of accurately establishing the sagittal inclination of the maxillary cast on

the articulator. A purposeful neglect or a failure to transfer accurately the antero-posterior relationship can result in readily measurable occlusal discrepancies in the final prosthesis, while failure to reproduce the correct vertical relationship can result in unnatural axial inclination of maxillary anterior teeth.

DISCUSSION:

In 1955, Page.^[1] stated that a reference plane is the physical requirement in orienting any body 3 dimensionally. Numerous reference planes have been described to orient the maxillary cast on the articulator. Gonzalez and Kingary.^[2] put forth 3 criteria in the selection of any plane of orientation which include ease of location, convenience and reproducibility. In accordance with these guidelines the most commonly employed plane is the Frankfort Horizontal plane (F-H plane).

Mc Collum.^[3] first introduced the F-H plane to prosthodontics in 1939 when he developed the 'axis-orbital' plane of orientation which he justified as being "horizontal or nearly so when the body is erect". The F-H plane was originally an anthropologic reference adopted at Anthropologic Congress in Frankfurt, Germany in 1882. This plane has been cited as easily accessible, well defined and on an average coinciding well with the true horizontal plane relative to Natural Head Position (NHP). True Horizontal is that plane which is perpendicular to the forces of gravity whereas NHP is a position of head most comfortable for a patient gazing at the horizon.

However some studies have shown that any intracranial reference plane, including F-H plane reveals a wide variation between subjects relative to the True Horizontal. Hence a suitable plane of reference comprised of carefully located anterior and fixed posterior points of reference is selected to help in accurate orientation of the maxillary cast in the sagittal plane.

Posterior fixed points of reference

In the use of an arbitrary face bow, the posterior points are accurately-located soft tissue points on the surface of skin which are at an established dimension from the true hinge axis of three-dimensional mandibular motions. Worthy researchers have stated different soft tissue points based on sound mathematical derivations through their studies.

Beck.^[4] in his study declared that the Bergstrom point, a point situated 10 mm anterior to the centre of a spherical insert- equivalent for auditory meatus and 7 mm inferior to the F-H plane is closest clinically to the transverse hinge axis. Also he identified Beyron point – a point 13mm anterior to the the posterior margin of the tragus of the ear situated on a line from the centre of the tragus to the outer canthus of the eye as the next most accurate point of reference.

Hanau.^[5] described the use of a point located 13mm anterior to the auditory openings while Swenson [6] located the same point by measuring 11mm from the upper part of the tragus. Gysi.^[7] located

the axis by intersection of a line 10 mm from the central point on the posterior curvature of each tragus to the corner of the eye.

All the above mentioned fixed points when joined with their counterparts on opposite side represent the arbitrary transverse hinge axis which is believed to be located near the true hinge axis with a potential discrepancy of 5mm as stated by Weinberg [8]. This error would result in an antero-posterior displacement error of 0.2 mm at the 2 molar region as claimed by him through his studies.^[8]

In removable prosthodontics with non rigid attachments an error of such small magnitude is nullified by the inherent tolerances in occlusion and 'Resilient and Like Effects' of the supporting structures. In contrast, the practice of fixed prosthodontics demands precise milling of cusp pathways. For such procedures the use of a kinematic face bow to locate the true hinge axis is a step in the right direction.

Failure to precisely determine the correct 'maxillary base – starting condylar position' relationship will result in a prosthetic failure of the prosthesis. Interceptive and deflective tooth contacts due to disharmony in border and intra border mandibular movements are undesirable both in natural and artificial occlusions and can contribute to periodontal trauma, muscle spasm and TMJ disorders.

The anterior point of reference

Variation exists in the selection of an anterior point of orientation which with the posterior points on the transverse hinge axis forms the horizontal plane of reference. The merits of precisely locating the horizontal plane of reference on the instrument are four-fold. Firstly, it relates the maxillary cast to the articulator's mechanical axis and the vertical axis. Also it positions the upper cast according to the condylar determinants and the mean plane of the articulator and finally it maintains a harmony between the posterior determinants and the anterior guidance. With the practice of repeating the complicated and time-consuming recording techniques such as pantography becoming obsolete, it is imperative for us to use a constant third point of reference and repeatable posterior points. Various anterior points of reference are as follows:

1. *Orbitale*

Salzmann described orbitale as the point on the lower margin of the orbit which is directly below the pupil when the eye is open and patient looks straight ahead. Many authors have specified various planes of reference that can be taken into consideration but more recently investigators have noted the F-H plan is usually parallel to the floor when patient is sitting in an upright position.

Cephalometrically the F-H plane is a horizontal plane that passes through right and left porion and orbitale. Clinically the maxillary cast is oriented to the above mentioned plane by using an orbitale

pointer attached to the frame of the facebow, the end of which is placed at the level of the point described by Salzmann. When transferred to the instrument the end of the pointer is placed level with the condylar plane utilizing the orbitale indicator of the articulator, thus orienting the cast to the (condylar) axis-orbitale plane which closely parallels the F-H plane.^[9]

Because of the ease of locating the anterior point of reference and the ease of teaching and understanding, the axis – orbital plane is widely put into practice by clinicians and students alike.^[9-11]

2. *Orbitale minus 7 mm*

Cephalometrically the F-H plane passes through both the poria and one orbitale as stated above. However Sicher has recommended the use of mid-point of upper border of the external auditory meatus as the posterior cranial landmarks on a patient as hard tissue porion cannot be accurately measured. Gonzalez and Kingary disputed the above concept by cephalometrically determining the F-H plane was not parallel to the axis-orbital plane but was located 7mm superior to it.^[12] Adjusting the orbital pointer 7mm above the orbital indicator or placing the orbital pointer 7mm below the orbitale was suggested as a compensation for the error. Ultimately F-H plane of the patient will become the horizontal plane of reference in the articulator.^[3]

3. *Nasion minus 23 mm*

As described by Sicher, nasion is a soft tissue landmark located as the deepest part of the midline depression just below the level of eyebrows. Quickmount facebow used with a whipmix articulator makes use of this concept by having a nasion guide in its construction. This is attached to a cross bar which is situated 23mm away and which lies in the approximate region of orbitale, thereby implying that the anterior cross bar and not the nasion guide is the true anterior reference point locator. Hence a Quickmount facebow used with a whipmix articulator also makes use of an approximate axis – orbital plane as horizontal plane of reference.^[13-15]

4. *Incisal edge plus articulator mid point to articulator axis-horizontal plane distance*

Guichet in his book on occlusion pointed out that the planned plane of occlusion should be near the mid horizontal plane of the articulator. Any deviation from the same would lead to supra-infra positioning of the casts relative to upper and lower members of the instrument.^[2,16] Thus, he elaborated that the distance between the axis-horizontal plane and mid horizontal plane of the articulator should be measured.

Subsequently this dimension is transferred to the patient by marking a point at the same distance from the planned incisal edge position. The same point is now regarded as the anterior point of reference which is preserved by measuring vertically downwards to it from the medial canthus of the eye.

However there are two basic fallacies associated with the use of this technique. Firstly use of this procedure does not relate F-H plane or axis orbital plane parallel to the horizontal plane and additionally the actual occlusal plane will not be parallel to the horizontal plane unless by coincidence.^[4,17]

5. *Ala of the nose*

Snow recommended that the occlusal plane be made parallel to the Bromell's plane / Camper's plane and oriented to the articulator so that it is parallel to its maxillary and mandibular members. Also a similar plane known as the prosthetic plane was put forward by Gysi and Kohler. Okane et al.^[18] further noted that ala-tragus line is chosen as the plane coincides with the function of maximum masticatory forces but minimum muscular activity.

Generally speaking ala of the nose is usually defined as the rounded eminences of the inferior lateral surface of the nose. A line joining this anterior point with the tragus of the ear describes the the Camper's plane.

Hence if desired, the anterior reference pointer of the facebow can be set to right or left alae and hinge axis – ala plane can be transferred to the articulator as the horizontal reference plane.

A secondary method of establishing this relationship is to make a wax occlusal rim parallel to Camper's plane and setting the initial or tentative anterior occlusal plane by checking the desired location of

maxillary anteriors.^[9,13] Subsequently the anterior occlusal plane is transferred to the articulator with the help of a facebow making sure that upper and lower members of the articulator are parallel to the tentative occlusal plane. Finally the ala-axis plane and the occlusal plane become the plane of reference.

However, various patient related factors will have a bearing on the final occlusal plane. Relying on the sole judgement of dental auxiliaries in deciding and maneuvering the occlusal plane will lead to an unsightly or 'unhealthy' occlusal plane.

THE ANTERIOR POINT OF REFERENCE – AN ESTHETIC STANDPOINT

Careful planning and implementation in the selection of a suitable anterior point of reference will give the operator an opportunity to visualize anterior teeth and articulation in the instrument in the same frame of reference that would be used when looking at the patient.

The primary objective of achieving esthetic harmony in the form and position of anterior teeth is accomplished by orienting the maxillary cast relative to F-H plane as justified by Mc Collum.^[4,19-22]

Also a periodic evaluation between patients or for the same patient at different periods of time is permissible only by the way of a constant third point. Although the use of F-H plane is favoured by dentists and anthropologists alike, auxiliary personels should also receive education about the plane of reference

used and the rationale for its usage. Prosthesis cannot be considered in the highest regard if the dentist accurately orients the maxillary cast by utilizing any one of the anterior points of reference and an ignorant technician arbitrarily mounts the casts on the articulator.^[23-25] Such incompetency on the part of dental auxiliary will lead to undesirable cant of maxillary occlusal plane and lines of force that will not be at right angles to the mean plane of the ridge.

The following technique can be used as more convenient, practical and less time-consuming alternative option.^[5,26-28] If the Camper's line horizontal reference plane is used, raise the back of the articulator to achieve the effect of the Frankfort horizontal plane mounting. If the Frankfort horizontal plane reference is used, raise the anterior of the articulator to achieve the effect of paralleling the occlusal plane and Camper's line with the horizontal.

DYNAMISM IN ANTERIOR POINT OF REFERENCE – A POTENTIAL SOURCE OF ERROR!

After the development of the Snow face bow, attempts were made to give the occlusal plane an individual position in the third dimension. Any neglect to proper orientation of the maxillary cast will lead to its deviation as a unit in lateral, vertical and antero-posterior planes. Most recent investigators have demonstrated the F-H plane being an acceptable horizontal reference plane and that maxillary cast can be oriented to it by

using an infra-orbitale pointer attached to a facebow so that the occlusal plane when viewed on the articulator is the same as that in a patient sitting upright.

However this belief was challenged by Gonzalez and Kingary.^[2] who determined cephalometrically that the condylar axis was situated 7.1 mm below the radiographic porion. They suggested compensating for this error by adjusting the orbital pointer 7mm above the orbitale indicator or vice-versa. Compensation for the same can also be accomplished by selecting the infraorbital foramen which is located approximately 7 mm inferior to the originally selected orbitale. The recent Hanau Springbow utilizes the same as the anterior reference point.

At the same time Stade et al.^[29] through their study with the use of bubble gauges determined there is an elevation of 16.4 +/- 5.64 mm at the mid-incisal level with the use of orbitale as the third point of reference. This also produces an increase in the protrusion of maxillary incisors by 10 degrees which further increases upper lip fullness and reduces lower lip support.

However Weinberg stated that an error of such big magnitude (16 mm) has no effect on centric occlusion as there is an accompanying raising or lowering of occlusal plane as well. On the other hand such an error will affect eccentric condylar readings which inturn influence buccolingual cusp inclines. In the hypothetical patient an elevation in the mounting by 16 mm will result in a

reduction of the protrusive condylar inclination from 40 to 31 degrees and a concomitant decrease in balancing cusp incline from 40 to 35.5 degrees. All of it reduces the cusp height by 0.2 mm at the second molar region.

Even though literature is not devoid of articles warranting the use of orbitale as the anterior point of reference, still it has not been established clearly that intended application of orbitale as the third point actually occurs in dentulous subjects.

Likewise another recommended point is the incisal notch in the incisal guide pin of the articulator as the anterior reference point. Usually this is accomplished by elevating the maxillary cast while the facebow is still attached to the articulator until the maxillary incisal edges are aligned to the level of the incisal notch. This point is arbitrarily set 30mm below the horizontal condylar plane (a plane described by the centre of condylar spheres and infra orbital indicator) and is termed as Incisal Reference notch. However this measurement is not calibrated to approximate the average distance between orbitale and maxillary incisal edges.

Applebaum et al.^[30] determined that this distance on an average from the representative population is 53.99 mm +/- 4.17 mm (54mm) which can be adjusted to 47 mm taking into the account the error of inferior positioning which occurs due to usage of orbitale.

A similar study by Bailey and Nowlin.^[10] clearly demonstrated that the use of

incisal notch as an anterior point of reference allowed casts to be mounted in a close relationship with the F-H plane; although it does not orient the occlusal plane on the articulator as it is to the F-H plane. Also considering the limitation of maximum horizontal condylar guidance angle on Hanau articulator, the authors recommend the use of incisal notch for dentulous subjects.

Also Krueger and Schneider.^[16] utilized the co relation between natural Head Position and True Horizontal Plane and advocated the use of NHP rather than F-H plane. This was based on the fact that the average fluctuation in NHP in each subject was sufficiently smaller than the determined variation of FHP in respect to True Horizontal thus warranting its use.

An extra cranial point of reference namely a standard line level (bubble gauge) can also be used to capture the true horizontal plane relative to NHP. Such a procedure offers a more accurate esthetic representation on the instrument.

Ow, Djeng and Ho.^[31,32] through cephalometric studies on Chinese subjects found out that an anterior facial point located 43mm above the maxillary incisal plane or resting maxillary lip level, in line with the medial canthus could solve the problem of inferior positioning of the occlusal plane on the articulator.

CONCLUSION:

The idea that the porion and the orbitale would form a plane parallel to the reference horizontal was originally

adopted in 1882. Since porion is a point not easily referenced by the articulator or the face bow, it was easy for early designers of articulator and face-bow to substitute the axis for the porion. This forms the basis for the emergence of axis-orbital plane as the reference horizontal. However errors in the selection of this reference horizontal can result in

substantial errors in the final occlusion of the prosthesis and also result in unnatural axial inclination of the maxillary anterior teeth. A compromised esthetic outcome can arise by the use of an anterior reference point which is not in harmony with the design of the articulator.

REFERENCES:

1. Page HL. The cranial plane. *Dent Digest* 1955;61:152
2. Gonzales JB, Kingery RH. Evaluation of planes of reference for orienting maxillary casts on articulators. *J Am Dent Assoc* 1968;76:329-36
3. McCollum BB. The mandibular hinge axis and a method of locating it. *J Prosthet Dent* 1960;10:428-35
4. Beck. A clinical evaluation of the Arcon concept of articulation. *J Prosthet Dent* 1959;9:409.
5. Hanau RL. Articulation defined, analyzed and formulated. *J Am Dent Assoc* 1926;13:1694-707.
6. Swenson MG. Complete dentures 1947, 2nd edn. The C. V. Mosby Company, St. Louis, p 180.
7. Gysi A. Practical application of research results in denture construction. *J Am Dent Assoc.* 1929;16:199–223.
8. Weinberg IA. An evaluation of the face-bow mounting. *J Prosthet Dent* 1961;11:32.
9. Ercoli C, Graser GN, Tallents RH, Galindo D. Face-bow record without a third point of reference. Theoretical considerations and an alternative technique. *J Prosthet Dent* 1999;82:237-241.
10. Bailey JO Jr, Nowlin TP. Evaluation of the third point of reference for mounting maxillary casts on the Hanau articulator. *J Prosthet Dent* 1984;51:199-201.
11. Pitchford JH. A reevaluation of the axis-orbital plane and the use of orbitale in a facebow transfer record. *J Prosthet Dent* 1991;66:349-355.
12. Wilkie ND. The anterior point of reference. *J Prosthet Dent* 1979;41:488-496.
13. Galindo D, Tallents RH, Graser GN, Ercoli C. Face-bow record without a third point of reference: Theoretical considerations and an alternative technique. *J Prosthet Dent* 1999;82:237-241.
14. Bergstrom G. On the reproduction of dental articulation by means of articulators. *Acta Odontol Scand Suppl* 1950;9 (Suppl. 4):3-149.
15. McWilliam JS, Rausen R. Analysis of variance in assessing registrations of natural head position. *Swed Dent J* 1982;15:239

16. Krueger GE, Schneider RL. A plane of orientation with an extracranial anterior point of reference. *J Prosthet Dent* 1986;56:56-60
17. Frankel R. The applicability of the occipital reference base in cephalometrics. *Am J Orthod* 1980;77:379.
18. Okane H. The effect of anteroposterior inclination of the occlusal plane on biting force. *J Prosthet Dent* 1979; 44:497–501
19. Augsburger KI. Occlusal plane relation to facial type. *J Prosthet Dent* 1953;75:5.
20. Bjerin R. A comparison between the Franklorr horizontal and the Sella Turcica-Nasion as reference planes in cephalometric analysis. *Acta Odontol Scand* 1957;1:15.
21. Downs WB. The role of cephalometrics in orthodontics. Case analysis and diagnosis. *Am J Orthod* 1952;38:162.
22. Lundstrom A. Head posture in relation to slope of the sella-nasion line. *Angle Orthod* 1982;5:279
23. Brandrup-Wognsen T. Face-bow, its significance and application. *J Prosthet Dent* 1953;3:618-630.
24. Dos Santos Junior J, Nelson SJ, Nummikoski P. Geometric analysis of occlusal plane orientation using simulated ear-rod facebow transfer. *J Prosthodont* 1996;5:172-181.
25. Olsson A, Posselt U. Relationship of various skull reference lines. *J Prosthet Dent* 1961;11:1045-1049.
26. Freitas A de. A comparison of the radiographic and prosthetic measurement of the sagittal path movement of the mandibular condyle. *J Oral Surg* 1970;30:631-638.
27. Owen EB. Condyle path: Its limited value in occlusion. *J Am Dent Assoc* 1948;36:284-290.
28. Kumar JS, Gupta G, Bansal S, Gupta P. Variability and validity of the anterior point of reference”: A cephalometric study. *Baba Farid Uni Dent J* 2011;2:107-111.
29. Stade E.H, Hanson J.G, Baker C.L. Esthetic considerations in the use of facebow. *J Prosthet Dent* 1982;48:253-256.
30. Lauciello FR, Appelbaum M. Anatomic Comparison to arbitrary reference notch on Hanau articulators. *J Prosthet Dent* 1978;40:676-681.
31. Richard K.K. Ow, S.K. Djeng, C.K. Ho, The relationships of upper facial proportions and the plane of occlusion to anatomic reference planes, *J Prosthet Dent* 1989;61(6):727-733
32. Richard K.K. Ow, S.K. Djeng, C.K. Ho, Orientation of the plane of occlusion. *J Prosthet Dent* 1990;64(1):31-36.