

Occlusal Plane Location in Edentulous Patients: A Review

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Abstract Occlusal plane orientation is an important factor in the construction of a complete denture. Occlusal plane could be oriented using landmarks in the mandibular arch as well as in the maxillary arch. In the mandibular arch there are few landmarks which could be used to orient the occlusal plane like the retromolar pad, corner of the lips (lower lip length) whereas the maxillary arch has a number of landmarks, of which the ala-tragal line is the most commonly used and the same being the most controversial. In the following article different landmarks and its accuracy for orientating the occlusal plane in an edentulous subject as studied by various authors has been discussed.

Keywords Occlusal plane · Orientation · Ala-tragal line

Introduction

Complete denture prosthodontics is a challenge for the restoring dentist for the reason that rehabilitation of edentulous patients with conventional complete dentures, be it tissue supported or implant supported, has to be done by considering various biological and mechanical factors to

restore functions and health of the stomatognathic system [1]. Developing an occlusion that is compatible with functional movements of the stomatognathic system is one of the key factors in determining the prognosis of the completely edentulous patients [2].

One of the important factors that help us in the establishment of ideal occlusion is the orientation of the occlusal plane. Occlusal plane is the average plane established by the incisal and occlusal surfaces of the teeth; it is not a plane but represents the planar mean of the curvature of the surfaces [3].

Occlusal Plane Significance

The correct orientation of the occlusal plane plays a vital role in optimal esthetic achievement. In the natural smile, the incisal tips follow the curve of the lower lip. This effect is an expression of a correctly oriented occlusal plane; if the occlusal plane hangs posteriorly, the lip-line viewed from the front will appear straight and contribute more than any other factor to the so-called ‘denture look’. With the occlusal plane correctly oriented, however, the natural anterior curve will be achieved almost automatically and contribute a proper sense of perspective to the dental composition [4].

The plane of occlusion, forms an essential part of the concept of mechanically balanced articulation [5]. The position of occlusal plane in denture wearers should be as close as possible to the plane, which was previously occupied by the natural teeth [6]. Such position of the occlusal plane provides normal function of the tongue and cheek muscles, thus enhancing the denture stability [4, 7–10]. It is believed that teeth oriented on an occlusal plane in harmony with the individuals physiognomy is

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responsible, in part, all conditions being equal, for stable, retentive full dentures [11].

Faulty orientation of the occlusal plane will jeopardize interaction between tongue and buccinators muscles [6]. Where the occlusal plane is too high, the tongue cannot rest on the lingual cusps of the lower denture and prevent its displacement. Also it forces the tongue into a new position that is higher than its normal position [12]. This higher position of the tongue causes the floor of the mouth to raise and create undue pressure on the border of the lingual flange and results in partial loss of border seal [12]. There is also tendency for accumulation of food in the buccal and lingual sulci [5]. An occlusal plane that is too low could lead to tongue and cheek biting [4].

Occlusal Plane Orientation

Considering the importance of the accurate establishment of the location and inclination of occlusal plane on function, esthetics and speech, a method to conform it to the occlusal plane that existed in the natural teeth seems necessary. The question which arises in clinical practice is how to discover which position was occupied by the “natural occlusal plane” after the loss of natural teeth and exactly, how can the optimal position of the occlusal plane be found in every edentulous patient [13].

The occlusal plane in anterior and posterior regions may vary and therefore, these should be evaluated separately.

It is generally agreed that in the anterior region the vertical height of the occlusal plane is governed by esthetic requirements [6, 14] and less frequently by functional demands [6]. The anterior maxillary occlusal plane may be determined by lip relationships at rest and when smiling. Speech also provides for positional accuracy [15]. When viewed from the front, the occlusal plane should be parallel to the interpupillary line [16].

With regard to the orientation of the occlusal plane in the posterior region, however, there are contrasting views. Various authors have postulated various landmarks for determining the occlusal plane.

Landmarks for Occlusal Plane Orientation in Mandibular Arch

In the mandibular arch, location of the occlusal plane is functionally related to mastication [15].

Various landmarks have been used to orient the occlusal plane in the mandibular arch e.g. retromolar pad, lateral borders of the tongue, the buccinators groove and commissure of the lips.

Retromolar Pad

The retromolar pad is divided into 2 or 3 parts by various authors. Boucher [17] and Hall [18] recommended placing the occlusal plane such that it terminates posteriorly at the medial two thirds of the retromolar pad. Piermatti [19] said the occlusal plane should terminate at the upper level of the retromolar pad while Rahn and Heartwell [20] said posterior height should not exceed half the height of the retromolar pad. Engelmeier [21] said in the sagittal view the occlusal plane is determined by the approximate juncture of the upper and middle thirds of the retromolar pad.

Lundquist and Luther [22] determined the plane of occlusion in relation to the retromolar pad by placing a 16 gauge wire on the tip of the mandibular cuspid and by posteriorly extending the wire to the distolingual cusp tip of the second or third molar. The relationship of the occlusal plane to the retromolar pad was determined by intersection of the wire and the pad. In this study, the pad was divided into two parts and it was found that in 75 % of subjects the plane terminated in the lower half of the retromolar pad. A study done by Shigli et al. [23] used the same method as Lundquist and Luther [22] but divided the retromolar pad into three parts and found out that the mandibular occlusal plane coincided with the lower 1/3rd of the retromolar pad in majority of cases.

Ismail and Bowman [24] in their study made lateral cephalograms of dentulous patients on which the natural occlusal plane was marked. After extraction of the natural teeth complete dentures were fabricated in which the occlusal plane was tentatively determined. During teeth arrangement, the middle third of the retromolar pad was used as reference for posterior plane. Then on tracings of the cephalograms, the palatal plane, the natural occlusal plane and the prosthetic plane was marked and the relation was established. They concluded that the occlusal plane should be modified by placing the second molars at the level of the upper third of the retromolar pad rather than the middle or lower third.

A study done by Gupta et al [25] used a metallic scale which passed along the cusp tip of cuspid to mandibular second or third molar and extended posteriorly to the retromolar pad. They concluded that in maximum number of cases the occlusal plane coincided with the middle third of the retromolar pad.

The retromolar pad is a pear shaped area that forms only after the removal of the most distal molar [26]. Also it is a soft tissue area and at times its anterior and posterior borders cannot be demarcated accurately. Therefore relying only on this one landmark cannot guarantee complete validity to the occlusal plane orientation. However, when used as one of the guides for the occlusal plane orientation, the area in the lower third of the retromolar could be used.

Lateral Border of the Tongue

Yasaki [27] Nagle and Sears [28] suggested orienting the occlusal plane on the same level as the lateral border of the tongue, to fulfill the theory that food is controlled on the occlusal table by the tongue.

A study done by Ghosn et al. [29] made neutral zone moldings using phonation and found that the ala-tragus line extending from the inferior border of the ala of the nose to the inferior border of the tragus presented the closest relationship to the prosthetic occlusal plane corresponding to the lateral borders of the tongue.

The tongue is a highly movable organ in the oral cavity and thus its reliability in the occlusal plane orientation is questionable. Also, after extraction of all teeth the tongue becomes hypertrophied, resulting in the change of the anatomy of the lateral border of the tongue.

Commissure of the Lips

Lunquist and Luther [22] in their study used a stainless steel wire that was placed bilaterally on the occlusal embrasures between the mandibular cuspid and first premolar with minimal opening of the mouth to check the relation of the commissure of the lips to the occlusal plane. It was observed in this study that the commissures were within a range of 1–3 mm, either superiorly or inferiorly, to the occlusal plane.

In a study done by Shigli et al. [23] impressions were made with the help of an oral screen which extended to the distal aspect of the mandibular second molar on both sides. They observed that the commissure of the lip was inferior to the occlusal plane by 1.37 mm.

Deciding on the commissure of lips as a guide for occlusal plane orientation is most unreliable, as with age there is drooping or turning down of the corners of the mouth. Therefore, commissures cannot be similar to as observed in dentulous patients.

Buccinator Groove

A study done by Lunquist and Luther [22] made intraoral vestibular impressions with the help of a plastic screen which was cut to fit the labial and buccal vestibules without impinging the mucosa. The relation of the buccinator groove was first established with respect to the commissure of the lips and then to the occlusal plane. They found out that in 90–95 % of subjects the commissure of the lips was in the same plane as that of the buccinator groove, and thus, the occlusal plane is in the range of 1–3 mm to the commissure of the lips as well as of the buccinator groove.

Shigli et al. [23] in their study used vestibular impressions with the help of an oral screen to determine the relation of the buccinator groove to the occlusal plane and

found that the mean value of all readings of buccinators groove was 0.94 mm below the mandibular occlusal plane.

Gupta et al. [25] used a custom made buccinator groove relator to compare the level of the buccinators groove to the occlusal plane. They concluded that in 70 % of males and 66 % of females the occlusal plane was as the same level as the buccinator groove and can be used as a reliable landmark for orientation.

The buccinator groove could be a reliable landmark only in patients with good muscle tone as aging causes progressive loss of muscle tone.

Landmarks for Occlusal Plane Orientation in Maxillary Arch

Various landmarks have been used to orient the occlusal plane in the maxillary arch e.g. parotid papilla, hamular notch- incisive papilla plane, ala-tragus line.

Parotid Papilla

Winkler [16] suggested that the parotid papilla is located 1/4th inch (6 mm) above the occlusal surface of maxillary first molar teeth.

Lunquist and Luther [22] measured the distance with a different reference for the occlusal plane (i.e. cusp tip of maxillary molars) and suggested parotid papilla was located 4 mm above the occlusal plane.

Shigli et al. [23] in their study found out that mean distance of parotid papilla was 2.56 mm above the maxillary occlusal plane. They made impressions with the help of an oral screen which extended to the distal aspect of the mandibular second molar on both sides.

Foley and Latta [30] used the parotid papilla as a reference guide for occlusal plane orientation. They examined dentulous patients to determine the distance of the occlusal plane from the inferior border of the right and left parotid papillae. They found that the parotid papilla was 3.3 mm above the occlusal plane.

The above cited studies show that there is a sizable dissimilarity in the position of the parotid papilla, ranging from 2.56 mm to 6 mm, above the occlusal plane in dentulous subjects. Therefore, this landmark alone is not an accurate guide for occlusal plane orientation.

Hamular Notch–Incisive Papilla

Cooperman [31] and Rich [32] observed in their study that the occlusal plane showed a close relationship to the hamular notch–incisive papilla plane.

Fu et al. [33] in their study used a three dimensional surveying software to check parallelism between the

hamular notch–incisive papilla plane and four types of occlusal planes formed by different anterior and posterior reference points on maxillary teeth and found out that parallelism exists between the natural occlusal plane (defined as mesial-incisal edge of upper right central incisor and distal-buccal cusp tips of upper first molars) and hamular notch–incisive papilla plane.

Jayachandran et al. [34] evaluated the reliability of the hamular notch/incisive papilla plane (HIP) in establishing the occlusal plane. The study was done both in dentulous as well as edentulous patients. In dentate subjects, the maxillary stone cast was mounted on the Wills surveyor with HIP made parallel to the horizontal plane using the tripodding method. The vertical distance between the occlusal plane and floor of the surveyor was measured at four points. When the measured values were equal, the two planes were confirmed to be parallel for that situation. In the edentulous subjects, the occlusal plane, established clinically using the ala-tragal line, was compared with the HIP radiographically using lateral cephalograms. They concluded that the HIP was parallel to the occlusal plane.

Even though, the hamular notch and the incisive papilla are constant landmarks and do not change over time, this cannot be easily used as a reliable tool to orient the occlusal plane in an edentulous subject as two planes can be parallel to each other at any height. The cant of occlusal plane can be established but not the supero-infero position.

Ala-Tragus Line

One of the most popular methods is to orient the occlusal plane parallel to a line drawn from the lowest point of the ala of the nose to the external auditory meatus or tragus. Definitions of the ala-tragus line by different authors are a cause of confusion due to disagreement on the exact point of reference, on the ala and the tragus, for this line. Clapp [35] in 1910 was the first to relate Camper's line/plane to occlusal plane.

Numerous authors have stated as well as researched in this area and found out that all the three parts of the tragus i.e. superior, middle and inferior have been proved to be guides for occlusal plane orientation in edentulous patients.

Superior

Lloyd [16], Anthony [36] and Miller [37] define it as a line running from the inferior border of the ala of the nose to the superior border of the tragus. Boucher [38] defines it as the line running from the inferior border of the ala of nose to the superior border of the tragus of the ear. Trapozzano [39, 40] used the upper border of the tragus as a reference point.

Gupta et al. [25] in their study used a custom made occlusal plane analyzer to check the posterior reference point on the tragus and concluded that in 80 % of female subjects,

the occlusal plane was found parallel to Camper's plane with the anterior reference point as the ala of the nose and the posterior reference point as the superior part of the tragus.

Sadr et al. [41] conducted a study in which the subjects were photographed in natural head position while clenching on a Fox plane. After tracing the photographs, the angles between the following lines were measured: the occlusal plane (Fox plane) and the superior border of ala-tragus, the occlusal plane (Fox plane) and the middle of ala-tragus as well as the occlusal plane (Fox plane) and the inferior border of ala-tragus. It was found out that the superior border of ala-tragus line was almost parallel to the occlusal plane.

Al Quran et al. [42] carried out a study to determine the most reliable ala-tragus line as a guide for the orientation of the occlusal plane in complete denture patients by the analysis of prosthodontically related craniofacial reference lines and angles of lateral cephalometric radiographs. They concluded that the superior border of the tragus with the inferior border of the ala of the nose was most accurate in orienting the occlusal plane.

Middle

Ismail and Bowman [24] describe it as a line passing from the ala of the nose to the center of the tragus of external auditory meatus. Camper's line which is an anthropologic measurement on skulls projected to the living head as a line passing from the ala of the nose to the center of the tragus of the external auditory meatus [43]. Spratley [44] describes it as a line running from the center of the ala to the center of the tragus. The Glossary of Prosthodontic terms [5–8] [3, 45–47] defines it as a line running from the inferior border of the ala of the nose to some defined point on the tragus of the ear, usually considered to be the tip of the tragus.

A study done by Shigli et al. [23] using a custom made occlusal plane relator concluded that the line drawn from the ala of the nose to the middle of the tragus was found to be parallel to the maxillary occlusal plane.

Gupta et al. [25] in their study also fabricated a occlusal plane analyzer and concluded that in 72 % of female subjects, the occlusal plane was found parallel to Camper's plane with the anterior reference point as the ala of the nose and the posterior reference point as the middle part of the tragus.

In a study of 2,048 tragi forms, Solomon et al. [48] found that Camper's plane was parallel to the occlusal plane when the tragus reference point was situated between the superior border and the middle of the tragus.

Inferior

Simpson et al. [49] state that it is a line running from the ala of the nose to the inferior border of the tragus.

A study carried out by Karkazis and Polyzois [7] also advocates the use of the inferior border of tragus as a

posterior landmark. Their cephalometric study concluded that the ala-tragus line or the Camper's line extending from the lower margin of the ala to the inferior border of the external auditory meatus presented the closest relationship to the natural occlusal plane. According to them, the inferior border of tragus is an excellent equivalent soft tissue landmark to the lower border of external auditory meatus.

van Niekerk et al. [50] constructed the plane of occlusion according to their subjective criteria of esthetics, function, and comfort. The established plane of occlusion was then checked against the ala-tragus line only at the final denture insertion appointment. Their results showed a close relationship between the two planes if the tragal reference of the ala-tragus line was dropped to the inferior border of tragus.

Cephalometric studies done by Rostamkhani et al. [51] on individuals with Angle's Class III Malocclusion and Sharifi et al. [52] on individuals with Angle's Class I jaw relation found out that the occlusal plane had a stronger tendency to be parallel to the line joining the ala of the nose and inferior border of the tragus. Rostamkhani et al. [51] in their study attached radiopaque markers to the intended points on the soft tissue of the tragus and then standard lateral cephalograms were obtained from each subject.

Cephalometric study done by Hindocha et al. [53] found out that the tragal reference in their study population was more towards the inferior of the tragus. They obtained lateral cephalograms after outlining the tragus and the base of the ala of the nose with radiopaque markers.

A study done by Hartono [54] made mirror photographs in a cephalometric laboratory to determine the part of the tragus to be used for marking the ala-tragus line and concluded that the line connecting the lowest part of the ala to the inferior margin of the tragus can be used as a guide to the orientation of the occlusal plane.

A study carried out by Chaturvedi et al. [55] on dentulous and edentulous subjects to find out the most appropriate point on tragus to be used as a reference point at time of marking ala-tragus line while establishing occlusal plane also concluded that the inferior point is the most appropriate. Lateral cephalograms of all subjects were taken. The tragus was marked at all three points and three lines were formed by joining to the ala of the nose. The angle formed by each line (SA plane, MA plane, IA plane) with Frankfort Horizontal (FH) plane was measured by using custom made device and modified protractor.

Study by Kumar et al. [56] used digital photography in orthognathic profile patients to determine accurately the part of the tragus to be used to form the ala-tragal line and found out that the line joining from ala to the lower border of the tragus was parallel to the occlusal plane in 53.3 % of the subjects.

The ala-tragus line is the most controversial landmark in occlusal plane orientation. However, this extra-oral landmark is reliable as both its ends do not change with age. Majority of the studies show that the line joining the inferior portion of the tragus with the ala of the nose is more often than not parallel to the occlusal plane. Nonetheless, the superior and middle part of the tragus cannot be completely overruled as the lines formed with these landmarks and the ala of the nose have also proved to show parallelism with the occlusal plane. Therefore, a combination of more than one landmark should be used along with the ala-tragus line for orienting the occlusal plane.

Other Methods of Orienting the Occlusal Plane

Nagle and Sears [28] positioned the occlusal plane parallel to and in the midway between the residual ridges.

Swenson [57] states that the relative size and shape of the bearing area of the mandible and maxillae influences the decision as to the position of the occlusal plane.

Roberts [58] recommended positioning it halfway between the maxillary and mandibular ridges parallel to the Frankfort plane.

Nissan et al. [59] conducted a cephalometric study on denture wearers to investigate the relationship between the anatomical structures (e.g. retromolar pad, occlusal plane and camper's plane) used to determine the occlusal plane and the facial skeletal shape. They found out that there was no correlation between the facial skeletal shape and location of the anatomical structures.

Petricevic et al. [60] did a study to evaluate whether the occlusal plane measurements on digital photographs were reliable for the reconstruction of occlusal plane. Casts were mounted in the S.A.M. 2 "P" articulator by a quick mount face-bow transfer and angles between the articulator horizontal plane and the occlusal plane (AHP-OP) recorded. A Fox plane was placed over the maxillary dental arch and a quick-mounting face-bow was positioned and lateral digital photographs were taken. The angles between the face bow and the Fox plane (FB-FP) were measured. Results showed that there was no significant difference between AHP-OP and FB-FP angles and thus concluded that measurements of occlusal plane inclination from digital photographs could be helpful in prosthodontic reconstruction treatment.

Conclusion

Various landmarks are available for the orientation of occlusal plane in edentulous patients. However, based on the various studies done on dentulous patients, no single

method seems entirely accurate to locate the occlusal plane. Therefore, using one method alone will not suffice the determination of occlusal plane in edentulous patients. A combination of various landmarks along with a judicious clinical judgment should be taken into account for the location of the occlusal plane in edentulous patients.

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