

Reliability of Anatomic Reference Planes in Establishing the Occlusal Plane in Different Jaw Relationships: A Cephalometric Study

Prince Kumar · Hari Parkash · Akshay Bhargava · Sharad Gupta · Dinesh Kumar Bagga

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Abstract The purpose of this study was to evaluate the reliability of different anatomic reference planes in determination of Occlusal plane in dentulous and edentulous subjects with Angle's class I and class II Maxillomandibular relationship. Eighty subjects were included in the study which was divided into four Groups based on dentition and skeletal relationship. The Group I ($n = 20$) and Group II ($n = 20$) includes young and completely dentulous subjects in Angle's class I and class II relationship, respectively. The Group III ($n = 20$) and Group IV ($n = 20$) subjects were completely edentulous in Angle's class I and class II relationship, respectively. For all subjects, right lateral cephalograms were taken and cephalometric analysis was done and data obtained from cephalometric tracings were then statistically analyzed. The results showed no significant difference of angle between Occlusal plane and Frankfort Horizontal plane, Camper's plane and Palatal plane when Group I and Group III, and Group II and Group IV subjects were compared. The Frankfort Horizontal plane, Camper's plane and the Palatal plane may be used as

a reliable guide to establish Occlusal plane in edentulous subjects in both Angle's class I and class II Maxillomandibular relationships.

Keywords Complete denture · Frankfort Horizontal plane · Occlusal plane · Reference plane

Introduction

With the increasing life expectancy in the last few decades the number of individuals seeking complete denture services have risen considerably [1]. Most of the factors involving fabrication of complete denture prosthesis are controlled by the operator. The loss of teeth is accompanied by inadvertent esthetic and biomechanical consequences. Prosthodontists are often confronted by unrealistic demands of edentulous patients complaining about ever increasing facial wrinkles and protruded chin with difficulties in mastication and speech. Complete rehabilitation of edentulous condition requires ideal positioning of teeth so that they appear natural and create a pleasing profile and yet, are in harmony with function, phonetics and mastication.

Orientation of the Occlusal plane is an essential part of clinical complete denture fabrication. Considering the importance of the accurate establishment of its location and effect of its inclination on function, esthetics and speech, a method to guarantee its conformity with the Occlusal plane of the missing teeth seems necessary [2]. The orientation of Occlusal plane has lead to innumerable controversies. A number of guides for its orientation have been implicated.

The Camper's plane was the first effort in modern dentistry to establish Occlusal plane. It was based on scientific research and was made parallel to Ala-Tragus plane

P. Kumar (✉)
Department of Prosthodontics, Shree Bankey Bihari Dental College and Research Centre, Masuri, 201302 Ghaziabad, India
e-mail: princekumar@its.edu.in

H. Parkash · A. Bhargava · S. Gupta
Department of Prosthodontics, ITS Dental College, Ghaziabad, India
e-mail: aksdr2000@yahoo.co.in

S. Gupta
e-mail: sharadssv@gmail.com

D. K. Bagga
Department of Orthodontics, School of Dental Sciences, Sharda University, Greater Noida, India
e-mail: dr.dineshbagga@gmail.com

posteriorly [3, 4]. Previous studies by Ow et al. [5] advocated use of lead foil while Karkazis and Polyzois [6] had used ill-defined radiopaque markers for Occlusal plane location on the radiographs whereas Shigali et al. [7] used number of soft tissue landmarks for Occlusal plane determination (retromolar pad, parotid papilla, commissure of lips, buccinators groove and Camper's plane) and they had not found any single soft tissue landmark that could be used as a reliable guide in determining Occlusal plane.

Recent past has witnessed many studies relating the Occlusal plane to Anatomic Reference planes. Karkazis and Polyzois [6], used Camper's plane while Siefert [8] utilized Frankfort Horizontal plane as a guide to correctly orient Occlusal plane. However, there is little information available that compares the artificial Occlusal plane to that of natural dentition and in addition the reliability of Camper's plane as a clinical guideline for establishment of Occlusal plane needs to be tested. As the vertical jaw relations are typically based on clinical acumen and the establishment of the Occlusal plane is to a large extent arbitrary, this study was undertaken to determine the reliability of different anatomic reference planes and their use as an aid to determine Occlusal plane in both dentulous and edentulous subjects with Angle's Class I and Class II Maxillomandibular relationship using cephalometrics.

Materials and Methods

To conduct this study a total of 80 subjects were selected from the Out Patient Department of Prosthodontics. Based on the dentition and skeletal jaw relationship, subjects were divided into four Groups (Group I, II, III, IV) having 20 subjects each. Group I and Group II includes young and completely dentulous subjects with skeletal class I and class II jaw relationship, respectively. While in Group III and Group IV, subjects were completely edentulous with skeletal class I and class II jaw relationship, respectively, for whom complete dentures (in balanced occlusion) were fabricated. For all subjects (Group I, II, III and IV) right lateral cephalograms were taken and cephalometric analysis was done, to evaluate the reliability of different anatomic reference plane in determination of Occlusal plane.

Inclusion Criteria for Group I and Group II

1. Dentulous subjects in the age group of 18–35 years with Angle's class I and Angle's class II occlusion, respectively, with no history of orthodontic treatment and no skeletal or Maxillo-mandibular anomaly.
2. Minimal attrition of the teeth with no missing teeth in the maxillary and mandibular arch.

3. All subjects having full complement of permanent teeth up to the second permanent molars in the upper and lower arches.

Inclusion Criteria for Group III and Group IV

1. Edentulous subjects in the age group of 45–60 years with healthy residual ridges showing Angle's class I and class II ridge relations, respectively.
2. Selected subjects must be edentulous for a period not more than 1 year.
3. None of the subject has undergone preprosthetic surgery.

For Group I and II subjects the soft tissue points were marked by using barium sulphate radiopaque dye which was applied over the skin of superior margin of Tragus and inferior margin of the Ala of nose with a thin brush (Sable brush No. 2). Right lateral cephalograms were taken by a standard technique with the mandible closed in maximum intercuspation and lips in relaxed position. On cephalometric tracing, Occlusal plane was located as the line joining the points of the mesiobuccal cusp tip of mandibular I molar and tip of most lingually placed incisor tooth. For Group III and IV subjects, balanced dentures were then fabricated for each subject by conventional technique using semi adjustable articulator and Face bow for orientation jaw relation.

Following complete denture fabrication, a 0.010" Orthodontic ligature wire was adapted on left lateral incisor and left first molar on the lower denture. On the lateral incisor it was adapted in the centre of incisal edge and running labio-lingually to the full length of tooth. On the molar it was adapted occlusally and running from mesio-buccal to distolingual aspect of tooth (Fig. 1).

Ala-Tragus soft tissue points were marked by using radiopaque marker (barium sulphate dye) following which right lateral cephalograms were taken by a standard

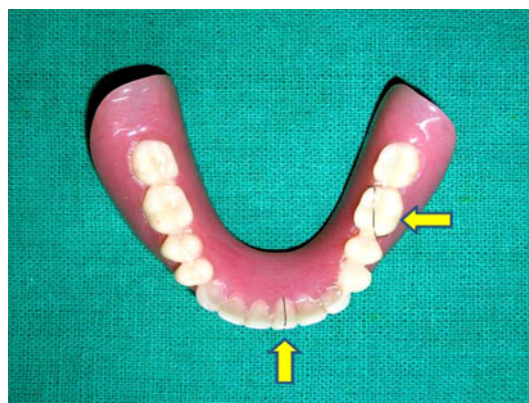


Fig. 1 Ligature wire adapted on the mandibular denture

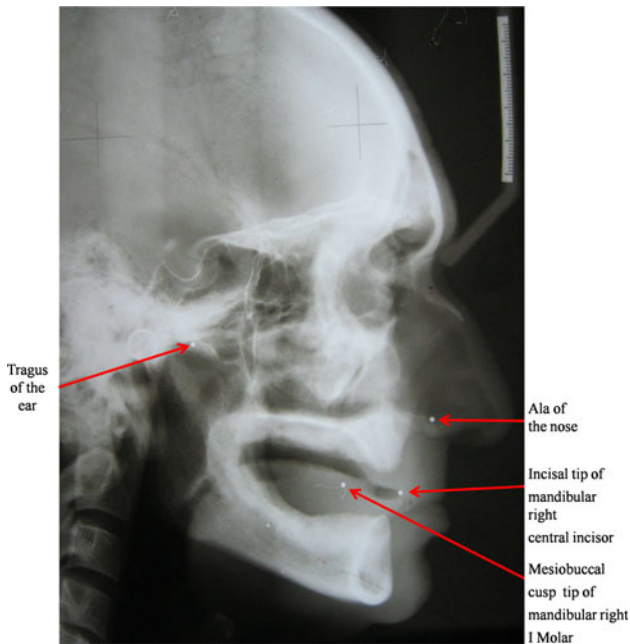


Fig. 2 Lateral cephalogram of Group III (Edentulous subject with Angle's class I Maxillomandibular relationship) showing marked radiopaque landmarks

technique with the dentures closed in centric occlusion and lips in relaxed position (Fig. 2). A 8' × 10'' green sensitive film (Kodak) was positioned parallel to the subject's mid sagittal plane. Subject's left side was kept towards the image receptor with the eyes looking towards infinity with the Frankfort Horizontal plane kept parallel to the floor of the X-ray room. The subject to source distance and the subject to film distance were adjusted and maintained to 5 feet and 8 inches, respectively.

The radiographs were taken at a constant current of 10 mA and an exposure time of 18 s; the kV varied between 65 and 80 kV. The radiographs with any kind of exposure or developing artifact or superimposition were discarded.

Cephalometric Analysis

All cephalograms were traced on a standard acetate tracing paper of a thickness of 5 microns with the help of 0.5 mm lead pencils. The following landmarks, points, planes, spaces and angles were traced and analyzed in the study (Figs. 3 and 4):

1. Skeletal landmarks: Anterior nasal spine (ANS), posterior nasal spine (PNS), Menton (Me), Nasion (N), Orbitale (Or), Porion (Po), and Gonion (Go).
2. Soft tissue landmarks: Inferior border of Ala of nose and superior most margin of Tragus.

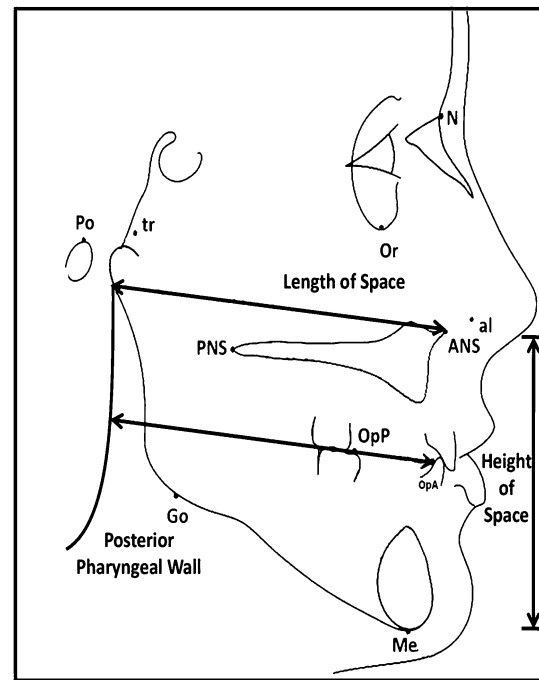


Fig. 3 Length and height of Maxillo-mandibular space outlined on the tracing of a lateral cephalogram

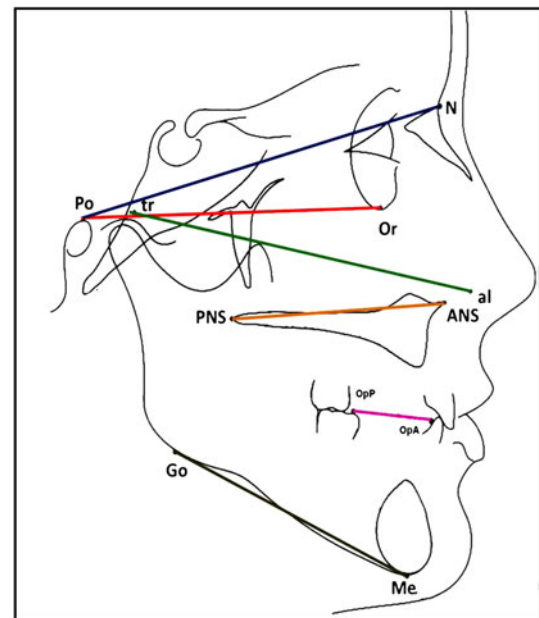


Fig. 4 Reference planes and angles are outlined on the tracing of a lateral cephalogram in edentulous subject

3. Dentate landmarks: Outline of lower incisor, upper incisor, mandibular molar and maxillary molar.
4. U points: Is the point where the Occlusal plane dissects the posterior pharyngeal wall.
5. Maxillo-mandibular Space: It is an enclosed space bounded anteriorly and laterally by all teeth,

posteriorly by the pharyngeal wall, superiorly by the hard palate and inferiorly by tongue and floor of the mouth.

6. Anatomic reference planes.

- Frankfort Horizontal plane: Plane drawn from the porion to orbitale.
- Camper's plane: Cephalometrically, it is a plane passing from the acanthion to the centre of the bony external auditory meatus. Clinically, it is a plane established by the inferior border of the right or left Ala of the nose and the superior border of the Tragus of both ears.
- Maxillary Palatal plane: Plane drawn from the anterior nasal spine to posterior nasal spine.
- Occlusal plane: Plane established by joining the Incisal and Occlusal surfaces of the teeth in one plane.
- Mandibular plane: Tangent to lower border of mandible at menton to gonion.

Results

All the angular and linear measurements in each group are tabulated with their Mean, Standard Deviation and Range of variables. Table 1 and Fig. 5 depicts comparison of angular variables of the Group I and Group II; the two sample T-test was applied which showed significant difference in the Means of all angular variables except Occlusal plane to Frankfort Horizontal plane angle, Occlusal plane to Camper's plane angle and Occlusal plane to Palatal plane angle (p value ≥ 0.05). Thereby showing that among Angle's classes I dentulous and edentulous subjects, the cant of the Occlusal plane was constant with the subsequent loss of teeth (Complete edentulousness).

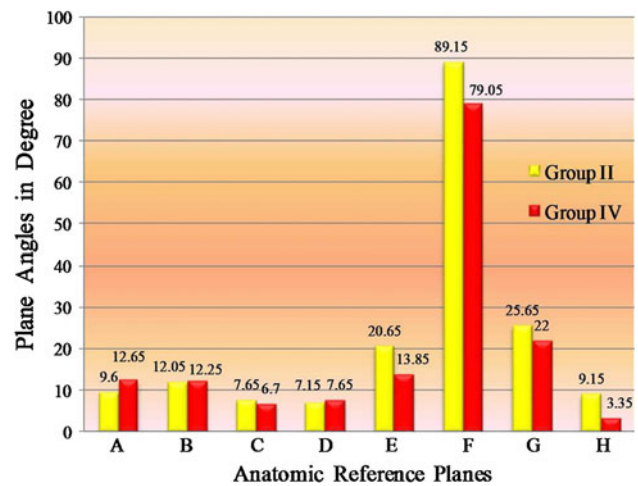


Fig. 5 Comparison of the relationship of Occlusal plane with the anatomic reference planes Group I and Group III

However, the Occlusal plane-Mandibular plane angle and Maxillomandibular plane angle showed marked reduction with gradual loss of teeth and thus resulting into overall loss of vertical dimension at occlusion. Similar comparison in Group II and Group IV showed identical findings what obtained among Group I and Group III subjects (Table 2, Fig. 6).

This comparison indicates that among Angle's class I and II dentulous and edentulous subjects, the cant of the Occlusal plane in relation to the maxillary base was constant with the loss of teeth. However, the Occlusal plane-Mandibular plane angle and Maxillomandibular plane angle showed mild reduction with the loss of teeth. The Maxillomandibular bisector plane was closely approximated to the Occlusal plane in edentulous subjects which may be attributed to the increase in Occlusal plane-Palatal plane angulation and correspondence decrease in Occlusal plane-Mandibular plane angle.

Table 1 Comparison of the relationship of Occlusal plane with the anatomic reference planes in Group I and Group III; two sample t-test for comparison of individual angular variables between two Groups I and Group III

S.No	Variables	Group I ($n = 20$)		Group III ($n = 20$)		p Value
		Mean	SD	Mean	SD	
1.	Angle between Frankfort Horizontal plane and Camper's plane	11.20	2.41	13.35	1.69	.007*
2.	Angle between Occlusal plane and Frankfort Horizontal plane	10.60	1.69	10.35	1.49	1.000
3.	Angle between Occlusal plane and Camper's plane	7.05	2.25	7.35	2.66	1.000
4.	Angle between Occlusal plane and Palatal plane	6.00	1.91	6.55	1.53	1.000
5.	Angle between Occlusal plane and Mandibular plane	16.15	3.26	11.00	1.74	.000*
6.	Angle between Porion-Nasion-anterior Nasal Spine	78.50	4.44	70.50	1.85	.050*
7.	Angle between Maxillary plane and Mandibular plane	22.25	3.17	17.55	1.31	.000*
8.	Angle between Occlusal plane and Maxillo-mandibular bisector plane	7.80	2.44	4.15	1.59	.050*

* p value ≤ 0.05 (significant)

Table 2 Comparison of the relationship of Occlusal plane with the anatomic reference planes in Group II and Group IV; two sample t-test for comparison of individual angular variables between two Groups II and Group IV

S.no.	Variables	Group II (n = 20)		Group IV (n = 20)		p Value
		Mean	SD	Mean	SD	
1.	Angle between Frankfort Horizontal plane and Camper’s plane	9.60	1.78	12.65	2.03	.000*
2.	Angle between Occlusal plane and Frankfort Horizontal plane	12.05	1.79	12.25	1.44	.832
3.	Angle between Occlusal plane and Camper’s plane	7.65	2.00	6.70	1.78	.942
4.	Angle between Occlusal plane and Palatal plane	7.15	1.21	7.65	1.49	.980
5.	Angle between Occlusal plane and Mandibular plane	20.65	1.75	13.85	1.89	.000*
6.	Angle between Porion–Nasion–anterior nasal spine	89.15	4.56	79.05	2.30	.050*
7.	Angle between Maxillary plane and Mandibular plane	25.65	1.92	22.00	2.17	.000*
8.	Angle between Occlusal plane and Maxillo-mandibular bisector plane	9.15	2.39	3.35	1.08	.000*

*p value ≤ 0.05 (significant)

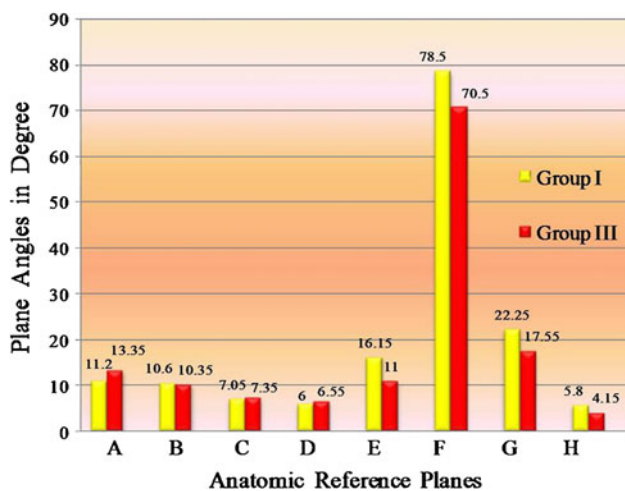


Fig. 6 Comparison of the relationship of Occlusal plane with the anatomic reference planes in Group II and Group IV

The comparison between the dentulous ($n = 40$) and edentulous group ($n = 40$) was done irrespective to the skeletal jaw relationships (class I or class II). The comparison depicts that among dentulous and edentulous subjects, the cant of the Occlusal plane in relation to the Maxillary base was maintained with the loss of teeth and this consistency did not alter with the different skeletal jaw relationships (Angle’s class I and class II). So, the class I and class II jaw relationship had no effect on the relation and angulations of the above mentioned angulations. However, the Maxillomandibular bisector plane was closely approximated to the Occlusal plane in edentulous subjects which may be attributed to the increase in Occlusal plane-Palatal plane angulation and correspondence decrease in Occlusal plane-Mandibular plane angle.

T-test was applied to evaluate the position of Occlusal plane as related to Maxillomandibular space dimensions (height, length, and Maxillomandibular angle) in dentulous

and edentulous subjects. The Maxillomandibular space length was non significant when compared in dentulous and edentulous subjects in both Angle’s class I and class II subjects ($p > 0.05$). However, Maxillomandibular space height showed significant difference in dentulous and edentulous subjects ($p < 0.05$). The above results showed that there was reduction of the height of Maxillomandibular space in the edentulous subjects than that of dentulous subjects of both Angle’s class I and class II jaw relationship. Again it may be perceived here that Angle’s class I and class II does not seem to affect the length of the Maxillomandibular space.

Discussion

In complete denture fabrication the Prosthodontist is responsible for rehabilitating natural form and function and for developing an occlusion that is most compatible to the craniofacial structures and neuromuscular mechanism. One of the greatest challenges in prosthetic rehabilitation of edentulous patient is to accurately establish lost Occlusal plane. The location of Occlusal plane in complete denture fabrication is very subjective and it is widely variable depending upon the uncertainty of reference landmarks and the individual judgment. Several principles have been postulated to determine the Occlusal plane like upper lip [9], lateral margins of tongue [10], two-third of the height of the retromolar pad, parallel to the Camper’s plane and interpupillary lines [11]. Recent studies have advocated the use of Cephalometrics in determining and evaluating the position of the Occlusal plane in dentulous & edentulous patients [6, 12]. A cephalometric study done by Van Niekerk et al. [11] on 33 edentulous patients, found the angulation of Occlusal plane to Camper’s plane as 3.45°

Table 3 Correlation matrix for Occlusal plane to Frankfort Horizontal plane angulation

S.No	Variables	Correlation r (n = 20)			
		Group I	Group II	Group III	Group IV
1.	Angle between Frankfort Horizontal plane and Camper's plane	.31	-.14	.21	-.26
2.	Angle between Occlusal plane and Camper's plane	-.76 ^a	-.71 ^a	-.86 ^a	-.81 ^a
3.	Angle between Occlusal plane and Palatal plane	.59 ^a	.54 ^a	.43	-.30
4.	Angle between Occlusal plane and Mandibular plane	-.31	-.22	.38	.01
5.	Angle between Porion–Nasion–anterior nasal spine points	-.76 ^a	-.80 ^a	-.25	-.14
6.	Angle between Maxillary plane and Mandibular plane	-.19	.07	-.10	-.05
7.	Angle between Occlusal plane and Maxillo-mandibular bisector plane	-.21	-.20	-.22	-.19

^a r value = Positive correlation

whereas Koller et al. [13] and Karkazis and Polyzois [6] reported it as 7.00° and 10.00° respectively. Seifert et al. [8] have concluded Occlusal plane-Frankfort Horizontal plane angulation as 11.42° in dentulous subjects whereas Celebic et al. [14] proposed it as 9.43° and 8.53° in dentulous and edentulous subjects.

The comparison of Occlusal plane with Camper's plane angulation was non significant that indicates a constant relationship between these in dentulous and edentulous subjects with Angle's class I jaw relationship. Karkazis and Polyzois [6] correlated Occlusal plane with Camper's planes in dentulous and edentulous subjects and reported the inclination of artificial Occlusal plane–Camper's plane (10.00° ± 3.25°) almost the same as the inclination of natural Occlusal plane–Camper's plane (7.00° ± 2.88°). The minor discrepancy observed in his results in dentulous and edentulous Group (up to 3°) may be attributed to the use of centre of the Tragus as posterior reference point instead of superior margin of Tragus. However, Koller et al. [13] reported a mean angulation of Occlusal plane–Camper's plane as 7.00° which was almost similar to the finding of our study in edentulous class I subjects and they explained this discrepancy on the basis of bone resorption and subsequent decrease in the height of Occlusal plane. This relative consistency of Occlusal plane–Camper's plane angulation has also been observed in Angle's class II dentulous and edentulous subjects. Thus the skeletal jaw relationship (Angle's class I and class II) appears not to affect the Occlusal plane relationship with Frankfort Horizontal plane, Camper's plane and Palatal plane Occlusal plane–Frankfort Horizontal plane angulation as 10.60° and 10.35° in Group I (dentulous class I) and Group III (edentulous class I), respectively, and on statistical analysis the comparison was found to be non significant (Table 2, $p > 0.05$). Seifert et al. [8] reported this angulation as 11.42° which differed slightly (>2°) from our angular finding. This much variation may be accepted clinically since Shillingburg et al. [15] stated that up to 8°

of difference in angular perception does occur in binocular vision. If we are to understand that a visual error is possible, then it may be a reasonable to state that there is relative consistency in the angle between Occlusal plane–Frankfort Horizontal plane in dentulous and edentulous subjects with Angle's class I jaw relationship. Moreover, both these planes are highly correlated (coefficient of correlation $r = -0.76$ and -0.86 , $p < 0.05$) indicating their strong association (Table 3). These findings are similar with the correlations (Occlusal plane–Frankfort Horizontal plane angle and Occlusal plane–Camper's plane angle) made by Seifert et al. [8] ($r = -0.80$). These findings suggest relatively stable relation of the Frankfort horizontal plane and Camper's plane with Occlusal plane.

The location of Occlusal plane in relation to Maxillo-mandibular space was determined relative to height and length of Maxillomandibular space by measuring the perpendicular distance between menton (Me) to ANS whereas length is measured as a distance from lingual surface of Mandibular left incisor to the point where it bisect the posterior pharyngeal wall [16]. There were various researchers in literature who studied the dynamic nature of vertical dimensions in edentulous subjects [17–19]. The variability that occurred in vertical dimension was universally discussed on the basis of resorption of lower ridge. Moreover, the edentulous patients generally tries to stabilize the mandibular denture in the lower arch that result into relative settling of lower denture. This brings the mandible into more forward and upward position which thereby results into decreased Occlusal vertical dimension. The results showed that the height of the Maxillomandibular space relative to Angle's class I and class II relationship were similar, however, there is marked reduction in height of the Maxillomandibular space in the edentulous subjects as compared to dentulous subjects.

Though an effort was put to correlate certain anatomical planes as a anatomical guides to ease the establishment of the lost Occlusal plane, we still cannot say any reference

plane to be definitive. If the concept that the Occlusal plane has to be based on what existed naturally, then the three anatomical planes (i.e.; Camper's plane, Frankfort Horizontal plane and Palatal plane) are accurate. However, various parameters such as increase in tongue size, loss of neuromuscular control, variability in resorption in both Maxilla and Mandible, sequel of natural tooth extraction, are variables which are difficult to standardize in patients. Further studies on longer scale with specific inclusion criteria's need to be conducted. The use of three dimensional imaging modality and digitalization is required. The analysis of Angle's class III Maxillomandibular relationship also needs to be done to get more comprehensive understanding.

Conclusion

The following conclusions were arrived from this study:

1. Among all the reference planes evaluated, only three planes i.e. Frankfort Horizontal plane, Camper's plane and the Palatal plane showed a definitive relation with Occlusal plane in both dentulous and edentulous subjects with Angle's class I and II Maxillomandibular relationship.
2. The relation of Occlusal plane with anatomic reference planes in both dentulous and edentulous subjects was not found to be influenced by the type of skeletal jaw relationship i.e. Angle's Maxillomandibular relationships.
3. The Maxillomandibular space evaluated in both dentulous and edentulous state showed the space to be larger in the dentulous state as compared to edentulous state for both Angle's class I and class II Maxillomandibular relationships.

The present study therefore advocates that establishing the Occlusal plane parallel to the Camper's plane and then transferring the orientation jaw relation to the semi adjustable articulator (with Face Bow) using Frankfort Horizontal plane would serve as a definite guide for correct establishment of Occlusal plane in edentulous subjects with Angle's class I or class II Maxillomandibular relationship.

Conflict of interest None declared

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