The Position of the Occlusal Plane in Natural and Artificial Dentitions as Related to Other Craniofacial Planes

Firas A.M. AL Quran, PhD, MSc Med, BDS,[1] Abdalla Hazza'a, PhD, MSc Med, BDS,[2] & Nabeel Al Nahass, MSc Dent, DDS[3]

[1] Associate Professor in Prosthetic Dentistry, Faculty of Dentistry, Jordan University of Science and Technology (JUST), Irbid, Jordan
[2] Associate Professor in Oral and Maxillofacial Radiology, Faculty of Dentistry, Jordan University of Science and Technology (JUST), Irbid, Jordan
[3] Private Practice, Dubai, United Arab Emirates

Keywords
Occlusion; cephalometric; plane; orientation.

Correspondence
Firas A.M. AL Quran, PO Box 3030, Irbid 22110, Jordan. E-mail: firasalquran@yahoo.com, firasq@just.edu.jo

Accepted December 10, 2009

doi: 10.1111/j.1532-849X.2010.00643.x

Abstract

Purpose: This study aimed at determining the most reliable ala-tragus line as a guide for the orientation of the occlusal plane in complete denture patients by use of cephalometric landmarks on dentate volunteers.
Materials and Methods: Analysis was made for prosthodontically related craniofacial reference lines and angles of lateral cephalometric radiographs taken for 47 dentate adults. Variables were determined and data were analyzed using SPSS (SPSS, Inc., Chicago, IL).
Results: Occlusal plane angle formed between the occlusal plane and Camper's plane had the lowest mean value in the angle formed with Camper's I, which represents the measure taken from the superior border of the tragus of the ear with a score of 2.1°. The highest was measured in the angle formed with Camper's III with a score of 6.1°, while the angle formed with Camper's II was 3.2°. The differences between the three planes in relation to the occlusal plane was significant ($p < 0.001$).
Conclusion: The superior border of the tragus with the inferior border of the ala of the nose was most accurate in orienting the occlusal plane.

Occlusal plane orientation is one of the most important clinical procedures in removable prosthodontic treatment for edentulous patients. It is the most important plane to be determined in complete denture work, as it is a vital and important basis for tooth arrangement. The occlusal plane position is considered to be the primary link between function and esthetics. The orientation of the occlusal plane is lost in patients rendered edentulous and should be relocated if complete dentures are to be esthetic and to function satisfactorily. For example, if the occlusal plane is placed too high, the tongue cannot rest on the lingual cusps of the mandibular denture and prevents the denture's displacement. There is also a tendency for accumulation of food in the buccal and lingual sulci. On the other hand, if the occlusal plane is placed too low, it could lead to tongue and cheek biting.[1]

Complete dentures are constructed to function in the mouth as an integral part of the masticatory system; therefore, they should be designed to conform to the patient's physiologic jaw relations. The plane of occlusion forms one essential physiologic concept of jaw relation and occlusion. The plane of occlusion in complete dentures has often been oriented anteriorly to fulfill esthetic requirements and posteriorly parallel to Camper's line, which is a horizontal line drawn through the lower part of the nose and the orifice of the ear.[2]

According to surveys,[3-6] occlusal plane orientation differs considerably among schools in Japan, the US, and Canada; however, the most widely used method in determining the plane of occlusion was the ala-tragus line method. Zarb et al[7] suggested anatomical landmarks that clinically determine the plane of occlusion. They said that the occlusal plane should be parallel to the hamular notch-incisive papilla plane, whereas other researchers have reported a close relationship between the ala-tragus line and occlusal plane.[6]

The use of a number of anatomical landmarks as guides from life or biometric guides for artificial tooth position has been suggested by many authors.[8-11] Anatomical landmarks suggested to clinically determine the position of the occlusal plane are the upper lip, corner of the mouth,[11] lateral margins of the tongue, two-thirds of the height of the retromolar pad, parallel to the ala-tragus (Camper's plane) and interpupillary lines,[6,7] parallel to the hamular notch-incisive papilla plane, and 3.3 mm below the parotid papilla.[12,13]

A common concept is that the occlusal plane should be parallel to a line drawn from the lowest point of the ala of the

nose to the external auditory meatus or tragus of the ear.[14,15] There are differences in the literature concerning which part of the tragus to use, since some researchers believe in using the lower border of the tragus, others believe in using the middle part of the tragus, and still others believe in using the upper part.[6,7,16]

The occlusal plane of dentures must be oriented as closely as possible to the occlusal plane that existed in the natural dentition. By doing so, the tongue and cheeks will be more effective during deglutition and mastication, and speech and esthetics will be improved.[17] On the other hand, other researchers believe that reproducing the natural occlusal plane in complete dentures is not necessary due to conditions in natural dentitions differing from those of artificial dentures. They feel reproducing the natural occlusal plane offers no advantages for the extra care involved.[16,18-21] Therefore, what is considered normal arrangement of teeth could be modified to suit edentulous needs; however, it would seem reasonable that dentures should not depart too radically from what they are replacing.

Since 1931, cephalometric analysis has served as a valuable adjunct to dental research and diagnosis, although its clinical application has been directed largely toward orthodontics. Cephalometry is of special value to prosthodontics, in that it can be used to reestablish the correct position of lost structures such as the teeth. This can be achieved by identifying a predictable relationship between the teeth and other cranial landmarks not subjected to postextraction changes.

In this study, cephalometric analysis has been used to investigate the relationship between the natural occlusal plane and anatomical structure in the skull.[22]

Materials and methods

This study aims at determining the most reliable ala-tragus line as a guide for the orientation of the occlusal plane in complete dentures and the use of cephalometric landmarks to predict the occlusal plane orientation in edentulous patients. Prior to beginning the study, the research was approved by the Board Research Committee at the Faculty of Dentistry at the Jordan University of Science and Technology (JUST). Further approval was sought and received from the JUST Deanship of Research. This study included 51 fully dentate subjects with Angle's class I occlusion. The subjects were randomly selected. After clinical examination, four patients were excluded, because they either refused X-ray exposure, or because we were unable to locate the requested anatomical landmarks accurately.

This group of volunteers consisted of 47 young adults selected from fourth and fifth year dental students. The criteria for selection of these patients was the presence of 28 to 32 natural teeth in an ideal arch alignment, with Angle's class I molar relationship, a pleasing profile, and no history of orthodontic treatment.

Left lateral cephalograms were taken of the subjects by a standard technique with the mandible closed in maximum intercuspation. The dentulous occlusal plane was located as the line averaging the points of the posterior occlusal contact from the first permanent molar to the bicuspids to the most lingually placed incisor tooth.

A cephalometric radiograph was taken for each patient, using an Orthopantomograph model Orthophos-5 (Siemens, Erlangen, Germany) with a focal film distance of 5 feet. Radiographs were obtained at 66 to 69 kVp and 15 to 16 mA according to the individual's physical status. Kodak T-MAT films (Eastman, Kodak, Rochester, NY) with Siemens special screens (Siemens) were used for conventional cephalometric radiography. An automatic processor with daylight loader (XR 24, Durr Dental, Bietigheim-Bissingen, Germany; 230 V and 50 to 60 Hz) was used with RP X-Omat (Kodak, Chalon-Sur-Saone, France) chemicals.

Barium sulfate creamy mix was applied to the teeth, one drop on the incisal edge of the left maxillary central incisor, and another drop painted to cover the mesio-palatal cusp of the left maxillary first molar. Another creamy mix of barium sulfate was painted on the skin on the left side of each patient's face in the shape of a triangle to mark required landmarks to be shown in the final radiograph. The apex of the triangle superiorly pointed to the lower border of the ala of the nose, and the other one was applied to mark the whole tragus of the ear. The apex of the painted triangle of the tragus pointed posteriorly to the tragus so that the lowest angle between occlusal plane and ala-tragus line at the superior, middle, and inferior border of the tragus could be identified.

Each subject was radiographed in standing position. Patients were asked to close in centric occlusion. The lips and the rest of the body were relaxed. Using the cephalostat, the patient's head was fixed bilaterally by the ear rod and anteriorly by a plastic stopper on the bridge of the nose. The cassette with the film inside was at the right side of the patient's face. The ear rods were inserted into the external auditory meatus with appropriate care to prevent the tragus from being forced anteriorly by direct pressure from the ear rods; however, displacement in this horizontal direction was considered unlikely to produce vertical distortion of the tragus point to an extent that would cause unacceptable error in the measurements. Each traced cephalogram was placed on the conventional viewing box. The cephalometric points used in this study are the following.

Ala (point A): The lowest point of the left ala of the nose represented by the superior apex of the triangular barium sulfate applied to the skin of the left side of the face.

Tragus (point T): The whole tragus of the left ear represented by the triangular barium sulfate applied to the skin of the face of the dentate and edentate subjects.

The cephalometric planes and lines used in this study are the following.

Ala-tragus line (Camper's plane): The line joining point A with point T.

Occlusal plane: The line connecting the lowest point of the incisal edge of the left maxillary central incisor with the lowest point of the mesio-palatal cusp of the left maxillary first molar.

For the purpose of comparison, angles rather than linear measurements were used, since angles can be compared directly in individuals of different sizes without the need of an index. The angular measurements were recorded to the nearest degree. Measurements were done according to a method described by Jaccobson.[23] The angles to be studied, were as follows.

Table 1 Angle between occlusal plane in the dentate group and Camper's I, II, and III

	Mean	Maximum	Minimum	Std. deviation	N
Camp I	2.0638°	12.00°	0.00°	2.11006°	47
Camp II	3.1574°	8.00°	0.00°	1.63318°	47
Camp III	6.1255°	11.00	2.00°	1.65352°	47

Camp I-OP: Angle between Camper's I (superior border of tragus) and occlusal plane.

Camp II-OP: Angle between Camper's II (middle border of tragus) and occlusal plane.

Camp III-OP: Angle between Camper's III (inferior border of tragus) and occlusal plane.

SPSS (SPSS, Inc., Chicago, IL) was used to calculate the mean and standard deviation of all angular measurements, age for the whole sample, and for both sex groups.

Results

Subjects involved in this study included 47 dentate fourth and fifth year dental students (21 men, 26 women). Their age ranged from 21 to 34 years old.

Occlusal plane angle formed between the occlusal plane and Camper's plane had the lowest mean value in the angle formed with Camper's I, which represents the measure taken from the superior border of tragus of the ear with a score of 2.1°. The highest was measured in the angle formed with Camper's III, with score of 6.1°, while the mean angle formed with Camper's II was 3.2° (Table 1). The differences between the three planes in relation to the occlusal plane were found to be significant ($p < 0.001$) (Table 2).

Discussion

An analysis of cephalometric lines and angles could provide useful information on the craniofacial skeleton and the orientation of the occlusal plane in dentulous and edentulous subjects. The plane of occlusion has been recognized as an essential functional part of the craniofacial skeleton.[24-27]

Angular variables were used in this study to illustrate variations in artificial occlusal plane (AOP) orientation in relation to other craniofacial planes and to determine the validity of the use of the ala-tragus line as a reference point for occlusal plane orientation. Complete dentures are constructed to function in the mouth in harmony with the masticatory system; therefore, the complete dentures should be designed in accordance with all jaw movements and relations. Part of designing the complete denture is orienting the occlusal plane in the most acceptable cant for esthetics and function. Investigators have suggested various concepts and methods for the orientation of the occlusal plane in complete dentures based on morphologic studies on natural and artificial dentitions and on clinical experience.[6,16,28-30]

Historically, the assessment of a patient's occlusal line has been performed by comparing its inclination with selected craniofacial reference lines. The ala-tragus line was the most commonly used and widely taught method for the orientation of the plane of occlusion.[3,4]

In the literature, there is controversy in defining Camper's plane, which is considered the most popular plane used to orient the occlusal plane in edentulous patients. Definition of the Camper's line causes confusion, because the exact reference points are controversial. For example, the Glossary of Prosthodontic Terms[31] states that the Camper's line runs from the inferior border of the ala of the nose to the superior border of the tragus, while for Spratley[16] it runs from the center of the ala to the center of the tragus. Among seven of the most famous prosthodontic textbooks, only Boucher's provides a definition.[8] Two other textbooks[32,33] recommend the concept without defining it, while Basker et al,[34] Grant and Johnson,[35] and Neill and Naim[36] provide only pictorial representation, illustrating Camper's line as extending to a point, not at the superior border, but at the center of the tragus of the ear, corresponding to the definition of Ismail and Bowman,[30] which predates Boucher's definition. However, investigations into the clinical reliability of Camper's line serve only to compound the confusion, as Ismail and Bowman[30] compared the use of an ala-tragus line oriented to the middle of the tragus with the occlusal plane of natural teeth, and concluded that dentures constructed accordingly would have an occlusal plane set far too low posteriorly. This is contraindicated by Abrahams and Carey,[37] who concluded that the occlusal plane of complete dentures conforming to a line oriented to the superior border of the tragus results in the occlusal plane being leveled far too high posteriorly.

In the present study, we used three Camper's planes, based upon the superior, middle, and inferior part of the tragus; as

Table 2 Significant difference between Camper's I, II, and III, by predicting the *p*-value (< 0.001)

Test value = 0						
95% Confidence interval of the difference						
Upper	Lower	Mean difference	Sig. (2-tailed)	df	t	
2.6834	1.4443	2.06383	.000	46	6.705	Camp I
3.6370	2.6779	3.15745	.000	46	13.254	Camp II
6.6110	5.6400	6.12553	.000	46	25.397	Camp III

Camper's plane I is the line extending from the inferior border of the ala of the nose to the superior border of the tragus of the ear, Camper's plane II is the line extending from the inferior border of the ala of the nose to the middle border of the tragus of the ear, and Camper's III is the line extending from the inferior border of the ala of the nose to the inferior border of the tragus of the ear. The lowest mean angle formed between Camper's I and the natural occlusal plane was 2.1°, Camper's II was 3.2°, and Camper's III was 6.1° (Table 1). Nissan et al,[38] on the other hand, recorded the angle formed between occlusal plane and Camper's line as 7.08°. Abrahams and Carey[37] reported the angle formed between the natural occlusal plane and Camper's plane to be 9.66°. Augsburger[28] found the angle of the occlusal plane deviated from Camper's plane by 3.2° to 7.85° in dentate patients of different facial types.

Van Niekerk et al[6] recorded a 2.45° angle between the occlusal plane of the complete denture and the ala-tragus line. Karkazis and Polyzois[22] did not find a correlation between Camper's plane and the occlusal plane of natural teeth (average 2.84°) or artificial teeth (average 3.25°); however, the inclination of the occlusal plane on complete dentures was similar to the natural occlusal plane. The difference between the average angle (2.0°) made by the occlusal plane and Camper's plane as found in the present study and that of other studies can be explained by the use of different points of measurement. Van Niekerk et al[6] used the inferior border of the tragus as the posterior border of the ala-tragus line, whereas Karkazis and Polyzois[22] used the center of the tragus as the posterior border of Camper's plane.

According to the findings of this study, Camper's I is the most suitable plane to orient the occlusal plane, forming a stop anteroposteriorly following the curve of the ramus of the mandible, and establishing a curve that would serve the artificial teeth to be set in a way to prevent any interferences that would dislodge the denture during protrusive movement, making the dentures more stable and ensuring satisfactory service. On the other hand, an investigation[30] has been carried out that compared the occlusal plane orientation before extraction of natural teeth and when artificial teeth were arranged so that the AOP paralleled the ala-tragus line. The results indicated that the natural occlusal plane was higher posteriorly than the AOP, which disagrees with what had been shown by Wylie,[39] Abrahams and Carey,[37] and Ow et al.[27] One can see the controversy regarding the position of the natural occlusal plane in relation to the AOP (determined by the use of the ala-tragus line). Moreover, in actual practice, the determination of the AOP by the ala-tragus line is taken only as an approximation and as the mean of the angle formed between the two planes. The ala-tragus line has proved to be a useful reference line for the initial orientation of the occlusal plane in complete dentures. Therefore, the ala-tragus line may be modified to be extended from the inferior part of the ala of the nose to the superior part of the tragus of the ear, instead of the mid- or inferior-tragus points. The differences between Camper's I, II, and III were tested and revealed a significant statistical difference (Table 2), which means that using Camper's I to orient the occlusal plane would make a significant difference in the esthetics and comfort of the complete denture.

The results of this study found that the superior border of the tragus is the most acceptable point to orient the occlusal plane, which complies with Boucher,[8] the Glossary of Prosthodontic Terms,[31] and Trapozzano.[40] On the other hand, this study does not agree with the findings of other studies. Van Niekerk[6] has suggested the use of the inferior part of the tragus rather than middle or superior, while Ismail and Bowman[30] suggested the use of the middle part of the tragus.

Conclusion

Within the limitations of this study, it can be 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.

References

1. Monteith BD: A cephalometric method to determine the angulation of the occlusal plane in edentulous patients. J Prosthet Dent 1985;54:81-87
2. Karkazis HC, Polyzois GL: Cephalometrically predicted occlusal plane: implications in removable prosthodontics. J Prosthet Dent 1991;65:258-264
3. Levin B, Sauer LJ: Results of a survey of complete denture procedure taught in American and Canadian dental schools. J Prosthet Dent 1969;22:171-177
4. Ukai H, Yanagide S, Ratoh Y, et al: Examination into the questionnaire, "Results of a survey of complete denture procedures taught in Japanese dental schools" Prac Prosthod 1979;3:324
5. Lundquist DO, Luther WW: Occlusal plane determination. J Prosthet Dent 1970;23:489-498
6. van Niekerk FW, Miller VJ, Chem C, et al: The ala-tragus line in complete dentures prosthodontics. J Prosthet Dent 1985;53:67-69
7. Zarb GA, Bolender CA, Carlsson GE: Boucher's Prosthodontic Treatment for Edentulous Patients (ed 11). St. Louis, Mosby, 1997
8. Boucher CO: Complete denture prosthodontics—state of the art. J Prosthet Dent 1975;34:372-383
9. Roraff AR: Arranging artificial teeth according to anatomic landmarks. J Prosthet Dent 1977;28:120-130
10. Murray CG: Anterior tooth positions in prosthodontics. Aust Dent J 1977;22:113-119
11. Hickey JC, Zarb GA, Bolender CL: Boucher's Prosthodontic Treatment for Edentulous Patients (ed 12). St. Louis, Mosby, 2004
12. Rich H: Evaluation and registration of the H.I.P. plane of occlusion. Aust Dent J 1982;22:162-168
13. Foley PF, Latta GH Jr: A study of the position of the parotid papilla relative to the occlusal plane. J Prosthet Dent 1985;53:124-126
14. Anthony LP: The American Textbook of Prosthetic Dentistry. Philadelphia, Lea and Febiger, 1967
15. Lammie GA: Full Dentures. Oxford, Blackwell, 1956
16. Spartley MH: A simplified technique for determining the occlusal plane in full denture construction. J Oral Rehab 1980;7: 31-33
17. Kapur KK, Soman S: The effect of denture factors on masticatory performance. Part II the location of the food platform. J Prosthet Dent 1965;15:451-463

18. Cocker WL: The occlusal plane. Brit Dent J 1925;46:463-464
19. Kurth LE: The posterior occlusal plane in full denture construction. J Am Dent Assoc 1940;27:92-95
20. Pound E: Modern American concepts in aesthetics. Int Dent J 1960;10:154-172
21. Fish EW: Principles of Full Denture Prostheses (ed 6). London, Staples, 1964
22. Karkazis HC, Polyzois GL: Cephalometrically predicted occlusal plane: implication in removable prosthodontics. J Prosthet Dent 1991;65:258-264
23. Jaccobson A, Canfield PW: Introduction to Radiographic Cephalometry. Philadelphia, Lea and Febiger, 1985
24. Kapur KK, Lestrel PE, Chauncey HH: Development of prosthodontic craniofacial standards: occlusal plane location. J Dent Res 1982;61:222. Abstract 391
25. Ow RK, Keng SB, Djeng SK, et al: A radiographic interpretation of craniofacial reference lines in relation to prosthodontic plane orientation. J Prosthet Dent 1986;31:326-334
26. Ow RK, Djeng SK, Ho CK: The relationships of upper facial proportions and the plane of occlusion to anatomic reference planes. J Prosthet Dent 1989;61:727-733
27. Ow RK, Djeng SK, Ho CK: Orientation of the plane of occlusion. J Prosthet Dent 1990;64:31-36
28. Augsburger RH: Occlusal plane relation to facial type. J Prosthet Dent 1953;3:53-65
29. Hartono R: The occlusal plane in relation to facial types. J Prosthet Dent 1967;17:549-557
30. Ismail YH, Bowman JF: Position of the occlusal plane in natural and artificial teeth. J Prosthet Dent 1968;20:407-411
31. Glossary of prosthodontic terms. J Prosthet Dent 2005;94: 10-92
32. Sharry JJ: Complete Denture Prosthodontics (ed 3). New York, McGraw-Hill, 1974
33. MacGregor AR: Fenn, Liddlelow and Gimson's Clinical Dental Prosthetics (ed 3). Oxford, Wright, Butterworth, 1983
34. Basker RM, Davenport JC, Tomlin HR: Prosthetic Treatment of the Edentulous Patient (ed 1). London, Macmillan, 1976
35. Grant AA, Johnson W: An Introduction to Removable Denture Prosthetics. Edinburgh, Churchill Livingstone, 1983
36. Neill DJ, Naim RI: Complete Denture Prosthetics. Bristol, John Wright Sons, 1975
37. Abrahams R, Carey PD: The use of ala-tragus for occlusal plane determination in complete dentures. J Dent 1979;7: 339-341
38. Nissan J, Barnea E, Zeltzer C: Relationship between the craniofacial complex and size of the resorbed mandible in complete denture wearers. J Oral Rehab 2003;30:1173-1176
39. Wylie WL: The Naso-meatal line as guide for the determination of the occlusal plane. J Dent Res 1944;23:309-312
40. Trapozzano V: Occlusal records. J Prosthet Dent 1955;5:325-333