A cephalometric analysis to establish a correlation of different ridge relations to three levels of camper's line in edentulous patients: An *in vivo* study

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Abstract

Aim: This study was undertaken with an aim to establish a relationship between normognathic (Class I), retrognathic (Class II), and prognathic (Class III) ridge relation and superior, middle, and inferior levels of the ala-tragus line in edentulous individuals, by utilizing arbitrary and cephalometric methods.

Methodology: Ninety edentulous male patients were selected for the study, and after establishing tentative jaw relation, radiopaque ball bearings were attached on three levels of the tragus and inferior part of the ala of the nose. Furthermore, orthodontic wire was attached to maxillary occlusal rims. Lateral cephalometric radiographs were taken, and tracings were carried out to compare and to evaluate the cephalometrically derived ridge relations with that of the visually analyzed ridge relations based on the mounted casts in relation to the ala-tragus line. The results obtained were statistically analyzed using one-way ANOVA test, and multiple comparisons were carried out using the Bonferroni tests. The interoperator variability for obtaining ridge relations using visual analysis and the cephalometrically obtained ridge relations were analyzed using the Kappa statistics.

Results: The result obtained states that 78 participants out of 90 participants are in total agreement with the Kappa value of 0.8.

Conclusion: The study concluded that for Class I and Class III, the inferior part of the tragus forming the ala-tragus line, and for Class II, the middle part of the tragus should be considered for establishing the occlusal plane.

Keywords: Ala-tragus line, camper's line, cephalometric analysis, complete denture, occlusal plane, yen angle

INTRODUCTION

The placement of the occlusal plane in the fabrication of complete denture forms the basic platform for ideal teeth arrangement to fulfill necessary mechanical, esthetic, and phonetic requirements, and also aid in proper respiration and deglutition.[1] Hence, the occlusal plane should be established as identical as possible.

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The orientation of occlusal plane anteriorly is governed by the esthetic and less frequently by functional requirements. However, there are contrasting views with regard to the orientation of occlusal plane in the posterior region. The most commonly used reference to establish the occlusal plane posteriorly is the Camper's Line, which was originally postulated in 1780, by Petrus Camper, passes through the anterior nasal spine and center of the external auditory meatus.[2] However, changes have been made such that the line passes through the superior part of the tragus of the ear. Some dentists position the occlusal plane parallel to and mid-way between the residual ridges while some recommend placing the occlusal plane terminating posteriorly at the anterior two-third of the retromolar pad.[3,4] Hence, dilemma prevails whether to consider maxillary or mandibular landmarks to establish the occlusal plane. Although predecessor considered mandibular landmarks as criteria to establish occlusal plane, the successors gradually shifted to maxillary landmarks for the establishment of occlusal plane considering esthetics as useful criteria.

Literature shows the consideration of superior, middle, and inferior points of tragus as posterior reference points. However, there is no scientific evidence as to which point of tragus should be considered in reference to ridge relation. Hence, this study was designed to establish a relationship between normognathic (Class I), retrognathic (Class II), and prognathic (Class III) ridge relations with superior, middle, and inferior levels of ala-tragus line in edentulous individuals, by utilizing arbitrary methods and cephalometric landmarks.

METHODOLOGY

Ninety edentulous male patients in the age group of 45–70 years, visiting the Department of Prosthodontics, Pacific Dental College and Hospital, Udaipur, Rajasthan, having high well-rounded ridge configuration (Atwood's Order III) were selected for the study after obtaining the ethical clearance from the Institutional Research and Review Board. Participants with anatomical deformity of external ear and nose, ridge deformity, and suffering from oral diseases such as oral submucous fibrosis, temporomandibular disorders, systemic diseases such as neuromuscular disorders, and osteoporosis were excluded from the study.

Fabrication of permanent denture base and occlusal rims
Denture fabrication procedure for each patient was initiated as per the standard clinical protocols. The fabrication of permanent denture base for maxillary and mandibular master casts was carried out using heat-cured acrylic resin using compression molding technique. Two radiopaque ball bearings of 3.175-mm diameter were fixed in the incisive papilla region of maxillary denture base and central incisor region of mandibular denture base, respectively [Figure 1]. Wax rims were made on maxillary and mandibular permanent denture bases according to ideal dimensions.

Recording of maxillomandibular relationship
The mandibular occlusal rim was adjusted intraorally using the stable intraoral landmarks such as the corner of the mouth anteriorly and the anterior two-third of the retromolar pad area posteriorly at the level of the lateral border of the tongue.[5,6] The maxillary occlusal plane was adjusted to the established mandibular occlusal plane. Tentative jaw relations were established using Niswonger's method and Silverman's closest speaking space. The facebow transfer was made, and the maxillary cast was oriented to semi-adjustable articulator. The mandibular cast was oriented to maxillary cast in centric relation. Based on the recorded maxillomandibular relations, the patients were categorized into three groups as follows:
a. Normognathic (Class I)
b. Retrognathic (Class II)
c. Prognathic (Class III).

After the establishment of maxillomandibular relationship, a 3 cm long orthodontic wire of 21G was adapted on the right side of the maxillary occlusal rim depicting the established occlusal plane [Figure 2].

Preparation of the subject for lateral cephalogram
Three radiopaque ball bearings of 3.175-mm diameter were attached on the superior, middle, and inferior parts of tragus, and one ball bearing at inferior border of ala of the nose using an adhesive tape [Figure 3]. The maxillary and mandibular occlusal rims were placed intraorally, and the patient's mandible was guided in centric relation.

Lateral cephalograms
Kodak 8000 c machine was used for taking lateral cephalograms [Figure 4], and films were exposed at 70 kVp and 30 mA. Similar to this, 90 lateral cephalometric radiographs, 1 for each participant [Figure 5] were obtained.

Tracing of lateral cephalogram
Cephalometric tracings were carried out by an orthodontist using 0.35-mm lead pencil on acetate paper over an illuminated light box for all cephalograms [Figure 6]. Natural head position (NHP) (formed at an angle of
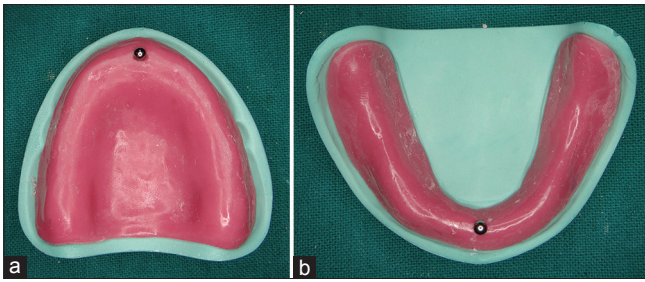
Figure 1: (a) Maxillary permanent denture base with radiographic marker. (b) Mandibular permanent denture base with radiographic marker
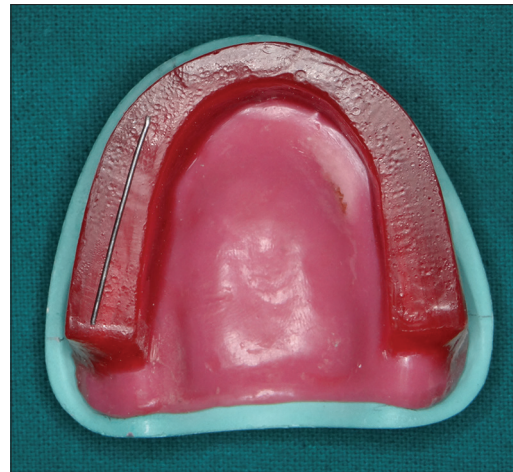

Figure 2: Orthodontic wire fixed over maxillary occlusal rim

Figure 3: Radiographic markers attached extraorally

Figure 4: Patient positioned on cephalostat

Figure 5: Lateral cephalometric radiograph

Figure 6: Tracing of lateral cephalometric radiograph

7° from sella (Se)-nasion (N) line when the Frankfort horizontal plane is parallel to floor) was taken as the reference plane for measuring all the angles. The following points and planes were constructed on the tracings:

1. Ala of the nose
2. Superior tragus point (T1)
3. Middle tragus point (T2)
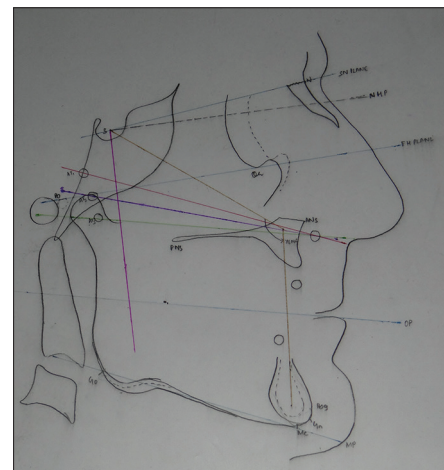4. Inferior tragus point (T3)
5. Occlusal plane (OP)
6. Ala-Superior Tragus (AT1)
7. Ala-Middle Tragus (AT2)
8. Ala-Inferior Tragus (AT3).

Taking NHP as the reference, a perpendicular line was dropped down to OP from sella. This perpendicular line forms an angle with OP which is denoted as NHP-OP angle. The same perpendicular line also forms angles with three levels of ala-tragal lines (NHP-AT1, NHP-AT2, and NHP-AT3 angles). These angles were measured and compared to NHP-OP angle. Out of the three NHP-AT (Ala-Tragus) angles, the angle which is near to NHP-OP angle is considered as the optimum reference plane to establish the occlusal plane.

The skeletal relationship between the maxilla and mandible was assessed using the Yen angle.[7] It is created by drawing a line from sella to the midpoint of maxillary ridge up to the midpoint of mandible on cephalogram. If this angle is in the range of 117°–123°, it is Class I (Normognathic). Similarly, for Class II and Class III, the Yen Angle is <117° and more than 123°, respectively. The correlation between the different ala-tragus lines and profile is depicted in the following tables.

RESULTS

The values obtained in the methodology were subjected to statistical analysis using SPSS version 16 (IBM SPSS Statistics Inc., Chicago, Illinois, USA) Windows software program to compare and correlate the values.

ANOVA test was used for quantitative data within three groups for each method. Tables 1 and 2 shows ANOVA analysis for visual and cephalometric methods, respectively, which reveals proximity of mean values OP angle to AT3 (ala-inferior tragus) for Class I and Class III participants, OP-AT2 (ala-middle tragus) for Class II participants with a $P < 0.001$. This suggests a significant difference between all the parameters in each class.

Multiple comparisons [Tables 3 and 4] were carried out using the Bonferroni test for both visual and cephalometric methods. Table 3 shows the statistical insignificancy between the occlusal plane and AT3 in Class I, occlusal plane and AT2 in Class II, and occlusal plane and AT3 in Class III with the $P = 1$, 0.165, and 0.492, respectively. Furthermore, Table 4 shows the statistical insignificancy between the occlusal plane and AT3 in Class I, occlusal plane and AT2 in Class II, and occlusal plane and AT3 in Class III with the $P = 0.362$, 1, and 0.817, respectively.

The interoperator variability was analyzed using the Kappa statistical analysis. Table 5 shows the Kappa statistical correlation between visual analysis and Yen angle which reveals that for visual analysis Class I, out of 30 participants, 28 participants are coinciding with cephalometric studies

except two participants which were categorized into Class II and Class III.

The symmetric measures of Kappa[13] value are shown in Table 6. The value obtained is 0.8 which indicates excellent correlation and agreement between the two. Out of 90 participants, 78 participants are in total agreement with the classification.

To correlate the arbitrarily established and cephalometrically derived parameter by two different clinicians, the results were interpreted using the Kappa Statistics as shown in Table 5.

DISCUSSION

The use of the ala-tragus line (Camper's line) as a guide to establish the occlusal plane has gained popularity as it is easily visualized. Even though controversies exist in selecting the posterior point of tragus (superior, middle, and inferior) to form the ala-tragus line. The occlusal plane is made parallel to this line to establish tentative jaw relation. While establishing the occlusal plane, the adjustment is done depending on the availability of height of maxillary occlusal rim and space for lower occlusal rim, the posterior point of tragus is decided which can vary in patients with different maxillo-mandibular skeletal relation. No study is available in literature which has correlated the relation between tragus points to a definite skeletal relation. Thus, an *in-vivo* study was designed for

Table 1: The ANOVA statistical analysis for Class I, Class II, and Class III for visual analysis

Class: Visual analysis	n	Mean	Mean squares	F	P
Class I					
Occlusal plane angle	30	9.03	625.146	125.071	<0.001*
AT3 angle (inferior tragus)	30	8.83			
Class II					
Occlusal plane angle	30	12.9	360.672	120.091	<0.001*
AT2 angle (middle tragus)	30	13.8			
Class III					
Occlusal plane angle	30	10.5	596.615	76.205	<0.001*
AT3 angle (inferior tragus)	30	9.1			

*Significant difference

Table 2: The ANOVA statistical analysis for Class I, Class II, and Class III ridge relation based on the Yen angle

Class: Yen angle	n	Mean	Mean squares	F	P
Class I					
Occlusal plane angle	38	9.45	764.752	155.781	<0.001*
AT3 angle (inferior tragus)	38	8.47			
Class II					
Occlusal plane angle	21	14.1	278.713	69.136	<0.001*
AT2 angle (middle tragus)	21	14.67			
Class III					
Occlusal plane angle	31	10.26	625.598	77.516	<0.001*
AT3 angle (inferior tragus)	31	9.06			

*Significant difference

Table 3: Multiple comparisons using Bonferroni test for Class I, II & III ridge relations based on visual analysis

Class	Lines (I)	Lines (J)	Mean difference (I-J)	SE	P
Class I	Occlusal plane angle	AT3 angle (inferior tragus)	0.2	0.576	1*
		AT2 angle (middle tragus)	−4.033	0.548	<0.001
		AT1 angle (superior tragus)	−8.367	0.6	<0.001
Class II	Occlusal plane angle	AT3 angle (inferior tragus)	3.233	0.476	<0.001
		AT2 angle (middle tragus)	−0.9	0.388	0.165*
		AT1 angle (superior tragus)	−4.8	0.473	<0.001
Class III	Occlusal plane angle	AT3 angle (inferior tragus)	1.4	0.777	0.492*
		AT2 angle (middle tragus)	−2.833	0.727	<0.001
		AT1 angle (superior tragus)	−7.133	0.645	<0.001

*No significant difference. SE: Standard error

Table 4: Multiple comparisons using Bonferroni test for Class I, II, III ridge relations based on Yen Angle

Class	Lines (I)	Lines (J)	Mean difference (I-J)	SE	P
Class I	Occlusal plane angle	AT3 angle (inferior tragus)	0.974	0.502	0.362*
		AT2 angle (middle tragus)	−3.395	0.484	<0.001
		AT1 angle (superior tragus)	−7.526	0.551	<0.001
Class II	Occlusal plane angle	AT3 angle (inferior tragus)	3.381	0.587	<0.001
		AT2 angle (middle tragus)	−0.571	0.44	1*
		AT1 angle (superior tragus)	−4.714	0.602	<0.001
Class III	Occlusal plane angle	AT3 angle (inferior tragus)	1.194	0.779	0.817*
		AT2 angle (middle tragus)	−2.968	0.716	<0.001
		AT1 angle (superior tragus)	−7.226	0.63	<0.001

*No significant difference. SE: Standard error

Table 5: Cross Tabulation between visual analysis and Yen angle to correlate arbitrarily established and cephalometrically derived parameters by two operators

Class: Visual analysis	Class: Yen angle			Total
	Class I	Class II	Class III	
Class I	28	1	1	30
Class II	10	20	0	30
Class III	0	0	30	30
Total	38	21	31	90

Table 6: Symmetric measures for the Kappa value

Symmetric measures		
	Value	P
Measure of agreement (κ)	0.800	<0.001
Number of valid cases	90	

Not assuming the null hypothesis

correlating the established occlusal plane to ridge relation for edentulous patients. Cephalometrics was utilized in the study to confirm the arbitrarily established occlusal plane and to correlate it with ridge relations. The skeletal relation that was considered is the Angle's skeletal classification to define the profile of the patient. An attempt has been made whether any particular point of tragus (superior, middle, and inferior) matches to any of the Angle's classification.

All the clinical and laboratory procedures were performed with required protocols. The technique advocated by Wright *et al.*,[8] in 1949, was used to establish the occlusal plane in this study.

The present study considered a cephalometric indicator, Yen Angle to determine the maxillomandibular relationship. The cephalometric tracing for all 90 cephalometric radiographs was carried out by an orthodontist. The clinical and cephalometric readings were carried out simultaneously by two different clinicians, respectively, to prevent the biased results to increase the accuracy of the study result. To confirm the results obtained by two different operators for assessing the ridge relations using visual analysis and Yen angle, further assessment was done using the Kappa statistics which gives a value of 0.8. This reveals that 78 participants out of 90 participants are in total agreement with this correlation of the occlusal plane to the profile of the patient.

The results obtained reveals co-instance of occlusal plane to inferior part of the tragus in Class I and Class III ridge relations, and middle part of the tragus in Class II which is in accordance with the previous studies conducted by Clapp (1910), Dalby (1912), van Niekerk *et al.*,[9] Karkazis *et al.*,[10] and Hindocha *et al.*[11]

The second parameter of the study establishes the occlusal plane to the profile (ridge relation) of the patient using Yen angle (Class I: 117°–123°, Class II: <117°, and Class III: >123°). The result reveals coincidence of inferior part of the tragus for Class I and Class III and middle part of the tragus for Class II. The incorporation of Yen angle to assess the sagittal relationship of maxilla and mandible for an edentulous subject is used for the first time for a research on edentulous patients as no study is found in literature which supports the use of this indicator. The results obtained are in accordance with the studies conducted by Venugopalan *et al.*[12] in 2012, for dentulous subjects.

Clinical implications
1. The profile of the patient infers approximate posterior reference point for the establishment of the occlusal plane rather than arbitrarily establishing posterior reference point.

Suggestions for future study
1. This study can be further improved by the inclusion of more number of participants and considering other cephalometric landmarks for comparison and evaluation of arbitrarily established the occlusal plane to cephalometrically derived angles.

CONCLUSION

Within the limitations of this study, the results obtained are as follows:
1. For normognathic (Class I) and prognathic (Class III) ridge relationship, the point to be considered is inferior part of tragus to establish the occlusal plane
2. For retrognathic (Class II) ridge relationship, ala-tragus line formed by the ala of the nose and middle part of tragus is parallel to the established occlusal plane.

Declaration of patient consent
The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Conflicts of interest
There are no conflicts of interest.

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