Position of Occlusal Plane in Dentate Patients with Reference to the Ala-Tragal Line Using a Custom-Made Occlusal Plane Analyzer

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Keywords
Ala-tragal line; dentate; occlusal plane; occlusal plane analyzer; tragus.

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Abstract

Purpose: The purpose of this study was to determine which of the three positions on the tragus, (superior, middle, inferior) when joined with the ala of the nose for the ala-tragal line was most parallel to the natural occlusal plane in dentate patients.

Material and Methods: This study was carried out on 500 individuals, selected randomly and who agreed to participate in the study. A custom-made occlusal plane analyzer was used to check the parallelism between the ala-tragal line and the occlusal plane. The tragus was divided into three parts: superior, middle, and inferior. The instrument was placed in the participant’s mouth, and the posterior points on the tragus were determined.

Results: For the 500 dentate participants in this study, the most common location of the posterior point on the tragus was the inferior part of the tragus (50.8%). The second most common location of the tragus was the middle part (24.7%), followed by the superior location (12.1%).

Conclusion: The results of this study indicated that the occlusal plane was found parallel to a line joining the ala of the nose and the inferior part of the tragus in a slight majority of the participants.

Among the many factors that lead to successful treatment of edentulous patients with complete dentures, orientation of the occlusal plane is an important one. The occlusal plane location is lost in edentulous patients and should be positioned accurately if complete dentures are to function satisfactorily. The position of the occlusal plane forms the basis for ideal teeth arrangement and should fulfill the necessary mechanical, esthetic, and phonetic requirements, as well as aid in respiration and deglutition.

The plane of occlusion forms an essential part of the concept of mechanically balanced articulation. The position of the occlusal plane in denture wearers should be as close as possible to the plane previously occupied by the natural teeth. Such position of the occlusal plane provides normal function of the tongue and cheek muscles, and may enhance denture stability. It is believed that teeth oriented on an occlusal plane in harmony with the individual’s facial features are responsible, in part, all conditions being equal, for stable, retentive complete dentures. Faulty orientation of the occlusal plane may jeopardize the interaction between tongue and buccinator muscles and result in food collection in the sulcus and/or biting the cheek and tongue. If the occlusal plane is too high superiorly, the tongue will not rest on the lingual cusps of the mandibular denture teeth; these tooth locations may prevent denture displacement. Also this position may alter the tongue into a new position that may be higher than its normal position. This higher position of the tongue causes the floor of the mouth to rise and may create undue pressure on the border of the lingual flange and result in partial loss of border seal.

It is generally agreed that in the anterior region of the maxilla and mandible, the vertical heights of the occlusal plane are influenced by esthetic requirements and less frequently by functional demands. However, there are contrasting views with regard to the orientation of the occlusal plane in the posterior region. Authors have postulated various landmarks for determining the occlusal plane. Swenson stated that the relative size and shape of the denture-bearing area of the mandible and maxilla influences the decision as to the position of the occlusal plane. Boucher and Hall recommended placing the occlusal plane vertically such that it terminated posteriorly at
the medial two-thirds of the retromolar pad, and Ismail and Bowman\textsuperscript{21} did a lateral cephalometric study on dentate patients to prove the same. Nagle and Sears\textsuperscript{22} suggested positioning the occlusal plane parallel to the midway point between the residual ridges vertically. Roberts\textsuperscript{23} recommended positioning it halfway between the maxillary and mandibular ridges parallel to the Frankfort plane. Yasaki\textsuperscript{24} suggested orienting the occlusal plane on the same level as the lateral border of the tongue, and Merkeley\textsuperscript{25} conducted a clinical study to prove the same. Lundquist and Luther\textsuperscript{26} did a clinical study with the help of vestibular impressions on dentate patients to position it parallel with the buccinator groove. Foley and Latta\textsuperscript{27} did a clinical study on dentate patients and found parotid papilla 4 mm above the occlusal plane in dentate patients. Cooperman\textsuperscript{28} and Rich\textsuperscript{29} did a clinical study and oriented it parallel to the hamular notch-incisive papilla plane. Boccaletti\textsuperscript{30} did a clinical study and modified the occlusal plane according to its relation to the inclination of the condylar path as well as according to the individual requirements of the kinematics of the lower jaw.

One of the most popular methods has been 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.\textsuperscript{8} Definitions of the ala-tragus line by different authors have been a cause of confusion due to disagreement on the exact point of reference, on the ala and the tragus, for this line.\textsuperscript{31} Landain,\textsuperscript{32} Sclar,\textsuperscript{33} and Miller\textsuperscript{34} define the ala-tragal line as a line running from the inferior border of the ala of the nose to the superior border of the tragus. Ismail and Bowman\textsuperscript{21} have described it as a line passing from the ala of the nose to the center of the tragus of external auditory meatus. Van Niekerk et al\textsuperscript{35} and Simpson et al\textsuperscript{36} have stated that it is a line running from the ala of the nose to the inferior border of the tragus. Spratley\textsuperscript{37} described it as a line running from the center of the ala to the center of the tragus. The Glossary of Prosthodontic terms (editions 5 to 8)\textsuperscript{38-41} defined 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. Trapozzano\textsuperscript{42,43} used the superior border of the tragus as the reference point. Camper’s line, which is an anthropologic measurement on skulls, projected to the living head as a line passing from the alae of the nose to the center of the tragus of the external auditory meatus.\textsuperscript{44} Boucher\textsuperscript{45} defined it as the line running from the inferior border of the ala of nose to the superior border of the tragus of the ear.

In the past, research has been carried out by various authors to determine the relationship between the ala-tragal line and occlusal plane. Some of these studies were cephalometric studies (Rostamkhani et al,\textsuperscript{46} Sharifi and Rostamkhani,\textsuperscript{47} Hindocha et al,\textsuperscript{48} Chaturvedi and Thombare,\textsuperscript{49} Al Quran et al\textsuperscript{50}), some used the modified Trubyte occlusal plane plate (Hartono\textsuperscript{51}) and photography (Kumar et al\textsuperscript{52} and Sadr and Sadr\textsuperscript{53}), and some used the custom-made occlusal plane analyzer (Shigli et al,\textsuperscript{31} Gupta and Singh\textsuperscript{54}).

The aim of this study was to determine which of the three positions of the tragus (superior, middle, inferior) when joined with the inferior border of the ala of the nose in a straight line was most parallel to the natural occlusal plane, in dentate individuals using a custom-made occlusal plane analyzer. The null hypothesis was that there would be no differences in occlusal plane coinciding with the ala-tragal line (superior, middle, inferior positions).

**Materials and methods**

This study was carried out on 500 individuals (250 men, 250 women) who were students from Yenepoya University, Mangalore, India; they were selected randomly. Informed consent was obtained from all of the participants. Ethical clearance was obtained from the ethical committee of the institution, Yenepoya Dental College, Mangalore, to conduct the study.

Participants with the following criteria were included in the study: Participants ranged from 18 to 25 years old. All had Angle’s class I molar relationships, with a full complement of healthy, natural teeth. Participants did not have any history of orthodontic treatment. Individuals with periodontitis,\textsuperscript{55} who had abraded teeth,\textsuperscript{56} were restored with fixed or removable partial dentures, and with crowding\textsuperscript{57} of teeth were not included in the study.

The armamentarium used in the study consisted of the following: A custom-made occlusal plane analyzer (Fig 1A), a digital caliper (hardened stainless steel 150 mm 0.01 mm LCD Micrometer Vernier Digital Vernier Caliper; GY Enterprises, Pune, Maharashtra; Fig 1B), and an indelible pencil (Fig 1C). A custom-made occlusal plane analyzer was fabricated using the following components:

1. One Fox Plane made of AISI/SAE 316 stainless steel (Steel Authority of India Limited—SAIL, Nagpur, India), 1 mm thick (Fig 2A).
2. Two rectangular plates with rounded borders, 15 mm × 3.5 mm, each made of AISI/SAE 316 stainless steel (SAIL), 1 mm thick (Fig 2B).
3. Two Universal Tofflemire Retainers (API Dental Instruments, New Delhi, India; Fig 2C).

The metal components were assembled. A mark was made at the center of each extraoral arm of the Fox Plane, where the Tofflemire Retainers were attached. The Tofflemire Retainers were stabilized at a 90° angulation to the extraoral portions of the Fox Plane. The head of the Tofflemire Retainer was laser welded at this position (Fig 2D). A mark was made 15 mm from the anterior portion of the rectangular plate. The rectangular plate was stabilized at 90° to the vise of the Tofflemire Retainer and laser welded (Fig 2E). The same procedure was repeated on the opposite side.

Anatomical landmarks on the tragus used in the study (Fig 3A) were the incisura anterior\textsuperscript{58} (anterior notch), incisura intertragica\textsuperscript{59} (intertragic notch), and the tragus. The anterior notch was located between the supratragic tubercle and the crus of the helix. The intertragica notch was identified as the deep notch between the anti-tragus and the tragus.

Participants were seated in the dental chair in an upright position with head unsupported. Two lines were drawn on the superior- and inferior-most points on the tragus (Fig 3A) with an indelible pencil. The distance between these two points was measured with a digital caliper (Fig 3B). The values obtained were divided by three. The distances between the...
anterior notches and the intertragica notches were then divided into three parts using the superior, middle, and inferior values (Fig 3C). The intraoral part of the custom occlusal plane indicator was placed in the patient’s mouth so that it touched the incisal edges of the maxillary central incisors and the mesio palatal cusp of the first molars. The instrument was held steady with one hand, and the vice knob of the Tofflemire Retainers were rotated counterclockwise until the rectangular arms moved, and the anterior portions coincided with the lower borders of the ala of the nose. The posterior point on the tragus was then determined as to whether it coincided with the superior, middle, or inferior portion (Fig 3D). The same procedure was followed for all 500 individuals on the left and right sides.

**Statistical analysis**

Data obtained in this study were analyzed using SPSS v.17, (SPSS Inc., Chicago, IL). Descriptive statistics were recorded in frequency and percentages. The statistical analysis was performed using $\chi^2$ test to find the association between gender and
tragus position. A $p$-value $< 0.05$ was considered statistically significant.

**Results**

Of the 1000 tragus points, the occlusal plane coincided with the ala-tragal line at the inferior position in 508 (50.8%), at the middle position in 247 (24.7%), and at the superior position in 121 (12.1%); 124 (12.4%) did not coincide with any part of the tragus (Table 1). The occlusal plane coincided with the ala-tragal line at the inferior position in 52.2% of the women compared to 49.4% of the men. It coincided with the middle position in 28.2% of the women compared to 21.2% of the men, and the superior position in 10% of the women, compared to 14.2% of the men. It did not coincide in 9.6% of the women compared to 15.2% of the men. There was a statistically significant difference in the positions of tragus points between men and women ($p = 0.002$).

**Discussion**

The results of this study demonstrated that in 50.8% (508/1000 tragus points) of the participants, the occlusal planes were parallel to lines joining the inferior borders of the ala of the nose and the inferior parts of the tragus, which accepts the null hypothesis. A higher proportion of both genders also demonstrated inferior positions of the tragus coinciding with the ala-tragal line (52.2% and 49.4%, respectively). Previous studies have shown that all three positions on the tragus (i.e., superior, middle, inferior) have proved to be guides to determine the ala-tragal line; these findings were used to establish the plane of occlusion in completely edentulous patients.

The results of this study are in agreement with a study done by van Niekerk et al,\textsuperscript{35} and many others including Rostamkhani et al,\textsuperscript{46} Sharifi and Rostamkhani,\textsuperscript{47} Hindocha et al,\textsuperscript{48} Chaturvedi and Thombare,\textsuperscript{49} Hartono,\textsuperscript{51} and Kumar et al\textsuperscript{52} who reported that the occlusal plane was parallel to a line joining the inferior part of the ala and inferior part of the tragus, and that these landmarks should be used to orient occlusal planes in edentulous patients during complete denture fabrication.

On the other hand, the results of this study were not in agreement with previous studies done by other researchers who concluded that the occlusal plane was not parallel to the middle\textsuperscript{45,50} or superior\textsuperscript{45,48,50} parts of the tragus. This study showed that the middle portion of the tragus was the posterior determinant in 24.7% of the participants; the superior portions were the posterior determinants in 12.1% of the participants. However, studies done by Shigli et al\textsuperscript{31} and Gupta and Singh,\textsuperscript{54} where occlusal plane relators were used to determine the relative parallelism of the ala-tragus line and occlusal plane, 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 and Singh\textsuperscript{54} found this result in 72% of the male population. Al Quran et al,\textsuperscript{50} Sadr and Sadr,\textsuperscript{53} and Gupta and
Singh concluded that the superior border of the tragus when joined with the ala of the nose were parallel to the occlusal plane. Gupta and Singh found this result in 80% of the female population.

A review of the literature shows that the relation between the occlusal plane and the ala-tragal line has been assessed by a number of methods (i.e., occlusal plane analyzer, cephalometric radiographs, photography, etc.). Though many studies showed results similar to those in this study, findings of other studies cannot be completely ruled out. Results where the occlusal plane coincided with superior and middle portions of the tragus may still be valid. Other studies have reported that the retromolar pad, lateral borders of the tongue, buccinator grooves, commissure of the lips, and parotid papilla have also been reported as aids in determining the locations of the occlusal planes in edentulous patients. Assessment of these landmarks, in conjunction with noting the locations of the ala-tragal line, may assist clinicians in establishing artificial occlusal plane locations.

A statistically significant association was found between gender and posterior occlusal plane positions of the tragus \((p = 0.002)\). In a higher proportion of female participants, the occlusal plane coincided with inferior and middle positions (52.2%, 28.2%) of the tragus of the ear than male participants (49.4%, 21.2%). Also, in a higher proportion of the men, the occlusal plane coincided with the superior position (14.2%) of the tragus of the ear in comparison to the women (10%). Therefore, according to the results of this study, for both male and female patients, the inferior positions may be considered to be the standard reference.

Some limitations should be noted. The individuals who participated in this study were between 18 and 25 years old, whereas the results would be applicable to edentulous patients who are usually older. Also age changes within the tragus and ala of the nose were not taken into consideration.

### Conclusions

Based on the results of this study, if the occlusal plane is oriented to the ala-tragal line during the rehabilitation of edentulous patients, the inferior border of the tragus should be considered as the posterior landmark for this line. In this study, the occlusal plane was parallel to the inferior portion of the tragus in the ala/tragal line in more than half of the participants (50.8%). It should be noted that the findings of this study were reported for a relatively young dentate population and that denture wearers are generally older than this studied population.

### References

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### Table 1 Tragus position coinciding in men and women

<table>
<thead>
<tr>
<th>Tragus position</th>
<th>Superior (%)</th>
<th>Middle (%)</th>
<th>Inferior (%)</th>
<th>None (%)</th>
<th>(\chi^2)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men (n = 500)</td>
<td>71 (14.2)</td>
<td>106 (21.2)</td>
<td>247 (49.4)</td>
<td>76 (15.2)</td>
<td>15.313</td>
<td>0.002*</td>
</tr>
<tr>
<td>Women (n = 500)</td>
<td>50 (10)</td>
<td>141 (28.2)</td>
<td>261 (52.2)</td>
<td>48 (9.6)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Statistically significant \(p < 0.05\).
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