RESEARCH ARTICLE

Relationship of natural occlusal plane with different anatomical landmarks

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Abstract

Objective: To evaluate the parallelism of natural maxillary occlusal plane with inter-pupillary line and ala-tragus line, and to evaluate the anatomic relationship of natural mandibular occlusal plane with retromolar pad among dentate subjects.

Method: The cross-sectional study was conducted from September 2017 to February 2018 at Fatima Jinnah Dental College, Karachi, and comprised front and profile photographs of subjects aged 20-28 years while holding the camper's plane against the maxillary occlusal plane. The photographs were imported in a software and an interpupillary line was drawn and the angle with Camper's plane was measured. On both profile pictures, lines were drawn from base of the ala to the superior, middle and inferior points on the tragus. The angle between ala-tragus line and Camper's plane were measured. Intra-orally, height of the mandibular occlusal plane in relation to the retromolar pad was evaluated using a stainless steel scale. Data was analysed using SPSS 23.

Results: Of the 109 subjects with a mean age of 23.03±1.36 years, 76(69.72%) were females. Horizontal parallelism of occlusal plane with inter-pupillary line was observed with a mean angle of 1.17±1.27 degrees. The angle between the occlusal plane and the inferior ala-tragus line was 4.25 degrees on the right side, and 4.50 degrees on the left. Intraorally, mandibular occlusal plane coincided with the inferior 48(44%) and the middle third 48(44%) of the retromolar pad.

Conclusions: Inter-pupillary line and retromolar pad area should be used as a guide in the determination of plane of occlusion. The ala-tragus line was not found to be a reliable guide.

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Introduction

The current Glossary of Prosthodontic Terms (GPT) has defined occlusal plane as "the average plane established by the incisal and occlusal surfaces of teeth; generally it is not a plane but represents the planar mean of the curvature of these surfaces." In full-mouth rehabilitation, determination of occlusal plane is considered an essential clinical procedure.[1] The occlusal plane (OP) in edentulous patients must be oriented as close as possible to the one which existed prior to teeth extraction.[2] In literature, numerous techniques and biometric guidelines have been proposed for correctly locating the OP, which can broadly be divided into intraoral and extraoral approaches. Intraoral landmarks include upper lip,[3] commissure of the mouth[4,5] height of the retromolar pad (RMP),[3-6] hamular notch-incisive papilla plane[7] and buccinator groove.[4] Commonly described extraoral landmarks include inter-pupillary line (IPL)[3] and Camper's plane or the ala-tragus line (ATL).[8]

Conventionally, OP is made parallel anteriorly (horizontally) with the IPL and posteriorly (sagittally) with ATL.[9] IPL is an imaginary horizontal line joining the centre of pupils of both eyes. OP is recommended to be kept parallel with the IPL when viewed from the front.

The OP analyser, commonly known as the Camper's plane, has been used for the orientation of OP since 1924.[10] It was suggested that when maxillary occlusal plane was kept parallel to ATL, the biting force was found to be the greatest during clenching with the least muscle activity.[11]

In the earlier editions of GPT (5th-8th), the specific part of ATL was not defined.[1] It was identified by a number of studies exploring the most appropriate point of tragus to be used for ATL.[8,12-16] However, the present edition of GPT has categorically defined ATL as "a line running from the inferior border of the ala of the nose to the superior border on the tragus of the ear".[1]

Intraorally, the OP is commonly kept at the two-third height of RMP area.[3] The RMP is a triangular soft tissue pad at the distal end of the residual alveolar ridge. The anterior aspect of the triangle is keratinised, called pear-shaped pad, while the posterior part is composed of non-keratinised epithelium, loose connective tissue, glandular tissue, fibres of the buccinator and superior constrictor muscles, temporalis tendon and the pterygomandibular raphe. RMP is resistant to resorption because of underlying dense cortical bone and muscle attachments. This makes this area a stable posterior landmark even in patients with excessive alveolar ridge resorption.

In prosthodontics, the question whether the natural maxillary OP is parallel with the ATL and IPL has

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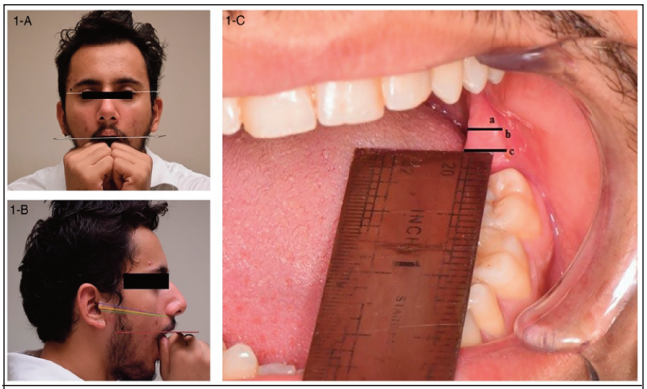

Figure: 1-A; Frontal photograph: a=Inter-pupillary line and b = maxillary occlusal plane. 1-B; Profile photograph: blue= Superior ala-tragus line, yellow= Middle ala-tragus line, green= Inferior ala-tragus line and red =Maxillary occlusal plane. 1-C; Intra-oral photograph; of relationship of mandibular occlusal plane with retromolar pad area; a= superior third, b= middle third, c= inferior third.

fundamental importance, as this paradigm eventually determines the position of the prosthetic teeth on the complete dentures. Till date, to the best of our knowledge, there is no study available on the topic in Pakistani population. The current study was planned to evaluate the parallelism of natural maxillary OP with IPL and ATL, and to determine the anatomic relationship of the natural mandibular OP coinciding with RMP in dentate subjects.

Subjects and Methods

The cross-sectional study was conducted from September 2017 to February 2018 at the Fatima Jinnah Dental College and Hospital, Karachi. After approval from the institutional ethics review board, the sample size was calculated using World Health Organisation (WHO) calculator[17] in the light of literature[5] with OP coinciding with middle-third of RMP among 43.3% subjects. Using the anticipated population proportion with 10% absolute precision at 95% confidence level, the sample size was calculated, and inflated by 15%.

The sample was gathered using non-probability purposive sampling from among healthy dental students on the campus aged 20-28 years, having intact secondary dentition till second molar with normal occlusion, no previous orthodontic or prosthetic treatment, and with no periodontal disease. Those with history of maxillofacial trauma, surgery, missing or crowded teeth, or presence of crown and bridge work or retained deciduous teeth, were excluded.

After taking informed consent, all the selected participants were photographed using a Nikon D5300 camera with 105mm lens (ISO 500, f 1/5.6, exposure time 1/200), placed on an adjustable tripod stand. Photographs were taken in natural head position with the subject's head unsupported while holding the Camper's plane in contact with the natural maxillary OP. The camera was placed at the height same as that of participant's head. One front and two profile (right and left) photographs were taken. AutoCAD software 2017 was used to measure the angles formed between OP, represented by Camper's plane, and IPL in horizontal dimension and OP with ATL in sagittal dimension. A non-parallel relationship was considered for the angle difference >2 degrees (Figure 1A).

In each of the lateral profile photograph, superior, middle and inferior points were marked on the tragus of the ear. Three imaginary lines were drawn in AutoCAD starting anteriorly from the base of the ala of nose and extending posteriorly towards the tragus of the ear (Figure 1B). The OP angle with ATL passing from ala of nose to the superior border of the tragus of the ear was labelled as the ATLs angle. The OP angle with ATL taken from the middle point of the tragus of the ear labelled as the ATLm angle. And the angle formed with ATL taken from the lower border of the tragus of the ear was labelled as the ATLi angle.

The correlation of OP with RMP was evaluated with the help of a thin 6-inch rigid stainless steel scale (Figure 1C). RMP was divided into three equal zones, namely superior, middle and inferior with two imaginary lines. The aforementioned scale was placed on the cusp tip of the mandibular canine passing posteriorly to the disto-lingual cusp of the last molar tooth. The relationship of mandibular OP with respect to the vertical height of RMP was recorded. The measurements were recorded for both right and left sides.

Data was analysed using SPSS 23. Means and standard deviation (SD) of continuous variables were computed. Sharpio-Wilko test was applied to check data normality. The data of maxillary OP was normally distributed, while mandibular data was non-normal. Thus, the choice of statistical test was made accordingly. Paired sample T-test was applied to compare the two sides of the face for each OP and ATL. Pearson's correlation test was employed to determine correlation of the right and left pairs of the three ATLs. Wilcoxon's sign rank test was applied to compare the two sides of the arch for the relationship of OP and RMP. $P<0.05$ was set as the level of significance.

Results

Of the 109 subjects with a mean age of 23.03±1.36 years, 76(69.72%) were females. Molar classification was Class I in 85(77.98%), Class II in 21(19.27%) and Class III in 3(2.75%) subjects. Overall, 63(57.79%) subjects exhibited acceptable parallelism of the maxillary OP with IPL. The OP-IPL angle did not exceed 5 degrees with the mean angle being 1.17±1.27 degrees.

Table-1: Descriptive statistics of angles formed between occlusal plane and facial landmarks (n=109).

Angle formed with occlusal plane	Minimum	Maximum	Mean±SD
Inter-pupillary line	0	5	1.17±1.27
Superior ala-tragus line right	0	17	7.61±4.43
Superior ala-tragus line left	0	23	8.28±4.63
Middle ala-tragus line right	0	15	5.42±3.78
Middle ala-tragus line left	0	19	6.03±4.17
Inferior ala-tragus line right	0	13	4.25±2.92
Inferior ala-tragus line left	0	16	4.50±3.30

SD: Standard deviation

Table-2: Bilateral symmetry for angles formed between occlusal plane and ala-tragus line on both sides of the face (n=109).

Right to left comparisons and correlations		Mean difference	SE	*p*-value*	Correlation	*p*-value**
Pair 1	superior ala-tragus line right superior ala-tragus line left	-0.67	0.28	0.019	0.79	<0.001
Pair 2	middle ala-tragus line right middle ala-tragus line left	-0.60	0.27	0.027	0.75	<0.001
Pair 3	inferior ala-tragus line right inferior ala-tragus line left	-0.25	0.24	0.305	0.66	<0.001

SE: Standard Error;p-value* is derived from Paired T-test; *p*-value ** is based on Pearson's correlation test.

Table-3: Relationship of mandibular occlusal plane with retromolar pad position on both sides (n=109).

Mandibular Occlusal plane-retromolar pad	Right side n (%)	Left side n (%)	test statistics*	*p*-value
Superior Third	13 (11.9)	18 (16.5)	-0.64	0.52
Middle Third	48 (44.0)	43 (39.4)		
Inferior Third	48 (44.0)	48 (44.0)		

*Wilcoxon's sign rank test was applied; ** Out of 109 pairs, there were 63 ties where left side RMP= right side RMP

Only inferior ATL was relatively parallel to the maxillary OP with a mean OP-ATLi angle of 4.25±2.92 degrees on the right side. The superior ATL was the least parallel with OP and the mean angle was 8.28±4.63 degrees on the left side. All readings on the left side were slightly greater than the right side, indicating subjectivity in the recording of such facial landmarks (Table 1).

There were statistically significant differences in two sides of the face for superior and middle ATL ($p<0.05$), but inferior ATL was bilaterally comparable. (Table 2).

The mandibular OP was mostly coincident with both the inferior and middle-third of RMP 48(44% in each zone). The difference in the two sides for mandibular OP-RMP was not significant ($p=0.52$) (Table 3).

Discussion

The correct orientation of OP is a complex but important clinical step in the fabrication of complete dentures or full-mouth rehabilitation. Correct OP contributes not only to desirable aesthetics but also to the comfort and stability of the final prosthesis.[6] Different anatomical landmarks have been described for the determination of the natural OP, (pre-extraction plane of occlusion) for the edentulous patients needing complete dentures.[3-8] The present study determined the parallelism of natural maxillary OP with ATL and IPL. Moreover, the anatomic relationship of mandibular OP with RMP was also explored.

Various investigators have made recommendations regarding orientation of OP with respect to related anatomical landmarks. Zarb et al.[3] recommended that OP should be kept parallel to IPL. On the other hand, Zheng et al.[18] suggested the use of orthodontics to achieve parallelism between OP and IPL, believing that it will result in a symmetrical smile and superior aesthetics. Olivares et al.[19] conducted a study on clinical pictures edited with 0, 2 and 4 degree angles between OP and IPL. The participants included were orthodontists, general dentists and lay people. The highest acceptance was for pictures exhibiting parallelism in OP and IPL, but a difference of 2 degrees was within an acceptable aesthetic range. In the present study, over 50% participants had OP parallel with IPL. This is contrary to findings of Gupta et al. who observed such parallelism in only 13% subjects.[12] Jain et al. found only 20% parallelism between OP and IPL.[20] These differences are probably due to different methodology adopted by the studies.

For the determination of natural OP in the sagittal dimension, various studies[8,12-16] have recommended tragus of ear as the suitable anatomic landmark. However, there was no clarity until the publication of the 9th edition of the GPT,[1] as to which part of the tragus is used for that. Now, it is certain that the superior part of the tragus serves as the posterior determinant of the OP in the sagittal dimension. Winkler,[21] Al Quran et al.[8] and Gupta et al.[12] also favoured using the superior border of the tragus as the reference point for OP. The present study, in contrast, observed that inferior ATL, derived from using inferior border of the tragus, served as the closest to the natural OP.

Subhas et al.[22] studied the relationship of OP with three different ATLs in 75 subjects with different head forms. They used lateral cephalometric radiographs of dentate subjects aged 18-25 years, and stated that middle ATL was a reliable landmark for individuals having mesiocephalic head form, and for those with dolichocephalic and brachycephalic head forms, superior ATL could be used as a reliable reference point in determining OP.

Abrahams et al.[23] Karkazis et al.[6] and Priest et al.[24]

suggested that ATL is not parallel to OP. One of the studies[23] found a 9.66° angle between natural OP and ATLs, while another[6] observed a 2.88° angle between natural OP and ATLm, and one study[24] found mean angle of 3.03±4.49 between OP and ATLs, and -4.09±4.39 with ATLi. They didn't measure the angle with the mid-point of the tragus. The current study found minimum angles for OP-ATLs and OP-ATLm to be 7.610 and 5.720, respectively.

Studies[13,16,25] have recommended the lower part of the tragus as the reference point for the ATL for determining OP. It has also been suggested that the position of OP be kept at right angle to the direction of occlusal forces to get maximum occlusal stability.[15] It has been suggested that OP should be kept parallel and closer to the mandibular ridge in patients with extreme resorption. This reduces the potential leverage in the complete denture. Additionally, when OP is established parallel to ATL at the inferior border of tragus, it is more perpendicular to the occlusal forces and, thus, gets closer to the mandibular ridge.[13] The present study proposes that the lower border of the tragus should be used for locating OP in complete denture prosthetics. On the other hand, Jain et al. found that OP was mostly parallel with the middle of the tragus of the ear.[20]

There is a wide variability among studies for choosing and employing landmarks for natural OP determination. Moreover, differences are there in sample size, points of measurement and in methodology employed in these studies. Some have used cephalometry,[6,8,23,26] others have employed OP analyser,[5,9,12,16] while some have used photographs[13-15] as was the case in the present study.

The distal extension of mandibular complete denture rests over RMP. Traditionally, the mandibular OP should coincide with RMP, but the specific part of RMP was not clear. In the present study, almost half of the subjects had their mandibular OP coinciding with the inferior third of RMP. This finding is in agreement with Shigli et al.[5] They divided the RMP into three zones and found that 56.7% participants had their mandibular OP coinciding with lower one-third of the RMP, and 43.3% at the middle-third. More interestingly, there was not even a single subject in which OP coincided with the superior RMP. Lundquist et al.[4] divided RMP into two halves, and observed that in 75% individuals, the OP was found at the lower half of RMP. Jain et al. discovered approximately half of the time the OP was parallel with middle-third of RMP.[20]

One of the limitations of the current study is that it did not consider the changes occurring in position of tragus and ala of nose with increasing age as the study was carried out among young individuals. Moreover, cephalometric variables, such as skeletal profile, jaw prognathism, skeletal malocclusion, posterior facial height and curve of Spee, were not taken into account. These anthropometric measurements could have affected the determination of the natural OP.

It is recommended that dentists should re-establish the OP in edentulous patients by using IPL and inferior ATL for maxillary arch and middle and inferior-third junction of RMP for mandibular arch.

Conclusions

Maxillary OP was found parallel to the inferior ATL saggitally and IPL was found anteriory. Mandibular OP coincided at the junction of inferior and middle-third of RMP.

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Conflict of Interest: None.

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