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RELATIONSHIP OF ANTERIOR AND POSTERIOR OCCLUSAL PLANES WITH DIFFERENT SAGITTAL AND VERTICAL PATTERNS IN ADULTS

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ABSTRACT

INTRODUCTION: The Occlusal plane plays an important role during orthodontic treatment. The occlusal plane affects the position of the mandible, smile esthetics, masticatory function, and stability post-orthodontic treatment.
OBJECTIVES: To evaluate the relationship of the anterior occlusal plane (AOP) and the posterior occlusal plane (POP) with skeletal and vertical patterns.
MATERIALS AND METHODS: Lateral cephalometric radiographs of 180 adult patients of the different classes of malocclusion were used. Several angular measurements were measured and compared among all study groups to evaluate the existence of a relationship between AOP and POP with skeletal and vertical patterns.
RESULTS: The skeletal patterns showed a significant difference in AOP angle relative to both SN plane and FH plane among all classes of malocclusion (p-value =0.000**) having a steeper inclined plane in Class II and flat inclined plane in Class III. While no significant difference was found in the POP angle relative to FH (p=0.217) among all classes of malocclusion. As for the vertical patterns a significant difference it was found in both AOP and POP relative to both SN plane and FH plane (P=0.000**) among the three vertical pattern groups showing steep incline planes in high angle group.
CONCLUSION: The occlusal planes were found to have an impact on the jaw base where the variation in its angulation of different occlusal planes had affected both sagittal and vertical facial patterns. AOP relative to SN and FH were steeper in Class II and flat in Class III, while the POP relative to FH showed the same value in Classes II and III.
KEYWORDS: Anterior occlusal plane, Posterior occlusal plane, Malocclusion, Skeletal patterns, Vertical pattern, Lateral cephalometric radiograph

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INTRODUCTION

The occlusal plane plays a key role in many aspects during orthodontics treatment because it affects the position of the mandible, smile esthetics, masticatory function, and stability post-orthodontic treatment. It's well established that there is an association between occlusal plane inclination and various skeletal patterns. Studies had revealed that steeper occlusal planes were common in Class II malocclusion and flat occlusal planes were found in Class III malocclusion (1). The vertical jaw discrepancy also showed a variation of in the occlusal plane inclination it was found that hyper-divergent individuals tend to have steeper occlusal plane inclinations while hypo-divergent individuals tend to have flatter occlusal plane (2).

The occlusal plane is typically described in cephalometric tracings as a straight line. For a more precise explanation of the sagittal curve of occlusion (3), Fushima et al. divided the maxillary occlusal plane into AOP and POP (4). Previous studies (1, 4, 5) related AOP and POP to sagittal planes have revealed mandibular retrognathism and prognathism, but failed to investigate the relation of AOP and POP to different vertical patterns. Therefore, this study aims to evaluate AOP and POP in different skeletal patterns and vertical patterns using lateral cephalometric radiographs.

MATERIALS AND METHODS

The study was through 180 lateral cephalograms radiographs of Egyptian orthodontic patients of both genders with different classes of malocclusion (60 radiographs per class) from the Orthodontic Department, Faculty of Dentistry, Tanta University, Egypt. The Sample was selected with subjects; between the age of 15–25 years, free medical history or syndromes, no previous history of orthodontic treatment or prosthetic or dental restorations.
Sample size calculation:
The total sample size in this study is calculated at $N = 158$ based on the significance level was 0.05 and the power was90%.
The sample size formula used is as follows:

$$N>\frac{(U+V)^2\times(\sigma1^2+\sigma2^2)}{(\mu1-\mu2)^2}*$$

*Where N is the calculated sample size per malocclusion group, U is one-sided percentage point of the normal distribution corresponding to 100%- the power, V is the percentage point of the normal distribution corresponding to the two-sided significance level, $\sigma1^2$ and $\sigma2^2$ are standard deviations, μ1 - μ2 is the difference between the mean values

2.1. Cephalometric analysis

A group of cephalometric landmarks was manually traced and pointed on each radiograph by the same researcher (6-8). (table 1) The tracing was done twice for each radiograph after two weeks. Radiographs were then distributed into the classes of malocclusion according to the ANB angulations;

In skeletal Class I subjects, 2≤ANB≤4.

In skeletal Class II subjects, ANB>4

In skeletal Class III subjects, ANB<2.

The sample was also divided according to FMA into different vertical pattern (low angle ≤23̊, normal angle ±25̊, high angle 27̊≤) according to the cephalometric standards for the Egyptian population. (9)

The occlusal planes were each traced on the lateral cephalometric radiographs as the following: Occlusal plane (OP*)*: a plane drawn from incisal edge of the maxillary central incisor to midpoint of the maxillary first molar. Anterior occlusal plane (AOP*)*: a plane drawn from the incisal edge of the maxillary central incisor to the cusp tip of the maxillary second premolar. Posterior occlusal plane (POP)*:* a plane drawn from the cusp tip of the maxillary second premolar to the midpoint of the maxillary second molar at the occlusal plane. After identifying the occlusal planes, the angles were measured between occlusal planes, and both the Sella Nasion (SN) plane and the Frankfort horizontal (FH) plane were tabulated.

Statistical analysis

All cephalometric radiographs used in this study were traced and analyzed by the same operator. To minimize the errors in landmarks identification, landmarks were re-checked by the same operator and intra-examiner reliability was assessed. Both means and standard deviations were calculated for each cephalometric variable measurement (table 2). To evaluate the reliability and accuracy of cephalometric measurements, 18 lateral cephalometric radiographs were randomly selected, retraced, and analyzed again after one month after initial tracing by the same investigator. Errors in identifying and locating cephalometric landmarks and measurements of the determining variables were assessed by Dahlberg' formula (10)

A two-way (ANOVA) was carried out to describe AOP and POP between all classes of malocclusion. Post-hoc Scheffe test was also done to locate significant differences between different malocclusion classes. All of the statistical analysis was made using SPSS software (SPSS for Windows, Version 25.0, Chicago, IL, USA).

Table (1): Cephalomtric landmarks and angular measurments used in the study	
Nasion (N):	Junction of nasal and frontal bone
Sella (S):	Midpoint of sella turcica
Orbitale (O)	The lowest point on the lower margin of the orbit.
Porion (Po):	Superior point of the external auditory meatus.
Point-A (Subspinale):	Most concave point in the premaxilla.
Point-B (Supramentale):	Most concave point in the symphysis
Gnathion (Gn)	Most anterior inferior portion of symphysis
Gonion (Go)	Most inferior posterior portion of angle of the mandible.
Downs	
FH plane	The line joining Po and O points
Stiener (˚)	
SN	The line joining S and N points
SNA	Angle formed by SN and NA planes
SNB	Angle formed by SN and NB planes
ANB	Angle between SNA and SNB planes
MP	The line joining Go and Gn points
Denture frame (˚)	
FH -MP	Angle formed by FH and MP
Occlusal plane (˚)	
SN- AOP˚	Angle between the SN plane and AOP
SN –POP˚	Angle between the SN plane and POP
FH- OP˚	Angle between the FH plane and OP
FH –AOP˚	Angle between the FH plane and AOP
FH –POP˚	Angle between the FH plane and POP

Table (2): Mean, maximum, minimum, Error standard deviation (SD) and reliability coefficient for different measurements.

Variables		Mean	maximum	minimum	SD	F/p-value
SNA	Class I	80	86	72	3.812	5.293 0.006*
	Class II	81	88	75	3.860	
	Classs III	78	87	70	5.091	
SNB	Class I	77	83	69	3.787	18.705
	Class II	74	80	70	3.403	
	Class III	79	86	69	4.309	
ANB	Class I	3.15	4	2	0.860	215.055 0.000**
	Class II	6.60	10	5	1.475	
	Class III	-0.25	-8	1	2.627	
FMA	Class I	23.45	31	16	4.526	27.894 0.000**
	Class II	25.95	32	17	4.151	
	Class III	20.55	27	15	3.067	

RESULT

Concerning the anteroposterior relationship, the AOP/SN, AOP/FH ,and OP/FH revealed a highly significant difference (P<0.05) between all classes of malocclusion having a steeper plane in Class II. While a significant difference was found regarding the POP/SN. In contrarily non-significant difference was found regarding POP/FH having both Class II and Class III with the same mean value. Relating the different classes of malocclusion to AOP/SN and AOP/FH it was found to have a highly significant value between Class II and Class III. Moreover, the POP/FH showed non-significant value upon comparing between class II and class III. (Table 3) Concerning the vertical patterns AOP/SN, AOP/FH, POP/SN ,and AOP/FH displayed a highly significant difference (P<0.05) between all groups of the vertical pattern having all variables steeper in High angle group. Finally, upon comparing different vertical pattern regarding the occlusal plane both AOP and POP showed a highly significant value concerning the angular measurement of AOP/SN and AOP/FH upon low angle vs. high angle groups. On the other hand, the POP/FH showed a significant value concerning angular measurements upon low angle vs. high angle groups. (Table 4)

Table (3): Comparison of Class I, Class II and Class III regarding different occlusal plane relative to SN and FH plane

	Class I	Class II	Class III	f	p-value	P_1	P_2	P_3
AOP/SN						0005 *.	0.003*	0.000**
Mean	19.05	21.75	16.25	20.910	0.000**			
SD	4.757	4.336	4.866					
POP/SN						0.785	0.082	0.015*
Mean	27.25	27.85	25.80	4.350	0.014*			
SD	5.623	4.513	4.644					
OP/FH						0.0000**	0.489	0.013*
Mean	9.45	11.90	10.15	8.499	0.000**			
SD	3.725	3.187	3.113					
AOP/FH						0.0000**	0.925	0.001**
Mean	8.60	11.30	8.85	10.056	0.000**			
SD	3.988	3.126	3.763					
POP/ FH						0.238	0.283	1
Mean	15.60	16.90	16.90	1.543	0.217			
SD	5.708	3.564	4.520					

F for ANOVA test, Pairwise comparison between each 3 groups was done using **Post Hoc Test (Tukey)**
p: p value for comparing between the studied groups
p_1: p value for comparing between **Class I** and **Class II**
p_2: p value for comparing between **Class I** and C**lass III**
p_3: p value for comparing between **Class II** and **Class III**
*: Statistically significant at $p \leq 0.05$, ** Highly significant at $P \leq 0.001$.

Table (4): Comparison of Low angle, normal and High angle regarding different occlusal plane relative to SN and FH plane

	Low angle	Normal	High angle	f	P-value	P_1	P_2	P_3
AOP/SN						0.008*	0.609	0.008*
Mean	17.37	20.14	21.13	10.686	0.000**			
SD	5.362	5.173	3.517					
POP/SN						0.036*	0.836*	0.003*
mean	25.50	27.79	28.38	6.511	0.002*			
SD	5.476	4.448	4.025					
OP/FH						0.305	0.001**	0.000**
mean	9.40	10.29	12.75	17.138	0.000**			
SD	2.875	2.578	4.174					
AOP/FH						0.275	0.010*	0.000**
mean	8.47	9.50	11.75	13.114	0.000**			
SD	3.669	2.725	4.066					
POP/ FH						0.378	0.171	0.002*
mean	15.43	16.57	18.31	6.247	0.002*			
SD	5.106	3.703	4.132					

F for ANOVA test, Pairwise comparison between each 3 groups was done using **Post Hoc Test (Tukey)**
p: p value for comparing between the studied groups

p_1: p value for comparing between **Low angle** and **Normal**
p_2: p value for comparing between **Low angle** and **High angle**
p_3: p value for comparing between **Normal** and High angle
*: Statistically significant at $p \leq 0.05$, ** Highly significant at $P \leq 0.001$.

DISCUSSION

The occlusal plane appraised relative to the craniofacial form, growth, masticatory function, malocclusion, mandibular morphology and position, esthetics ,and TMJ.(1)

The relationship of the occlusal plane to the sagittal pattern

Studies (1,4,5,11,12) assessing the skeletal variability pattern noted that varying degree of the occlusal plane inclination exists. Some researchers might argue that there is an ideal range for the occlusal plane stating that Class II being steeper and Class III being flatter regarding the occlusal plane inclination. But, on the opposite hand, few studies (2,12) have evaluated the relation of occlusal plane inclination relative to different vertical facial patterns and whether or not the vertical patterns contribute to the occlusal plane inclination.

From the revealed data it was found that the AOP/SN showed a highly statistical difference between different classes of malocclusion with the steepest plane in Class II, whereas the POP/SN was flatter in Class III. For AOP/FH and OP/FH, it showed a highly significant value among all classes showing that Class II having the steepest plane. Results provided similar values of AOP and OP this may be due to the close similarity between both reference lines. This points out that the position of the incisal edge of the maxillary central incisor is the strategic point in the two planes AOP and OP. Ishikawa et al (14) explained it in the studied that both upper incisor inclination and occlusal plane inclination were a significant factors in dentoalveolar compensation of skeletal Class I and III. Finally from the revealed data POP/ FH showed no significance among all groups and Classes II and III had the same steepness. These results come in contrast to Celar et al (12) and Tanka and Sato (1) in which Class II had steeper POP and Class III had flatter POP. This controversy in the results between this study and other studies may be due to the potential weakness of FH related measurement identification of porion and orbital may be problematic giving an error in measurements (12) and also agrees with Ishikawa (14) findings that AOP inclination is an important contributing skeletal malocclusion.

Different outcomes were found from previous studies, Celar et al (12) stated in this study that there was no significant association between AOP/SN and that Class I had the steepest plane concerning AOP/FH and final that POP/FH was flat in class III due to mandibular growth in Class III. Tanaka and Sato (1) only used the FH plane and the study showed no statistical difference between AOP/FH and OP/ FH and that Class II has the steepest and Class III having a flatter POP/FH. Ardani et al (15) results revealed that a significant difference between classes I and III considering both AOP/SN and AOP/FH.

This controversy in the results between this study and other studies(1,4,5,6) is due to ethnical group difference between them and also the sample size used in the other studies was not properly distributed among all groups.

The relationship of the occlusal plane to vertical facial patterns

Few data exist on the occlusal plane effect on the vertical facial patterns. Some suggest that the occlusal plane had a robust relationship with the vertical dimension, and also the angular measurement of ANB which is affected by the vertical dimension. Eppard (13) and Anawar and Fida (2) studies states that hyper-divergent tends to have steepening of the occlusal plane inclination causing an increase in facial divergence.

The results from this study had shown a highly significant difference among all groups relative to both AOP/SN and POP/SN with the high angle having the steepest plane. As few studies measured the occlusal plane inclination relative to the horizontal plane (FH) and its relation to the vertical facial patterns. A highly statistically significant difference was found in all groups regarding AOP/FH and POP/FH. This indicates the steeping of the occlusal plane inclination in high angle. While the POP/FH also showed steeping of the occlusal plane at high-angle causing anti-clockwise rotation of the mandible. In summary, the occlusal plane inclination is shown to be closely related to vertical dimension steeper occlusal plane inclination is related to high angle whereas flatter occlusal plane are related to low angle case.

Finally from the clinical point of view, it is preferable to consider the occlusal plane, when correcting the anteroposterior component of malocclusion by changing the OP inclination to adapt the mandible into a therapeutic position. As esthetically it is undesirable to change the OP angulation and that any change in OP inclination should be avoided as it affects the attractiveness of the smile and therapeutic change of OP inclination necessitate further studies.

CONCLUSIONS

Within the confines of this study, it can be concluded that:

In skeletal Class II malocclusion pattern, the AOP relative to both SN and FH plane tends to have a steep plane, while for skeletal Class III the AOP relative to SN and FH plane tend to be flat.

Skeletal Classes II and III had the same values regarding the POP relative to FH plane.

High angle patterns has steeper AOP and POP leading to a downward forward position of the mandible

Recommendation

The AOP and POP inclination should be considered in every patient for the diagnosis of orthodontic treatment. Also, the study of both AOP and POP should be included while planning the orthodontic tooth movement and smile design. Finally, the sample size needs to be emphasized for further accuracy of Egyptian norms

CONFLICT OF INTREST

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REFERENCES

1. Tanaka EM, Sato S. Longitudinal alteration of the occlusal plane and development of different dentoskeletal frames during growth. Am. J. Orthod. Dentofacial Orthop. 2008;134:602 e1—602e11.
2. Anwar N, Fida M. Compensation for vertical dysplasia and its clinical application. Eur J Orthod. 2009; 31:516–522.
3. Marshall SD, Caspersen M, Hardinger RR, Franciscus RG, Aquilino SA, Southard TE. Development of the curve of Spee. Am J Orthod. 2008;134:344–352.
4. Fushima K, Kitamura Y, Mita H, Sato S, Suzuki Y, Kim Y. Significance of the cant of the posterior occlusal plane in Class II division 1 malocclusions. Eur J Orthod. 1996;18:27–40.
5. Coro JC, Velasquez RL, Coro IM, Wheeler TT, McGorray SP, Sato S. Relationship of maxillary 3-dimensional posterior occlusal plane to mandibular spatial position and morphology. Am J Orthod Dentofacial Orthop. 2016;150:140–152
6. Trpkova B, Major P, Prasad N, Nebbe B. Cephalometric landmarks identification and reproducibility: a meta analysis. Am J Orthod Dentofacial Orthop. 1997;112:165–170
7. Jacobson A, Jacobson R. Radiographic Cephalometry. Chicago: Quintessence Pub.2006:2:49–51.
8. Phulari B. An atlas on cephalometric landmarks. JP medical Pub 2013:1:193–210.
9. Aboul-Azm S, Fahmy M. Facial esthetics of Egyptians with normal occlusion. Alex Dent J 1980;1:63–72.
10. Dahlberg G. Statistical methods for medical and biological students. Br Med J.1940; 2: 358–59.
11. Celar A, Freudenthaler JW, Celar RM, Jonke E, Schneider B. The Denture Frame Analysis: an additional diagnostic tool. Eur J Orthod;1998: 579–587.
12. Čelar A, Tafaj E, Graf A, Lettner S. Association of anterior and posterior occlusal planes with different Angle and skeletal classes in permanent dentitions. J OrofacOrthop 2018; 79:267–276
13. Eppard H. The occlusal plane inclination relative to craniofacial form: A cephalometric investigation. MPH Thesis. Virginia, USA: West Virginia University. 2012:1–16.
14. Ishikawa H, Nakamura S, Iwasaki H, Kitazawa S, Tsukada H, Sato Y. Dentoalveolar compensation related to variations in sagittal jaw relationships. Angle Orthod 1999;69:534–538.
15. Ardani IGWA, Wicaksona A, Hamid T. The occlusal plane inclination analysis for determining skeletal class III malocclusion diagnosis. Clin Cosmet Investing Dent.2020:163–171.