Evaluation of Some Lateral Cephalometric Methods for Determination of Occlusal Plane Inclination

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Ocjenjivanje nekih kefalometrijskih metoda mjerenja pri određivanju nagiba protetske plohe

Acta Stomatol. Croat.
1994; 28: 11–18

Summary

The objective of this study was to test the value of some lateral cephalometric methods in the determination of occlusal plane inclination in edentulous patients. Sixty lateral skull radiograms were taken in male subjects with no history of orthodontic treatment, with Angle class I occlusion and 28–32 teeth in the jaws.

The lengths of the ANS-HN, ANS-PNS, HN-IP and N-S plane, and the angle between the above mentioned planes and the occlusal plane were measured. Descriptive statistics and correlation analysis were carried out. Results revealed no correlation between the length of Cook's plane (ANS-HN) and the angle between Cook's plane and the occlusal plane ($r = -0.0575$; $p = 0.331$); between the length of the HIP plane and the angle between the HIP and the occlusal plane ($r = 0.089$; $p = 0.249$); between the ANS-PNS plane and the angle between the ANS-PNS and the occlusal plane ($r = -0.0234$; $p = 0.036$); and between the N–S plane and the angle between the N-S and the occlusal plane ($r = -0.2343$; $p = 0.036$). The HN-IP plane was not parallel to the occlusal one ($x = 8.3 +/- 3.56$, range 2–17).

According to our results, Sloane's and Cook's theory and Rich's theory should be rejected. Also, the length of the maxillary or the cranial base had no strong correlation with the angle between these planes and the occlusal plane. So, the length of the ANS-HN, HN-IP, ANS-PNS and N-S could not be used to predict the occlusal plane inclination. Accordingly, other methods rather than these methods evaluated in this study should be used for the occlusal plane determination in edentulous patients.

Key words: *occlusal plane, cephalometrics*

ORIGINAL PAPER

Received: July 21, 1993
Primljeno: 21. srpnja 1993.

Introduction

According to contemporary concepts, the position of occlusal plane in denture wearers should be as close as possible to the position which was previously occupied by the occlusal plane of the natural teeth, in order not to change afferent proprioceptive and efferent regulatory mechanisms which ensure normal function of the cheek, tongue and masticatory muscles. One of the major problems in complete denture construction is the lack of reproducible reference structures for occlusal plane determination.

Therefore, many theories and methods have been proposed over the years to facilitate correlation of the artificial occlusal plane to the natural one (1). Some of the current concepts include: 1) Establishing the occlusal plane according to aesthetic requirements anteriorly and parallel to Camper's line posteriorly (2–8); 2) Positioning the occlusal plane to terminate posteriorly at the middle or upper third of retromolar pad (9–11); 3) Parallel to and in the midway between the residual ridges (9, 12); 4) Parallel to the lateral border of the tongue (13–17); 5) parallel to the buccinator grooves and the commissurae of the lips (18); 6) In a specific relation to the parotid papilla (19); 7) Establishing the occlusal plane according to the angle with the Frankfurt horizontal plane on the models mounted in an articulator (20–22); 8) According to some cephalometric criteria (23–27).

Cephalometric analysis has served for many years in dental research and diagnosis. Although its clinical application has been directed mainly toward orthodontics, some authors introducted it to prosthodontics to identify predictable relationships between the teeth and other cranial landmarks that are not subjected to postextraction changes in order to reestablish spatial position of the lost teeth in edentulous subjects.

Sloane and Cook (28) in 1953, in a study on 26 dry skulls found that a plane of occlusion was strongly correlated to the length of the line connecting the anterior nasal spina (ANS) and the hamular notch (HN).

ANS-HN was defined as the Cook's plane and the angle between the Cook's plane and the occlusal plane was found to be strongly and inversely correlated to the length of the Cook's plane. Eighteen years later L'Estrange and Vig (22), using a cephalometric method confirmed the Sloane's and Cook's theory, comparing this phenomenon to the denture in a glass of water. Rich (29) observed that the occlusal plane tends to be parallel to the hamular notch-incisive papilla plane (HN-IP – HIP plane).

The objective of this investigation was to find out if the above mentioned cephalometric measurements could be used for occlusal plane determination in everyday clinical practice. For that reason the hypothesis that the angulation of the occlusal plane is related to: 1) The Cook's plane or, 2) to the HIP plane was rechecked. It was also examined; 3) if the angulation of the occlusal plane is related to the skeletal base of the maxillae (anterior nasal spina – posterior nasal spina (ANS-PNS)), and the last objective of this study was 4) to find out if the angulation of the occlusal plane is correlated to the length of the cranial base – (nasion – sella line (N-S)).

Materials and Methods

Lateral skull radiograms from 60 young males, with the jaws in the habitual occlusion were used for the cephalometric measurements. All the subjects had Angle class I occlusion, no history of orthodontic treatment and 28–32 teeth present. These radiograms were available from the project sample: »Characteristics of Craniofacial Complex in Gonadal Disgenesis« No. 3–02–383 Ministry of Science, Technology and Informatics of the Republic of Croatia.

Lateral skull radiograms of the subjects were made on the Ortoceph 5 »Siemens« exp. 80 KV; 5 mA. All the structures from the radiograms were traced on acetate papers and the following points were identified and measured according to Solow (30).

The following parameters were measured: The length of the Cook's plane (ANS-HN); the length of the maxillary skeletal base (ANS-PNS); the length of the HIP plane (HN-IP); the length of the cranial base (N-S), as well as the angles between the above mentioned planes and the occlusal plane (Figure 1.).

The measurements were made by a calliper with a precision of 0.1 mm and a protractor with a precision of 0.1°.

Data were analysed using descriptive statistical methods; mean (x), standard deviation (SD), frequency (f), frequency percentages (fp) and cummulative percentages (cp) were calculated. The correlation analysis was also made.

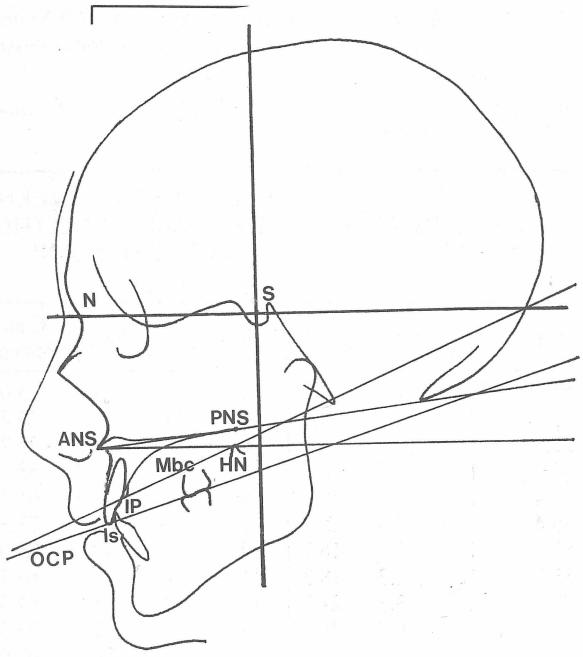

Figure 1. *Points on the lateral radiogram according to Solow*

Slika 1. *Referentne točke na telerentgenogramu prema Solowu*

OCL – occlusal plane,
ANS – anterior nasal spina,
PNS – posterior nasal spina,
HN – hamular notch,
IP – incisive papilla,
N – nasion,
S – sella,
Is – incisal point of the upper central incisor,
Mbc – meziobuccal cusp of the upper first molar.

Table 1. *The length of the Cook's plane and the angle between the Cook's plane and the occlusal plane*

Tablica 1. *Dužina Cookove ravnine i kut između Cookove i okluzalne plohe*

THE LENGTH OF THE COOK'S PLANE (ANS-HN) (mm)				THE ANGLE BETWEEN THE ANS-HN AND THE OCCLUSAL PLANE (degrees)			
Value	Frequency	Percent	Cum Percent	Value	Frequency	Percent	Cum Percent
51.0	1	1.7	1.7	5	1	1.7	1.7
52.0	2	3.3	5.0	7	2	3.3	5.0
54.0	1	1.7	6.7	9	1	1.7	6.7
55.0	6	10.0	16.7	10	5	8.3	15.0
56.0	8	13.3	30.0	11	5	8.3	23.3
57.0	3	5.0	35.0	12	6	10.0	33.3
58.0	10	16.7	51.7	13	2	3.3	36.7
59.0	2	3.3	55.0	14	6	10.0	46.7
60.0	6	10.0	65.0	15	3	5.0	51.7
61.0	1	1.7	66.7	16	3	5.0	56.7
62.0	4	6.7	73.3	17	6	10.0	66.7
63.0	2	3.3	76.7	18	4	6.7	73.3
64.0	3	5.0	81.7	19	1	1.7	75.0
65.0	6	10.0	91.7	20	8	13.3	88.3
66.0	3	5.0	96.7	21	2	3.3	91.7
67.0	2	3.3	100.0	22	1	1.7	93.3
				23	3	5.0	98.3
Total	60	100.0		25	1	1.7	100.0
				Total	60	100.0	
$\bar{x}$ = 59.417		SD = 4.139		$\bar{x}$ = 15.317		SD = 4.553	
		r = – 0.0575		p = 0.331			

$\bar{x}$ – arithmetic mean,
SD – standard deviation,
r – correlation coefficient,
p – level of significance.

Results

Arithmetic mean (x), standard deviation (SD), frequency (f), percentage of frequency (fp) and cummulative percentage (cp) for ANS-HN distance (in mm) (Cook's plane) are presented in the Table 1, as well as the same parameters for the angle between the ANS-HN (Cook's plane) and the occlusal plane. No linear correlation exists between the length of the ANS-HN and the angle between ANS-HN and the occlusal plane ($r = -0.0575$; $p = 0.331$).

Table 2. shows the results for the length of the HN-IP plane and the angle between the HN-IP and the occlusal plane. No linear correlation exists between the length of HN-IP and the angle between HN-IP and the occlusal plane ($r = 0.0890$; $p = 0.249$).

In the Table 3. the results of the length of the ANS-PNS and the angle between the ANS-PNS and the occlusal plane are presented. No strong linear correlation exists between the ANS-PNS and the angle between ANS-PNS and the occlusal plane ($r = -0.2343$; $p = 0.036$).

Values for the cranial base (N-S length) and the angle between the N-S and the occlusal plane are presented in the Table 4.

Again, there is no correlation between the length of the N-S and the angle between the N-S and the occlusal plane ($r = -0.1213$; $p = 0.178$).

Table 2. *The length of the HIP plane and the angle between the HIP plane and the occlusal plane*

Tablica 2. *Dužina HIP ravnine i kut između HIP i okluzalne plohe*

THE LENGTH OF THE »HIP« PLANE (HN-IP) (mm)				THE ANGLE BETWEEN THE HN-IP AND THE OCCLUSAL PLANE (degrees)			
Value	Frequency	Percent	Cum Percent	Value	Frequency	Percent	Cum Percent
43.0	5	8.3	8.3	2	2	3.3	3.3
46.0	2	3.3	11.7	3	6	10.0	13.3
47.0	3	5.0	16.7	4	3	5.0	18.3
48.0	6	10.0	26.7	5	5	8.3	26.7
49.0	5	8.3	35.0	7	4	6.7	33.3
50.0	7	11.7	46.7	8	14	23.3	56.7
51.0	7	11.7	58.3	9	3	5.0	61.7
52.0	9	15.0	73.3	10	10	16.7	78.3
53.0	11	18.3	91.7	12	8	13.3	91.7
55.0	2	3.3	95.0	14	2	3.3	95.0
56.0	1	1.7	96.7	15	1	1.7	96.7
57.0	2	3.3	100.0	16	1	1.7	98.3
				17	1	1.7	100.0
Total	60	100.0		Total	60	100.0	
$\bar{x}$ = 50.317		SD = 3.327		$\bar{x}$ = 8.3		SD = 3.567	
		r = 0.089		p = 0.247			

$\bar{x}$ – arithmetic mean,
SD – standard deviation,
r – correlation coefficient,
p – level of significance.

Table 3. *The length of the maxillary base (ANS-PNS) and the angle between the ANS-PNS and the occlusal plane*

Tablica 3. *Dužina maksile (ANS-PNS) i kut između maksile (ANS-PNS) i okluzalne plohe*

THE LENGTH OF ANS-PNS (mm)				THE ANGLE BETWEEN THE ANS-PNS AND THE OCCLUSAL PLANE (degrees)			
Value	Frequency	Percent	Cum Percent	Value	Frequency	Percent	Cum Percent
52.1	1	1.7	1.7	4	3	5.0	5.0
52.7	2	3.3	5.0	5	13	21.7	26.7
53.3	1	1.7	6.7	6	6	10.0	36.7
53.5	1	1.7	8.3	7	4	6.7	43.3
54.4	1	1.7	10.0	8	11	18.3	61.7
55.4	3	5.0	15.0	9	7	11.7	73.3
55.6	1	1.7	16.7	10	7	11.7	85.0
55.7	1	1.7	18.3	11	1	1.7	86.7
56.4	2	3.3	21.7	13	3	5.0	91.7
56.6	4	6.7	28.3	14	1	1.7	93.3
56.7	3	5.0	33.3	16	4	6.7	100.0
56.8	2	3.3	36.7	Total	60	100.0	
57.5	1	1.7	38.3				
58.0	1	1.7	40.0				
58.7	1	1.7	41.7				
58.9	3	5.0	46.7				
59.0	1	1.7	48.3				
59.3	1	1.7	50.0				
59.4	1	1.7	51.7				
59.7	2	3.3	55.0				
59.8	1	1.7	56.7				
60.5	1	1.7	58.3				
60.7	3	5.0	63.3				
61.4	3	5.0	68.3				
62.0	2	3.3	71.7				
62.1	1	1.7	73.3				
62.3	2	3.3	76.7				
63.1	1	1.7	78.3				
63.3	4	6.7	85.0				
63.7	1	1.7	86.7				
63.9	1	1.7	88.3				
64.4	2	3.3	91.7				
66.2	2	3.3	95.0				
66.6	2	3.3	98.3				
67.3	1	1.7	100.0				
Total	60	100.0					
$\bar{x}$ = 59.5		SD = 3.874		$\bar{x}$ = 8.167		SD = 3.195	
		r = – 0.234		p = 0.036			

$\bar{x}$ – arithmetic mean,
SD – standard deviation,
r – correlation coefficient,
p – level of significance.

Table 4. *The length of the cranial base (N-S) and the angle between the N-S and the occlusal plane*

Tablica 4. *Dužina baze lubanje (N-S) i kut između baze lubanje i okluzalne plohe*

THE LENGTH OF THE CRANIAL BASE (N-S) (mm)				THE ANGLE BETWEEN THE N-S AND THE OCCLUSAL PLANE (degrees)			
Value	Frequency	Percent	Cum Percent	Value	Frequency	Percent	Cum Percent
70.7	1	1.7	1.7	5	1	1.7	1.7
70.8	2	3.3	5.0	6	1	1.7	3.3
72.7	2	3.3	8.3	7	1	1.7	5.0
73.1	1	1.7	10.0	8	6	10.0	15.0
73.4	3	5.0	15.0	10	3	5.0	20.0
73.8	1	1.7	16.7	11	4	6.7	26.7
73.9	2	3.3	20.0	12	4	6.7	33.3
74.8	2	3.3	23.3	13	7	11.7	45.0
75.1	3	5.0	28.3	15	12	20.0	65.0
75.2	1	1.7	30.0	17	5	8.3	73.3
75.6	1	1.7	31.7	18	5	8.3	81.7
75.9	1	1.7	33.3	19	4	6.7	88.3
76.4	1	1.7	35.0	20	6	10.0	98.3
76.6	2	3.3	38.3	21	1	1.7	100.0
77.2	1	1.7	40.0	Total	60	100.0	
77.3	2	3.3	43.3				
77.7	3	5.0	48.3				
77.9	2	3.3	51.7				
78.0	1	1.7	53.3				
78.2	1	1.7	55.0				
78.6	3	5.0	60.0				
78.8	2	3.3	63.3				
78.9	1	1.7	65.0				
79.2	1	1.7	66.7				
79.3	2	3.3	70.0				
79.4	3	5.0	75.0				
79.9	2	3.3	78.3				
80.5	5	8.3	86.7				
80.6	1	1.7	88.3				
81.9	1	1.7	90.0				
83.5	4	6.7	96.7				
86.8	2	3.3	100.0				
Total	60	100.0					
$\bar{x}$ = 77.69		SD = 3.609		$\bar{x}$ = 14.183		SD = 4.152	
		r = – 0.1213		p = 0.178			

$\bar{x}$ – arithmetic mean,
SD – standard deviation,
r – correlation coefficient,
p – level of significance.

Discussion

Although many theories have been proposed for determining the level of the occlusal plane in edentulous patients, still no one is fully accepted. Recently, some cephalometric methods have been introduced in prosthodontics and some reproducible reference structures have been correlated to the position of the natural occlusal plane. Sloane and Cook (28) defined the Cook's plane as a plane representing the maxillary skeletal base (ANS-HN) and stated that the length of this plane is strongly and inversely correlated to the angle between the Cook's plane and the occlusal plane. This theory was confirmed by L'Estrange and Vig (28), using lateral cephalometry. They compared this phenomenon to the position of the denture in a glass of water.

But in 1991. Karkasis and Polyzois (31) on 22 lateral skull radiograms found no strong correlation between the length of the Cook's plane and the angle between the occlusal and the Cook's plane ($r = -0.4085$, $p > 0.05$). As the sample in their study was rather small, we wanted to recheck this hypothesis. Our results on the 60 lateral radiograms again revealed no correlation ($r = -0.0575$; $p = 0.331$) and we concluded that Sloane's and Cook's hypothesis should not be used for occlusal plane determination.

Rich (29) in 1982, on 32 maxillary casts found that the HIP plane (HN-IP) tends to be parallel to the occlusal one. This plane has been used for mounting the maxillary edentulous casts in a special articulator designed for Triad (Dentsply Int.) denture system. Again, in our study we had to reject this assertion. The mean angle, in our study, between the HIP plane and the occlusal plane was $x = 8.3 +/- 3.56$ (with the range from 2 to 17). We also tested if any correlation existed between the length of the HIP plane and the angle between the HIP and the occlusal plane ($r = 0.0890$, $p = 0.249$), but no correlation was found. So, we had to reject Rich's hypothesis that the HIP plane tends to be parallel to the occlusal plane. Also, no correlation was found between the length of the HIP plane and the angle between the HIP and the occlusal plane.

While analysing lateral skull radiograms, it is rather difficult to identify hamular notch. As the ANS-PNS plane also represents the maxillary base, we wanted to check if any correlation exists between the length of ANS-PNS and the angle between the ANS-PNS and the occlusal plane.

Although this correlation factor could be considered as significant ($p = 0.036$; $r = -$

0.2343), r was so small that practically no correlation existed.

Our last observation was to compare the length of the skeletal base (N-S) to the occlusal plane. The N-S plane is considered as a genetic constant and is not submitted to any environmental influences like the maxillary base or the mandible. The N-S plane embriologically belongs to the chondrocranium, and is influenced only by hereditary factors, while the maxilla and the mandible as the part of viscerocranium are influenced by both, hereditary and aquired environmental factors (32, 33).

However our results showed no correlation between the N-S length and the angle between the N-S and the occlusal plane ($r = -0.1213$; $p = 0.178$).

The Monteith's method can also be mentioned, although it was not a subject of our investigation. Monteith predicted the occlusal plane inclination to the Frankfort plane by measuring PONANS (porion-nasion-anterior nasal spine) angle (24–26). He found so strong correlation that he calculated even a regression formula. Later, Karkasis and Polyzois (31), Chow (33) and Seifert et al (34) found no such correlation and rejected this hypothesis.

According to our results, as well as to the results from the other studies (31, 33, 34), it seems that the lateral cephalometric measurements evaluated in this study, which may be usefull tools in studying maxillomandibular jaw relationship, or alveolar bone loss in long term denture studies (35–37) are of limited value for prediction of the occlusal plane inclination.

Conclusions

1. No correlation is found between the length of the Cook's plane and the angle between the Cook's plane (ANS-HN) and the occlusal plane ($r = -0.0575$; $p = 0.331$).
2. The HIP plane (HN-IP) is not parallel to the occlusal plane ($x = 8.3 +/- 3.56$, range 2–17). No correlation is found between the length of the HIP plane and the angle between the HIP and the occlusal plane ($r = 0.089$; $p = 0.249$).
3. No strong correlation is found between the length of the maxillary base (ANS-PNS) and the angle between the ANS-PNS and the occlusal plane ($r = -0.2343$; $p = 0.036$);
4. No correlation is found between the length of the cranial base (N-S) and the angle between the N-S and the occlusal plane ($r = -0.1213$; $p = 0.178$).

From the obtained results, it seems that the lateral cephalometry methods that are evaluated in this study are of limited value for the prediction of the occlusal plane inclination in complete denture construction.

OCJENJIVANJE NEKIH KEFALOMETRIJSKIH METODA MJERENJA PRI ODREĐIVANJU NAGIBA PROTETSKE PLOHE

Sažetak

Ovaj rad načinjen je s ciljem da se utvrdi mogućnost primjene nekih kefalometrijskih kriterija pri određivanju nagiba protetske plohe kod bezubih pacijenata. U tu svrhu mjerenja su izvršena na 60 lateralnih kranijalnih snimaka muških ispitanika s međučeljusnim odnosom – Angle klasa I, bez prethodnog ortodontskog tretmana. Mjerene su dužine ANS-HN; ANS-PNS; HN-IP i N-S te kutovi između navedenih ravnina i okluzalne plohe. Napravljena je deskriptivna statistika i analiza korelacije.

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Rezultati su pokazali da nema korelacije između dužine Cookove ravnine (ANS-HN) i kuta između te ravnine i okluzalne plohe (r = – 0,0575; p = 0,331), između dužine HN-IP i kuta HN-IP i okluzalne plohe (r = 0,089; p = 0,249); između ANS-PNS i kuta između ANS-PNS i okluzalne plohe (r = – 0,0234; p = 0,036), kao niti između dužine N-S i kuta između N-S i okluzalne plohe (r = – 0,2343; p = 0,036). Ravnina HN-IP nije bila paralelna s okluzalnom ravninom (x = 8,3 +/– 3,56, u rasponu od 2–17).

Na osnovi dobivenih rezultata potrebno je odbaciti teoriju Sloana i Cooka, a također i Richovu teoriju. Niti dužina maksilarne, a niti kranijalne baze također nema izraženu korelaciju s kutom između tih ravnina i okluzalne plohe. Dakle, dužine ANS-HN, HN-IP, ANS-PNS i N-S ne mogu se koristiti pri određivanju nagiba protetske plohe, već se u tu svrhu moraju primijeniti neke druge metode.

Ključne riječi: *protetska ploha, kefalometrija*

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