



**A Study to Evaluate the Effect of Variation in an Arc of Radius, Anterior and Posterior Survey Point on Occlusal Plane Analysis**

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**Introduction**

An increased patients' desire for aesthetic restoration, as seen in recent times, requires the restorative dentist to use a holistic approach in the management of teeth and its supporting structures; in order to achieve optimal function, aesthetics and comfort. One of the crucial factors in prosthetic rehabilitation of the dentition is the establishment of the patients' functional and aesthetic occlusal plane. When multiple long span posterior restorations are planned, proper management of the occlusal plane in order to achieve posterior disclusion, become a necessary consideration.

Very often, patients with mutilated dentition requiring rehabilitation, report to restorative dentist with severe worn out canine and other posterior teeth. Hence, it is mandatory to re-establish appropriate height of canine based on various factors like aesthetics, phonation and other biomechanical needs. Very often patients report with

attrition of premolar and molar because of inadequate disocclusion. In these situations alteration of canine position would change the existing occlusal plane determined as curve of Spee.

Occlusal plane analyser has long been used to assist the operator in the development of an initial mandibular occlusal plane in diagnostic casts and later as an integral part of both the contour of the definitive restorations<sup>[1]</sup>.

It eliminates posterior protrusive interferences and helps to achieve plane of occlusion, which permits the anterior guidance to disclude posterior teeth without interferences. This study makes an effort to study on influence of variation of dimension of Anterior and Posterior survey lines (ASL and PSL) on the mandibular canine as well as rest of the posterior dentition.

## Materials and methods

A total of 26 subjects were examined and study models of their maxillary and mandibular dentition were made. The study included patients with full complement of teeth with class-I molar relationship.

### Selection criteria

Students and the patients from A.B. Shetty memorial institute of dental sciences, Mangaluru were taken for the study. Patient between age group of 18-55 yrs were selected. Informed consent to participate and to use the data were obtained from each patient, following explanation of the purpose and methods to be used in the study.

### Exclusion criteria

Absence of mandibular canine, first premolar, second premolar, first molar and second molar teeth. Extruded or intruded canine and posterior teeth.

### Procedure

Impressions were made using irreversible hydrocolloid material (DPI- Algitec) for both the maxillary and mandibular dentitions of all the selected patients, using appropriate stock trays. Once the casts were obtained, the orientation relation of the maxilla to the cranium was transferred using face bow to Hanau wide view-II articulator 183 series. Later the mandibular cast were articulated. A four inch radius curve was drawn on the broadricks occlusal plane analyser referred to as Anterior survey line (ASL), from the distal slope of the lower canine referred to as anterior survey point (ASP) and posterior survey line (PSL) from the distal slope of disto-buccal cusp of the lower second molar referred to as posterior survey point (PSP) [figure:1,2]. From the point of intersection of these two curves, referred to as Central survey point (CSP), a four inch radius curve was drawn on the buccal surface of lower posterior teeth and canine, which represents occlusal plane (OP) [figure:3]. Similarly, by changing radius of arc from 101.6mm to

103.2 mm, 104.8mm, 100 mm and 98.4 mm respectively from ASP and PSP, respective point of intersection (survey centres) were named as ASC<sub>1</sub>,ASC<sub>2</sub>,ASC<sub>3</sub>,ASC<sub>4</sub>,PSC<sub>1</sub>,PSC<sub>2</sub>,PSC<sub>3</sub>,PSC<sub>4</sub>. An occlusal plane of four inch radius was drawn on the lower canine and lower posteriors by varying the height of canine, denoted as (OP<sub>1</sub>,OP<sub>2</sub>,OP<sub>3</sub>,OP<sub>4</sub>)[figure:4] and by varying height of lower second molar denoted as (OP<sub>5</sub>,OP<sub>6</sub>,OP<sub>7</sub>,OP<sub>8</sub>) [figure:5]. Distance was measured from the cusp tips of each tooth to the corresponding occlusal planes[figure:6].The rate of influence of these variations of height of lower canine or change in radius of arc of ASP and height of lower second molar or change in radius of arc of PSP on occlusal plane of each tooth was recorded and analysed.

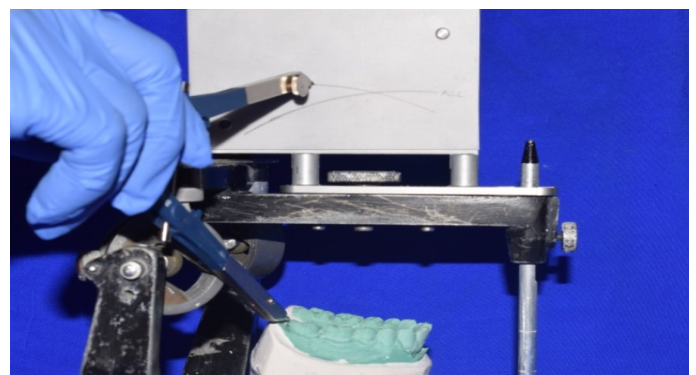
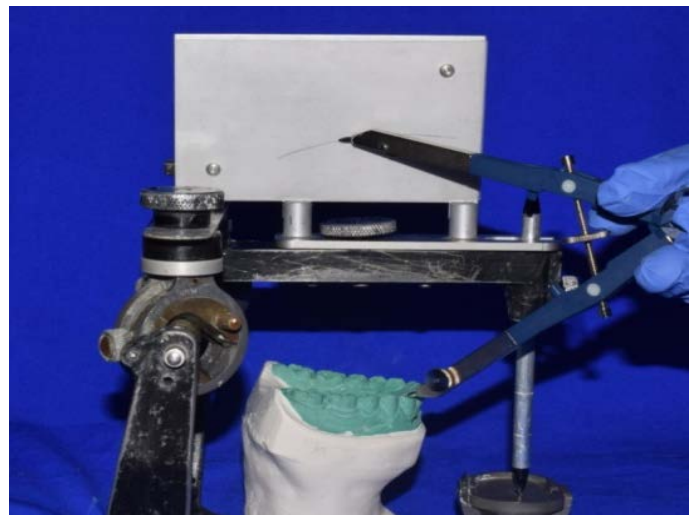


Figure:1; ASL of 4 inch radius was drawn from ASP

Figure:2; PSL of 4 inch radius was drawn from PSP

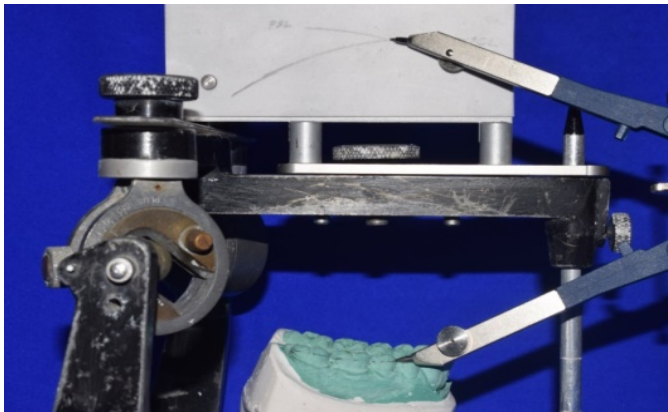


Figure: 3, From CSP, a four-inch radius curve is drawn on the teeth (OP)

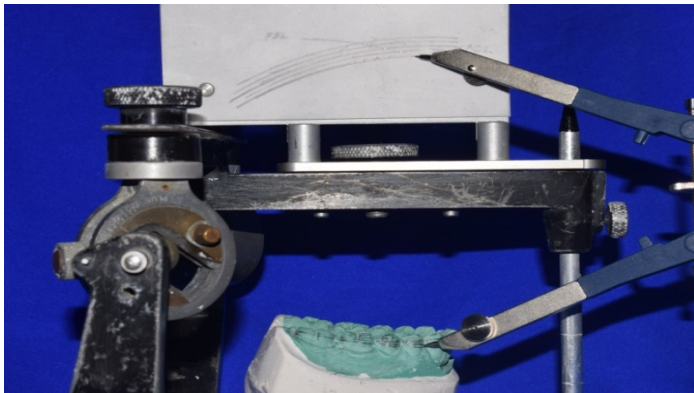


Figure: 4, Occlusal plane namely OP<sub>1</sub>,OP<sub>2</sub>,OP<sub>3</sub>,OP<sub>4</sub> of four inch radius drawn by varying the height of the canine.

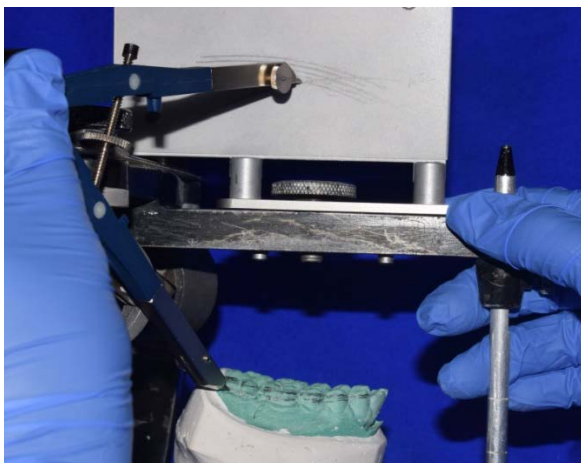


Figure: 5, Occlusal plane namely OP<sub>5</sub>,OP<sub>6</sub>,OP<sub>7</sub>,OP<sub>8</sub> of four inch radius drawn by varying the height of the second molar.

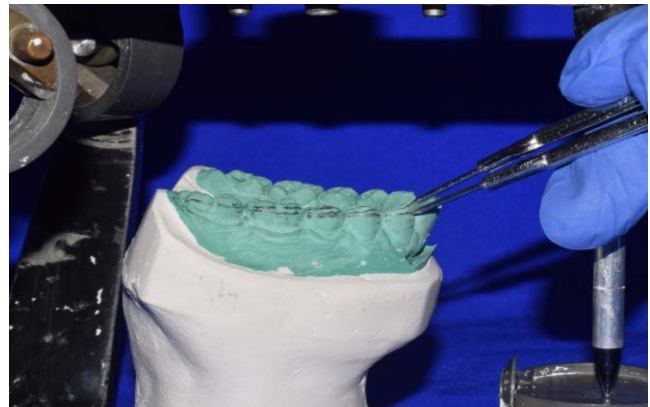


Figure:6, Distance measured from the cusp tips of each tooth to the corresponding occlusal planes.

### Results

Descriptive and analytical statistics were done. The Pearson correlation and linear regression analysis was used to check associations. SPSS software (Statistical Package for Social Sciences) Version 20.1 (IBM Corporation, Chicago, USA). The results obtained were tabulated as follows:

Table 1: Measured distance from the cusp tip of each tooth to occlusal planes:

Survey Centre	Arc of Radius (mm)	Canine	First Premolar	Second Premolar	First Molar (M)	First Molar (D)	Second Molar (M)	Second Molar(D)	Occlusal plane
CSP	101.6	2.3	2.71	2.76	2.53	2.42	2.3	2.28	OP1
ASC1	103.2	1.096	1.73	1.88	1.88	1.98	2.3	2.28	OP2
ASC2	104.8	0.096	0.51	0.846	1.34	1.48	2.3	2.28	OP3
ASC3	100	3.461	3.865	3.788	3.5	3.211	2.3	2.28	OP4
ASC4	98.4	4.76	4.98	4.76	4.19	3.692	2.3	2.28	OP5
PSC1	103.2	2.3	2.63	2.46	1.88	1.69	1.01	0.92	OP6
PSC2	104.8	2.3	2.67	2.42	1.5	1.25	0.53	0.4	OP7
PSC3	100	2.3	2.73	3.05	3.65	3.461	3.61	3.76	OP8
PSC4	98.4	2.3	2.8	3.19	4.07	3.98	4.44	4.25	OP9

\*(mm): millimetres,(M): Mesial, (D): Distal,(OP): Occlusal plane, (CSP): Central survey point,(ASC): Anterior survey centre, (PSC): Posterior survey centre

Table 2: Correlation and linear regression analysis of variation in radius of arc of (ASC) on various teeth

†Highly significant at p<0.001

Table 2: Correlation and linear regression analysis of variation in radius of arc of (ASC) on various teeth

Tests		Canine	First Premolar	Second Premolar	First Molar Mesial	First Molar Distal	Second Molar Mesial	Second Molar Distal
Mean ±S.D.		2.34 ±1.85	2.75 ±1.75	2.80 ±1.50	2.68 ±1.16	2.55 ±0.89	2.30 ±0.00	2.28 ±0.05
Pearson Correlation	R	-0.999	-1.000	-1.000	-0.995	-0.995	0.000	-0.289
Goodness of Fit	P-Value	<0.001 <sup>†</sup>	<0.001 <sup>†</sup>	<0.001 <sup>†</sup>	<0.001 <sup>†</sup>	<0.001 <sup>†</sup>	-	0.638
	R <sup>2</sup>	0.998	1.000	1.000	0.990	0.991	0.000	0.083
ANOVA	F-Value	1637.19	3771.18	6103.39	308.892	323.405	0.000	0.273
	P-Value	<0.001 <sup>†</sup>	<0.001 <sup>†</sup>	<0.001 <sup>†</sup>	<0.001 <sup>†</sup>	<0.001 <sup>†</sup>	0.000	1.000
Linear Regression	B	1.15	1.09	0.96	0.723	0.55	0.000	0.001
	S.E.	0.018	0.011	0.008	0.026	0.020	0.000	0.001
	P-Value	<0.001 <sup>†</sup>	<0.001 <sup>†</sup>	<0.001 <sup>†</sup>	<0.001 <sup>†</sup>	<0.001 <sup>†</sup>	-	0.638

<sup>†</sup>Highly significant at p<0.001

Table :3: Correlation and linear regression analysis of variation in radius of arc of (PSC) on various teeth.

		Canine	First Premolar	Second Premolar	First Molar Mesial	First Molar Distal	Second Molar Mesial	Second Molar Distal
Mean ±S.D.		2.30 ±0.00	2.70 ±0.064	2.77 ±0.34	2.72± 1.10	2.56 ±1.15	2.37 ±1.66	2.32± 1.6915
Pearson Correlation	R	0.000	-0.387	-0.979	-0.985	-0.991	-0.991	-0.985
Goodness of Fit	P-Value	-	0.045	<0.001 <sup>†</sup>	<0.001 <sup>†</sup>	<0.001 <sup>†</sup>	<0.001 <sup>†</sup>	<0.001 <sup>†</sup>
	R <sup>2</sup>	0.000	0.786	0.959	0.971	0.983	0.982	0.971
ANOVA	F-Value	0.000	11.045	69.336	100.55	170.32	159.12	99.024
	P-Value	-	0.211	<0.001 <sup>†</sup>	<0.001 <sup>†</sup>	<0.001 <sup>†</sup>	<0.001 <sup>†</sup>	<0.001 <sup>†</sup>
Linear Regression	B	0.000	0.0363	0.2104	0.6826	0.7146	1.02	1.04
	S.E.	0.000	0.007	0.016	0.043	0.035	0.052	0.066
	P-Value	-	0.045	<0.001 <sup>†</sup>	<0.001 <sup>†</sup>	<0.001 <sup>†</sup>	<0.001 <sup>†</sup>	<0.001 <sup>†</sup>

<sup>†</sup>Highly significant at p<0.001

Table 4: Rate of influence of change in height of canine and second molar on occlusal plane passing through various tooth per 1.58 mm change of radius of arc.

	Canine teeth	First premolar	Second premolar	First molar mesial	First molar distal	Second molar mesial	Second molar distal
ASC	1.15	1.09	0.96	0.723	0.55	0.000	0.001
PSC	0.000	0.0363	0.21014	0.68256	0.7141	1.02	1.04

\*All measurements are in millimetres, ASC: Anterior survey centre, PSC: Posterior survey centre

On evaluation of the results it can be noted that the occlusal plane of 4 inch radius did not pass through the cusp tips of lower posteriors as well as the canine, it always passed beneath the cusp tips, of lower canine and lower posteriors in all cases. According to the curve of Spee, ideally cusp tips will be arranged touching the sphere of four inch radius. However in this study, none of teeth showed that the curve of Spee (represented as occlusal plane - OP) was touching the cusp tips of the lower canine and the lower posteriors. This variation was

seen, may be, as Posterior survey line (PSL) was drawn from the distal slope of the disto-buccal cusp of the second molar. Possibly, if it was drawn from the anterior most point of the condyle, these results may have varied. When a 4-inch radius curve was drawn from the CSP, representing occlusal plane (OP), deepest occlusal plane line was located on second premolar at a distance of 2.76 mm from the tip of the cusp followed by first premolar at a distance of 2.71mm from the tip of the cusp, mesio-buccal of the first molar at a distance of 2.53mm from the tip of the cusp, disto-buccal of the first molar at a distance of 2.42mm from the tip of the cusp. The occlusal plane represented as a curve, being most shallow at the canine and second molar, and gradually getting deeper, being deepest at the 2<sup>nd</sup> premolar, can be attributed as one of the reasons in successfully achieving disocclusion. This is facilitated by the fact canine being closest to anterior controlling factor namely anterior guidance and second molar being very close to posterior controlling factors namely condylar guidance which dictates the eccentric movement along a curved path. Thus, the occlusal plane line was located on canine at a distance of 2.30mm from the cusp tip and distal of the second molar at a distance of 2.28mm from the tip of the cusp, being deepest in the second premolar(2.76mm). (As mentioned in **Table: 1**)

It indicates that by varying the height of the lower canine, the highest mean value with respect to variation of occlusal plane in relation to cusps tips, was obtained for the second premolar (2.80mm) and lowest mean value with respect to variation of occlusal plane in relation to cusps tips was obtained in relation to distal of the second molar (2.28mm). While the standard deviation with respect to variation of occlusal plane in relation to cusps tips, was seen highest in relation to canine (1.85mm) and lowest in relation to mesial of the second molar (0.00mm). [As mentioned in **table: 2**]. While, by varying the height

of the lower second molar, the highest mean value with respect to variation of occlusal plane in respect to cusps tips was obtained in relation to second premolar (2.77mm) and lowest in relation to canine (2.30mm) and the standard deviation was seen highest in relation to distal of the second molar (1.69mm) and lowest in relation to canine (0.00mm). [As mentioned in **table: 3**]. This shows that by varying the height of the canine or by altering the dimensions of Anterior survey centres (ASC) there was least change in influence was seen on the occlusal plane of mesial and distal of lower second molar. Similarly, by varying the height of the lower second molar or by changing the dimensions of Posterior survey centres (PSC), there was least change in influence was found on the occlusal plane of canine.

Also, when the height of the canine was increased or decreased per 1.58mm, the maximum rate of influence was recorded on the canine at the rate of 1.15mm followed by first premolar (1.09mm), second premolar (0.96mm), mesial of the first molar (0.723mm) and distal of the first molar (0.55mm), whereas the minimum rate of influence was found on mesial of the second molar (0.00mm) and distal of the second molar (0.001mm). Similarly, when the height of the second molar was increased or decreased by 1.58mm, the maximum rate of influence was recorded on the distal of the second molar at the rate of 1.04mm and mesial of the second molar (1.028mm) followed by distal of the first molar (0.71mm), mesial of the first molar (0.68mm), whereas minimum rate of influence was seen on canine (0.00mm) and the first premolar (0.036mm) [As given in **table: 4**]. Thus, by changing the height of the canine, correlation recorded with respect to variation of location of occlusal plane on canine, first premolar, second premolar, mesial and distal cusp of the first molar was found to be highly significant i. e; ( $p < 0.001$ ). This further indicates the change in height of canine and radius of arc of ASP would significantly affect the location of

occlusal plane, among the above mentioned teeth. This correlation can be made use in developing a planned scheme of occlusion during protrusion. Whereas distal of the second molar, did not significantly get influenced i. e; ( $p > 0.05$ ) and no correlation was found between the radius of arc and the distance between the cusp tips to occlusal plane (OP) with respect to the mesial of the second molar as ( $R = -0.000$ ) [**table: 2**], which means that the regression coefficient is “0” indicating value is independent of variation in radius of arc. This finding denotes change in radius of arc of ASP or change in height of lower canine does not influence location of occlusal plane with respect to the lower second molar.

Similarly, by changing the height of the 2<sup>nd</sup> molar, correlation recorded with respect to variation of location of occlusal plane on distal of the first molar, mesial of the second molar, mesial of the first molar, and distal of the second molar, second premolar, and first premolar was found to be statistically significant ( $p < 0.01$ ). Whereas no correlation was found between the radius of arc and the distance between the cusp tips to occlusal plane (OP) with respect to the canine as ( $R = -0.000$ ) [**table : 3**], which means that the regression coefficient is “0” indicating value is independent of variation in radius of arc. It can be noted since protrusive movement is in the forward and downward direction; the occlusal plane in the form of an arc is descending from the ASP. Change in height of canine / radius of arc without altering the posterior occlusal plane might result in disocclusion of the posterior teeth.

### Discussion

In the modern era of dentistry, with the recent increase in patients' demands for aesthetic restorations in the anterior as well as the posterior region, the integrated management of disease of the teeth, their supporting structures and the rehabilitation of the dentition to function and aesthetic has become an important criteria. Managing the occlusal

curve becomes an essential consideration when multiple long span restorations are considered. The Broadricks flag is a useful apparatus used to provide a guide to the most appropriate position and orientation of posterior occlusal scheme. Where the natural curve of Spee is deranged. Semi-adjustable articulator are more in use and have become well-known for prosthodontics rehabilitation. Canine is one of the most common teeth to wear. Very often the height of the canine has to be varied with the permissible limit determined by aesthetics, phonetics and anterior occlusal plane to get disocclusion by varying it along the Anterior survey line (ASL). Even though variation is possible, the direct influence on the amount of disocclusion or tooth contact or in relation to occlusal plane is not studied yet. This is an attempt to find out what is the influence of variation in the height of canine and height of second molar, specifically in relation to millimetres or inch (with respect to this study 1.58mm of variation is taken), which could be of help if one has to develop disocclusion or group function. If one knows what is the influence of variation of ASP/PSP on occlusal plane, one can plan his treatment either to achieve disocclusion or to achieve occlusal contact in case of group function, that is by increasing or decreasing the arc radius accordingly. As per the findings of this study by changing the height of canine alone and by not altering the heights of posterior teeth, one can be in a better position to achieve disocclusion. In order to develop group function of the premolars, it would be necessary to increase a cuspal height of posterior teeth, either by maintaining or along with increase in height of canine. In this study the influence of change in Anterior and Posterior survey points (ASP and PSP) and their influence on occlusal plane analysis were studied [Table:1]. Correlation and linear regression analysis of variation in radius of arc of Anterior survey centre (ASC) and posterior survey centre (PSC) on various teeth was done, which was found to be

highly significant ( $p < 0.001$ ) [Table:2,3]. It was found that by varying the height of lower canine, there was least change in influence was seen on the occlusal plane of mesial and distal of lower second molar. Similarly, by changing the height of lower second molar, there was least change in the influence was found on the occlusal plane of canine [Table:4]

As the occlusal plane ascends towards PSP; which is a second molar, change in radius of arc from PSP or change in height of second molar will cause posterior occlusal plane to become steeper, resulting in interferences of posterior teeth during protrusion. This can be cited as one of the reasons why radius of arc from PSP or height of second molar should be not be altered. Rate of influence of change in height of canine was determined in this study. If the posterior occlusal plane is kept shallower than the occlusal plane resulting from the influence of change in canine height, the occlusal plane achieved there by is more likely to produce disocclusion. Reverse may also be true to achieve group function.

#### **Limitations of the study**

1. It is a technique sensitive procedure, which requires precision and understanding, as there are high chances of determining an error
2. It is difficult to carry out in cases with absence of lower canine or even in the cases with missing mandibular posterior teeth.
3. The current study has been carried out using Hanau wide view -II, taking Frankfort horizontal plan as a reference plane.

#### **Conclusions**

It can be concluded that variations in the height of lower canine have more influence on occlusal plane compared to variations in the height of lower second molar. In majority of the cases, occlusal plane were passing beneath the cusp tips of canine and posterior teeth. By changing the height of canine alone and by not altering the height of posterior

teeth, one can be in a better position to achieve disocclusion and by changing the height of lower second molar alone it is more likely to introduce interferences during protrusive movement.

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