

Increased Occlusal Vertical Dimension and Its Influence on Lip Position at Smile in Dentulous Adults

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ABSTRACT

Introduction: Increasing occlusal vertical dimension (OVD) is often indicated in complex prosthodontic rehabilitations to gain restorative space and improve the occlusal relationship and esthetics. However, any alterations made in OVD will also influence the lip position mainly during rest and smile. This study aims to determine the influence of the vertical dimension of occlusion on lip positions at a smile.

Methods: 30 samples between the age group of 20 - 30 years were included in this study meeting the selection criteria. The acrylic splint of varying thicknesses of +2mm, +4mm, +6mm, +8mm was prepared on the dental stone cast of a patient that was articulated in a semi-adjustable articulator after tentative facebow transfer. Smile photograph of each individual at the occlusal vertical dimension of +0mm, +2mm, +4mm, +6mm, +8mm was taken using a DSLR camera mounted on a tripod using the prepared acrylic splints. Digital measurements were done in photographs using the Adobe Photoshop software.

Results: The study's results demonstrate that increasing the OVD significantly affects the inter labial distance, incisal edge to lower lip distance, and the display zone area. However, the study found no notable alterations in the distance from the incisal edge to the upper lip or in the intercommissural width with the same increased OVD. These findings demonstrate on how changes in OVD can influence various orofacial measurements.

Conclusion: Within the limitation of this study, it can be concluded that with the increase in the OVD, inter labial distance, incisal edge to lower lip distance, and display zone area are increased. But upper lip position and inter commissural width should not be expected to be changed with increased OVD.

Key words: Dental esthetics, Dental photography, Esthetic smile, Occlusal vertical dimension

INTRODUCTION

A loss in the interarch space may be a result of tooth structure loss, leading to loss of OVD. Prosthodontic rehabilitation in these scenarios often involve increasing the OVD

and re-establishing the lost vertical dimension. This alteration will minimize the need for alternative biologically invasive procedures like crown lengthening, intentional endodontic treatments, aggressive tooth preparations, etc. It also improves the esthetic display of the tooth, correct the relationship of the anterior teeth, and also help in the re-installation of the physiological occlusion. Despite the obvious advantages, it has been reported that increased OVD causes hyperactivity of the muscles of mastication, increase in occlusal forces, bruxism, and temporomandibular disorders.¹ However, these changes are transitory and

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are well accepted by the individual due to the dynamic nature of the dentoalveolar complex and masticatory system.^{1,2}

Additionally, it is implicated that alteration in the OVD also alters soft tissue profile of the lower third of the face which in turn can affect esthetics, comfort, and function.³ This increased distance is more likely to change the relationship of the lip and tooth while smiling as shown by a study by Chou JC et al. They found that increasing the OVD shifted the lower lip downward during smiling without affecting the maxillary gingival display and buccal corridor.⁴ However, contradictory results have been reported where alteration of OVD from 2 to 6 mm had no visually distinguishable esthetic changes.⁵ Remiszewski et al, on the other hand, found that raising OVD by 5 mm significantly decreases face naturalness as judged by 20 prosthodontists and 20 general dentists in a research on 10 dentate subjects.⁶ Similar research executed by general dentists and Prosthodontists, however, did not find any association between increased OVD and objectively reduced face height and perceived aesthetics.⁵ These reports shows that the literature is clearly inconsistent with this regard and there is a need to understand the effect of altering the OVD on the esthetics. Hence, this study has been done to determine the effect of increased occlusal vertical dimension on the position of the lip while smiling so that it can be quantified scientifically and can be applied in future treatment planning.

METHODS

Ethical clearance was obtained from the Institutional Review Committee, Peoples Dental College and Hospital, Kathmandu (Reference no: 01, CH no - 08,2077/2078). A sample size of 30 was selected from the patients meeting the selection criteria visiting the People's Dental College and Hospital from November 2020 to October 2021. Informed written consent was

taken from all study participants. The anonymity and confidentiality of the participants were assured and maintained.

Intraoral examination followed by impression of the both maxilla and mandibular arch was made using irreversible hydrocolloid impression material (Chromatic Alginate Impression Material, Elvydent) in-stock metal trays. The cast was prepared with a dental stone (Neelkanth Dental Stone, Neelkanth Ortho Dent Pvt. Ltd.) and the base was prepared with the dental plaster after disinfecting the cast (Figure 1). Tentative facebow transfer was taken using a Hanau spring bow (Figure 2) and the bite registration was made (Bite registration wax, Ruthinium Group). Casts of the subject were mounted using the obtained facebow and bite registration record in a semi-adjustable articulator (Hanau wide view, Whip Mix) (Figure 3). After mounting the cast in a semi-adjustable articulator, occlusal splints were prepared using self-cure acrylic resin (Rapid Repair, Tru Lon). Self-cure acrylic was mixed and adapted on the occlusal surface of the mounted mandibular cast from 1st premolar to 2nd molar. (Figure 4) Vertical dimension was increased by +2, +4, +6, +8mm in the articulator using the incisal pin, and occlusal splints of individual vertical dimensions were prepared using above mentioned procedure. After the complete setting of the acrylic, excess material was trimmed off and polished to ensure proper fit on the occlusal surface. Later these records were used intraorally to increase the vertical dimension at occlusion. These records were disinfected and stored in a labeled plastic bag.

Patient was prepared for a photograph and was made to achieve a natural head position by looking at a distant point. A DSLR camera (Nikon D5600 with 18-55mm lens) mounted on a tripod at a fixed distance from a patient was used to photograph the patient. The patient was instructed to say 'M, M, M', relax and smile. Three photos for each vertical dimension of

occlusion, i.e., from +0mm to +8mm, were made while smiling. Photographs made for individual vertical dimensions were transferred to Adobe Photoshop software (Figure 5) and measurements were done as follows:

i. Interlabial distance

The vertical distance between the lower border of the upper lip and the upper border of the lower lip is measured at the midline of the face. (Figure 6a)

ii. Intercommisural width

Distance between the right and left commissure of the mouth. (Figure 6b)

iii. Incisal edge to upper lip distance

The vertical distance from the midpoint of incisal embrasure between the two central incisors and the lower border of the upper lip. (Figure 6c)

iv. Incisal edge to lower lip distance

The vertical distance from the midpoint of incisal embrasure between the two central incisors and the upper border of the lower lip. (Figure 6d)

v. Display zone area

The total display zone area was measured using the tracing tool available in the software. (Figure 6e)

The width of the central incisors was measured from the stone model and used to standardize the digital measurements.

Data were entered in Microsoft Office Excel 2019 and exported to SPSS (Statistical Package for the Social Sciences) version 16 for analysis. Descriptive statistics were expressed as frequency, percentage, mean and standard deviation. One way ANOVA test was used to assess the difference in mean interlabial distance, mean intercommisural width, mean incisal edge to upper lip distance, mean incisal edge to lower lip distance, and mean display zone area at various occlusal vertical

dimensions. Post hoc Bonferroni test was used for inter-group comparison if the difference was found to be statistically significant. The level of significance was set at a p -value < 0.05 .

RESULTS

A total of 30 study participants were included in the study of which 12 (40%) were male and 18 (60%) were female. The age of the study participants ranged from 20 to 30 years with a mean age of 26.20 ± 2.75 . The inter labial distance at the increased OVD was found to be statistically significant with a p -value < 0.001 . (Table 1) Intergroup comparison of the change in inter labial distance was found to be statistically significant between +0 mm and +4 mm, +0 mm and +6 mm, +0 mm and +8 mm and between +2 mm and +8 mm. The difference in inter commissural width at this increased OVD was not found to be statistically significant with a p -value of 0.12. (Table 1) Similarly, the difference in incisal edge to upper lip distance at this increased OVD was not found to be statistically significant with a p -value of 0.91. (Table 1)

The difference in incisal edge to lower lip distance at this increased OVD was found to be statistically significant with a p -value < 0.001 . (Table 1) There was a statistically significant difference in mean incisal edge to lower lip distance between +0 mm and +4 mm, +0 mm and +6, +0 mm and +8 mm and was also seen between +2 mm and +8 mm OVD. In case of the display zone area, at this increased OVD, it was also found to be statistically significant with a p -value < 0.001 . (Table 1) The intergroup comparison showed a statistically significant difference in mean display zone area between +0 mm and +4 mm, +0 mm and +6 mm, +0 mm and +8 mm OVD. A statistically significant difference in mean display zone area was also seen between OVD +2 mm and +8 mm with a p -value of 0.01. (Table 1)

Table 1: Results of measurements

	Occlusal vertical dimension	Mean±SD (mm)	F value	95% Confidence Interval		p-value
				Lower Bound	Upper Bound	
Interlabial Distance	+0 mm	9.73±2.49	11.635	8.80	10.66	<0.001*
	+2 mm	11.47±3.09		10.31	12.62	
	+4 mm	13.07±3.62		11.72	14.42	
	+6 mm	14.07±3.58		12.73	15.40	
	+8 mm	15.40±4.64		13.67	17.13	
Intercommissural Width	+0 mm	61.17±5.35	1.867	59.17	63.16	0.12
	+2 mm	63.07±6.46		60.65	65.48	
	+4 mm	64.53±5.25		62.57	66.49	
	+6 mm	64.20±5.12		62.29	66.11	
	+8 mm	63.90±4.67		62.16	65.64	
Incisal Edge to Upper Lip Distance	+0 mm	7.75±3.35	0.242	6.49	9.00	0.91
	+2 mm	7.90±2.91		6.82	8.98	
	+4 mm	8.23±2.84		7.17	9.29	
	+6 mm	8.33±2.66		7.34	9.33	
	+8 mm	8.30±2.87		7.23	9.37	
Incisal Edge to Lower Lip Distance	+0 mm	1.67±1.52	10.652	1.10	2.23	<0.001*
	+2 mm	3.70±3.08		2.55	4.85	
	+4 mm	4.93±3.64		3.57	6.29	
	+6 mm	5.73±3.88		4.29	7.18	
	+8 mm	7.07±4.41		5.42	8.71	
Display Zone Area	+0 mm	423.05±127.49	9.076	375.44	470.66	<0.001*
	+2 mm	542.63±187.58		472.59	612.67	
	+4 mm	615.42±224.32		531.66	699.18	
	+6 mm	659.19±219.05		577.40	740.99	
	+8 mm	723.82±266.40		624.35	823.29	



Figure 1: Primary Impression

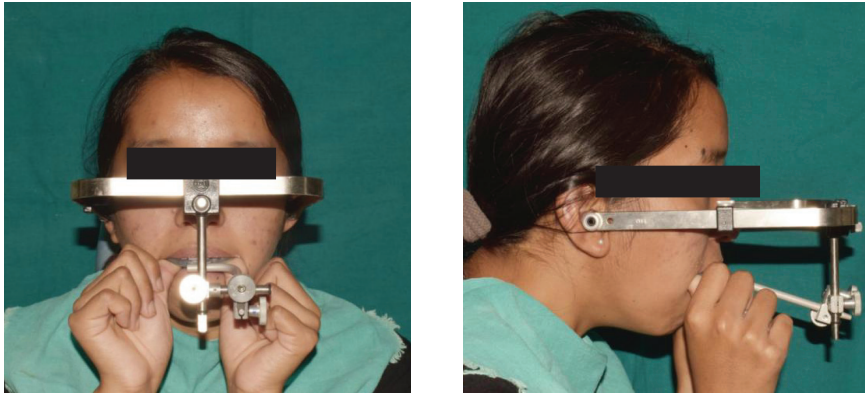


Figure 2: Facebow Transfer

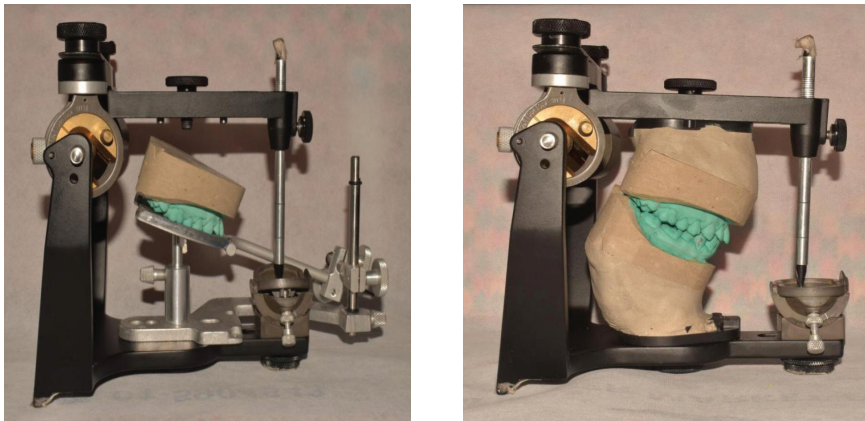


Figure 3: Mounting of cast on semi adjustable articulator

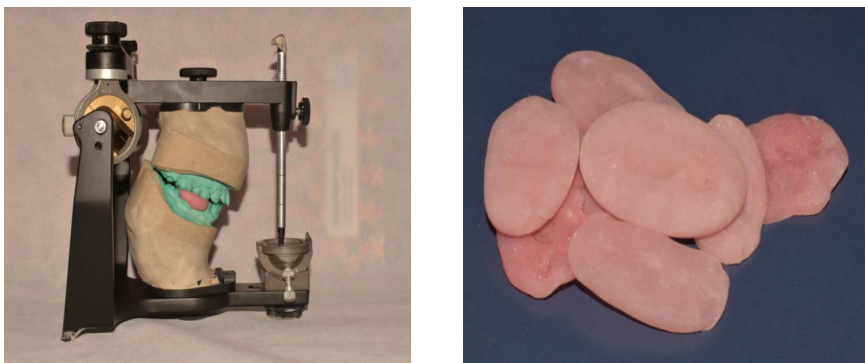


Figure 4: Preparation of acrylic splint of different OVD

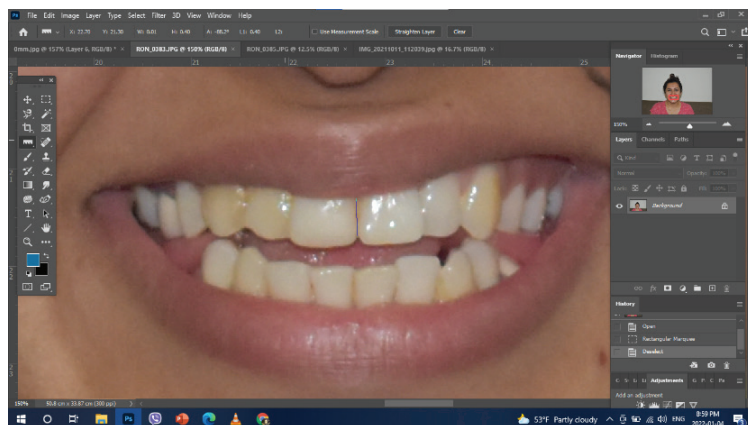


Figure 5: Measurements done in Adobe Phostoshop



Figure 6: 6a: Interlabial distance; 6b: Intercommisural width; 6c: Incisal edge to upper lip distance; 6d: Incisal edge to lower lip distance; 6e: Display zone area

DISCUSSION

A smile is a facial expression that is defined by the upward curving of the corners of the lips and is frequently used to communicate joy, amusement, or scorn. There are two types of smile known as Enjoyment or Duchenne smile and Posed or Social smile.⁷ Because the posed smile is repeatable and can be created on-demand, it is frequently employed for analyzing face esthetics and smiling features. The enjoyment or unposed smile, on the other hand, is instinctive and spontaneous, expressing genuine human emotion. In Prosthodontics and Esthetic Dentistry, lip position and the amount of tooth and gingival presentation during smiling

and speech are key diagnostic criteria.⁸ For facial aesthetics, a pleasing smile is necessary. The position of the upper lip, its curvature, the parallelism of the anterior incisal curve with the lower lip, the relationship between the maxillary anterior teeth and the lower lip, and the number of teeth visible during the smile all influence the aesthetics of the face.⁹ The position of the lips, the inter commissural width, the inter labial distance, and the smile index are the soft tissue determinants of the esthetic smile.

With the increase in the occlusal vertical dimension, lower facial height will ultimately increase leading to the increased separation of the maxilla and the mandible. Hence, it is

probable that the upper and lower lips positions will also change during smiling. Various studies had been conducted to determine the effect of increased occlusal vertical dimension on the lip position and facial esthetics. These studies had shown that there is a substantial change in facial esthetics with the increase in the occlusal vertical dimension.^{4, 10-15} Cephalometric analysis and other various studies using wax rims with differences in the OVD, had also exhibited similar results.¹⁶⁻¹⁹ Similar research including a panel of professional evaluators and the patients themselves, had also discovered that restoring OVD had a substantial impact on their facial attractiveness.¹¹ In this study, the initial mean inter labial distance in this study was 9.73 ± 2.49 mm which gradually increased to 11.47 ± 3.09 mm, 13.07 ± 3.62 mm, 14.07 ± 3.58 mm, 15.40 ± 4.64 mm when OVD was changed to +2mm, +4mm, +6mm, +8mm respectively. These findings suggested that the inter labial distance was increased as the OVD was increased. These results agreed with some similar studies where the lip position was evaluated at various OVD.^{4,12,14,20}

The position of the commissure is affected by the modiolus which is formed by the merging of eight different muscles. Among these muscles, zygomaticus major and triangularis muscles are of prime concern as they are originated from the zygomatic arch and the mandible. When the vertical dimension is altered, the modiolus's position might be changed, altering the inter commissural width. In this study, no significant changes were found in the distance between the two commissures of the mouth with the increase in the vertical dimension of occlusion. A similar result was obtained in a study by Parmar et al. where no significant changes were obtained in inter commissural width.¹⁵ Whereas few other studies had concluded that inter commissural width was slightly decreased with an increased OVD.^{4,14}

The significance of the upper lip position during smiling has been thoroughly documented in the literature. The "average smile," according to Tjan, is one in which 75 % to 100 % of the maxillary anterior teeth and interproximal gingiva are visible.²¹ According to Hulsey, the patients with an upper lip that was at the height of the gingival border of the upper central incisor were the most attractive.²² The impact of OVD on upper lip position has yet to be investigated. According to a case study by David S. Frey, increasing the vertical dimension improves the crown-to-gingiva ratio and so reduces the gummy smile.²³ However, there was no statistically significant change in the upper lip at a smile with increasing OVD was found in the present investigation. Individual variations or patient adaptation following an enhanced OVD may have accounted for the observed lowering of the upper lip at the smile.²³ Another reason may be due to the common habit of photographing the patient with his or her head angled down. However, the result of this study advocated that the upper lip at smile should not be expected to change while altering the vertical dimension of occlusion.

In the case of the incisal edge to lower lip distance, an average distance of 1.67 ± 1.52 mm was found, which was increased to 3.70 ± 3.08 mm, 4.93 ± 3.64 mm, 5.73 ± 3.88 mm, 7.07 ± 4.41 mm with an increase of OVD to +2mm, +4mm, +6mm, +8mm respectively. These results were similar to those found in previous studies.^{4,14} And were similarly found consistent with those of Gross et al.⁵, who found a linear rise in lower face height of about 50% of the increments at the incisal level, which was between 2 and 8mm. In a similar study by Alvétez-Temoche et al.²⁰, the incisal edge to lower lip distance was found to be 1.85 ± 2.08 mm at +0mm OVD which amounted to 3.04 ± 2.49 and 4.19 ± 2.87 mm with an increase in OVD to +2mm and +4mm respectively.

The "display zone," as defined by Ackerman, is the region enclosed by the upper and lower lips.¹⁰ Teeth and the gingival scaffold are two components of the smile that fall inside this display zone. In this study, the display zone area was calculated by tracing the interior region between the upper and lower lips during smiling. A mean display zone area was found to be 423.05 ± 127.49 mm². A statistically significant increase in the display zone was obtained with the increase in the occlusal vertical dimension. Previous studies had also shown similar results that supports the finding of this study.^{4,14,15,20} Because the location of the maxillary central incisal edge is governed by the position of the maxillary lip on rest, a larger display zone might result in more mandibular teeth being shown. This may result in an esthetic compromise, as the patient may begin to exhibit "too many teeth," which is considered unattractive.

Because of the necessity for restorative space, improving occlusal relationships, limiting interventions, or enhancing esthetics, the occlusal vertical dimension is frequently adjusted in patients with or without an apparent loss of OVD.²⁴ The current study's findings on the effect of increased OVD on the lip position at smile suggest that the OVD should only be altered to the extent necessary to limit the unfavorable influence on facial esthetics. A comprehensive evaluation and study of facial contours, facial esthetics, and temporomandibular joint and muscle functioning should be carried out when contemplating an increase in OVD. Furthermore, before an amount of OVD increase is decided, this intended increase in OVD should be evaluated using removable appliances and interim restorations where applicable.

The study was conducted on a limited sample size of young adults which may not reflect the entire population. For greater clinical significance, further study needs to be expanded

to include a broader population. The age group of 20 to 30 years were only included in this study. Hence, age differences of a significant magnitude should be expected. Similarly, OVD has not been lost in any of the participants in this research. Patients who have undergone substantial tooth structure loss or tooth loss are likely to respond differently once OVD is restored.

CONCLUSION

Within the limitation of this study, it can be concluded that change in inter labial distance, incisal edge and the lower lip distance and the display zone area can be expected with an increase in the occlusal vertical dimension. But the increased occlusal vertical dimension does not affect the incisal edge to upper lip distance and the incisal edge to upper lip distance.

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