Effect of Increasing Occlusal Vertical Dimension on Smile Parameters

Pahari S[1], Pradhan Joshi S[2], Shrestha P[3], Sah S[4], Verma A[5]

[1]PG resident, NAMS, Bir Hospital, Kathmandu, Nepal
[2]Professor, NAMS, Bir Hospital, Kathmandu, Nepal
[3]Associate Professor, NAMS, Bir Hospital, Kathmandu, Nepal
[4,5]Assistant Professor, NAMS, Bir Hospital, Kathmandu, Nepal

ABSTRACT

Introduction: Increasing Occlusal Vertical Dimension (OVD) becomes important aspect of complex prosthodontic treatment for maintaining balance between form of oral structures and function of stomatognathic system. The purpose of this study is to determine the effect of increasing OVD on various smile parameters during posed smile.

Methodology: This observational descriptive study included 30 patients, 14 male and 16 females, visiting dental department of National Academy of Medical Sciences (NAMS), Bir Hospital. Four polyvinyl siloxane bite records were fabricated on stone cast mounted on a semi-adjustable articulator increasing OVD by +1 mm, +2 mm, +3 mm and +4 mm taking incisal pin as a reference. Photographs of posed smile were taken at OVD of +0 mm, +1 mm, +2 mm, +3 mm and +4 mm using a DSLR camera mounted on a tripod. Head position was stabilized using a head positioning device of a cephalometric unit during photography. Adobe photoshop CS6 extended was used to calculate the various measurement in pixel which was converted into mm with help of conversion ratio obtained. Data were then processed and analyzed using SPSS software at the 5 % significance level.

Result: One-way repeated measures ANOVA found statistically significant differences in interlabial gap height, incisal edge to lower lip distance, smile index and display zone area with increasing OVD. No statistically significant differences were found for intercommisural width and incisal edge to upper lip distance.

Conclusion: Within the limitations of this study, the excessive increase of OVD may lead to excessive interlabial gap height, incisal edge to lower lip distance, and display zone area. Also, the increase of OVD may lead to reduced smile index. No change may be expected in the position of upper lip with increase of OVD. In addition, a change in the intercommisural width of the smile should not be expected with increasing OVD.

Key words: Vertical Dimension, Smile Parameters, Smile index

INTRODUCTION

The occlusal vertical dimension (OVD) is the distance between two selected anatomic landmarks or points, usually, one on the tip of the nose and the other on the chin, when on maximum intercuspation. Increasing OVD implies increasing the distance between the mandible and maxilla by modification of teeth, the position of teeth, or occlusal rims.[1] Increasing OVD is necessary for complex prosthodontic treatment, which may lessen the requirement of endodontic procedures and clinical crown lengthening.[2]

A smile can be defined as a facial expression that is characterized by an upward curving of the corners of the mouth.[3] A pleasing esthetic

Conflict of Interest: None

***Corresponding Author**
Dr. Samrat Pahari,
PG Resident, Prosthodontic unit, Dental Department, National Academy of Medical Sciences (NAMS), Bir Hospital, Kathmandu
Phone No: +977-9862205087
E-mail: samratpahari19@gmail.com

smile depends on the harmonious relationship between parameters in the display zone of the smile framed by the upper lip and lower lips. Soft tissue determinants of the display zone include interlabial gap, intercommisure width, smile index (width/height), lip thickness, and gingival architecture.[4] A smile is classified into a social smile (posed or voluntary) and an enjoyment smile (involuntary).[5, 6] A study done by Husley[7] and Rigsbee[8] concluded that the reproducibility of posed smile was great which was later correctly tested by Ackerman et al.[5]

Esthetics, comfort and function are affected by loss in OVD along with the soft tissue profile of lower face.[9] It is Implicated that alteration in OVD alters the soft tissue esthetics as, distance between the corner of mouth as well as relationship between the lip and tooth while smiling.[10, 11] According to Turner and Missirlian increasing OVD not violating freeway space can be easily adapted by the masticatory system.[12] Jaafar Abduo concluded that increasing the OVD, particularly with fixed restoration is a predictable and stable procedure.[13] A study reported that the patients who had their OVD increased, patients found themselves younger after treatment.[14] Orenstein et al. found that incremental increase in anterior guide pin opening up to 5 mm did not co-relate to a similar increase in lower facial height, additionally, it made no difference in a judge's perception of facial esthetics.[9] Gross and Oramianer found that increasing the OVD significantly increases the measurement of the lower facial height.[15]

The amount of OVD that can be increased without subsequent negative alteration in facial esthetics and smile parameters is of utmost importance. Available scientific data suggest that the alteration in OVD can alter the facial esthetics and smile parameters of patients, but the available data are sparse. Similar studies relating to OVD and smile parameters was not available in the context of Nepal. Hence, the objective of this study was to determine the effect of increasing OVD on smile parameters in patients visiting the Prosthodontic unit, Department of dental surgery, National Academy of Medical Sciences (NAMS), Bir Hospital, so, that the obtained scientific data would be helpful in future treatment planning.

METHODOLOGY

This Observational descriptive study was conducted at Prosthodontic unit, Department of dental surgery, NAMS, Bir Hospital, Kathmandu after ethical clearance from Institutional Review Board (IRB) of NAMS. The Duration of study period was one year starting from March 2021 to February 2022. Sample size was calculated and convenience sampling was done. Sample included volunteers aged 21-30 years, among patients visiting Dental department. Patients with Presence of intact anterior teeth and Posterior segments with at least 3 teeth in occlusion were included in the study. Patients with any history of surgery in facial area, neurological disorders, temporomandibular disorders and persistent ear infections were excluded from the study. Any patients with known allergy to impression and bite registration materials were also in the study Prior to research, every participant was informed about the purpose of the study. Informed consent was taken and exclusion and inclusion criteria were taken care of. Personal data regarding each participant was recorded on the Proforma. The data was kept confidential and was used only for research purpose maintaining anonymity. The study was conducted in two phases.

First phase: Maxillary and mandibular impression of the participants was made with irreversible hydrocolloid impression material (Zelgan 2002, Dentsply sirona) in metal stock tray. Silicon bite registration (Jet Bite, Coltene, Switzerland) was made in maximum intercuspation (MI). Impressions were disinfected and were poured in type III dental stone (Neelkanth ortho dent, India). Arbitrary

facebow transfers using Hanau™ springbow earpiece facebow were obtained (Fig.1). The cast were retrieved, trimmed, indexed and were articulated on semi adjustable articulator (Hanau™ wide-vue arcon articulator, USA) in MI with help of silicon bite registration initially made (Fig.2,3). Fabrication of occlusal bite records were done extraorally on the articulator to prevent any subjective discrepancies induced during the procedure. After articulation the vertical dimension was increased on the articulator using incisal pin. The incisal pin markings were used and opening of +1, +2, +3, and +4 mm was obtained in the articulator. The corresponding occlusal bite records were fabricated using silicon material (Jet Bite, Coltene, Switzerland) extending from 1st premolar to 2nd molar. These occlusal registrations were used to obtain desired openings in OVD in the mouth. The occlusal registrations were trimmed properly for proper visualization, seating and stability. The occlusal registrations were disinfected and properly stored in a labelled bag (Fig.4).

Second phase: Head positioning device of lateral cephalometric device (Sirona Dental X-ray system) was utilized for positioning of the participants. Natural head position (NHP) was achieved by asking subject to fix his/her eyes on the mirror in front as previously described by Beni Solow and Anthe Tallgreen (1976)[16]. NHP is considered to be a reliable and repeatable head position[17]. A digital single reflex camera (Canon 250D) was used to acquire photographic data by mounting the camera on tripod stand and adjusting it according to height of participants. Distance from the head positioning device to the camera was kept same for every patient. For accurate positioning of the tripod between the sessions, marks were made on the floor for tripod stand. The participants were asked to close gently on the back teeth say "M, M, M", relax and smile. Three images were made of the posed smile. This procedure was repeated with each occlusal registration intraorally (Fig.5). The digital images were imported into software (Photoshop CS6 extended, Adobe systems) and various measurements were made, which included the width of maxillary central incisors between distoincisal line angle, the interlabial gap height, the intercommisural width, the incisor edge to upper lip distance, and the incisal edge to lower lip distance with help of ruler tool. All the measurements were made in pixels (Fig.6,7). The intercommisural width was divided by interlabial height for calculating the smile index. Display zone was traced with lasso tool in the software and measurement was made in pixels. The combine width of maxillary central incisor between distoincisal line angle was measured in stone cast using Vernier calliper (Mitutoyo, Japan) and was recorded in millimeter to 2 decimal places (Fig.8). The distance was measured 3 times and mean was obtained. The mean measurement of combined width of maxillary central incisor between distoincisal line angle in 15 images in pixel was divided by average measurement in millimeter and a conversion ratio for each participant was obtained. Pixel measurement was converted into millimetres with the help of conversion ratio.

Statistical analysis: The measurements were recorded in excel spread sheet and transferred to Statistical Package for Social Sciences (SPSS) 22.0 for further analysis. Mean and standard deviation of measurement associated with smile parameters were calculated. One-way repeated measures ANOVA was used with level of significance 0.05 for each smile parameter. In case of a statistically significant difference, pairwise comparison was done with Bonferroni corrected paired t tests.

RESULTS

Mean statistics along with standard deviation of each smile parameters in different OVD was determined (Table.1). One-way repeated measures ANOVA test for each smile parameter

with different OVD was calculated. The change in OVD showed statistically significant change in interlabial gap height, incisal edge to lower lip distance, smile index and display zone area whereas it was not statistically significant for intercommisural width and incisal edge to upper lip distance (Table.2). Pairwise comparison of statistically significant parameters was determined and there was statistically significant difference between all pairs of each parameter with P value <0.05 (Table. 3,4,5,6).

Table 1: Descriptive statistics of smile parameters/esthetic norms

Esthetic norms	OVD	N	Mean	Std. Deviation
Interlabial gap height	0	30	7.5450	2.37496
Interlabial gap height	+1	30	8.9353	2.40727
Interlabial gap height	+2	30	9.8453	2.48858
Interlabial gap height	+3	30	10.7017	2.43906
Interlabial gap height	+4	30	11.4913	2.45760
Intercommisural width	0	30	54.5753	5.54427
Intercommisural width	+1	30	54.4173	5.53421
Intercommisural width	+2	30	54.6087	5.47151
Intercommisural width	+3	30	54.7070	5.51686
Intercommisural width	+4	30	54.6050	5.54921
Incisal edge - Lower lip	0	30	1.4403	1.03514
Incisal edge - Lower lip	+1	30	2.6577	1.19386
Incisal edge - Lower lip	+2	30	3.4603	1.32306
Incisal edge - Lower lip	+3	30	4.3200	1.25121
Incisal edge - Lower lip	+4	30	5.1603	1.33403
Incisal edge - upper lip	0	30	6.1340	2.21234
Incisal edge - upper lip	+1	30	6.1483	2.11781
Incisal edge - upper lip	+2	30	6.3520	2.15289
Incisal edge - upper lip	+3	30	6.3253	2.06035
Incisal edge - upper lip	+4	30	6.3137	2.15969
Smile Index	0	30	7.8177	2.12021
Smile Index	+1	30	6.3927	1.34603
Smile Index	+2	30	5.7777	1.12764
Smile Index	+3	30	5.2820	.94240
Smile Index	+4	30	4.8977	.84134
Display zone area	0	30	324.7200	112.09364
Display zone area	+1	30	394.7597	115.03283
Display zone area	+2	30	437.3907	115.77174
Display zone area	+3	30	486.5497	119.12838
Display zone area	+4	30	521.2983	127.01455

Table 2: One-way repeated measures ANOVA for esthetic norms/smile parameters

Esthetic norms	Type III sum of squares	df	Mean square	F	P
Interlabial gap	283.860	2.168	130.954	249.274	<0.001*
Intercommisural width	1.321	3.230	0.409	1.015	0.393
Incisal edge-lower lip	250.196	2.102	119.020	349.764	<0.001*
Incisal edge- upper lip	1.314	2.247	0.585	2.236	0.109
Smile index	156.977	1.289	121.783	88.748	<0.001*
Display zone area	716109.181	2.070	345980.412	241.82	<0.001*

df: degree of freedom, P value (Greenhouse-Geisser) <0.05 statistically significant*

Table 3: Pairwise comparisons for interlabial gap height

OVD (I)	OVD (J)	Mean Difference (I-J)	Std. Error	P[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
0	+1	-1.390	.136	<0.001*	-1.804	-.977
	+2	-2.300	.169	<0.001*	-2.814	-1.787
	+3	-3.157	.174	<0.001*	-3.684	-2.629
	+4	-3.946	.193	<0.001*	-4.534	-3.359
+1	0	1.390	.136	<0.001*	.977	1.804
	+2	-.910	.089	<0.001*	-1.181	-.639
	+3	-1.766	.121	<0.001*	-2.134	-1.399
	+4	-2.556	.157	<0.001*	-3.033	-2.079
+2	0	2.300	.169	<0.001*	1.787	2.814
	+1	.910	.089	<0.001*	.639	1.181
	+3	-.856	.089	<0.001*	-1.127	-.586
	+4	-1.646	.122	<0.001*	-2.016	-1.276
+3	0	3.157	.174	<0.001*	2.629	3.684
	+1	1.766	.121	<0.001*	1.399	2.134
	+2	.856	.089	<0.001*	.586	1.127
	+4	-.790	.072	<0.001*	-1.008	-.571
+4	0	3.946	.193	<0.001*	3.359	4.534
	+1	2.556	.157	<0.001*	2.079	3.033
	+2	1.646	.122	<0.001*	1.276	2.016
	+3	.790	.072	<0.001*	.571	1.008

Based on estimated marginal means
*. The mean difference is significant at 0.05 level.
b. Adjustment for multiple comparisons: Bonferroni.

Table 4: Pairwise comparison for Incisal edge to lower lip distance

OVD (I)	OVD (J)	Mean Difference (I-J)	Std. Error	P[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
0	+1	-1.217	.084	<0.001*	-1.474	-.961
	+2	-2.020	.109	<0.001*	-2.350	-1.690
	+3	-2.880	.117	<0.001*	-3.236	-2.524
	+4	-3.720	.157	<0.001*	-4.196	-3.244
+1	0	1.217	.084	<0.001*	.961	1.474
	+2	-.803	.063	<0.001*	-.995	-.610
	+3	-1.662	.108	<0.001*	-1.990	-1.334
	+4	-2.503	.136	<0.001*	-2.916	-2.089
+2	0	2.020	.109	<0.001*	1.690	2.350
	+1	.803	.063	<0.001*	.610	.995
	+3	-.860	.094	<0.001*	-1.145	-.574
	+4	-1.700	.118	<0.001*	-2.058	-1.342
+3	0	2.880	.117	<0.001*	2.524	3.236
	+1	1.662	.108	<0.001*	1.334	1.990
	+2	.860	.094	<0.001*	.574	1.145
	+4	-.840	.070	<0.001*	-1.054	-.626
+4	0	3.720	.157	<0.001*	3.244	4.196
	+1	2.503	.136	<0.001*	2.089	2.916
	+2	1.700	.118	<0.001*	1.342	2.058
	+3	.840	.070	<0.001*	.626	1.054

Based on estimated marginal means
*. The mean difference is significant at 0.05 level.
b. Adjustment for multiple comparisons: Bonferroni.

Table 5: Pairwise comparison of smile index

OVD (I)	OVD (J)	Mean Difference (I-J)	Std. Error	P[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
0	+1	1.425	.192	<0.001*	.840	2.010
	+2	2.040	.243	<0.001*	1.302	2.778
	+3	2.536	.261	<0.001*	1.743	3.329
	+4	2.920	.282	<0.001*	2.064	3.776
+1	0	-1.425	.192	<0.001*	-2.010	-.840
	+2	.615	.074	<0.001*	.392	.838
	+3	1.111	.114	<0.001*	.764	1.458
	+4	1.495	.137	<0.001*	1.079	1.911
+2	0	-2.040	.243	<0.001*	-2.778	-1.302
	+1	-.615	.074	<0.001*	-.838	-.392
	+3	.496	.067	<0.001*	.293	.699
	+4	.880	.089	<0.001*	.610	1.150
+3	0	-2.536	.261	<0.001*	-3.329	-1.743
	+1	-1.111	.114	<0.001*	-1.458	-.764
	+2	-.496	.067	<0.001*	-.699	-.293
	+4	.384	.041	<0.001*	.258	.510

+4	0	-2.920	.282	<0.001*	-3.776	-2.064
	+1	-1.495	.137	<0.001*	-1.911	-1.079
	+2	-.880	.089	<0.001*	-1.150	-.610
	+3	-.384	.041	<0.001*	-.510	-.258

Based on estimated marginal means
*. The mean difference is significant at 0.05 level.
b. Adjustment for multiple comparisons: Bonferroni.

Table 6: Pairwise comparison of Display zone area

OVD (I)	OVD (J)	Mean Difference (I-J)	Std. Error	P[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
0	+1	-70.040	8.204	<0.001*	-94.964	-45.115
	+2	-112.671	8.475	<0.001*	-138.417	-86.925
	+3	-161.830	9.263	<0.001*	-189.972	-133.687
	+4	-196.578	9.794	<0.001*	-226.333	-166.824
+1	0	70.040	8.204	<0.001*	45.115	94.964
	+2	-42.631	3.833	<0.001*	-54.274	-30.988
	+3	-91.790	6.472	<0.001*	-111.451	-72.129
	+4	-126.539	7.969	<0.001*	-150.749	-102.328
+2	0	112.671	8.475	<0.001*	86.925	138.417
	+1	42.631	3.833	<0.001*	30.988	54.274
	+3	-49.159	3.803	<0.001*	-60.713	-37.605
	+4	-83.908	5.202	<0.001*	-99.711	-68.104
+3	0	161.830	9.263	<0.001*	133.687	189.972
	+1	91.790	6.472	<0.001*	72.129	111.451
	+2	49.159	3.803	<0.001*	37.605	60.713
	+4	-34.749	3.324	<0.001*	-44.848	-24.650
+4	0	196.578	9.794	<0.001*	166.824	226.333
	+1	126.539	7.969	<0.001*	102.328	150.749
	+2	83.908	5.202	<0.001*	68.104	99.711
	+3	34.749	3.324	<0.001*	24.650	44.848

Based on estimated marginal means
*. The mean difference is significant at 0.05 level.
b. Adjustment for multiple comparisons: Bonferroni.

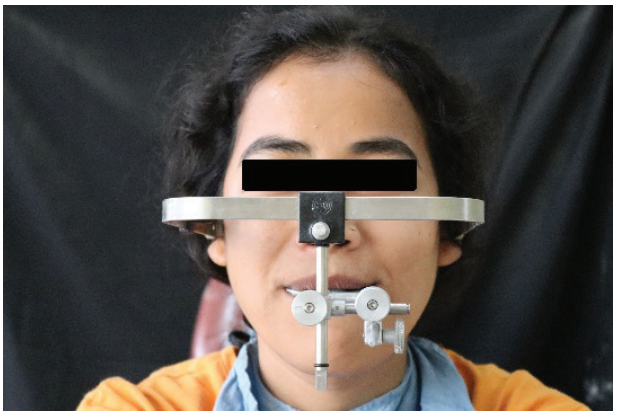

Figure 1: *Facebow transfer*

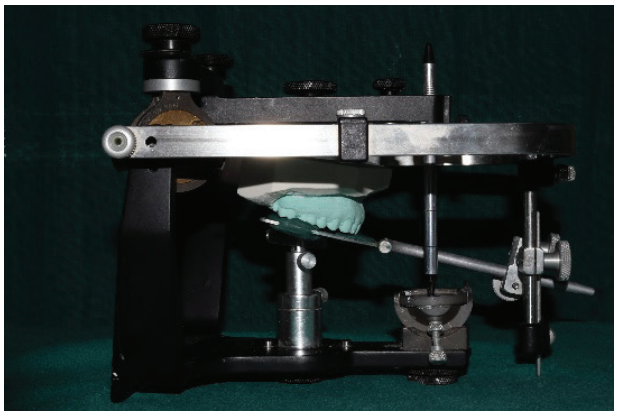

Figure 2: *Facebow transfer record in semi-adjustable articulator*

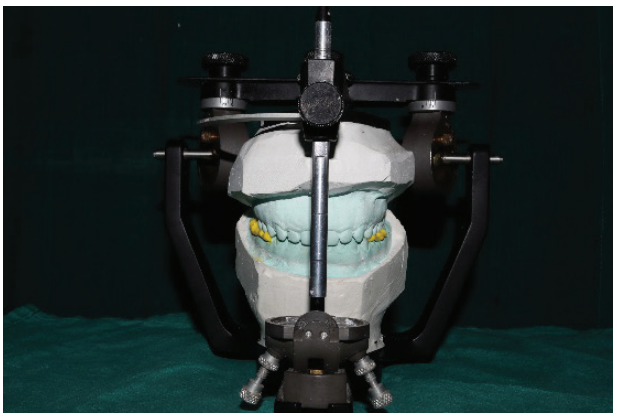

Figure 3: *Articulation on Semi-adjustable articulator in MI*

Figure 4: *Silicon occlusal bite records at opening of +1, +2, +3 and +4 mm*

Figure 5: *Posed smile in 0, +1, +2, +3 and +4 mm of OVD*

Figure 7: *Tracing of smile parameters*

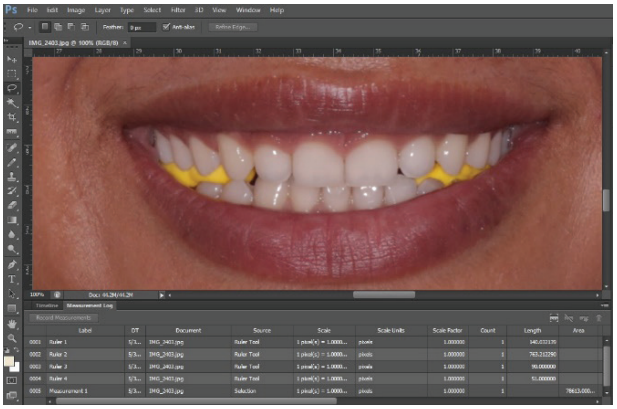

Figure 6: *Calculations in Photoshop cs6 extended (Adobe systems)*

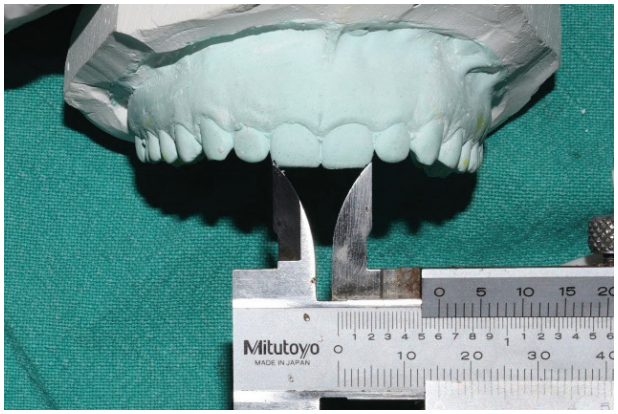

Figure 8: *Measurement of combine width of maxillary central incisor between distoincisal line angle in mm*

DISCUSSION

In this study, a significant increase in interlabial gap height, incisal edge to lower lip distance and display zone area was noted with increase in OVD. Also, these smile parameters showed statistical significance difference among pairs when comparison were made for each OVD. So, the result supported the rejection of null hypothesis. Similarly, a significant decrease in smile index was observed with increase in OVD. Statistically significant difference was seen among pairs for smile index when comparison was made for each OVD, supporting the rejection of null hypothesis. Contrary to this, no significant change was seen in intercommisural distance and incisal edge to upper lip distance with increase in OVD, thus the null hypothesis was accepted.

The rationale for including young individuals aged 21-30 years in this study was to obtain uniformity among study population. Intact dentition, well-coordinated neuromuscular system and properly maintained OVD was easy to obtain in young population so that the effect of increased OVD can be properly evaluated. Also, this study used photographic method instead of videographic method to record posed smile photos due to superior resolution that can be acquired from still photographs, which increased the accuracy of measurement. The recent study done by McNamara et al[18] discovered no statistically significant difference between smiles that were recorded with photographic methods.

Study done by Alvítez-Temoche D et al[19], Parmer et al[20], Razzaque et al[11] and Chou et al[21], found significant increase in interlabial gap height with increase in OVD, which was similar to this current study. The mean interlabial gap height at +0 mm was 10.70 mm, 10.27 mm, 11.57 mm, and 10.42 mm from study done by Alvítez-Temoche D et al[19], Parmer et al[20], Razzaque et al[11] and Chou et al[21] respectively. Whereas, the mean interlabial gap height at +4 mm was 12.91, 16.13mm, 17.59 mm and 13.48 mm from study done by Alvítez-Temoche D et al[19], Parmer et al[20], Razzaque et al[11] and Chou et al[21] respectively. Also, the video analysis done by McNamara et al[18] to study the esthetics of posed smile found average interlabial gap height to be 10.40 mm. The mean value found in this current study was less compared to the previous studies. These variations can be justified by the point of reference for increasing OVD and the difference in the study population between studies.

Study done by Alvítez-Temoche D et al[19], Parmer et al[20], Razzaque et al[11] and Chou et al[21], found no significant change in intercommisural width with increase in OVD, which was similar to this current study. Contrary to this, study done by Sun J et al[22] found significant change in intercommisural width with increase in OVD. The study done by Sun J et al[22] evaluated the change in intercommisural distance with increased OVD without smile whereas this current study evaluated the change in intercommisural distance with increased OVD in posed smile. Also, no other similar studies evaluating smile has shown significant change. From these findings it can be suggested that the function of modiolus, function of muscle of facial expression specifically Zygomaticus major, which is primarily responsible for smile, is not altered by increasing OVD during smile. Comparing the result of this study with the study done by Sun J et al[22], it can be suggested that, the position of related muscles is altered by increasing OVD during rest leading to alteration in intercommisural width.

Similar to this current study, no significant change was observed in incisal edge to upper lip distance with increase in OVD in the study done by Alvítez-Temoche D et al[19], Parmer et al[20], Razzaque et al[11] and Chou et al[21]. Contrary to that, a report of two clinical cases by D S

Frey[23] reported that, increasing OVD decreases excessive gingival display at smile. Individual variations or patient adaptation following an enhanced OVD may have accounted for the observed lowering of the upper lip at the smile in the case report by D S Frey[23]. Another reason may be due to the common habit of photographing the patient with his or her head angled down. Comparing results with similar studies it can be said that the upper lip at smile is not expected to move down with increase in OVD.

Similar to this current study, study done by Alvítez-Temoche D et al[19], Parmer et al[20], Razzaque et al[11] and Chou et al[21], found significant increase in incisal edge to lower lip distance with increase in OVD. The mean incisal edge to lower lip distance at +0 mm was 1.85 mm, 2.90 mm, 3.87 mm and 2.28 mm from study done by Alvítez-Temoche D et al[19], Parmer et al[20], Razzaque et al[11] and Chou et al[21] respectively. Whereas, incisal edge to lower lip distance at +4 mm was 4.19 mm, 7.51 mm, 7.04 mm and 5.29 mm from study done by Alvítez-Temoche D et al[19], Parmer et al[20], Razzaque et al[11] and Chou et al[21] respectively. This current study shows significant increase in interlabial gap height but no significant change in incisal edge to upper lip distance in increasing OVD, which signifies that the increase in tooth display after increased OVD is mainly due to increased display of lower incisors. So, the evaluation of lower incisors becomes important aspect before increasing OVD in complex prosthodontic cases.

Study done by Alvítez-Temoche D et al[19], Parmer et al[20], Razzaque et al[11] and Chou et al[21], found significant decrease in smile index with increase in OVD, which was similar to this current study. In a study done by Desai et al[24], average smile index of 6.73 mm was found in age group of 20 to 29 years age group which was similar to this current study. Desai et al[24] also found that the smile index increased with the age. So, the smile index and age can be corelated for judgement making in cases requiring alteration in OVD.

In this study, a significant increase in display zone area was noted with increase in OVD with a high standard deviation that indicates a considerable amount of display zone area variation in participants. Similar result was obtained in study done by Alvítez-Temoche D et al[19], Parmer et al[20], Razzaque et al[11] and Chou et al[21]. So, as there is no significant change in position of maxillary lip with increase in OVD, the increase in display zone area due to increased OVD may lead to exposure of more mandibular teeth leading to unesthetic smile.

The stomatognathic system remains stable and efficient with proper balance between occlusion, sound temporomandibular joint, soft tissue determining esthetics and oro-facial musculature. Initially the balance is achieved by adaptive response in the system which may be beneficial but not always predictable. An increased OVD may lead to intrusion or wearing of teeth to maintain initial OVD[11]. Various studies have determined the safety margin of increasing OVD without disrupting the balance to be 5 mm[25, 26], and also this increase in OVD is hard to be perceived. This study has evaluated the facial esthetics within this safety margin that may be beneficial during treatment planning in complex prosthodontic treatment. The current study's findings on the effect of increased OVD on smile parameters 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, final OVD should always be determined after providing patients with temporary provisional

restoration, that would be helpful in determining the proper balance between facial esthetics and health of stomatognathic system.

The limitations of this study are:

1. The age range of 21-30 years used in this study may not represent the typical prosthodontic patient. There was no any loss of OVD in those patients and were with proper occlusion. It is likely that patients who have had extensive loss of tooth structure or loss of teeth will behave differently as OVD is restored. So, anticipation of significant discrepancies with age is needed.
2. The study was conducted on limited population in patient visiting National Academy of Medical Sciences, which may not represent the whole of the Nepalese population. Further study needs to be expanded to include a broader population.
3. The bulkiness and removable nature of the polyvinyl siloxane bite registrations may have negatively influenced the smile.
4. In this study, all of the data was collected in one sitting. So, the long-term adaptation of the facial muscles could not be assessed.

CONCLUSION

Within the limitations of this study, the following conclusions were drawn:

1. Increase in OVD lead to increase in interlabial gap height, increase in incisal edge to lower lip distance and increase in display zone area in posed smile.
2. Increase in OVD lead to decrease in smile index in posed smile.
3. No change is expected in the position of upper lip with increase of OVD in posed smile.
4. Change in the intercommisural width of the smile should not be expected with increasing OVD in posed smile.

REFERENCES

1. Glossary of Prosthodontic Terms, GPT-9. The Academy of Prosthodontics Foundation. J Prosthet Dent. 2017;117(5S):e1-e105.
2. Keough B. Occlusion-based treatment planning for complex dental restorations: Part 1. International Journal of Periodontics & Restorative Dentistry. 2003;23(3).
3. Krishnan V, Daniel ST, Lazar D, Asok A. Characterization of posed smile by using visual analog scale, smile arc, buccal corridor measures, and modified smile index. American journal of orthodontics and dentofacial orthopedics. 2008;133(4):515-23.
4. Ackerman MB, Ackerman JL. Smile analysis and design in the digital era. Journal of clinical orthodontics. 2002;36(4):221-36.
5. Ackerman J, Ackerman M, Brensinger C, Landis J. A morphometric analysis of the posed smile. Clinical orthodontics and research. 1998;1(1):2-11.
6. Peck S, Peck L, editors. Selected aspects of the art and science of facial esthetics. Seminars in orthodontics; 1995: Elsevier.
7. Hulsey CM. An esthetic evaluation of lip-teeth relationships present in the smile. AMER J ORTHODONTICS. 1970;57(2):132-44.
8. Rigsbee 3rd O, Sperry TP, BeGole E. The influence of facial animation on smile characteristics. The International journal of adult orthodontics and orthognathic surgery. 1988;3(4):233-9.
9. Orenstein NP, Bidra AS, Agar JR, Taylor TD, Uribe F, Little MD. Changes in Lower Facial Height and Facial Esthetics with Incremental Increases in Occlusal Vertical Dimension in Dentate Subjects. International Journal of Prosthodontics. 2015;28(4).
10. Batwa W, Grewal B, Gill D. Smile analysis: what to measure. Dental Update. 2014;41(6):483-9.
11. Razzaque A, Joshi S, Dhaded S, Sajjan C, Konin P, Subashani T. Occlusal vertical dimension: Effect on esthetic norms at smile. Indian Journal of Dental Sciences. 2018;10(4):220.
12. Turner KA, Missirlian DM. Restoration of the extremely worn dentition. The Journal of prosthetic dentistry. 1984;52(4):467-74.

13. Abduo J. Safety of increasing vertical dimension of occlusion: a systematic review. Quintessence international. 2012;43(5).
14. Mohindra N, Bulman J. The effect of increasing vertical dimension of occlusion on facial aesthetics. British dental journal. 2002;192(3):164-8.
15. Gross MD, Ormianer Z. A preliminary study on the effect of occlusal vertical dimension increase on mandibular postural rest position. International Journal of Prosthodontics. 1994;7(3).
16. Solow B, Tallgren A. Head posture and craniofacial morphology. American Journal of Physical Anthropology. 1976;44(3):417-35.
17. Cooke MS, Orth D, Wei SH. The reproducibility of natural head posture: a methodological study. American Journal of Orthodontics and Dentofacial Orthopedics. 1988;93(4):280-8.
18. McNamara L, McNamara Jr JA, Ackerman MB, Baccetti T. Hard-and soft-tissue contributions to the esthetics of the posed smile in growing patients seeking orthodontic treatment. American journal of orthodontics and dentofacial orthopedics. 2008;133(4):491-9.
19. Alvítez-Temoche D, Calderón I, Ayala G, Watanabe R, Romero-Tapia P, Mayta-Tovalino F. Effectiveness of the increase of the occlusal vertical dimension in the smile of young Peruvian adults: A quasi-experimental study. Journal of International Oral Health. 2020;12(3):197-202.
20. Parmar DR, Mehta SP, Sutariya PV, Bhatia YA, Gupta NK. Influence of occlusal vertical dimension on lip positions at smile in completely dentulous adults. The Journal of the Indian Prosthodontic Society. 2020;20(1):69.
21. Chou J-C, Thompson GA, Aggarwal HA, Bosio JA, Irelan JP. Effect of occlusal vertical dimension on lip positions at smile. The Journal of Prosthetic Dentistry. 2014;112(3):533-9.
22. Sun J, Lin Y-C, Lee JD, Lee SJ. Effect of increasing occlusal vertical dimension on lower facial form and perceived facial esthetics: A digital evaluation. The Journal of Prosthetic Dentistry. 2021;126(4):546-52.
23. Frey D. Bite alteration for reducing gummy smiles: two case reports. Cosmetic Dentistry English. 2010;4:18-22.
24. Desai S, Upadhyay M, Nanda R. Dynamic smile analysis: changes with age. American journal of orthodontics and dentofacial orthopedics. 2009;136(3):310. e1-. e10.
25. Abduo J, Lyons K. Clinical considerations for increasing occlusal vertical dimension: a review. Australian dental journal. 2012;57(1):2-10.
26. Moreno-Hay I, Okeson J. Does altering the occlusal vertical dimension produce temporomandibular disorders? A literature review. Journal of oral rehabilitation. 2015;42(11):875-82.