6-25-2013

Changes in Facial Esthetics and Lower Facial Height with Increases in Occlusal Vertical Dimension in Dentate Models

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Recommended Citation
Orenstein, Noah Philip DMD, "Changes in Facial Esthetics and Lower Facial Height with Increases in Occlusal Vertical Dimension in Dentate Models" (2013). Master's Theses. 453.
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Changes in Facial Esthetics and Lower Facial Height with Increases in Occlusal Vertical Dimension in Dentate Models

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Doctor of Dental Medicine, University of Pennsylvania, Philadelphia, PA 2008

A Thesis

Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Dental Sciences at the University of Connecticut 2013
Master of Dental Science Thesis

Changes in Facial Esthetics and Lower Facial Height with Increases in Occlusal Vertical Dimension in Dentate Models

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2013
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**ABSTRACT:**

The esthetics of the face is affected by facial form and facial height. Comprehensive Prosthodontic treatment can affect the lower facial height (LFH) when there are changes in occlusal vertical dimension (OVD). The importance of OVD is well known to the dental clinician in both removable and fixed prosthodontics. Changes in OVD can also affect maxillary tooth position, gingival display, and position of the occlusal plane.

Previous studies have reported the significance of vertical facial height on overall facial esthetics. However, there is limited research about the relationship of changes in OVD with facial esthetics. This study had two parts: Part A investigated the objective changes in facial height as a product of incremental increases in OVD and Part B evaluated the subjective assessments of facial esthetics with increases in OVD.

After obtaining IRB approval and written consent, 20 models of White, Black, Asian, and Asian-Indian races with class I occlusion, were assessed. All models had diagnostic casts and a facebow record made. The casts were poured and mounted on a semi-adjustable dental articulator. Mandibular overlays of 2mm, 3mm, 4mm, and 5mm thicknesses were fabricated in light cured dental acrylic resin. These measurements were made on the pin of the articulator. These overlays were then placed in the model’s mouths.

Part A involved clinical measurement of the distance between pro-nasale and soft tissue menton for each model at 0mm, 2mm, 3mm, 4mm, and 5mm increases above their normal bite.

For Part B the same models had frontal and profile facial digital images recorded using a Nikon D90 digital camera under standardized conditions. Each model was photographed in maximum intercuspatation (MIP) and again wearing each of the four mandibular overlays. The digital images of 8 models were selected based on pre-determined exclusion criteria, were de-
identified, collated, and displayed to 60 judges (30 laypeople, 15 general dentists, and 15 prosthodontists.) Using a 100-mm Visual Analogue Scale (VAS), all subjects (judges) were asked to rate the esthetics of each model, with each of the five planned mandibular splints of (0, 2, 3, 4, 5mm).

Results from Part A of the study indicated that a systematic increase of 1.0mm in OVD reflected an increase of LFH by 0.63; this increase in LFH was uncorrelated with OVD (r=.123; p >.20). Therefore, systematic increases in OVD did not reflect similar increases in measured facial height for all races and both sexes.

Results from Part B of the study revealed first, that the relationship between ratings of facial esthetics and changes in mandibular splint thickness were uncorrelated up to 5mm in increased OVD. Second, that when model race and subject race were the same, ratings of esthetics were effected (p < .01). Third, that when model gender and subject gender were the same ratings of esthetics were unaffected (p > 0.80.) And fourth, that the subject’s background status (layperson, prosthodontist, general dentist) was uncorrelated to their ability to detect changes in facial esthetics with incremental increases in mandibular splint thickness.

This was the first study to systematically asses the relationship between OVD and facial esthetics. Although the study indicates that a systematic increase of 1.0mm in OVD reflected an increase of LFH by 0.63mm, contrary to expectations, this measured facial height was unrelated to increasing OVD up to an increase of 5mm. Additionally, the results indicated that an increase of OVD up to 5mm was unrelated to subject’s evaluation of facial esthetics of various models. Additionally, background status (layperson, general dentist, prosthodontist) did not relate to an increased ability to detect changes in LFH in models with OVD increases up to 5.0 mm.

This research can provide the clinician with guidelines for making treatment decisions,
regarding increases in OVD and its relationship to facial esthetics. Additionally, these studies can serve as a foundation for future research in comparing the ways OVD can affect objective and subjective considerations of facial esthetics.
**BACKGROUND:**

**Introduction**

Physical esthetics and beauty has long been considered a driving force in social interactions. The importance of developing an esthetic awareness is taught to children at a very early age with the understanding that what is beautiful is good. Throughout the lifespan, physical esthetics can impact an individual’s popularity, social interactions, educational development, job competency, and additional life opportunities.

Previous research has shown that more esthetic children are perceived to be more popular, have better personal attitudes, attain more education, enjoy better social relationships, are more independent, and less afraid than their more less esthetic peers.

The face has been found to be the central feature taken into account in making overall esthetic judgments of others. It is for this reason that the cosmetic industry is a multi-billion dollar a year business and that of the 13.1 million cosmetic (surgical and minimally invasive) procedures performed in 2010, 92.3% involved the head and face. Over the last 25 years, there has been expansive growth in the study of the human face and the way people observe facial esthetics and beauty. As of 1975, the scientific literature only contained five articles on this subject annually. In the 1990’s, over 150 scientific articles were written. Currently, entire scientific journals and a multitude of specialties are dedicated to this area of interest. Due to the quantity of variables that define facial esthetics Plastic Surgeons, Head and Neck Surgeons, Oral and Maxillofacial Surgeons, Orthodontists, and Prosthodontists are all have an interest in investigating those aspects that define esthetics and beauty in the face.

In Dentistry, individual faces are evaluated in all three dimensions of space: transverse, anteroposterior (A-P), and vertical although the latter two have been shown to be more important
in studies of facial esthetics. In an A-P dimension, a patient’s maxillary-mandibular skeletal relationship is evaluated and classified. A Class I relationship involves the mandible positioned 2-3mm posterior to the maxilla, a Class II relationship involves the mandible in a greater than 3mm retruded position from the maxilla, and a Class III relationship involves the mandible in a more protruded position relative to the maxilla. In a vertical dimension, with the patient observed from the profile, a patient’s Lower Facial Height (LFH) can be evaluated. On average, the vertical distance from the middle of the eyebrows (soft tissue glabella) to the base of the nose (soft tissue subnasale), and the base of the nose to the lowermost point on the chin (soft tissue menton) should be equal. If these are not coincident, a patient can be classified as having an increased or decreased LFH. Additionally from this orientation the Frankfurt-Mandibular Plane Angle (FMPA) can be evaluated. The FMPA is the angle created by the intersection of two lines from the external auditory meatus to the lower border of the orbital margin and the lower border of the mandible. The average angle is 28 degrees or at approximately the most posterior extent of the cranium. In the vertical dimension, individuals can also be classified based on the Cephalic index, which is the ratio of the maximum width of the head multiplied by 100 divided by its maximum length. For women Dolicocephalic are long headed individuals with a score of less than 75, Mesocephalic are medium headed individuals with a score in between 75-83, and Brachycephalic are short headed individuals with a score above 83. The averages for men are in a very similar range.
Significance of Occlusal Vertical Dimension

One of the most important aspects in facial esthetics involves the Occlusal Vertical Dimension (OVD), which may also be referenced as the Vertical Dimension of Occlusion (VDO). In order to understand this concept, it is important to understand the principle of occlusal position. As defined by the Glossary of Prosthodontic Terms Eighth Edition, this is the relationship of the mandible and maxilla when the jaw is closed and the teeth are in contact.9 Taking this into consideration, OVD can be understood as the measured vertical distance between any two arbitrary points placed on the face as supported by the occluding members.9 OVD is different from the related concepts of Physiologic Rest Position and Vertical Dimension at Rest (VDR). These terms involve the postural position of the mandible when both an individual is resting comfortably in an upright position and the masticatory muscles are in a state of minimal contraction. VDR, like OVD, is the measured vertical distance between any two arbitrary points, but while the mandible is at rest.9 These concepts involve the balance of the entire masticatory system and are important concepts in removable and fixed prosthodontics.

Commonly, a decrease in OVD results from a loss in posterior tooth support and can be seen in individuals with complete edentulism (loss of all teeth) or partial edentulism (loss of a few teeth) involving all teeth posterior to the canine.10 With no posterior teeth remaining in one or both jaws, there is no support to prevent further upward movement of the mandible towards the maxilla. Edentulous individuals or partially edentulous patients without posterior teeth have their OVD supported by complete dentures. In fully dentate patients or partially edentulous individuals with remaining posterior teeth, OVD is supported by the intercuspatation of these posterior teeth. Changing OVD in these patients requires treatment on all remaining posterior teeth, which can involve any combination of orthodontic therapy, orthognathic surgery, and
prosthodontic rehabilitation. Attempting to limit treatment to selected teeth would result in premature occlusal contacts and uneven occlusal schemes, which can be harmful during mastication. Individuals interested in prosthodontic treatment that affect or alter OVD should understand the emotional, chronological, and financial investment required for treatment.

Individuals who present with decreased OVD do so because of advanced tooth abrasion, attrition, or loss. These individuals may present with collapsed facial appearance, improper lip support, changes in phonetics, angular cheilitis, naso-labial fold prominence, and reduction in muscle tonus. In contrast, the general belief in Prosthodontics is that patients who having been restored through dental treatment to a greater vertical dimension than their physiologic rest position may develop temporomandibular disorders (TMD), tooth loss, tooth intrusion and regression. For this reason, it may be important for individuals interested in full mouth fixed or removable prosthodontic rehabilitation to consider a period of provisionalization to allow for muscles to adapt to an increase in vertical length. Additionally, it is important to identify individuals with vertical height issues and to understand how to restore these patients to their correct OVD. The first step in doing this is to determine a patient’s proper vertical dimension.

The clinical assessment of vertical dimension can be accomplished using the patient’s pre-extraction records, physiologic rest position, measurement of closing forces, tactile sense, phonetics and closest speaking space, force exerted between the teeth on swallowing, and ideal facial dimensions and esthetics. While the importance of defining proper vertical dimension is clear amongst dentists, no single method of measuring OVD has been proven precise and accurate, and most clinicians use a combination of methods and ‘clinical judgment’ to identify this physiologic point. Traditional views of OVD have shown this to be a fixed and unalterable position. Nonetheless, adaptation to increased OVD with removable occlusal devices after 1
week\textsuperscript{16} and fixed appliances after 2 years\textsuperscript{17} seems to show that OVD may in fact be a more flexible range than traditionally believed. Although more research is needed on this topic, it is clear that patients need to be approached on an individual basis to determine the OVD that is both esthetically and functionally acceptable.

The primary reasons for increasing OVD in fixed prosthodontic treatment are to allow for control of function and occlusion, to restore posterior bite collapse, to create space for prosthetic restorations, and to eliminate the need for surgical crown lengthening in an attempt to improve esthetic tooth proportions.\textsuperscript{18} In patients with excessive tooth abrasion and wear, prosthodontic intervention may involve full mouth rehabilitation to gain restorative space. Turner and Missirlan\textsuperscript{10} reported a classification of tooth wear. Category 1 describes individuals with excessive tooth wear and a loss of OVD, Category 2 describes individuals with excessive tooth wear without loss of OVD but with available space for restorative materials, and Category 3 describes individuals with excessive wear without loss of OVD but with limited space for restorative materials. Fixed prosthodontic rehabilitation that involves an excessive increase in OVD, can result in phonetic, comfort, and esthetic challenges.
REVIEW OF THE LITERATURE:

Theoretical Literature:

Few studies have been conducted on OVD and facial esthetics from a prosthodontic perspective. Most of the research on this subject has originated from an orthodontic or orthognathic surgical viewpoint. These specialties have conventionally evaluated facial esthetics using orthodontic measurements and calculated angles. As a result, few studies have used methodologies clinically relevant to prosthodontics. Additionally, most orthodontic and orthognathic research has been conducted using only profile images of models. Although this approach had its classical value in cephalometrics, it is not relevant in conventional prosthodontics which focuses on key frontal esthetic parameters, such as eye-tooth relationships. Lastly, the existing studies on OVD that are relevant to prosthodontics are limited in applicability because both models and subjects (judges) are of the same racial backgrounds, which may have led to biases in rating esthetics.

In their 2005 article, Knight et al. photographed 30 male and 30 female Caucasian models in the right profile view, ¾ view, and frontal view. All three views were mounted together and a panel of twelve judges (six clinicians and six non-clinicians) was asked to rank the photographs according to esthetics. The photos were then measured for soft tissue cephalometric points ANB angle (A-point, nasion, B-point: indicates skeletal relationship between maxilla and mandible) and ALFH/TLFH (Anterior Lower Facial Height as measured from soft tissue columella to soft tissue menton /Total Lower Facial Height as measured from soft tissue nasion to soft tissue menton: indicates a relationship between lower face height to total face height.) Both the ANB angle and ALFH proportion have been studied extensively in orthodontic research and are recognized as being influential in observer ratings of facial esthetics. Although
Knight et al.\textsuperscript{21} show minimal correlation between soft tissue ANB angle and ALFH percentages in ratings of esthetics, trends suggested that the most esthetic faces had ANB angles around 5 degrees and faces with ANB values varying widely from the norm were perceived as less esthetic. Additionally, greater ALFH percentages (longer faces) were seen as less esthetic in females, while lesser ALFH percentages (shorter faces) were seen as less esthetic in males. In an evaluation of preference between clinicians and non-clinicians, both groups were in agreement regarding the most esthetic faces.

Additional orthodontic literature has suggested that both clinicians and lay people are sensitive to relatively small horizontal changes while rating models when viewed from the profile.\textsuperscript{24} Another segment of the literature, instead of focusing on unaltered images to determine numerical ranges for standardizing esthetics, began altering the vertical dimension of silhouette images in attempt to learn more about its relevance to facial esthetics. In a study by Johnston et al.\textsuperscript{25}, social science students rated the esthetics of a series of nine facial profile silhouettes representing a range of vertical lower facial proportions. The cephalometric film of a male patient, whose dentoskeletal measurements closely matched normative values, was shortened or lengthened at equal intervals of 2 percent, to create four images shorter and four images taller than the original. Subjects (judges) were then asked to rate the esthetics of each profile on a numerical scale from 1-10, with 1 representing least esthetic and 10 very esthetic. For each silhouette, subjects (judges) were then asked whether or not they would seek treatment if that image represented their own profile.

The results showed that subjects rated the original image to be the most esthetic and as lower face proportions diverged from the norm esthetic scores declined. Overall, longer faced images scored lower than shorter faced images. Similarly, images with longer lower face
proportions motivated subjects (judges) to seek treatment more than images with reduced proportions.\textsuperscript{26-27}

One of the limitations of this study was that 91\% percent of the subjects (judges) were female. But, previous studies\textsuperscript{23} have shown that the relationship between subject (judge) gender and model gender does not have significant influence on ratings of esthetics.

Although this group of studies attempted to objectively define a range of values for esthetics, the studies fall short in their clinical applicability. The use of silhouettes, although routinely used in this type of research, eliminates soft tissue variations in ratings of esthetics, which limits the data’s applicability. Additionally, performing the alteration of lower facial dimension digitally, based on soft tissue cephalometric points, also has it’s limitations. For Orthodontists and Prosthodontists alike, the effect of OVD on LFH, both empirically and based on subjective assessment of esthetics, has not been studied in a way that can be applied to clinical practice.

The only clinically relevant study on this topic was performed by Gross et al.\textsuperscript{28} They evaluated the ability of subjects (judges) to detect increases of OVD in fully dentate adult models. The faces of 22 models were photographed in a standardized manner from an anterior view. Initial photographs were taken both at MIP and clinical rest. Four additional sets of photos were taken while models wore maxillary overlays with increasing OVD in increments of 2.0 mm, 4.0 mm, 6.0 mm, and 8.0 mm. Model’s faces were initially marked and photographed to assess soft tissue changes with changes in OVD. Secondarily, all marks were removed and models were re-photographed in the same manner. Separately, 10 subjects (judges) (5 dentists and 5 lay people) were asked to arrange each series of photos in ascending order of face height, from minimum to maximum for all models. All subjects (judges) were instructed to specifically
evaluate face height while arranging the photos. Objectively, results showed linear increases in soft tissue lower face height by 0.5 mm for every 1 mm increase in occlusal vertical dimension. Subjectively, subjects (judges) were unable to detect changes in face height in the range of 2.0 mm, 4.0 mm, and 6.0 mm. On average only 50% of subjects (judges) were able to correctly identify the proper location in sequence for images of increased OVD of 2.0 mm, 4.0 mm, and 6.0 mm. Nonetheless, a significant difference did exist between dentists and non-dentists, with dentists making fewer mistakes.

Although this study began to discuss the impact increased OVD has on facial esthetics, its subjective analysis only assessed the subject’s ability to detect changes in soft tissue facial characteristics. Significant limitations exist in this study, as judges were informed that they were evaluating lower face height and were asked only to arrange the series of photographs according to ascending order. This rank order approach to evaluating images does not effectively assess esthetic perceptions, and acts merely to evaluate the subject’s capacity to detect differences in pictorial images. Additionally, the numbers of judges in this study were very few (10), limiting its generalizability.

In an additional study, evaluators were asked, in a match pair design, to evaluate silhouetted frontal images in which the LFH of one of the images was incrementally increased or decreased by 1.0 mm. Results showed that subjects (judges) were able to detect a change at +/- 1.0 mm. Although this illustrates another way of designing a study on LFH, the clinical relevance is questionable.

The majority of published research related to this topic lacks clinical applicability. From the use of silhouettes to using profile or frontal images only, to altering OVD arbitrarily, to
match-paired study designs, all of the studies conducted had potential bias and did not allow an evaluation of the correlation between changes in OVD, LFH, and facial esthetics.

**Procedural Literature:**

Lundstom et al.\(^{30}\) have extensively discussed the issue of natural head position with regard to cephalometrics. That is, how can one produce a natural head position for the purpose of measurement that is replicable over multiple trials. This is an important consideration for studies of facial esthetics involving photography. Bidra et al.\(^{29}\) utilized still frame digital photography using a standardized technique to evaluate facial reference markers while evaluating facial and dental midlines on 249 models in natural head position. Howells and Shaw\(^{31}\) showed correlation between esthetic ratings assigned to live models and photographs of the same model. Phillips et al.\(^{32}\) found that the photographic view presented of the model had no impact on subject perceptions of esthetics. The authors of this study recommended using multiple views of the same model presented simultaneously. A recently published study by Varlik et al.\(^{26}\) reported on the correlation of lower facial height in silhouettes and perceptions of esthetics and perception of need for treatment by lay people. Their use of a VAS scale proved to be an effective methodology in the quantification of esthetics. Additional studies have cited limitations to using other methods, such as rank order and matched pair designs, which is why a VAS was be used in the study that is discussed here. Lastly, Gross et al.\(^{28}\) used both maxillary dental acrylic resin overlays and a Boley Gauge to clinically measure the maximum gingival contours and soft tissue lower face height changes. The methodology described in the studies listed above served as a basis for methodology adopted in the current project.
**Rationale for the study:**

It appears that facial proportions have an impact on subject’s perception of esthetics. A significant body of orthodontic and orthognathic literature\(^ {21-23}\) reports clear trends in preference for LFH as an indicator of general facial appearance. In general, observers prefer average facial proportions of ALFH/TLFH approximating 55%.\(^ {25}\) Ratings of facial esthetics decreased as proportions diverted from the norm with slight preferences for dolichocephalic profiles for males and brachycephalic profiles for females.\(^ {21}\) Additionally, relationships have been made between changes in OVD and soft tissue ALFH proportions.\(^ {25}\)

In removable and fixed prosthodontics, clinicians are routinely asked to make decisions about OVD and its relationship to patients’ esthetics. Appropriate vertical dimension plays an important role in removable prosthodontics, complete arch fixed prosthodontics, comprehensive implant-based rehabilitation, speech, tooth size and proportions, deglutition, esthetics, and occlusion. Since the majority of studies are orthodontic reports that arbitrarily modify LFH and do not involve VDO, there is limited clinical relevance to prosthodontics. Due to the lack of scientific information, the clinician has no choice but to rely on anecdotal experience and clinical judgment.

Additionally, there is some debate as to whether cultural preferences affect observations of facial esthetics. Most of the studies written on this topic are restricted by racial homogeneity in models and subjects (judges.) In the research of Ioi et al.\(^ {27}\) facial esthetics of Japanese models with varied ALFH was evaluated by Japanese subjects (judges.) Results showed a preference toward more brachycephalic facial form in women. But, in the research of Varlik et al.\(^ {26}\) which conducted an ALFH/facial esthetics study on Turkish models and subjects (judges), no statistically significant preference was seen in females at +/- 0.0 to 2.0mm of ALFH change.
That both of these studies make opposite conclusions, while evaluating the same variables, indicates that preferences in facial esthetics may be affected by race. Although some studies debate this proposition, few studies have investigated cross racial preferences in LFH with regards to facial esthetics.

Only one study\textsuperscript{28} has effectively evaluated the relationship between OVD and LFH effectively from a prosthodontic perspective. Although there is a large body of research that makes scientific inferences on anterior facial esthetics as it pertains to perceptions of facial esthetics, much of this literature lacks clinical applicability and may be confounded by small subject sample sizes and racial preferences in esthetics. Though ALFH:TLFH has been shown to significantly influence raters’ perception of esthetics and OVD has been shown to bear influence on changes in ALFH,\textsuperscript{26} no study has directly linked OVD to facial esthetics. As such, the aim of this study was to evaluate the objective changes in lower facial height and subjective changes in facial appearance with increases in occlusal vertical dimension in dentate models. The changes were also analyzed for variations in race, gender, and background of the subject (layperson, prosthodontist, general dentist.)
Terminology Used In The Study:

(Glossary of Prosthodontic Terms⁹)

Occlusal Vertical Dimension (OVD): Relationship of the mandible and maxilla when the jaw is closed and the teeth are in contact.

Maximum Intercuspation (MIP): the complete intercuspation of the opposing teeth independent of condylar position, sometimes referred to as the best fit of the teeth regardless of the condylar position.

Dentate: 1: possessing natural teeth 2: a condition in which natural teeth are present in the mouth

Splint: any removable artificial occlusal surface used for diagnosis or therapy affecting the relationship of the mandible to the maxilla. It may be used for occlusal stabilization, for treatment of temporomandibular disorders, or to prevent wear of the dentition

(Glossary of Orthodontic Terms⁷)

Pro-nasale: Most forward point of the tip of the nose.

Sub-nasale: The intersection of the columella of the nose and the upper lip.

Soft tissue menton: The most inferior point on the chin in the lateral view.
PART A:

Specific Objectives

To know if:

1. Objective changes occur in lower facial height with incremental increases in occlusal vertical dimension in dentate models.

Hypothesis:

This study tested the following null hypotheses:

1. There is no difference between measurement in lower facial height (measured from pronasale to soft tissue menton) with incremental increases in OVD in dentate models.

Research Goal:

1. To understand how incremental changes in OVD affects soft tissue dimensions of the lower third of the face.

The maximum increment of OVD increase to 5.0mm was chosen in this study because it is a maximum increase that is clinically relevant in Fixed Prosthodontics.
Part A:

Model Acquisition

- Human Models: An initial IRB approval (#12-130-2) was obtained for 20 pre-doctoral and post-doctoral dental students with an age range of 20-35 years at the University of Connecticut Health Center. A minimum of two students from each of the following racial profiles were selected: White, Black, Asian, Asian-Indian/South Asian.

- Each of the 20 models was provided with both a detailed verbal explanation and a brief handout describing the study and the nature of their participation. A written consent form was also provided for them to read and attest to with their signature. All models were assured of the privacy of their pictures and the dignified manner of use of their pictures.

Inclusion criteria of the models:

- Age range of 20-35 years.
- Complete maxillary and mandibular dentition in Class I relationship.\(^8\)
- No orthognathic or plastic surgeries.
- No gross facial asymmetry.
- No history of any congenital conditions/trauma affecting facial form and appearance.
Exclusion criteria of the models:

- Inability to obtain an image with good resolution or any other measurement.
- Inability to understand both: the written informed consent paper and the verbal explanation.
Part A:

Model Characteristics

Table 1 shows the distribution of models used in Part A.

Models (N=20)

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<tr>
<td>Total</td>
<td>7</td>
<td>13</td>
<td>20</td>
</tr>
</tbody>
</table>

Table 1. Characteristics of models used in Part A.
Part A:

Model characteristics based on race.

a. Whites: 9
b. Blacks: 3
c. Asians: 4
d. Asian-Indians: 3

Graph 1. Racial distribution of all models in study 1.
**Part A:**

Model classification based on gender

a. Females: 7

b. Males: 13

Graph 2. Gender distribution of all models enrolled in Part A.
Part A:

Model classification based on age

Average age of Models = 26.6 years old

Graph 3. Age distribution of all models enrolled in Part A.
Part A:

Materials and Methods:

- Each model had maxillary and mandibular impressions made with medium body polydimethylsiloxane (Algin-X Ultra; Dentsply, York, PA) and hinge-axis facebow made (Hanau Spring Bow; WhipMix, Ft. Collins, CO) with polyvinylsiloxane registration material (Regisil Rigid; Dentsply Caulk, Milford, DE). Impressions were poured with type IV gypsum product (Castone; Dentsply Trubyte, York, PA) trimmed and mounted with a Hanau facebow mounting jig to a Hanau Wide-Vue Articulator (WhipMix) in maximum intercuspidation (MIP.)

- Both maxillary and mandibular casts were coated with a thin film of vaseline (Petroleum Jelly; Unilever, Trumbull, CT). At increased incisal pin/vertical dimension measurements of 2mm, 3mm, 4mm, and 5mm respectively, mandibular overlays were fabricated from right first mandibular premolar to left first mandibular premolar using dental light cured composite resin splint material (Primosplint; Primotec, Westport, CT). After polymerization, mandibular overlays were adjusted back into MIP at the desired vertical dimension with articulating paper (Accufilm; Parkell, Edgewood, NJ.) Overlays were extended to the first mandibular premolar to allow for sufficient occlusal coverage. Consideration was made to extending the overlay further posterior to the molar regions but after a pilot analysis, where the splint was fabricated to the first molar, there were excessive prematurities in occlusal contacts and a need for aggressive adjustment of the splint to accommodate. Additionally, at OVD increases of 2mm and 3mm, the splint was so thin that it impeded its own function, in comparison to
the splints of 4mm and 5mm thickness. Despite this problem, the first premolar allowed for a sufficient extension of material to provide stability to the overlay, allowed for an anterior increased vertical stop, and allowed for the measuring of the material at the premolar region to additionally verify proper thickness/vertical increase of the overlay.

- At a second visit, the previously fabricated composite resin overlays were clinically verified using calipers from the maximum apical gingival contour of the maxillary and mandibular right central incisors. Overlays were adapted intraorally until each subject was able to close reliably and comfortably.

- Five points were marked directly on each model’s face, with a fine tip dry erase marker (Expo, Sanford Ink Co. Oak Brook, IL) at the following locations: trichion, midbrow, pro-nasale, sub-nasale, and soft tissue menton.
Part A:

Measurement

- A digital caliper (Neiko 01407A Stainless Steel 6-Inch Digital Caliper; Neiko Tools, Independence, MO) was used to clinically measure the soft tissue points pro-nasale and soft tissue menton\(^{15}\) for each evaluated vertical height with different overlays: natural bite (0mm), +2mm, +3mm, +4mm, and +5mm. Measurements were additionally made between trichion to mid-brow, mid-brow to subnasale, and subnasale to soft tissue menton.
Part A: Data Analysis

Data for this study were analyzed using a 5 (mandibular thickness of model) x 2 (model sex) x 2 (model race) x 2 (measurements) mixed model factorial design. Data were analyzed using the Linear Mixed Models procedure in SPSS (International Business Systems, Armonk, NY). The first model examined the data only as a function of Measurement Opportunity to evaluate reliability of measurement. The next analysis examined main effects attributable to model mandibular thickness, model sex, and model race.

All factors and interactions were entered simultaneously, and Type III sums of squares were used to evaluate results. All resulting main effects and interactions were then scrutinized for significance and interpreted.
**Part A:**

**Results**

Lower facial height (LFH) measurements were made between pro-nasale and menton to correlate with each of the five thicknesses of mandibular splint height (0.0mm, 2.0mm, 3.0mm, 4.0mm, 5.0mm). Each measurement was made twice.

**Statistical analysis, tables, and graphs:**

a. Intra-class correlation coefficients (ICC) between the first and second measurements of the objective data

b. Mean values and confidence intervals for model’s lower facial height at each mandibular splint thickness

c. Average measurements of lower facial height resulting from increases in mandibular splint thickness.

d. Mean difference and confidence intervals of lower facial height for each mandibular splint thickness.

e. Table of estimates and confidence intervals for measurements of lower facial height with increases in mandibular splint thickness
a. Table of Reliability Analysis

Table 1 presents reliability analysis of objective measures. Items measured at Time 1 are paired with the same items measured at Time 2.

<table>
<thead>
<tr>
<th>Mandibular Splint Thickness (in mm)</th>
<th>LFH Measurement 1 (in mm)</th>
<th>LFH Measurement 2 (in mm)</th>
<th>Reliability (ICC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>80.78</td>
<td>80.95</td>
<td>.999</td>
</tr>
<tr>
<td>2</td>
<td>82.28</td>
<td>82.22</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Table 2. Intra-class correlation coefficients (ICC) for objective data.

**Interpretation**: Both ICC’s were statistically significant beyond the .001 alpha level. The reliabilities were all quite acceptable, and indicate a high consistency between measurements taken twice by the same investigator using standard procedures.
b. Table of mean values and confidence intervals for model’s lower facial height at each mandibular splint thickness.

Table 3 displays the mean measured value (in mm) for model’s lower facial height (measured from pronasale to menton) at each interval of mandibular splint thickness 0-5mm.

<table>
<thead>
<tr>
<th>ManThick</th>
<th>Mean</th>
<th>Std. Error</th>
<th>df</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
</tr>
<tr>
<td>0</td>
<td>80.865</td>
<td>2.004</td>
<td>95</td>
<td>76.886</td>
</tr>
<tr>
<td>2</td>
<td>82.250</td>
<td>2.004</td>
<td>95</td>
<td>78.272</td>
</tr>
<tr>
<td>3</td>
<td>82.828</td>
<td>2.004</td>
<td>95</td>
<td>78.850</td>
</tr>
<tr>
<td>4</td>
<td>83.376</td>
<td>2.004</td>
<td>95</td>
<td>79.397</td>
</tr>
<tr>
<td>5</td>
<td>84.067</td>
<td>2.004</td>
<td>95</td>
<td>80.089</td>
</tr>
</tbody>
</table>

Table 3. Averaged measurements and confidence intervals of lower facial height (in mm) across all models for each mandibular splint of thickness 0mm, 2mm, 3mm, 4mm, and 5mm.

**Interpretation:** The table shows increases in lower facial height as mandibular splint thickness increases.
c. Graph of average measurements of lower facial height resulting from increases in mandibular splint thickness.

Graph 4 displays the average measured values (in mm) for model’s lower facial height (measured from pronasale to menton) for mandibular splint thickness 0, 2, 4, and 5mm.

Graph 4. Average measurements of lower facial height resulting from increases in mandibular splint thickness.

**Interpretation:** The objective data in Graph 4 shows linear increases in measurements of LFH as a product of increased thickness of mandibular splints.
d. Table of mean difference and confidence intervals of lower facial height for each mandibular splint thickness.

Table 4 displays the mean difference and confidence intervals of lower facial height for each mandibular splint thickness for Table 3.

<table>
<thead>
<tr>
<th>(I) ManThick</th>
<th>(J) ManThick</th>
<th>Mean Difference (I-J)</th>
<th>Std. Error</th>
<th>Df</th>
<th>Sig.</th>
<th>95% Confidence Interval for Difference</th>
<th>95% Confidence Interval for Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
<td>Upper Bound</td>
</tr>
<tr>
<td>0</td>
<td>2</td>
<td>-1.385</td>
<td>2.834</td>
<td>95</td>
<td>0.626</td>
<td>-7.012</td>
<td>4.241</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>-1.963</td>
<td>2.834</td>
<td>95</td>
<td>0.49</td>
<td>-7.59</td>
<td>3.663</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>-2.511</td>
<td>2.834</td>
<td>95</td>
<td>0.378</td>
<td>-8.138</td>
<td>3.115</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>-3.203</td>
<td>2.834</td>
<td>95</td>
<td>0.261</td>
<td>-8.829</td>
<td>2.424</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>1.385</td>
<td>2.834</td>
<td>95</td>
<td>0.626</td>
<td>-4.241</td>
<td>7.012</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>-0.578</td>
<td>2.834</td>
<td>95</td>
<td>0.839</td>
<td>-6.204</td>
<td>5.048</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>-1.126</td>
<td>2.834</td>
<td>95</td>
<td>0.692</td>
<td>-6.752</td>
<td>4.501</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>-1.817</td>
<td>2.834</td>
<td>95</td>
<td>0.523</td>
<td>-7.444</td>
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<tr>
<td>3</td>
<td>0</td>
<td>1.963</td>
<td>2.834</td>
<td>95</td>
<td>0.49</td>
<td>-3.663</td>
<td>7.59</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0.578</td>
<td>2.834</td>
<td>95</td>
<td>0.839</td>
<td>-5.048</td>
<td>6.204</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>-0.548</td>
<td>2.834</td>
<td>95</td>
<td>0.847</td>
<td>-6.174</td>
<td>5.079</td>
</tr>
<tr>
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<td>--------</td>
<td>-------</td>
<td>-----</td>
<td>-------</td>
<td>--------</td>
<td>-------</td>
</tr>
<tr>
<td>5</td>
<td>-1.239</td>
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<td>95</td>
<td>0.663</td>
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<td>4.387</td>
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<tr>
<td></td>
<td>4</td>
<td>-0.692</td>
<td>2.834</td>
<td>95</td>
<td>0.808</td>
<td>-6.318</td>
<td>4.935</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>2.511</td>
<td>2.834</td>
<td>95</td>
<td>0.378</td>
<td>-3.115</td>
<td>8.138</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1.126</td>
<td>2.834</td>
<td>95</td>
<td>0.692</td>
<td>-4.501</td>
<td>6.752</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0.548</td>
<td>2.834</td>
<td>95</td>
<td>0.847</td>
<td>-5.079</td>
<td>6.174</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>-0.692</td>
<td>2.834</td>
<td>95</td>
<td>0.808</td>
<td>-6.318</td>
<td>4.935</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>0.692</td>
<td>2.834</td>
<td>95</td>
<td>0.808</td>
<td>-4.935</td>
<td>6.318</td>
</tr>
</tbody>
</table>

Table 4. Mean difference and confidence intervals of lower facial height for each mandibular splint thickness.

**Interpretation:** This table indicates that there is no relationship between increases in mandibular splint thicknesses and lower facial height.
e. Table of estimates and confidence intervals for measurements of lower facial height with increases in mandibular splint thickness

Table 5 shows the estimates and confidence intervals for measurements of lower facial height with increases in mandibular splint thickness.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Std. Error</th>
<th>df</th>
<th>t</th>
<th>Sig.</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Upper Bound</td>
</tr>
<tr>
<td>Intercept</td>
<td>80.909345</td>
<td>1.68551</td>
<td>98</td>
<td>48.003</td>
<td>.000</td>
<td>77.564500</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>84.254189</td>
</tr>
<tr>
<td>ManThick</td>
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<td>.512885</td>
<td>98</td>
<td>1.231</td>
<td>.221</td>
<td>-.386463</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.649145</td>
</tr>
</tbody>
</table>

Table 5. Estimates and confidence intervals for measurements of lower facial height with increases in mandibular splint thickness

**Interpretation:** A systematic increase of 1.0mm in OVD reflected an increase of LFH by 0.63; this increase in LFH was uncorrelated with OVD (r=.123; p >.20). Therefore, systematic increases in OVD did not reflect similar increases in measured facial height for all races and both sexes.
PART B:

Specific Objectives:

To know if:

1. There are changes in subject/judge’s perceptions in facial esthetics with incremental increases in OVD in dentate models for the following situations:
   a) All types of subjects (judges) taken together
   b) When models and subjects (judges) are of similar or different races.
   c) When models and subjects (judges) are of similar or different genders.
   d) When the subjects (judges) have different background statuses (Layperson, General Dentist, and Prosthodontist)

Hypothesis:

This study tested the following null hypotheses:

There is no difference between:

1. Subject’s (Judge’s) perceptions in facial esthetics with incremental increases in OVD in dentate models in the following situations:
   a) All types of subjects (judges) taken together
   b) When models and subjects (judges) are of similar or different races.
   c) When models and subjects (judges) are of similar or different genders.
   d) When the subjects (judges) have different background statuses (Layperson, General Dentist, and Prosthodontist)
Research Goal:

1. To know whether, or at what increment of millimeters in OVD, do subjects (judges) perceive changes in facial esthetics with incremental increases in OVD in dentate models as a product of the following

   (a) All types of subjects (judges) taken together

   (b) When models and subjects (judges) are of similar or different races.

   (c) When models and subjects (judges) are of similar or different genders.

   (d) When the subjects (judges) have different background statuses (Layperson, General Dentist, and Prosthodontist)

The maximum increment of OVD increase to 5.0mm was chosen in this study because it is a maximum increase that is clinically relevant in Fixed Prosthodontics.
Part B:

Model Acquisition

- The same models as described in Part A, were used, on the second visit, for 11 full face digital photographs.
- Models were asked to remove any cosmetic accessories (hats, earrings, necklaces, lipstick) prior to presenting to the second visit.
- Out of the 20 models, 8 models were chosen deliberately based on satisfying the racial and gender pre-requisites set for Part B of the study.
Part B:

Chosen model characteristics

Table 6 shows the distribution of models used in Part B.

Models (N=8)

<table>
<thead>
<tr>
<th></th>
<th>Female</th>
<th>Male</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Black</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Asian</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Asian-Indian</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>4</td>
<td>4</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 6. Characteristics of models used in Part B.
Part B:

Model Characteristics Based on Race

a. Whites: 2
b. Blacks: 2
c. Asians: 2
d. Asian-Indians: 2

Graph 5. Racial distribution of all models for Part B.
Part B:

Model Characteristics Based on Gender

a. Females: 4

b. Males: 4

Graph 6. Gender distribution of all models in Part B.
Part B:

Model Characteristics Based on Age

Average age = 25.0 years old

Graph 7. Age distribution of all models in Part B.
Part B:

Photography of faces

- Models were seated in front of a black background, 4 feet away from a digital camera (Nikon D90; Nikon, Melville, NY) that was mounted on a tripod. Full face photographs of each model from the frontal and profile views were made with the head in natural head position guided to true horizontal and under standardized lighting conditions.\(^{29}\)

- Five digital photographic images were taken each from frontal and profile views (Total 10 images) at MIP (0 mm as baseline), +2mm, +3 mm, +4mm, and +5mm vertical opening, using the same mandibular splints fabricated for Part A.

- Each digital photograph was stored in JPEG format. Using a photography editing software program (Adobe Photoshop CS4; Adobe Systems, San Jose, CA), full face frontal and profile images were standardized. All photos were cropped to 5.8” x 4.5”, evaluated for consistency in head position, facial expression, picture color saturation, and lightness/darkness. Additionally, each photo was evaluated for consistency in magnification by overlaying each digital image.

- Using a slide creation software program (Microsoft PowerPoint 2010; Microsoft; Mountain View, CA) the frontal and profile image of the same model at the same OVD, MIP (0 mm as baseline), +2mm, +3 mm, +4mm, and +5mm vertical opening were paired to create a slide.

- Slideshow images of the first 8 models enrolled into the study, who satisfied the gender and racial requisites for the subjective phase of the study, were utilized for the Part B.
• Five slides for each of the ten models were collated and utilized to create a slideshow of 40 total slides.
PART B:

Subject/Judge Acquisition

- Human subjects (judges): 30 Laypeople, 15 General Dentists, 15 Prosthodontists of various races and ages. All subjects (judges) were either asked to participate while waiting in the main lobby of the University of Connecticut Health Center or at one of the regional dental meetings in Connecticut or New York City.
- Must be more than 18 years old.
- Layperson: Non-dental professional.
- Dentist: General Dentist, Prosthodontist.

Exclusion criteria of the judges (laypeople and dentists):

- Inability to understand both: the written informed consent and the verbal explanation of the research project.
- Personal recognition of any research models.
Part B:

Subject/Judge Characteristics

Table 7 shows the distribution of subjects (judges) used in Part B.

<table>
<thead>
<tr>
<th></th>
<th>Female</th>
<th>Male</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>21</td>
<td>21</td>
<td>42</td>
</tr>
<tr>
<td>Black</td>
<td>1</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Asian</td>
<td>3</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>Asian-Indian</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>26</td>
<td>34</td>
<td>60</td>
</tr>
</tbody>
</table>

Table 7. Characteristics of subjects (judges) used in Part B.
**Part B:**

**Subject characteristics based on background status:**

a. Laypeople: 30

b. General Dentists: 15

c. Prosthodontists: 15

Graph 8. Distribution of background (layperson, prosthodontist, general dentist) of all subjects (judges) in Part B.
Part B:

Subject/Judge characteristics based on race

a. White: 42
b. Black: 5
c. Asian: 9
d. Asian-Indian: 4

Graph 9. Overall subject distribution based on race for all subjects (judges) enrolled in Part B.
Part B:

Subject/Judge characteristics based on gender

a. Female: 26

b. Male: 34

Graph 10. Overall subject distribution based on gender for all subjects (judges) enrolled in study
Part B:

Subject/Judge characteristics based on age

Average Age of Subject= 44.28 years

Graph 11. Overall subject distribution based on age for all subjects (judges) enrolled in study
Part B:

Rating Procedures

- Prior to sitting in evaluation of the slideshow, each subject was provided a written consent and demographic form both to read and to attest to with their signature. This form obligated the subjects to maintain confidentiality of the model’s involvement in the study.

- Each subject, after fulfilling inclusion criteria, was provided a brief handout describing selective components of the study and the nature of their participation. In this handout, subjects (judges) were instructed both on the presentation of the models and on how to use a VAS scale. Subjects (judges) were informed that although the same eight models were photographed five separate times, no single pair of images had the same facial appearance. After viewing the first round of 40 photographs, the subjects (judges) were asked if they recognized any of the models. If an affirmative answer (YES/NO format) was provided, the particular subject was excluded from the study. Every effort was made to solicit subjects (judges) outside the normal geographic regions of the models.

- Each collated digital image presented as a slide show presentation was viewed twice by each subject/judge. The order of photo presentation followed a differently randomized sequence for each viewing per subject. Subjects (judges) had 7 seconds for each slide (timed by the Microsoft PowerPoint software.) Subjects (judges) were provided a printed copy of the VAS scale. Each print out had 80 individual 100-mm visual analogue scales (VAS) corresponding to the order of images and anchored on the left as least esthetic and on the right as most
esthetic. Subjects (judges) were asked to draw a line on the scale according to their rating of esthetics. The exact instructions that were presented to the subjects (judges) was: “You will be asked to examine a total of 80 digital slides. This includes multiple images of the same person. Within each slide you will witness a frontal and profile view of the same model with the same facial appearance. Although the same ten models were photographed, no slide will have exactly the same facial appearance. For each slide, please draw an intersecting line on the measurement scale, with the left side being least esthetic and the right side being most esthetic, according to your perception of esthetics.”
Part B:

Data Analysis

Data for this study were analyzed using a mixed model factorial design with 2 (gender of model) X 4 (race of model) X 5 (mandibular thickness of model) X 2 (Trials) within-subjects (judges) factors, and 1 between-subjects (judges) factor with 3 levels (General dentist vs. Lay person vs. Prosthodontist). Data were analyzed using the General Linear Mixed Models procedure in SPSS. The first model examined the data only as a function of Trial to evaluate the reliability of the repeated assessments. The next analysis examined main effects attributable to each of the within-subjects (judges) factors (model gender, model race, model mandibular thickness) and the between-subjects (judges) effect. Non-significant effects for the within-subjects (judges) factors, or for the between-subjects (judges) factor (Subject professional status) allowed for that factor to be excluded in succeeding analyses.

The final analysis was a complete factorial analysis that included all possible interactions of those factors that remained significant in prior analyses. All factors and interactions were entered simultaneously, and Type III sums of squares was used to evaluate results. All resulting main effects and interactions were then scrutinized for significance and interpreted.
**Data reliability and consistency:**

All data collection and data analysis was done by one observer. For facial measurements, the measurements were taken twice using the same digital calipers, separated by 30 seconds each. The measurements yielded consistent results. Results indicated that second ratings by subjects (judges) were somewhat but significantly higher than first ratings. Despite this ratings were highly reliable [Table 8].

For data analysis, entire sets of measurements were evaluated at random to ensure accuracy and reliability. A reliability measure test indicated high consistency between measurements.
Part B:

**Statistical measurements:**

- Facial esthetics ratings (0-100) on VAS made by Laypeople, General Dentists, and Prosthodontists of different genders and race of models wearing mandibular splints of 0.0mm, 2.0mm, 3.0mm, 4.0mm, and 5.0mm respectively.

**Statistical analysis, tables, and graphs:**

a. Table of means and confidence intervals for subjects (judges) ratings of esthetics between trials  

b. Table of overall effect for ratings of esthetics related to mandibular splint thickness.  

c. Table means and confidence intervals for effects on esthetics by mandibular splint thickness  

d. Graph of mean values for effects on esthetics by mandibular splint thickness  

e. Table of mean differences for ratings of esthetics (0-100) for different mandibular splint thicknesses  

f. Means and confidence intervals for ratings of esthetics when model and subject are of the same or different races  

g. Means and confidence intervals for ratings of esthetics when model and subject are of the same or different races  

h. Table of means and confidence intervals for ratings of esthetics related to subject background (layperson, general dentist, prosthodontist)  

i. Table of means and confidence intervals for ratings of esthetics (0 - 100) when comparing subject background at each thickness of mandibular splint  

j. Ratings of esthetics (0 - 100) when comparing subject background at each thickness of
mandibular splint

**k.** Mean differences and confidence intervals relating subject (judge) background at each level of mandibular splint thickness
a. Table of means and confidence intervals for subjects (judges) ratings of esthetics between trials

Table 8 compares the means and confidence intervals for ratings of esthetics, as rated by all subject’s/judge’s, between trial 1 and trial 2.

<table>
<thead>
<tr>
<th>Trial</th>
<th>Mean</th>
<th>Std. Error</th>
<th>df</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
</tr>
<tr>
<td>First(^a)</td>
<td>53.365</td>
<td>.391</td>
<td>4800</td>
<td>52.598</td>
</tr>
<tr>
<td>Second(^b)</td>
<td>55.279</td>
<td>.391</td>
<td>4800</td>
<td>54.512</td>
</tr>
</tbody>
</table>

a. First v. Second: \(I - J = -1.913, \text{se} = 0.554, \text{df} = 4800, p < .001\)

b. Second v. First: \(I - J = 1.913, \text{se} = 0.554, \text{df} = 4800, p < .001\)

Table 8. Means and confidence intervals for ratings (0 - 100) of esthetics by trial.

**Interpretation:** This data shows that subjects (judges) rated models as more esthetic on the second trial \(p < .001\) than on the first.
b. Table of overall effect for ratings of esthetics related to mandibular splint thickness.

Table 9 displays the impact mandibular splint thickness had on a subject’s (judge’s) overall ratings of esthetics.

<table>
<thead>
<tr>
<th>Source</th>
<th>Numerator df</th>
<th>Denominator df</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mand Splint Thickness</td>
<td>4</td>
<td>4800</td>
<td>.502</td>
<td>.734</td>
</tr>
</tbody>
</table>

Table 9. Tests of fixed effects for dependent variable: esthetics rating (0-100)

**Interpretation:** This data shows that mandibular splint thickness does not have an impact on subject’s (judge’s) overall rating of esthetics (df:4800; p<.734).
c. Table means and confidence intervals for effects on esthetics by mandibular splint thickness

Table 10 displays data comparing the overall average value of esthetics, as rated by all subjects (judges), for each mandibular splint thickness.

<table>
<thead>
<tr>
<th>Mand Thickness</th>
<th>Mean</th>
<th>Std. Error</th>
<th>df</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
</tr>
<tr>
<td>0</td>
<td>55.035</td>
<td>.618</td>
<td>4800</td>
<td>53.823</td>
</tr>
<tr>
<td>2</td>
<td>53.875</td>
<td>.618</td>
<td>4800</td>
<td>52.663</td>
</tr>
<tr>
<td>3</td>
<td>54.374</td>
<td>.618</td>
<td>4800</td>
<td>53.162</td>
</tr>
<tr>
<td>4</td>
<td>54.217</td>
<td>.618</td>
<td>4800</td>
<td>53.005</td>
</tr>
<tr>
<td>5</td>
<td>54.109</td>
<td>.618</td>
<td>4800</td>
<td>52.897</td>
</tr>
</tbody>
</table>

Table 10. Table means and confidence intervals for effects on esthetics by mandibular splint thickness

**Interpretation:** The data reflect an initial decrease in overall rating of esthetics from mandibular splint thickness 0-2mm (55.035 to 53.875), then an increase from 2-3mm (53.875 to 54.374), then a progressive decrease from 3-5mm (54.374 to 54.217 to 54.109). This trend in ratings reveals that there is no direct correlation between increase in mandibular splint thickness (OVD) and facial esthetics ratings.
d. **Graph of mean values for effects on esthetics by mandibular splint thickness**

Graph 12 represents the data presented in Table 10 comparing the mean value of esthetics, shown on the ordinates as rated by all subjects (judges,) for each mandibular splint thickness.

![Graph of mean values for effects on esthetics by mandibular splint thickness](image)

**Graph 12. Mean values for affects on esthetics by mandibular splint thickness**

**Interpretation:** The data reflects an initial decrease in overall rating of esthetics from mandibular splint thickness 0-2mm (55.035 to 53.875), then an increase from 2-3mm (53.875 to 54.374), then a progressive decrease from 3-5mm (54.374 to 54.217 to 54.109.)
e. Table of mean differences for ratings of esthetics (0-100) for different mandibular splint thicknesses

Table 11 shows the significance (p-values) for table 10 and explains whether ratings of esthetics were correlated to thickness of mandibular splint.

<table>
<thead>
<tr>
<th>(I) Mand Thickness</th>
<th>(J) Mand Thickness</th>
<th>Mean Difference (I-J)</th>
<th>Std. Error</th>
<th>df</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2</td>
<td>1.160</td>
<td>.874</td>
<td>4800</td>
<td>.184</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>.661</td>
<td>.874</td>
<td>4800</td>
<td>.449</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>.818</td>
<td>.874</td>
<td>4800</td>
<td>.349</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>.927</td>
<td>.874</td>
<td>4800</td>
<td>.289</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>-1.160</td>
<td>.874</td>
<td>4800</td>
<td>.184</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>-.499</td>
<td>.874</td>
<td>4800</td>
<td>.568</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>-.342</td>
<td>.874</td>
<td>4800</td>
<td>.696</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>-.234</td>
<td>.874</td>
<td>4800</td>
<td>.789</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>-.661</td>
<td>.874</td>
<td>4800</td>
<td>.449</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>.499</td>
<td>.874</td>
<td>4800</td>
<td>.568</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>.157</td>
<td>.874</td>
<td>4800</td>
<td>.858</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>.265</td>
<td>.874</td>
<td>4800</td>
<td>.762</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>-.818</td>
<td>.874</td>
<td>4800</td>
<td>.349</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>.342</td>
<td>.874</td>
<td>4800</td>
<td>.696</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>-.157</td>
<td>.874</td>
<td>4800</td>
<td>.858</td>
</tr>
<tr>
<td></td>
<td>.108</td>
<td>.874</td>
<td>4800</td>
<td>.901</td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>-.927</td>
<td>.874</td>
<td>4800</td>
<td>.289</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>.234</td>
<td>.874</td>
<td>4800</td>
<td>.789</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>-.265</td>
<td>.874</td>
<td>4800</td>
<td>.762</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>-.108</td>
<td>.874</td>
<td>4800</td>
<td>.901</td>
<td></td>
</tr>
</tbody>
</table>

Table 11. Mean differences for ratings of esthetics (0-100) for different mandibular splint thicknesses

**Interpretation:** This table expands on previously cited data and indicates that facial esthetics is not affected by increases of mandibular splint thickness up to 5.0mm. As a result, the data failed to reject the null hypothesis, which stated that increases in mandibular splint thickness has no effect on perceptions of facial esthetics.
f. **Table of means and confidence intervals for ratings of esthetics when model and subject are of the same or different races**

Table 12 reports the overall ratings of esthetics by judges, when model and subject race were not the same and when model and subject race were the same.

<table>
<thead>
<tr>
<th>Model and Subject Races</th>
<th>Mean</th>
<th>Std. Error</th>
<th>df</th>
<th>95% Confidence Interval</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
<td>Upper Bound</td>
</tr>
<tr>
<td>Not Same(^a)</td>
<td>53.626</td>
<td>.328</td>
<td>4800</td>
<td>52.984</td>
<td>54.268</td>
</tr>
<tr>
<td>Same(^b)</td>
<td>56.411</td>
<td>.567</td>
<td>4800</td>
<td>55.298</td>
<td>57.523</td>
</tr>
</tbody>
</table>

\(^a\) Not Same v. Same: \(I - J = -2.785, \text{se} = 0.655, \text{df} = 4800, p < .000\)

\(^b\) Same v. Not Same: \(I - J = 2.785, \text{se} = 0.655, \text{df} = 4800, p < .000\)

Table 12. Means and confidence intervals for ratings of esthetics when model and subject are of the same or different races

**Interpretation:** Ratings of esthetics were affected significantly \((p < .000)\) based on race of model and subject. Models ranked higher (56.411) when subjects (judges) were of the same race versus when they were of different races (53.626.) Though statistically significant, it is important to understand that the magnitude of difference between the 2 values is very small, as the VAS was recorded on a scale of 1 to 100.
g. Table of means and confidence intervals for ratings of esthetics when model and subject are of the same or different genders

Table 13 reports data on overall ratings of esthetics by judges when model and subject gender were not the same and when model and subject gender were the same.

<table>
<thead>
<tr>
<th>Model and Subject Gender</th>
<th>Mean</th>
<th>Std. Error</th>
<th>df</th>
<th>95% Confidence Interval</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Same(^a)</td>
<td>54.971</td>
<td>.433</td>
<td>4800</td>
<td>54.121</td>
<td>55.820</td>
<td></td>
</tr>
<tr>
<td>Same(^b)</td>
<td>55.066</td>
<td>.433</td>
<td>4800</td>
<td>54.216</td>
<td>55.915</td>
<td></td>
</tr>
</tbody>
</table>

\(a\). Not Same v. Same: \(I - J = -0.95, \text{ se } = 0.567, \text{ df } = 4800, p < .867\)

\(b\). Same v. Not Same: \(I - J = 0.95, \text{ se } = 0.567, \text{ df } = 4800, p < .867\)

Table 13. Means and confidence intervals for ratings of esthetics when model and subject are of the same or different races

**Interpretation:** Although the mean values show that when models and subjects (judges) are of the same gender they report higher ratings of esthetics (55.066) than when they are of not the same gender (54.971), this difference is not significant (\(p < .867\).
h. Table of means and confidence intervals for ratings of esthetics related to subject background (layperson, general dentist, prosthodontist)

Table 14 reports the overall ratings of esthetics by judges based on background of the subject (layperson, general dentist, prosthodontist.)

<table>
<thead>
<tr>
<th>Subject Status</th>
<th>Prof</th>
<th>Mean</th>
<th>Std. Error</th>
<th>df</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layperson</td>
<td>a,b</td>
<td>50.893</td>
<td>.392</td>
<td>4800</td>
<td>Lower Bound: 50.124, Upper Bound: 51.662</td>
</tr>
<tr>
<td>General Dentist</td>
<td>c</td>
<td>61.479</td>
<td>.555</td>
<td>4800</td>
<td>Lower Bound: 60.391, Upper Bound: 62.566</td>
</tr>
<tr>
<td>Prosthodontist</td>
<td></td>
<td>54.023</td>
<td>.555</td>
<td>4800</td>
<td>Lower Bound: 52.936, Upper Bound: 55.111</td>
</tr>
</tbody>
</table>

a. Layperson v. General Dentist: I – J = -10.59, se = 0.68, df = 4800, p < .001
b. Layperson v. Prosthodontist: I – J = -3.13, se = 0.68, df = 4800, p < .001
c. General Dentist v. Prosthodontist: I – J = 7.46, se = 0.7, df = 4800, p < .001

Table 14. Means and confidence intervals for ratings of esthetics related to subject background (layperson, general dentist, prosthodontist)

**Interpretation:** Ratings of esthetics are affected significantly (p < .000) when subjects (judges) are of different backgrounds (layperson, general dentist, prosthodontist). General Dentist’s ratings of esthetics are highest (61.479), followed by Prosthodontist’s (54.023), followed by Laypeople (50.893)
i. Table of means and confidence intervals for ratings of esthetics (0 - 100) when comparing subject background at each thickness of mandibular splint

Table 15 reports ratings of model esthetics by subjects (judges), based on the background of the subject (layperson, general dentist, prosthodontist) and the thickness of mandibular splint.
<table>
<thead>
<tr>
<th>Mand Thickness</th>
<th>Subject Prof Status</th>
<th>Mean</th>
<th>Std. Error</th>
<th>df</th>
<th>95% Confidence Interval</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Layperson</td>
<td>51.572</td>
<td>.877</td>
<td>4800</td>
<td>49.853-53.291</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>General Dentist</td>
<td>62.748</td>
<td>1.240</td>
<td>4800</td>
<td>60.317-65.179</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prosthodontist</td>
<td>54.250</td>
<td>1.240</td>
<td>4800</td>
<td>51.819-56.681</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Layperson</td>
<td>50.211</td>
<td>.877</td>
<td>4800</td>
<td>48.493-51.930</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>General Dentist</td>
<td>61.617</td>
<td>1.240</td>
<td>4800</td>
<td>59.186-64.048</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prosthodontist</td>
<td>53.460</td>
<td>1.240</td>
<td>4800</td>
<td>51.030-55.891</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Layperson</td>
<td>51.230</td>
<td>.877</td>
<td>4800</td>
<td>49.511-52.949</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>General Dentist</td>
<td>61.183</td>
<td>1.240</td>
<td>4800</td>
<td>58.752-63.614</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prosthodontist</td>
<td>53.852</td>
<td>1.240</td>
<td>4800</td>
<td>51.421-56.283</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Layperson</td>
<td>50.757</td>
<td>.877</td>
<td>4800</td>
<td>49.038-52.476</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>General Dentist</td>
<td>60.569</td>
<td>1.240</td>
<td>4800</td>
<td>58.138-63.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prosthodontist</td>
<td>54.785</td>
<td>1.240</td>
<td>4800</td>
<td>52.355-57.216</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Layperson</td>
<td>50.695</td>
<td>.877</td>
<td>4800</td>
<td>48.976-52.414</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>General Dentist</td>
<td>61.277</td>
<td>1.240</td>
<td>4800</td>
<td>58.846-63.708</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prosthodontist</td>
<td>53.769</td>
<td>1.240</td>
<td>4800</td>
<td>51.338-56.200</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 15. Table of means and confidence intervals for ratings of esthetics (0 - 100) when comparing subject background at each thickness of mandibular splint.
**Interpretation:** Ratings of esthetics were affected significantly, see Table 14, when subjects (judges) were of different backgrounds (layperson, general dentist, prosthodontist). However, the ability to detect changes in facial esthetics with increases in mandibular splint thickness did not correlate to a person’s background (layperson, prosthodont, general dentist.)
Graph of ratings of esthetics (0 - 100) when comparing subject background at each thickness of mandibular splint

Graph 13 displays the information from Table 12 which is the ratings of model esthetics by subjects (judges), based on the background of the subject (layperson, general dentist, prosthodontist) and the thickness of mandibular splint.

Graph 13. Ratings of esthetics (0 - 100) when comparing subject background at each thickness of mandibular splint
**Interpretation:** Overall, laypeople rated models as less esthetic than did Prosthodontists, followed by general dentists. Additionally, perception of esthetics based on subject’s background (layperson, prosthodontist, general dentist) at different mandibular splint thicknesses did not appear to be significant at any level. These results indicated, within the limitations of this study, that the ability to detect changes in facial esthetics with increases in mandibular splint thickness did not relate to a person’s background (layperson, prosthodontist, general dentist.)
k. Mean differences and confidence intervals relating subject (judge) background at each level of mandibular splint thickness

Table 16 compares the mean differences and confidence intervals relating subject (judge) background at each level of mandibular splint thickness (0mm, 2mm, 3mm, 4mm, 5mm).

<table>
<thead>
<tr>
<th>Mand Thickness</th>
<th>(I) Subject Prof Status</th>
<th>(J) Subject Prof Status</th>
<th>Mean Difference (I-J)</th>
<th>Std. Error</th>
<th>df</th>
<th>Sig.</th>
<th>95% Confidence Interval for Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
</tr>
<tr>
<td>0</td>
<td>Layperson</td>
<td>General Dentist</td>
<td>-11.176</td>
<td>1.519</td>
<td>4800</td>
<td>.000</td>
<td>-14.153</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prosthodontist</td>
<td>-2.678</td>
<td>1.519</td>
<td>4800</td>
<td>.078</td>
<td>-5.655</td>
</tr>
<tr>
<td></td>
<td>General Dentist</td>
<td>Layperson</td>
<td>11.176</td>
<td>1.519</td>
<td>4800</td>
<td>.000</td>
<td>8.199</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prosthodontist</td>
<td>8.498</td>
<td>1.754</td>
<td>4800</td>
<td>.000</td>
<td>5.060</td>
</tr>
<tr>
<td></td>
<td>Prosthodontist</td>
<td>Layperson</td>
<td>2.678</td>
<td>1.519</td>
<td>4800</td>
<td>.078</td>
<td>-.299</td>
</tr>
<tr>
<td></td>
<td></td>
<td>General Dentist</td>
<td>-8.498</td>
<td>1.754</td>
<td>4800</td>
<td>.000</td>
<td>-11.936</td>
</tr>
<tr>
<td>2</td>
<td>Layperson</td>
<td>General Dentist</td>
<td>-11.405</td>
<td>1.519</td>
<td>4800</td>
<td>.000</td>
<td>-14.382</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prosthodontist</td>
<td>-3.249</td>
<td>1.519</td>
<td>4800</td>
<td>.032</td>
<td>-6.226</td>
</tr>
<tr>
<td></td>
<td>General Dentist</td>
<td>Layperson</td>
<td>11.405</td>
<td>1.519</td>
<td>4800</td>
<td>.000</td>
<td>8.428</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prosthodontist</td>
<td>8.156</td>
<td>1.754</td>
<td>4800</td>
<td>.000</td>
<td>4.718</td>
</tr>
<tr>
<td></td>
<td>Prosthodontist</td>
<td>Layperson</td>
<td>3.249</td>
<td>1.519</td>
<td>4800</td>
<td>.032</td>
<td>.272</td>
</tr>
<tr>
<td></td>
<td></td>
<td>General Dentist</td>
<td>-8.156</td>
<td>1.754</td>
<td>4800</td>
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Table 16. Mean differences and confidence intervals relating subject (judge) background at each level of mandibular splint thickness
**Interpretation:** Table 16 validates the data from Graph 13 that background status did have an effect in overall perceptions of esthetics. Nonetheless, Table 15 shows no effect related to background status (layperson, general dentist, prosthodontist) while evaluating differences in mandibular thickness. As previously seen, the ratings did not show a significant increase (or decrease) for any group versus the other as mandibular splint thickness increased.
DISCUSSION:

The last several decades have seen an explosive interest in the areas of facial esthetics. Today many multi-billion dollar a year industries exist surrounding these topics spanning from retail to cosmetic surgery. This increased public awareness and layperson sensitivity has resulted in more of an esthetic awareness. The field of dentistry has embraced these changes with advances in new technologies and materials.

For the dental clinician, research on esthetics is valuable not only in removable and fixed prosthodontics but also in orthodontics and orthognathic surgery. The importance of OVD in dentistry has long been understood on a functional level. The need to increase or decrease OVD based on requirements for restorative space, or to control function and occlusion, has long been understood. Nonetheless, increases of OVD above normal levels have not been comprehensively evaluated from the standpoint of facial esthetics. Patients in need of prosthodontic intervention involving increases in OVD are commonly asked to endure extensive treatment with significant psychological and financial investment. Although the functional limitations of exaggerated increases in OVD are known, little research has directly correlated increases in OVD with objective soft tissue changes and the resultant subjective perceptions of these changes.

This investigation was divided into 2 separate studies, an objective study (Part A) and a subjective study (Part B). Part A evaluated changes in lower facial height with incremental increases in OVD in fully dentate individuals. Incremental increases in OVD were achieved by fitting twenty models with mandibular splints of varied thickness (0.0 mm, 2.0 mm, 3.0 mm, 4.0 mm, and 5.0 mm). Measurements of OVD were acquired in real time, in contrast to making photographs and measuring from the digital images, for clinical applicability.
The splints utilized in Part A and Part B were fabricated with a light cured resin to provide ease of adjustment and intraoral verification. Splints were made indirectly to the measured thicknesses of 2-5mm by opening the anterior incisal pin on the articulator. This was done for clinical relevance to mimic procedures and average increases in OVD that are utilized for patients undergoing this type of dental rehabilitation. Lastly, splints were extended to the second premolar region. This was done because at OVD increases of 2mm and 3mm, the splint was so thin in the molar region that it impeded its own function, in comparison to the splints at 4mm and 5mm thickness.

In this study, intra-class correlation coefficients of between trial measurements displayed very high consistency, indicating that the reliability of the individual making the measurements (NPO) was acceptable. The results displayed a systematic increase of LFH by 0.63 per 1.0mm increase in OVD. But, this increase in LFH was uncorrelated with OVD \((r=0.123; p > 0.20)\). Therefore, systematic increases in OVD did not reflect similar increases in measured facial height for all races and both genders. Although the previous research by Gross et al.\(^{28}\) indicates a positive correlation of LFH:OVD of 0.5:1, the data from this study did not.

Part B of the present study investigated relationships between subject (judge) perceptions of both facial change and esthetics with increases in OVD up to 5.0mm. These variables were assessed in the following four situations: All subjects (judges) taken together, when models and subjects (judges) were of similar or different races, when models and subjects (judges) were of similar or different genders, and when subjects (judges) were of varied backgrounds (Layperson, General Dentist, and Prosthodontist.)

All models selected for esthetic evaluation were class I canine, between the ages of 20-35 years old, and from diverse racial backgrounds (White, Black, Asian, and Asian-Indian.) As this
was one of the first studies investigating this topic, the use of class I canine models allowed for a baseline to be set for future research. The age demographic was selected because this was the most popular age range found in the literature on facial esthetics. Utilizing similarly aged models allowed this research to be more applicable to other previous published literature on the same topic. Lastly, this study was one of the first research projects to provide racial and gender diversity between its subjects and models. Although racial\textsuperscript{34} and gender\textsuperscript{35} preferences have been validated by previous research in psychology, most previous dental literature in facial esthetics has been conducted regionally and with sizable gender and racial preferences; this affects sample homogeneity and may contribute biases in ratings.

Data from Part B is as follows. First, ratings of facial esthetics were not influenced by the alterations of OVD used here. Second, when model race and subject race were the same, ratings of esthetics were effected (p < .01). Third, when model gender and subject gender were the same ratings of esthetics were unaffected (p > 0.80.) And fourth, the subject’s background status (layperson, prosthodontist, general dentist) was uncorrelated to their ability to detect changes in facial esthetics with incremental increases in mandibular splint thickness.

It can be assumed from this data, that Laypeople are either the most critical at assessing facial esthetics or that facial esthetics does not depend on any one single feature.\textsuperscript{35} This data indicates that subject’s background status does not relate to an increased ability to detect changes in LFH in models with OVD increases up to 5.0 mm. These results therefore fail to reject the null hypothesis.

This information is relevant to all dental providers dealing with changes in OVD/LFH because it indicates that increasing OVD up to 5.0 mm over MIP does not have an impact in subjective observations of facial esthetics. This is clinically significant information as it
improves clinician’s confidence in decisions about increasing OVD and its impact on facial esthetics.
LIMITATIONS TO THE STUDY:

Although this investigation made methodological improvements over many previous studies on facial esthetics, and made the topic more relevant to the specialties of Prosthodontics, Orthodontics and Oral Maxillofacial Surgery, some limitations remained. First, the study involved measuring points placed on movable soft tissues at increased OVD with mandibular splints placed on the anterior teeth. The combination of these factors made the consistency of measuring soft tissue points challenging, as models had the tendency to tense their facial muscles, specifically their chin, as the thickness of mandibular splint increased. Due to the variability in this muscle tonus, it made achieving consistency in the measurements difficult. Second, the splints only extended to the pre-molar regions and not the entire arch due to material challenges. Although considerations were made to extend the overlays further posterior to the molar regions, after conducting a pilot analysis, where the splint was fabricated to the first molar, there were excessive prematurities in occlusal contacts and a need for excessive adjustment of the splint. Nonetheless, a full arch splint may have provided more reliability in creating a more precise increase in OVD.

Third, the study was primarily conducted at the University of Connecticut Health Center in Farmington, CT. Due to the location of the health center and the particular demographic represented there, the model and subject racial and age distribution was not even. Fourth, the use of a visual analog scale (VAS), although both a popular method for evaluating facial esthetics and a method that has been used significantly in dental and socio-psychological literature, has its limitations. Reports on the accuracy of this rating system have been based on the subject’s training and familiarity with the assessment instrument.\textsuperscript{32} Although all subjects (judges) were provided with detailed instructions on how to use the VAS, there were variations of
understanding between subjects (judges). Additionally, prolonged exposure to visual analog scales have shown to result in cognitive fatigue\textsuperscript{33}, which may additionally affect results.
**FUTURE STUDIES:**

This study was one of the first, in addition to Gross et al.\textsuperscript{28}, to investigate both the relationship between OVD and LFH and the subjective perceptions of models with incremental increases in LFH. Considering the limitations of this study and the results found, this study could be used to suggest additional research. Overall, future studies can be performed on this same topic with larger sample sizes, with more varied subjects and models, with models of different occlusal relationships, and can be transported to more clinical situations. Specifically regarding Part A of this study, error may have been incorporated in the analog fabrication of the splints. In the near future, digital impressions and rapid prototyping or milling, may eliminate the potential for error in the fabrication of the splints. Additionally, use of digital radiography such as Computerized Tomography and Magnetic Resonance Imaging and the advances in radiological software may allow investigators to determine a more reliable approach to evaluating correlations between OVD and LFH. With regards to Part B, identifiers of facial esthetics are being evaluated in many scientific disciplines. With regards to advances that can be made in dentistry, this study focused on perceptions of individuals with a full dentition at OVD increases above MIP. Future studies can be performed on individuals previously diagnosed with loss of OVD or who have been restored to an increased OVD above tolerated limits. This study may also be used for research that investigates similar variables on models and subjects (judges) of different ages, races, and backgrounds. Finally, this study may be used in the future to determine additional trends regarding facial esthetics, which can enhance existing information on changes in esthetics related to dentists involved in clinical Orthodontics, Orthognathic Surgery, and Prosthodontics.
CONCLUSIONS:

This 2-part study investigated the changes related to occlusal vertical dimension and lower facial height objectively and subjectively on models with incremental increases in OVD up to 5.0 mm. Ratings of model facial esthetics were compared across race, gender, and background of subject (layperson, prosthodontist, general dentist). Data were analyzed using the General Linear Models procedure in SPSS. Based on the findings of the study, the following conclusions were drawn:

- Results from Part A revealed an increase in lower facial height by 0.63 mm for every 1.0 mm increase in occlusal vertical dimension. This estimated value cannot be correlated (Sig. (two tailed) p < .221) across any specific race, gender, or incremental increase of mandibular splint thickness.

- Results from part B revealed the following:
  1. The relationship between facial esthetics and mandibular splint thickness was not significant up to 5.0mm increase in OVD.
  2. When the model and subject races were the same there was a statistically significant impact on overall assessments of esthetics at (p < .000). Subjects (judges) rated models of the same race slightly higher than models of other races. Though statistically significant, it is important to understand that the magnitude of difference between the 2 values is very small, as the VAS was recorded on a scale of 1 to 100.
  3. When model and subject gender were the same there was no statistically significant impact on ratings (p < 0.86.)
4. The ability of a subject to detect changes in facial esthetics with increases in mandibular splint thickness did not relate to a person’s background (layperson, prosthodontist, general dentist.)

This was the first study to make correlations between OVD and facial esthetics clinically relevant. The results indicate a relationship of .63mm (p<.221) increase of lower facial height to each 1 mm of OVD increase. Additionally, and in accordance with the limitations of this study, the data reveal that an increase of OVD of 5.0mm appears to make no difference in a subject’s evaluation of facial esthetics. Additionally, background status (layperson, general dentist, prosthodontist) does not relate to an increased ability to detect changes in LFH in models with OVD increases up to 5.0 mm.

This research can provide the clinician with guidelines for making treatment decisions, regarding increases in OVD and its relationship to facial esthetics. Additionally, it can act as a foundation for future research in comparing the ways OVD can affect objective and subjective considerations of facial esthetics.
References:


Appendix:

**Title:** Changes in Facial Esthetics and Lower Facial Height with Increases in Occlusal Vertical Dimension in Dentate Models

**Form 1: Recruitment of Models**

Dear ____________.

My name is Dr. Noah Orenstein and I am a second year Prosthodontic Resident at UConn. As a partial fulfillment of requirement for my Master of Dental Sciences degree, I am conducting a survey study evaluating vertical facial height and perceptions of Esthetics. Although similar studies have been performed on this topic they have not been clinically valuable; this will be the first study to attempt this.

You are invited to take part in this study because you are between 20-35 years old, have a full complement of teeth, and fulfill the proper gender and racial requisites for the study. Your initial involvement will require a 5 minute screening appointment, which will help to identify your place in the study.

Full involvement in the study will require the making of dental impressions on you upper and lower teeth and then at a second visit, eleven facial pictures taken as well as the placement of easily erasable identification marks on your face. In appreciation of your time for participation in the study you will receive a $5.00 Starbucks gift card at the completion of your participation.

You will be one of twenty pre- or post- doctoral dental students to enroll at UCHC. Your participation is entirely voluntary and if you decide not to participate it will not affect your status at UCHC.

Nonetheless, you were selected specifically for the study and I would appreciate you taking a moment to seriously consider participating. Although, like most medical research, you will not individually benefit from participation in the study, your participation will contribute to the overall knowledge and improvement of dental science.

I look forward to hearing from you.

Sincerely,
Noah Orenstein
(860) 679- 4070
NOrenstein@gde.uchc.edu
**Title:** Changes in Facial Esthetics and Lower Facial Height with Increases in Occlusal Vertical Dimension in Dentate Models

**Form 2: Recruitment of Models- form for screening:**

**Demographic Information**

Age:

Gender: (circle one)  Male / Female

Race: (circle one)  Asian White Black Asian-Indian

---------------------------------------------------------------------------------------------------------------------------------------

*To be filled out by Investigator (NO)*

Between 20 - 35 years old?

Yes/No

Complete maxillary and mandibular dentition?  Yes/No

Class I molar relationship?

Yes/No

Gross facial asymmetry?  Yes/No

Orthognathic or plastic facial surgeries  Yes/No

History of any congenital conditions/trauma affecting facial appearance?

Yes/No

Subject #_____
Title: Changes in Facial Esthetics and Lower Facial Height with Increases in Occlusal Vertical Dimension in Dentate Models

Form 3: Information sheet to be read before consent form is presented to subject

VDO AND FACIAL ESTHETICS RESEARCH STUDY – Dr. Noah Orenstein

Thank you for your kind interest in this study! The VDO and facial Esthetics research study is being conducted as a partial fulfillment of requirement for my Master of Dental Sciences degree from the Department of Reconstructive Sciences, UCONN School of Dental Medicine.

This study will examine the relationship of increases in vertical dimension of occlusion on objective changes in facial soft tissue landmarks and subjective perceptions on a rating of Esthetics by judges (lay people and dentists). Vertical face heights are important parameters in esthetic dentistry, encompassing Prosthodontics, Orthodontics, and Orthognathic Surgery. Although similar studies have been performed on this topic they have not been clinically valuable. This is the first study that will actually attempt to relate the way changes in vertical dimension are perceived in general assessments of facial Esthetics. The results will help to better understand the extent to which clinicians can change this variable and have it remain within social means of acceptability.

The study will examine 20 models through digital images. Your participation in the study will require providing consent for impressions of your maxillary and mandibular dentition, facebow recordings, placement of removable appliances in your mouth, digital images to be taken of your face, as well as the placement of five easily erasable identifying ink marks on your face. These tiny marks will be placed on your forehead, between your eyebrows, on the tip of your nose, just below your nose, and at the bottom of your chin. The digital images will be analyzed using specific software to study the co-relation of these anatomic landmarks with vertical facial dimension. No methods used in this study can be construed as unsafe or place you in any pain or risk.

This study has been approved by the IRB and the dignity and privacy of your pictures is assured. Please feel free to ask any related questions.

NOrenstein@gde.uchc.edu
**Title:** Changes in Facial Esthetics and Lower Facial Height with Increases in Occlusal Vertical Dimension in Dentate Models

**Form 4: Consent Form for models.**

**Principal Investigator (PI):** Dr. Avinash Bidra, BDS, MScD  
**PI Phone Number:** (860) 679-2649  
**Co-Investigator(s):** Dr. Noah Orenstein, DMD  
**Title of Research Study:** Changes in Facial Esthetics and Lower Facial Height with Increases in Occlusal Vertical Dimension in Dentate Models  
**Expected Duration of Subject’s Participation:** 2 Phases; 1.5 Hours Cumulative  
**IRB Number:**  
**Name of Research Participant:**

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**What Is The Purpose Of This Research Study?**

The purpose of this study is to look at the way increasing in the amount of space between your upper and lower teeth affects the distance between your nose and your chin (vertical face height.) Additionally, the study will examine the extent to which judges (non-dentists and dentists) can detect differences in Esthetics based on pictures that will be taken at different vertical face heights.

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**Why Am I Invited To Participate?**

You are invited to take part in this study because you are between 20-35 years old, are not missing any teeth, have Angle’s class I molar relationships (normal bite), and fulfill the proper gender and racial needs for the study.

---

**How Many Other People Do You Think Will Participate?**

We estimate that 20 people will enroll at UCHC as models. The second phase of the study will involve 60 judges from inside and outside the UCHC community.

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**Is Participation Voluntary?**

Participation in this study is voluntary. Before making a decision about whether to participate in this research study, please read this consent form carefully and discuss any questions you have with the researcher. If you want to talk with other people prior to making a decision to participate you are free to do so.

If you decide to participate in the study, you are free to withdraw from it at any time. If you decide not to participate or you withdraw from the study, your decision will not affect your status at the University of Connecticut Health Center/John Dempsey Hospital nor will there be any penalty or loss of benefits to which you are otherwise entitled.

---

**How Long Will My Participation In This Study Last?**

You will be asked to meet with the co-investigator two times over the next month. Each visit will last one hour.
What Are the Costs To Me For Participating In This Study?
There will be no costs to you for participating.

What Procedures Will Be Done? Are They Safe?
The first appointment will involve the making of dental impressions on your upper and lower teeth. The second appointment will involve having eleven facial pictures taken as well as the placement of easily erasable identification marks (made with a felt tip pen) on your face, as required by the study. In the second phase of the study, the pictures will be viewed by 60 judges, some affiliated and some unaffiliated with UCHC, on a computer screen. Judges will be excluded from the study if they are familiar/recognize you, the subject. All of these procedures are safe, completely reversible, involve no foreseeable risks, and will not cause any harm. Additionally, there will be no cost to you as related to any parts of this study.

What Are the Benefits Of Participating In This Study?
This research study will take one year to complete. Like most medical research, you will not individually benefit from participating in the study, but will contribute to the overall knowledge and improvement of dental science. The results from this study will help to better understand the extent to which clinicians can modify facial height as part of comprehensive Prosthodontic treatment.

Will I Be Compensated For Participating In This Study?
In appreciation of your time for your participation in the study, you will receive a $5.00 Starbucks gift card.

At any point during the study, you have the option not to participate in this study. There are no risks associated with this study but, if you decide to withdraw, all information related to your participation in the study will be deleted.

How Will My Personal Information Be Protected?
Although all attempts will be made to do so, confidentiality of personal information cannot be guaranteed. Nonetheless, the following procedures will be used to maintain the confidentiality of your data. The study staff (principal investigator and research coordinator) will keep all study records in a locked secure location. Research records will be labeled with a code and all contents of the research record will be labeled with only that code. The code will be derived from your first and last initial followed by a sequential 2 digit number that reflects how many people have enrolled in the study. All electronic files (e.g., database, spreadsheet, etc.) containing identifiable information will be password protected. Any computer hosting such files will also have password protection to prevent access by un-authorized users. Data that will be shared with others will be coded as described above to help protect your identity.

At the conclusion of this study the researchers may publish their findings. Information will be presented in summary format and you will not be identified in any publications or presentations by name or by image.
What Happens to the Sample if I Withdraw from the Study?
If you choose to withdraw from the study after your photographs and demographic information has been obtained, we will remove the data and all records in our research files containing your information will be deleted.

What If I Decide To Stop Participating In The Study?
You are free to stop taking part in this study at any time. If you decide to stop taking part in the study, your relationship with your faculty, residents, or anyone else in the University of Connecticut Health Center will not be affected. If you decide to withdraw we ask that you let us know by e-mailing Noah Orenstein at NOrenstein@gde.uchc.edu.

What If I Experience An Adverse (Bad) Event Related To My Participation?
If you have an adverse event you should tell the principal investigator as soon as possible. You may contact Dr. Avinash Bidra by e-mail at BIDRA@uchc.edu.

The Principal Investigator is willing to answer any questions you have about the research. You are encouraged to ask questions before deciding whether to take part. You are also encouraged to ask questions during your study participation. If you have questions, complaints or concerns about the research, you should contact the Principal Investigator at above listed e-mail address.

What if I Have Questions?
If you have questions about your rights as a research subject you may contact a coordinator at the Institution Review Board at 860-679-1019 or 860-679-4851.

You may also call a coordinator at the Institutional Review Board if you want to talk to someone who is not a member of the research team in order to pass along any suggestions, complaints, concerns or compliments about your involvement in the research, or to ask general questions or obtain information about participation in clinical research studies.

Please do not call the IRB number for medical related issues or to schedule or cancel an appointment.

Consent To Participation:
By signing this form you the participant acknowledge that you have read, or have had read to you, this informed consent document, have talked with research personnel about this study, have been given the opportunity to ask questions and have them satisfactorily answered, and voluntarily consent to participate in this project as described in this form.

By signing this form the individual obtaining consent is confirming that the above information has been explained to the subject and that a copy of this document, signed and dated by both the person giving consent and the person obtaining consent, along with a copy of the Research Participant Feedback Form, will be provided to the participant.
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Title: Changes in Facial Esthetics and Lower Facial Height with Increases in Occlusal Vertical Dimension in Dentate Models

Form 5: Data Collection Form

Subject’s Name:

E-mail address:

Phone Number:

Age:

Gender: (circle one)  Male / Female

Race: (circle one)  Asian  White  Black  Asian-Indian

Distance Between (in mm):

Trichion to Mid-Brow:

Mid- Brow to Soft tissue subnasale:

Soft tissue subnasale to Soft Tissue Menton:

Splint Height  Distance between pro-nasale and soft tissue menton (mm)

MIP (0mm)

+2 mm

+3 mm

+4 mm

+5 mm

JPEG Images: ______ to ______.

Subject #____
Title: Changes in Facial Esthetics and Lower Facial Height with Increases in Occlusal Vertical Dimension in Dentate Models

Form 6: Information sheet for judges

Facial Perception Research Study – Dr. Noah Orenstein

Thank you for your kind interest in this study! The facial perception research study is being conducted as a partial fulfillment of requirement for my Master of Dental Sciences degree from the Department of Reconstructive Sciences at UConn School of Dental Medicine. Part of this study examines perceptions of facial Esthetics. Although similar studies have been performed on this topic they have not proven to be clinically valuable for Prosthodontics and this study is hoping to change this fact.

Eight models had frontal and profile digital photographic images taken. You will be asked to examine a total of 80 digital slides. This includes multiple images of the same person. Within each slide you will witness a frontal and profile view of the same models with the same facial appearance. Although the same ten individuals were photographed, no slide will have the same facial appearance. You will have 5 seconds to view each slide and rate facial Esthetics on a scale, which will be numbered correspondingly in the order of the slides and anchored on the left as least esthetic and on the right as very esthetic.

Your participation in the study will require providing consent. Your signature will verify your agreement to maintaining the confidentiality of the subject’s involvement in the study.

This study has been approved by the IRB and the dignity and privacy of your answers are assured. Please feel free to ask any related questions.

NOrenstein@gde.uchc.edu
Title: Changes in Facial Esthetics and Lower Facial Height with Increases in Occlusal Vertical Dimension in Dentate Models

Form 7: Data Collection form of Judges

Age:

Gender: (circle one)  Male  /  Female

Race: (circle one)  Asian  White  Black  Asian-Indian

Participation as:  Layperson  /  Prosthodontist (please circle)

(If a Prosthodontist please answer):

□  How long have you been in practice? ______ years

Judge #___
**Title:** Changes in Facial Esthetics and Lower Facial Height with Increases in Occlusal Vertical Dimension in Dentate Models

**Form 8: Data Collection form for Subject’s (Judge’s) evaluation of models (Visual Analogue Scale)**

Example of VAS used:

1. least esthetic _______________________________ most esthetic