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A Dynamic Analysis: the Smile and Display of Dentition during Speech

Allen Yaghoubzadeh
University of Connecticut Health Center

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Allen Yaghoubzadeh, B.S., D.D.S.

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Abstract

The objective of this retrospective study is to follow up on a previous Dynamic Smile Analysis and videographically analyze and develop averages for soft tissue norms with respect to the display of dentition during speech. These values would then be compared cross-sectionally across different age groups to see whether changes attributable to the aging process could be seen. A secondary objective was to compare averages for soft tissue norms in the display of dentition during speech to averages for soft tissue norms in the display of dentition during the smile. **Materials and Method**: Records from a previous study in which video equipment was used to capture video for 261 subjects were re-evaluated to find appropriate frames to analyze for speech. Two frames for each subject were selected; one frame representing the maximal display of maxillary incisors during speech and the second representing the widest transverse display of dentition during speech. After excluding 40 subjects the data for the remaining 221 subjects was analyzed. These averages were then compared to averages attained in the previous study to compare the display of the dentition during speech to the display of the dentition during smile. **Results**: On average, a difference in 1.29 mm was seen in the display of the maxillary incisors during speech at maximal display and during the smile. An average of 7.23 mm of maxillary incisors is readily visible during maximum display of maxillary incisors during speech, as compared to 8.52 mm during the smile. The constructed smile index was also smaller when measured during the speech when compared to the smile index by an average of 2.58 units. **Conclusion**: This study helps to establish age-related dynamic norms for the display of dentition during speech. The dynamic measures

indicate that the display of dentition is greater, on average, during the smile than at speech.

APPROVAL PAGE

Master of Dental Science Thesis

A Dynamic Analysis: The Smile and Display of Dentition During Speech

Presented by
Allen Yaghoubzadeh, B.S., D.D.S.

Major Advisor: Ravindra Nanda, B.D.S., M.D.S., Ph.D.

Minor Advisor: Flavio Uribe, D.D.S.,M.D.S.

Minor Advisor: David Shafer, D.D.S., M.D.

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Table of Contents:

List of Tables

List of Figures

Introduction

I. Objective of Research

The objective of this retrospective study is to follow up on a previous Dynamic Smile Analysis and videographically analyze and develop averages for soft tissue norms with respect to the display of dentition during speech. This study will compare these averages to ones previously derived for the display of dentition during the posed smile using similar methods and materials. Areas of concentration for evaluation shall be incisor display during vowel pronunciation for the soft "e," and buccal corridor display during vowel pronunciation for the hard "e." Although the frames needed would most likely correspond to these vowels, the selection of the frames to be analyzed would not be limited to these vowels. The entire speech would be analyzed to find frames which best correspond to the maximal display of the maxillary incisors and the widest transverse dental display during speech.

II. Review of Literature

Currently, the trend of pursuing smile-oriented, esthetic results while planning orthodontic treatment has been observed [1]. Clinicians in both prosthodontics and orthodontics regard the smile as an integral part of treatment planning and as the cornerstone of treatment objectives [2]. Therefore, it should not be surprising to find this new trend in treatment making such a big impact in the literature. A beautiful smile has become priceless; it has an impact on every aspect of day to day life. People have found that it can affect your job, your choice of friends, and even your choice for a mate [3]. As such, people are turning their efforts into attaining an improved smile through the use of orthodontic treatment.

Naturally, as people start focusing more on the physical attributes of an esthetic smile while attaining treatment, researchers also start reorienting their focus of study to finding scientific qualifications that assess the smile and that help the clinician provide patients with optimal treatment outcomes. As smile research has become more encompassing, researchers have developed numerous methods and strategies to obtain the best diagnostic tool for analyzing the spontaneous and the social smile. One of the methods moved the analysis of the smile from a static to a dynamic one [4].As the field of smile analysis evolved, researchers broadened the analysis to encompass the display of dentition during speech [5]. Zachrisson [6] was one of the first to suggest that the smile be assessed during speech, as he proposed that the word "cheese" be used to evaluate the display of dentition. He suggested the use of analyzing the patient in articulating the word "cheese" because it would help to obtain a repeatable method which would present an ideal lip-tooth presentation at smile. Other researchers [7] further investigated the idea of analyzing the smile with the use of the patient in speech as a diagnostic tool. The studies compared dental display findings for the posed smile, spontaneous smile, and speech. The studies showed many differences in the display of the dentition during the smile, and as such, the display of the dentition during speech started garnering more individual attention from researchers.

Regardless of the method used in analyzing the smile, the goal has always been to find a result that obtains an esthetic, well-balanced relationship between the dentition and the soft tissue frame. With more and more focus directed towards optimizing the various relationships between the soft tissue and the dentition, the scope of interest for quantifying these relationships has also broadened. As the display of the dentition during speech has started to garner more attention in the analysis of the smile, many researchers have also begun to notice that more time is spent in displaying the dentition during speaking than during smiling.

At first glance, the task of analyzing the display of the dentition during speech becomes a daunting task, as there seems to be an infinite value of different lip movements and postures during speech. Fortunately, a 3-D analysis model that studied lip movement found that the lip motion in speech production could be efficiently described by a small number of degrees of freedom [8]. Thus, looking at the speech in specific dimensions would help to analyze the display of the dentition during speech through the full range of lip motion.

As more clinicians come to consider the subtle display of the dentition during speech as a diagnostic tool to gain optimal relationships of the dentition and the soft tissues during the smile, clinicians find themselves spending more time trying to obtain a subjective result for the display of dentition during speech. As the trend becomes more popular, it becomes paramount for research to help establish esthetic norms in analyzing this measure of orthodontic control. This study will help quantify the ideal display of dentition through the soft tissue frame during speech using a dynamic static evaluation [1]. Furthermore, this study will compare the display of dentition during speech with the display of dentition during the smile using absolute and constructed numbers obtained through selected frames of a dynamic record.

Although many studies have previously attempted to quantify measurements for the display of the dentition during speech [7], many of them stopped short of qualifying the changes that occur to it. In addition to comparing the display of the dentition during speech to the display of the dentition during the smile, this study will also help to develop norms for the display of the dentition during speech within different age groups. Thus, it will help elucidate the impact of the process of aging to the display of the dentition during speech.

III. Biological Changes in Aging

In addition to understanding the importance of the display of the dentition through the soft tissue frame, it is paramount to have an understanding of how the soft tissue frame changes with respect to the display of the dentition during aging. In a previous study at the University of Connecticut, a cross-sectional analysis demonstrated changes to the display of the dentition during the smile throughout the aging process [9]. This result was not surprising to find as aging is a normal process associated with biology in all members of the animal kingdom.

This process is not only one that occurs at a macroscopic level, but it is also one that originates at a cellular level. Changes possibly due to oxidative damage, genomic instability, mitochondrial DNA, and systemic controls are at the heart of the aging process [10]. Of special importance, are the changes in the soft tissue frame during the process of aging. The changes during the process of aging have an important impact on the display of the dentition during speech. At rest, the lips have been described by many as undergoing changes including thinning, inversion, increased lip length, and redundancy [11, 12]. Although many differences were noted in the smile when doing a cross-sectional analysis, many of the expected changes were not found [9]. The reason may be due to the fact that the orbital muscles in contraction are contracting the lips to the same length as in younger individuals. Although the muscles in aging are slower to reach peak contraction, reaching the full smile in dynamic analysis allows for the evaluation of the smile at its peak. Thus, the effects of aging are masked when analyzing the soft tissue frame during the smile. Therefore, evaluating these soft tissue display parameters at speech may help further elucidate the differences noted in aging.

There are also many other histological features of aging that should noted in the soft tissue display, as they may effect our perception of it. For example, changes in the epidermis and dermis have a profound impact on our perception of the soft tissue frame. Because of exposure to sunlight, the epidermis and dermis of the soft tissue frame show the impact of the process of aging much more readily than do the epidermis and dermis of unexposed areas. The process of aging brings about changes in the epidermis that include a flattening of the dermo-epidermal junction, nuclear atypia, loss of melanocytes, a loss in the number of Langerhans cells, variability in thickness, and variability in cell size and shape. The process of aging in the dermis brings about atrophy due to fewer fibroblasts, fewer mast cells, fewer blood vessels, and shortened capillary loops. Furthermore, dermal alterations in collagen, elastin, and glycosaminoglycans are seen in the process of aging [13-22].

Muscles also show changes during the process of aging. A significant reduction in the cross-sectional area and density of muscles has been reported as a result of the process of aging [23, 24]. There is also evidence of muscle wasting and weakness resulting from loss of functioning motor units. The surviving motor units are enlarged and show relatively slow twitches and firing rates [25-27]. Although maximal contraction is still achieved, the isometric and dynamic strengths in its contraction decline [23], while the time needed to reach peak tension is significantly prolonged during the process of aging [28]. As previously mentioned, this phenomenon may be the reason that changes in the length of the upper lip were not noted in an earlier dynamic study on the display of dentition through the soft tissue frame during the smile.

IV. Rationale

As previously noted, one of the main reason people seek orthodontic treatment is to improve esthetics and the visible display of the dentition during the smile. However, more recently, it has been noticed that the display of the dentition during speech is equally as important. Ideal occlusion should certainly remain the primary goal in orthodontic treatment, but esthetic outcomes are equally as critical in patient satisfaction. Sarver and Ackerman state that esthetic considerations are paramount in treatment planning. Secondly, rigid rules cannot be applied to this process because almost an infinite variety of faces could be esthetic; however, it's important to have general guidelines in optimizing dentofacial esthetics while satisfying other treatment goals [29].

Despite the ever increasing emphasis placed on the esthetics of the display of dentition through the soft tissue frame, the majority of the orthodontic literature and diagnosis is based on the patients' lateral cephalogram, profile picture, and occlusion. A reason that smiles and the display of dentition through the soft tissue frame during speech have not been readily studied in the past could be due to the difficulty in capturing a reliable, repeatable smile and the difficulty in capturing the patient's musculature patterns during speech.

The most important part of an orthodontic treatment is accurate diagnosis of malocclusion and supporting hard and soft tissue structures. When a patient smiles, the soft tissue drape creates a display zone for their teeth. The supporting structures which define this display zone (i.e. lip thickness, intercommisure width, interlabial gap, smile index, and gingival architecture) are also present during the display of the dentition through the soft tissue frame during the speech.

Although the literature concerning the smile and other facets of the display of dentition through the soft tissue frame is a broad and multifaceted subject, most studies have traditionally dealt with the matter in a static fashion where an induced smile in an artificial setting was studied [2]. As such, the smile was recorded as a single point in time, thus incorporating an unavoidable method of error in the collected data, not to mention disregard to the area of study regarding the display of dentition during speech. Most studies capture (or attempt to capture) the peak, or maximum extent, of the smile by using a single photometric image. Obviously, in addition to the uncertainty of acquiring the image at the correct moment, this information lacks information regarding evolvement, as Vicky [2] pointed out that the smile is a 3 staged response, and that merely capturing it at a single moment in time may present the clinician with misleading information. Moreover, evolvement of the smile becomes more dynamic as the process of aging comes into effect.

Many researchers have become more active in evolving from methods of analyzing the smile in the static image to analyzing the smile in the dynamic approach to diagnosing different facets of it. This approach also allows the clinician and researcher to analyze the patient's dental display during speech. In fact, it has even been said that the gold standard for assessing the smile and the display of the dentition during speech is both the clinical exam and a dynamic record of the patient smile [1]. Sarver and Ackerman have shown that a dynamic record can be analyzed in many different frames, as well as to aid in recording the dynamic display of dentition during speech [4, 29].

In addition to allowing the researcher to capture the smile at its peak and to visualize the patient's display of dentition through the soft tissue during speech, the dynamic record also gives the researcher another advantage that a static record of the smile will not. Because the dynamic record captures many frames, finding the smile at its peak or finding an articulated phrase in a series of words not only becomes easier, but it also becomes more reproducible [30], reducing the margin of error in any study.

As researchers began orienting their methods for analyzing the smile to methods that would yield repeatable data, as in the display of dentition during speech, a new focus for analysis emerged. Researchers started comparing the display of the dentition during the smile to the display of the dentition during speech [7]. They started noticing quantitative differences between the two. As such, a void was found in the literature in topics that quantified the display of dentition during speech. This study will help quantify the ideal display of dentition through the soft tissue frame during speech using a dynamic static evaluation [1].

A new method for capturing and analyzing smiles as well as the display of the dentition through the soft tissue frame during speech, which is both affordable and time efficient, has been developed. Recent articles [4, 29] explain this method through the use of videography and computer software. Recording for five seconds, while having the patient say "Chester eats cheesecake on the Chesapeake", relax, and then smile, at 30 frames per second, produces 150 frames which can be analyzed. This method allows the researcher to find the widest smile more accurately as well as allowing the researcher to study the patient's musculature patterns during speech. Separate software is then used to make measurements on selected frames.

More recently, Ackerman [5] stated that the frame representing the "chee" articulation, was best suited in representing an ideal lip-tooth presentation at smile. In reference to this study, it was determined to use frames representing this articulation and frames representing the most display of maxillary and mandibular incisor display for analysis.

V. Scientific Background

Ackerman and Sarver [4] have introduced methods which used videography to analyze smiles. They used a digital video camera mounted on a tripod and placed it at a fixed distance from the patient. They set the lens parallel to the true perpendicular of the face in natural head position, and the camera is raised to the level of the patient's lower facial third. Then the patient is asked to repeat the phrase "Chelsea eats cheesecake by the Chesapeake," relax, then smile. About five seconds of dynamic smile analysis video is obtained for each patient at each time point. The video clip is downloaded to their software where it is compressed and converted to a 4 MB video file. They then search for the frame which best represents the patient's "natural unstrained social smile". The selected frame is then captured and exported as a JPEG file which can be analyzed for measurements.

In this study, a method similar to that introduced by Ackerman and Sarver [4] will be used. In fact, the protocol will follow standards for record taking and research at the University of Connecticut for dynamic smile analysis. Some key differences from protocol used by Ackerman and Sarver [4] will be the camera and the software used. This study will use a camera already in use at the clinic, a Canon GL 2 MiniDV, which will obtain better quality video. The software will also be PC based, as opposed to the mac based software proposed by Sarver and Ackerman's research [4].

Null Hypothesis

General Null Hypothesis

1. The display of the dentition will be the same at speech as the display of the dentition during smile.

Specific Null Hypotheses

1. The amount of maxillary incisor exposed at its peak value, during speech, will not decrease with age.
2. The amount of maxillary incisal display during maximal display of maxillary incisors during speech is different from that recorded during the smile.
3. The upper lip length during certain articulations is not correlated to the amount of maxillary incisor exposed during smile.
4. The length of the upper lip during speech will stay the same during the aging process.
5. The amount of contraction seen in the upper lip during speech will stay the same during the aging process.
6. The amount of mandibular incisor display, during speech, will not show an increase with age.
7. Interlabial height during maximal display of maxillary incisors will stay the same during the aging process.
8. The constructed smile index will yield measurements different from those produced by dynamic analysis of the smile.
9. The amount of buccal corridor is different in speech than the amount of buccal corridor during smile.

Materials and Methods

The study will be conducted on a previously researched Dynamic Record sample which was previously analyzed by the University of Connecticut, Division of Orthodontics. The sample will already have an informed consent provided. This study will conduct analysis on different frames from the previously analyzed dynamic records. The frames that this study will analyze will include frames for both the pronunciation of the hard and soft "e" per Ackerman's protocol [29, 30] and Zachrisson's finding [6], which correlate best to the frames that represent maximal display of the maxillary and mandibular incisors as well as widest dental display. Although the frames would most likely correspond to these vowels, the frames were not limited to these vowels. The whole speech was analyzed to find the frames which best represented the maximal display of maxillary incisors and the widest transverse dental display during speech.

I. Materials

1. Canon GL-2 miniDV camera
2. Gateway E2000 P04 computer
3. 15" Gateway FPD1530 monitor
4. ScenalyzerLive 4.0
5. Adobe Photoshop CS2
6. Microsoft Excel

The samples used in this study were those from which a previous study at the University of Connecticut was conducted [9]. The study design was similar to that which was proposed by Ackerman and Sarver [1, 4, 29-31]. Some notable differences were the camera and software used to conduct the investigation. In this study, a newer miniDV camera (Canon GL-2) was used to create better resolution of JPEG files. A millimeter ruler was included in the study video to help standardize the frames in order to obtain direct measurements. The videos were uploaded to the computer through the ScenanlyzerLive 4.0 software program, a PC based video analyzing program, which was utilized in this study as apposed to the Mac based program described by Ackerman and Sarver [4]. The videos were then analyzed frame by frame in order to export JPEG files of the frames which best represented maximal incisor display and widest dental display during speech. Adobe Photoshop CS2 was used to measure the smile features on the JPEG files.

II. Subject Recruitment

The University of Connecticut Institutional Review Board approval was obtained for the study and subject selection process (IRB Number: 07-045-1). The subjects were students/residents, staff, faculty, patients, and parents/guardians at the University of Connecticut Health Center. The decision to participate in the study was left solely to the discretion of the subject, and it was made clear that their decision was voluntary. The subject's decision for involvement in the study would have no effect on their status as a student, patient, employee, or guardian. The protocol for obtaining this informed consent for inclusion in the study as a subject involved a full explanation to potential subjects that the study would be solely on lip movements and the display of dentition, and that involvement would be anonymous as the records only captured movement of the lips focused from the chin to the nose. A short questionnaire (Appendix A) was also given to the subjects following the 5 second dynamic record. Dynamic records of 261 subjects were taken sequentially. Of these 261 subjects, 40 subjects were excluded from the data analysis for the reasons shown in Table 1. The remaining 221 subjects were then separated into five categories based on the following age ranges: Group(G)1 (15-19 year old), G2 (20-29 year old), G3 (30-39 year old), G4 (40-49 year old), and G5 (50 years and older). A description of the sample is illustrated in Tables 2 and 3. The ages ranged from 15-70 years of age and 59.7% (132 subjects) were female and the remaining 40.3% (89 subjects) were male. Furthermore, 59.3% (131 subjects) had a history of orthodontic treatment while 40.7% (90 subjects) reported no history of orthodontic treatment.

Table 1. Exclusion Criteria

Reason for Exclusion	Total
Anterior prosthodontics	26
Video error	1
Did not smile	6
Head position off	4
Lip enhancements	1
Lip irregularity	1
Lips not at rest	1
Total	40

Table 2. Description of Study Sample (age groups)

Age group	Total (%)
15-19	49 (22.2)
20-29	64 (29.0)
30-39	35 (15.8)
40-49	42 (19.0)
50+	31 (14.0)
Total (%)	221 (100)

Table 3. Description of Study Sample (Gender and history of orthodontic treatment)

Gender		History of Orthodontics	
Female (%)	Male (%)	Yes	No
132 (59.7)	89 (40.3)	131 (59.3)	90 (40.7)

Inclusion criteria:

1. All people over 15 years of age
2. no active orthodontic treatment
3. ability to understand their voluntary involvement in the study and to answer questions on the questionnaire (Appendix A)

Exclusion criteria:

1. missing tooth visible in smile
2. prosthodontic work on teeth/tooth visible in smile
3. gross facial asymmetries

4. Excessive dental attrition
5. lip irregularities or history of lip surgery
6. inability to determine natural head position, occlusal plane, or any measurements
7. inability to hold the millimeter ruler parallel to the lens
8. Exclusion from the previous study
9. Patients in an angry or sad mood

For analytical purposes, the subjects that were included and analyzed in the first study, were then included and re-analyzed in the second study. The measurements made in the second study would then be compared to the measurements made in the first study to help find similarities and differences in the display of the dentition through the soft tissue frame during both speech and smile.

Dynamic records of speech also raise a question of patient emotion during the record. If, for example, a patient entered the clinic in a happy mood, and underwent the dynamic record in a happy mood would these records be different under normal moods. In 2005, Lee and colleagues [32] analyzed the speech under different moods. They observed that the happy mood and the normal mood did not create any differences in articulation. They noted that the only moods that would alter speech articulation were the upset moods and the sad moods. For this reason, angry or sad patients were also excluded from the study.

III. Method of Data Collection

First, the subjects who agreed to voluntarily participate in the study were asked questions including age, sex, and history of orthodontic or prosthodontic treatment from a short questionnaire (Appendix A). The only record matching the dynamic record to the questionnaire was the study number that each subject was given. This study number was stated in both the dynamic record and also marked on the top of the questionnaire. A Canon GL-2 miniDV video camera was set on a tripod approximately 4 feet away from the standing subject in order to take the dynamic record. The subjects were instructed to hold their head in natural head position by looking straight into an imaginary mirror. If position required correction the researcher helped the subject into natural head orientation [33]. The camera lens was adjusted parallel to the apparent occlusal plane and the camera focused only on the dentofacial complex (corresponding to the area from the nose to the chin). Focusing the field of vision to only the dentofacial complex would help to maintain anonymity of the subject. Included in the captured area in the dynamic record were two rulers with millimeter markings. These two rulers were made to fit perpendicular to each other in order to help minimize error. If the subject was unable to hold the ruler perpendicular in one dimension to the angle in which the dynamic record was taken, the second ruler would still be perpendicular to the camera. The subjects were given the following instructions; They were told to hold the millimeter ruler to their chin and to say: "Subject number ____, Chester eats cheesecake by the Chesapeake," relax for a few seconds after saying the phrase, and then to smile. The recording began a second before the subject began speaking and the ended a second after they finished smiling.

The video clip was then downloaded to a Gateway computer (E2000 P04) and uploaded to ScenalyzerLive 4.0 (Vienna, Austria) software, a video editing program. Each frame was analyzed and the two frames which best represented the maximal display of incisors during speech and the widest transverse display of dentition during speech was captured for the study.

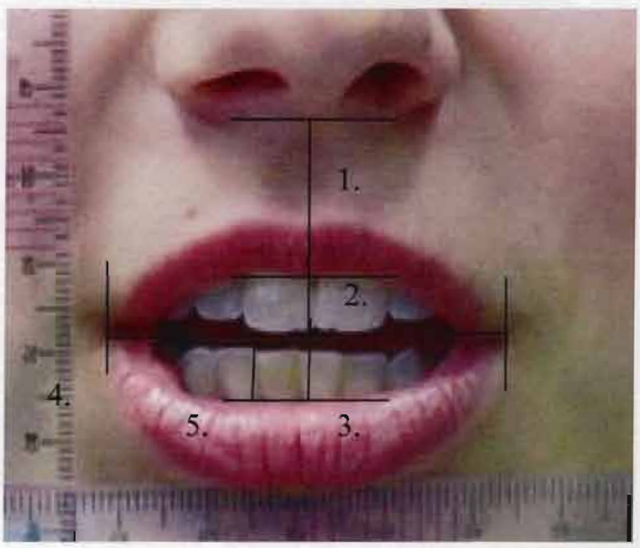
The captured frames were then converted into a JPEG file by the Scenalyzer program and renamed within Microsoft Windows XP Professional with appropriate subject number and width/height frame (example: 1 width, 1 height, etc.).

Each file was opened in Adobe Photoshop CS2 (San Jose, CA) and adjusted using the millimeter ruler in the frame to help standardize the photos in order to take direct measurements from the frames. The following procedure was used to adjust each picture. First, the resolution was changed to 300 pixels/inch by going to image>image size. Then, the ruler function was chosen on Adobe Photoshop CS2 and set to millimeter. It was determined which cross configuration millimeter ruler was most parallel to the camera lens. If neither ruler was parallel then the subject was excluded from the study. Then, on the parallel end of the ruler a 10 mm length, close to the smile area, was measured. That number was divided into 10 (10/measurement on JPEG file) and multiplied by the width value found in image size screen (image>image size). The resulting number was copied and pasted in place of the width reading and the changes were applied to the JPEG file. To check the accuracy of these steps the 10 mm area on the ruler was measured again. If done correctly, this measurement would read 10 mm and thus direct measurements could be recorded from that JPEG file. In Adobe Photoshop CS2 the following measurements were obtained and entered into Microsoft Excel:

Measurements on Most Incisor Display during Speech Frame (Figure 1)

1. Upper lip length- from subnasale to stomion superius
2. Maxillary incisal display – from stomion superius to maxillary incisal edge
3. Distance from the maxillary incisors to the lower lip – from maxillary incisal edge to stomion inferius
4. Intercommissural width – point from right to left commisures
5. Mandibular incisor display – Most coronal point visible on the mandibular incisor to stomion inferius
6. Interlabial gap - direct measurement only taken if lower lip covers maxillary incisal edge, otherwise measurement #2 plus #3 is used

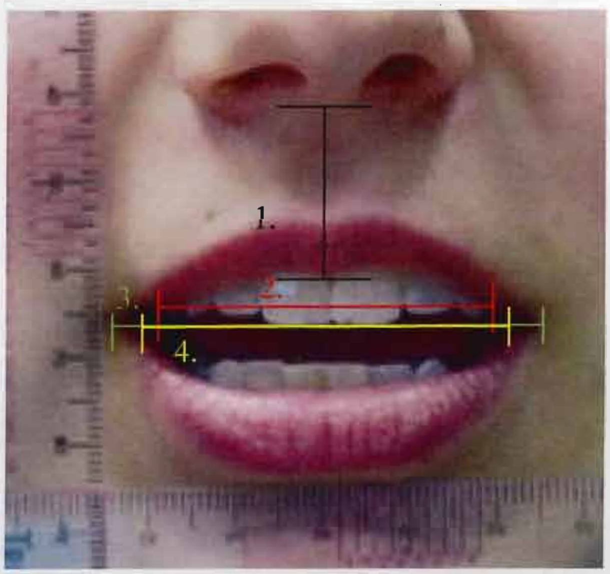
<u>Figure 1.</u> Maximal Display of Maxillary Incisors



Measurements on Widest Display of Dentition during Speech Frame (Figure 2)

1. Upper lip length- subnasale to stomion superius
2. Widest display of dentition – from the most buccal point of the most posterior tooth displayed on both left and right sides
3. Outer intercommissural width
4. Inner intercommissural width
5. Buccal corridors – a constructed measurement, please see definitions section for construction.
6. Maxillary Incisal Display – Stomion superius to maxillary incisal edge
7. Mandibular incisor display - Most coronal point visible on the mandibular incisor to stomion inferius

Figure 2. Widest Transverse Display of Dentition



For the distance measurements, if the central incisors were not at the same levels two measurements were taken and the average used for that subject.

From the questionnaire, the age (in years), sex (male or female), and history of orthodontic treatment (yes or no) were also entered in Excel. If the subject reported any anterior prosthodontic work or any history of lip surgery they were excluded from the study as per the exclusion criteria.

For dental display measurements, the frame with the larger corresponding measurement was used in the study for analytical purposes. Although the maxillary incisor display was always largest in the 1st figure, the mandibular incisor was greater in the 2nd figure in 7 of the subjects.

IV. Definitions

Moore et al [34] defined the buccal corridor as the difference between visible maxillary dentition width and inner commissure width divided by inner commissure width reported as a percentage. This percentage represents the amount of the inner commissure width occupied by the buccal corridor. In this study, a constructed buccal corridor will be used for analysis. This measure will then be compared to previous measures obtained through analysis done on dynamic records at the University of Connecticut. This measure will help determine whether the buccal corridor exists during speech, or whether it is a phenomenon limited to the smile.

To quantify the frontal smile Ackerman et al [29, 31] described smile index as the area framed by the lips during social smile. The smile index was determined by dividing the outer intercommissural width by the interlabial height during smile. In this study, the smile index will be made using a constructed method. As speech is a dynamic phenomenon, it was important to make these measurements by taking the interlabial gap at maximal incisal display, as it would be largest at this point, and to use the outer intercommissural width during the widest display of dentition. We would then use this constructed index, and compare it to the smile index obtained in previous dynamic smile analysis studies at the University of Connecticut to determine whether this would be an accurate assessment of the display of dentition during speech.

Many of these definitions have variations throughout the literature; however, those outlined above are used in this study.

a. Amount of maxillary incisor exposed during speech
b. Amount of mandibular incisor exposed during speech
c. Widest transverse display of dentition during speech
d. Change in length (elasticity) of the upper lip
e. Upper lip length
f. Stomion Superius to maxillary incisor edge (used to determine maximal maxillary incisor display)
g. Stomion Inferius to maxillary incisor edge

h. Intercommissural width

i. Change of intercommisural width during speech

j. Constructed Smile Index

k. Constructed Buccal Corridor

The comparison of the constructed indices will help to determine whether using the display of dentition during speech will help to yield results that are comparable to a reproducible social smile. For the distance measurements if the central incisors are not at the same levels two measurements will be taken and the average will be used for that subject.

For each measurement we will use a significance level of $\alpha = 0.05$. A sample of 125 individuals will yield 80% power to detect a weak correlation ($p = 0.25$). The age groups will be (1) 15-19, (2) 20-29, (3) 30-39, (4) 40-49, and (5) 50+. The subjects will be students/residents, staff, faculty, patients, and parents/guardians at the University of Connecticut Health Center. Their decision to participate has no effect on their status as student, employee, patient, or guardian.

For each area measured a statistical analysis will be done to obtain average, median, and standard deviation. The questionnaire will be used to obtain age related statistics. A students t-test will be applied to all categories with continuous data, with the use of ANOVAs to help determine whether any statistically significant differences exist for the different age groups. Further, a Fischer's exact test will be used to help compare averages for gender differences and differences for subjects who had undergone orthodontic treatment versus subjects that have not undergone orthodontic treatment.

Results

Specific Hypothesis 1

In order to test the hypothesis that the amount of maxillary incisor exposed at its peak value during speech will not decrease with age, a one-way analysis of variance (ANOVA) was conducted. Age was used as a between-subjects factor, and differences in amount of maxillary incisor peak exposure during speech was examined among the age groups.

Descriptive statistics are presented below. Evident from the data is the fact that not all the age groups exhibit the same average maxillary peak exposure during speech. The data suggest that the three youngest age groups exhibit approximately the same average levels of maxillary exposure, and that these three groups exhibit larger maxillary exposure on average than the two oldest age groups.

Table 4. Analysis for Maxillary Peak Exposure during Speech

Overall, differences in the average maxillary peak exposure during speech across age

					95% Confidence Interval for Mean			
	N	Mean	Std. Dev.	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
15-19	49	7.41	1.76	2.52	6.91	7.92	3.20	11.70
20-29	64	7.58	2.03	2.53	7.08	8.09	3.00	12.30
30-39	35	8.17	2.16	0.37	7.42	8.91	4.10	12.70
40-49	42	6.43	2.27	0.35	5.72	7.14	0.00	11.00
50 +	31	5.04	2.35	0.42	4.18	5.9	0.00	10.00
Total	221	7.06	2.29	0.15	6.58	7.35	0.00	12.70

groups is significant ($F(4,216) = 12.00$, $p < 0.001$), in line with clinical observations. Post-hoc pairwise analyses using Tukey's HSD test statistics were conducted to more fully examine age differences in maxillary exposure during speech. These follow-up analyses reveal that age groups 1, 2, and 3 do not significantly differ from one another (all *p values* > 0.05). Group 2 has a significantly larger maxillary exposure compared to group 4 ($p = 0.046$) and group 5 ($p < 0.001$). Group 3 also exhibits a larger maxillary exposure during speech than either group 4 ($p < 0.05$) or group 5 ($p < 0.001$). Finally, age group 4 exhibits a larger maxillary exposure than does age group 5 ($p < 0.05$).

Taken together, these results suggest that there are no significant differences in maxillary peak exposure during speech for patients in the age range of 15 to 39 years; But, there is an average decline noted for the 40 – 49 age group, which continues after age 50.

<u>Gender Differences in Maxillary Peak Exposure During Speech</u>. The descriptive statistics for maxillary exposure are presented below for males and females.

To examine differences in maxillary peak exposure during speech as a function of gender and orthodontic treatment status, Student's t-tests for independent samples were used.

Table 5. Maxillary Peak Exposure during Speech (Gender)

Group Statistics

	Gender	N	Mean	Std. Deviation	Std. Error Mean
SS to MIE	Male	89	6.08	2.44	0.26
	Female	132	7.72	1.92	0.17

On average, females exhibited larger maxillary peak exposure during speech than did males ($t(219) = -5.59$, $p < 0.001$).

Orthodontic Treatment Differences in Maxillary Peak Exposure During Speech. Descriptive statistics for average maxillary exposure are presented below for patients who have not had prior orthodontic treatment and for those that have had prior treatment.

Table 6. Maxillary Peak Exposure during Speech (Treatment)

Group Statistics

	Orthodontic Tx Status	N	Mean	Std. Deviation	Std. Error Mean
SS to MIE	No Tx	90	6.64	2.63	0.28
	Tx	131	7.35	1.98	0.17

On average, those patients who have had no orthodontic treatment exhibited smaller average maxillary peak exposure during speech compared to patients who have had prior orthodontic treatment ($t(219) = -2.26$, $p < 0.05$). The findings were well within statistical significance.

Specific Hypotheisis 2

This hypothesis will be further addressed in the comparative analysis section of the results. It will be addressed by comparative analysis 3.

Specific Hypothesis 3

To test the hypothesis that upper lip length during speech is not associated with amount of maxillary incisor exposed during smile, a correlational analysis using Pearson's *r* was conducted. First, the overall relationship is analyzed, followed by a correlational analysis conducted separately for each age group and by gender.

Overall, there is a significant negative correlation between upper lip length and amount of maxillary incisor displayed during smiling ($r(219) = -0.30$, $p < 0.001$), indicating that smaller upper lip lengths tend to be associated with increased maxillary incisor amounts visible when smiling. When examined by age group, a significant negative correlation was found for Age Group 2 ($r(62) = -0.39$, $p < 0.005$) and Age group 4 ($r(40) = -0.32$, $p < 0.05$) only. For females, there was a significant negative correlation between lip length and amount of maxillary incisor exposed during smiling ($r(130) = -0.28$, $p < 0.05$); however, there was no significant relationship between these variables for males.

Specific Hypothesis 4

To test the hypothesis that lip length (in both widest transverse display of dentition and maximum display of maxillary incisors during speech) does not vary by age, two one-way ANOVAs were conducted using Age Group as the between-subjects factor, upper lip length in widest transverse display of the dentition during speech as the dependent variable in one analysis, and upper lip length in the maximal display of the maxillary incisors during speech as the dependent variable in the second analysis.

Descriptive statistics for upper lip length measures are reported below [widest transverse display of the dentition and maximal display of the maxillary incisors].

Table 7. Analysis for Upper Lip Length during Speech

Descriptives

		95% Confidence Interval for Mean			
		Lower Bound	Upper Bound	Minimum	Maximum
Upper Lip length in Widest transverse dental display (WTDD)	15 - 19	18.43	20.28	10.20	26.40
	20 - 29	18.77	20.16	12.90	25.60
	30 - 39	19.35	21.00	15.20	25.10
	40 - 49	19.49	21.66	14.30	30.70
	50+	20.12	22.16	15.90	26.10
	Total	19.60	20.40	10.20	30.70
Upper Lip length in maximum display of maxillary incisors (MDMI)	15 - 19	17.31	19.18	9.70	24.50
	20 - 29	17.41	18.85	9.40	24.30
	30 - 39	17.65	19.18	15.20	23.90
	40 - 49	18.05	20.67	13.20	34.80
	50+	18.76	20.92	14.10	24.70
	Total	18.25	19.10	9.40	34.80

Average measures of upper lip length in the widest transverse display of the dentition appear to be relatively the same across age groups except for the oldest group (50+), who exhibit a slightly higher upper lip length in width than the younger groups. The same general pattern is observed for measures of upper lip length in the maximal display of the maxillary incisors during speech.

Analyses indicated an overall significant difference among age groups for lip length measured in widest transverse display of dentition ($F(2,216) = 2.63$, $p < 0.05$) but not for lip length measured in maximum display of maxillary incisors. The findings indicate that length of the upper lip in the widest transverse display of dentition during speech is somewhat larger on average for the oldest patients (50+) than it is for the other age groups. The results also indicate that lip length as measured by the maximum display of maxillary incisors during speech is relatively stable across the different age groups examined in this study with no significant differences noted from the analysis.

Post-hoc tests using Tukey's HSD test statistic do not indicate a statistically significant upper lip length (in widest transverse display of dentition) for those patients 50 or older, as compared to patients in the youngest age category ($p < 0.05$); no other pairwise differences were found. None of the pairwise Tukey HSD tests were significant for lip length measured in maximal display of the maxillary incisors during speech.

Differences in Lip Length (in both widest transverse display of dentition and the maximal display of maxillary incisors during speech) by Gender. Descriptive statistics by gender on measures of upper lip width and upper lip height are presented below.

Table 8. Analysis for Upper Lip Length during Speech (Gender)

Group Statistics

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Upper Lip length in WTDD	Male	89	21.47	2.94	0.31
	Female	132	19.01	2.66	0.23
Upper Lip length in MDMI	Male	89	20.33	2.81	0.3
	Female	132	17.56	2.99	0.26

On average, males had larger lip lengths in the widest transverse display of the dentition during speech ($t(219) = 6.47$, $p < 0.001$) and lip lengths during the maximal display of maxillary incisors during speech ($t(219) = 6.92$, $p < 0.001$) as compared to females.

Specific Hypothesis 5

To test the hypothesis that the amount of change in the length of the upper lip during speech will remain the same across age groups, a one-way ANOVA was conducted. The 5 age categories were used as the between-subjects factor, and change in upper lip length during speech served as the dependent variable.

Descriptive statistics are shown below. As can be seen, change in upper lip length was relatively the same, on average, across the 5 age groups examined in this study.

Table 9. Contractility of Upper Lip Length during Speech

Descriptives

Contractility in upper lip length

					95% Confidence Interval for Mean	
	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound
15 - 19	49	1.11	0.93	0.13	0.85	1.38
20 - 29	64	1.34	1.46	0.18	0.97	1.70
30 - 39	35	1.76	1.60	0.27	1.21	2.31
40 - 49	42	1.22	3.15	0.49	0.23	2.20
50+	31	1.30	1.07	0.19	0.91	1.69
Total	221	1.33	1.80	0.12	1.09	1.57

Observed differences in average change in upper lip length during speech were not statistically significant ($F(4,216) = 0.71$, $p > 0.05$), providing no evidence that change in upper lip length differs by age category.

<u>Change in Upper Lip Length During Speech by Gender</u>. Also examined was whether differences in gender are evident in the change in upper lip length during speech. Descriptive statistics are shown below.

Table 10. Contractility of Upper lip length during Speech (Gender)

Group Statistics

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Contractility of upper lip	Male	89	1.14	1.16	0.12
	Female	132	1.45	2.12	0.18

Although the data suggest that females exhibit a slightly larger change in upper lip length than do males, the observed difference is not statistically significant ($t(219) = -1.24$, $p > 0.05$). Therefore, no evidence for a gender difference in change in upper lip length during speech is found.

Specific Hypothesis 6

A one-way ANOVA was used to test the hypothesis that amount of mandibular incisor display does not differ by age. Descriptive statistics are shown on the next page. The pattern of findings suggests that the average mandibular incisor displayed during speech is relatively the same across age groups 1 – 3, with an increase evident in age groups 4 and 5.

Table 11. Mandibular Incisor Display during Speech

Descriptives

Mandibular Incisor Display

					95% Confidence Interval for Mean	
	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound
15 - 19	49	4.06	1.98	0.28	3.49	4.63
20 - 29	64	3.64	1.72	0.22	3.21	4.07
30 - 39	35	3.91	1.86	0.32	3.27	4.55
40 - 49	42	4.46	1.42	0.22	4.02	4.91
50+	31	4.85	2.15	0.39	4.07	5.64
Total	221	4.10	1.85	0.12	3.86	4.35

Overall, average amount of mandibular incisor displayed during speech is not the same across age groups ($F(4,216) = 2.88$, $p < 0.05$). To determine which age groups significantly differed, pairwise post-hoc tests were conducted with Tukey's HSD statistic. Pairwise analysis indicated that the only pairwise difference was between Group 2 and Group 5 ($p < 0.05$). Together, these analyses indicate that the amount of mandibular incisor displayed during speech is relatively stable across age groups with the exception that patients in the age range 20-29 tend to display less mandibular incisor during speech then those patients who are 50 years of age or older.

<u>Mandibular Incisor Display by Gender</u>. Gender differences in mandibular incisor display during speech were also examined. Descriptive statistics are presented below.

Table 12. Mandibular Incisor Display during Speech (Gender)

Group Statistics

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Mandibular Incisor Display	Male	89	4.17	2.03	0.22
	Female	132	4.06	1.72	0.15

It is Evident from the above table that both males and females tend to exhibit about the same amount of mandibular incisor display during speech. The observed differences in means is not statistically significant ($t(219) = 0.45$, $p > 0.05$).

Mandibular Incisor Display by Orthodontic Treatment Status. Differences in amount of mandibular incisor displayed during speech for patients who have not had previous orthodontic treatment compared to those who have had such treatment were also examined. Descriptive statistics are shown below.

Table 13. Mandibular Incisor Display during Speech (Treatment)

Group Statistics

	Orthodontic Tx Status	N	Mean	Std. Deviation	Std. Error Mean
Mandibular Incisor Display	No Tx	90	4.18	1.96	0.21
	Tx	131	4.05	1.77	0.16

The slight difference seen in the above table was not statistically significant ($t(219) = 0.48$, $p > 0.05$). Thus, there is no evidence that the amount of mandibular incisor displayed during speech is different for patients who have had previous orthodontic treatment as compared to patients that have had such treatment.

Specific Hypothesis 7

Four analyses were conducted to test the hypothesis that interlabial height and intercommissural width remains the same across age. Each analysis consisted of a one-way ANOVA with age group as the between-subjects factor; separate ANOVAs were conducted for the four dependent variables of interest: Interlabial height during maximal display of maxillary incisors, intercommissural width at the widest transverse dental display, change in intercommissural width, and widest dental display. Descriptive statistics for each of these analyses are presented below.

Table 14. Smile Index and Widest Dental Display

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
Interlabial Height	15 - 19	49	11.37	2.74	0.39	10.58	12.16	6.90	19.10
	20 - 29	64	11.10	2.59	0.32	10.45	11.75	6.40	15.90
	30 - 39	35	11.74	3.45	0.58	10.55	12.93	5.70	21.90
	40 - 49	42	10.23	2.44	0.38	9.47	10.99	5.80	15.40
	50+	31	9.81	2.80	0.50	8.79	10.84	4.80	17.80
	Total	221	10.92	2.83	0.19	10.54	11.29	4.80	21.90
Intercom missural Width	15 - 19	49	44.00	6.79	0.97	42.05	45.95	29.30	57.40
	20 - 29	64	45.40	5.84	0.73	43.94	46.86	31.60	58.20
	30 - 39	35	45.67	7.10	1.20	43.24	48.11	29.30	62.80
	40 - 49	42	44.12	6.92	1.07	41.97	46.28	31.20	59.80
	50+	31	44.47	7.43	1.34	41.74	47.19	33.50	58.10
	Total	221	44.76	6.67	0.45	43.87	45.64	29.30	62.80
Change in intercom misural width	15 - 19	49	5.70	5.36	0.77	4.16	7.24	-1.90	27.00
	20 - 29	64	7.78	5.91	0.74	6.30	9.25	-5.10	23.40
	30 - 39	35	7.06	6.27	1.06	4.91	9.21	-8.50	21.20
	40 - 49	42	9.40	7.08	1.09	7.19	11.61	-1.40	37.70
	50+	31	6.19	5.07	0.91	4.33	8.05	-9.40	17.30
	Total	221	7.29	6.07	0.41	6.48	8.09	-9.40	37.70
Widest dental display	15 - 19	49	39.19	6.67	0.95	37.28	41.10	25.20	51.50
	20 - 29	64	39.83	6.27	0.78	38.26	41.39	24.90	54.70
	30 - 39	35	39.82	6.71	1.13	37.51	42.12	25.10	55.30
	40 - 49	42	37.93	6.06	0.93	36.04	39.82	26.50	53.60
	50+	31	37.40	6.17	1.11	35.13	39.66	29.00	49.90
	Total	221	38.98	6.39	0.43	38.14	39.83	24.90	55.30

Only 2 of the 4 analyses conducted revealed statistically significant differences between the age groups. Age groups were found to differ in terms of average interlabial height during speech ($F(4,216) = 3.03$, $p < 0.05$), and change in intercommissural width during speech ($F(4,216) = 2.55$, $p < 0.05$). These analyses were followed up with pairwise analyses using Tukey's HSD test statistic. Looking at the means of the 5 age groups for interlabial height, it appears that age groups 1 – 4 exhibit about the same average interlabial height, which is larger in comparison to the interlabial height exhibited by age group 5. Post-hoc pairwise analyses revealed that group 3 showed significantly larger interlabial height than did group 5 ($p < 0.05$), with no other pairwise differences reaching statistical significance. Post-hoc analyses conducted for change in intercommissural width indicated that only groups 1 and 4 differed significantly ($p < 0.05$), with group 4 exhibiting a larger change in intercommissural width in comparison to age group 1. No other pairwise differences were statistically significant.

Interlabial Height during maximal display of maxillary incisors and Intercommissural width during widest transverse display of dentition by Gender. Gender differences in the four variables were also examined using a series of Student's t-tests for independent groups. The descriptive statistics from this series of analyses are shown below.

Table 15. Smile Index and Widest Dental Display (Gender)

Group Statistics

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Interlabial Height	Male	89	10.15	2.83	0.30
	Female	132	11.43	2.72	0.24
Intercommissural Width	Male	89	43.72	7.39	0.78
	Female	132	45.46	6.08	0.53
Change in intercommisural width	Male	89	6.40	6.05	0.64
	Female	132	7.89	6.03	0.53
Widest dental display	Male	89	37.16	6.44	0.68
	Female	132	40.21	6.08	0.53

Analysis revealed that females show larger average interlabial height than males do ($t(219) = -3.37$, $p < 0.001$), and also exhibit larger average dental display during speech as compared to males ($t(219) = -3.57$, $p < 0.001$). Though females also tended to show larger average intercommissural width and change in intercommissural width compared to males, the observed differences were only marginally statistically significant, please see table 27 for further analysis.

Specific Hypothesis 8

Age differences in the constructed smile index were examined using a one-way ANOVA, with post-hoc tests using Tukey's HSD test statistic to evaluate pairwise average differences between age groups. Descriptive statistics from this analysis are shown below.

Table 16. Smile Index

Descriptives

Smile Index

	N	Mean	Std. Deviation
15 - 19	49	4.00	0.82
20 - 29	64	4.34	1.26
30 - 39	35	4.17	1.20
40 - 49	42	4.49	1.02
50+	31	4.88	1.54
Total	221	4.34	1.19

Overall, there was a significant difference in constructed smile index as a function of age ($F(4,216) = 3.01$, $p < 0.05$). Average smile index values among the first 3 age groups appear to be relatively alike, while the smile index for those subjects in groups 4 and 5 appear to be somewhat higher by comparison. Post-hoc significance tests indicated that only groups 1 and 5 differed ($p < 0.05$), with group 1 exhibiting a smaller average smile index score than those subjects in group 5. No other pairwise differences were significant. The analysis indicates that the smile index is smallest for those subjects in the age range of 15 to 19, and largest for subjects over 50 years of age.

Gender Differences in Smile Index. Gender differences in the constructed smile index were examined with a Student's t-test for independent samples. Descriptive statistics are shown below

Table 17. Smile Index (Gender)

Group Statistics

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Smile Index	Male	89	4.60	1.40	0.15
	Female	132	4.17	1.00	0.09

The gender difference in smile index scores seen above is statistically significant ($t(219) = 2.67$, $p < 0.05$). On average, males exhibited a larger smile index than did females.

Specific Hypothesis 9

The Differences in the amount of buccal corridor during speech by age was examined using a one-way ANOVA with age groups as a between-subjects factor. The descriptive statistics from the analysis are presented below.

Table 18. Percentage of Buccal Corridor

Descriptives

Percentage of Buccal Corridor

	N	Mean	Std. Deviation
15 - 19	49	0.11	0.05
20 - 29	64	0.12	0.07
30 - 39	35	0.13	0.05
40 - 49	42	0.14	0.04
50+	31	0.16	0.07
Total	221	0.13	0.06

Overall, there was a significant difference in buccal corridor measurements as a function of age ($F(4,216) = 3.59$, $p < 0.05$). Pairwise differences were examined with post-hoc significance tests using Tukey's HSD test statistic. The post-hoc tests indicated that only age group 1 significantly differed from age group 5 ($p < 0.05$), with those in the age range of 15 to 19 exhibiting smaller average buccal corridor measures than those patients 50 years of age and older. No other pairwise differences were statistically significant.

<u>Gender Differences in Buccal Corridor Measures</u>. A Student's t-test for independent samples was used to examine whether there was a gender difference in buccal corridor measurements. The descriptive statistics are presented below.

Table 19. Percentage of Buccal Corridor (Gender)

Group Statistics

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Percentage of Buccal Corridor	Male	89	0.15	0.07	0.01
	Female	132	0.12	0.05	0.00

Males displayed larger average buccal corridor measures than did females ($t(219) = 3.93$, $p < 0.001$).

Differences in Buccal Corridor by Orthodontic Treatment Status. A Student's t-test for independent samples was also conducted to examine whether buccal corridor width differed for patients who have not had prior orthodontic treatment compared to those who have has such treatment. The descriptive statistics from that analysis is shown below.

Table 20. Percentage of Buccal Corridor (Treatment)

Group Statistics

	Orthodontic Tx Status	N	Mean	Std. Deviation	Std. Error Mean
Percentage of Buccal Corridor	No Tx	90	0.14	0.06	0.01
	Tx	131	0.12	0.06	0.01

On average, buccal corridor width was not significantly different for those patients who have had prior orthodontic treatment as compared to those patients who have not has such treatment ($p > 0.05$).

Comparative Analysis between Smile and Speech

To examine whether there are differences between speech and smile, a series of mixed-model analyses of variance (ANOVA) were conducted. The analyses treated measures of speech and smile for each patient as a within-subjects factor since each patient provided a measure on each indicator of interest. Age Group, Gender, and Orthodontic Treatment Status were used as between-subjects factors in the analyses.

Comparative Analysis 1

To examine whether differences existed in the upper lip length measured during widest transverse dental display during speech and during the smile for each age group, a 2 (speaking vs. smiling) by 5 (Age Group) mixed-model ANOVA was conducted, with the first factor treated as a within-subjects factor and the second factor treated as a between-subjects factor. The results are reported below, beginning with the descriptive statistics.

Upper lip length (measured during widest transverse display of the dentition) during speech for each age category is shown in the top half of the table, and Upper lip length (measured in smile) during smiling for each age group is shown in the bottom half of the table.

Table 21. Upper lip in Smile and Speech

Descriptive Statistics

	AgeGroup	Mean	Std. Deviation	N
During widest transverse dental display during speech	15 - 19	20.40	2.87	49
	20 - 29	19.66	3.04	64
	30 - 39	19.40	2.77	35
	40 - 49	19.91	3.46	42
	50+	20.88	2.77	31
	Total	20.00	3.02	221
during smile	15 - 19	22.21	2.76	49
	20 - 29	21.87	3.02	64
	30 - 39	21.66	2.89	35
	40 - 49	21.43	3.34	42
	50+	22.82	2.68	31
	Total	21.96	2.97	221

The analysis indicated that, regardless of age, there was a significant difference in upper lip length (measured in widest transverse display of the dentition) during speech compared to when smiling ($F(1,216) = 225.22$, $p < 0.001$). On average, upper lip length (measured during widest transverse display during speech) during speech was 20.00, and was 22.00 during smiling. Thus, overall, upper lip length was somewhat smaller in width when speaking than it was when smiling.

The speaking/smiling differences by age group interaction was not statistically significant ($F(4,216) = 1.18$, $p > 0.05$), indicating that the differences between upper lip length (in widest transverse display of dentition) between speaking and smiling were about the same for each age group (i.e., did not differ by age).

Comparative Analysis 2

A 2 (upper lip length in maximal display of maxillary incisors during speech vs. during smiling) by 5 (age group) mixed-model ANOVA was conducted to examine whether lip length during maximal display of maxillary incisors differed during speech from lip length during smiling by age. These findings are reported below, beginning with the descriptive statistics table.

Table 22. Upper Lip Length in Smile and Speech (maximal)

Descriptive Statistics

	AgeGroup	Mean	Std. Deviation	N
During maximal display of maxillary incisors	15 - 19	19.25	2.89	49
	20 - 29	18.31	3.66	64
	30 - 39	18.20	2.64	35
	40 - 49	18.56	3.57	42
	50+	19.20	2.75	31
	Total	18.67	3.22	221
during smile	15 - 19	17.25	2.91	49
	20 - 29	17.06	2.52	64
	30 - 39	16.95	2.48	35
	40 - 49	17.14	3.11	42
	50+	18.11	2.30	31
	Total	17.25	2.70	221

As before, the top half of the table contains upper lip length (maximal display of maxillary incisors) during speech for each age group, and the bottom half contains that same measure during smiling for each age group.

Analysis indicates that, regardless of age group, there is a significant difference in upper lip length (maximal display of maxillary incisors) during speech as compared to during smiling ($F(1,216) = 83.89$, $p < .001$). On average, upper lip length was larger during speech than it was during smiling (18.67 vs. 17.25).

The speaking/smiling differences by age group interaction was not statistically significant ($F(4,216) = 1.14$, $p > 0.05$), indicating that the differences between upper lip length (in maximum display of maxillary incisors) between speaking and smiling were about the same for each age group (i.e., did not differ by age).

Comparative Analysis 3

A 2 (amount of maxillary incisor exposed during speech vs. during smiling) by 5 (age group) mixed-model ANOVA was conducted to examine whether maxillary exposure differed during speech from amount of maxillary exposed during smiling by age group. These findings are reported below, beginning with the descriptive statistics table.

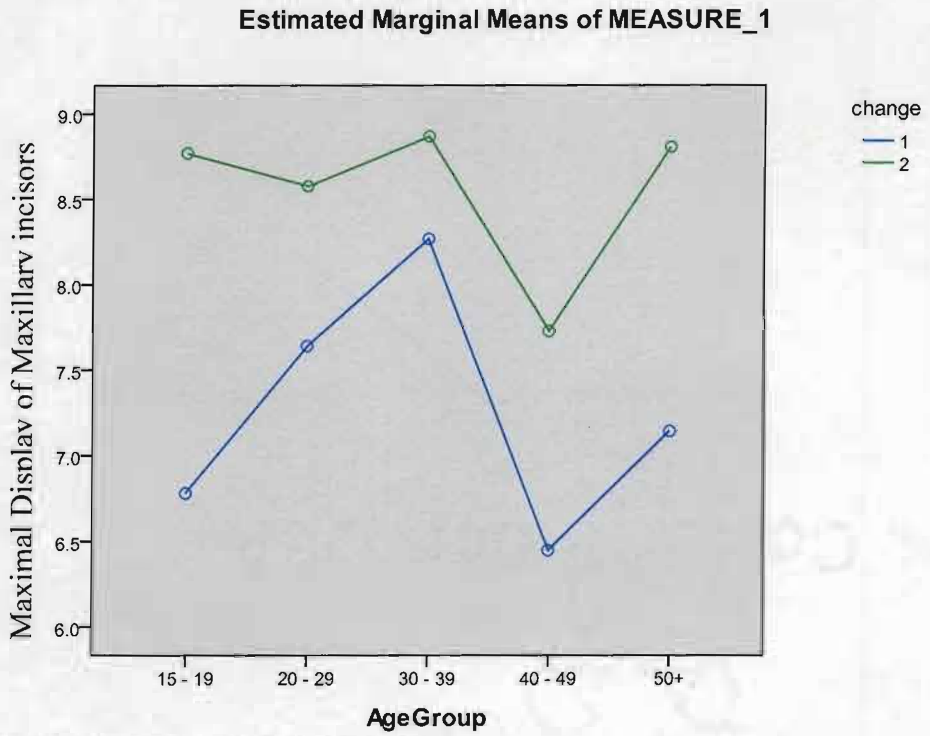
Table 23. Maxillary Incisor Display in Speech and Smile

Descriptive Statistics

	AgeGroup	Mean	Std. Deviation	N
Maximal Incisor Display during Speech	15 – 19	6.78	2.23	40
	20 – 29	7.64	2.18	51
	30 – 39	8.27	2.02	26
	40 – 49	6.45	2.25	35
	50+	7.14	2.05	24
	Total	7.23	2.23	176
Incisor display during smile	15 – 19	8.77	2.07	40
	20 – 29	8.58	2.22	51
	30 – 39	8.87	2.22	26
	40 – 49	7.73	2.68	35
	50+	8.80	2.06	24
	Total	8.52	2.28	176

Analysis indicates that, regardless of age group, there is a significant difference in the amount of maximal display of maxillary incisor exposed during speech as compared to during smiling ($F(1,171) = 77.89$, $p < .001$). On average, less maxillary incisor was exposed during maximal display of maxillary incisors during speech than it was during smiling (7.23 vs. 8.52). Amount of maxillary incisor exposed during maximal display of maxillary incisors during speech vs. during smiling also differed by age ($F(4,171) = 2.97$, $p < 0.05$). The pattern of age difference can be seen in the following graph.

Figure 3. Comparison of Incisor on Speech and Smile



Differences in maxillary incisor exposure between speech and smiling are evident for the youngest age group, but become less apparent in the subsequent age groups, although some differences are evident throughout. For subjects in the age range of 15 to 19, more maxillary incisor is exposed while smiling then is exposed while speaking. Such differences converge for age groups 20 to 29 and 30 to 39. For the age group 40 to 49, there is again less maxillary incisor exposed during speaking than is exposed while smiling, and such differences in exposure continue for those 50 years and older.

Comparative Analysis 4

A 2 (smile index during speech vs. during smiling) by 5 (age group) mixed-model ANOVA was conducted to examine whether smile index values differed during speech from smile index scores during smiling by age group. These findings are reported below, beginning with the descriptive statistics table.

Table 24. Smile Index in Speech and Smile

Descriptive Statistics

	AgeGroup	Mean	Std. Deviation	N
Constructed Smile Index	15 - 19	4.31	1.14	49
	20 - 29	4.26	1.06	64
	30 - 39	3.85	1.22	32
	40 - 49	4.83	1.19	42
	50+	4.54	1.28	30
	Total	4.36	1.19	217
Smile Index	15 - 19	6.64	2.57	49
	20 - 29	7.04	2.75	64
	30 - 39	6.22	2.02	32
	40 - 49	7.71	4.05	42
	50+	6.96	2.56	30
	Total	6.94	2.91	217

Analysis indicates that, regardless of age group, there is a significant difference in the smile index during speech as compared to during smiling ($F(1,212) = 171.96$, $p < 0.001$). On average, the smile index was smaller during speech than it was during smiling (4.36 vs. 6.94).

The speaking/smiling differences by age group interaction was not statistically significant ($F(4,212) = .39$, $p > 0.05$), indicating that the differences in the smile index between speaking and smiling were about the same for each age group (i.e., did not differ by age).

Comparative Analysis 5

A 2 (buccal corridors during speech vs. during smiling) by 5 (age group) mixed-model ANOVA was conducted to examine whether the buccal corridor measures differed during speech from those same measures during smiling by age group. These findings are reported below, beginning with the descriptive statistics table.

Table 25. Buccal Corridors in Smile and Speech

Descriptive Statistics

	AgeGroup	Mean	Std. Deviation
Percentage of Buccal Corridor During Speech	15 - 19	0.14	0.06
	20 - 29	0.11	0.06
	30 - 39	0.11	0.04
	40 - 49	0.14	0.05
	50+	0.15	0.07
	Total	0.13	0.06
Percentage of Buccal Corridor During Smile	15 - 19	0.11	0.06
	20 - 29	0.12	0.05
	30 - 39	0.11	0.04
	40 - 49	0.13	0.05
	50+	0.14	0.06
	Total	0.12	0.05

The analysis indicated that, regardless of age, there was a marginally significant difference in buccal corridor measures during speech compared to when smiling ($F(1,212) = 3.86$, $p = 0.051$). On average, buccal corridor measures were slightly higher during speech (0.13) than they were during smiling (0.12).

The speaking/smiling differences by age group interaction was not statistically significant ($F(4,212) = 1.57$, $p > 0.05$), indicating that the differences between buccal corridor measures between speaking and smiling were about the same for each age group (i.e., did not differ by age).

Further Analysis not included in the hypothesis

Analysis of differences in innercommisural width by age were conducted using a one-way ANOVA. Descriptive statistics from the analysis are shown below.

Table 26. Analysis of Intercommissural Width

Descriptives

Inner commisural width

					95% Confidence Interval for Mean			
	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
15 - 19	49	44.00	6.79	0.97	42.05	45.95	29.30	57.40
20 - 29	64	45.40	5.84	0.73	43.94	46.86	31.60	58.20
30 - 39	35	45.92	7.32	1.24	43.40	48.43	29.30	62.80
40 - 49	42	44.12	6.92	1.07	41.97	46.28	31.20	59.80
50+	31	44.47	7.43	1.34	41.74	47.19	33.50	58.10
Total	221	44.80	6.72	0.45	43.91	45.69	29.30	62.80

There were no statistically significant differences in intercommissural width as a function of age ($F(4,216) = .66$, $p > 0.05$). Thus, the age groups all exhibit about the same intercommissural width.

Gender and Intercommissural Width. To examine gender differences in intercommissural width, a Student's t-test for independent samples was used. Results are shown below.

Table 27. Analysis of Intercommissural Width (Gender)

Group Statistics

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Inner commisural width	Male	89	43.72	7.39	0.78
	Female	132	45.52	6.15	0.54

Females exhibited larger intercommissural width on average as compared to males. The difference was marginally significant ($t(219) = -1.96$, $p = .051$).

Discussion

This study was undertaken to analyze the age changes that result with the aging process in terms of the display of dentition during speech. In addition, this study compares certain aspects in the display of the dentition during speech to similar aspects during the display of the dentition during smile [9]. Given that the subjects were from the same sample population in both this study and the previous study one, the authors felt that the measurements for the display of the dentition during both the smile and the speech were more amenable to comparison as ethnic bias and other confounding factors usually present in a typical retrospective study were not applicable.

It is important to point out that an ideal research on this subject would consist of a long-term longitudinal study to evaluate the changes that would occur to the display of the dentition during the smile and speech. However, because this study compared the changes in the display of dentition during speech to those obtained during the smile, it was imperative to use the same sample population that was used in the reference research study that obtained the measurements for the display of the dentition during the smile. Other factors also contributed to the choice of the study being cross sectional. These factors included financing such a project, patient drop off from such studies, and changes in the methods of evaluation over the long term. Thus, this study was cross-sectional in order to compare results for the display of the dentition during the speech to the previously obtained results for the display of dentition during the smile. Although there are certain limitations in undertaking a cross-sectional study, the previous study's reported results were comparable to many other studies analyzing the display of dentition [3, 5, 6, 9, 29]. Furthermore, the sample that was used made it possible to study the display of the dentition through the full range of speech as the records used were dynamic ones [1, 4, 31].

This study also further divided the sample population into groups of orthodontically treated and non-orthodontically treated sub-groups. The rationale behind creating these sub-groups was to further evaluate claims made in the current orthodontic literature that treatment leads to "fuller buccal corridors" and that the display of the maxillary incisors is also fuller.

The first measurement addressed in this study was the maximal display of maxillary incisor during speech. The amount of maxillary incisor display during speech varied as the subject went from the articulation of one syllable to the articulation of another syllable. Because the study would compare this measurement to the amount of maxillary incisor display during the smile, it was determined to measure the incisors during the articulation which represented the greatest display of maxillary incisors. Besides its comparability to the amount of incisor display during smile, this measurement was one that could be reproducibly captured for analysis using the methods described earlier. This study showed that the amount of maxillary incisor display stayed relatively constant with a small increase from age group 1 to age group 3 chronologically. However, there was a decrease in the maximal display of the maxillary incisor when averages from age group 3 were compared to age group 5. Previous studies on the display of the maxillary incisors on smile and rest [35] mentioned that greater displays of maxillary incisors were correlated to a more youthful appearance. Thus it would not be surprising to find that the two older age groups showed a decrease in the maximum display of maxillary incisors during speech. Previous smile studies also noted that there was a decrease in the amount of incisal display during smile with age [36].

After finding a trend in the maximal display of the maxillary incisors, the study was conducted to find out whether there was a correlation between the amount of maxillary incisors displayed during the smile and the maximal display of maxillary incisors during speech. This study found a statistically significant difference between the maximal display of maxillary incisors during speech and the amount of maxillary incisors during the smile. This was not surprising finding given that "gummy" gingival lines were not very frequently encountered during the analysis of the speech.

After comparing the maximum display of maxillary incisors during speech to the amount of maxillary incisor displayed during the smile, we looked for differences in this measurement between orthodontically treated and non-orthodontically treated sub-groups within the sample population. In terms of the display of the maxillary incisors during speech, there was a clinically detectable difference, which was statistically significant. As previously mentioned, this result was not surprising. In any active, fixed-appliance, the forces acting on the dentition are considered to be eruptive and expansive, in both buccal and facial directions. So when orthodontically treated subjects recorded a greater maximal display of maxillary incisors than the non-orthodontically treated subjects, it was a predictable result.

The study also compared male and female sub-groups within the population for differences in the maximal display of maxillary incisors during speech. In previous studies [2, 5, 37], it has been shown that females had, on an average, a higher smile line than their male counterparts. Given that the length of the upper lip was recorded to be longer in the male sub-group of the sample population during speech and that the contractility of the upper lip during speech was greater in the female sub-group, it was expected to see a greater maximal display of maxillary incisors in females during speech. Table 5 shows that, on average, the female population showed 1.65 mm more maxillary incisor during speech than the male population ($p < 0.001$).

The next category that was analyzed in this study was that of the upper lip. The previous study done on the sample population reported that the upper lip length increased by 1 mm on average. A steady increase was noted in the length of the upper lip during the widest transverse dental display, but not during the maximal display of maxillary incisors. The finding for lip length in widest transverse dental display was not statistically significant. The finding may not be statistically significant because the measurement was made when the upper lip is in contraction. As seen in this study, the contraction of the upper lip is not affected by age, thus the increase was nominal. Other studies analyzing the length of the lips also confirm an increase of the upper lip [38].

This study also compared the length of the upper lip during maximal display of maxillary incisors during speech to the length of the upper lip during smile. A statistically significant difference in the length of the upper lip was noted between the maximum display of the maxillary incisors during speech when compared to the length of the upper lip during the smile. The length of the upper lip during maximal display of maxillary incisors was longer than the length of the upper lip during the smile. This would help explain why the maximal display of maxillary incisors during speech is less than the display of maxillary incisors during smile.

Contractility of the upper lip, as seen by changes from the length of the upper lip during maximal display of maxillary incisors during speech to the length of the upper lip during widest transverse display of dentition during speech, clinically showed a steady increase until age groups 4 and 5. However, this finding was not statistically significant. This trend was similar to the trend found in the maximal display of the maxillary incisors during speech and the aging process, and may be an explanation as to why this finding was recorded.

The differences in length of the upper lip between male and female subjects in the sample population were also evaluated. As eluded to previously, the length of the upper lip was, on average, larger in the male sub-group than in the female sub-group at each age group with a statistical significance. This difference may account for a few other differences noted in the study. As previously mentioned, the length of the upper lip in males may account for one of the many reasons that there is a greater maximum display of maxillary incisors during speech for females than there is for males.

The difference in the contractility of the upper lip was also analyzed for differences between the male and female sub-groups within the sample population. Again, the female sub-group recorded a clinically greater measurement across the different age groups. This finding is in agreement with that made by Peck and Peck [39]. Having a greater contractility of the upper lip combined with a shorter length for the upper lip would help explain why females generally showed a greater maximal display of maxillary incisors during speech. Although clinically significant, this finding was not statistically significant. Females were noted to have greater interlabial heights, which could lead to a greater display of mandibular incisors during speech if contractility of the upper lip was not seen. Because females showed greater maximal display of maxillary incisors, and not a greater display of the mandibular incisors, this greater interlabial height should be viewed as an indicative difference in the contractility of the upper lip.

The next variable that was assessed was the amount of mandibular incisor displayed during speech. The only group to show a statistically significant difference in this measurement was the age group over 50. The amount of mandibular incisor display during speech increased with age (p , 0.05); which was in agreement with the study conducted by Vig [36]. The only outlier in this finding was age group 2.

The mandibular incisor display during speech was then further investigated for differences between the orthodontically treated and non-orthodontically treated subgroups within the sample population. As previously mentioned, there was no statistically significant difference found between the two groups. This was a surprising finding given the fact that the average age for the non-orthodontically treated group was a lot greater than the average age for the orthodontically treated group. However, it has been proposed that orthodontic movement always has an extrusive effect on the dentition. Assuming that the older group would naturally show an increase in mandibular incisor display, the younger group could have a "catch-up" effect when comparing the two groups because of the extrusive effects on the dentition due to orthodontic treatment. If one were to compare the amount of mandibular incisor display between orthodontically treated and non-orthodontically treated subjects within the same age groups, a statistically significant difference might be found between the two groups. However, this was not evaluated in this study.

Differences in the amount of mandibular incisor display during speech between male and female sub-groups with the sample population were also investigated. The males showed a clinically significant greater average for mandibular incisor display during speech. However, this finding was not statistically significant. Although females, on average, had greater interlabial heights, and would thus be expected to have greater display of mandibular incisors during speech, they did not. The greater upper lip contractility was probably the main reason for the greater interlabial height. Because females showed greater maximal display of maxillary incisors, this greater interlabial height could be correlated to the contractility of the upper lip, and not the position of the lower lip within the soft tissue frame of the dental display. Thus, it seems perfectly reasonable to see the male population having a greater mandibular incisor display during speech despite the greater interlabial height in females. On the other hand, although the male population showed an increase in mandibular incisor display, the interlabial height was less than the female population. Again, this emphasizes the role of contraction of the upper lip as the primary factor in the averages of the two measurements.

As referenced above, the interlabial height during the maximal display of maxillary incisors was also analyzed in a cross-sectional manner. No observable trend could be observed when analyzing this variable; however, a slight overall decrease was noted. This finding was interpreted to mean that the interlabial height did not change with respect to age. This finding could be used to explain the increase in mandibular incisor display during speech through the aging process. Although the maximal display of maxillary incisors during speech stayed constant for the first three age groups, the general trend was a decrease in that amount from age group 3 to age group 5. Given that no trend could be found in the interlabial height, it is safe to assume that interlabial height stays relatively constant throughout age. Combining these two factors, a stable interlabial height and a decreasing maximal display of maxillary incisors during speech, it would make it foreseeable to find an increase in the display of mandibular incisors during speech.

The interlabial height was then analyzed to find differences between the male and female sub-groups within the population. As expected, females showed a greater interlabial height during maximal display of maxillary incisors during speech that was statistically significant. The biggest contributor to this difference may have been the contractility of the upper lip during maximal display of maxillary incisors during speech and the shorter length of the upper lip. In fact, the sexual dimorphism of the contractility of the upper lip has been observed in previous studies [39]. Because males, on average, showed a greater display of mandibular incisors, contributing this interlabial height to both the upper and lower lips would not be amenable to the results obtained in this study.

The next variable that was measured was the intercommissural width during the widest transverse dental display. This variable stayed relatively constant throughout the aging process. This finding was expected as well. The previous study [9] found a small increase in the smile index as the age group increased. Having seen a relatively constant interlabial height with respect to time in our study, to have a constructed smile index that had similar patterns to those found during the smile would mean that either this measurement would increase or stay relatively constant.

The intercommissural width during the widest transverse dental display was also analyzed for differences between male and female sub-groups within the sample population. On average, females showed a greater intercommissural width for the widest transverse dental display, which was marginally, statistically significant. This finding can translate to one or two more teeth showing in the widest transverse dental display during speech for females than for males. This may be correlated to the fact that females have a larger percentage of buccal corridors than males. The percentage of buccal corridor is a variable that will be further expanded upon later.

Combining the previous two variables allowed for a constructed measurement that could be compared to the smile index analyzed for the smile in the previous study on this sample population. The smile index was popularized by Ackerman [29, 30] for evaluating the smile. To help make a correlation between the smile and speech, a constructed measurement was made. This measurement had a general trend in which the smile index was seen to increase with increasing age. This trend was determined to be statistically significant. The only group that did not conform to this trend was age group 3. Although this may not be expected given the relative constancy in the interlabial height and the intercommissural width during the widest transverse dental display, the changes in the interlabial height during speech still showed an insignificant trend in which the interlabial height decreased overall. This decrease combined with a relatively stable intercommissural width could lead to an increase in the "constructed smile index."

After obtaining this constructed index, it was compared to the smile index that was obtained from the previous study [9]. Both indices showed the same trend in an overall increase in the smile index, with both having group 2 as an outlier. The smile index was significantly greater in the smile than when constructed during speech. This was due to the fact that, on average, the intercommissural width was wider during the smile than during speech.

The constructed smile index was then further analyzed to find differences between male and female sub-groups within the sample population. It was found that the constructed smile index was significantly larger for male subjects than for female subjects. This finding should not come as a surprise, as this difference may be due to the fact that interlabial height during maximal display of maxillary incisors during speech was proportionately greater in females than in males when comparing this number to the intercommissural width during widest dental display, which was also greater in females.

The widest transverse dental display was also assessed in this study. With age a decrease was noted in the transverse width of the dental display. This finding was in agreement with other studies previously conducted on the transverse dimension [40].

This measurement was then analyzed to see whether there were any differences observable between orthodontically treated and non-orthodontically treated sub-groups within the sample population. The orthodontically treated sub-group actually showed greater measurements than the non-orthodontically treated counterparts. This finding was not surprising, as it has often been mentioned that the two primary effects of fixed orthodontic appliances are extrusion of teeth and overall expansion of the arches, in the buccal and facial dimensions. However, there are some factors that may be confounding in this finding. First, the average age of the orthodontically treated sub-group was 27, while the average age of the non-orthodontically treated sub-group was 40. The transverse dimension is subject to contractive forces from the soft tissue over time, and the fact that the non-orthodontically treated sub-group is older would pre-dispose that subgroup to having a smaller measurement for the widest dental display. Also some of the orthodontically treated subjects underwent palatal expansion, leading to a wider transverse display of dentition [3, 41].

The widest transverse dental display during speech was then analyzed for differences between the widest transverse display of dentition during the smile. In general, it was noted that the smile led to greater measurements in the transverse dental display than the widest transverse dental display during speech. This finding was in agreement with the fact that the intercommissural width was greater during smile when compared to intercommissural width during the widest transverse display of the dentition in speech. However, the differences were not statistically significant.

The widest transverse display of dentition during speech was then analyzed to find differences between the male and female sub-groups within the sample population. It was noted that female subjects in the sample population had a wider transverse display of dentition in comparison to the male subjects within the sample population. This finding was in agreement with previous studies on the subject of transverse dimension of the smile [3]. However, the finding was not found to be statistically significant in this study.

The percentage of buccal corridor was then analyzed during speech. In general, there was a statistically significant increase in this measurement with age. This finding was not surprising as, noted earlier, the intercommissural width at the widest transverse display of dentition stayed relatively constant with a small increase overall. Combining this, with the fact that the widest transverse display of dentition decreases over time, would lead to an increasing percentage of buccal corridor.

The percentage of buccal corridor during speech was then compared to the percentage of buccal corridor during smile, as obtained in the previous study. It was found that the percentage of buccal corridor was marginally ($p = 0.051$) greater in speech than during the smile.

The previous study [9] evaluated the buccal corridors in order to determine what amount of perceived buccal corridors was considered average. The authors of the previous study found that 12% for the percentage of buccal corridors was considered average. They followed this measurement throughout the aging process. However, they did not analyze the difference in orthodontically treated and non-orthodontically treated subjects in the sample population. This study made it a priority to analyze this measurement for differences in the percentage of buccal corridor between orthodontically and non-orthodontically treated sub-groups within the sample population. The percentage of buccal corridor was no different in orthodontically treated patients than it was in non-orthodontically treated patients. It should be noted that the percentage of buccal corridor should have no impact or significance in the impact of the smile [42]. As it does not have an impact on the smile, the percentage of buccal corridor during speech should also be non-significant in terms of attractiveness, as there was no clinically nor statistically significant finding that would be used to differentiate the percentage of buccal corridor during the smile and during speech.

The percentage of buccal corridor was then assessed for differences between female and male sub-groups within the sample population. On average, the percentage of buccal corridor was greater in the male population than in the female population. This finding was not surprising given that females had a greater widest transverse display of dentition during the speech.

Conclusions

1. The display of the dentition during speech is different from the display of the dentition during the smile in many ways. The amount of maximal incisor display is different, the widest dental display is different, and so are many other indices that were described. There are also many differences in the soft tissue as well, that may contribute to the differences in dental display. The upper lip length is longer in speech than it is in smile and the intercommissural width is smaller in speech than it is in smile.

   Despite the many differences noted between the speech and the smile, there are some similarities. In the soft tissue the percentage of buccal corridor is statistically the same.

2. The maximum display of maxillary incisors during speech will decrease with age. Despite being consistent for the first three age groups, the maximum display of maxillary incisors during speech decreases significantly during the older 2 age groups.

3. The maximal display of maxillary incisors during speech is less than the display of maxillary incisors during the smile. The maximum display of the maxillary incisors is correlated to the length of the upper lip during speech, and the length of the upper lip was shown to be longer during speech than it was during the smile.

4. The length of the upper lip during speech was shown to be relatively stable throughout the aging process. Contractility of the upper lip was also seen to be relatively stable during the aging process with a clinically significant drop in contractility in the 4th age group, where a clinically significant difference was also noted in the length of the upper lip. This contractility may explain the difference between the findings in this study and the previous one [9].

5. The amount of mandibular incisor display, during speech, did show a difference in respect to age. The most statistically significant finding came when age group 2 was compared to the age group 5. The younger age group showed significantly less mandibular incisor during speech than did the older age group.

6. The interlabial height during maximal display of maxillary incisors stayed relatively constant through the first 4 age groups and then dropped in age group 5. The intercommissural width stayed relatively stable throughout the aging process. These two findings lead to a slight decrease in time to the constructed smile index.

   The constructed smile index was also compared to the smile index from the previous study [9]. It was found that the constructed smile index was significantly smaller than the smile index.

7. The percentage of buccal corridor during speech was found to be larger than the percentage of buccal corridor during smile by a marginal statistical significance.

Females were shown to have a smaller percentage of buccal corridor when compared to their male counter-parts. Their were no statistically significant differences in the percentage of buccal corridor when orthodontically treated and non-orthodontically treated subjects were compared for the percentage of buccal corridor during speech.

Figure 1

Questionnaire: A Dynamic Smile Analysis in Young Adult Individuals

Shyam Desai, DMD

Department of Orthodontics

University of Connecticut Health Center

Subject #

Age

Sex	Male	Female
Have you ever had orthodontic treatment?	YES	NO
If yes to above,		
Have you had maxillary expansion? (RPE, rapid palatal expansion)	YES	NO
Have you had teeth removed for orthodontic treatment?	YES	NO
Have you ever had any facial surgery?	YES	NO
If yes to above then where?		
Have you ever had prosthodontic treatment?	YES	NO
If yes to above,		
Did you ever have any crowns, bridges, veneers, dentures, or partial dentures?	YES	NO

If yes, point to where they are. ______________________________

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