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June 2, 2003

LIP PROFILE PREFERENCES IN VARYING SAGITTAL MANDIBULAR POSITIONS

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science at Virginia Commonwealth University.

by

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I first thank God, who is my Rock. He enables me to do all things through Christ who strengthens me.

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Lastly, I dedicate this work to my wife, Kate. You have been there for me through all of this and much more. Thank you so much for your patience, encouragement, and love.

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Abstract

LIP PROFILE PREFERENCES IN VARYING SAGITTAL MANDIBULAR POSITIONS

By Grant Gordon Coleman, D.M.D.

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Major Director: Steven J. Lindauer, D.M.D., M.D.Sc.
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The purpose of this study was to determine the influence of sagittal mandibular position on preferred lip position in profile. Five androgynous silhouette profiles differing only in the degree of mandibular retro- or prognathism (-25º, -18º, -11º, -4º, & +3º facial contour angles) were created. Using a computer animation program, evaluators moved the lips independently into the position deemed to be the most esthetic for each profile. Evaluators included adolescent orthodontic patients, parents of patients, and orthodontists. In general, no differences in preferred lip position were found between the –11º & -4º profiles or between the –18º & +3º profiles, but preferences for each of the three profile groupings (-11º & -4º, -18º & +3º, and –25º) were different. No differences were found

among the three evaluator groups or between male and female evaluators. Scattered and inconsistent differences were found among lip preferences for male and female profiles.

Introduction

An important aspect of orthodontic diagnosis and treatment planning depends on placement of the dentition within the skeleton to achieve maximum soft tissue esthetics. This is a paradigm shift from the standards used by the specialty in the first half of the twentieth century. Using cephalometrics as a diagnostic tool, optimizing the angulation of the teeth within the underlying skeletal structures was the driving force behind orthodontic treatment planning. Early works by Downs[1], Steiner[2], and Tweed[3] illustrate attempts to find the ideal dental and skeletal relationships to produce balanced, stable results. However, these early analyses paid little attention to the importance of the soft tissues of the face in maximizing facial harmony and esthetics.

Burstone[4], realizing that the soft and hard tissues must be considered together in determining an orthodontic treatment plan, stated that "The most desirable positions of the teeth and supporting structures for facial harmony cannot be determined from the denture alone." In a challenge to the common belief that merely positioning the teeth and skeleton in the "ideal" positions would produce good facial esthetics, he advocated that soft tissue profile analysis should be an important consideration in orthodontic treatment planning.

Ricketts[5] investigated the relationship among the nose, lips, and chin. He developed his "Esthetic Plane" (E-plane), a line extending from the tip of the nose to the tip of the chin, and concluded that it was a convenient reference line for the analysis of lip

position. In a later article, Ricketts[6] presented his Law of Lip Relation, stating that "In a normal white person at maturity, the lips are contained within a line from the nose to the chin, the outlines of the lips are smooth in contour, the upper lip is slightly posterior to the lower lip when related to that line, and the mouth can be closed with no strain." He estimated from clinical observation that the lower lip of adults should be positioned 4mm posterior to the E-plane +/-3mm. For children, he suggested that the lips be slightly fuller, on average 2mm posterior to the E-plane +/-3mm. Ricketts stressed the importance of balance of the lips relative to the nose and chin, pointing out that overly protruded or retruded lips were unharmonious and unesthetic.

In 1967, Burstone revisited the role of the soft tissues in orthodontics. In the article *Lip Posture and Its Significance in Treatment Planning*[7], he stated that lip posture is a critical element not only of overall facial esthetics but also of post-treatment stability and function. Burstone asserted that lip posture should be a consideration when determining where to position the upper and lower incisors during orthodontic treatment.

It became apparent that orthodontists needed to consider not only the static relationship of the lips to other soft tissue structures but also how this relationship changed with growth. Forsberg[8] in 1979 evaluated three groups of 20 male and 20 female patients with average ages of approximately 8, 12, and 25 years. All subjects were untreated and had Class I molar relationships with normal overbite and overjet. Each had a cephalometric radiograph taken in centric occlusion, and the lip profile was evaluated relative to Ricketts' E-plane. Forsberg found that the upper and lower lips became progressively more retruded with age for both males and females. The average upper lip

position was consistently more retrusive than the lower lip. No significant differences between upper and lower lip position were found between male and female subjects except that female subjects at age 12 had a more retruded average lower lip position than males at age 12. The author stated that his findings were partly explained by the proportionately larger growth of the nose relative to the other facial soft tissues with age.

Peck and Peck[9] in 1970 studied how laymen's views of what constituted an esthetic face compared with accepted cephalometric standards. Records were taken of 52 young adult subjects that were recognized as attractive. The sample included professional models, performers, and beauty pageant winners, with an average age of 21 years, 2 months. Mean measured values were consistently fuller and more protrusive than what would have been ideal under the Margolis, Downs, and Steiner cephalometric analyses. The investigators concluded that a more direct evaluation of facial soft tissues was needed instead of rigid adherence to cephalometric ideals.

Cox and Van der Linden[10] attempted to determine if there was a difference in profile preference between orthodontists and laymen. Ten orthodontists and ten laymen evaluated silhouette profiles of three groups of 29 males and three groups of 29 females. The investigators found no significant differences in the esthetic ratings of the profiles between the professionals and the laymen. They also concluded that the faces regarded as the least esthetic were generally more convex.

In an effort to clarify what might be the ideal features of the soft tissue profile, investigators studied different aspects of the facial profile and their effect on esthetics. Foster[11] traced the profile of an 18 year old white female and darkened it into a black

silhouette to reduce the effects of distracting variables such as hair, complexion, and eyes. He used this profile as a baseline and then manipulated the lips horizontally in 2mm increments to create three progressively protruded profiles and three progressively retruded profiles. The set of seven profiles was presented to subjects of differing educational and ethnic backgrounds. Each subject was told to select the profile they thought best represented a male and female 8 year old, 12 year old, 16 year old, and adult. For all subjects, there was a trend toward selecting fuller lip profiles for the 8, 12, and 16 year olds and flatter profiles for adults. No sex differences were found except for the "adult" category, where all subjects preferred fuller lips for females than for males.

Czarnecki[12] in 1993 developed a study in which different aspects of a standardized profile were varied in order to determine what were the most and least desirable combinations of different facial features. An "average" androgynous silhouette was developed. Six sets of seven profiles were created, with different facial features varied in each set, including nose, lip, and chin relationships, facial angle and angle of convexity. In order to analyze only the horizontal aspects of each face, the vertical relationships were unchanged in all of the profiles. Subjects were asked to rank the seven profiles in each set from most desirable to least desirable. The six profile sets were presented twice, and subjects were asked to evaluate them separately as male and female profiles to determine if there was an influence of gender in the evaluation of esthetics. Czarnecki found that preferred horizontal lip position was closely linked to nose and chin position. When a larger nose or chin was present, subjects preferred fuller lips for both males and females. Subjects also preferred fuller lips for female profiles than for male.

In their article *Facial Soft Tissue Harmony and Growth in Orthodontic Treatment*, Nanda and Ghosh[13] reiterated the importance of balancing the relationships of the nose, lips, and chin. They reported that "…it is mandatory that the orthodontist understand clearly the necessary correction of the nose-lip-chin relationship of a given patient before making critical decisions relating to extraction versus non-extraction procedures for the correction of malocclusions." This has become a commonly accepted principle in contemporary orthodontic treatment planning.

As computers have become more powerful and the ability to smoothly animate images has developed, several profile studies have utilized computer-animated profiles instead of static images. Hier[14] scanned a photo of a young adult white male and adjusted the image digitally to create a comparable female profile. Using animation software, he moved the lips in each profile from very retruded to very protruded positions and then spliced the images together to make a smoothly-flowing animated movie. The morphed area extended from subnasale to soft tissue B point. Male and female subjects were shown the movie and asked to press the computer mouse button when the appearance of the profile first became acceptable, and to release the button when the profile became unacceptable again. This identified a "zone of acceptability" for each subject for the male and female profiles. The subjects watched the movie again and clicked the mouse at the point where the profile was most pleasing, called the "most pleasing point," or "MP point." The results showed that both male and female subjects preferred fuller lips than suggested by Ricketts' original E-plane standards. Female subjects preferred a fuller lip position than

male subjects for the "MP point" of the profiles. Also, subjects that had never received orthodontic treatment preferred slightly fuller lips than orthodontically-treated subjects. Several other studies[15,16,17] have used computer animation and the "zone of acceptability" concept in profile analysis.

To date there have been no studies to evaluate specifically the influence of sagittal mandibular position alone on preferred lip position in profile. A wide range of mandibular positions is encountered in the orthodontic patient population. It would be valuable to understand more fully what lip positions are considered most esthetic for different degrees of mandibular retro- and prognathism. Previous studies have required evaluators to select preferred lip positions from a fixed array of choices and have not permitted the upper and lower lip positions to be changed relative to each other.

The purpose of this study was to determine the influence of sagittal mandibular position on preferred lip position. A series of profiles was created that differed in sagittal mandibular position alone, and subjects were given complete control over upper and lower lip positioning using computer animation. The black silhouette androgynous profiles were evaluated twice by each subject, first using the assumption that the profile was of a male and second assuming it was of a female, to determine if there was any influence of gender on preferred lip position. Evaluator groups included orthodontists, adolescent orthodontic patients, and parents of orthodontic patients, and differences in lip preferences among these groups were evaluated. Responses from male and female evaluators were also compared to evaluate differences between them.

Hypothesis

The following null hypotheses were tested:

1. There is no difference in preferred lip position among facial profiles with varying sagittal mandibular positions.
2. There is no difference in lip profile preference among orthodontists, adolescent orthodontic patients, and parents of orthodontic patients.
3. There is no difference in lip profile preference between male and female facial profiles.
4. There is no difference in lip profile preference between male and female evaluators.

Materials and Methods

The cephalometric soft tissue profile of a white male patient treated in the orthodontic department at Virginia Commonwealth University School of Dentistry was traced. The patient displayed a Class I dental and skeletal pattern with vertical and sagittal measurements within the range of normal. Following the recommendations of Foster[11] and Czarnecki[12], the profile was changed to a black androgynous silhouette by tracing the profile and cutting it out of black paper to reduce the influence of any distracting or sex-defining features. As in Czarnecki's study, all vertical relationships were unaltered in order to evaluate only the sagittal aspects of the profile.

To create a range of sagittal mandibular positions representative of what might be encountered in clinical practice, the area from subnasale to soft tissue B point was erased, and the mandibular portion of the silhouette from soft tissue B point to soft tissue menton was cut out. To establish a middle "normal" mandibular position, the mandibular cut-out was positioned sagitally to create a facial convexity angle (g-sn-pg) of -11°.

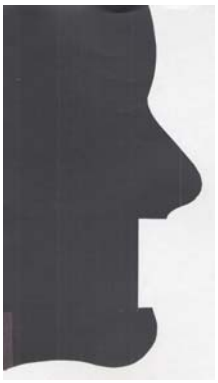

Figure 1: -11º "normal" profile

From this midpoint, the mandible was moved horizontally in increments of 7° to create a series of profiles with facial convexity angles of -25°, -18°, -4°, and +3°, representing moderate and severe Class II profiles, and moderate and severe Class III profiles. The lower face of the profile was divided into an upper one-third and a lower two-thirds, and a line was drawn to be the dividing point between the upper and lower lips.

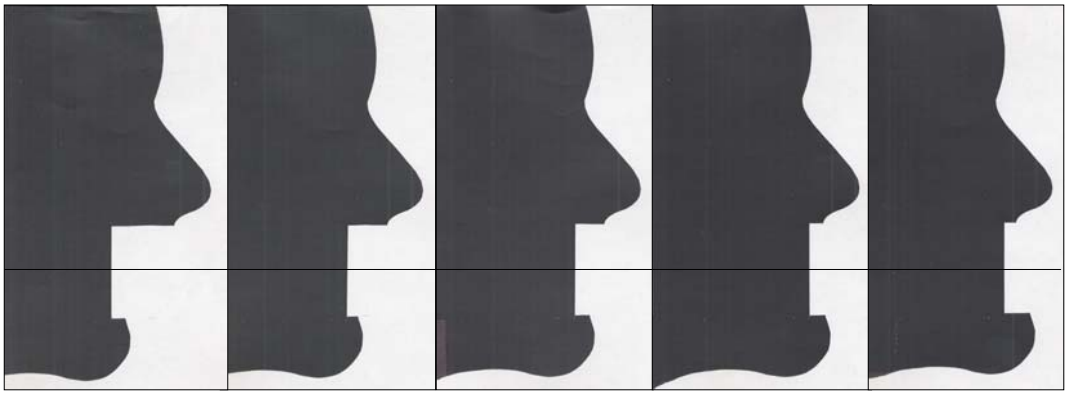

Figure 2: -25º, -18º, -11º, -4º, and +3º profiles, respectively, from left to right

Using various facial photographs as references, upper and lower lips were drawn for each profile from a most retruded position to a protruded position extending several millimeters beyond Ricketts' E-plane.

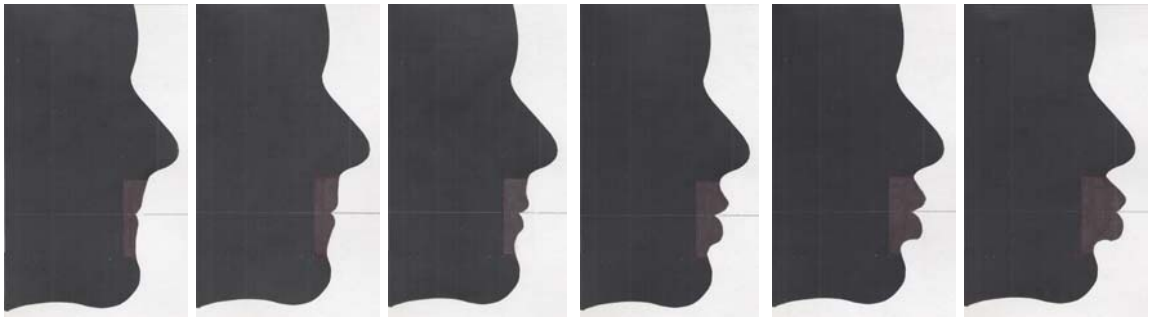

Figure 3: "Stages" of lip protrusion for the –11º profile scanned into the computer prior to morphing

The sequential images for each profile were scanned into a computer and, using the graphic design software Flash MX (Macromedia, Inc., San Francisco, CA), the images were morphed together and animated to create a smoothly-flowing continuum of lip positions from the most retruded to the most protruded positions. The program was designed so that, using the keypad, the upper and lower lips could be moved independently to any position between the retruded and protruded extremes.

Evaluators were limited to Caucasians and included 20 male and 20 female orthodontists, 20 male and 20 female adolescent orthodontic patients between the ages of 10 and 18 years, and 20 male and 20 female parents of orthodontic patients.

Table 1: Description of Evaluators

	Number of Evaluators						
	Gender			Age			
Evaluator	Female	Male	All	Mean	SD	Minimum	Maximum
Patient	20	20	40	14.2	1.96	10	18
Orthodontist	20	20	40	41.8	10.34	28	68
Parent	20	20	40	43.5	6.82	30	59

Using the computer keypad, each evaluator moved the upper and lower lips to the positions they felt appeared the most pleasing for each profile. The profiles were presented individually in two sets. Evaluators were instructed to assume that the first set of profiles was of a male. The first male profile, the -11° norm, was repeated to evaluate intra-examiner reliability. The second set of profiles, unchanged but presented in a different order, was assumed to be of a female. Table 2 describes the profiles and the order in which they were presented. For each new profile shown, the program automatically moved the upper and lower lips separately from the most retruded to the most protruded position and back to demonstrate to examiners the full range of possible lip positions.

The evaluators' response for each profile was printed to scale so that linear measurements of lip position could be performed manually.

Table 2: Description of Profiles and Order of Presentation

Severity	Degree	Profile Presentation Order
Severe Class II	-25º	Male 4, Female 2
Moderate Class II	-18º	Male 2, Female 4
Class I	-11º	Male 1, Male 6, Female 5
Moderate Class III	-4º	Male 3, Female 3
Severe Class III	+3º	Male 5, Female 1

There were eleven printed profiles for each evaluator. Ricketts' E-plane was drawn on each printed response and the perpendicular distances from the E-plane to the upper and lower lips were measured using a digital caliper and recorded to the nearest hundredth of a millimeter.

Statistical Analysis

A mixed-model repeated-measures ANOVA was used to determine differences in lip profile preference related to changes in mandibular position. Between-subject factors considered were evaluator group (patient, orthodontist, or parent) and evaluator sex. Within-subject factors considered were the five different mandibular positions. Interactions considered were between evaluator group*mandibular position and evaluator sex*mandibular position.

Tukey's HSD was used to determine differences between the five different profiles separately for the upper and lower lip positions.

A significance level of 0.05 was used for all analyses.

Results

Repeatability

To test intraexaminer reliability, the –11º male profile was repeated within the series presented to evaluators. Repeated-measures ANOVA was used to compare the identical profiles and revealed that preferences for both upper and lower lip position between the two differed significantly ($p < 0.0001$). The preferred upper and lower lip positions for the second –11º profile were fuller than the first. The lower lip averaged 0.72mm fuller ($p < 0.0001$) and the upper lip averaged 0.55mm fuller ($p < 0.0014$) in the second profile. This suggests that differences in preferred lip positions for the other profiles studied would have to be greater than 0.72mm to be considered meaningful. Data comparing the lip position preferences for the replicate profiles are presented in Table 3.

Table 3: Comparison of Replicate Profiles

	Mean	SE	95%CI	
Profile		Lower Lip		
First -11° Male	5.48	0.181	5.12	5.84
Second -11° Male	4.76	0.181	4.41	5.12
Difference	-0.72	0.171	-1.05	-0.38
		Upper Lip		
First -11° Male	7.59	0.181	7.24	7.95
Second -11° Male	7.04	0.181	6.68	7.40
Difference	-0.55	0.171	-0.89	-0.22

"Mean" is the distance from the E-plane to the lip in millimeters.

Overall Differences

A mixed-model repeated-measures ANOVA (Table 4) was used to determine differences in lip profile preference related to changes in mandibular position. Between-subject factors considered were evaluator group (patient, orthodontist, or parent) and evaluator sex. Neither of these was found to be a statistically significant factor ($p > 0.20$) influencing positioning preference for either the upper or the lower lips. Within individual subjects, mandibular position was found to significantly influence lip profile preferences for both the upper lip ($p < 0.0001$) and the lower lip ($p < 0.0001$). The effect of mandibular position on lip profile preference was different among evaluator groups for the upper lip ($p = 0.0001$) and the lower lip ($p = 0.0036$) but was not different between male and female evaluators ($p > 0.40$ and $p > 0.15$, upper and lower lips, respectively).

Table 4: ANOVA Results

		Lower Lip		Upper Lip	
Source	df	F	p-value	F	p-value
Between-subject factors					
Sex	1	1.35	0.2481	0.89	0.3478
Group	2	0.96	0.3875	0.44	0.6440
Within-subject factors	117				
Mandibular Position	10	88.51	<.0001	110.04	<.0001
Interactions					
Evaluator Sex*Mand. Position	10	1.44	0.1569	1.05	0.4017
Evaluator Group*Mand. Position	20	2.08	0.0036	2.65	0.0001

Differences Among Profiles with Varying Mandibular Positions

Average upper and lower lip position preferences for each profile and evaluator group are shown in Figure 4 and Figure 5. All of the average preferred lip positions were posterior to the E-plane.

Within each of the evaluator groups, there were significant differences in preferred lip position for the five different mandibular positions ($p < 0.0001$). Tukey's HSD was used to determine the differences.

For both upper and lower lips within the patient evaluator group, the –11º and –4º profiles were not different, the –18º and +3º profiles were not different, but each of the three profile groupings (-11º & -4º, -18º & +3º, -25º) were significantly different from each other.

Within the orthodontist evaluator group, lower lip position for the –11º and –4º profiles was not different, for the –18º and +3º profiles was not different, but each of the three profile groupings (-11º & -4º, -18º & +3º, -25º) were different from each other. For upper lip position, all of the five profiles differed significantly from each other.

For parent evaluators, lower lip position for the –11º and –4º profiles was not different, but each of the four profile groupings (-11º & -4º, -18º, +3º, -25º) were different from each other. For upper lip position, the –11º and –4º profiles were not different, the -18º and +3º profiles were not different, but each of the three profile groupings (-11º & -4º, -18º & +3º, -25º) were different from each other.

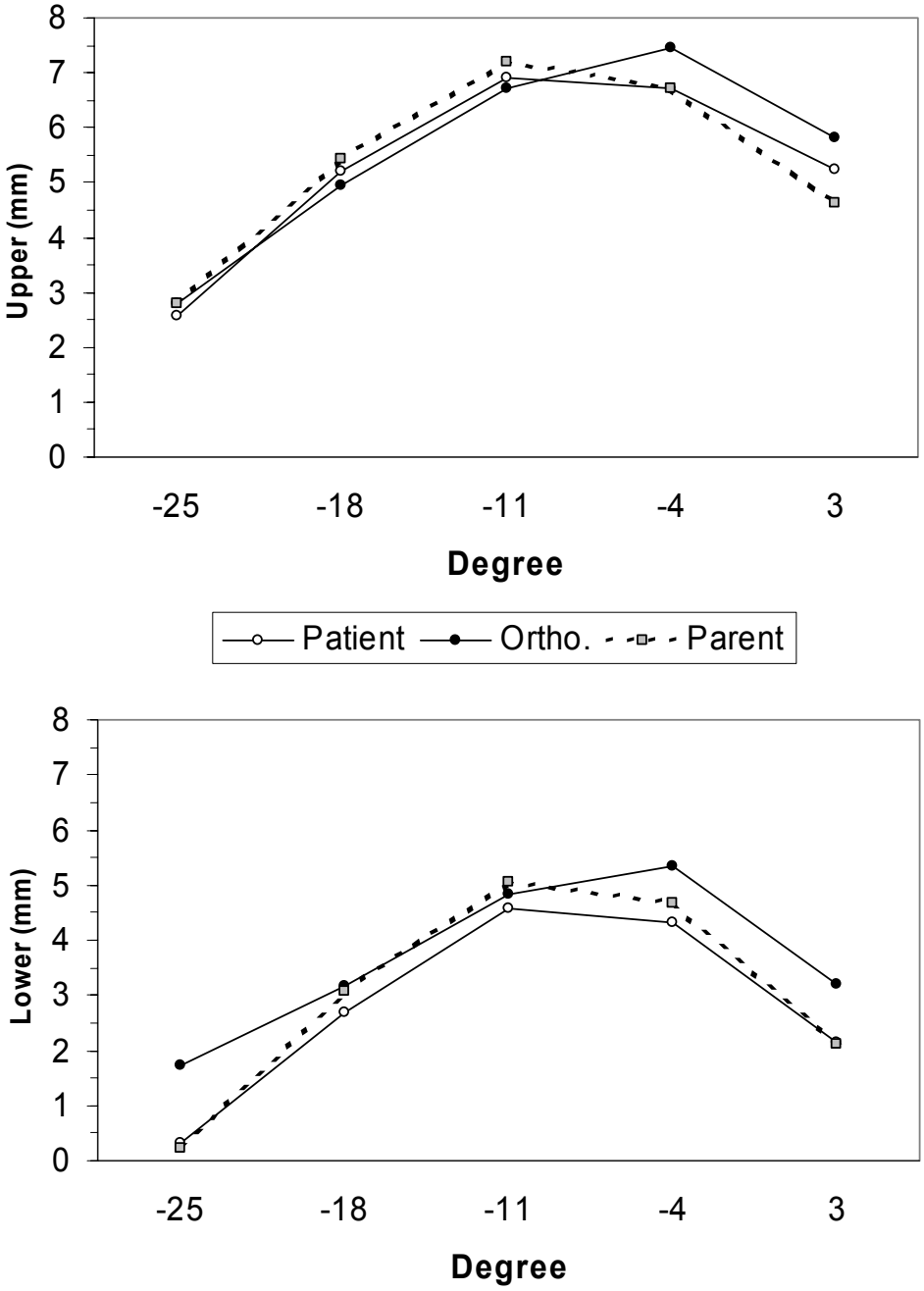

Figure 4: Mean upper lip and lower lip positions measured from the E-plane for each profile

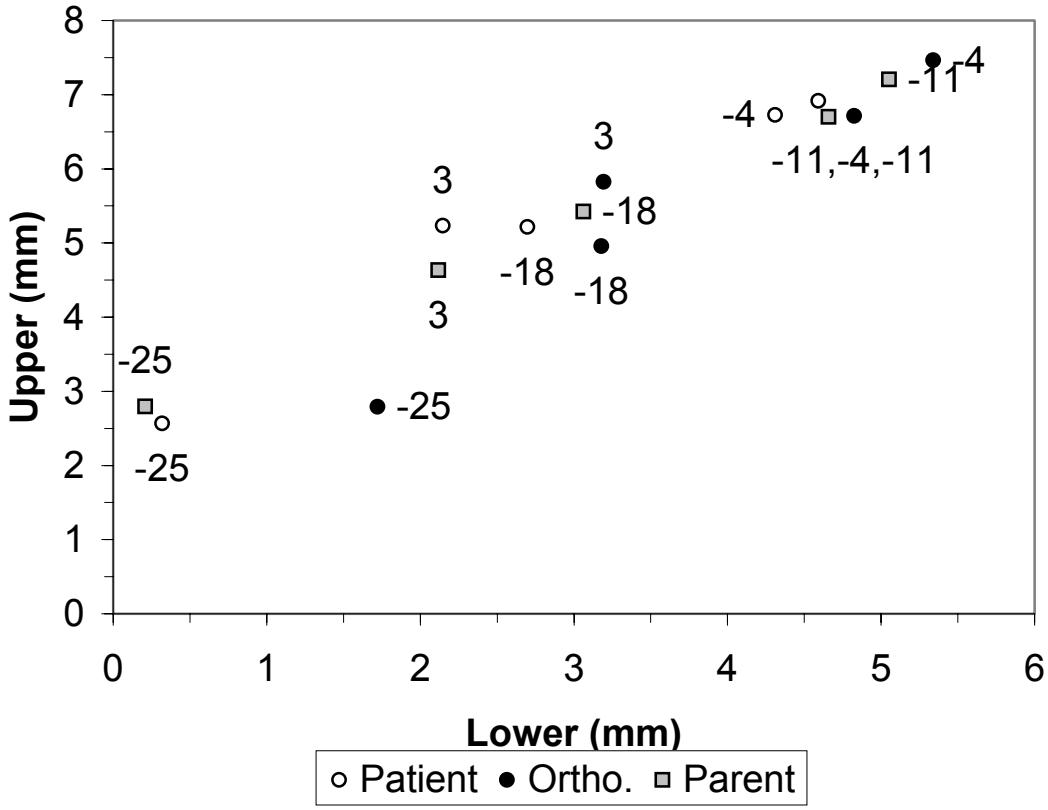

Figure 5: Mean lip positions behind the E-plane for each profile and evaluator group

Differences Among Evaluator Groups

There were no significant differences in preferred upper or lower lip position among patient, orthodontist, and parent evaluators for any of the five profiles with one exception: for lower lip position for the -25° profile, patient and parent responses differed significantly from that of orthodontists ($p = 0.0039$). Patient and parent evaluators placed the lower lip in a fuller position than did orthodontists. Table 5 shows average lip positions for each of the three evaluator groups.

Table 5: Mean Upper and Lower Lip Positions Within Each Evaluator Group (Male and Female Profiles Combined)

	Lower Lip				Upper Lip			
	Evaluator = Patient							
Degree	Mean	SE	95% CI		Mean	SE	95% CI	
+3	2.15	0.358	1.45	2.85	5.23	0.351	4.54	5.92
-4	4.31	0.358	3.61	5.01	6.73	0.351	6.04	7.42
-11	4.59	0.334	3.94	5.25	6.92	0.332	6.27	7.57
-18	2.70	0.358	1.99	3.40	5.22	0.351	4.53	5.91
-25	0.32	0.358	-0.38	1.02	2.57	0.351	1.88	3.26
	Evaluator = Orthodontist							
+3	3.19	0.358	2.49	3.90	5.83	0.351	5.14	6.52
-4	5.34	0.358	4.64	6.04	7.46	0.351	6.78	8.15
-11	4.83	0.334	4.17	5.48	6.71	0.332	6.06	7.37
-18	3.18	0.358	2.48	3.88	4.96	0.351	4.27	5.65
-25	1.72 *	0.358	1.02	2.42	2.79	0.351	2.10	3.48
	Evaluator = Parent							
+3	2.12	0.358	1.41	2.82	4.64	0.351	3.95	5.32
-4	4.66	0.358	3.96	5.36	6.70	0.351	6.01	7.39
-11	5.05	0.334	4.40	5.71	7.21	0.332	6.56	7.86
-18	3.06	0.358	2.36	3.76	5.42	0.351	4.73	6.11
-25	0.21	0.358	-0.49	0.91	2.80	0.351	2.11	3.49

* Orthodontists different from the two other evaluator groups ($p = 0.0039$).

Differences Between Male and Female Profiles

The mean preferred lip positions by profile sex and evaluator group are shown in Table 6. For lower lip position, two profiles in the patient evaluator group and three profiles within the parent evaluator group showed significant differences in lip preference between male and female profiles, while orthodontist evaluators showed no significant differences in preferred lower lip position. For upper lip position, one profile in the patient evaluator group, two profiles in the orthodontist evaluator group, and three profiles in the parent evaluator group showed significant differences in lip preference between male and

female profiles. In all cases where a significant difference was found, evaluators preferred fuller lips for the female profiles than for the male profiles.

Table 6 – Mean Preferred Lip Position for Each Mandibular Position by Profile Sex and Evaluator Group

		Lower Lip				Upper Lip			
	Profile	Evaluator = Patient							
Degree	Sex	Mean	SE	95% CI		Mean	SE	95% CI	
+ 3	Female	2.03	0.419	1.21	2.85	5.09	0.402	4.30	5.88
	Male	2.26	0.419	1.44	3.08	5.37	0.402	4.58	6.16
- 4	Female	4.57	0.419	3.74	5.39	7.08	0.402	6.29	7.87
	Male	4.05	0.419	3.23	4.87	6.37	0.402	5.58	7.16
-11	Female	3.95	0.419	3.13	4.77	6.05	0.402	5.26	6.83
	Male	5.39 *	0.419	4.57	6.21	7.69 *	0.402	6.90	8.48
	Male #2	4.43	0.419	3.61	5.25	7.01 *	0.402	6.22	7.80
-18	Female	2.29	0.419	1.47	3.12	4.81	0.402	4.02	5.60
	Male	3.10	0.419	2.28	3.92	5.63	0.402	4.84	6.41
-25	Female	-0.23	0.419	-1.06	0.59	1.86	0.402	1.07	2.65
	Male	0.87 *	0.419	0.05	1.69	3.27	0.402	2.48	4.06
		Evaluator = Orthodontist							
+ 3	Female	3.12	0.419	2.30	3.94	5.67	0.402	4.88	6.45
	Male	3.27	0.419	2.44	4.09	5.99	0.402	5.20	6.78
- 4	Female	4.88	0.419	4.06	5.70	7.02	0.402	6.23	7.80
	Male	5.80	0.419	4.98	6.62	7.91 *	0.402	7.13	8.70
-11	Female	4.42	0.419	3.60	5.24	6.24	0.402	5.45	7.02
	Male	5.19	0.419	4.36	6.01	7.01 *	0.402	6.22	7.79
	Male #2	4.87	0.419	4.05	5.69	6.90	0.402	6.12	7.69
-18	Female	2.79	0.419	1.97	3.61	4.69	0.402	3.90	5.48
	Male	3.57	0.419	2.74	4.39	5.23	0.402	4.44	6.02
-25	Female	1.48	0.419	0.66	2.30	2.67	0.402	1.88	3.45
	Male	1.96	0.419	1.14	2.79	2.92	0.402	2.13	3.71
		Evaluator = Parent							
+ 3	Female	1.89	0.419	1.07	2.71	4.57	0.402	3.79	5.36
	Male	2.34	0.419	1.52	3.16	4.70	0.402	3.91	5.49
- 4	Female	4.44	0.419	3.62	5.26	6.56	0.402	5.77	7.34
	Male	4.87	0.419	4.05	5.69	6.84	0.402	6.05	7.63
-11	Female	4.31	0.419	3.49	5.13	6.33	0.402	5.54	7.12
	Male	5.86 *	0.419	5.04	6.68	8.08 *	0.402	7.29	8.87
	Male #2	4.99	0.419	4.16	5.81	7.21 *	0.402	6.42	8.00
-18	Female	2.50	0.419	1.68	3.32	5.01	0.402	4.22	5.79
	Male	3.62 *	0.419	2.80	4.44	5.84 *	0.402	5.05	6.63
-25	Female	-0.31	0.419	-1.13	0.52	2.31	0.402	1.52	3.09
	Male	0.72 *	0.419	-0.10	1.54	3.29 *	0.402	2.50	4.08

* Male different than Female ($p < 0.05$)

Differences Between Male and Female Evaluators

There was no significant difference in preferred upper or lower lip position between male and female evaluators within the three evaluator groups ($p > 0.16$).

Discussion

Orthodontic practitioners encounter a wide range of mandibular positions in the patient population. Moderate to extreme degrees of retro- and prognathic mandibular position are often found, and challenging treatment decisions must be made in an attempt to maximize the esthetic and functional benefits to each patient. In those cases where surgical intervention is not a viable option, compromises in the orthodontic treatment plan must be considered. Positioning of the lips is one of the most important factors affecting overall facial balance in attempts to maximize facial esthetics, especially when jaw position cannot be altered.

In this study, the influence of sagittal mandibular position on upper and lower lip position preferences was specifically investigated. Using computer animation technology, subjects were given control over the positioning of the upper and lower lips for a series of profiles differing only in sagittal mandibular position. The profiles were presented twice, first as male and second as female, to test for any gender differences. A replicate profile was included to evaluate intra-examiner reliability. The results revealed that mandibular position does significantly impact preferred lip position relative to Ricketts' Esthetic Plane and that different esthetic standards should be applied to the range of profiles encountered in clinical practice.

Repeatability

Preferences for both upper and lower lip positions differed significantly between the two replicate profiles ($p < 0.0001$). Examiners preferred fuller lips in the second of the replicates, averaging 0.72mm fuller for the lower lip and 0.55mm fuller for the upper lip. Although these differences were statistically significant, they were small enough to be considered clinically unimportant. For this reason, later analyses involving the –11º profile averaged the responses for the two replicates.

There are two possible explanations for the differences observed. First, evaluators may have experienced a "learning curve" effect by which, as they progressed through the different profiles, their preferences and their skill at selecting the lip positions changed so that they intentionally selected fuller lips when viewing the replicate profile. The second possibility is that evaluators were simply inconsistent in their choice of lip positions, resulting in the observed differences. Since, for the replicate profiles, lip position preferences differed by an average of 0.72mm, any differences between profiles of less than 0.72mm should be considered clinically insignificant.

Differences Among Profiles with Varying Mandibular Positions

Figures 4 and 5 and Table 5 demonstrate a fairly consistent trend among the three evaluator groups. For both upper and lower lips, the average preferred position did not differ between the –18º (Moderate Class II) and +3º (Severe Class III) profiles or between the –11º (Class I) and –4º (Moderate Class III) profiles, while preferences in the –25º (Severe Class II) profiles always differed significantly from the others. This pattern was generally consistent among all three evaluator groups with two minor exceptions: 1) for

orthodontist evaluators, all five profiles differed significantly from each other for upper lip position, and 2) for parent evaluators, the –18º and +3º profiles were different for lower lip position.

Profiles representing the average lip positions selected by the evaluators are presented in Figure 6. In general, evaluators preferred the fullest lips for the most retrognathic (-25°) profile, less full lips for the Moderate Class II (-18°) and Severe Class III (+3°) profiles, and the most retrusive lips for the Class I (-11°) and Mild Class III (-4°) profiles (all relative to Ricketts' Esthetic Plane). A possible explanation for this trend is that evaluators were attempting to compensate for or distract from larger skeletal discrepancies in the profiles by making the lips more full. Another interpretation of these findings is that the use of Ricketts' E-Plane, which is partly defined by the soft tissue chin point, is an unreliable method for determining the most esthetic lip positions in differing mandibular positions. Perhaps another reference line derived from different anatomical points and less greatly influenced by variations in sagittal mandibular position would yield more consistent lip position preferences among differing facial profiles.

It is interesting to note that, with the evaluators' preferred lip positions, the nasiolabial angle became progressively more acute and the labiomental fold became progressively more shallow as the profiles progressed from most retrognathic to most prognathic. These extremes are natural compensations that would be expected in severe Class II or Class III skeletal profiles.

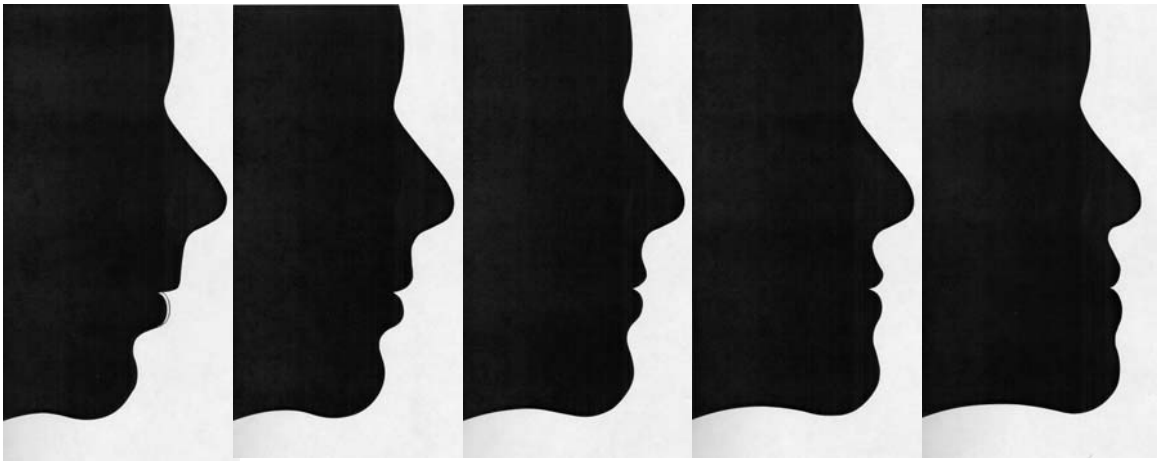

Figure 6: Mean Lip Positions Preferred for All Evaluators (-25º, -18º, -11º, -4º, & +3º, respectively from left to right). The more protrusive lower lip outline shown for the –25º profile is the mean preference of the patient and parent evaluators.

Differences Among Evaluator Groups

The finding that there were generally no differences in preferred lip position among the three evaluator groups for any of the five different profiles is in agreement with previous findings by Cox and Van der Linden[10], who found no difference in the esthetic rating of profiles between orthodontists and laymen. The consistency in lip profile preferences among patients, orthodontists, and parents is quite remarkable given the wide range of possible positions for the lips for each profile and the high degree of control evaluators had over where to place the individual lips. This is an encouraging result when treatment planning is considered, suggesting that esthetic goals of orthodontic clinicians with regard to lip position are in harmony with those of patients and their parents.

Differences Between Male and Female Profiles

The differences that were found between preferred lip positions for the male and female profiles were scattered and inconsistent (Table 6). These differences ranged from 0.77mm to 1.75mm. No trends could be identified to clarify why certain profiles in certain evaluator groups showed gender differences while others did not. It is of interest to note that, whenever a significant difference was detected, the preference was always for fuller lips for the female profile. This agrees with previous findings by Czarnecki.[12]

Although these scattered profile-gender differences were present, the differences among profiles with different mandibular positions were consistent across the male and female profiles for both the upper and lower lips. For this reason, lip positions for the male and female profiles were combined when analyzing overall lip preference for each of the five different profiles within each evaluator group.

Differences Between Male and Female Evaluators

There were no differences in preferred lip position between male and female evaluators within the three evaluator groups ($p > 0.16$). This contrasts with Heir's[14] findings, where female subjects preferred a fuller lip position for the observed profiles than did male subjects.

Conclusion

This study evaluated the influence of sagittal mandibular position on preferences for upper and lower lip position in profile. Evaluator groups included orthodontists, orthodontic patients, and parents of patients. Using a computer animation program, evaluators moved the upper and lower lips to the positions they deemed to be most esthetic for a series of profiles that differed only in the sagittal mandibular position. The profiles were presented twice, first as male and second as female, to test for any gender differences. A replicate profile was included to evaluate intra-examiner reliability.

Results showed that mandibular position does significantly influence preferred upper and lower lip position in profile. In general, preferred lip positions did not differ between the Class I (-11°) and Moderate Class III (-4°) profiles or between the Moderate Class II (-18°) and Severe Class III (+3°) profiles, but lip positions were significantly different between the three profile groupings (-11° & -4°, -18° and +3°, and –25°). Fuller lip positions relative to Ricketts' E-plane were generally preferred for the more extreme retro- and prognathic profiles, while more retrusive lip positions were preferred for the more average profiles. Nasiolabial angles became progressively more acute and labiomental folds more shallow with changing lip position preferences as the profiles progressed from most retrognathic to most prognathic.

Preferred lip positions were generally similar among orthodontists, patients, and parents of patients and between male and female evaluators. Differences in lip positions between male and female profiles were scattered and inconsistent, but when present always showed a preference for fuller lips for the female profiles.

The findings from this study suggest that sagittal mandibular position should be considered by the orthodontic practitioner during the treatment planning process when determining the ideal lip position for an individual patient. Using Ricketts' E-plane to analyze lip position, the amount of lip protrusion deemed most esthetic varies depending on the sagittal position of the mandible. Fuller lips relative to the E-plane might be considered more esthetic and necessary for the achievement of overall facial balance in patients where more extreme degrees of retro- or prognathism are encountered, while less full lips may be more acceptable for patients with average skeletal profiles.

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VITA

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