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Assessing the Influence of Chin-Throat Length on Perceived Profile Attractiveness

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Abstract

Introduction: The submental-cervical angle is often considered an important esthetic parameter when evaluating lower profile morphology, while the chin-throat (C-T) length has not traditionally been considered. The purpose of this study was to evaluate the perception of facial attractiveness ratings of convex profiles with different C-T lengths. **Methods:** This investigation was a questionnaire-based study. A series of digitally manipulated profile images of a Caucasian female and male subject were altered to similar skeletal class II facial convexity and the C-T length from soft tissue menton to throat point was adjusted in 5mm increments from 8-43mm. Survey participants included orthodontic clinicians, orthodontic patients and lay people that rated the images on 100mm visual analogue scales (VASs). **Results:** There was an overall direct linear relationship with the mean attractiveness rankings and C-T lengths. Participants in all groups (total n=261) gave significantly higher rankings for the longer C-T lengths (33-43mm) compared to the shorter C-T length profiles (8-23mm), and rankings were significantly different ($p < 0.001$) for the various C-T lengths presented. In regards to surgical intervention, all three observer groups expressed a significantly increased desire to elect surgical correction of both the female and male profiles with the shortest C-T lengths (8-13mm). **Conclusions:** Longer C-T lengths (33-43mm) were perceived as more esthetically acceptable for both the female and male skeletal class II profiles presented. Since the chin-throat length is altered as a result of mandibular orthognathic

surgery it should be considered more routinely in diagnoses and treatment planning in addition to other standard facial angles. Furthermore, a surgical treatment plan should be considered for patients with C-T lengths $\leq 13\text{mm}$.

Keywords: Profile, Attractiveness, Orthodontics, Orthognathic surgery, Facial esthetics, Throat-length, Chin-throat length

Introduction:

The perception of a human face can elicit a wide array of emotional, physical and social inferences.¹ Likewise, the judgement of facial attractiveness also affects a diverse range of critical social implications. These can range from friendships and mate selection, an individual's occupational successes, confidence, judgements on intelligence, and reportedly can also influence election results.¹⁻³ Despite the complexities of facial attractiveness, extensive studies have shown that there is not only a range of acceptable facial forms and traits, but there is also considerable agreement across diverse cultures on what is deemed attractive.¹ A fundamental attribute of an esthetically pleasing face is one in which the various facial features are well proportioned, balanced, and relate well to other facial features, when viewed from the front or the side.⁴ Although balance and harmony alone do not necessarily make an attractive face, it is important to study the range of acceptable variations between the different facial components.⁵

Orthodontists plan treatment that can alter a patient's facial appearance, whether through orthodontic treatment alone or a combination of orthodontic treatment, growth modification, and orthognathic surgery. As such, orthodontic training focuses on clinical abilities to identify dentofacial deformities, risk factors for obstructive sleep apnea, and a thorough understanding of facial esthetics.⁶ Orthognathic surgery of the mandible to correct dentofacial deformities, improve facial esthetics and treat obstructive sleep apneas affect positional changes of the hyoid bone, tongue, and suprahyoid musculature and therefore not only affect the airway, but impact overall esthetics of the submental soft tissue components and chin prominence.⁷⁻⁹

Despite the aid of numerous diagnostic cephalometric analyses and facial measurements developed over the years, the point at which normal becomes abnormal cannot always be easily defined and is often determined by the clinician's sense of balance and the patient's perception

of imbalance.¹⁰ However, patients' perceptions of their own conditions can vary greatly, and a rather mild discrepancy can be perceived by the individual as severe enough from a psychosocial aspect to motivate the patient to seek treatment. Because of this, patients may be reluctant to admit their exact motives for treatment during a patient interview.^{11, 12}

Several investigations have aimed to bridge the gap between clinician and patient perceptions, by evaluating select facial angles or measurements and how they influence overall profile attractiveness among orthodontic clinicians, their patients, and the public. Some of the facial parameters evaluated in these studies include: lip position, submental-cervical angle, mentolabial angle, nasofacial angle, varying degrees of facial convexity, chin height, lower face height, and chin prominence.¹³⁻²⁰ However, no studies were found that addressed how changes in the chin-throat length could influence the esthetic perception of the facial profile. While the submental-cervical angle is often considered during diagnosis as a key parameter of lower face esthetics, the chin-throat length (C-T length), as viewed in the profile, can also greatly impact the overall appearance of an individual, as it may influence the perception of chin prominence.

The purpose of this study was to qualitatively evaluate the effect that modified chin-throat lengths have on the perception of facial attractiveness when assessing convex profiles among orthodontists, orthodontic patients, and laypersons. Additionally, this study aimed to investigate the perception of the need or desire for corrective surgical procedures among these groups for each profile presented. The null hypotheses investigated were that there was no difference in the perception of facial attractiveness ratings with different chin-throat lengths at all, or among the three observer groups. Secondly, the authors assessed how all three observer groups compared in their desire to elect surgical correction for each altered chin-throat length profile.

Materials and Methods:

This investigation was an anonymous, one-time, questionnaire-based study utilizing a digital survey platform (Survey Monkey, San Mateo, CA) to evaluate the effect of incremental changes in the chin-throat length on the perceived attractiveness of convex facial profiles consistent with skeletal class II mandibular deficiency. The target audience for participation was orthodontic clinicians, orthodontic patients, and laypersons who were asked to rate the altered profile photos.

Ethical approval

This study was approved by the Institutional Review Board of the 59th Medical Group Wing, Air Force Postgraduate Dental School, JBSA-Lackland Air Force Base, Texas. In accordance with Revised Common Rule, Section 219.116, a waiver of documentation for informed consent was obtained. All survey participants agreed to an informational informed consent presented at the start of the survey which indicated that proceeding to the next page for the study to commence gave implied consent. The female and male subjects whose photos were altered in the study signed photo release documentation and agreed to research participation.

Image Creation

The images chosen for use in this study were selected from the existing patient population with records in the Dolphin Imaging 11.95 database (Patterson Dental, Saint Paul, MN) from the Air Force Postgraduate Dental School, Lackland Air Force Base, San Antonio, Texas. The selection criteria included both a female and male patient of similar race/ethnicity and similar age with existing orthodontic records on file. Patients that seemed too young in appearance that could be perceived as still undergoing jaw growth and development were excluded. Once subjects were chosen, updated profile photos were taken for the purpose of this

study to ensure limited distractors such as eccentric hair-styles, facial hair, or make-up, and to achieve optimal lighting.

To further standardize the evaluation, both patient images were then altered in the lower third to portray similar class II skeletal convexities according to Down's facial angle of convexity ($G'-Sn-Pog' = 20^\circ$, Normative value = 12° , Standard Deviation = 2°) using the treatment simulation function in Dolphin Imaging software. Since the only variable being assessed was the influence of the C-T lengths on convex profiles, any adverse effects on the lips that resulted from the class II manipulation were corrected to isolate the testing of only the one variable. Further, while the male subject had a pronounced throat point, to ensure consistency in measurements, a more defined throat point was created on the female subject. These photos were then considered the baseline patient photos from which chin-throat length manipulation was completed for the study parameters. Adobe Photoshop Elements 2021 Photo Editor (San Jose, CA) was used to ensure consistency in all images presented after the alterations were made.

A total of 16 different color photographs were included in the survey. Each male and female profile had the chin-throat length – measured from soft tissue menton to throat point – adjusted in 5mm increments to generate a total of eight images with throat-lengths ranging from 8-43mm (Fig.1). To ensure the measured increments and overall C-T lengths were consistent, the patient's profile photos were superimposed on their lateral cephalometric radiograph which contained an embedded 100mm ruler (Fig. 2). Chin-throat length adjustments were done in PowerPoint (Microsoft PowerPoint version 16.45, Redmond, WA) using an overlay section of the neck containing throat point which was cut and pasted over the calibrated profile photo and incrementally moved backward to lengthen or forward to shorten. Vertical gridlines were added to measure C-T lengths with the 100mm ruler used for conversion to adjust for resizing and

magnification errors. This process ensured that digital measurements represented clinically applicable C-T lengths. The submental-cervical angle was also measured to ensure it remained consistent across all images for the male and female profiles, respectively.

Survey Design

The composite of eight photos for each patient was displayed initially together and survey participants were asked to choose the most attractive profile image out of the eight presented (Fig.1). Supplementary questions then displayed one image at a time, with no labels, in random order, and observers were asked to rate the profile on a 100mm visual analogue scale (VAS). The following descriptive terms were used as anchor points for the ends and middle of the sliding VAS as follows: left (0mm): “Less Attractive,” middle (50mm): “Normal/Average,” and right (100mm): “More Attractive.” Additionally, for each image, participants were asked if they would consider having corrective jaw-surgery to improve the facial appearance if it was their face (Fig.3).

Results:

The scores of 261 participants were evaluated using the SPSS package for statistical analysis (version 24.0; IBM, Armonk, NY). Note that “orthodontist” or “orthodontic clinician” respondents (n=98) in this study included participants under the following sub-categories: Orthodontist (n=66), Orthodontic Resident (n=26), Oral Surgeon (n=4), and Oral Surgery Resident (n=2). At the end of data collection, there were a total of 300 respondents, with 137 in the orthodontist group. All surveys completed by participants that indicated they were either a general dentist or other dental specialist in a subsequent question were omitted from evaluation. While the investigators do not equate a lesser knowledge level of other dental colleagues to that of the average layperson, for the purpose of this study, the groups being surveyed were

specifically identified to evaluate if a heightened awareness or advanced knowledge of facial aesthetics would affect results. The various demographics by group that were collected are reported in the Figure 4 table.

Descriptive statistics including the mean and standard deviation were used to assess the outcome measure, which was the facial attractiveness ratings of different chin-throat lengths. To test our first null hypothesis, a one-way repeated measures analysis was completed and showed that there was a significant difference ($p < 0.001$) for both the female and male profile attractiveness ratings at different chin-throat lengths, therefore rejecting the null hypothesis. In regards to the most attractive female and male profile, when participants were presented the eight images for side-by-side comparison (Fig.1), the majority preferred the 38mm C-T length profiles (F7: 46.4%, M7:30.3%) and the 43mm profiles (F8: 31.4%, M8: 28%) were the next favored (Fig. 7). These findings were further validated when the individual female and male profiles with C-T lengths 33-43mm – presented in random order – were rated with the highest mean values across all groups (Fig. 5a, 6a). In fact, there was no significant difference in mean rank attractiveness ratings between the longer (33-43mm) C-T length profiles for either the male or female profiles.

A two-way ANOVA comparing chin-throat lengths and the different groups of raters was performed to test our second null hypothesis. This determined that for the female profiles presented, there was a significant interaction ($p < 0.022$) between chin-throat length and rater group, making interpretation of the main effects impossible, since there was no definitively predictable pattern in how they differed. Tukey post-hoc analysis showed that the orthodontist group was significantly different from the other two groups of raters, but only at specific chin-throat lengths. A Bonferroni correction was applied to adjust for multiple comparisons which

reduced the p-value for significance to $p < 0.006$. A significant difference between the orthodontists' attractiveness ratings compared to the layperson and patient groups for the female profiles with 28mm and 33mm C-T lengths ($p < 0.001$), thus rejecting the null hypothesis. However, in regards to the male profiles presented, there was not a statistically significant difference in the interaction term, as the ratings of the three groups followed a predictable pattern for the chin-throat lengths presented, which failed to reject the null hypothesis for the male profiles (Figures 6a & 6b).

Chi-square tests were performed to assess the third null hypothesis that there was no difference in the perceived need for surgical correction among the three groups of survey participants when rating the various profiles. The statistical analysis revealed significant differences in the responses among the groups surveyed for both female and male profiles at random C-T lengths, thus rejecting the null hypothesis. The data showed that for both the female and male profiles with the shortest C-T lengths ≤ 13 mm, more than 50% of survey participants in each group responded that they would consider jaw surgery to improve the profile, if it were theirs. The percentage of "Yes" responses ranged from 50.0 – 90.8% for male profiles F1 – F2, and 53.5% - 71.4% for female profiles F1 – F2 (Figures 5a & 6a).

Discussion:

The orthodontic diagnosis and treatment planning of patients should always focus on a comprehensive assessment of not only the dental and facial esthetics, but occlusal and temporomandibular joint functions as well as potential sleep-related breathing disorders. Obstructive sleep apnea can have severe co-morbidities and orthognathic surgery can potentially improve or adversely affect the nasopharynx and hypopharynx airway spaces.^{7-9, 21} Likewise, these surgeries also impact chin prominence and submental soft tissue esthetics.⁷⁻⁹ The facial

lower-third, including the submental-cervical area, is a major determinant of profile attractiveness, and is thus a critical area of the orthodontic evaluation.¹⁹ According to Kiyak, the majority of Class II patients (41 – 89%) present with an aesthetic chief complaint when seeking orthognathic surgery, which makes esthetic evaluation of primary importance.²² However, many patients seek orthodontic treatment with solely dental-focused chief complaints and are often unaware of how their dental-skeletal discrepancy could affect their profile esthetics. Consequently, they may not include this in a chief complaint, even when probed about esthetic concerns. Another subset of orthodontic patients, may be entirely unaware any profile imbalance even exists. Including proper treatment recommendations for profile augmentation may be more difficult for clinicians in these instances.

Countless studies on attractiveness have revealed the complexities that come with defining beauty, and that what is considered attractive to patients and the average layperson may not concur with what orthodontists and surgeons perceive as attractive based on their experience and advanced training.^{19,22} The purpose of this study was to qualitatively evaluate if different chin-throat lengths influenced the perception of facial attractiveness of convex profiles and to compare if these perceptions differed among orthodontic clinicians, orthodontic patients, and laypersons. Further, this study aimed to investigate the perceived need or desire for corrective surgical procedures among the groups surveyed based on the profiles presented.

With regard to outcomes, the changes in throat length had a direct relationship with overall attractiveness ratings, revealing that shorter C-T lengths garnered much lower ratings, and increasing the C-T length increased the attractiveness rating. This was true for all three groups of the targeted survey participants. For the male profiles, the attractiveness rankings across the groups were similar for each chin-throat length presented. This suggests that changes

in throat length can have such an apparent effect on the profile that its detection is less influenced by the advanced facial esthetics training orthodontists receive compared to the evaluation of other facial attributes.

With respect to how the ratings compared across the groups, the layperson and orthodontic patient groups were more highly critical, particularly of the female profiles presented (F3 – F7) as compared to the orthodontist group attractiveness ratings (Fig. 5a & 5b). This observation may indicate the general public prefers a less convex profile (or more chin prominence) on a female than has traditionally been thought. Indeed, a recent article in Vogue magazine titled “How the Defined Jaw Replaced High Cheekbones as Beauty’s Most-Wanted” references a 2017 study by the American Society for Dermatologic Surgery, and describes the rising trend in both men and women seeking aesthetic procedures to help improve jawline definition and eliminate excess submental fat.²³

In a study conducted by the John Radcliffe Hospital, Oxford, United Kingdom, clinicians rated patients as needing orthognathic treatment higher than the patients themselves, and surgeons deemed even more so that surgical treatment was necessary.²⁵ Similarly, the results of this study found significant differences in the clinicians’ greater desire to elect surgery versus the patient and layperson groups for the M1 – M3 profiles (C-T length 8-18mm). However, for other male and female profiles, it was generally a higher percentage of the patient and layperson groups that desired surgical correction compared to the orthodontic clinician group. Although it is not surprising that orthodontists and oral surgeons would be more sensitive in detecting profile imbalance based on the nature of their training, patient groups can also demonstrate a higher sensitivity than the average person due to their own personal motivations for treatment, a heightened awareness from patient education throughout treatment, or their overall treatment

experiences. All of these factors appear to be consistent with the results of this study. For instances in which the layperson groups were more critical in attractiveness ratings or more readily elected jaw surgery over the orthodontists, shifting views on esthetics combined with an increase in self-perception or decrease in self-esteem, with growing social media use and influence, may be to blame.²⁶

The limitations of this study include sample size, evaluation of a non-traditional or not routinely studied facial parameter, use of a 100mm VAS, and an innovative study design with the use of color photographs as opposed to profile silhouette images. In regards to sample size, the groups surveyed would ideally have had equal participation rates for better comparison, and larger sample sizes to be more statistically significant. These goals were difficult to achieve given the unsolicited, anonymous and voluntary nature of this survey coupled with data collection time constraints. The literature search provided no previous studies that evaluated the chin-throat length and the impact changes in length may have on an individual's appearance. There is also limited data to support if an established and generally accepted normative measurement for this facial parameter already exists. In regards to the attractiveness rankings, the authors chose to use a 100mm VAS as the rating mechanism in this study based on its simplicity and relative ease to quickly submit responses and avoid survey fatigue. Based on the number of questions being asked and the lack of control in ensuring survey completion the investigators preferred the benefits of the VAS over a Likert scale, for instance, to maximize the sample size. However, some disadvantages of using a VAS include the larger variation and standard deviation in the responses, the potential that observers did not interpret anchor point descriptor words in the same manner, and the inability to discriminate how many millimeters of difference in rankings are clinically relevant.²² Finally, most attractiveness studies found in the

literature search evaluated facial esthetic parameters by having participants rate computer-generated silhouette images that often fail to accurately represent an actual human face with the harsh lines and sharp angles created. The use of real human faces allows the ability to smooth lines and blend features even after manipulation for survey parameters to present a more realistic image, and thus may be more accurate for facial attractiveness focused studies. Of course, there are benefits to silhouette images since they can eliminate extrinsic factors, such as complexion, hair styles, facial hair and other traits like age or weight that can undoubtedly influence perceived attractiveness.^{2, 22}

Conclusions:

Orthognathic repositioning of the mandible will almost always serve to improve the functional occlusion, but depending on the original dentofacial deformity, it can influence the airway space and esthetic submental soft tissues, either positively or negatively. Contrary to a skeletal class III correction which may involve mandibular setback surgery and adversely create a “double-chin” appearance, a class II skeletal profile will benefit from mandibular advancement or genioplasty advancement procedures to increase the chin-throat length and stretch the submental soft tissues more esthetically.⁹ Furthermore, it is important to properly evaluate the treatment goals of the lower third and all potential benefits that may come with either a surgical or non-surgical treatment option. While the submental-cervical angle is often considered during esthetic evaluation of the lower third, this study demonstrated that chin-throat length can significantly impact the overall appearance of an individual as well.

It should be noted that the following conclusions and results of this study are based on the assumption that other key angles and measurements of the throat form and lower third evaluation were acceptable as presented on the profiles of the study subjects. While it was necessary to

isolate only one variable for proper evaluation, it is more likely in a clinical setting that several areas of facial imbalance will present together. Lower profile morphology is not only affected by dentofacial deformity, but also skin tonicity and neck strap muscular changes that occur with normal aging or submental adiposity.¹⁹ The diagnosis and necessary treatment may also be multifactorial in nature and may require adjunctive esthetic procedures in conjunction with orthognathic surgery for optimal improvements.

- The results of this study demonstrate that longer chin-throat lengths (33-43mm) rendered the skeletal class II retrognathic profiles as esthetically acceptable for both female and male Caucasian subjects.
- For both the female and male convex profiles, chin-throat lengths ≤ 23 mm were generally rated as below average (mean ranks 13.9-55.9mm on 100mm VAS) by observers across all groups. This may represent a borderline esthetically acceptable C-T length.
- In regards to threshold values for the desire to elect surgical intervention along with decreased attractiveness ratings, C-T lengths ≤ 13 mm for both females and males suggest a surgical treatment plan should be considered.
- When evaluating patients for a surgical vs. non-surgical correction of a skeletal class II malocclusion, C-T length should be evaluated in addition to other routine facial angles during assessment of the lower profile morphology.
- All orthognathic surgery treatment plans should consider the chin-throat length and how treatment may impact the esthetics of this area.

Figure & Captions:

Figure 1. (a). All eight female images generated (A – Dd) ranged sequentially from the longest C-T length, A = 43mm to the shortest, Dd = 8mm. While these images were presented together initially, when participants were asked to select the most attractive of the eight profiles, subsequent questions presented only one male or female image in random order. **(b)** All eight male images generated (E – Hh) ranged sequentially from the longest C-T length, E = 43mm to the shortest, Hh = 8mm.

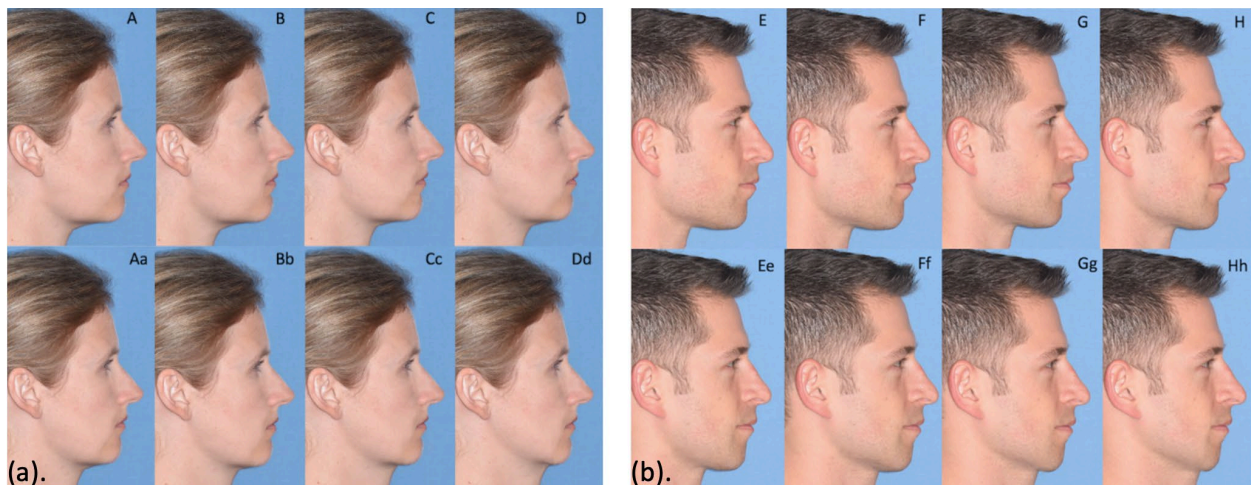


Figure 2. All images were calibrated using superimpositions of the patient's original lateral cephalometric radiographs with digital 100mm rulers and gridline measurements to adjust for any resizing and magnification errors. This process ensured the digital measurements would represent clinically applicable C-T lengths. Because the images had already had the facial convexities altered, the original lateral cephalometric radiographs would not adapt fully in the lower third.

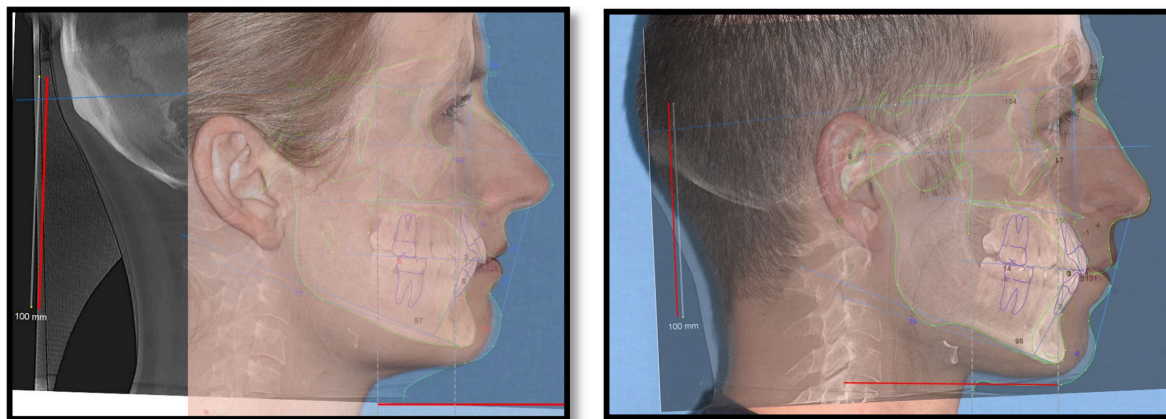



Figure 3. Example of subsequent survey questions that repeated for each male and female photo, which were presented in random order.



* 2. Rate the attractiveness of this profile using the sliding scale below:

Less Attractive Normal/Average More Attractive

* 3. If this was your profile, would you consider a jaw surgery to improve it?

Yes

No

Figure 4. Demographics: Survey participants by group (Total n=261)

Observer Group	Number (n)	% Female	% Male	Age Range (yrs)	Mean Age (yrs)	Age Range Distribution	% White/Caucasian
Orthodontic Clinician	98	47.96%	52.04%	25-65+	39.3	36% (25-34) 38% (35-44) 20% (45-54) 6% (55+)	81.63%
Orthodontic Patient	77	70.13%	29.87%	18 - 65+	37.6	13% (18-24) 29% (25-34) 38% (35-44) 12% (45-54) 5% (55-64) 3% (65+)	57.14%
Layperson	86	67.44%	32.56%	18 - 65+	42.2	2% (18-24) 22% (25-34) 42% (35-44) 16% (45-54) 15% (55-64) 2% (65+)	66.28%

Figure 5(a). Data Table: Female VAS Attractiveness Ratings & Surgical Desire by Group

Female Profile	Image Identifier	Chin-Throat Length (mm)	Orthodontists (n=98)		Patients (n=77)		Layperson (n=86)	
			Mean Rank	Surgical Desire % Yes	Mean Rank	Surgical Desire % Yes	Mean Rank	Surgical Desire % Yes
F8	A	43	72.5	1.0%	71.0	1.3%	70.9	4.7%
F7	B	38	73.9	0.0%	68.6	2.6%	67.5	3.5%
F6	C	33	73.4	0.0%	63.6	3.9%	63.6	4.7%
F5	D	28	64.6	1.0%	55.4	7.8%	58.5	4.7%
F4	Aa	23	51.1	7.1%	45.7	26.0%	47.2	16.3%
F3	Bb	18	47.7	14.3%	41.3	23.4%	45.9	18.6%
F2	Cc	13	25.5	65.3%	24.3	67.5%	26.5	53.5%
F1	Dd	8	20.2	71.4%	21.9	68.8%	21.1	59.3%

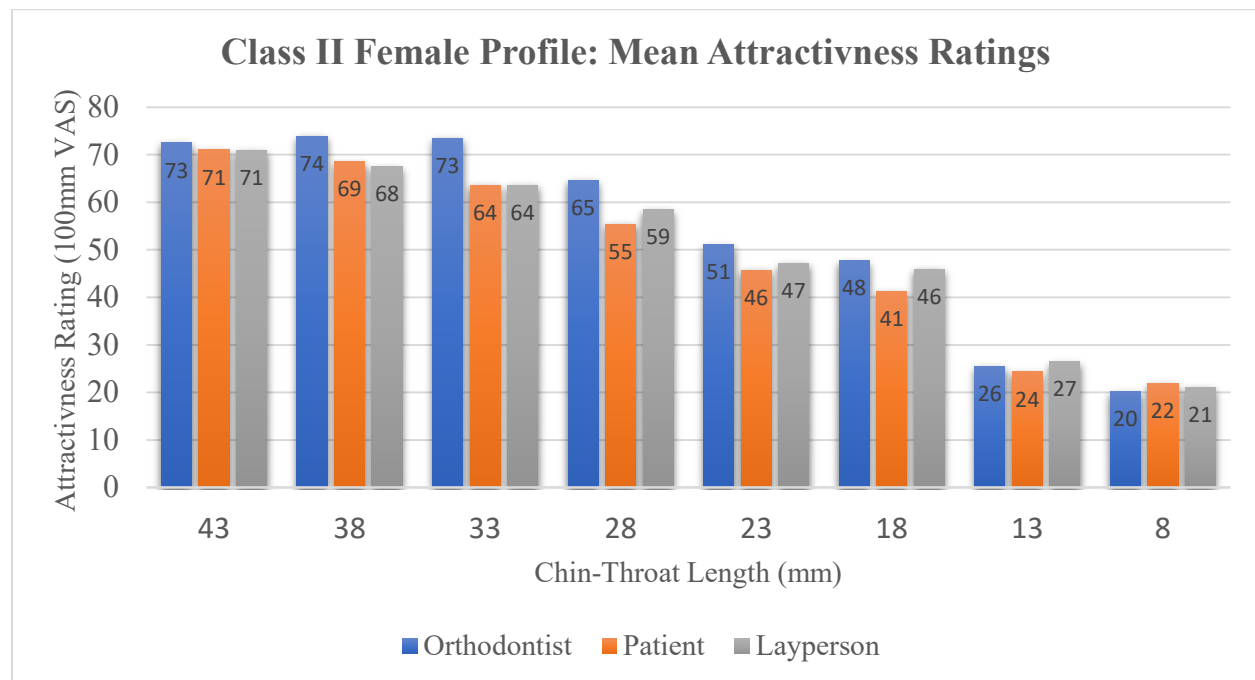
Figure 5 (b). Bar Graph: Female VAS Attractiveness Ratings

Figure 6 (a). Data Table: Male VAS Attractiveness Ratings & Surgical Desire by Group

Male Profile	Image Identifier	Chin-Throat Length (mm)	Orthodontists (n=98)		Patients (n=77)		Layperson (n=86)	
			Mean Rank	Surgical Desire %Yes	Mean Rank	Surgical Desire %Yes	Mean Rank	Surgical Desire % Yes
M8	E	43	67.9	1.0%	63.7	2.6%	65.5	1.2%
M7	F	38	70.6	1.0%	65.9	0.0%	66.4	2.3%
M6	G	33	67.0	2.0%	63.3	2.6%	63.7	4.7%
M5	H	28	59.9	2.0%	58.4	7.8%	58.2	1.2%
M4	Ee	23	55.9	8.2%	50.7	16.9%	49.8	9.3%
M3	Ff	18	39.5	40.8%	38.5	36.4%	41.4	20.9%
M2	Gg	13	22.6	75.5%	25.8	61.0%	24.5	50.0%
M1	Hh	8	14.2	90.8%	13.9	85.7%	16.7	73.3%

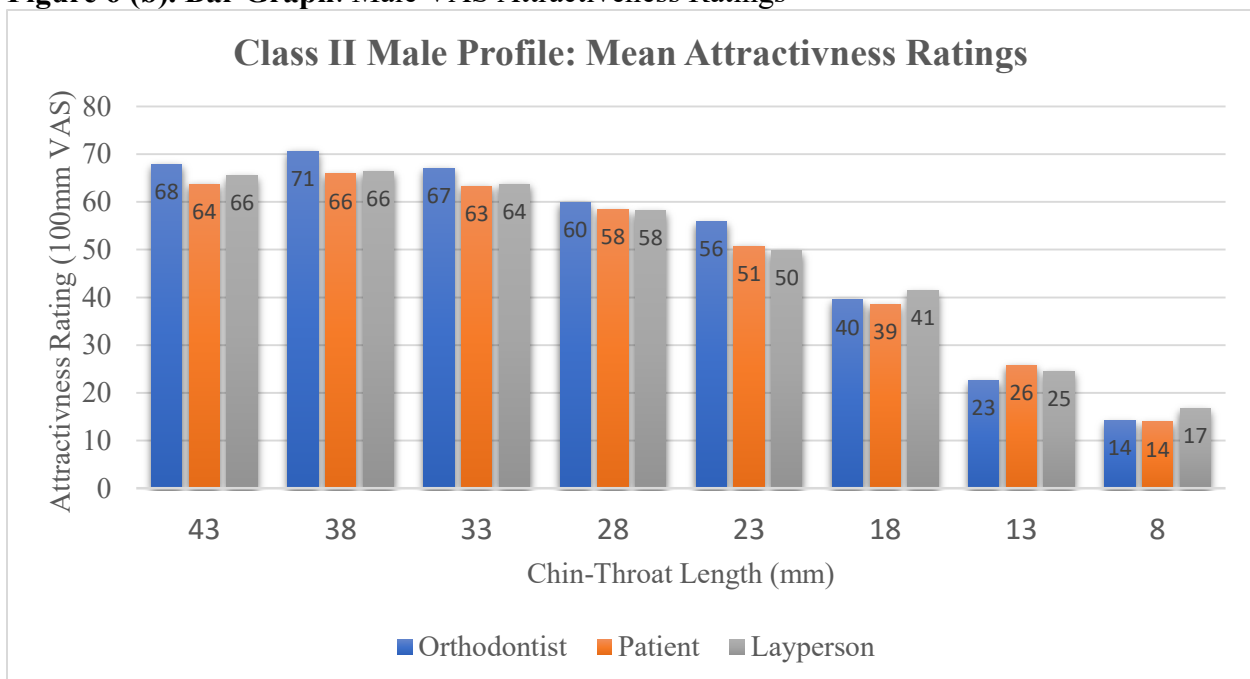
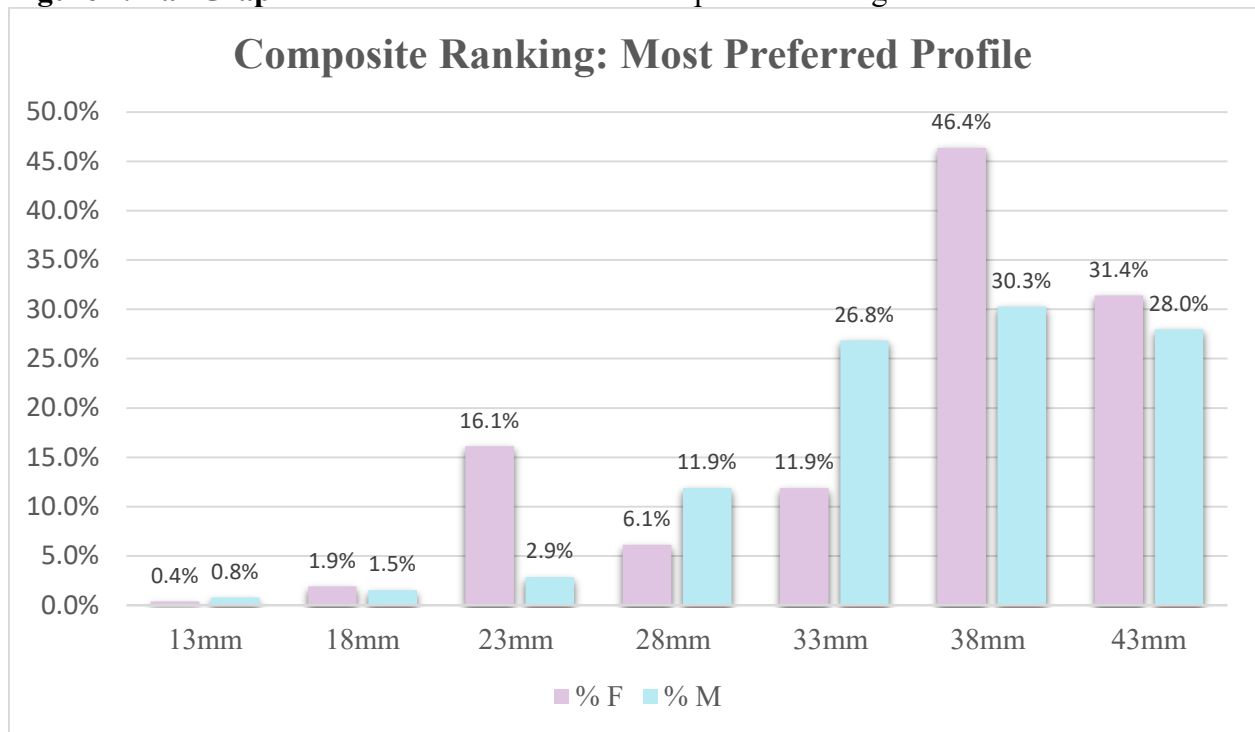
Figure 6 (b). Bar Graph: Male VAS Attractiveness Ratings

Figure 7. Bar Graph: Female and Male Profile Composite Rankings

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