SMILE PREFERENCES & AGE

Peter E. Weber

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Approved by:

Tung T. Nguyen

Lorne D. Koroluk

Ceib L. Phillips

ABSTRACT

Peter E. Weber: Smile Preferences & Age
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Introduction: Increasing numbers of adults are seeking orthodontic treatment to improve their smile esthetics. The objective of this study was to determine laypeople's preferences for gingival display and buccal corridor size of the smile as a function of the age of the person smiling and the age of the evaluator. **Methods:** Smiling facial photos of 3 male and 3 female patients in different age groups were digitally altered to change gingival display and buccal corridor size and presented to respondents of varying ages who ranked each set based on attractiveness. Multivariate analysis was performed to determine preferences with respect to age and gender. **Results:** In general, people preferred a smile with smaller buccal corridors and lip position even with the gingival margin of the maxillary incisors or slightly below. Limited differences were found based on age. **Conclusions:** Age alone does not seem to determine smile preferences.

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LITERATURE REVIEW

Adult treatment has quickly grown to become a major part of orthodontic practice. As recently as the 1970's adult orthodontics was rare, but today approximately 30% of all orthodontic patients receiving comprehensive treatment are above the age of 18.[1] Esthetic concerns are frequently most important to the orthodontic patient, as the desire for an attractive smile is often the main reason people of all ages seek out orthodontic treatment.[2, 3] It is commonly held that soft-tissue and esthetic considerations should also come first in orthodontic treatment planning.[2-4] Ackerman et al[3] stated that the emerging soft-tissue paradigm in diagnosis and treatment planning places greater emphasis on clinical examination of soft tissue function and esthetics than has previously been the case and called for new information in these areas. Many authors and researchers have answered this call, as smile esthetics has become a popular topic in the orthodontic literature. It must be stated that a confounding factor influencing any esthetic research is the fact that definitions of beauty and attractiveness are not static over time and can vary a great deal between individuals, and racial, social, and economic groups.[5-10] However, there is a significant amount of consensus on attractiveness across different ethnic and social groups.[5]

The basis for much research in the area of smile esthetics is the social or posed smile. The posed smile is reproducible reliably,[9, 11, 12] which gives it utility in research endeavors. Ackerman et al[11] called for the posed smile to become part of the orthodontic record in 1998. Walder et al[12] stated that the posed smile is reproducible reliably when measured objectively, but

cautioned that subjective analysis can detect differences between repeated posed smiles. The posed smile is evaluated on the basis of two major characteristics during orthodontic treatment planning: the amount of maxillary incisor and gingival display and the transverse dimension or width of the smile.[13]

Buccal Corridor

The transverse dimension of the smile is referred to in terms of broadness of the smile and more specifically by the presence and size of buccal corridors.[13] The buccal corridor was introduced to the prosthodontic literature by Frush and Fisher[7] and defined as the space created between the buccal surface of the posterior teeth and the corner of the lips when the patient smiles. Buccal corridors have often been considered a function of maxillary width, but are actually also influenced by a variety of other factors.[13] Ackerman and Ackerman[14] noted that the appearance of buccal corridors is strongly influenced by lighting. Buccal corridors appear larger in ambient light but become smaller and can vanish altogether if enough light can penetrate into the smile from the front. Muscular factors involved in the animation of a smile also influence buccal corridors.[15-17] Rubin[15] stated that characteristics of the smile are influenced by the style of smile that the patient has, which is determined by which muscle groups are recruited during the smile and to what extent each muscle group functions. The anterior-posterior positioning of the maxilla with respect to the lips is another key determinant in the appearance of buccal corridors.[18-20] If the maxilla is retrusive, the wider portion of the dental arch is consequently positioned more posteriorly with respect to the anterior oral commissure. In this case, the buccal corridors appear larger. If the maxilla is more anteriorly positioned, the wider part of the arch is closer to the lips, and buccal corridors appear smaller in a smile.[18-20] Arch form is another factor which influences buccal corridors. For a given patient, the wider the arch form in the premolar

area, the smaller the buccal corridors appear.[20] Some have suggested that orthodontic treatment involving the extraction of premolars may result in a narrow arch and therefore larger buccal corridors, but multiple studies seem to disprove this contention.[21-24] Isiksal et al[23] found that extraction patients actually showed a slightly wider dental arch relative to the soft tissue when compared to non-extraction patients and untreated controls. Johnson and Smith[24] analyzed smiling photographs of 30 extraction and 30 non-extraction patients and found that buccal corridor size was not affected by premolar extractions. Gianelly[21] measured anterior and posterior arch widths on post-treatment study models from 25 non-extraction and 25 extraction patients. He found no differences in arch widths, except the mandibular canine width was 1mm larger in the extraction group.

The most esthetic size for buccal corridors has been a subject of some debate in the literature. After defining the buccal corridor, Frush and Fisher[7] stated that its exact size wasn't critical and should be judged by the eye of the clinician when fabricating a denture. They did, however, caution that total absence of buccal corridors is characteristic of an artificial "denture" smile. A few studies have supported the notion that buccal corridor size does not affect the attractiveness of a smile.[23, 25, 26] Hulsey[25] had laypeople evaluate cropped photos of smiles and found that the buccal corridor to be of no significance to an attractive smile. There may have been an issue with the definition of buccal corridors though, as they were measured from the canines to the corners of the mouth. Isiksal et al[23] presented cropped smile photographs to orthodontists, dental specialists, dentists, artists, parents and plastic surgeons for evaluation. Esthetic scores were not affected by any transverse characteristic of the smile. Roden-Johnson et al[26] digitally modified cropped photographs by adding very small buccal corridors if none were present or removing buccal corridors if present by adding tooth material. 30 sets of 2 pictures

(one original, one modified) were thus created, and presented to laypeople, dentists, and orthodontists for evaluation. They found that the presence of buccal corridors did not influence smile esthetics. However, this study did not quantify the size of the buccal corridors used in the images, which appear small, and there is a chance that they might not have been large enough to elicit a response.

Other authors have claimed, and many studies have shown that laypeople and clinicians prefer absent or minimal buccal corridors as opposed to larger ones.[20, 27-35] Morley and Eubank[35] stated that larger buccal corridors can make a smile less esthetic and used the term "deficient vestibular reveal" or DVR to describe this condition. Parekh et al[28, 29] published two papers which used a web-based survey to assess attractiveness and acceptability of various sizes of buccal corridors and various shapes of smile arcs simultaneously. Excessive buccal corridors were rated as less attractive and acceptable than ideal or absent buccal corridors. Neither the gender of the subject whose smile was being rated nor the gender of the rater appeared to affect the results. Moore et al[32] created full-face color slides of 5 men and 5 women who had just completed orthodontic treatment and were randomly selected to be enrolled into the study. The slides were digitally altered to produce 5 different sizes of buccal corridor. 15 male and 15 female laypeople evaluated a series of pairs of photos of the same patient with different sized buccal corridors. The smaller the buccal corridor, the more attractive the smile was rated. They concluded that minimal buccal corridors are esthetic on men and women and suggested that large buccal corridors should be added to a patient's orthodontic problem list. Martin et al[30] performed a paper survey which consisted of 4 digitally-altered cropped smile photographs per page, with varying sizes of buccal corridor. The photos also varied in whether or not the first molars were visible in the smile, and some buccal corridor asymmetry was added in several

photos. Both laypeople and orthodontists preferred smiles with no buccal corridors or smaller buccal corridors. Orthodontists were more sensitive than laypeople when evaluating buccal corridors and attractiveness. Mild buccal corridor asymmetry was not perceived by laypeople. Ioi et al[31] combined a cropped extra-oral photo of one female patient with an intraoral photo of another patient and made the image symmetrical digitally. 6 modified images were created with different sized buccal corridors (from 0 to 25% of intercommisural width). The images were rated by Japanese and Korean orthodontists and patients using a visual analog scale. Orthodontists and patients rated buccal corridors similarly. Male patients/laypeople were more tolerant of wider buccal corridors than their female counterparts. Overall, respondents preferred small buccal corridors (0-10%). Dunn et al[36] found that laypeople prefer a smile which has a greater number of teeth displayed.

Broad arch forms have gained popularity in orthodontics recently, with the thought that these arch forms will widen the smile and decrease buccal corridors.[20, 26] Sarver and Ackerman[20] stated that when the arch form is narrow or collapsed, the smile may also appear narrow and therefore present inadequate transverse smile characteristics. This could include pronounced and unesthetic buccal corridors. Orthodontic expansion and widening of these arches can decrease the size of the buccal corridors, thus improving the transverse dimension of the smile.[13, 20, 30, 32] However, several authors who have found minimal or no buccal corridors to be most attractive have cautioned against using these findings as rationale for routine expansion in patients with normal maxillae.[30, 32]

Gingival Display

The major vertical characteristic used in the evaluation of the posed smile is the amount of maxillary incisor and gingival display.[13] Similar to the previous discussion of buccal corridors, there are multiple factors which affect gingival display in a smile. Some of these factors are: philtrum and upper lip height, vertical maxillary dimension, maxillary incisal angulation, and muscle recruitment involved in animating the smile.[15, 37-40] Sarver[37] explained that there are multiple reasons for excessive gingival display in a smile including: vertical maxillary excess, short philtrum height, excessive animation, and maxillary incisor angulation which is too upright. The opposite of these factors can lead to insufficient maxillary incisor display. Rubin's[15] findings regarding smile style and muscular factors involved in animation (discussed previously) are also relevant to gingival display. Dickens et al[38] noted that gingival and maxillary incisor display is largely affected by facial soft tissue dimensions. They recommended consideration of referral to a plastic surgeon in cases where soft tissue issues such as lip proportion or dimension were involved or at fault in dentofacial problems encountered by the orthodontist. Peck et al[39] found that the presentation of a gingival smile was related to anterior vertical maxillary excess and ability to raise the upper lip much higher than average. They concluded that people who display significant gingiva when smiling have significantly more efficient lip elevation muscle action than people with more average lip lines.

Sexual dimorphism also seems to affect gingival display, as females tend to have increased gingival display as compared to males.[9, 10, 41-43] Rigsbee et al[9] stated that women have greater facial animation on smile than men. Vig and Brundo[10] studied subjects of various ages, from under 30 to over 60, and found that women show more incisor than men at rest and when animating. Tjan et al[41] showed in a sample of 454 dental and dental hygiene students between

the ages of 20 and 30 that females were twice as likely to have high smiles and males were twice as likely to have low smiles. Peck et al[42] found that high smile lines were significantly more common in females, and low smile lines more common in males in a sample of 88 subjects with a mean age of 15. Peck and Peck[43] reported mean gingival display of approximately 1mm for females and -1mm for males aged 15 years on average.

There are differences in the literature when it comes to the ideal relationship of the upper lip to the maxillary incisors and gingiva in a smile. Some studies and authors claim that the ideal elevation for the upper lip in a smile is such that the lower margin of the upper lip is even with the gingival margins of the maxillary central incisors.[20, 25, 44] Mackley[44] stated that the most attractive smiles have the lower margin of the upper lip even with the margin of the maxillary central incisors and suggested that the orthodontist must consider moving the maxillary incisors vertically in order to achieve maximum improvement to a patient's smile. The ratings of attractiveness by laypeople who evaluated cropped photos of smiles in Hulsey's[25] study were influenced by the height of the upper lip to the maxillary central incisors. The smiles ranked most attractive had the gingival margin of the maxillary centrals at the height of the upper lip.

Other authors have stated that complete maxillary incisor display with some gingival display is more attractive than lack of gingival display or partial tooth coverage by the upper lip.[13, 38, 45, 46] Sarver[13] suggested that some amount of gingival display is acceptable and is often esthetic and youthful appearing. Chiche et al[46] stated that 1mm of gingival display in a smile is esthetically ideal and 2 to 3mm can be esthetically acceptable. No research was cited to back up this claim. Kokich et al[8], in what may have been the first study to use computer-based modification to analyze smile esthetics[27], digitally altered images of a cropped smiles to evaluate various esthetic factors of the smile. As part of this study, a set of images testing

gingival display was created by moving the upper lip to create gingival levels from 6mm visible gingival display to 2mm of maxillary central incisor coverage by 2mm increments. Orthodontists, dentists, and laypeople evaluated the images and rated them according to attractiveness. No group (orthodontists, dentists, laypeople) discriminated between 2mm of lip coverage or 0mm. All three groups discriminated between those two levels and 2mm of gingival display though. Laypeople rated the smile as unattractive when the gingival level hit 4mm. Orthodontists were more sensitive. The authors suggested that since there was a significant difference in esthetic interpretation of gingival display between laypeople and orthodontists with the laypeople being more tolerant of increased gingival display, orthodontists and surgeons must be prudent in suggesting or planning maxillary impaction to correct a "gummy smile". In a follow-up study of similar design, Kokich et al[45] tested gingival display preferences in smaller increments. Orthodontists and laypeople found 3mm of gingival display or greater to be unattractive. Based on the results of both studies, the authors concluded that 1 to 2mm of visible gingiva in a smile is generally not regarding as unattractive and suggested that it is probably better for the patient to show some gingiva in a smile rather than none at all. The authors recommended that clinicians be aware of the fact that not every esthetic problem they perceive as a professional will be noticed by laypeople. In a previous publication, Kokich[47] gave treatment tips for orthodontic improvement of the smile with excess gingival display, including indications for surgical and non-surgical options.

In contrast to the recommendation that a bit of gingival display in the smile is better than none, some studies have found that laypeople identify 2mm of maxillary incisor coverage as most attractive,[27, 33, 48] or prefer partial coverage of the maxillary incisors as opposed to any gingival display.[23, 33, 48, 49] Isiksal et al[23] reported that esthetic scores decreased as maxillary

gingival display increased. Ker et al[27] digitally created a cropped image of a smile and analyzed various characteristics involved in smile esthetics. 243 laypeople took the computer-based survey and were able to adjust the variable being analyzed through a continuous range by using a slider bar. The respondents were asked to select an ideal value and a range of acceptability for each smile esthetic variable in the study. One of the factors analyzed was buccal corridors (results cited previously) and another was gingival display. Gingival display was rated as ideal at -2mm or 2mm of lip coverage over the maxillary central incisors. The range of acceptability ranged from -6mm to 2mm of gingival display. Based on the wide range of values that laypeople tolerated, the authors cautioned clinicians not to sensitize patients and lead them to desire unrealistic or clinically impossible results. Ioi et al[49] digitally created a cropped smile image as a composite of a female intraoral and extra-oral photograph and adjusted the amount of gingival display by moving the intraoral image vertically. 11 images, from 5mm gingival display to 5mm of maxillary central incisor coverage, were created. Korean and Japanese orthodontists and orthodontic patients rated the images based on attractiveness. Female laypeople preferred 0 to 2mm of upper lip coverage over the maxillary central incisor and a larger range of negative gingival display was preferred by males. The orthodontists' ratings matched closely with the female laypeople. Springer et al[33] digitally created mirrored and symmetric full face views of one male and one female of average attractiveness. Multiple aspects of smile esthetics were altered and analyzed singularly. 96 laypeople used a slider to morph the images continuously and choose ideal values and upper and lower limits of acceptability for each variable studied. One variable under consideration was buccal corridor size (results cited previously) and another was gingival display. The ideal value for gingival display was 2.3mm of coverage for the maxillary central incisor by the lip. The acceptable range was 7mm of coverage to 1mm of

gingival display for the female model and 6mm of coverage to 2mm of gingival display for the male model. The authors noted that the respondents did not seem to like any gingival display at all at the central incisors. No differences were found between male and female respondents. Kaya and Uyar[48] studied gingival display and smile arc simultaneously. A composite cropped smile image was created from a female intraoral photo and extra-oral photo. 5 levels of gingival display were digitally created: -4mm, -2mm, 0mm, 2mm, and 4mm and combined with various shapes of smile arcs. 70 dentists, 70 orthodontists, and 70 laypeople evaluated the resultant images and rated them according to attractiveness. The highest rated smiles included 2mm of maxillary central incisor coverage by the upper lip for dentists and laypeople, and 0mm for the orthodontists. Positive gingival display was a negative influence on smile attractiveness across all rater groups. The authors noted that when gingival display is insufficient, flat smile arcs are preferred and with excessive gingival display vaulted smile arcs are preferred. Age, group (dentist, orthodontist, laity), and sex of the respondents all had no effect on perception of attractiveness.

Aging and the Smile

The soft tissues of the face have a significant influence on the major vertical and transverse characteristics of the smile.[15-17, 37-40] Several authors investigated changes in the lips during growth and aging of younger patients, but did not present data beyond early adulthood.[50-52] Mamandras[50] used serial computerized cephalometry to study changes in the lips of 32 untreated subjects. The lips became thicker and longer as the subjects aged from 8 to 18 years-old. Vig and Cohen[51] took cephalometric radiographs as patients grew from 4 to 20 years-old and found that lip competence increases with age. Genecov et al[52] took cephalometric radiographs on 64 patients 7 to 18 years-old and determined that the anterior-posterior relative

position of the lip to a vertical reference line stayed constant during maturation and the anterior growth and projection of the nose continued after the completion of skeletal growth in males and females. The authors also noted that the angular shapes and relative positions of the nose, lips, and chin stayed fairly constant throughout the development period.

The perioral soft tissue sags with advancing age in adulthood as skin stretches, flattens, and loses elasticity.[53] Plastic surgery literature commonly discusses this age-related sagging of the facial soft tissues including changes in the lips.[54] These changes have a direct effect on smile esthetics. Formby et al[55] studied cephalometric radiographs on patients between 18 and 42 years of age and found that the lips become thinner with aging. Bishara et al[56] analyzed cephalometric radiographs on patients at age 25 and then 46 and discovered that the lips appear more retrusive with age.

As adults age, the philtrum, upper lip, and commissure lengthen,[17, 20, 38, 57] and the ability of the muscle to raise the upper lip in a smile decreases.[16, 17, 58] Janzen[58] noted that with loss of tonicity of the facial muscles, the lip will move less. Chetan et al[17] made video recordings of 241 patients aged 0 to 50 years. They found that upper lip length on smile increase with age, decreasing maxillary incisor and gingival display in men and women, and these changes were evident earlier in men. They also noted that the intercomissural width increased at rest but decreased on smile with advancing age. The authors concluded that changes in lip elevation contributed less than the sagging of the upper lip in lowering the lip line of the smile with aging. Dickens et al[38] used a cross-sectional sample of 1367 patients of various ages from an orthodontic private practice to analyze age-related soft-tissue changes in the lower face. They found that the length of the philtrum of the upper lip is initially short, but increases faster in height than the commissure at adolescence, which results in maximum maxillary incisor display

at age 11 in females and 12 in males. The continued lengthening of the philtrum and commissure results in decreased maxillary incisor and gingival display on smile as a person ages. The authors cautioned orthodontists to carefully consider these age-related changes prior to initiating maxillary incisor intrusion on a patient. Singh et al[57] made video recordings of 195 subjects between 15 and 55 years of age and took measurements of the smile. They found that upper lip length on smile increased for males and females, but maxillary incisor display decreased more significantly for males. In conclusion, the authors stated that the smile narrows vertically with age, especially in men.

Multiple other authors and studies have also stated or demonstrated that the soft tissue changes associated with aging result in less maxillary incisor and gingival display in the smile.[10, 13, 16, 20, 39, 41] One study showed an increase in buccal corridor size with advancing age.[16] Vig and Brundo[10] stated that perhaps their most interesting finding was the gradual decrease in maxillary central incisor exposure with increasing which was accompanied by a gradual increase in exposure of the mandibular dentition. Desai et al[16] took video recordings of 221 subjects ranging in age from 15 to 70 years-old and made measurements at rest and smile. They found that as people age, especially beyond the age of 40, there is a decreased ability of the muscles to raise the upper lip in a smile. The maxillary incisors are displayed less in the smile, by 1.5 to 2mm, with advancing age. There is a small increase in buccal corridor space with increased age. The authors concluded that with advancing age, the smile gets relatively narrower vertically and wider transversely. People with high smiles in their youth may end up with normal smiles later in adulthood and those with normal smiles may end up with low smiles. Peck et al[39] compared their orthodontic-aged sample with a mean age of 15 years, to the young adult sample of Tjan et

al[41] (ages 20 to 30) and noted that a gingival smile line was three times more common in the younger sample.

Sarver and Ackerman[20] summarized the changes caused by maturation and aging of soft tissues by explaining that with increasing age, there is lengthening of the resting philtrum and commissure heights, decrease in tissue turgor, decrease in maxillary display at rest and decrease in maxillary incisor and gingival display when smiling. They stated that time is the 4th dimension that should be considered in smile analysis and orthodontic treatment planning due to these dynamic factors.

REFERENCES

1. Proffit WR, Fields HW, Sarver DM. Contemporary Orthodontics. 5th ed. St Louis, MO: Elsevier Mosby; 2013.

2. Proffit WR. The soft tissue paradigm in orthodontic diagnosis and treatment planning: a new view for a new century. J Esthet Dent. 2000;12(1):46-9.

3. Ackerman JL, Proffit WR, Sarver DM. The emerging soft tissue paradigm in orthodontic diagnosis and treatment planning. Clin Orthod Res. 1999 May;2(2):49-52.

4. Sarver DM, Ackerman JL. Orthodontics about face: the re-emergence of the esthetic paradigm. Am J Orthod Dentofacial Orthop. 2000 May;117(5):575-6.

5. Collins M. The Eye of the Beholder: Face Recognition and Perception. Semin Orthod. 2012 September 2012;18(3):229-34.

6. Czarnecki ST, Nanda RS, Currier GF. Perceptions of a balanced facial profile. Am J Orthod Dentofacial Orthop. 1993 Aug;104(2):180-7.

7. Frush J, Fisher R. The dynesthetic interpretation of the dentogenic concept. J Prosthet Dent. 1958;8(4):558-81.

8. Kokich VO,Jr, Kiyak HA, Shapiro PA. Comparing the perception of dentists and lay people to altered dental esthetics. J Esthet Dent. 1999;11(6):311-24.

9. Rigsbee OH,3rd, Sperry TP, BeGole EA. The influence of facial animation on smile characteristics. Int J Adult Orthodon Orthognath Surg. 1988;3(4):233-9.

10. Vig RG, Brundo GC. The kinetics of anterior tooth display. J Prosthet Dent. 1978 May;39(5):502-4.

11. Ackerman JL, Ackerman MB, Brensinger CM, Landis JR. A morphometric analysis of the posed smile. Clin Orthod Res. 1998 Aug;1(1):2-11.

12. Walder JF, Freeman K, Lipp MJ, Nicolay OF, Cisneros GJ. Photographic and videographic assessment of the smile: objective and subjective evaluations of posed and spontaneous smiles. Am J Orthod Dentofacial Orthop. 2013 Dec;144(6):793-801.

13. Sarver DM. The importance of incisor positioning in the esthetic smile: the smile arc. Am J Orthod Dentofacial Orthop. 2001 Aug;120(2):98-111.

14. Ackerman MB, Ackerman JL. Smile analysis and design in the digital era. J Clin Orthod. 2002 Apr;36(4):221-36.

15. Rubin LR. The anatomy of a smile: its importance in the treatment of facial paralysis. Plast Reconstr Surg. 1974 Apr;53(4):384-7.

16. Desai S, Upadhyay M, Nanda R. Dynamic smile analysis: changes with age. Am J Orthod Dentofacial Orthop. 2009 Sep;136(3):310.e1,10; discussion 310-1.

17. Chetan P, Tandon P, Singh GK, Nagar A, Prasad V, Chugh VK. Dynamics of a smile in different age groups. Angle Orthod. 2013 Jan;83(1):90-6.

18. Ackerman MB. The effect of maxillary position on anterior tooth display [thesis]. Rochester, NY: University of Rochester; 2000.

19. Sarver DM. The face as determinant of treatment choice. In: Frontiers of dental and facial esthetics. Craniofacial Growth Series. Vol 38. Ann Arbor, MI: Center for Human Growth and Development; University of Michigan; 2001. p.19-54.

20. Sarver DM, Ackerman MB. Dynamic smile visualization and quantification: Part 2. Smile analysis and treatment strategies. Am J Orthod Dentofacial Orthop. 2003 Aug;124(2):116-27.

21. Gianelly AA. Arch width after extraction and nonextraction treatment. Am J Orthod Dentofacial Orthop. 2003 Jan;123(1):25-8.

22. Golwalkar SA, Shetty V. Arch widths after extraction and nonextraction treatment in class I patients. J Contemp Dent Pract. 2013 Mar 1;14(2):312-5.

23. Isiksal E, Hazar S, Akyalcin S. Smile esthetics: perception and comparison of treated and untreated smiles. Am J Orthod Dentofacial Orthop. 2006 Jan;129(1):8-16.

24. Johnson DK, Smith RJ. Smile esthetics after orthodontic treatment with and without extraction of four first premolars. Am J Orthod Dentofacial Orthop. 1995 Aug;108(2):162-7.

25. Hulsey CM. An esthetic evaluation of lip-teeth relationships present in the smile. Am J Orthod. 1970 Feb;57(2):132-44.

26. Roden-Johnson D, Gallerano R, English J. The effects of buccal corridor spaces and arch form on smile esthetics. Am J Orthod Dentofacial Orthop. 2005 Mar;127(3):343-50.

27. Ker AJ, Chan R, Fields HW, Beck M, Rosenstiel S. Esthetics and smile characteristics from the layperson's perspective: a computer-based survey study. J Am Dent Assoc. 2008 Oct;139(10):1318-27.

28. Parekh S, Fields HW, Beck FM, Rosenstiel SF. The acceptability of variations in smile arc and buccal corridor space. Orthod Craniofac Res. 2007 Feb;10(1):15-21.

29. Parekh SM, Fields HW, Beck M, Rosenstiel S. Attractiveness of variations in the smile arc and buccal corridor space as judged by orthodontists and laymen. Angle Orthod. 2006 Jul;76(4):557-63.

30. Martin AJ, Buschang PH, Boley JC, Taylor RW, McKinney TW. The impact of buccal corridors on smile attractiveness. Eur J Orthod. 2007 Oct;29(5):530-7.

31. Ioi H, Kang S, Shimomura T, Kim SS, Park SB, Son WS, et al. Effects of buccal corridors on smile esthetics in Japanese and Korean orthodontists and orthodontic patients. Am J Orthod Dentofacial Orthop. 2012 Oct;142(4):459-65.

32. Moore T, Southard KA, Casko JS, Qian F, Southard TE. Buccal corridors and smile esthetics. Am J Orthod Dentofacial Orthop. 2005 Feb;127(2):208,13; quiz 261.

33. Springer NC, Chang C, Fields HW, Beck FM, Firestone AR, Rosenstiel S, et al. Smile esthetics from the layperson's perspective. Am J Orthod Dentofacial Orthop. 2011 Jan;139(1):e91-e101.

34. Gul-e-Erum, Fida M. Changes in smile parameters as perceived by orthodontists, dentists, artists, and laypeople. World J Orthod. 2008 Summer;9(2):132-40.

35. Morley J, Eubank J. Macroesthetic elements of smile design. J Am Dent Assoc. 2001 Jan;132(1):39-45.

36. Dunn WJ, Murchison DF, Broome JC. Esthetics: patients' perceptions of dental attractiveness. J Prosthodont. 1996 Sep;5(3):166-71.

37. Sarver DM. Esthetic Orthodontics and Orthognathic Surgery. Anonymous St. Louis, MO: Mosby; 1998.

38. Dickens S, Sarver D, Proffit WR. Changes in Frontal Soft Tissue Dimensions of the Lower Face by Age and Gender. World J Orthodontics. 2002;3(4):313-20.

39. Peck S, Peck L, Kataja M. The gingival smile line. Angle Orthod. 1992 Summer;62(2):91,100; discussion 101-2.

40. Epker BN, Fish L. Surgical-orthodontic correction of open-bite deformity. Am J Orthod. 1977 Mar;71(3):278-99.

41. Tjan AH, Miller GD, The JG. Some esthetic factors in a smile. J Prosthet Dent. 1984 Jan;51(1):24-8.

42. Peck S, Peck L, Kataja M. Some vertical lineaments of lip position. Am J Orthod Dentofacial Orthop. 1992 Jun;101(6):519-24.

43. Peck S, Peck L. Selected aspects of the art and science of facial esthetics. Semin Orthod. 1995 Jun;1(2):105-26.

44. Mackley RJ. An evaluation of smiles before and after orthodontic treatment. Angle Orthod. 1993 Fall;63(3):183,9; discussion 190.

45. Kokich VO, Kokich VG, Kiyak HA. Perceptions of dental professionals and laypersons to altered dental esthetics: asymmetric and symmetric situations. Am J Orthod Dentofacial Orthop. 2006 Aug;130(2):141-51.

46. Chiche G, Kokich VG, Caudill R. Diagnosis and Treatment Planning of Esthetic Problems. In: Chiche G, Pinault A, editors. Esthetics of Anterior Fixed Prosthodontics. Quintessence; 1994. p.33.

47. Kokich V. Esthetics and anterior tooth position: an orthodontic perspective. Part II: Vertical position. J Esthet Dent. 1993 Jul-Aug;5(4):174-8.

48. Kaya B, Uyar R. Influence on smile attractiveness of the smile arc in conjunction with gingival display. Am J Orthod Dentofacial Orthop. 2013 Oct;144(4):541-7.

49. Ioi H, Kang S, Shimomura T, Kim SS, Park SB, Son WS, et al. Effects of vertical positions of anterior teeth on smile esthetics in Japanese and korean orthodontists and orthodontic patients. J Esthet Restor Dent. 2013 Aug;25(4):274-82.

50. Mamandras AH. Linear changes of the maxillary and mandibular lips. Am J Orthod Dentofacial Orthop. 1988 Nov;94(5):405-10.

51. Vig PS, Cohen AM. Vertical growth of the lips: a serial cephalometric study. Am J Orthod. 1979 Apr;75(4):405-15.

52. Genecov JS, Sinclair PM, Dechow PC. Development of the nose and soft tissue profile. Angle Orthod. 1990 Fall;60(3):191-8.

53. Peck S, Peck H. The aesthetically pleasing face: an orthodontic myth. Trans Eur Orthod Soc. 1971:175-84.

54. Fanous N. Aging lips. Esthetic analysis and correction. Facial Plast Surg. 1987 Spring;4(3):179-83.

55. Formby WA, Nanda RS, Currier GF. Longitudinal changes in the adult facial profile. Am J Orthod Dentofacial Orthop. 1994 May;105(5):464-76.

56. Bishara SE, Treder JE, Jakobsen JR. Facial and dental changes in adulthood. Am J Orthod Dentofacial Orthop. 1994 Aug;106(2):175-86.

57. Singh B, Ahluwalia R, Verma D, Grewal SB, Goel R, Kumar PS. Perioral age-related changes in smile dynamics along the vertical plane: a videographic cross-sectional study. Angle Orthod. 2013 May;83(3):468-75.

58. Janzen EK. A balanced smile--a most important treatment objective. Am J Orthod. 1977 Oct;72(4):359-72.

SMILE PREFERENCES & AGE

Introduction

It is critical for the orthodontist to understand what characteristics make up a desirable smile or ideal esthetic result in the eyes of the patient. In fact, esthetic considerations are commonly considered to be of primary importance in developing orthodontic treatment plans.[1-3] Adult treatment is now a major part of orthodontic practice, with approximately 30% of patients above the age of 18 in the US.[4] The pursuit of an attractive smile is often the main motivation for patients of all ages who seek orthodontic treatment,[1, 3] so orthodontists need to know if variability in smile preferences exists based on the age of the patient being treated.

The posed smile is evaluated on the basis of two major characteristics during orthodontic treatment planning: the amount of maxillary incisor and gingival display and the transverse dimension or width of the smile.[5] The social or posed smile is reproducible reliably,[6-8] and the vertical and transverse characteristics of an ideal smile have been studied in depth. However, studies that address these characteristics have often used a cropped smile photo without a face, [9-21] and the few that have included the full face have not been specifically designed to consider the age of the subject/smile in question.[22-25] Patients tend to evaluate their smile esthetics in the context of a full face view in a mirror.[25] This perspective is a better depiction of what is visually presented during normal conversation.[23]

The transverse dimension of the smile is referred to in terms of broadness of the smile and more specifically by the presence and size of buccal corridors.[5] The buccal corridor is

defined as the space created between the buccal surfaces of the posterior teeth and the corner of the lips when a patient smiles.[26] Buccal corridors have often been considered a function of maxillary width, but are actually influenced by a large variety of factors.[5] The appearance of buccal corridors is strongly influenced by lighting: they appear larger in ambient light but much smaller or obliterated altogether if light can penetrate into the smile from the front.[27] Smile animation factors, including muscle group recruitment and function, influence buccal corridors as well.[28-30] The anterior-posterior positioning of the maxilla with respect to the lips also affects the appearance of buccal corridors. The wider portion of a retrusive maxilla is positioned farther away from the anterior oral commissure which causes buccal corridors to appear larger.[31-33]

Arch form is another key determinant in buccal corridor size.[33] Some suggest that orthodontic treatment with premolar extractions may result in a narrow arch and therefore larger buccal corridors, but studies seem to disprove this contention.[19, 21, 34, 35] Numerous authors have stated that laypeople and clinicians prefer absent or minimal buccal corridors as opposed to larger ones.[11-13, 15, 16, 22-24, 33, 36] A few others have found that buccal corridors do not affect the attractiveness of the smile,[14, 20, 21] but their studies may be hampered by faulty definition of buccal corridors or inadequate range of buccal corridor size to elicit a response.[15] Broad arch forms have gained popularity in orthodontics recently, with the thought that these arch forms will widen the smile and decrease buccal corridors.[14, 33] Narrow or collapsed arches may present with pronounced and unesthetic buccal corridors which may be decreased in size by orthodontic expansion thus improving the transverse dimension of the smile.[5, 15, 22, 33] However, the total absence of buccal corridors has been described as a characteristic of an unnatural or "denture smile".[5, 26]

As with buccal corridors, there are multiple factors that affect gingival display in a smile. These include: vertical maxillary dimension, philtrum height, maxillary incisor angulation, and muscle recruitment involved in animation.[28, 37-40] Sexual dimorphism also plays a role as females tend to have increased gingival display when compared to males.[6, 41-44] Some authors claim that the ideal elevation for the upper lip in a smile is such that the lower margin of the upper lip is even with the gingival margins of the maxillary central incisors.[20, 33, 45] It has also been stated that complete maxillary incisor display with some gingival display is more attractive than lack of gingival display or partial tooth coverage by the upper lip.[5, 10, 38, 46] On the contrary, other studies have found that laypeople identify 2mm of maxillary central incisor coverage as most attractive,[11, 18, 23] or prefer partial coverage of the maxillary incisors as opposed to any gingival display.[17, 18, 21, 23]

Considering the significant influence of the soft tissues on the major vertical and transverse characteristics of the smile,[28-30, 37-40] it is only logical that aging significantly affects the appearance of the smile. The perioral soft tissue sags with advancing age as skin stretches, flattens, and loses elasticity.[47] Plastic surgery literature commonly discusses this age-related sagging of the facial soft tissues including changes in the lips.[48] With aging, the lips get thinner and more retrusive.[49, 50] The philtrum, upper lip, and commissure lengthen.[30, 33, 38, 51] The ability of the muscles to raise the upper lip in a smile decreases.[29, 30, 52] These age-related soft tissue changes result in less maxillary incisor and gingival display and more mandibular incisor display in the smile.[5, 29, 30, 33, 38, 39, 41, 42, 51] The smile gets relatively narrower vertically and wider transversely with increasing age, and this may be more pronounced in men.[29, 51] With advancing age, intercommissural width increases at rest and decreases on smile, and the apparent size of buccal corridors slightly increases.[29, 30] These dynamic age-related factors make the

consideration of time, or the 4th dimension, mandatory during smile analysis and orthodontic treatment planning.[33]

People are more aware than ever of the treatment possibilities that exist with esthetic dentistry. Even patients who are advanced in age may request a dentition that appears youthful.[53] Should the orthodontist attempt to give the adult patient as youthful a smile as possible? The patient's vision of a youthful smile may not be what the orthodontist has in mind. Patients may also be concerned that their smile looks natural at a certain age. The esthetic preferences, ideals, and goals of the clinician may not always agree with those of the patient.[9-11, 14, 15, 21]

The aim of this study is to determine laypeople's preferences for gingival and maxillary tooth display and buccal corridor size of the smile as a function of the age of the subject whose smile is being evaluated as well as the age of the evaluator. If smile preferences do vary based on age, this should encourage orthodontists to discuss specific characteristics of smile design with each patient individually rather than applying theoretical standards.

Material and Methods

Three age groups were created to differentiate the participants in this study: 18-26 (young), 27-49 (middle), and 50+ (older). One representative male and female subject was selected from each of these age groups for a total of 6 subjects. The ages of the subjects were: 19 (young male), 18 (young female), 37 (middle male), 32 (middle female), 69 (older male), and 62 (older female). All selected subjects were Caucasian. Each subject exhibited excellent dental esthetics and a well-animated smile (large "frame" for tooth display). Each subject consented to

their involvement and the study was approved by the University of North Carolina institutional review board.

Full face smiling photographs and retracted frontal, center intraoral photographs were taken of each subject. The subjects were instructed to animate significantly on the smiling photographs, in order to create adequate vertical space between the lips to allow manipulation of the final composite image. Multiple center intraoral photos were taken at various vertical angulations (pitch). Additionally, for one subject (the young female), zoomed extra-oral photos were taken which captured the lips and surrounding tissues in a full smile but not the rest of the face, resulting in a cropped smile photo. The length of one maxillary central incisor was measured clinically and recorded for each of the 6 subjects.

For each subject, one central intraoral photo was selected which matched the pitch of the occlusal plane in the smiling photograph. Each set of two photos was loaded into Adobe Photoshop Elements 8.0 (Adobe Systems, San Jose, CA) and all manipulations of the photos were performed using this software. A measurement gauge was made using the clinically measured length of a central incisor (Fig 1). This gauge included marks at each mm along the long axis of the incisor and contour lines representing the outline form of the incisor. Using this measurement gauge, the size of the central intraoral photo was proportionally adjusted to match exactly with the size of the smiling photograph (Fig 2). Gingival and tooth shades of the intraoral photograph were adjusted to match the smiling photo. The intraoral image was layered within the frame of the lips in the smiling facial photograph and adjusted to idealize occlusal plane and dental midline to mid-sagittal plane (Fig 3).

For each of the 6 subjects, two sets of altered photos were then created. Two sets of altered photos were also created for the cropped smile photo (described previously) which did not include the rest of the subject's face. The first altered photo set included 5 photos with different vertical orientations, which resulted in 5 different amounts of gingival display: 4mm, 2mm, 0mm, -2mm, and -4mm. Similar to other studies which used digital modification, gingival display was defined as the distance between the inferior margin of the upper lip and the gingival margin of the maxillary central incisors.[9-11, 17, 18, 23] The intraoral photo was first positioned vertically such that the gingival margins of the maxillary central incisors were even with the margin of the upper lip. This position was used for the 0mm photo in the vertical set. 1mm buccal corridors were added bilaterally, and these minimal corridors were identical in all 5 vertical photos. Using the measurement gauge, the central intraoral photograph was moved down 2mm, and then 2mm more, to create the 2mm and 4mm gingival display photos. The intraoral photograph was then moved up 2mm from the 0 position, and then up another 2mm to create the -2mm and -4mm photos, which included 2mm and 4mm of maxillary central incisor coverage by the upper lip, respectively (Fig 4).

The second set of altered photographs for each subject included 4 different buccal corridor widths: 0mm, 2mm, 4mm, and 6mm. The vertical position of the intraoral photograph for this set was the 0mm vertical position described previously, where the margin of the upper lip is even with the gingival margins of the maxillary central incisors. The 0mm buccal corridor photo included no buccal corridors. The measurement gauge was used to create 2mm, 4mm, and 6mm buccal corridors bilaterally to complete the set (Fig 5). Similar to other studies which used digital modification, buccal corridors were measured from the inner commissure of the lips to the most lateral clearly visible tooth structure.[11-13, 15, 16, 22-24]

High-resolution 11" x 13" photo booklets (Fig 6-19) and response forms were generated. Each page of the 14 page booklet included either the 5 gingival display images for a given subject or the 4 buccal corridor images. The order of the 6 subjects and the arrangement of the images on a given page were both determined using a random number generator, and the altered sets using the cropped smile photo (no face) were placed last. Respondents were asked to rank each page of photographs from most attractive to least attractive. After the ranking was completed, respondents were asked to provide some demographic information including age and gender.

Data was collected in various locations on the UNC – Chapel Hill campus, including but not limited to the School of Dentistry and the hospital. Respondents were required to be 18 years of age or older, and were excluded if associated with the dental profession (dentists, specialists, dental assistants, hygienists, dental students, etc).

Statistical analysis

Attractiveness rankings relating to subject age and gender were summarized by descriptive statistics. Respondents were categorized by gender and age: 18-26 (young), 27-49 (middle), 50+ (older). In order to assess differences in preferences relating to respondent age and gender, respondents' top choices (preference for most attractive) of gingival display and buccal corridor size were analyzed separately for each subject and the cropped smile using stratified Mantel-Haenszel (MH) general association statistics. For each patient and the cropped smile, the association between respondent's age group and the top choice for gingival display and buccal corridor was analyzed adjusting for respondent gender and then the association

between respondent's gender and top choice was analyzed adjusting for respondent age group. Level of significance was set at 0.05.

Results

413 complete responses were collected, and there were a relatively equal number of respondents from each age group (18-26, 27-49, 50+) with equal gender distribution within the groups: 65 young male, 58 young female, 83 middle male, 62 middle female, 83 older male, 62 older female.

The data was initially analyzed by grouping the 2 subjects of each age group together and calculating mean rankings to test for differences in attractiveness for gingival display (Table 1) (Fig 20) and buccal corridor size (Table 2) (Fig 21) related to subject age. For all 3 age groups and the cropped smile, the highest ranked amount of gingival display was 0mm and the second highest ranked was -2mm. In all age groups and the cropped smile, the lowest ranked amount of gingival display was 4mm. All age groups and the cropped smile had 0mm buccal corridors ranked as most attractive. 2mm buccal corridors ranked as second most attractive for the cropped smile and both young and middle age groups while tying for most attractive in the older age group. In all age groups and the cropped smile the 6m buccal corridors ranked as least attractive. When evaluating this data using the frequency of a top attractiveness ranking for each image, the results matched with those using mean ranking.

The data was further analyzed by separating out each individual subject and calculating mean rankings to test for differences in attractiveness for gingival display (Table 3) (Fig 22) and buccal corridor size (Table 4) (Fig 23) related to subject age and gender. The 0mm of gingival display ranked as most attractive for every subject except the older female, where it came in a

close second. For the rest of the subjects, -2mm gingival display ranked second most attractive, except for the middle female, where 2mm gingival display was second. Least attractive for all subjects was 4mm of gingival display, except for the middle female where -4mm ranked least attractive. All the male subjects had 0mm buccal corridors ranked as most attractive and 2mm as second most attractive. For the female subjects the reverse was true, with 2mm ranked as most attractive and 0mm as second most attractive, except in the young female where the mean values for the two were equal. For all subjects, the largest 6mm buccal corridors were ranked least attractive. When evaluating this data using the frequency of a top attractiveness ranking for each image, the results again matched with those using mean ranking.

To determine any differences based on respondent age, individual subjects were isolated and only the respondents' top choices were analyzed, adjusting for respondent gender. Respondents in different age groups made similar choices for the most attractive gingival displays except when evaluating the young male subject ($p=0.002$) and the older female subject ($p<0.0001$) (Table 5). For both the young male and older female subject, young respondents were, in general, much more likely to choose 0mm as their preference than middle and older respondents who were less harmonious in their preference. The percentage of older respondents who preferred -2mm of gingival display for the older female patient was nearly twice as high as those who preferred 0mm.

For buccal corridors, respondents in different age groups differed significantly in their choices for most attractive buccal corridor size on the young male subject ($p=0.047$), the middle female subject ($p=0.007$), the older female subject ($p=0.004$), and the cropped smile (0.037) (Table 6). For the young male subject, virtually all the young respondents preferred 0mm or 2mm, while in the middle and older age groups higher percentages preferred the 4mm and 6mm

sizes. A similar pattern was seen for the older female subject. For the middle female subject, young respondents had a clear preference for choosing 2mm and rejecting 6mm, while in the middle and older groups there was no distinct preference for any of the buccal corridor options. For the cropped smile, the young respondents were more decisive in selecting the 0mm buccal corridors as top choice, while middle and older respondents had more equal preference for 0mm and 2mm.

To study differences based on respondent gender, subjects were again analyzed individually and only the respondents' top choices for attractiveness were considered, adjusting for respondent age. For gingival display, significant differences based on the gender of the respondents were limited to the older ($p=0.049$) and middle (0.002) female subject and were very minor (Table 7). For the older female subject, both male and female respondents selected 0mm as most attractive with the highest frequency, and -2mm with the second highest frequency, but female respondents were more likely to select -4mm as most attractive. For the middle female, male and female respondents again agreed with most frequently preferred (0mm) and second most frequently preferred (2mm) levels of gingival display, but females were more likely to choose 0mm and males more likely to choose 4mm.

When evaluating buccal corridor size, the male and female respondents only differed significantly for the cropped smile ($p=0.022$) (Table 8). The male respondents clearly preferred 0mm while the females were split evenly between 0mm and 2mm as the top choice.

Discussion

Ackerman et al[1] stated that the emerging soft-tissue paradigm in diagnosis and treatment planning places greater emphasis on clinical examination of soft tissue function and esthetics

than has previously been the case and called for new information in these areas. Many authors and researchers have answered this call, as smile esthetics has become a popular topic in the orthodontic literature. Increasing numbers of adults are seeking orthodontic care,[4] and it is important for orthodontists to consider smile esthetics as they relate to the adult patient. Perioral soft-tissues change with advancing age and this affects the smile. Therefore, the 4th dimension (time) must be considered during smile assessment in orthodontic treatment planning.[33]

This is the first study to evaluate laypeople's preferences for the major vertical and transverse characteristics of the smile on different aged subjects. Many studies have used cropped photos to analyze these factors,[9-21] while few have evaluated smile esthetics in the context of the full face.[22-25] In this study it was critical to provide full face views of the subjects to the respondents to display the cues which differentiate people according to age. Laypeople were targeted as respondents in this study as they are the group that receives orthodontic treatment and their opinion of the result is critical to clinical success.

When the male and female subject of each age group were paired for analysis, the results of this study showed no differences in preferences for gingival display or buccal corridor size based on subject age. When the subjects were evaluated individually, only minor differences were noted in overall preferences for gingival display. The older female subject had -2mm gingival display as the top-ranked level by a tiny margin over 0mm which was preferred for the rest of the subjects. The results for the middle female were more different from the rest of the group as the second most preferred gingival display level was 2mm and the least preferred was -4mm. This indicates that the respondents either preferred positive gingival display more on this subject than any other, or were more opposed to maxillary incisor coverage on this subject. These findings may result from the fact that the middle female had shortest maxillary central

incisor length relative to the vertical space between the lips in the smile. Not only was a high percentage of her maxillary central incisors hidden on the negative gingival display photos, a greater amount of mandibular incisor and tissue was displayed than most of the other subjects.

Since there doesn't seem to be an age-related pattern to these minor differences in overall gingival display preferences, they should not be ascribed to subject age. Any slight differences in preference likely have to do with differences in other facial features and dimensions which may not be determined by age. Flores-Mir et al[25], in a study which used full face photos, reported a similar effect as esthetic perceptions of anterior dentition varied significantly between the subjects whose smiles were evaluated. Springer et al[23] also noted significant differences in esthetic preferences between the two different subjects whose full face images were used in their study. The authors attributed these differences to the subjects' facial appearances.

In this study, no differences in overall preferences for buccal corridor size were noted corresponding to subject age. Though the mean ranks for buccal corridor size are very close for 0mm and 2mm, it is worth noting that 2mm is slightly preferred on the female subjects and 0mm on the males. This may be evidence of a small gender-specific difference in laypeople's preference for buccal corridor size. This finding would disagree with the studies of Parekh et al[12] and Moore et al[22] but may be supported by the study of Gul-E-Erum and Fida[24] who found that laypeople preferred small (10%) buccal corridors on a woman and no buccal corridors on a man.

Significant differences, though minimal, were noted for esthetic preferences based on respondent age. This contrasts with the work of Martin et al[15] and Kaya et al[18] who both found that respondent age had no significant effects on attractiveness ratings for buccal corridors and

gingival display, respectively. Assessing gingival display, respondents varied by age in their preferences for the young male and older female subjects. For both subjects, as respondent age increased, there was a gradual shift in top preference from the 0mm level to 2mm of upper incisor coverage. This trend of older respondents preferring a slightly "older" amount of gingival display and younger respondents a slightly more youthful gingival display would carry more weight if it was seen with more subjects in the study. For buccal corridor size, in three of the subjects (young male, middle female, older female) and the cropped smile, significant differences in preference were found based on respondent age. Young respondents were more decisive in selecting minimal buccal corridors as most attractive, while middle and older respondents were more varied in their rankings.

Several previous studies have found no significant differences in attractiveness ratings for gingival display and buccal corridor size based on respondent gender.[12, 13, 15, 18, 22] The statistical analysis in this study identified significant differences in gingival display preference for two of the subjects based on respondent gender, but these were fairly trivial. The only significant difference by respondent gender in buccal corridor size preference was for the cropped smile. Where female respondents were split between 0mm and 2mm buccal corridors as most attractive, male respondents were more firmly set on 0mm. This stands in contrast to the findings of Ioi et al[16] who noted that male laypeople were more tolerant of wider buccal corridors than females. However, when no gender-specific differences were found for buccal corridor size with 6 different subjects' full face photos, how relevant is the difference seen for the cropped smile? Flores-Mir et al[25] previously noted that the esthetic impact of the anterior dentition in a smile diminished on a full facial view as compared to a close-up view. The same effect is seen here.

The results of this study are in keeping with authors that have stated that the ideal elevation of the lip in a smile places its lower margin even with the gingival margin of the maxillary central incisors[20, 33, 45] and disagree with those who have found 2mm of maxillary incisor coverage to be ideal.[11, 18, 23] Laypeople in this study did not tend to prefer slight gingival display over slight maxillary incisor coverage, even in the younger subjects. The only exception to this generalization was found with the middle female subject. This finding stands in opposition to the statements of several authors,[5, 10, 38, 46] but agrees with other studies which found that some coverage of the maxillary incisors is preferable to any gingival display.[17, 18, 21, 23] However, if the 0mm gingival display level is usually preferred for all ages and the -2mm is second most desirable, orthodontists may need to consider keeping gingival display slightly greater than ideal in a young patient so that lip coverage will stay within the most desirable zone for as much of the patient's adult life as possible (considering the soft tissue changes that occur with aging).

This study's findings of preference for totally obliterated buccal corridors on the young female subject and all the male subjects does not agree with literature that suggests that absence of buccal corridors makes a smile look like a false or denture smile.[5, 26] Even the older male subject had 0mm buccal corridors ranked as most attractive, despite the fact that his age group would be most likely to actually have complete dentures. As suggested by Moore et al,[22] with more people maintaining their dentitions late into life, perhaps even the broadest of smiles are no longer considered denture smiles by the public, even when worn by an older adult, and are seen as a sign of youth and health. This study shows that laypeople have a clear preference for smaller buccal corridors in general which supports many other authors and studies with similar

findings[11-13, 15, 16, 22-24, 33, 36] and disagrees with those who have stated that buccal corridors do not influence smile attractiveness.[14, 20, 21]

Some studies that have digitally manipulated gingival display have done so by changing the lip position or the frame of the smile.[9, 10] In this study, the frame was kept constant. The advantage of this was the elimination of any confounding variables which are created by changing lip position and frame size. A possible disadvantage was the need for a significantly animated smile to allow enough vertical space to manipulate the images while avoiding any lower lip coverage of the maxillary incisors, even in the 4mm gingival display photos. There was concern that previous studies which had manipulated images similarly, but allowed the maxillary incisors to be covered by the lower lip in the images with positive gingival display[11, 17, 18] had added a confounding variable to bias respondents against those images with increased gingival display. However, a side-effect of creating a larger frame vertically for this study was increased mandibular incisor show on the negative gingival display images.

Many other studies have used a percentage or ratio to quantify buccal corridors,[11, 15, 16, 22, 29] but this study was designed using linear measurements. Ker et al[11] presented linear measurements alongside percentages, but the measurements seem far larger than what is depicted in the images. To the authors' knowledge, this is the first study to use the method described for accurately measuring and representing linear measurements when performing digital image modifications.

The findings of this study show that, in general, a smile with exactly 0mm gingival display and minimal buccal corridors may be most attractive. However, other studies have commented on the broad range of values for gingival display and buccal corridor size that can be

considered acceptable.[9-11, 15, 17, 23] The results of this study should not lead the orthodontist to overly sensitize patients to desire esthetic ideals that are not clinically achievable for their case, nor should they push the orthodontist to try to attain these ideals when it is not realistic or even beneficial for the patient. For example, as other authors have stated,[15, 22] the findings of preference for minimal buccal corridors should not justify routine expansion in normal maxillae. Some patients have narrower jaws and significant transverse animation of soft tissue on smile that will lead to increased buccal corridors. This isn't necessarily a problem that must be addressed. Furthermore, one must keep in mind that this study looked at two isolated characteristics of the smile which in reality may interact with many other esthetic features. For instance, the interaction of the smile arc with gingival display and buccal corridors has been studied by Kaya et al[18] and Parekh et al,[12, 13] respectively.

It is critical to discuss the esthetic goals of each case with the patient on an individual basis to ensure that the orthodontist and patient are on the same page. The orthodontist must find out specifically what a patient would like to change about his or her smile. Beauty is in the eye of the beholder and what is attractive to one person may not be to another. Definitions of beauty and attractiveness are not static over time and can vary a great deal between individuals, and racial, social, and economic groups.[6, 9, 26, 41, 54, 55] In this study alone there were multiple respondents who ranked the least popular values for gingival display and buccal corridor size as most attractive.

A discussion of this study would not be complete without mentioning a few of its limitations. First, gingival display and buccal corridor display levels were changed in 2mm increments to avoid overwhelming and burning out respondents with too many pictures to rank. Future studies could employ computer-based methods for pair-wise comparison and allow

continuous adjustment of variables. Secondly, the cropped smile was intended as a sort of control for comparison, but it is clearly female and not from an elderly person. However, this made it similar to the cropped smiles used in several other studies which used digital image manipulation.[11-18] Thirdly, as noted by Martin et al,[15] it is extremely difficult to artificially create natural looking buccal corridors. Other studies used very sharply defined buccal corridors,[11-16, 22] whereas this study attempted to soften the edges of the artificial buccal corridors slightly. Fourthly, as previously discussed, the large vertical frame needed for manipulation resulted in more mandibular tooth show on the negative gingival display photos. A future study could perhaps use intraoral photos with the teeth just slightly apart in order to avoid excessive lower incisor exposure in some of the modified images. Finally, this study simply used one male and one female subject from three age groups to assess smile preferences and age. Future studies may need to use many more subjects of various ages, or come up with a way to digitally "age" a patient in a realistic fashion, to allow more definitive statements to be made.

Conclusions

1. Preferences for gingival display and buccal corridor size in a given person's smile do not seem to be determined simply by the person's age.

2. Preferences for gingival display and buccal corridor size can vary depending on the person whose smile is being assessed and may involve consideration of various facial features and dimensions.

3. Preferences for gingival display and buccal corridor size do not seem to be consistently influenced by age of the evaluator.

4. There may be a gender specific preference for no buccal corridors on males and minimal (2mm) buccal corridors on females.

Tables

Table 1 - Mean rank* ± standard deviation of respondents' preference of gingival display for subjects of varying age.

Subject Age	-4mm	-2mm	0mm	2mm	4mm
Young	2.9 ± 1.17	3.9 ± 0.98	4.2 ± 0.97	2.7 ± 0.97	1.4 ± 0.84
Middle	2.2 ± 1.13	3.4 ± 1.24	4.0 ± 1.07	3.2 ± 1.18	2.1 ± 1.38
Older	2.8 ± 1.04	4.0 ± 0.88	4.2 ± 0.99	2.8 ± 0.98	1.2 ± 0.66
Cropped Smile	2.4 ± 0.99	3.8 ± 1.02	4.4 ± 0.86	3.0 ± 1.04	1.4 ± 0.92

* Higher ranks correspond to increased attractiveness as rated by respondents.

Table 2 - Mean rank* ± standard deviation of respondents' preference of buccal corridor size for subjects of varying age.

Subject Age	0mm	2mm	4mm	6mm
Young	3.1 ± 1.03	3.0 ± 0.86	2.3 ± 0.77	1.5 ± 0.93
Middle	3.0 ± 1.11	2.9 ± 0.92	2.4 ± 0.85	1.7 ± 1.10
Older	3.0 ± 1.14	3.0 ± 0.85	2.4 ± 0.80	1.5 ± 0.86
Cropped Smile	3.0 ± 1.11	2.9 ± 0.98	2.4 ± 0.82	1.8 ± 1.05

* Higher ranks correspond to increased attractiveness as rated by respondents.

Table 3 - Mean rank* ± standard deviation of respondents' preference of gingival display for subjects of varying age and gender.

Subject	-4mm	-2mm	0mm	2mm	4mm
Young Male	3.4 ± 1.17	3.8 ± 1.07	4.0 ± 1.03	2.5 ± 1.01	1.4 ± 0.93
Young Female	2.3 ± 0.92	4.1 ± 0.85	4.4 ± 0.84	2.8 ± 0.90	1.3 ± 0.75
Middle Male	2.6 ± 1.12	3.9 ± 1.05	4.0 ± 1.11	2.8 ± 1.14	1.6 ± 1.13
Middle Female	1.8 ± 1.00	2.9 ± 1.22	4.1 ± 1.02	3.6 ± 1.08	2.5 ± 1.47
Older Male	2.4 ± 0.90	3.9 ± 0.84	4.5 ± 0.82	3.0 ± 1.00	1.3 ± 0.64
Older Female	3.2 ± 1.02	4.1 ± 0.91	4.0 ± 1.06	2.6 ± 0.91	1.2 ± 0.69
Cropped Smile	2.4 ± 0.99	3.8 ± 1.02	4.4 ± 0.86	3.1 ± 1.03	1.4 ± 0.91

* Higher ranks correspond to increased attractiveness as rated by respondents.

Table 4 - Mean rank* ± standard deviation of respondents' preference of buccal corridor size for subjects of varying age and gender.

Subject	0mm	2mm	4mm	6mm
Young Male	3.2 ± 0.99	3.0 ± 0.93	2.2 ± 0.83	1.6 ± 0.94
Young Female	3.1 ± 1.06	3.1 ± 0.79	2.4 ± 0.70	1.4 ± 0.90
Middle Male	3.3 ± 1.05	3.0 ± 0.80	2.2 ± 0.70	1.5 ± 0.98
Middle Female	2.6 ± 1.09	2.9 ± 1.02	2.6 ± 0.92	1.9 ± 1.18
Older Male	3.4 ± 1.01	2.9 ± 0.82	2.3 ± 0.70	1.4 ± 0.83
Older Female	2.7 ± 1.17	3.1 ± 0.87	2.6 ± 0.85	1.6 ± 0.89
Cropped Smile	3.0 ± 1.11	2.9 ± 0.98	2.4 ± 0.82	1.8 ± 1.06

* Higher ranks correspond to increased attractiveness as rated by respondents.

Table 5- Percentage of top ranking for gingival display for subjects with significant differences based on respondent age.

Subject	Respondent Age	-4mm	-2mm	0mm	2mm	4mm
Young Male*	**Young**	15.45	25.20	52.03	6.50	0.81
	Middle	24.83	31.72	37.24	3.45	2.76
	Older	18.49	33.56	31.51	10.27	6.16
Older Female**	**Young**	4.88	32.52	56.91	4.88	0.81
	Middle	15.86	35.17	38.62	6.90	3.45
	Older	17.81	48.63	28.08	4.79	0.68

*MH test detects significant differences with p=0.002

**MH test detects significant differences with p<0.0001

Table 6- Percentage of top ranking for buccal corridor size for subjects with significant differences based on respondent age.

Subject	Respondent Age	0mm	2mm	4mm	6mm
Young male*	**Young**	55.28	35.77	3.25	5.69
	Middle	48.28	30.34	10.34	11.03
	Older	57.82	25.17	10.88	6.12
Middle Female**	**Young**	28.46	42.28	21.14	8.13
	Middle	28.08	28.08	23.29	20.55
	Older	31.03	24.14	22.76	22.07
Older Female***	**Young**	39.02	49.59	8.13	3.25
	Middle	36.30	31.51	22.60	9.59
	Older	37.24	39.31	18.62	4.83
Cropped Smile******	**Young**	55.28	23.58	6.50	14.63
	Middle	40.28	34.72	13.19	11.81
	Older	44.52	37.67	9.59	8.22

* MH test detects significant differences with p=0.047

** MH test detects significant differences with p=0.007

*** MH test detects significant differences with p=0.004

**** MH test detects significant differences with p=0.037

Table 7- Percentage of top ranking for gingival display for subjects with significant differences based on respondent gender.

Subject	Respondent Gender	-4mm	-2mm	0mm	2mm	4mm
Middle Female*	**Male**	2.61	12.61	40.43	24.35	20.00
	Female	4.42	7.18	52.49	22.65	13.26
Older Female**	**Male**	9.13	39.57	42.17	8.26	0.87
	Female	18.78	37.57	38.67	2.21	2.76

*MH test detects significant differences with p=0.049
**MH test detects significant differences with p=0.002

Table 8- Cropped smile: percentage of top ranking for buccal corridor size by respondent gender.*

Respondent Gender	0mm	2mm	4mm	6mm
Male	52.63	27.63	10.09	9.65
Female	38.46	37.91	9.89	13.74

* MH test detects significant differences with p=0.022

Figures

Figure 1 - Original extra-oral photograph of young male with measurement gauge

Figure 2 - Intraoral photograph of young male with measurement gauge

Figure 3 - Composite image of young male with measurement gauge

Figure 4 - Five gingival display photos for young male (-4mm, -2mm, 0mm, 2mm, 4mm)

Figure 5 - Four buccal corridor display photos for young male (0mm, 2mm, 4mm, 6mm)

Figure 6 - Page 1 of photo booklet: older female gingival display

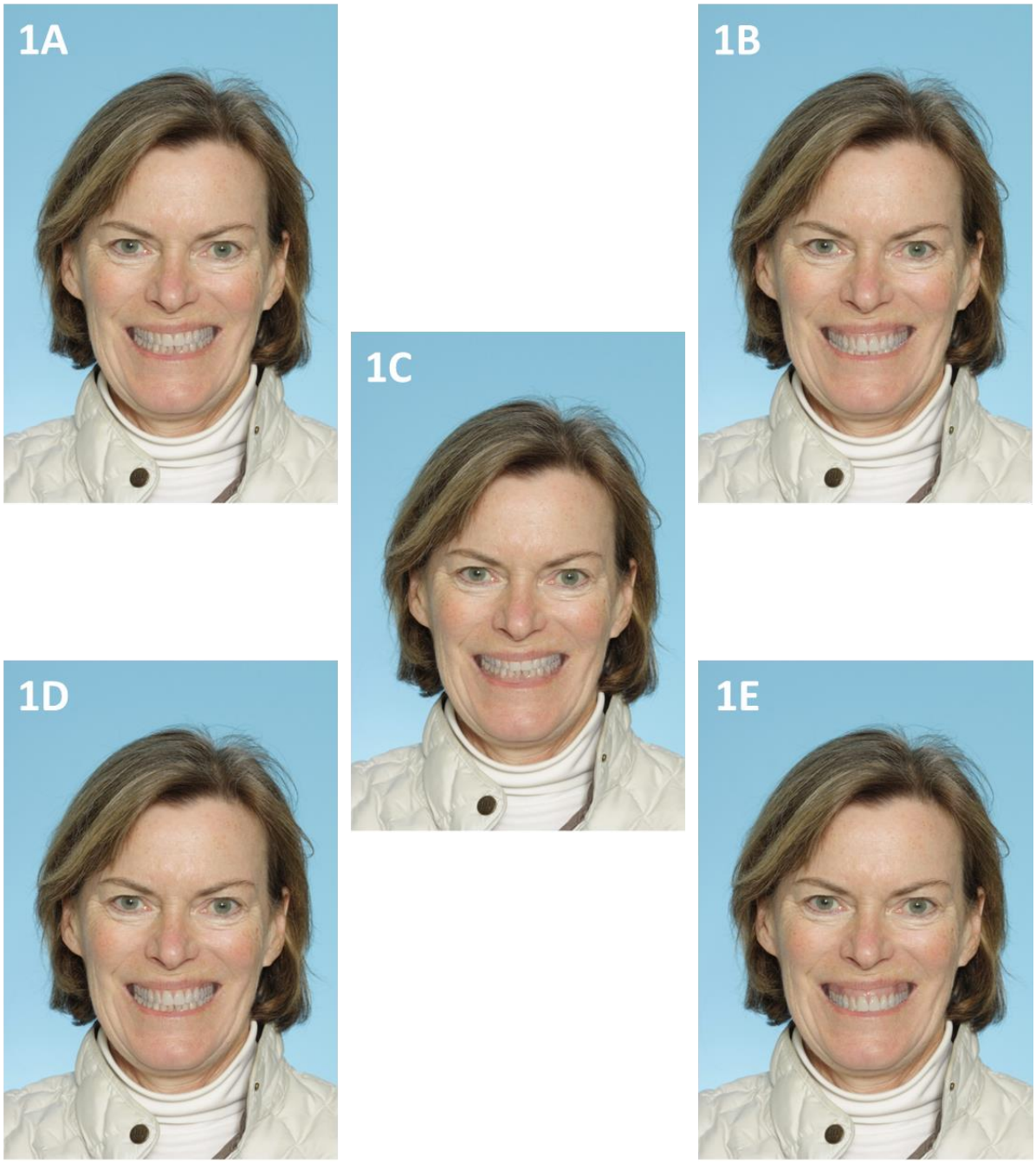


Figure 7 - Page 2 of photo booklet: older female buccal corridors

Figure 8 - Page 3 of photo booklet: young male gingival display

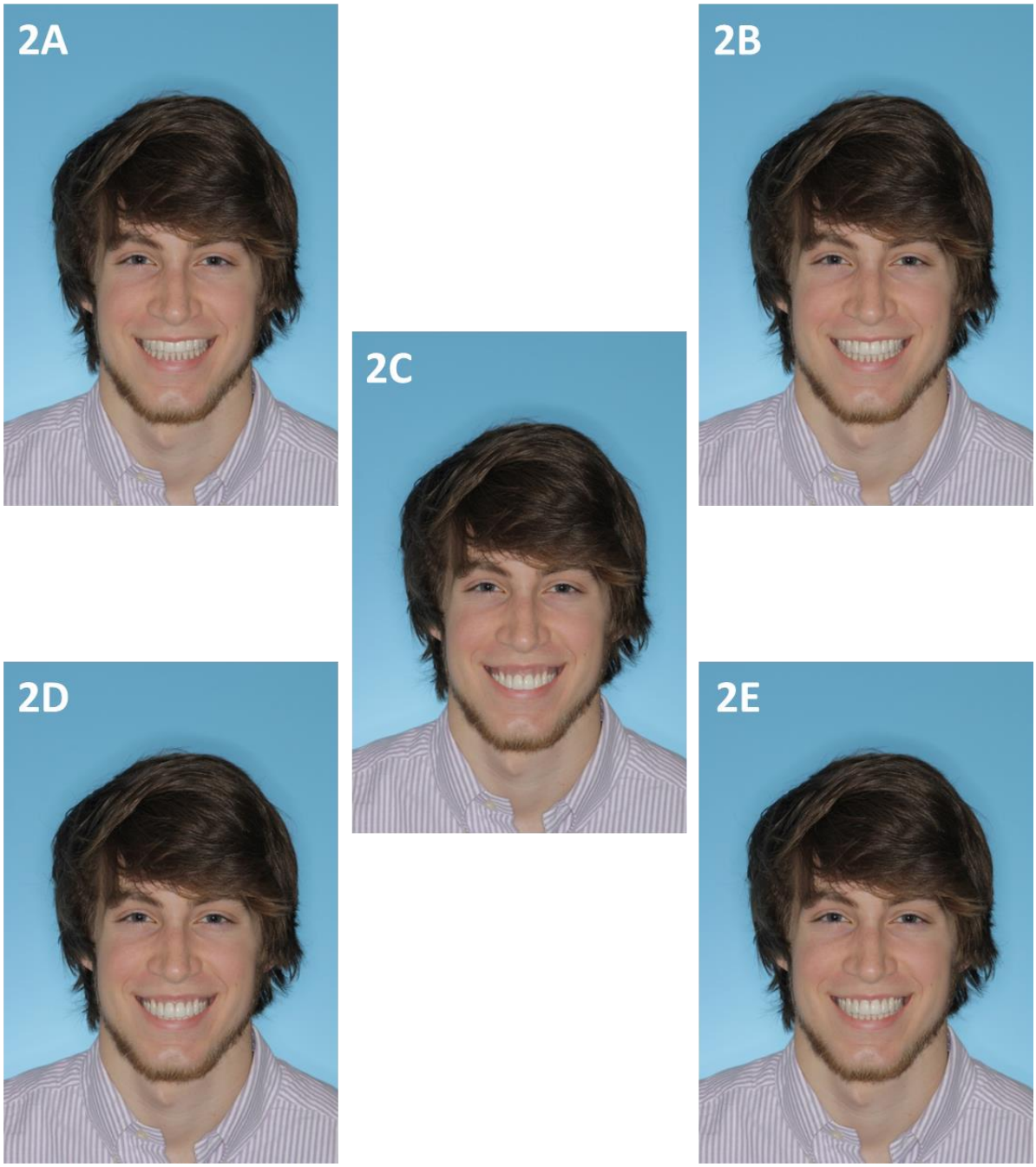


Figure 9 - Page 4 of photo booklet: young male buccal corridors

Figure 10 - Page 5 of photo booklet: middle female gingival display

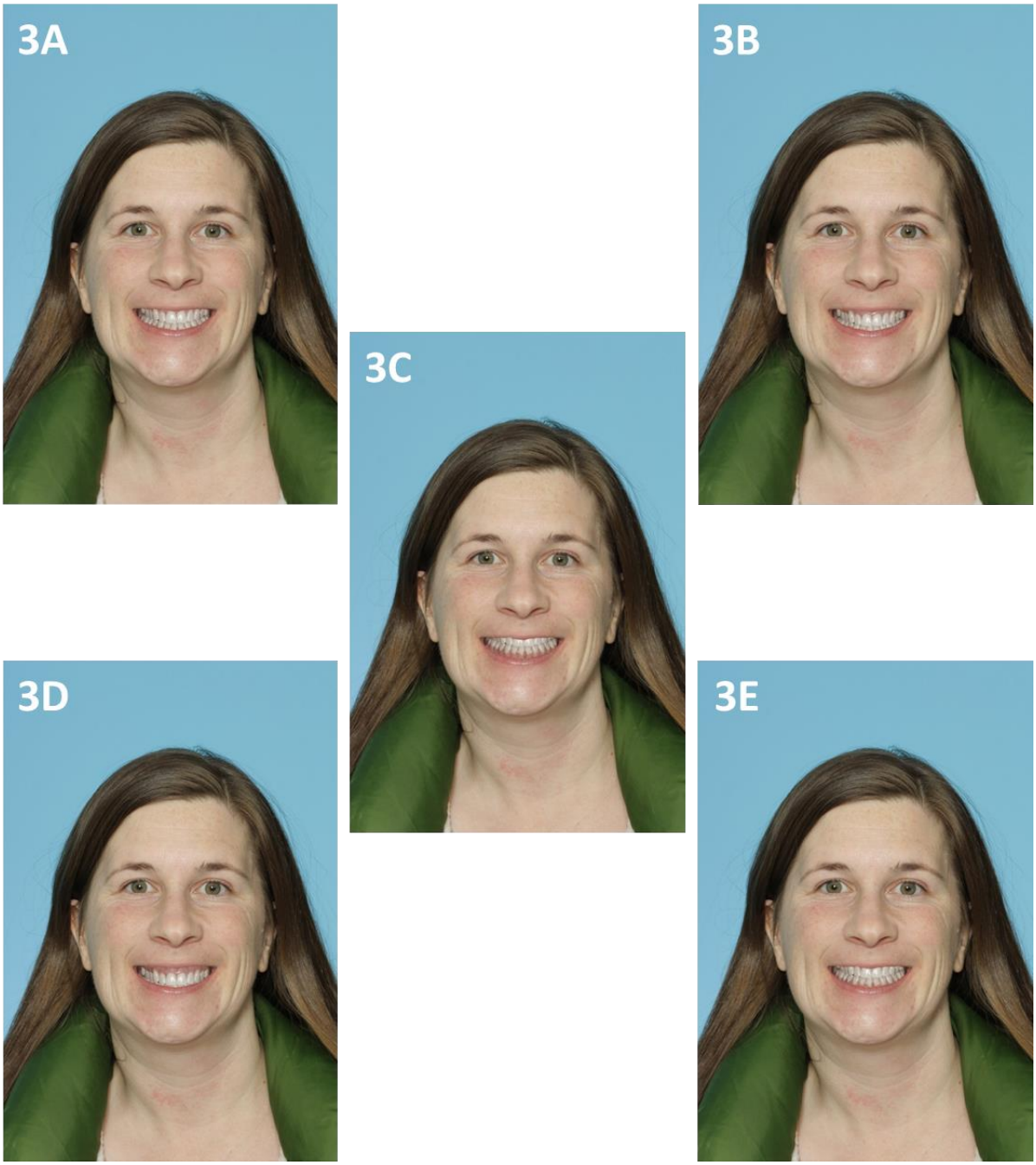


Figure 11 - Page 6 of photo booklet: middle female buccal corridors

Figure 12 - Page 7 of photo booklet: young female gingival display

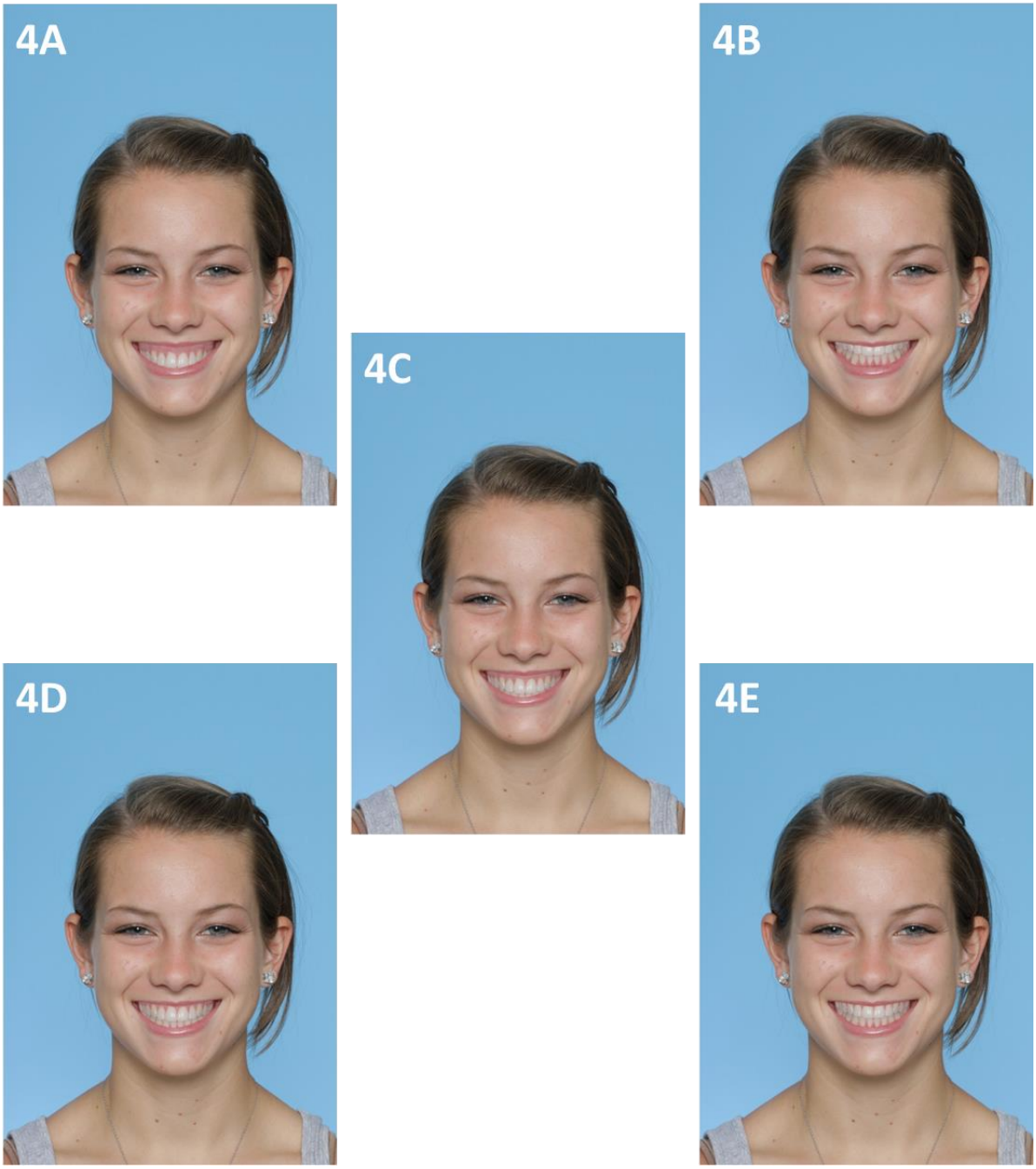


Figure 13 - Page 8 of photo booklet: young female buccal corridors

Figure 14 - Page 9 of photo booklet: older male gingival display

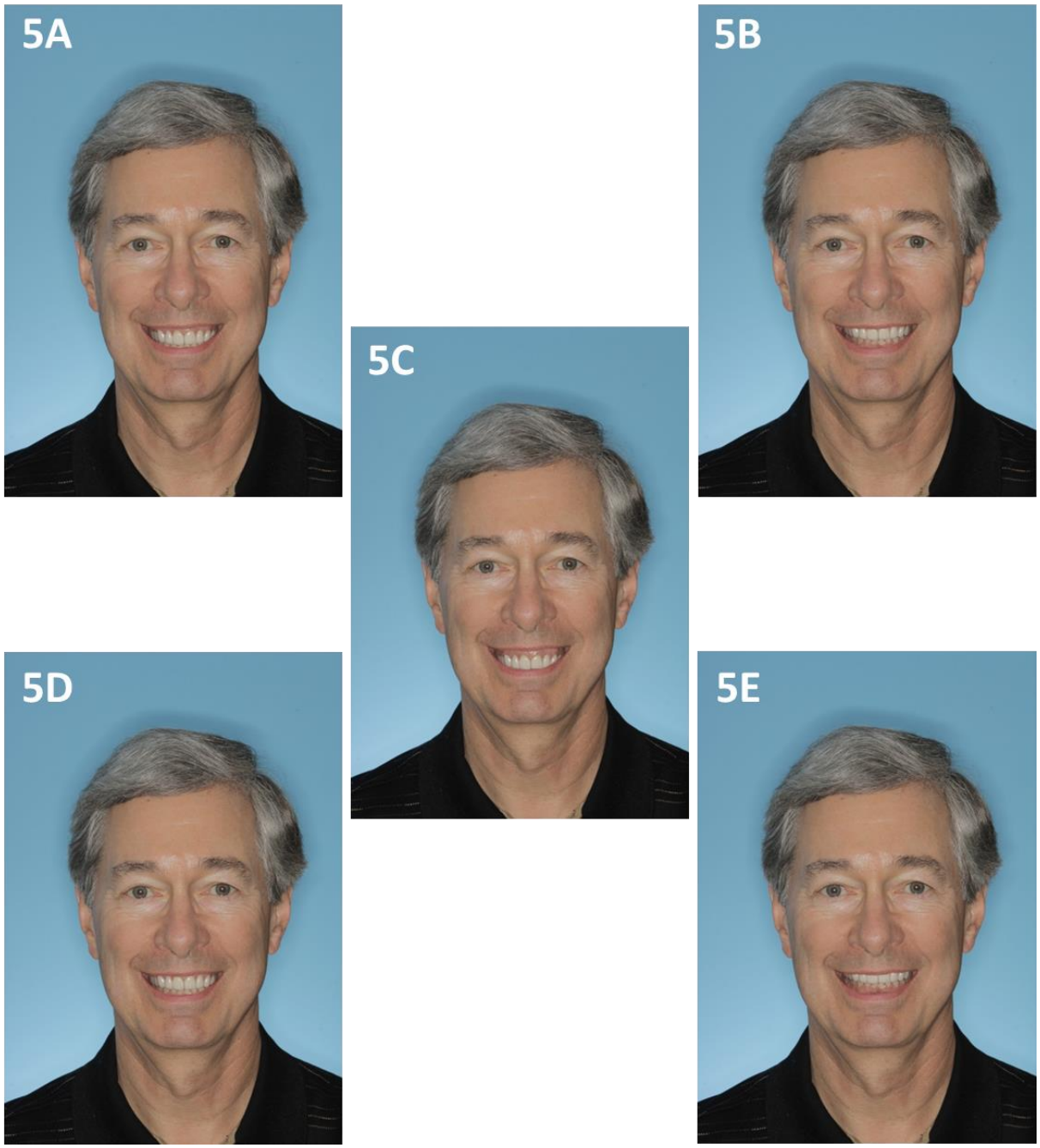


Figure 15 - Page 10 of photo booklet: older male buccal corridors

Figure 16 - Page 11 of photo booklet: middle male gingival display

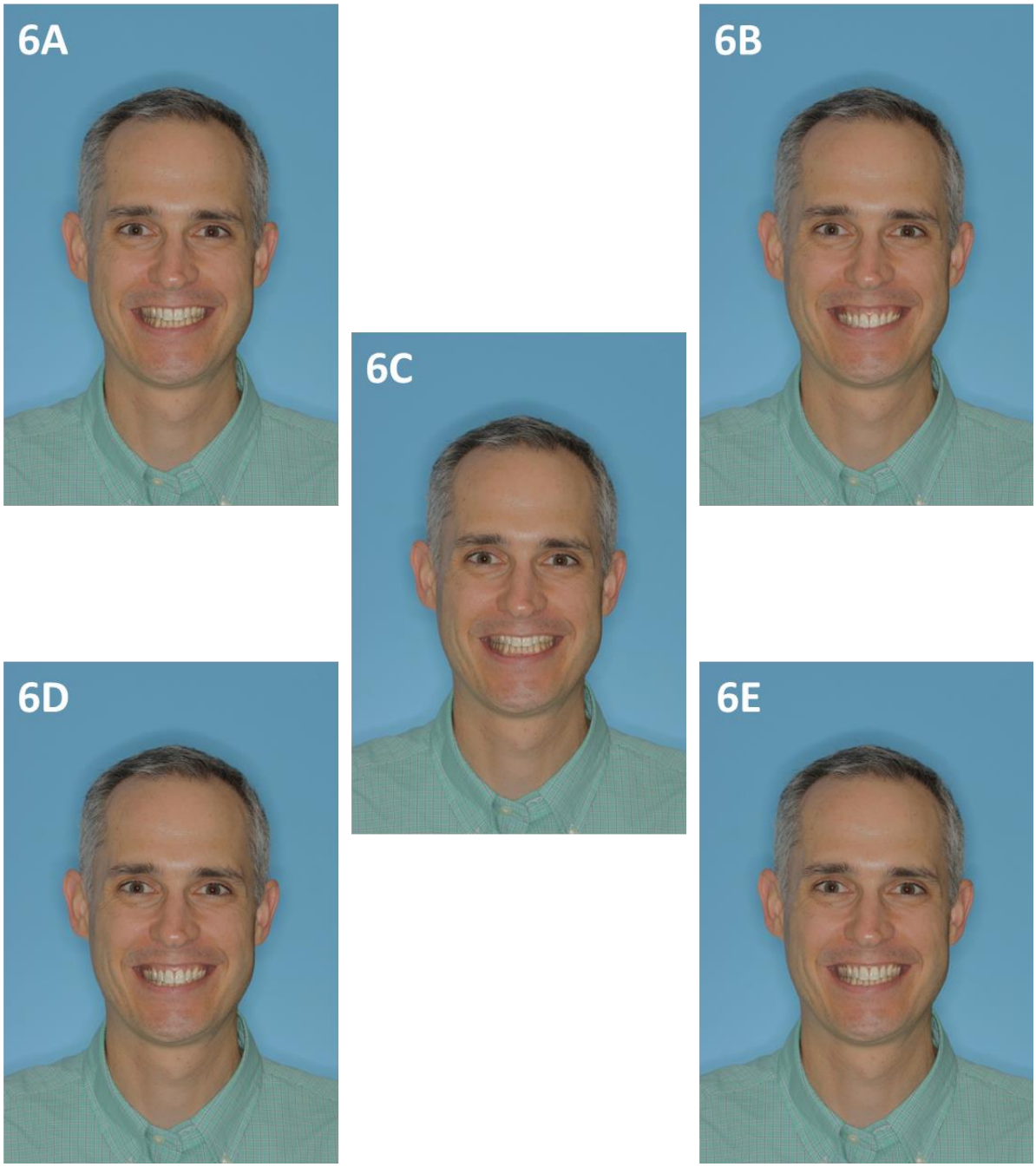


Figure 17 - Page 12 of photo booklet: middle male buccal corridors

Figure 18 - Page 13 of photo booklet: cropped smile gingival display

Figure 19 - Page 14 of photo booklet: cropped smile buccal corridors

Figure 20 - Mean rank (± standard deviation) of respondents' preference of gingival display of subjects of varying age. Higher ranks correspond to increased attractiveness as rated by respondents.

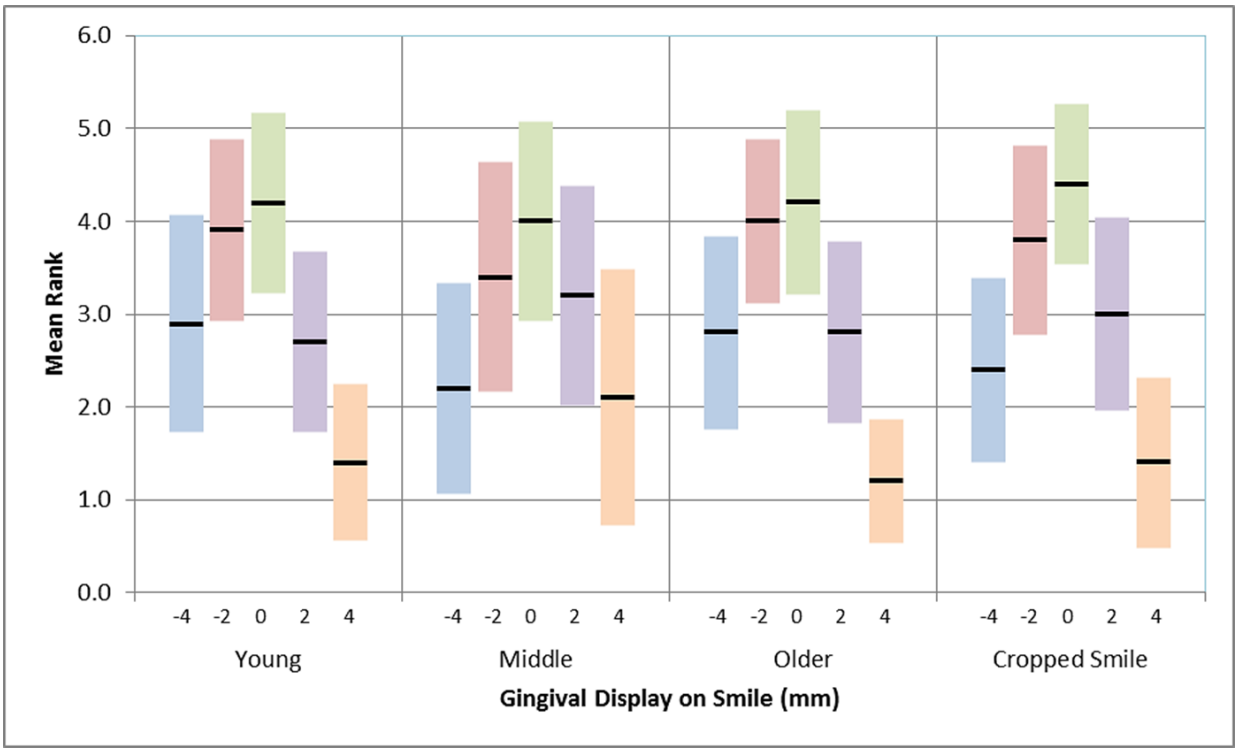


Figure 21 - Mean rank (± standard deviation) of respondents' preference of buccal corridor size of subjects of varying age. Higher ranks correspond to increased attractiveness as rated by respondents.

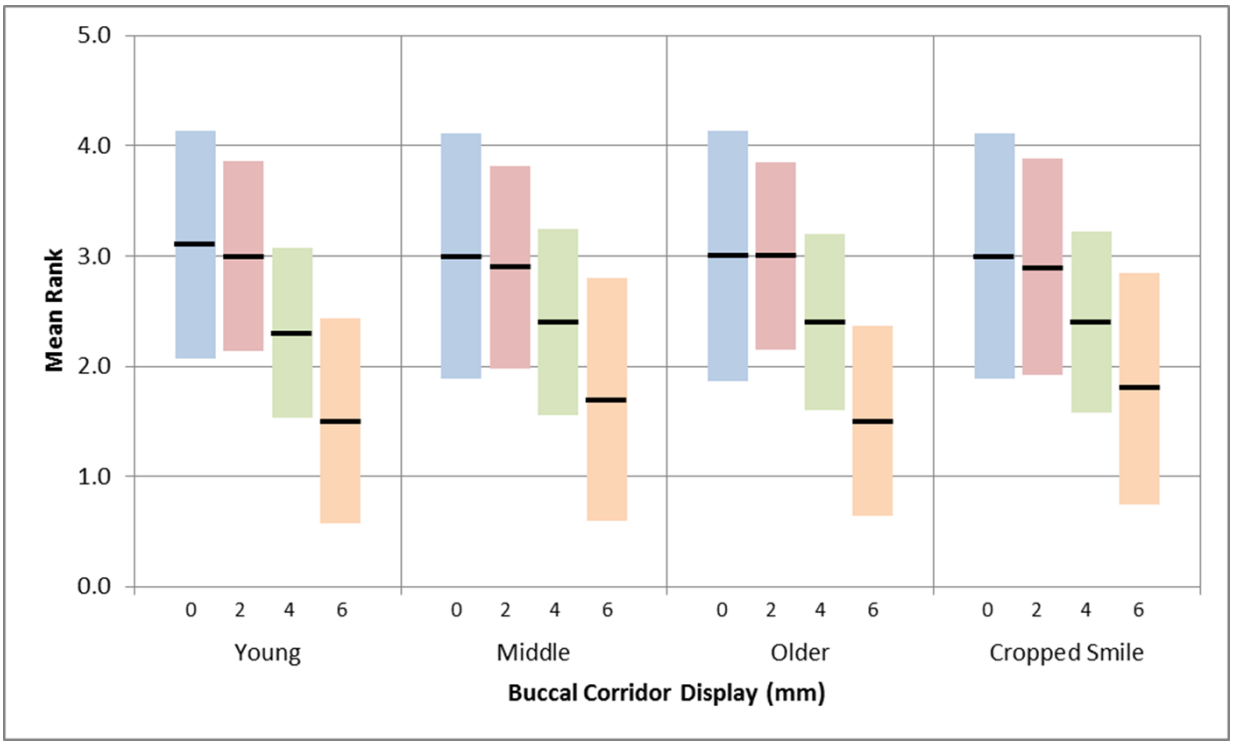


Figure 22 - Mean rank (± standard deviation) of respondents' preference of gingival display for subjects of varying age and gender. Higher ranks correspond to increased attractiveness as rated by respondents.

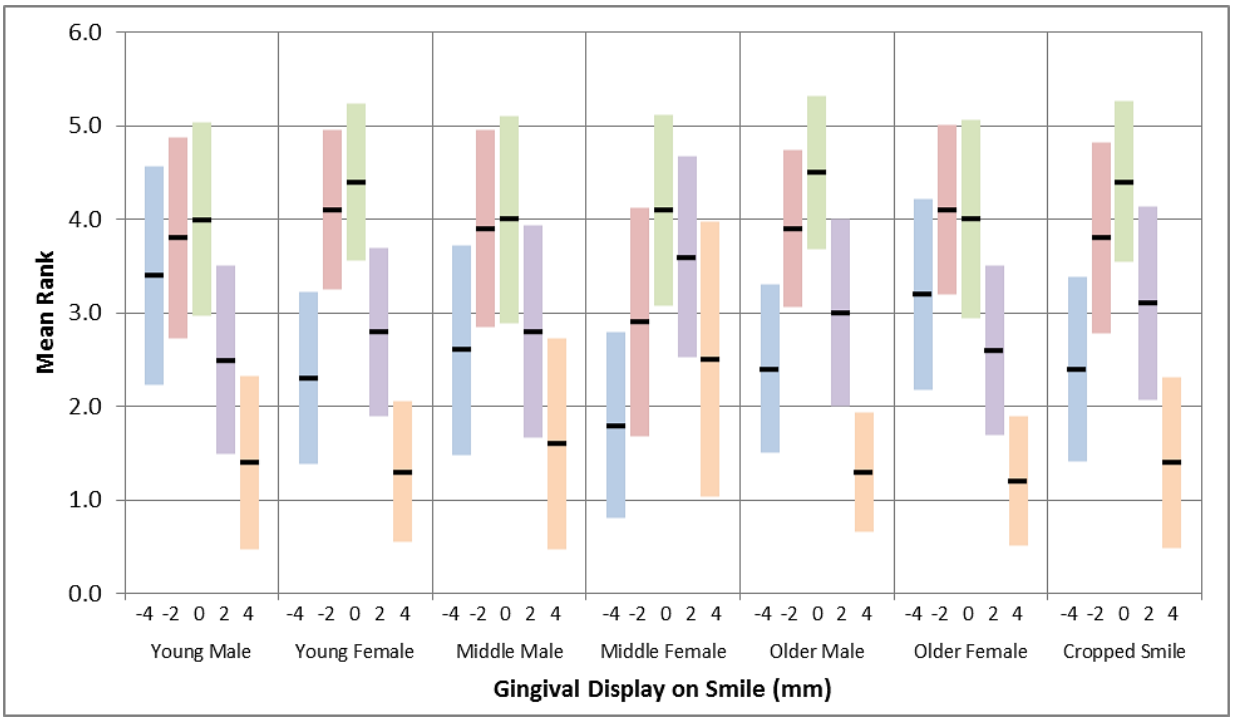
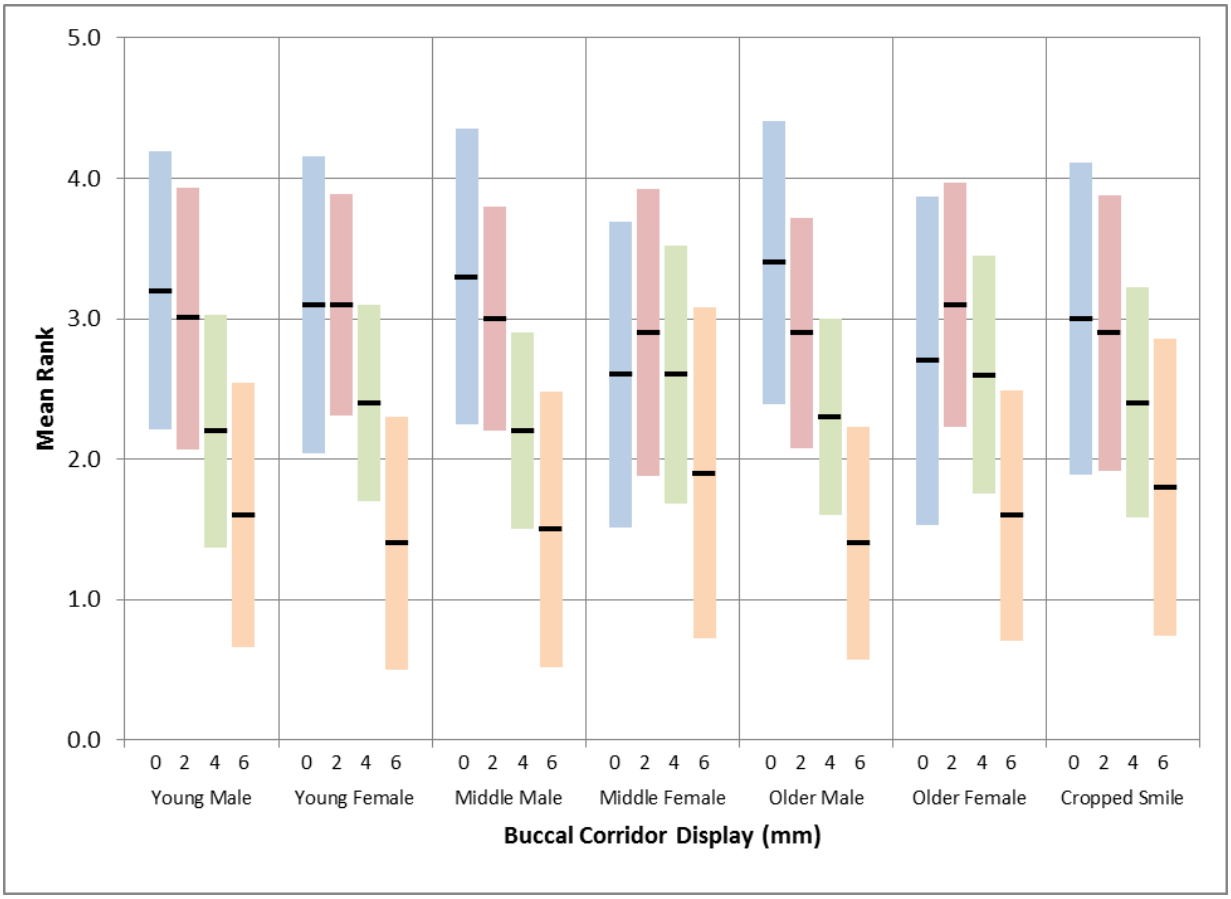


Figure 23 - Mean rank (± standard deviation) of respondents' preference of buccal corridor size for subjects of varying age and gender. Higher ranks correspond to increased attractiveness as rated by respondents.



REFERENCES

1. Ackerman JL, Proffit WR, Sarver DM. The emerging soft tissue paradigm in orthodontic diagnosis and treatment planning. Clin Orthod Res. 1999 May;2(2):49-52.

2. Sarver DM, Ackerman JL. Orthodontics about face: the re-emergence of the esthetic paradigm. Am J Orthod Dentofacial Orthop. 2000 May;117(5):575-6.

3. Proffit WR. The soft tissue paradigm in orthodontic diagnosis and treatment planning: a new view for a new century. J Esthet Dent. 2000;12(1):46-9.

4. Proffit WR, Fields HW, Sarver DM. Contemporary Orthodontics. 5th ed. St Louis, MO: Elsevier Mosby; 2013.

5. Sarver DM. The importance of incisor positioning in the esthetic smile: the smile arc. Am J Orthod Dentofacial Orthop. 2001 Aug;120(2):98-111.

6. Rigsbee OH,3rd, Sperry TP, BeGole EA. The influence of facial animation on smile characteristics. Int J Adult Orthodon Orthognath Surg. 1988;3(4):233-9.

7. Ackerman JL, Ackerman MB, Brensinger CM, Landis JR. A morphometric analysis of the posed smile. Clin Orthod Res. 1998 Aug;1(1):2-11.

8. Walder JF, Freeman K, Lipp MJ, Nicolay OF, Cisneros GJ. Photographic and videographic assessment of the smile: objective and subjective evaluations of posed and spontaneous smiles. Am J Orthod Dentofacial Orthop. 2013 Dec;144(6):793-801.

9. Kokich VO,Jr, Kiyak HA, Shapiro PA. Comparing the perception of dentists and lay people to altered dental esthetics. J Esthet Dent. 1999;11(6):311-24.

10. Kokich VO, Kokich VG, Kiyak HA. Perceptions of dental professionals and laypersons to altered dental esthetics: asymmetric and symmetric situations. Am J Orthod Dentofacial Orthop. 2006 Aug;130(2):141-51.

11. Ker AJ, Chan R, Fields HW, Beck M, Rosenstiel S. Esthetics and smile characteristics from the layperson's perspective: a computer-based survey study. J Am Dent Assoc. 2008 Oct;139(10):1318-27.

12. Parekh S, Fields HW, Beck FM, Rosenstiel SF. The acceptability of variations in smile arc and buccal corridor space. Orthod Craniofac Res. 2007 Feb;10(1):15-21.

13. Parekh SM, Fields HW, Beck M, Rosenstiel S. Attractiveness of variations in the smile arc and buccal corridor space as judged by orthodontists and laymen. Angle Orthod. 2006 Jul;76(4):557-63.

14. Roden-Johnson D, Gallerano R, English J. The effects of buccal corridor spaces and arch form on smile esthetics. Am J Orthod Dentofacial Orthop. 2005 Mar;127(3):343-50.

15. Martin AJ, Buschang PH, Boley JC, Taylor RW, McKinney TW. The impact of buccal corridors on smile attractiveness. Eur J Orthod. 2007 Oct;29(5):530-7.

16. Ioi H, Kang S, Shimomura T, Kim SS, Park SB, Son WS, et al. Effects of buccal corridors on smile esthetics in Japanese and Korean orthodontists and orthodontic patients. Am J Orthod Dentofacial Orthop. 2012 Oct;142(4):459-65.

17. Ioi H, Kang S, Shimomura T, Kim SS, Park SB, Son WS, et al. Effects of vertical positions of anterior teeth on smile esthetics in Japanese and korean orthodontists and orthodontic patients. J Esthet Restor Dent. 2013 Aug;25(4):274-82.

18. Kaya B, Uyar R. Influence on smile attractiveness of the smile arc in conjunction with gingival display. Am J Orthod Dentofacial Orthop. 2013 Oct;144(4):541-7.

19. Johnson DK, Smith RJ. Smile esthetics after orthodontic treatment with and without extraction of four first premolars. Am J Orthod Dentofacial Orthop. 1995 Aug;108(2):162-7.

20. Hulsey CM. An esthetic evaluation of lip-teeth relationships present in the smile. Am J Orthod. 1970 Feb;57(2):132-44.

21. Isiksal E, Hazar S, Akyalcin S. Smile esthetics: perception and comparison of treated and untreated smiles. Am J Orthod Dentofacial Orthop. 2006 Jan;129(1):8-16.

22. Moore T, Southard KA, Casko JS, Qian F, Southard TE. Buccal corridors and smile esthetics. Am J Orthod Dentofacial Orthop. 2005 Feb;127(2):208,13; quiz 261.

23. Springer NC, Chang C, Fields HW, Beck FM, Firestone AR, Rosenstiel S, et al. Smile esthetics from the layperson's perspective. Am J Orthod Dentofacial Orthop. 2011 Jan;139(1):e91-e101.

24. Gul-e-Erum, Fida M. Changes in smile parameters as perceived by orthodontists, dentists, artists, and laypeople. World J Orthod. 2008 Summer;9(2):132-40.

25. Flores-Mir C, Silva E, Barriga MI, Lagravere MO, Major PW. Lay person's perception of smile aesthetics in dental and facial views. J Orthod. 2004 Sep;31(3):204,9; discussion 201.

26. Frush J, Fisher R. The dynesthetic interpretation of the dentogenic concept. J Prosthet Dent. 1958;8(4):558-81.

27. Ackerman MB, Ackerman JL. Smile analysis and design in the digital era. J Clin Orthod. 2002 Apr;36(4):221-36.

28. Rubin LR. The anatomy of a smile: its importance in the treatment of facial paralysis. Plast Reconstr Surg. 1974 Apr;53(4):384-7.

29. Desai S, Upadhyay M, Nanda R. Dynamic smile analysis: changes with age. Am J Orthod Dentofacial Orthop. 2009 Sep;136(3):310.e1,10; discussion 310-1.

30. Chetan P, Tandon P, Singh GK, Nagar A, Prasad V, Chugh VK. Dynamics of a smile in different age groups. Angle Orthod. 2013 Jan;83(1):90-6.

31. Ackerman MB. The effect of maxillary position on anterior tooth display [thesis]. Rochester, NY: University of Rochester; 2000.

32. Sarver DM. The face as determinant of treatment choice. In: Frontiers of dental and facial esthetics. Craniofacial Growth Series. Vol 38. Ann Arbor, MI: Center for Human Growth and Development; University of Michigan; 2001. p.19-54.

33. Sarver DM, Ackerman MB. Dynamic smile visualization and quantification: Part 2. Smile analysis and treatment strategies. Am J Orthod Dentofacial Orthop. 2003 Aug;124(2):116-27.

34. Gianelly AA. Arch width after extraction and nonextraction treatment. Am J Orthod Dentofacial Orthop. 2003 Jan;123(1):25-8.

35. Golwalkar SA, Shetty V. Arch widths after extraction and nonextraction treatment in class I patients. J Contemp Dent Pract. 2013 Mar 1;14(2):312-5.

36. Morley J, Eubank J. Macroesthetic elements of smile design. J Am Dent Assoc. 2001 Jan;132(1):39-45.

37. Sarver DM. Esthetic Orthodontics and Orthognathic Surgery. Anonymous St. Louis, MO: Mosby; 1998.

38. Dickens S, Sarver D, Proffit WR. Changes in Frontal Soft Tissue Dimensions of the Lower Face by Age and Gender. World J Orthodontics. 2002;3(4):313-20.

39. Peck S, Peck L, Kataja M. The gingival smile line. Angle Orthod. 1992 Summer;62(2):91,100; discussion 101-2.

40. Epker BN, Fish L. Surgical-orthodontic correction of open-bite deformity. Am J Orthod. 1977 Mar;71(3):278-99.

41. Vig RG, Brundo GC. The kinetics of anterior tooth display. J Prosthet Dent. 1978 May;39(5):502-4.

42. Tjan AH, Miller GD, The JG. Some esthetic factors in a smile. J Prosthet Dent. 1984 Jan;51(1):24-8.

43. Peck S, Peck L, Kataja M. Some vertical lineaments of lip position. Am J Orthod Dentofacial Orthop. 1992 Jun;101(6):519-24.

44. Peck S, Peck L. Selected aspects of the art and science of facial esthetics. Semin Orthod. 1995 Jun;1(2):105-26.

45. Mackley RJ. An evaluation of smiles before and after orthodontic treatment. Angle Orthod. 1993 Fall;63(3):183,9; discussion 190.

46. Chiche G, Kokich VG, Caudill R. Diagnosis and Treatment Planning of Esthetic Problems. In: Chiche G, Pinault A, editors. Esthetics of Anterior Fixed Prosthodontics. Quintessence; 1994. p.33.

47. Peck S, Peck H. The aesthetically pleasing face: an orthodontic myth. Trans Eur Orthod Soc. 1971:175-84.

48. Fanous N. Aging lips. Esthetic analysis and correction. Facial Plast Surg. 1987 Spring;4(3):179-83.

49. Bishara SE, Treder JE, Jakobsen JR. Facial and dental changes in adulthood. Am J Orthod Dentofacial Orthop. 1994 Aug;106(2):175-86.

50. Formby WA, Nanda RS, Currier GF. Longitudinal changes in the adult facial profile. Am J Orthod Dentofacial Orthop. 1994 May;105(5):464-76.

51. Singh B, Ahluwalia R, Verma D, Grewal SB, Goel R, Kumar PS. Perioral age-related changes in smile dynamics along the vertical plane: a videographic cross-sectional study. Angle Orthod. 2013 May;83(3):468-75.

52. Janzen EK. A balanced smile--a most important treatment objective. Am J Orthod. 1977 Oct;72(4):359-72.

53. Davis BK. Dental aesthetics and the aging patient. Facial Plast Surg. 2006 May;22(2):154-60.

54. Collins M. The Eye of the Beholder: Face Recognition and Perception. Semin Orthod. 2012 September 2012;18(3):229-34.

55. Czarnecki ST, Nanda RS, Currier GF. Perceptions of a balanced facial profile. Am J Orthod Dentofacial Orthop. 1993 Aug;104(2):180-7.