Review Article

Influence of orthodontic treatment, midline position, buccal corridor and smile arc on smile attractiveness

A systematic review

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ABSTRACT

Objective: To assess the scientific evidence of the influence of some variables on smile attractiveness: orthodontic treatment, midline position, axial midline angulation, buccal corridor, and smile arc.

Materials and Methods: Literature was searched through PubMed, Web of Science, Embase, and All EBM Reviews. The inclusion criteria consisted of studies written in English; published in the past three decades; concerning the influence of orthodontic treatment, midline position, axial midline angulation, buccal corridor, and smile arc on smile esthetics; and judged by a minimum of 10 raters. Quality features evaluated were adequate description of samples, absence of confounding factors, and description of methods used to evaluate the smiles and statistical analyses.

Results: Initially, 203 articles were retrieved. Of these, 20 abstracts met the initial inclusion criteria and were selected. Thirteen articles were classified as high quality, seven as average, and none as low quality.

Conclusion: Four-premolar extraction or nonextraction treatment protocols seem to have no predictable effect on overall smile esthetics, meaning that if well indicated, extraction in orthodontics does not necessarily have a deleterious effect on facial esthetics. The selected articles recommend that a small dental midline deviation of 2.2 mm can be considered acceptable by both orthodontists and laypeople, whereas an axial midline angulation of 10° (2 mm measured from the midline papilla and the incisal edges of the incisors) is already very apparent, and considering studies dealing with real smiles, buccal corridor sizes and smile arc alone do not seem to affect smile attractiveness. (*Angle Orthod.* 2011;81:153–161.)

KEY WORDS: Orthodontics; Esthetics

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INTRODUCTION

For a long time, orthodontic treatment was primarily based on occlusal relationship results.[1] Currently, modern orthodontics also requires a harmonious balance between soft tissues and occlusion. The influence of smile attractiveness components is important because it allows the professional to identify the hierarchy of esthetic preference.[2] Therefore, knowledge of the influence of orthodontic treatment on smile attractiveness is very important, and recently, some smile components such as midline position, axial midline angulation, buccal corridor, and smile arc have received greater attention.[1–20]

A symmetrical dental arrangement is thought to be a fundamental component of an attractive smile, so that facial and dental midline coordination are basic to appreciation of facial harmony and balance.[21–24] Although subtle dental to facial midline asymmetry within normal limits is acceptable, significant midline discrepancies can be quite detrimental to dentofacial esthetics.[25] The axial midline angulation is also important. This irregularity can be easily detected and affects the final orthodontic esthetic results.[4,9,13]

Another essential smile feature is the transverse dimension of the smile. This characteristic refers to the buccal corridors. Their importance on smile attractiveness is well reported in the 1958 study of Frush and Fischer,[26] whose results demonstrated that the presence of buccal corridors added the illusion of a natural dentition, whereas its absence gave the patient an artificial appearance.

The smile arc is the relationship between the curvature of the incisal edges of the maxillary incisors and canines to the curvature of the lower lip in the posed smile.[27] Frush and Fisher[26] proposed that there should be harmony between the curvature of the incisal edges of the maxillary anterior teeth and the curvature of the upper border of the lower lip.

Understanding smile attractiveness is important because it is what most laypeople use as a parameter to judge whether treatment is successful or not.[2] Therefore, the purpose of this systematic review was to analyze the influence of orthodontic treatment, midline position, axial midline angulation, buccal corridor, and smile arc on smile attractiveness.

MATERIAL AND METHODS

Using the main terms *smile*, *orthodontics*, *esthetic*, *aesthetic*, and *attractive*, a computerized search was conducted in the following electronic databases: PubMed, Web of Science, Embase, and All Evidence-Based Medicine Reviews (EBM Reviews).

To identify potential articles, the initial search was performed by title and abstract. The initial four inclusion criteria were studies written in English; published between 1979 and 2009; quoting at least one of the following smile features: influence of orthodontic treatment, midline position, axial midline angulation, buccal corridor, and smile arc on smile esthetics; and judged by a minimum of 10 raters. This selection process was independently conducted by two researchers. Thereafter, the articles from the selected abstracts were independently evaluated by three researchers. Interexaminer conflicts were resolved by discussion on each article to reach a consensus regarding which articles fulfilled the main selection criteria.

The articles ultimately selected were then classified based on the following quality features: sample description, consideration of confounding factors, validity of the method, and statistical analyses.

Sample description was considered adequate when the author clearly established the initial aspect of the occlusion, whether actual or digital. Also, the treatment protocol chosen to be applied had to be stated as well as whether the features of the occlusion were digitally altered and to what extent.

To consider whether control of the confounding factors was adequate, distractors such as part of the nose, cheeks, skin color, and any blemishes or facial hair had to have been minimized.

Validity of the method was adequate when the selected studies with digital alteration showed natural modification of the smile features. For those not digitally altered, the photographs should have been standardized. The statistical analyses were judged by a statistician.

Afterwards, the application of these qualification features was used to classify the articles based on their scientific weight. Articles with all qualification features were classified as high, articles with one or two absences were classified as average, and those with three or more absences were classified as low.

RESULTS

After the database search, 168 articles were retrieved from PubMed, 59 from Web of Science, and 63 from Embase. All EBM Reviews identified only three papers. From hand search, two studies were identified (Table 1). The entire search strategy resulted in 203 abstracts, 65.5% of which were published between 2003 and August 2009. These results demonstrate that studies about the influence of smile attributes on smile attractiveness have considerably increased in the past few years.

In this systematic review, 20 articles met the initial inclusion criteria. The influence of orthodontic treatment, midline position, axial midline angulation, buccal corridors, and smile arc on smile attractiveness was stated in 3, 8, 3, 10, and 6 articles, respectively (Table 2). The summarized data of the 20 articles included in the review are shown in Tables 3 and 4. After quality feature analysis, 13 articles were classified as high-quality level, seven as average-quality level, and no article classified as a low-quality level (Table 5).

Influence of Orthodontic Treatment on Smile Attractiveness

Improvement in smile attractiveness by orthodontic treatment was assessed in three studies.[1,5,8] All studies

Table 1. Search Terms and Number of Articles Processed in Each Selection Phase

Database	Key Words	Results	Selected	% of Total Selected Abstracts
PubMed	(1) smile[a]; (2) orthodontic[a]; (3) esthetic[a]; (4) aesthetic[a]; (5) attractive[a]; (6) 1 and 2 and 3; (7) 1 and 2 and 4; (8) 1 and 2 and 5	168	16	80
Web of Science	(1) smile[a]; (2) orthodontic[a]; (3) esthetic[a]; (4) aesthetic[a]; (5) attractive[a]; (6) 1 and 2 and 3; (7) 1 and 2 and 4; (8) 1 and 2 and 5	59	9	45
Embase	(1) smile; (2) orthodontic; (3) esthetic; (4) aesthetic; (5) attractive; (6) 1 and 2 and 3; (7) 1 and 2 and 4; (8) 1 and 2 and 5	63	8	40
All EBM reviews	(1) smile[a]; (2) orthodontic[a]; (3) esthetic[a]; (4) aesthetic[a]; (5) attractive[a]; (6) 1 and 2 and 3; (7) 1 and 2 and 4; (8) 1 and 2 and 5	3	0	0
Hand search		2	2	10
Total		203[a]	21[a]	100[a]

[a] The final sum corresponds to the total references without repetition.

compared smile attractiveness among nonextraction and four-premolar extraction patients.[1,5,8] One of them also compared the smile attractiveness between treated and untreated subjects.[1]

After quality features evaluation, the three articles fulfilled all selection criteria and were classified as high quality and were used for this systematic review.[1,5,8] One study concluded that there was no difference with regard to smile attractiveness between orthodontically treated subjects and subjects with well-balanced faces and good occlusion.[1] Furthermore, treatment modality alone had no predictable effect on the overall esthetic assessment of the smile, and subjects with ideal occlusions and Class I malocclusions, when treated with or without extractions, did not show a difference in smile esthetics.[1,5,8]

Influence of Midline Position on Smile Attractiveness

The influence of midline position on smile esthetics was investigated in eight studies[3,4,6,7,9–12] and the influence of axial midline angulation in three studies.[4,9,13] Only two articles were classified as average quality,[4,12] and the others[3,6,7,9–11,13] were classified as high quality.

Comparing the perception of the dental midline deviation judged by orthodontists and other groups of

Table 2. Articles Included in the Review

Article	Year of Publication	Orthodontic Treatment	Midline Position	Axial Midline Angulation	Buccal Corridor	Smile Arc
Ioi et al.[15]	2009				X	
Rodrigues et al.[11]	2009		X			X
Gul-e-Erum and Fida[4]	2008		X	X	X	X
McNamara et al.[17]	2008				X	X
Shyagali et al.[12]	2008		X			
Ker et al.[7]	2008		X		X	X
Martin et al[16]	2007				X	
Parekh et al.[2]	2007				X	X
Pinho et al.[10]	2007		X			
Gracco et al.[14]	2006				X	
Isiksal et al.[1]	2006	X				
Parekh et al.[19]	2006				X	X
Moore et al.[18]	2005				X	
Roden-Johnson, Gallerano, and English[20]	2005				X	
Kim and Gianelly[8]	2003	X				
Thomas, Hayes and Zawaydeh[13]	2003			X		
Johnston et al.[6]	1999		X			
Kokich et al.[9]	1999		X	X		
Beyer and Lindauer[3]	1998		X			
Johnson and Smith[5]	1995	X				

Table 3. Summarized Data of the 20 Studies Included in the Review[a]

Article	Year of Publication	Subjects	Occlusion/Smile Description	Evaluated Area
Ioi et al.[15]	2009	A female smiling photograph digitally altered (6)	6 BC variations: extra broad (0% BC), broad (5% BCs), medium broad (10% BCs), medium (15% BCs), medium narrow (20% BCs), and narrow (25% BCs)	Mouth area
Rodrigues et al.[11]	2009	A male smiling photograph digitally altered (3)	Ideal control smile, dental midline deviation of 3 mm in relation to the patient's philtrum; reverse smile arc	Mouth area/face
Gul-e-Erum and Fida[4]	2008	A male and a female smiling frontal facial photographs, subjects digitally altered (36)	BCs: narrow, medium narrow, medium, medium broad, and broad; SA: consonant, nonconsonant, and flat smile; midline: dental to facial midline deviation 2 mm right and left, 1 mm right and left, and no deviation; axial midline angulation: no angle, 2.5° right and left, 5° right and left	Face
McNamara et al.[17]	2008	Smiles from video clips of patients seeking orthodontic treatment (60)	No significant skeletal asymmetry or anterior or posterior crossbite; no known missing or malformed teeth causing a tooth size discrepancy; and visible erupting or erupted maxillary permanent canines and first premolars	Mouth area
Shyagali et al.[12]	2008	A female smiling, digitally altered (5)	No deviation, maxillary dental midline deviation of 2 and 4 mm either to the right or left	Face (eyes, nose, and mouth)
Ker et al.[7]	2008	A sex-neutral face smile, digitally altered	BC variations: range of values 0–19 mm; SA: at maxillary canine 0–4 mm and at maxillary second molar 0–10 mm; midline: maxillary midline to face 0–4.4 mm and maxillary to mandibular midline 0–2.9 mm	Mouth area
Martin et al.[16]	2007	A female smiling photograph digitally altered (18)	Smiles that filled 84%, 88%, 92%, 96%, and 100% of the oral aperture; PM2-PM2 that filled 84%, 88%, 92%, and 96% of the oral aperture; smiles with asymmetrical BCs that filled 88%, 90%, 94%, and 96% of the oral aperture	Mouth area
Parekh et al.[2]	2007	A smile digitally altered (18)	3 BC variations (none, ideal, excessive) combined with 3 SA variations (flat, ideal, excessive)	Mouth area
Pinho et al.[10]	2007	A female smiling photograph digitally altered (5)	No deviation, maxillary dental midline deviation of 1, 2, 3 and 4 mm	Mouth area
Gracco et al.[14]	2006	A female smiling, digitally altered (3)	Minimal, moderate, and evident BCs	Mouth area
Isiksal et al.[1]	2006	Four first premolars extraction patients (25); nonextraction patients (25); untreated patients (25)	Excellent occlusion with Angle Class I molar and canine relationships and well-balanced faces	Lower third
Parekh et al.[19]	2006	A smile digitally altered (18)	3 BC variations (none, ideal, excessive) combined with 3 SA variations (flat, ideal, excessive)	Mouth area
Moore et al.[18]	2005	10 smiling photographs digitally altered in 5 images, creating 11 combinations of each patient (110 combinations)	BCs: narrow (28% BCs), medium narrow (22% BCs), medium (15% BCs), medium broad (10% BCs), and broad (2% BCs)	Face
Roden-Johnson et al.[20]	2005	30 female smiling photographs digitally altered to create more 30 female smiling photographs	20 orthodontically treated: 10 represent narrow tapered and tapered arch form, and 10 represent normal to broad arch form; 10 orthodontically untreated with Class I molar occlusion	Mouth area

Table 3. Continued

Article	Year of Publication	Subjects	Occlusion/Smile Description	Evaluated Area
Kim and Gianelly[8]	2003	Four first premolars extraction patients (12); nonextraction patients (12)	Had undergone orthodontic treatment during the time period of the study	Mouth area
Thomas et al.[13]	2003	One man and women smiling photograph digitally altered (18)	No deviation and maxillary dental midline deviation to the right and left at 5°, 10°, 15°, and 20° angles from the facial midline	Face
Johnston et al.[6]	1999	A female smiling photograph digitally altered (11)	No deviation and maxillary midline deviation to the right and left of 1, 2, 4, 6, and 8 mm	Face
Kokich et al.[9]	1999	Smiling photograph digitally altered (10)	No deviation and maxillary midline deviation of 1, 2, 3, and 4 mm; no angulation and incisor crown angulation of 1, 2, 3, and 4 mm	Mouth area
Beyer and Lindauer[3]	1998	A male and a female smiling frontal face video images digitally altered (16)	No deviation and maxillary dental midline deviation of 0.7, 1.4, 2.1, 2.8, 3.5, 4.2, and 4.9 mm	Face
Johnson and Smith[5]	1995	Four first premolars extraction patients (30); nonextraction patients (30)	No visible spaces, rotation, overjet, crossbite, deep bite, open bite, or midline discrepancy	Mouth area

[a] SA indicates smile arc; BC, buccal corridor.

dentists and laypeople, orthodontists had the greater perception of midline deviation[9,10] and dentists in general are more discerning than laypeople.[3,6,10] When analyzing the amount of acceptable dental deviation judged by orthodontists and laypeople, there was not a general agreement. According to one study, 1 mm of deviation is the maximum accepted by the orthodontists without decreasing smile esthetics.[10] Three articles agreed that deviations of up to 2 mm are acceptable by orthodontists,[3,6,12] whereas another study stated that only dental midline deviation greater than 4 mm is rated to be less esthetic by orthodontists.[9] One article stated that laypeople found maxillary to mandibular midline deviation acceptable until it exceeded 2.1 mm, and one-third of the raters accepted the maxillary to facial midline maximal deviation of 2.9 mm.[7] Two articles considered that the dental to facial midline deviation of 2 mm is considered normal.[4,12] In another article, laypeople were unable to detect 3 mm of dental deviation,[11] and in two articles, laypeople did not detect 4 mm of dental deviation.[9,10] In contrast, another study concluded that 4 mm of deviation can be noticed by 96% of laypeople.[6]

One study analyzed the perception of axial midline angulation, stating that orthodontists, general dentists, and laypeople were able to identify a 2-mm discrepancy in incisor angulation, measured from the midline papilla to the most gingival portion of the incisal embrasure between the maxillary central incisor crowns.[9] A similar study stated that discrepancies of 10° were unacceptable by 68% of orthodontists and 41% of laypeople,[13] whereas another study stated that 5° is perceived by orthodontists and laypeople.[4]

Influence of Buccal Corridor on Smile Attractiveness

In 10 studies, the impact of buccal corridors on smile attractiveness was analyzed.[2,4,7,14–20] Six studies were classified as average quality[2,4,15,16,18,19] and four as high quality.[7,14,17,20]

There was no agreement between the results from the selected articles. Two articles found no correlation between buccal corridors and smile esthetics.[17,20] The other articles concluded that large buccal corridors are considered less attractive.[2,4,7,14–16,18,19]

Influence of Smile Arc on Smile Attractiveness

The effects of smile arc on smile esthetics were evaluated in six studies.[2,4,7,11,17,19] Three articles were classified as high quality[7,11,17] and the other three as average quality.[2,4,19] An ideal smile arc or a consonant smile arc with the lower lip was considered the most acceptable smile arc variation in three articles.[2,7,19] On the other hand, one article stated that a flat smile is more attractive in males and a flat/consonant smile in females.[4] Two articles did not find a correlation between smile arc and smile esthetics.[11,17]

DISCUSSION

Quality Evaluation

A detailed sample description is an important component for a correct interpretation in smile attractiveness studies. Articles that did not report the sample description and their characteristics when required

Table 4. Summarized Data of the 20 Studies Included in the Review (Continued)[a]

Article	Year of Publication	Type of Raters	Authors' Conclusion
Ioi et al.[15]	2009	Japanese orthodontists (32); Japanese dental students (55)	Both the orthodontists and dental students preferred broader smiles to medium or narrow smiles.
Rodrigues et al.[11]	2009	Laypeople (20)	Variations from beauty norms of a smile do not necessarily result in reduced attractiveness.
Gul-e-Erum and Fida[4]	2008	Orthodontic residents (12); operative dentistry residents and consultants (12); art students (12); laypeople (12)	A broad and a flat smile in the male are preferred; a medium-broad and a flat/consonant smile in the female are preferred; midline deviation was considered unattractive in the male subjects by only orthodontic residents, while in the female subjects, it was considered unattractive by all groups, except operative residents; all groups perceived axial incisal angulation as unesthetic at a 5° change.
McNamara et al.[17]	2008	Orthodontists (30); laypeople (30)	No correlation was found between the size or ratio value of the buccal corridors distal to the most posterior teeth visible on smile. No correlation was found between smile arc and smile esthetics.
Shyagali et al.[12]	2008	Orthodontists (20); laypeople (20)	Discrepancies of 2 mm or more are likely to be noticed by both orthodontic and laypeople.
Ker et al.[7]	2008	Laypeople (243)	The ideal buccal corridor size was 16%, and the acceptability range was 8% to 22%; raters preferred a consonant smile but accepted a smile with minimal curvature as well; maxillary to mandibular midline deviation was acceptable until it exceeded 2.1 mm, and one-third of the respondents accepted the maxillary to face maximal deviation of 2.9 mm.
Martin et al.[16]	2007	Orthodontists (82); laypeople (94)	Large BCs are considered less attractive than those with small BCs.
Parekh et al.[2]	2007	Orthodontists (131); laypeople (115)	Large BCs and flat smile arcs are rated as less acceptable.
Pinho et al.[10]	2007	Orthodontists (50); prosthodontists (50); laypeople (50)	Midline shifts were perceived at 1 mm by orthodontists and 3 mm by prosthodontists; laypersons did not notice midline shifts.
Gracco et al.[14]	2006	Dentists (646); laypeople (1275)	A minimal buccal corridor was considered more attractive.
Isiksal et al.[1]	2006	Orthodontists (10); plastic surgeons (10); dental specialists (10); general dentists (10); artists (10); parents (10)	Treatment modality alone has no predictable effect on the overall esthetic assessment of a smile; a transverse characteristics of the smile appeared to be of little significance to an attractive smile.
Parekh et al.[19]	2006	Orthodontists (131); laypeople (115)	Large BCs and flat smile arcs are considered less attractive.
Moore et al.[18]	2005	Laypeople (30)	Large BCs are considered less attractive than those with small BCs.
Roden-Johnson et al.[20]	2005	Orthodontists (20); dentists (20); laypeople (20)	BCs does not influence smile esthetics.
Kim and Gianelly[8]	2003	Laypeople (50)	There is no predictable relationship between extraction and nonextraction treatment and the esthetics of the smile.

Table 4. Continued

Article	Year of Publication	Type of Raters	Authors' Conclusion
Thomas et al.[13]	2003	Orthodontists (50); laypeople (50)	Mean acceptable midline angulation for the male subject was 6.6° ± 4.5° for orthodontists and 10.7° ± 6.2° for laypeople. For the female subject, the mean acceptable threshold was 6.4° ± 4.0° for orthodontists and 10.0° ± 6.1° for laypeople. Discrepancies of 10° were unacceptable by 68% of orthodontists and 41% of laypeople.
Johnston et al.[6]	1999	Orthodontists (20); non–dental undergraduate students (20)	Dental to facial midline discrepancies of 2 mm are likely to be noticed by 83% of orthodontists and more than 56% of young laypeople.
Kokich et al.[9]	1999	Orthodontists (60); general dentists (57); laypeople (74)	A maxillary midline deviation of 4 mm was necessary before orthodontists rated it significantly less esthetic than the others; dentists and laypeople were unable to detect a 4-mm midline deviation. All three groups were able to distinguish a 2-mm discrepancy in incisor crown angulation.
Beyer and Lindauer[3]	1998	Orthodontists (30); general dentists (30); adolescent patients (30); parents (30)	The mean threshold for acceptable dental midline deviation was 2.2 ± 1.5 mm.
Johnson and Smith[5]	1995	Laypeople (10)	There is no predictable relationship between extraction and nonextraction treatment and the esthetics of the smile.

[a] BC indicates buccal corridor.

were considered inadequate because sample size and selection are the major source of bias in a large amount of studies.[28]

Elimination of the confounding factors is necessary to minimize the influence of background on facial attractiveness, such as part of the nose, cheeks, and chin. It is important to focus on the esthetics of the smile without distracting the interviewees.[5,8,10,14,17,20,29] Conversion of color photographs to black and white is also important in the articles that judge smiles of

Table 5. Quality Evaluation of the Selected Studies[a]

Article	Sample Description	Confounding Factors Considered	Validity Method	Statistical Analysis
Ioi et al.[15]	Adequate	Adequate	Inadequate (BCs)	Adequate
Rodrigues et al.[11]	Adequate	Adequate	Adequate (SA, ML)	Adequate
Gul-e-Erum and Fida[4]	Adequate	Adequate	Inadequate (BCs) Adequate (SA; ML; AMLA)	Inadequate
McNamara et al.[17]	Adequate	Adequate	Adequate (BCs, SA)	Adequate
Shyagali et al.[12]	Adequate	Adequate	Adequate (ML)	Inadequate
Ker et al.[7]	Adequate	Adequate	Adequate (BCs, SA; ML)	Adequate
Martin et al.[16]	Adequate	Adequate	Inadequate (BCs)	Adequate
Parekh et al.[2]	Adequate	Adequate	Inadequate (BCs) Inadequate (SA)	Adequate
Pinho et al.[10]	Adequate	Adequate	Adequate (ML)	Adequate
Gracco et al.[14]	Adequate	Adequate	Adequate (BCs)	Adequate
Isiksal et al.[1]	Adequate	Adequate	Adequate (OT)	Adequate
Parekh et al.[19]	Adequate	Adequate	Inadequate (BCs) Inadequate (SA)	Adequate
Moore et al.[18]	Adequate	Adequate	Inadequate (BCs)	Adequate
Roden-Johnson et al.[20]	Adequate	Adequate	Adequate (BCs)	Adequate
Kim e Gianelly[8]	Adequate	Adequate	Adequate (OT)	Adequate
Thomas et al.[13]	Adequate	Adequate	Adequate (AMLA)	Adequate
Johnston et al.[6]	Adequate	Adequate	Adequate (ML)	Adequate
Kokich et al.[9]	Adequate	Adequate	Adequate (ML, AMLA)	Adequate
Beyer and Lindauer[3]	Adequate	Adequate	Adequate (ML)	Adequate
Johnson and Smith[5]	Adequate	Adequate	Adequate (OT)	Adequate

[a] SA indicates smile arc; BC, buccal corridor; ML, midline; OT, orthodontic treatment; AMLA, axial midline angulation.

different subjects, because this procedure evens the skin shades of the sample and reduces the number of confounding factors.[1,5,20,29,30]

Most studies digitally altered the smile images to create variations of buccal corridors, midline deviations, and smile arcs. To validate the method, a natural smile appearance should be preserved. However, these characteristics were not found in many studies, especially those on buccal corridors.[2,4,15,16,18,19]

In this systematic review, two studies had deficiencies in their statistical analyses.[4,12] The statistical analysis is an important criterion to be considered in an article because the complete presentation of the data gives transparency to the investigation. For this systematic review, a statistician evaluated the statistical analyses of the selected articles.

The number of raters in these studies is also an important issue because they are representing part of a population and a misguided sample may have sufficient power to determine an effect for one particular parameter.[28] All selected studies did not calculate the appropriate rater group size, and consequently, a minimum of 10 raters in each group was considered as an inclusion criterion in this review.

Influence of Orthodontic Treatment on Smile Attractiveness

The orthodontist must be aware of the advantages and disadvantages of each treatment protocol. The analysis of the articles on the influence of orthodontic treatment suggests that a treatment modality alone cannot influence smile esthetics.[1,8] These results are expected because, in any group of subjects, there is individual variability—shape of the teeth, curl of the lips, and mouth expression—that could influence the smile perception as esthetically pleasing or not.[1] Therefore, it is not the fact of extracting or not that influences facial harmony but rather the correct indication of extractions.

Influence of Midline Deviation and Axial Midline Angulation on Smile Attractiveness

There was an agreement that orthodontists were more perceptive to midline discrepancies than laypeople.[3,6,9,10] Some studies suggest that, by virtue of their formal training and experience, orthodontists are more sensitive to aberrations in dentofacial appearance than the general public.[6,20] An important result is that all selected articles agree that a small dental midline deviation does not compromise the smile esthetics and is not perceived by laypeople.[3,6,7,9–11]

On average, orthodontists were able to detect midline deviations greater than 2.2 mm while laypeople were able to detect only midline deviations greater than 3 mm. Considering that either laypeople or another more accurate observer can be part of our patient's environment, it is advisable to use the most restricted limit of 2.2 mm as a boundary of acceptable midline deviation. Studies that used this average calculation were only those that established an acceptable limit of deviation. Those that only quoted the amount of deviation that could be detected without establishing the acceptable limit of deviation were not included. The limits are tighter regarding the axial midline angulation. Most of the articles agree that slight angulations such as 10° (2 mm measured from the midline papilla and the incisal edges of the incisors) are very apparent.[9,13]

Influence of Buccal Corridors on Smile Attractiveness

A controversial result concerns the influence of buccal corridors on smile attractiveness. It is interesting to note that one of the major differences between these articles is the type of samples. Almost all articles that used only digitally altered smiles as a sample suggest that the size of the buccal corridor has an influence on smile esthetics.[2,4,7,14–16,18,19] On the contrary, in articles in which the raters judged smiling photographs from different subjects, the results found no correlations between buccal corridor sizes and smile esthetics.[17,20] According to Kokich et al.,[9] there is a threshold level that a digital alteration must exceed for the viewer to detect it because both dentists and laypeople notice only the extremes.[14] If enough teeth are deleted from the lateral aspects on the smile, there would be some detraction from smile esthetics, and the smile would probably appear unnatural.[9] The size differences of the buccal corridors in patients may be more subtle, whereas the changes performed in the computer are more dramatic.[14]

It became clear that those studies that used digitally altered images brought out opposite results than those studies with actual images. Unfortunately, image alteration in those studies was too poor to be used as the variations that exist on actual patients. Hence, based on the articles that used actual subjects instead of digitally altered smiles, it is very acceptable to state that buccal corridor sizes alone do not affect smile esthetics, considering that those digital alterations do not represent natural buccal corridor diversity.

Influence of the Smile Arc on Smile Attractiveness

In reference to the smile arc influence, it is possible to state that the results are also related to the sample type, as observed in buccal corridor studies.[2,4,7,14–20] When the digitally modified smile arc was judged in its condition on influencing smile attractiveness, in almost

all articles, the smile arc interfered in smile esthetics.[2,4,7,19] When natural smiles were on trial, results showed that the smile arc did not interfere in smile attractiveness.[17] The tendency was to favor those articles that dealt with actual subjects and accept their conclusion that the smile arc alone is not able to influence the smile esthetics.

Finally, smile attractiveness is a set of features that must be considered in orthodontic treatment planning with the understanding that every aspect of the set is important in the final score of smile beauty.

CONCLUSIONS

- Nonextraction and four-premolar extraction treatment protocols seem to have no predictable effect on the overall esthetic assessment of the smile. This means that the simple fact of extracting teeth or not does not necessarily have a detrimental facial esthetic effect.
- A limit of 2.2 mm can be considered acceptable for midline deviation. Concerning the axial midline angulation, 10° (2 mm measured from the midline papilla and the incisal edges of the incisors) is already very apparent.
- Based on studies with actual subjects, neither buccal corridor sizes nor smile arc alone seem to affect smile attractiveness.

REFERENCES

1. Isiksal E, Hazar S, Akyalcin S. Smile esthetics: perception and comparison of treated and untreated smiles. *Am J Orthod Dentofacial Orthop*. 2006;129:8–16.
2. Parekh S, Fields HW, Beck FM, Rosenstiel SF. The acceptability of variations in smile arc and buccal corridor space. *Orthod Craniofac Res*. 2007;10:15–21.
3. Beyer JW, Lindauer SJ. Evaluation of dental midline position. *Semin Orthod*. 1998;4:146–152.
4. Gul-e-Erum, Fida M. Changes in smile parameters as perceived by orthodontists, dentists, artists, and laypeople. *World J Orthod*. 2008;9:132–140.
5. Johnson DK, Smith RJ. Smile esthetics after orthodontic treatment with and without extraction of four first premolars. *Am J Orthod Dentofacial Orthop*. 1995;108:162–167.
6. Johnston CD, Burden DJ, Stevenson MR. The influence of dental to facial midline discrepancies on dental attractiveness ratings. *Eur J Orthod*. 1999;21:517–522.
7. 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;139: 1318–1327.
8. Kim E, Gianelly AA. Extraction vs nonextraction: arch widths and smile esthetics. *Angle Orthod*. 2003;73:354–358.
9. Kokich VO Jr, Kiyak HA, Shapiro PA. Comparing the perception of dentists and lay people to altered dental esthetics. *J Esthet Dent*. 1999;11:311–324.
10. Pinho S, Ciriaco C, Faber J, Lenza M. Impact of dental asymmetries on the perception of smile esthetics. *Am J Orthod Dentofacial Orthop*. 2007;132:748–753.
11. Rodrigues CD, Magnani R, Machado MS, Oliveira OB. The perception of smile attractiveness. *Angle Orthod*. 2009;79: 634–639.
12. Shyagali TR, Chandralekha B, Bhayya DP, Kumar S, Balasubramanyam G. Are ratings of dentofacial attractiveness influenced by dentofacial midline discrepancies? *Aust Orthod J*. 2008;24:91–95.
13. Thomas JL, Hayes C, Zawaydeh S. The effect of axial midline angulation on dental esthetics. *Angle Orthod*. 2003; 73:359–364.
14. Gracco A, Cozzani M, D'Elia L, Manfrini M, Peverada CGS. The smile buccal corridors: aesthetic value for dentists and laypersons. *Prog Orthod*. 2006;7:56–65.
15. Ioi H, Nakata S, Counts AL. Effects of buccal corridors on smile esthetics in Japanese. *Angle Orthod*. 2009;79: 628–633.
16. Martin A, Buschang P, Boley J, Taylor R, McKinney T. The impact of buccal corridors on smile attractiveness. *Eur J Orthod*. 2007;29:530–537.
17. McNamara L, McNamara JA Jr, Ackerman MB, Baccetti T. Hard- and soft-tissue contributions to the esthetics of the posed smile in growing patients seeking orthodontic treatment. *Am J Orthod Dentofacial Orthop*. 2008;133: 491–499.
18. Moore T, Southard KA, Casko JS, Qian F, Southard TE. Buccal corridors and smile esthetics. *Am J Orthod Dentofacial Orthop*. 2005;127:208–213.
19. 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; 76:557–563.
20. 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;127:343–350.
21. Brisman AS. Esthetics: a comparison of dentists' and patients' concepts. *J Am Dent Assoc*. 1980;100:345–352.
22. Hulsey CM. An esthetic evaluation of lip-teeth relationships present in the smile. *Am J Orthod*. 1970;57:132–144.
23. Jerrold L, Lowenstein LJ. The midline: diagnosis and treatment. *Am J Orthod Dentofacial Orthop*. 1990;97: 453–462.
24. Lombardi RE. The principles of visual perception and their clinical application to denture esthetics. *J Prosthet Dent*. 1973;29:358–382.
25. Dierkes JM. The beauty of the face: an orthodontic perspective. *J Am Dent Assoc*. 1987;Spec No:89E–95E.
26. Frush JO, Fisher RD. The dynesthetic interpretation of the dentogenic concept. *J Prosthet Dent*. 1958;8:558–582.
27. Sarver DM. The importance of incisor positioning in the esthetic smile: the smile arc. *Am J Orthod Dentofacial Orthop*. 2001;120:98–111.
28. Tulloch JF, Medland W, Tuncay OC. Methods used to evaluate growth modification in Class II malocclusion. *Am J Orthod Dentofacial Orthop*. 1990;98:340–347.
29. 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;130:141–151.
30. Kerns LL, Silveira AM, Kerns DG, Regennitter FJ. Esthetic preference of the frontal and profile views of the same smile. *J Esthet Dent*. 1997;9:76–85.