Smile attractiveness in patients with Class II division 1 subdivision malocclusions treated with different tooth extraction protocols

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SUMMARY The aim of this study was to compare smile attractiveness between one, three, and four premolar extraction protocols in patients with Class II division 1 subdivision malocclusions and to analyse the aesthetic influence of buccal and posterior corridor widths on smile attractiveness.

The sample consisted of posed smile photographs obtained from 66 subjects, divided into three groups according to the treatment–extraction protocol. Group 1 was treated with one maxillary premolar extraction included 23 subjects, group 2 was treated with four premolar extractions included 23 subjects, and 20 patients in group 3 were treated with three premolar extractions. Buccal and posterior corridor widths of each photograph were measured in proportion to the smile width. To rate the posed smile photographs, panels of 70 orthodontists and 46 laypeople used a 10-point scale.

There were no significant differences in smile attractiveness scores between the three groups and between orthodontists and laypeople. Also buccal and posterior corridor widths did not differ between the groups and they did not influence the aesthetic scores.

It was concluded that smile attractiveness is similar in treatment protocols of one, three, and four premolar extractions and that widths of buccal and posterior corridors do not influence smile attractiveness in these groups.

Introduction

One of the primary goals of modern orthodontics is to improve facial aesthetics (Hulsey, 1970; Beyer and Lindauer, 1998; Ackerman et al., 2004; Isiksal et al., 2006). One of the facial characteristics that more positively influences it is the smile, second only to the eyes as the most important characteristics of facial attractiveness (Goldstein, 1969). Actually, smile attractiveness is an important topic in orthodontics and is frequently a greater motivational factor than functional improvement and dental health (Gochman, 1975; Margolis, 1997).

It was thought that premolar extractions were a detrimental factor on smile attractiveness because they decreased fullness of the dentition upon smiling (Dierkes, 1987; Spahl and Witzig, 1987). However, this concept was not scientifically confirmed (Johnson and Smith, 1995; Kim and Gianelly, 2003). It was also claimed that extractions lead to narrower dental arch widths creating dark intraoral spaces, lateral to the buccal segments, considered aesthetically unpleasant (Dierkes, 1987; Spahl and Witzig, 1987). Similarly, it was not scientifically substantiated that premolar extractions cause arch width reductions (Gianelly, 2003; Kim and Gianelly, 2003). Besides, there is no consensus in the literature on the influence of buccal corridor widths on smile attractiveness (Moore et al., 2005; Roden-Johnson et al., 2005; Gracco et al., 2006; Martin et al., 2007; McNamara et al., 2008; Ioi et al., 2009).

It has been demonstrated that asymmetric premolar extractions are a viable treatment alternative in many Class II subdivision malocclusions (Janson et al., 2003; Janson et al., 2004; Janson et al., 2007). However, there is still some resistance in using these treatment protocols, without any scientific foundation (Mailankody, 2006). Therefore, the purpose of this study is to compare the smile attractiveness of patients treated by symmetric and asymmetric treatment protocols of Class II division 1 subdivision malocclusions—with one, three, or four premolar extractions—and to evaluate the influence of buccal and posterior corridor widths on smile attractiveness.

Material and methods

This study was approved by the Ethics in Research Committee of Bauru Dental School, University of São Paulo.

The sample was selected from the files of the Orthodontic Department at Bauru Dental School, University of São Paulo. Sample size calculation was performed and showed that to detect a difference of 1.1 between three groups, with a standard deviation of 1.2 at a significance level of 5 per cent with
a power of 80 per cent it was necessary a minimum of 20 subjects in each group. Therefore, group 1 consisted of 23 subjects with Class II division 1 subdivision malocclusion (9 males and 14 females), with a mean age of 24.04 years (SD, 4.97; range, 14.59–33.27 years) that were treated with one first premolar extraction. Group 2 consisted of 23 subjects with Class II division 1 subdivision malocclusions (5 males and 18 females) with a mean age of 25.4 years (SD, 6.70; range, 16.86–42.62 years) that were treated with four first premolar extractions. Group 3 consisted of 20 subjects with Class II division 1 subdivision malocclusion (8 males and 12 females), with mean age of 21.63 years (SD, 5.27; range, 16.87–36.03 years), treated with three first premolar extractions. The additional inclusion criteria were the presence of all permanent teeth up to the second molars, no anterior diastemas, no periodontal disease, no dental anomalies, and PAR Index ≤ 7, as scored on the plaster casts taken at the evaluation time.

Frontal smiling photographs were taken of each subject by the same investigator (NCB) with a Nikon D-40 digital camera (Nikon Corporation, Tokyo, Japan), assembled with a Sigma 105 mm macro lens and a Sigma macro flash (Sigma Corporation of America, New York, USA). The macro lens was adjusted to focus at a constant object-to-lens distance of 60 cm obtaining an image of the lower facial third, including the nose tip and chin.

The photographs were taken at an average posttreatment time of 6.53 years (SD, 4.41) in group 1, 9.94 years (SD, 7.71) in group 2, and 5.61 years (SD, 4.68) in group 3. The subjects were instructed to sit maintaining the natural head position—a standardized and reproducible head position in an upright and natural posture with the visual axis in the horizontal (Moorrees, 1994). Several photos were taken of each subject at posed smile (Garber and Salama, 1996; Kim and Gianelly, 2003; Gracco et al., 2006; Ritter et al., 2006; McNamara et al., 2008) and the one which appeared more natural was chosen (Johnson and Smith, 1995; Kerns et al., 1997; Isiksak et al., 2006).

The chosen photograph was imported into Photoshop (Adobe Systems CS3, San Jose, California, USA) to eliminate any rotation due to head positioning and also to crop the nose, cheeks, and chin to reduce the number of confusing variables (Hulsey, 1970; Johnson and Smith, 1995; Kim and Gianelly, 2003; Roden-Johnson et al., 2005; Gracco et al., 2006; Kokich et al., 2006; Ritter et al., 2006; Pinho et al., 2007). The photographs were viewed under the same magnification on the computer screen and the smile photographs were cropped at a proportional standardized size of 21 × 12.4 cm. In addition, facial blemishes and facial hair were removed from the smiling photographs, and severely discoloured teeth were whitened to match the adjacent teeth. Subsequently, the photographs were converted to black and white (Hulsey, 1970; Johnson and Smith, 1995; Kerns et al., 1997; Roden-Johnson et al., 2005; Isiksak et al., 2006; Ritter et al., 2006; Figure 1). By eliminating all these variables, criteria not under orthodontic control are less likely to become a factor in rating the smile (McNamara et al., 2008).

Buccal and posterior corridors were evaluated. Initially, the following attributes of the smile were measured in millimetres through Adobe Photoshop software by using vertical lines as limits (Figure 2):

A. Smile width: the distance from outer commissure to outer commissure (Ritter et al., 2006; McNamara et al., 2008).

B. Width of all visible maxillary teeth: the distance from the distal aspect of the most posterior visible tooth on the right to the most posterior visible tooth on the left side of the maxilla.

Figure 1 Redution of confounding variables: (A) original image, (B) image cropped at a standardized proportion of 21 × 12.4 cm, (C) elimination of facial blemishes and facial hair, (D) image conversion to black and white.
The subjective aesthetic value of each smile was scored according to a 10-point numerical scale under each photograph where a score of 1 represented ‘the most unattractive’ and 10 represented ‘the most attractive’. The raters were allowed to compare the smiles. Therefore, during the evaluation, two photographs were shown each time. Immediately after rating the smile, the score was shown under the corresponding photograph in the Smile Gallery. An icon in each smile evaluation page could drive the rater to the Smile Gallery to revise the scores many times, if necessary (Figure 4). This allowed a good intrarater calibration method in evaluating the smiles.

**Error study**

Two weeks after the first evaluation, 18 orthodontists and 12 laypeople reevaluated the same smiles in a different arrangement. The attributes of smile were also remeasured by the same examiner (NCB). The casual errors were calculated according to Dahlberg’s formula (Dahlberg, 1940), $S^2 = \frac{\sum e^2}{2n}$, and the systematic errors were estimated with dependent $t$-tests, for $P < 0.05$ (Houston, 1983).

**Statistical analyses**

Normal distribution of the data was verified with the Kolmogorov–Smirnov test. The results demonstrated that all aesthetic scores had normal distribution in the groups.

Intergroup compatibility regarding age, posttreatment time, and the occlusal status (PAR) was compared by analysis of variance (ANOVA), and intergroup sex distribution was evaluated with chi-square test.

The influence of the treatment protocol, rater group, and of their interaction on smile aesthetics was evaluated with two-way ANOVA.

Buccal and posterior corridor sizes between the different treatment groups were compared with ANOVA, followed by Tukey tests, as a second step.

Correlation between buccal and posterior corridor sizes and smile aesthetics was evaluated with Pearson’s correlation coefficient. Results were regarded as significant at $P < 0.05$. These analyses were performed with Statistica software (Version 6.0; StatSoft Inc., Tulsa, Oklahoma, USA).

**Results**

No systematic errors were found, and the casual errors were 0.45 and 0.40 for orthodontists and laypeople, respectively, and 0.29, 0.15, and 0.16 for smile width, maxillary intercanine width, and width of all visible maxillary teeth.

The groups were compatible regarding age, posttreatment time, occlusal status, and sex distribution (Table 1).

There were no significant intergroup and inter-rater differences regarding smile aesthetics and also their interaction did not affect smile aesthetics (Table 2).
Buccal and posterior corridor sizes were similar between the groups (Table 3). There was no significant correlation between smile aesthetics and buccal and posterior corridor sizes (Table 4).

Discussion

Sample selection

Class II division 1 subdivision malocclusion patients treated with one and three premolar extractions were selected because Class II subdivision malocclusion can be classified into two types: type 1, characterized by distal positioning of the mandibular first molar on the Class II side, and type 2, characterized by mesial positioning of the maxillary first molar on the Class II side (Janson et al., 2007). Type 1 Class II subdivision malocclusion presents coincidence of the maxillary dental midline with the facial midline and deviation of the mandibular midline. Type 2 has the opposite characteristics (Janson et al., 2007). Therefore, one of the best treatment options for type 1 Class II subdivision malocclusion would be extraction of maxillary first premolars and one mandibular first premolar on the Class I side (Cheney, 1952, 1961; Lewis, 1976; Alavi et al., 1988; Janson et al., 2001) provided that the patient’s profile allows for retraction of the maxillary and mandibular incisors (Figure 5). Type 2 can be corrected with extraction of one
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Table 1  Intergroup comparison of subjects’ age, posttreatment time, occlusal status (PAR), and sex distribution (analysis of variance and chi-square test).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group 1 (one premolar extraction; n = 23)</th>
<th>Group 2 (four premolar extractions; n = 23)</th>
<th>Group 3 (three premolar extractions; n = 20)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>24.4 (SD: 4.97)</td>
<td>25.4 (SD: 6.70)</td>
<td>21.6 (SD: 5.28)</td>
<td>0.1017*</td>
</tr>
<tr>
<td>Posttreatment time</td>
<td>6.53 (SD: 4.41)</td>
<td>9.94 (SD: 7.71)</td>
<td>5.61 (SD: 4.68)</td>
<td>0.0536*</td>
</tr>
<tr>
<td>PAR index</td>
<td>2.22 (SD: 2.41)</td>
<td>2.52 (SD: 2.23)</td>
<td>2.35 (SD: 2.2)</td>
<td>0.3432**</td>
</tr>
<tr>
<td>Sex</td>
<td>Male: 9</td>
<td>5</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Female: 14</td>
<td>18</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>

*Analysis of Variance; **Chi-square test.

Table 2  Comparison of aesthetic score considering the influence of treatment protocols and rater’s group (two-way analysis of variance).

<table>
<thead>
<tr>
<th>Groups and raters</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 46*</td>
<td>n = 46*</td>
<td>n = 40*</td>
<td></td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>5.86 (1.06)</td>
<td>5.63 (1.36)</td>
<td>5.40 (1.13)</td>
<td>0.2104</td>
</tr>
<tr>
<td>Raters</td>
<td>Laypeople: n = 66</td>
<td>Orthodontist: n = 66</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.49 (1.24)</td>
<td>5.79 (1.14)</td>
<td></td>
<td>0.1516</td>
</tr>
<tr>
<td></td>
<td>Laypeople: n = 23</td>
<td>Orthodontist: n = 23</td>
<td></td>
<td>0.9912</td>
</tr>
<tr>
<td></td>
<td>5.71 (1.15)</td>
<td>6.01 (0.96)</td>
<td>5.49 (1.41)</td>
<td></td>
</tr>
</tbody>
</table>

*The number of observations is doubled because there are two groups of raters.
Table 3 Comparison of buccal and posterior corridor sizes between groups 1, 2, and 3 (analysis of variance).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Group 1 (one premolar extraction; n = 23)</th>
<th>Group 2 (four premolar extractions; n = 23)</th>
<th>Group 3 (three premolar extractions; n = 20)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buccal corridor</td>
<td>39.46 (SD: 4.01)</td>
<td>37.83 (SD: 4.67)</td>
<td>37.33 (SD: 2.85)</td>
<td>0.1828</td>
</tr>
<tr>
<td>Posterior corridor</td>
<td>17.76 (SD: 5.29)</td>
<td>18.89 (SD: 5.54)</td>
<td>17.51 (SD: 4.61)</td>
<td>0.6417</td>
</tr>
</tbody>
</table>

Table 4 Comparison of aesthetic score considering buccal and posterior corridors sizes (Pearson’s correlation).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Rater’s score of smile attractiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R</td>
</tr>
<tr>
<td>Buccal corridor</td>
<td>−0.0004</td>
</tr>
<tr>
<td>Posterior corridor</td>
<td>−0.1261</td>
</tr>
</tbody>
</table>

maxillary first premolar on Class II side (Figure 6). The final occlusion on the Class I side will have Class I molar and canine relationships, and the Class II side will have Class II molar and Class I canine relationships, with the maxillary and mandibular dental midlines coincident to each other and to the midsagittal plane (Cheney, 1952, 1961; Lewis, 1976; Alavi et al., 1988; Janson et al., 2001; Figures 5 and 6). Correction of dental midline deviation in these treatment approaches is facilitated since it is obtained concurrently with extraction space closure (Lewis, 1976). Additionally, Class II subdivision malocclusion can also be treated with four premolar extractions but with a smaller occlusal treatment success rate than treatment with three premolar extractions (Janson et al., 2003). However, because of the asymmetric relationships of the posterior segments produced with asymmetric extractions, it is questioned whether it could influence the smile aesthetics. Therefore, this study was designed to investigate this issue.

A non-extraction control group was not used because the primary objective of the study was to evaluate whether there were differences in smile attractiveness between symmetric and asymmetric extraction protocols and not with non-extraction protocols. Besides, it was already demonstrated that smile aesthetics do not differ between patients treated with and without four premolar extractions (Johnson and Smith, 1995; Kim and Gianelly, 2003; Isiksal et al., 2006).

Patients should present a maximum PAR score of 7 which is considered to be an acceptable occlusion (Birkeland et al., 1997; Woods et al., 2000; Freitas et al., 2007) to eliminate poor treatment results influence on the evaluation.

Methodology

In the aesthetic evaluation, the method of exhibiting only the smiles was preferred instead of including the whole face because it reduces the possibility of grading the smiles by characteristics that are not under orthodontic control (Johnson and Smith, 1995). This is a difficult methodological problem in studies of smile aesthetics (Johnson and Smith, 1995); however, evaluation of the smile out of the facial context is adopted in most studies on smile aesthetics (Hulsey, 1970; Johnson and Smith, 1995; Kokich et al., 1999; Kim and Gianelly, 2003; Roden-Johnson et al., 2005; Gracco et al., 2006; Isiksal et al., 2006; Martin et al., 2007; Pinho et al., 2007; McNamara et al., 2008).

Good reproducibility was demonstrated by the raters because there were no significant systematic errors and the casual errors were 0.38 and 0.39 for orthodontists and laypeople, respectively (Dahlberg, 1940; Houston, 1983). The groups were also compatible regarding age, posttreatment time, occlusal status, and sex distribution (Table 1).

Smile attractiveness

There was no difference on smile attractiveness between the aesthetic results of different treatment protocols of Class II division 1 subdivision malocclusion, i.e. with one, three, and four premolar extractions (Table 2). These results are consistent with previous studies which demonstrated an absence of correlation between smile aesthetics and treatment protocols (Johnson and Smith, 1995; Kim and Gianelly, 2003; Isiksal et al., 2006) and with those comparing treatment with four premolar extractions and without extractions (Johnson and Smith, 1995; Kim and Gianelly, 2003; Isiksal et al., 2006). It seems that individual variations such as tooth shape, curls of the lips, and mouth expression may induce the smile to be perceived as aesthetically pleasant or not (Isiksal et al., 2006).

There were also no significant differences in the aesthetic evaluation between the groups of raters or when the interaction of treatment with the groups of raters was simultaneously evaluated (Table 2). This means that both orthodontists and laypeople have the same perception of smile aesthetics and it is probably due to the fact that the smiles were judged as an aesthetic whole, and minor discrepancies in specific smile features were less of a decisive factor (McNamara et al., 2008). Equally, other recent studies on smile attractiveness did not demonstrate a statistically significant difference between groups of raters (Kerns et al., 1997; Gracco et al., 2006; Isiksal et al., 2006; Kokich et al., 2006; McNamara et al., 2008).
There were no significant differences between buccal and posterior corridor widths of the three groups (Table 3). There are some criticisms regarding premolar extractions concerning the relation between dental arch width and smile width (Johnson and Smith, 1995). Spahl and Witzig (1987) argue that removal of a tooth in each quadrant reduces the radius of the curve of the dental arch leading to a narrow denture that is not of sufficient size to fill the oral slit during a smile. In a study conducted by Johnson and Smith (1995), there was no difference in the proportion of intercanine widths and the distance between the most posterior visible teeth with the smile width in orthodontically treated patients with and without four premolar extractions, contradicting that extraction treatment protocols lead to a discrepancy between arch width and the soft tissues. Kim and Gianelly (2003) found that, in fact, in the group with four premolar extractions, the arch width was 1–2 mm broader when compared with patients treated without extractions.

Size of the buccal corridor is one of the most controversial aspects of smile attractiveness (Martin et al., 2007). A study has shown that buccal corridor reduction through maxillary expansion can dramatically improve smile aesthetics (Sarver, 2001). However, buccal and posterior corridor widths had no correlation with smile attractiveness, as has been previously shown (Hulsey, 1970; Kim and Gianelly, 2003; Roden-Johnson et al., 2005; Ritter et al., 2006; McNamara et al., 2008; Table 4). Although the evaluation methods are rather different, they all have compared buccal corridors of different subjects. These results can be explained because smile is the interaction of a set of factors. When smile is evaluated, many variables are observed at the same time. Therefore, buccal corridor size alone is not able to significantly influence smile aesthetics.

Several studies have suggested that the buccal corridor affects smile attractiveness, so a minimal buccal or posterior corridor would be considered as more attractive for orthodontists and laypeople (Moore et al., 2005; Gracco et al., 2006; Martin et al., 2007; Ioi et al., 2009) However, it is interesting to notice that most of these studies used only digitally altered smiles, emphasizing the buccal corridor. According to Kokich et al. (1999), there is a threshold level that a digital alteration must exceed for the viewer to detect because both dentists and laypeople only notice the extremes. However, if enough teeth are deleted from the lateral aspects of the smile, there would be some detraction from smile aesthetics and the smile would probably appear unnatural (Kokich et al., 1999). The size differences of the buccal corridors in patients may be more subtle whereas the changes performed in the computer are more dramatic (Gracco et al., 2006).

It should be emphasized that these results were obtained at the age ranges of the groups. Whether groups at older age ranges would present the same results is a topic that deserves further investigation.

**Clinical implications**

The current results suggest that well finished Class II division 1 subdivision malocclusion treatments with asymmetric extractions of either one or three premolars present similar smile attractiveness as if treated with four premolar extractions. Therefore, treatment of Class II division 1 subdivision malocclusions with one premolar, when correctly indicated, will provide good smile attractiveness. Additionally, and perhaps more importantly, treatment of Class II division 1 subdivision malocclusions with three premolar extractions besides presenting a greater treatment success rate, and less mandibular incisor and soft tissue retraction than the four premolar extraction protocol, also has similar smile attractiveness (Janson et al., 2003;
Janson et al., 2007). Consequently, it would be the preferred treatment alternative, among the two, whenever extractions can be performed.

Conclusions

1. Smile attractiveness is similar in treatment protocols of one, three, and four premolar extractions in Class II division I subdivision malocclusions.
2. Sizes of buccal and posterior corridors did not differ between patients with Class II division I subdivision malocclusions were treated with one, three, and four premolar extractions. Consequently, no correlation was found between widths of buccal or posterior corridor sizes and smile attractiveness.

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