Journal of Dental Sciences (2016) 11, 387—393

Available online at www.sciencedirect.com

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journal homepage: www.e-jds.com

ORIGINAL ARTICLE

Effects of tooth extraction on smile esthetics and the buccal corridor: A meta-analysis

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Received 2 April 2016; Final revision received 25 April 2016
Available online 6 July 2016

KEYWORDS
buccal corridor;
smile esthetics;
tooth extraction

Abstract *Background/purpose:* Smile esthetics is a critical factor for evaluating orthodontic treatment outcomes. The effects of tooth extraction on smile esthetics and buccal corridor remain controversial and have not been adequately investigated. Therefore, in this systematic review and meta-analysis, we evaluated the aforementioned effects.
Materials and methods: We searched clinical studies held in PubMed, MEDLINE, Embase, and the Cochrane Library up to May 2015, with no restriction. Study selection and data extraction were conducted by two reviewers independently. A random-effects model was used for conducting a meta-analysis to assess the mean difference between the esthetic score and the buccal corridor ratio of extraction and nonextraction groups.
Results: Six eligible studies were included in this meta-analysis. No significant difference was observed in the esthetic score and the buccal corridor ratio between extraction and nonextraction groups.
Conclusion: Tooth extraction does not affect smile esthetics or buccal corridor. However, additional detailed, large-scale, double-blinded, and randomized controlled trials are required for further evaluation.

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http://dx.doi.org/10.1016/j.jds.2016.04.003

Introduction

Smile esthetics has gained increased attention in orthodontic treatments because orthodontic patients now evaluate treatment outcomes not only on the changes of their facial profile, but also their smiles. However, most orthodontic studies emphasize lateral skeletal analysis rather than frontal smile esthetics.

Smile esthetics is associated with multiple factors, including the dentition and surrounding soft tissue. One of the essential factors of smile esthetics is the presence or absence of a buccal corridor.[1] The buccal corridor is defined as the space between the facial surfaces of the posterior teeth and the corners of the lips during smiling.[2] It remains unclear whether the buccal corridor should be measured according to the canines or to the last visible teeth, but previous studies have revealed an association between buccal corridor and smile esthetics. Some authors suggested that the presence or absence of a buccal corridor while smiling is not esthetically critical,[3] whereas some claim that smiles with a larger buccal corridor are less esthetically pleasing.[4–9]

Tooth extraction is common in orthodontic treatments. Some studies report that the arch width is not necessarily narrower in patients with tooth extraction.[10,11] However, others say that extraction may lead to constriction of the dental arches and reduced fullness of the dentition while smiling, resulting in an increased buccal corridor that can affect smile esthetics.[12,13]

The effects of tooth extraction on smile esthetics and the buccal corridor remain unclear; therefore, we conducted a systematic review and meta-analysis to analyze these effects.

Materials and methods

Selection criteria

We included clinical studies that fulfilled the following criteria: (1) compared smile esthetics between patients who did and did not undergo tooth extraction; (2) used post-treatment frontal smiling photos for grading; (3) considered all permanent dentitions; and (4) used fixed appliance for orthodontic treatments.

Studies were excluded from our meta-analysis for the following reasons: (1) the outcomes of interest were not clearly reported: (2) different comparison settings were used; (3) different outcome measurements were used; and (4) there was an overlap among authors, centers, and patients across published studies.

Search strategy and study selection

Studies were identified by conducting a computerized search of four databases, namely PubMed, MEDLINE, Embase, and the Cochrane Library, from their inception until May 2015. The following combination of keywords was used: extraction OR removal, esthetic OR esthetics OR smile OR attractive, and orthodontic OR orthodontics. We reviewed all retrieved abstracts, studies, and citations and identified additional studies by searching the references of relevant studies; no language restrictions were applied.

Data extraction

Two reviewers (Y.C.W. and C.L.C.) independently extracted the following information from each study: first author, year of publication, study design, total patients in each group, study population characteristics, and intervention and outcome methods. The individually recorded decisions made by the two reviewers were compared, and any disagreement was resolved by another reviewer (H.C.C.).

Outcome assessments

The primary outcome of this meta-analysis was the esthetic score of the patients. The secondary outcome was the buccal corridor ratio, which was further represented as intercanine width relative to smile width, and last visible teeth width relative to smile width.

Statistical analysis

Review Manager (version 5.3; Cochrane Collaboration, Oxford, England) was used to conduct the analysis. The meta-analysis was performed according to the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-analyses.[14] When necessary, standard deviations were estimated from the provided confidence interval (CI) limits, standard errors, or range values.[15] A random-effects model was used for assessing the esthetic score of the extraction and nonextraction groups. The effect sizes of continuous outcomes were reported as the mean difference[16]; the precision of an effect size was reported as 95% CI. Furthermore, statistical heterogeneity was assessed using the I^2 test, in which $I^2 \geq 50\%$ defined substantial heterogeneity. Because the data on buccal corridor reported by one study[17] were different from those in the other included studies, we performed a separate sensitivity analysis to eliminate the outlier data, thereby minimizing possible bias.

Results

Study characteristics

Figure 1 shows the flow chart describing the study selection. The search strategy detailed in the Materials and methods section yielded 724 citations. Of these, 706 citations were excluded because they were not clinical studies, were on a different topic, or were duplicated. We thus retrieved the full text of 18 manuscripts, and 12 were then excluded from the final review. Of these, 10 studies were excluded because different methodologies were used, including methodologies where the esthetic score was not evaluated while comparing the extraction and nonextraction groups,[18–24] and others where the esthetic score was evaluated from the lateral, not the frontal view.[25–27]

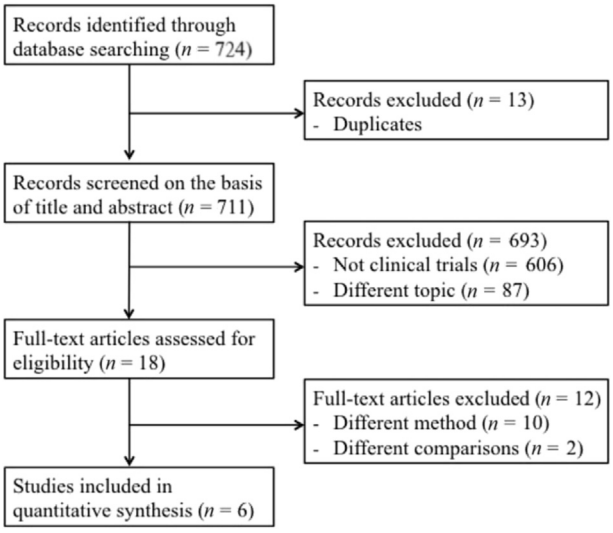

Figure 1 Flow chart of the search and selection process for studies.

The two remaining studies were excluded because different comparisons were used. In the first, control and nonextraction groups were compared[28] and in the second the changes in the extraction group were compared.[29] Thus, six studies were included in the final analysis.

Table 1 shows the characteristics and patient demographic data of each study included in this report. All six studies were published from 1995 to 2014, with sample sizes of 24–60 patients. Meyer et al[17,30] reported the results of buccal corridor and esthetic score on the same patients in two separate studies.

In all studies, the patients were divided into extraction and nonextraction groups. The pretreatment dental characteristics of the patients were mentioned only in three studies. The patients in the nonextraction group of one study revealed a mean space deficiency of 4.15 ± 1.76 mm and 3.16 ± 1.41 mm in the maxillary and mandibular arches, respectively,[31] whereas those in the extraction group revealed a mean space deficiency of 7.45 ± 2.12 mm and 5.02 ± 2.14 mm, respectively. In the other two studies,[17,30] the patients in the extraction and nonextraction groups had a mean space deficiency in the maxillary arch of 36.39 ± 4.41 mm and −0.54 ± 4.3 mm, respectively. For the extraction group, the first four premolars were removed in four studies,[31–34] whereas four premolars that were not specific to the first premolar were removed in the other two studies.[17,30] All studies evaluated smile esthetics, but one study did not report the esthetic score; it was thus not included in the meta-analysis.[32] The buccal corridor was measured in four studies, while one study only measured the intercanine width using a cast.[34]

Effects of tooth extraction on smile esthetics

Smile esthetics was measured from the post-treatment frontal smiling photograph of each patient. The photographs were judged by raters and given an esthetic score. All studies evaluated smile esthetics; however, one study did not report the esthetic score. We combined the esthetic scores of extraction and nonextraction groups from the other four studies to evaluate the effects of tooth extraction on smile esthetics.

The results revealed no significant differences in the esthetic scores of the extraction and nonextraction groups. The standard mean difference was 0.02 (95% CI, from −0.3 to 0.35, P = 0.90). The I^2 value was 23%, indicating mild heterogeneity across the studies (see Figure 2).

Table 1 Characteristics of the included studies.

Author (Year)	Study design	Patient number (male %)	Age	Space deficiency (mm)	Intervention	Outcome
Johnson (1995)[33]	Retro	E = 30 (50) N = 30 (50)	E = 16.4 N = 15.6	Unclear	E = 4 1st premolars extracted N = non-extraction	Esthetic score Buccal corridor ratio
Ghaffar (2011)[32]	Retro	E = 30 (33.3) N = 30 (36.7)	15–30	Unclear	E = 4 1st premolars extracted N = non-extraction	Buccal corridor ratio
Işiksal (2006)[31]	Retro	E = 25(48) N = 25 (48)	E = 19.08 N = 19.04	E = U 7.45 L 5.02 N = U 4.15 L 3.16	E = 4 1st premolars extracted N = non-extraction	Esthetic score Buccal corridor ratio
Meyer (2014 Part 1 & 2)[17,30]	Retro	E = 30 (36.7) N = 27 (48.1)	E = 14.33 N = 15.46	E = U 6.39 N = U −0.54	E = 4 premolars extracted N = non-extraction	Esthetic score (Part 2) Buccal corridor ratio (Part 1)
Kim (2003)[34]	Retro	E = 12 N = 12	E = 14.1 N = 14.2	Unclear	E = 4 1st premolars extracted N = non-extraction	Esthetic score

E = extraction group; N = nonextraction group; U = upper arch; L = lower arch.

Effects of tooth extraction on buccal corridor

The buccal corridor was also measured from the post-treatment frontal smiling photograph of each patient. To minimize magnification-related bias in photographs, the buccal corridor was defined as the intercanine width relative to the smile width ratio and as the last visible teeth width relative to the smile width ratio. Four studies evaluated the buccal corridor ratio, whereas one study measured only the intercanine width using a cast.[34] Thus, we combined the ratios from the four studies to evaluate the effects of tooth extraction on the buccal corridor.

The result of the intercanine width relative to the smile width ratio was not significantly different between the extraction and nonextraction groups, with the mean difference being 0.00 (95% CI, from −0.02 to 0.03, P = 0.85). The I^2 value was 62%, indicating moderate heterogeneity across the studies (see Figure 3).

The last visible teeth width relative to the smile width ratio was not significantly different between the extraction and nonextraction groups, with a mean difference of 0.00 (95% CI, from −0.01 to 0.02, P = 0.52). The I^2 value was 5%, indicating mild heterogeneity across the studies (see Figure 4).

The results of sensitivity analysis of the buccal corridor remained the same. The mean difference for the intercanine width relative to the smile width ratio was 0.01 (95% CI: from 0.00 to 0.03, P = 0.06), and the last visible teeth width relative to the smile width ratio was 0.00 (95% CI, from −0.02 to 0.02, P = 0.73). These results indicate that the outlier data did not affect the results of our meta-analysis (see Figures 5 and 6).

Discussion

Few studies have compared the effects of premolar extractions on frontal smile esthetics. In this meta-analysis, the esthetic score and the buccal corridor ratio of the extraction and nonextraction groups were not significantly different, indicating no difference in smile esthetics and buccal corridor after tooth extraction. Our results support the conclusions of a systematic review that tooth extraction is not necessarily detrimental to facial esthetics.[35] Some orthodontists consider that extraction reduces the arch width, which could increase the buccal corridor and lead to poor smile esthetics.[12,13] By contrast, Yang et al[36] concluded that the buccal corridor area ratio was not significantly different between extraction and

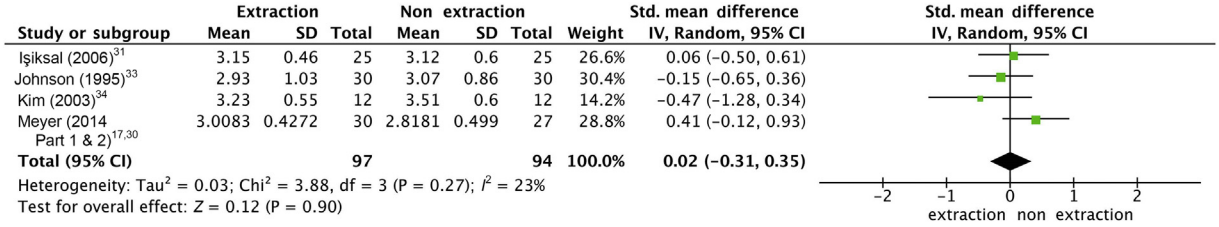

Figure 2 Forest plot of the effects of tooth extraction on the esthetic score. CI = confidence interval; df = degrees of freedom; IV = inverse variance; SD = standard deviation.

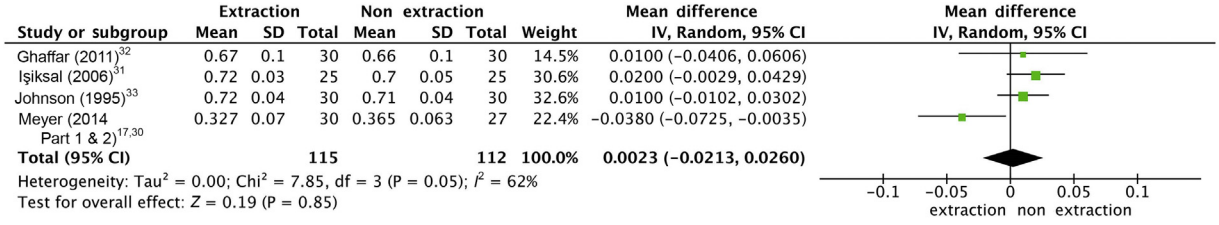

Figure 3 Forest plot of the effects of tooth extraction on the buccal corridor ratio (intercanine width:smile width). CI = confidence interval; df = degrees of freedom; IV = inverse variance; SD = standard deviation.

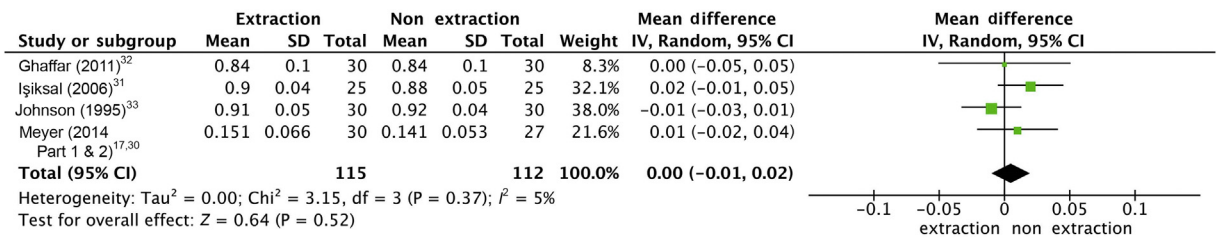

Figure 4 Forest plot of the effects of tooth extraction on the buccal corridor ratio (last visible teeth width:smile width). CI = confidence interval; df = degrees of freedom; IV = inverse variance; SD = standard deviation.

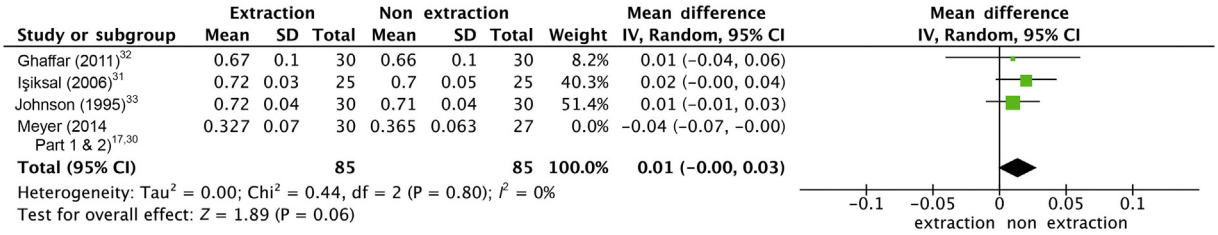

Figure 5 Forest plot of the sensitivity analysis of the buccal corridor ratio (intercanine width:smile width). CI = confidence interval; df = degrees of freedom; IV = inverse variance; SD = standard deviation.

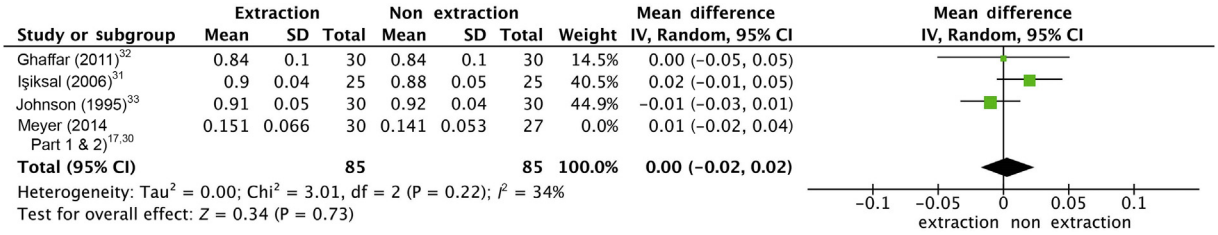

Figure 6 Forest plot of the sensitivity analysis of the buccal corridor ratio (last visible teeth width:smile width). CI = confidence interval; df = degrees of freedom; IV = inverse variance; SD = standard deviation.

nonextraction groups, similar to the findings of our meta-analysis.

Our conclusion that extraction did not significantly affect frontal smiling esthetics, in terms of both esthetic score and buccal corridor, was also similar to Dai et al.[37] In addition to the ratio of last visible teeth width to smile width for the measurement of buccal corridor used in Dai et al,[37] our study also presented the buccal corridor defined as the ratio of intercanine width to smile width. Interestingly, the intercanine width-defined buccal corridor was the most heterogeneous measurement between studies among all esthetic measurements (I^2 = 62%), where Meyer et al's study[17,30] was the only one having a lower and significant buccal corridor for both extraction and nonextraction groups, compared to the others. Therefore, our sensitivity analysis excluding the outlier studies showed that tooth extraction had a borderline significant, but in a lesser magnitude buccal corridor in terms of the ratio of intercanine width to smile width (Figure 5). Our study presented the effects of tooth extraction from individual studies, together with the estimated pooled result in the forest plot graph, as well as the sensitivity analysis by removing outlier data. This successfully enables us to detect the uniqueness of an intercanine width-defined buccal corridor. We need more studies to show whether Meyer et al's study was a special case, or if our meta-analysis results showing that the tooth extraction makes no difference are conclusive.

As previously explained, the included studies exhibited some heterogeneous characteristics, which were contributed by various clinical factors. First, there were no clear inclusion criteria for the patients in the studies. Second, the raters had different characteristics. Third, the format of the photographs used for rating was different among studies. Fourth, the perioral soft tissue may have influenced the raters' judgment, affecting the evaluated outcomes.

The pretreatment dental characteristics of the patients were mentioned only in three studies. Of these, one study differed in the patients' baseline between the groups, which may have introduced bias in the results because pretreatment characteristics between the extraction and nonextraction groups were different.

Many studies have evaluated the perceptions of different raters. Orthodontists were more critical than lay people in detecting minor discrepancies. Some studies have suggested that lay people rated more highly than dental professionals did,[6,38,39] whereas some studies have shown no difference between the observations by dental professionals and lay people.[5,9,40–42] In this meta-analysis, three studies recruited only lay people for esthetic evaluation and two studies combined lay people and dental professionals for assessment. Observational bias because of different raters in the studies may have resulted in heterogeneity.

The format of the photographs used for assessment in this meta-analysis was different. One study used full-face photographs and the other four used only perioral photographs. Yang et al[36] revealed a significant negative correlation between vertical facial patterns and the buccal corridor, suggesting that long-faced people may have a naturally smaller buccal corridor compared with short-faced people. Therefore, some previous studies have used full-face frontal photographs[4,8,43]; however, a limitation of using such photographs is that other facial features can confound the esthetic rating of the smiles.

With perioral photographs, smile esthetics is related to the surrounding soft tissue and dentition, including the lips,[40] gingival display,[38,44] curvature of the maxillary incisal edges,[45,46] coincidence of the dental midline with the facial midline,[47] color of the teeth,[48] and the buccal corridor. All these factors may influence the perception of smile esthetics.

The strengths of our meta-analysis include the comprehensive search for eligible studies, the systemic and

explicit application of eligibility criteria, and a rigorous analytical approach. However, our review is limited by the quality of the studies; all studies were retrospective. Three studies lacked the pretreatment characteristics of the patients,[32–34] whereas the other three studies[17,30,31] were without baseline characters shown in terms of how the extraction and nonextraction groups may have differed from baseline already. This may have caused observation bias.

In conclusion, the results of this study suggest no difference between smile esthetics and the buccal corridor in the extraction and nonextraction groups. Thus, treatment involving tooth extraction should not be solely based on smile esthetics but also on other factors such as overjet, overbite, crowding, and soft tissue characteristics. These findings are, however, based on evidence that may contain biases. For a more detailed evaluation, additional large-scale, double-blinded, and randomized controlled studies are necessary.

Conflicts of interest

The authors have no conflicts of interest relevant to this article.

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