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Effects of fixed orthodontic brackets on oral malodor

A systematic review and meta-analysis according to the preferred reporting items for systematic reviews and meta-analyses guidelines

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Abstract

Background: This systematic review and meta-analysis aimed to identify whether there is any relationship between fixed orthodontic appliances and malodor, and if self-ligating brackets (SLBs) prevent malodor better than conventional brackets (CBs).

Methods: The electronic databases PubMed, Ovid, EMBASE, and the Cochrane Library were searched from inception to September 2016; a manual search was also performed. Randomized controlled and clinical controlled trials, in which experimental groups received fixed orthodontic therapy and malodor was measured, were included. Patients treated with fixed orthodontic brackets were compared with those without any treatment, and SLB systems were compared with CB systems. Two reviewers independently selected potentially relevant studies, evaluated the risk for bias, extracted essential data, and synthesized findings using Review Manager version 5.3 (Copenhagen: The. Nordic Cochrane Centre, The Cochrane Collaboration, 2014).

Results: Four studies, involving a total of 152 participants, met the inclusion criteria. Fixed orthodontic appliances caused malodor from the initial visit to 2 to 3 months, but was only significant after the first week (mean difference 20.24 [95% confidence interval [CI] 11.75–28.74]; $P < .00001$). Plaque index, gingival index, and periodontal pocket depths demonstrated no statistical differences between the SLB and CB groups after the first week. However, SLBs significantly controlled malodor better than CBs after the first week (mean difference 4.32 [95% CI 6.02 to 2.61]; $P < .00001$). The quality of the included studies was relatively low and relevant research in this field is quite scarce.

Conclusions: Although the evidence base was relatively weak, fixed orthodontic treatment appeared to be a risk factor for malodor, independent of periodontal changes, and SLB systems controlled malodor better than CB systems.

Abbreviations: CBs = conventional brackets, CCTs = clinical controlled trials, CG = control group, CI = confidence interval, F = female, FEM = fixed-effect model, GI = gingival index, M = male, MD = mean difference, PI = plaque index, RCTs = randomized controlled trials, REM = random-effect model, SG = study group, SLBs = self-ligating brackets, VSCs = volatile sulfur compounds.

Keywords: meta-analysis, oral malodor, orthodontics, self-ligating brackets

1. Introduction

Foul breath and/or discernible smell originating from the oral cavity is frequently defined as halitosis, which affects 50% of the

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population.[1] It has been reported that 80% to 90% of the bad breath cases are due to problems in the oral cavity, thus known as oral malodor.[2] It is regarded to be a negative element in one's self-image and affects more aspects of daily life than social relations alone.[3] Researchers have suggested that oral malodor is primarily caused by volatile sulfur compounds produced by microbial metabolism within the saliva, dental plaque, tongue dorsum, and periodontal pockets.[4–7] However, whether there is a definite correlation between plaque index (PI) and oral malodor remains controversial.[8]

One of the risk factors for dental plaque accumulation and periodontal problems is malocclusion. It is broadly recognized that orthodontic treatment of malocclusion facilitates favorable conditions to maintain oral hygiene.[9] However, during the treatment period, fixed brackets, archwires, and other components hamper oral hygiene measurements, thus enhancing plaque attachment, or even lead to gingival inflammation or periodontitis.[9,10]

Recently, some investigators have reported that fixed orthodontic appliances can increase oral malodor,[11,12] and that oral malodor should be regarded as one of potential side effects of orthodontic treatments. Additionally, the effects of self-ligating bracket (SLB) and conventional bracket (CB) systems have been discussed widely, although a previous meta-analysis revealed that

SLBs do not outperform CBs in promoting oral health.[13] Some researchers have suggested that SLBs may prevent oral malodor[14]; others, however, disagree.[15]

Therefore, this systematic review and meta-analysis aimed to collect evidence to identify the effects of fixed brackets on oral malodor, and whether the effect of SLB systems differs from that of CB systems.

2. Methods

A systematic review and meta-analysis was performed according to the preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines. As a meta-analysis and systematic review, no ethical approval or patient consent was required.

This meta-analysis was designed and conducted according to instructions from the Cochrane Handbook.[16] The study design, participants, interventions, comparisons, and outcomes (i.e., PICO) definition was followed. Randomized controlled and clinical controlled trials that included subjects with permanent dentition, without systemic problems or poor oral hygiene, and experimental groups that received fixed orthodontic therapy were included. Patients treated with fixed orthodontic brackets were compared with those without any treatment, and SLB systems were compared with CB systems. Outcomes included oral malodor scores, PI, gingival index (GI), and periodontal pocket depths.

The following exclusion criteria were applied: clinical studies without comparison(s); reviews; case reports; and letters. Studies involving participants with poor oral condition or systemic diseases, investigations in which no measurement of malodor was performed, or those that included removable orthodontic appliances were also excluded.

2.1. Search strategy

The electronic databases PubMed, Ovid, Embase, and the Cochrane Library, from inception to September 2016, were searched. Search words included: orthodontic*, brace*, bracket*, and halitosis, malodor, bad breath, foul breath, offensive breath, breath odor, and discernible smell. Additionally, a manual search was conducted according the reference lists of relevant literature reports.

2.2. Study selection

Two reviewers (JH and JHJ) independently scanned the titles and abstracts of searched articles and selected potentially relevant studies. Any disagreement was resolved via consultation with a third reviewer (CYL). Relevant full-text studies were downloaded to identify whether they fulfilled the inclusion criteria. Any discrepancies were discussed among the 3 reviewers to reach consensus.

2.3. Bias assessment

According to the Cochrane Handbook, the following 7 aspects of bias were assessed: randomization sequence generation; allocation concealment; blinding of participants; blinding of outcome examiners; incomplete data; selective reporting; and other possible biases.

The risk for bias in research is assessed to be "low" if all 7 aspects are identified as "low," "high" if any of the aspects identified as "high," or "unclear" if no aspect identified as "high" but one or more aspects as "unclear."[16]

2.4. Data extraction

Two reviewers (JH and JHJ) extracted the following data independently: randomization; concealment and blinding; loss to

follow-up; demographic data; bracket types; types of ligation; malodor measurements; and PI, GI, and measurement intervals. Any controversies were addressed via consultation with a third reviewer (CYL).

Statistical analyses were performed using Review Manager version 5.3 (Copenhagen: The. Nordic Cochrane Centre, The Cochrane Collaboration, 2014). Heterogeneity was assessed using the I^2 statistic at a significance level of $\alpha = 0.05$, and mean difference (MD) with 95% confidence interval (CI) were adopted. Continuous data are presented as MD, while dichotomous data are expressed as relative risk. Subgroup analyses were performed based on measurement intervals. A random-effect model (REM) was applied when heterogeneity was high (>50%); otherwise, a fixed-effect model (FEM) was used.

3. Results

3.1. Study selection

A total of 355 articles were selected through the electronic search and 8 from the manual search; after removal of 135 duplicates, 228 studies remained. After full-text review of 7 potentially relevant articles, 4 met the inclusion criteria and were included in the systematic review and meta-analysis. The flow of the literature selection process is shown in Fig. 1. Detailed characteristics of the included studies are summarized in Table 1. All 4 studies used a halimeter manufactured by the same company to measure oral malodor and similar methods were used, as reported in Table 2.

3.2. Bias assessment

Among the 4 included studies, 3 were assessed as unclear risk and the other was evaluated as high risk. The quality of the included articles was relatively low, mainly because it was difficult to maintain participant blinding in the studies, and the randomization methods and concealment of allocation were not well developed. Bias assessment is illustrated in Fig. 2.
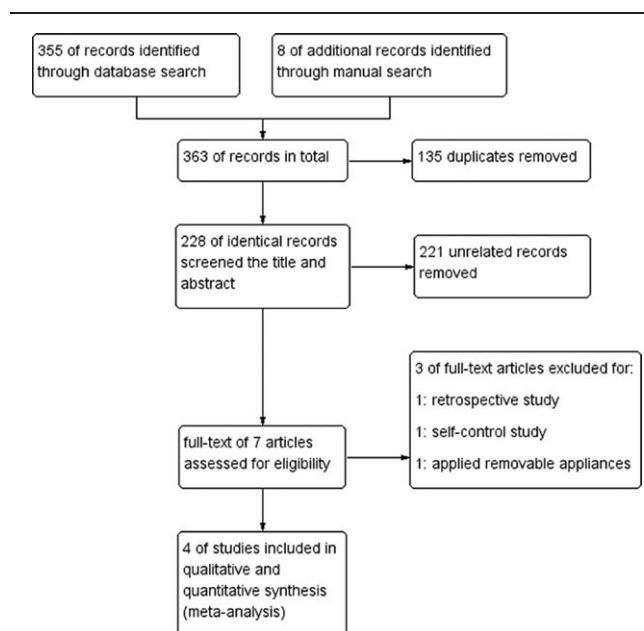

Figure 1. Flow diagram of the literature selection process.

Characteristics of the included studies.

Author	Year	Country	Study design	Number of participants	Age	Genders	Brackets	Type of ligation	Measurement intervals
Babacan et al	2011	Turkey	RCT	SG = 21, CG = 20	12–15 y	SG = 12F, 9M CG = 11F,9M	SG: CBs	Elastic	Before bonding, 1, 4 wks after bonding
Sokucu et al	2016	Turkey	CCT	SG = 13, CG = 12	No information	No information	SG: CBs	Steel wire	Before bonding, 1, 3, 5, 7, 9, 11, 13 mo after bonding
Kaygisiz et al	2015	Turkey	RCT	SLBs = 20, CBs = 20, CG = 20	12–18 y	28F, 32M	Group 1: SLBs Group 2: CBs	Steel wire	1 wk and immediate before bonding, 1, 4, 8 wks after bonding
Nalcaci et al	2013	Turkey	RCT	SLBs = 23, CBs = 23	SG = 14.48 ± 1.27 y, CG = 13.30 ± 1.61 y	SLBs = 11F,12M CBs = 13F,10M	SG: SLBs CG: CBs	Elastic	Before bonding, 1, 5 wks after bonding

CBs = conventional brackets, CCTs = clinical controlled trials, CG = control group, F = female, M = male, RCTs = randomized controlled trials, SG = study group, SLBs = self-ligating brackets.

3.3. Fixed orthodontic appliances versus control

Three of the included studies compared differences in the effects of CBs with ligation and an untreated control group. Malodor scores, PI, GI, and periodontal pocket depths were tested at the initial visit for bonding, 1 week after bonding, 1 month (4 or 5 weeks) after bonding, and 2 to 3 months after bonding. The data were synthesized into 3 subgroups based on the measurement intervals. Based on the heterogeneities of the subgroups, both the REM and FEM were applied to pool the MD and 95% CI.

As shown in Fig. 3, malodor scores demonstrated significant differences between the experimental and control groups only at 1 week after bonding (MD 20.24 [95% CI 11.75–28.74]; $P < .00001$), but was not significant at 1 month after bonding (MD 13.62 [95% CI −11.91–39.14]; $P = .30$), or 2 to 3 months after bonding (MD 0.14 [95% CI −0.01–0.30]; $P = .07$).

In comparing PIs (Fig. 4), the CB group demonstrated no statistical difference compared with the control group at either the initial visit or 1 week after bonding, but did, however, demonstrate a statistical difference at 1 month after bonding (MD 0.24 [95% CI 0.05–0.43]; $P = .01$). Similarly, GI was statistically different between the 2 groups only at 1 month after bonding (MD 0.30 [95% CI 0.06–0.54]; $P = .01$). Periodontal pocket depths demonstrated no statistical changes over the 3-month period after bonding.

3.4. CBs versus SLBs

Two included studies compared CBs with ligation and SLBs. The same subgroups were investigated based on measurement intervals, namely initial visit for bonding, 1 week after bonding, and 1 month (4 or 5 weeks) after bonding. Based on the heterogeneities of the subgroups, both REM and FEM were applied to pool the MD and 95% CI.

As illustrated in Fig. 5, the SLB group demonstrated a statistically significant advantage over the CB group 1 week after bonding (MD −4.32 [95% CI −6.02 to −2.61]; $P < .00001$). Although this advantage persisted 1 month after bonding, the difference was not statistically significant (MD −17.16 [95% CI −44.93 to 10.61]; $P = .23$).

PI and GI demonstrated similar trends over the first month after bonding, the results of SLB group exceeded that of the CB group 1 week and 1 month after bonding, with a nonsignificant advantage.

4. Discussion

Fixed orthodontic appliances impede oral hygiene measurement and create favorable conditions for plaque accumulation. Studies have demonstrated that periodontal problems are one of the potential side effects of orthodontic treatment,[17–20] although it remains controversial whether plaque is a causative factor of

Measurement methods used in the included studies.

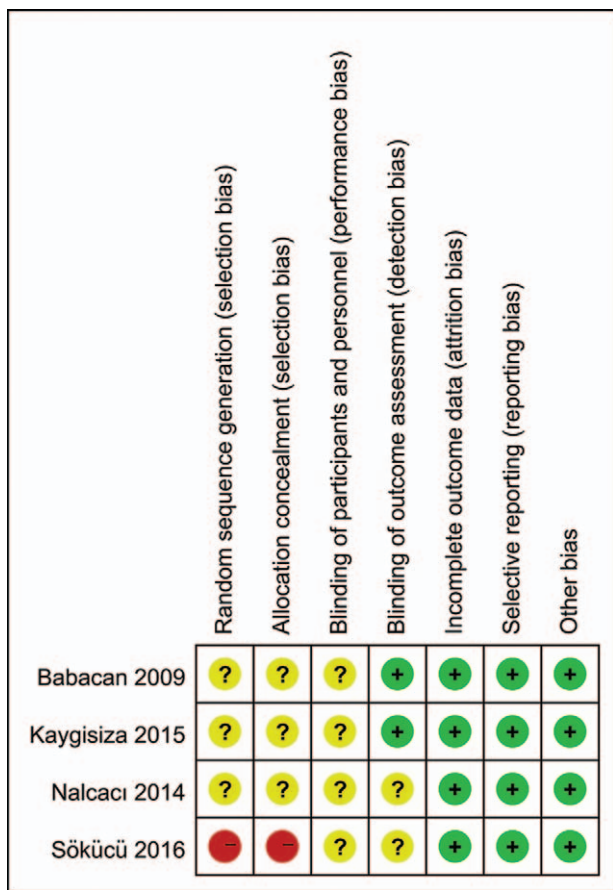| Author	Device	Company	Categories	Before sampling	Method	Recording
Babacan et al	Halimeter	Interscan, Chatsworth, CA	Normal (0–100 ppb), weak (101–150 ppb), strong (151–300 ppb), very strong (≥301 ppb)	Kept mouth closed for 60 s	A plastic straw was inserted above tongue dorsum but not touched the soft tissue. No breathing was allowed	Recorded the peak value and duplicated, calculated the mean value
Sokucu et al	Same as above	Same as above	Same as above	Same as above	Same as above	Measurements were duplicated and the mean values were calculated
Kaygisiz et al	Same as above	Model RH17R, Interscan, Chatsworth, CA	Not available	Breathe through nose for 3 min	Same as above	Repeated for 3 times and calculated the mean value
Nalcaci et al	Same as above	Interscan, Chatsword, CA	Normal (0–100 ppb), weak (101–150 ppb), strong (151–300 ppb), very strong (≥301 ppb)	Kept mouth closed for 1–2 min	Same as above	Peak value was recorded

Figure 2. Bias assessment of included studies.

Figure 3. Malodor score at various measurement intervals: experimental groups versus control groups at initial visit, 1 week, 1 month, and 2 to 3 months after bonding, outcome: 1.1 Malodor score. A: Random-effect model; B: Fixed-effect model.

malodor.[8] The present meta-analysis aimed to identify whether there is a relationship between fixed orthodontic appliances and malodor, and whether SLBs could prevent malodor better than CBs.

As shown in Fig. 3, malodor was more serious in the orthodontic group than the control group, although this difference was only significant at the first week and nearly significant at 2 to 3 months. Three of the included studies had observation periods not exceeding 3 months; consequently, we could not ascertain whether obvious malodor persisted after 3 months in orthodontic patients. Zurfluh et al[21] found significant differences in organoleptic measurements on the same subjects between the initial visit and at 3 months. Based on a 1-year observation, Sokucu et al[12] reported that oral malodor in orthodontic patients reached a peak after 7 months and stopped increasing during the ninth month of treatment.

The results of PI analysis revealed no significant difference between the 2 groups after the first week; however, the statistical advantage of the control group was observed at 1 month, and at 2 to 3 months (Fig. 4). As mentioned above, obvious differences in malodor appeared at 1 week, before plaque accumulation increased to a statistically significant level; thus, we suggest that plaque may not be the causative factor of malodor.

In addition, GI demonstrated a significant difference only after the first month, but not after the first week, or at 2 to 3 months, while periodontal pocket depths demonstrated no statistical difference over the measurement intervals. However, given the limited number of subjects involved in this meta-analysis, the relationship between malodor and periodontal condition needs to be confirmed in future, larger-scale research.

On the other hand, SLB systems were expected to better control oral hygiene conditions in orthodontic patients than CB systems because they avoid elastic or steel-wire ligation, thereby reducing retention sites for plaque accumulation.[17,18,22] However, some investigators have reported that this theoretical advantage may disappear in practice because the opening and closing mechanisms of SLBs provide hospitable retention sites for plaque.[13]

Despite the relationship between fixed orthodontic appliances and malodor, we also aimed to address whether SLBs could better control malodor in orthodontic patients compared with CBs. As revealed in Fig. 5, the prevalence of malodor was lower in the SLB group, although only significant at 1 week. In contrast, the results of PI and GI in the SLB group demonstrated a slight advantage over that of the CB group over the first month after bonding.

Because fixed orthodontic appliances led to obvious malodor at week 1, SLBs conquered the CB at the first week in the control of malodor. We suggest with weak evidence that SLB systems could be a consideration for orthodontic patients at high risk for malodor. Whether there is a long-term effect of SLBs needs to be confirmed in future research with longer observational periods.

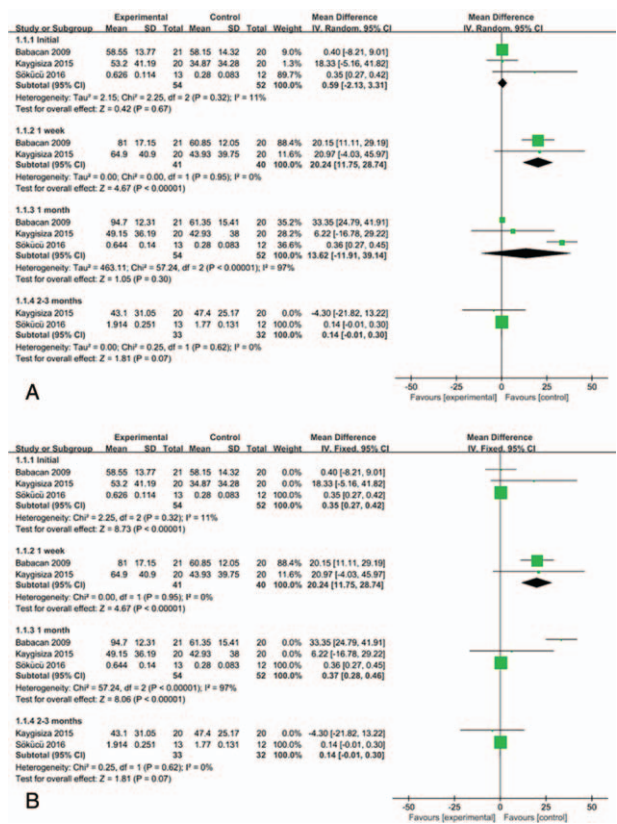**Figure 4.** Plaque index (PI) at various measurement intervals: experimental groups versus control groups at initial visit, 1 week, 1 month, and 2 to 3 months after bonding, outcome: 1.2 PI. A: Random-effect model; B: Fixed-effect model.

4.1. Limitations

Only 4 studies were included in this systematic review and meta-analysis, and the quality of these studies was relatively low. More research in this field is necessary to draw definitive conclusions

Figure 5. Malodor score at various measurement intervals: self-ligating bracket (SLB) groups versus conventional bracket (CB) groups at initial visit, 1 week, and 1 month after bonding, outcome: 2.1 Malodor score. A: Random-effect model; B: Fixed-effect model.

about the effect of orthodontic treatment or bracket types on malodor.

5. Conclusion

Fixed orthodontic therapy is a risk factor for malodor at 1 week after bonding, independent of the change in PI. SLB systems controlled malodor slightly better than CB systems, significantly at the first week after bonding and, thus, could be considered for orthodontic patients at high risk for malodor.

Author contributions

Cui-Ying Li and Jiu-Hui Jiang conceptualized and designed the project. Jing Huang, Cui-Ying Li, and Jiu-Hui Jiang, performed the literature screening, data extraction, bias evaluation, and analyzed the data. Jing Huang drafted the manuscript.
Conceptualization: Jing Huang.
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Formal analysis: Jing Huang, Cui-Ying Li, Jiu-Hui Jiang.
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Software: Jing Huang, Cui-Ying Li.
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Visualization: Jiu-Hui Jiang.
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Writing – review & editing: Jing Huang.

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