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Systematic Review

Vacuum-Formed Retainers Versus Lingual-Bonded Retainers: A Systematic Review and Meta-Analysis of Stability of Treatment Outcomes in Orthodontically Treated Patients

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Main Points

- A very low level of evidence suggests that both vacuum-formed retainers (VFRs) and lingual-bonded retainers (LBRs) are equally effective in maintaining treatment stability.
- A moderate level of evidence suggests that periodontal status was similar in both retainers.
- A moderate level of evidence suggests that there was no difference in the retainer failure rates of VFRs and LBRs.
- A moderate level of evidence suggests that VFRs were associated with speech difficulty, discomfort, and soreness in the lower arch than LBRs during baseline and 18 months follow-up time period, and they were better than LBRs in maintaining oral hygiene.

ABSTRACT

Objective: This review aimed at analyzing the literature comparing vacuum-formed retainers and lingual-bonded retainers for maintaining treatment stability and periodontal health and evaluating retainer failure and patient satisfaction.

Methods: Electronic databases such as PubMed, Cochrane Library, Ovid, Scopus, Web of Science, and Google Scholar were searched. Only randomized controlled trials were involved. Risk of bias was evaluated using Risk of Bias 2 Tool. Meta-analysis was performed and certainty of evidence was assessed with Grading of Recommendations Assessment, Development, and Evaluation approach.

Results: Five randomized controlled trials were included for qualitative analysis and 2 studies were included for quantitative analysis. Two studies concluded that lingual-bonded retainers were more effective than vacuum-formed retainers in maintaining treatment stability. Two studies had a high risk of bias and 3 studies had some concerns. No statistically significant difference in Little's Irregularity Index (standard mean difference = −0.10; *P* value = .61), inter-canine width (standard mean difference = 0.66; *P* value = .09), inter-molar width (standard mean difference = 0.08; *P* value = .85), arch length (standard mean difference = −0.18; *P* value = .60) between the 2 retainers was noted. Periodontal status and retainer failure rate (odds ratio= 2.28; *P* value = .23) were similar in both retainers. Patient discomfort, soreness, and speech difficulty were more with vacuum-formed retainers and oral hygiene maintenance was easier with vacuum-formed retainers.

Conclusion: A very low-level certainty of evidence suggests that both vacuum-formed retainers and lingual-bonded retainers were equally effective in maintaining treatment stability. Periodontal status and retainer failures were similar in both retainers. Vacuum-formed retainers were better for oral hygiene maintenance but were associated with discomfort, soreness, and speech difficulty than lingual-bonded retainers.

Keywords: Orthodontic retainer, periodontal, relapse, retention, stability, survival rate

INTRODUCTION

Orthodontic treatment is considered complete and successful as long as it is followed by an ideal retention protocol. The dentition is under the constant influence of mechanical forces from surrounding structures like tongue,

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cheeks, and lips. Furthermore, the microstructures around the teeth such as the periodontium and the alveolar bone also require adequate time to mature and adapt to their new position.[1] Until such time, it becomes crucial for the orthodontist to resort to means, which would facilitate holding the dentition passively in the newly moved position, just long enough for the surrounding dental tissues to readapt.

Retention appliances can be broadly classified into 2 categories, such as removable retainers (Hawley's retainer, Begg's wrap-around retainer, vacuum-formed retainers (VFRs), and tooth positioners) and fixed retainers (lingual-bonded retainers (LBRs)).[2] The choice of retention appliance used not only depends on the clinical requirement of the patient but also relies heavily on the patients' compliance.[3] Vacuum-formed retainers or thermoplastic retainers are popular among dentists, and patient's acceptance is more when compared with Hawley's appliance (HA) due to their superior aesthetics, comfort, and lesser incidences of breakage.[4,5] Several studies comparing the effectiveness of HA with VFRs have shown that VFRs are more effective in retaining treatment results.[3,5-9] As far as fixed retainers are concerned, LBRs are the most commonly preferred type of retainers by orthodontists and patients alike.[10] Multistrand braided coaxial wires are most often the preferred material of choice for LBR fabrication, which are bonded with the help of flowable unfilled composite.[11] The relatively smaller dimension of the wire makes it almost unnoticeable intraorally, favoring patient compliance. However, this is also the reason why most of the LBR failures go unnoticed, leading to relapse.[2]

Good periodontal health also plays a crucial role in maintaining the treatment outcomes of fixed orthodontic therapy. Microbial flora is considered to be one of the important causative factors of periodontal disease.[12] Several studies have shown that plaque accumulation is more around fixed retainers that serve as a reservoir for microbial flora predisposing the teeth to periodontal problems.[13-15]

Previous systematic reviews by Littlewood et al.[16], Al-Moghrabi et al.[17], Westerlund et al.[18] and Iliadi et al.[19] have compared removable and fixed retainers for treatment stability but were inconclusive owing to the lack of high-quality evidence. The present review specifically addresses the differences between VFRs and LBRs as there is no other previously published systematic review comparing these 2 retainers. Hence, the aim of this systematic review was to analyze the available literature on the comparison of orthodontic treatment stability, periodontal status, patient satisfaction, and failure rate of retainers between patients receiving VFRs and LBRs.

METHODS

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement. The review protocol was registered with the PROSPERO database (CRD42020215047).

The selection of articles for this systematic review was done based on the criteria mentioned in Table 1.

Search Strategy Employed for Study Identification

Detailed search strategies were developed and appropriately revised for each database, considering the differences in controlled vocabulary and syntax rules. The following electronic databases were searched individually by 3 authors (S.H., S.S., and R.K.J.): MEDLINE (via Ovid and PubMed, from 1946 to May 30, 2021), Google Scholar, the Cochrane Oral Health Group's Trials Register, SCOPUS, and Web of Science (Table 2).

Unpublished literature was searched on ClinicalTrials.gov, the National Research Register, and Pro-Quest Dissertation Abstracts and Thesis database. The search attempted to identify all relevant studies irrespective of language. The reference lists of all eligible studies were hand-searched for additional studies. Articles were screened for duplicates using EndNote Software (Version X9; Clarivate Analytics, Philadelphia, Pa, USA).

Eligibility and Screening of Retrieved Papers

A study was judged eligible when it included 2 treatment arms—retention using VFR and LBR and none of the exclusion criteria were fulfilled. After the removal of duplicates,

Table 1. Eligibility criteria for study selection

Category	Inclusion Criteria	Exclusion Criteria
Participants	Studies reporting on the subjects treated with retainers in maxillary/mandibular arch after fixed orthodontic treatment, irrespective of age, gender, and malocclusion	
Intervention	Vacuum-formed retainers, Essix retainers, pressure-formed retainers, thermoplastic retainers	Other removable retainers
Comparison	Fixed lingual retainer, lingual-bonded retainer	Other retainers or no comparison group
Outcomes	Primary outcome: treatment stability as assessed by parameters such as Little's Irregularity Index, arch width, and length changes Secondary outcome: periodontal status, the failure rate of retainers, and patient satisfaction	
Study design	Randomized clinical trials (RCTs)	Split-mouth RCTs Retrospective studies Case reports Comments, letters to the editor Narrative reviews Laboratory studies

Table 2. Search strategy table

Databases	Keywords/Mesh Terms	Total Count
PubMed	((((((((((orthodontic fixed lingual retainer) OR (orthodontic bonded retainer)) OR (lingual retainer)) AND (orthodontic vacuum formed retainer)) OR (orthodontic clear retainer)) OR (essix retainer)) OR (thermoplastic retainer)) AND (orthodontic stability)) OR (incisor crowding)) OR (post treatment stability)) AND (randomizedcontrolledtrial[Filter]))	1031
Ovid	(vacuum formed retainer OR essix retainer OR thermoplastic retainer) AND (bonded retainer OR lingual bonded retainer OR fixed lingual retainer).af.	78
Google Scholar	vacuum formed retainer AND thermoplastic retainer AND essix retainer AND bonded retainer AND fixed lingual retainer AND orthodontic stability AND orthodontic retention	139
Cochrane Library	(vacuum formed retainer):ti,ab,kw OR (clear retainer):ti,ab,kw OR (thermoplastic retainer):ti,ab,kw AND (orthodontic retainer):ti,ab,kw AND (bonded retainer):ti,ab,kw	62
SCOPUS	(vacuum formed retainer OR thermoplastic retainer OR essix retainer) AND (bonded retainer OR fixed lingual retainer) AND (orthodontic stability) AND (orthodontic retention)	65
Web of Science	((((((ALL=(vacuum formed retainer)) OR ALL=(thermoplastic retainer)) OR ALL=(essix retainer)) AND ALL=(lingual bonded retainer)) OR ALL=(fixed lingual retainer)) AND ALL=(orthodontic stability)) AND ALL=(orthodontic retention)	29

articles were screened on the basis of title and abstract. Full-text reading of the screened studies was carried out to finalize the included studies for the review. The sequential selection of studies for the review is represented in the PRISMA flow diagram (Figure 1).

Qualitative Assessment

The Cochrane Collaboration's Risk of Bias 2 tool was used for qualitative assessment in the following domains: randomization process, deviation from intended intervention, missing outcome data, measurement of the outcome, and selection of reported

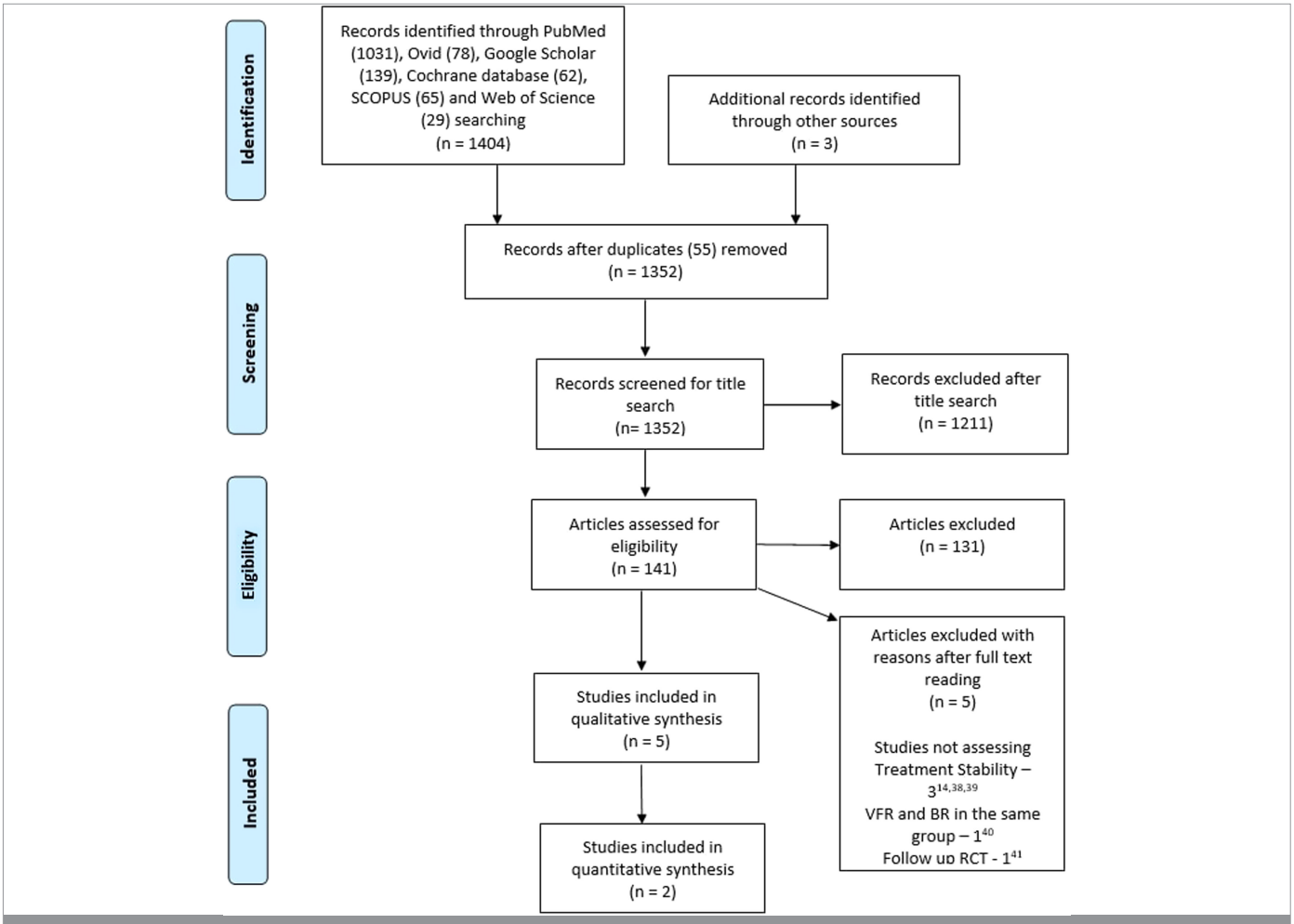

Figure 1. Preferred reporting items for systematic reviews and meta-analyses flow diagram of included studies

results. Risk of bias assessment was done individually by 3 authors (S.H., S.S., and R.K.J.). Disagreements were resolved by a joint discussion with the fourth author (A.B.). The authors of the included studies were contacted for clarification if required. Certainty of evidence was assessed using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach for their study design, risk of bias, inconsistency, indirectness, imprecision, and publication bias.[20]

Analysis of Data

A narrative description of the findings of all the included studies was provided, aiming at the stability of the treatment, periodontal status, patient perception, and failure rate of retainers. Meta-analysis of the primary outcome was performed using RevMan Web, and standard mean differences were computed. A subgroup analysis was performed for the outcome parameters evaluating the treatment stability (Little's Irregularity Index (LII), inter-canine width (ICW), inter-molar width (IMW), arch length (AL), overjet (OJ), and overbite (OB)). Similarly, meta-analysis for the secondary outcome (retainer failure) was performed using odds ratio. Publication bias analysis was also performed. Statistical heterogeneity was represented graphically by displaying estimated treatment effects from the included trials with 95% CIs. I^2 was used to quantify heterogeneity with values more than 50% indicating moderate to high heterogeneity. Fixed effects model was employed if the heterogeneity (I^2) $< 40\%$, and random effect model was employed if the heterogeneity (I^2) $> 40\%$.

RESULTS

Description of Included Studies

The sequential selection of studies for the review is represented in the PRISMA flow diagram (Figure 1). A total of 1404 records were identified after the preliminary search of 6 databases, and 3 records were obtained from the manual search. After removal of duplicates and application of inclusion and exclusion criteria, 10 articles were subjected to full-text reading and 5 were excluded with reasons[14,38-41] (Appendix 1). A total of 5 studies were included in this systematic review for qualitative analysis, and meta-analysis of the primary outcome and secondary outcome (retainer failure) was performed for 2 of the included studies (Figures 2 and 3). Two additional articles were included in this review for qualitative assessment since they were a continuation of the included studies.[21,22] The characteristics of participants, comparison groups, follow-up period, and the outcomes of the included studies are presented in Table 3.

A total of 396 participants were involved across the 5 selected studies, out of which 173 were males and 223 were females. All included studies had reported on changes in LII, AL, ICW, and IMW of either arch for treatment stability. Overjet and OB were evaluated in 3 of the 5 included studies,[24-27] whereas 1 study additionally evaluated extraction space opening.[23] Two of the 5 included studies reported on the plaque index (PI) and gingival index (GI),[22,25] whereas 1 study reported on calculus index (CI),[22] bleeding on probing (BOP), and pocket depth (PD).[25] Retainer failure was reported in 2 of the 5 studies.[24,27] Patient satisfaction was evaluated in 2 of the 5 included studies.[21,27] Three of the 5 included studies had evaluated the review outcomes only in the mandibular arch,[23-25] 1 study had evaluated the review outcomes in the maxillary arch,[26] and 1 study had evaluated in both maxillary and mandibular arches.[27] Different follow-up periods and retainer wear protocols were followed in each of the included studies, as depicted in Table 3. Measurements of treatment stability outcomes were performed using manual study cast and digital caliper in 1 study,[23] scanned digital model and different digital software in the rest of the studies.[24-27] Only 2 of the 5 included studies had reported about the inclusion of extraction as well as non-extraction cases, but the percentage of patients who underwent extraction was not reported by both the studies.[24,27] Three of the 5 studies[24-26] had excluded patients who underwent orthognathic surgery and 1 study had excluded patients who underwent maxillary expansion.[24]

Risk of Bias/Methodological Quality Assessment of Included Studies

Out of the 5 randomized controlled trials included for this review, 2 were deemed to have a high risk of bias,[23,27] whereas the 3 other studies were adjourned to have some concerns for the risk of bias assessment[24-26] (Figures 4 and 5).

None of the included studies reported blinding of operator and patient since it was not possible due to the nature of the intervention being delivered. Blinding of the outcome assessor was done only in 3 of the 5 included studies.[23,25,26] Intention to treat analysis was done in 3 out of the 5 included studies to address the missing outcome data.[24,26,27]

A high risk of bias was given for the trial by O'Rourke et al.[23] for the domain assessing bias due to deviation from intended intervention, whereas the other 4 trials had some concerns in this domain. Studies by Forde et al.[27] and Krämer et al.[24] had some concerns in the domain assessing the measurements of the outcomes as these 2 studies reported partial or no blinding of the outcome assessor. Studies by O'Rourke et al.[23], Forde et al.[27] and Alrawas et al.[25] presented some concerns in the domain assessing the selection of the reported studies as these studies were not pre-registered and there was no information indicating any deviation from the pre-specified plan.

TREATMENT STABILITY

The data for the treatment stability in 2 of the included studies were mentioned as median and interquartile range,[24,27] in 1 study, the same was mentioned in terms of the difference between the median and interquartile range between appointments,[23] and in the studies by Naraghi et al.[26] and Alrawas et al.[25] mean and standard deviations (SDs) were performed for assessing the outcome parameters.

Little's Irregularity Index

Two studies reported increased LII scores for VFRs which were statistically significant at the 6-month time interval in 1 study[23] and at 3 and 12 months in another study.[27] The other 3 studies, however, reported no statistically significant difference in LII scores

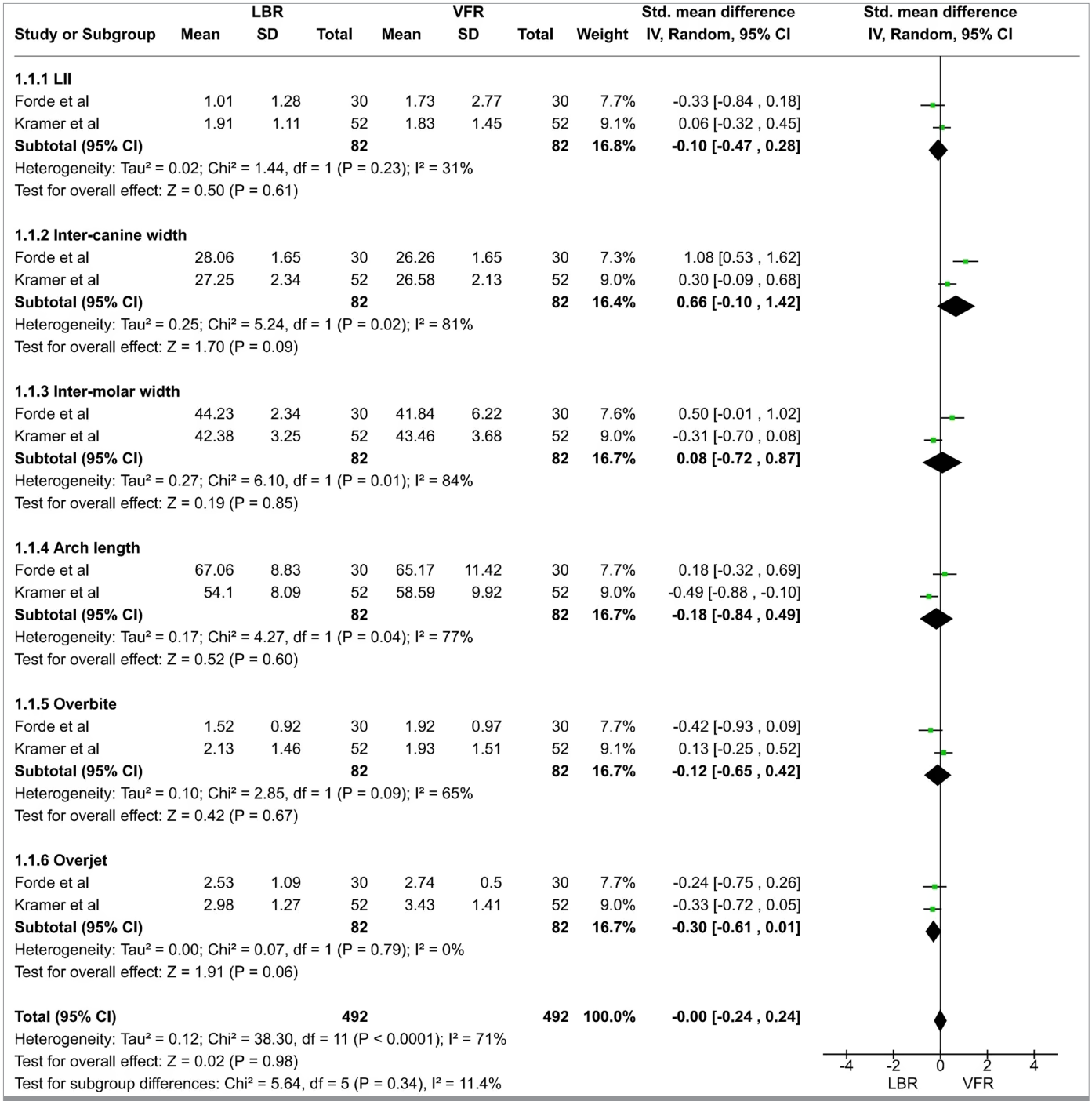

Figure 2. Meta-analysis of primary outcome parameters using the random-effects model

between 2 groups at the end of 3 months,[25] 6 months,[24,25,27] and 2 years.[26] Meta-analysis including the 2 studies[24,27] was done with a random-effects model. Low heterogeneity (I^2 = 31%) was noted. No statistically significant difference in the LII scores between the 2 retainers was noted (standard mean difference (SMD) = −0.10; *P* value = .61, 95% CI = −0.47 to 0.28) (Figure 2).

Inter-Canine and Inter-Molar Widths

Three out of 5 included studies reported that there was no statistically significant difference in ICW, and all 5 studies reported that there was no statistically significant difference in the IMW between VFRs and LBRs at any time interval, indicating adequate stability of retention in the transverse dimension with both retainers. One study showed a small but statistically significant increase of ICW in patients on VFRs.[26] Another study showed a statistically significant decrease in ICW for patients on multi-stranded stainless steel lingual retainers (MSLR).[25] Meta-analysis for ICW including the 2 studies[24,27] was done with a random-effects model. At 6th month, there was no statistically significant difference in ICW measurements between the 2 retainers (SMD = 0.66; *P* value = .09, 95% CI = −1.10 to 1.42). A high heterogeneity was observed for this parameter (I^2 = 81%) (Figure 2).

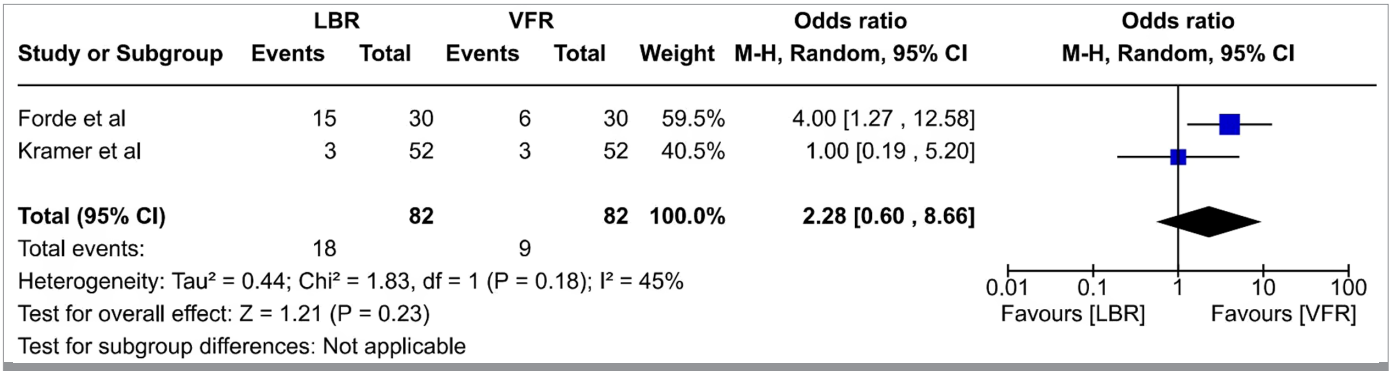

Figure 3. Meta-analysis of secondary outcome parameter (retainer failure) using odds ratio

Meta-analysis for IMW showed no statistically significant difference between the 2 retainers (SMD = 0.08; *P* value = .85, 95% CI = −0.72 to 0.87), with high heterogeneity (I^2 = 84%) which may be due to methodological differences in measuring the different parameters evaluated in the review (Figure 2).

Arch Length

Out of the 5 studies, 2 of them reported no statistically significant difference in AL between the 2 retainers.[23,26] Two studies reported an increase in AL with LBR retainers,[25,27] and 1 study reported AL reduction in both the retainers.[24] Meta-analysis involving 2 studies[24,27] revealed that there was no statistically significant difference between the 2 retainers (SMD = −0.18; *P* value = .60, 95% CI = −0.84 to 0.49) with a high heterogeneity (I^2 = 77%) (Figure 2).

Overjet and Overbite

Three out of the 5 studies had evaluated OJ and OB.[24,26,27] Two studies showed no statistically significant difference in the OJ and OB between the 2 retainers.[26,27] Only 1 study showed a small but statistically significant increase of OB in the VFR group, whereas the OJ also showed a small variation within 6-month period but was stable in the 18-month follow-up period.[24] Random-effects meta-analysis involving 2 studies[24,27] revealed that there was no significant difference in the OJ (SMD = 0.26; *P* value = .59, 95% CI = −0.71 to 1.24) and OB (SMD = −0.12; *P* value = .67, 95% CI = −0.65 to 0.42) between the 2 retainers (Figure 2).

Publication Bias

Analysis for publication bias revealed that the standard error for the ICW was high and was an outlier for 1 study. All the other primary outcome parameters also had a high standard error. Publication bias analysis for the secondary outcome parameter also revealed high standard error for retainer failure rate. Thus, publication bias was suspected (Figures 6 and 7).

Grading of Recommendations Assessment, Development, and Evaluation Assessment

The included studies revealed a very low level of certainty of evidence as assessed by the GRADE approach on the influence of retainer type for maintaining the overall stability of achieved treatment results (Table 4). On the assessment of individual outcome parameters evaluating the stability of achieved treatment results, the level of certainty of evidence for LII, AL, OJ, and OB was moderate. Inter-molar width had a low level of certainty of evidence, whereas ICW had a very low level of certainty of evidence. On the assessment of the secondary outcomes using GRADE approach, the level of certainty of evidence for periodontal status, retainer failures, and patient satisfaction was moderate.

Periodontal Status

Only 2 of the 5 included studies evaluated the periodontal status in patients receiving VFR and LBR.[22,25] Storey et al.[22] had assessed PI, GI, and CI in both groups. A statistically significant increase in the PI scores was observed in patients with LBRs at the third month evaluation when compared with the baseline evaluation. No statistically significant difference was observed in CI and GI between the 2 retainers. Alrawas et al.[25] had assessed PI, GI, BOP, and PD in CAD/CAM lingual retainer (CAD/CAM LR), MSLR, nickel-free titanium lingual retainer (SSLR), and VFR. Intergroup comparison of lower anterior teeth for periodontal health showed no statistically significant difference in PI, GI, BOP, and PD between all the 4 groups.

Retainer Failure

Two of the 5 studies had evaluated the failure rate of retainers.[24,27] One study showed a survival rate of 63.3% for LBRs and 73.3% for VFRs in maxillary arch, and 50% and 80% for LBRs and VFRs in the mandibular arch, respectively.[27] Another study showed a combined failure rate of just 5.8%, and there was no difference in retainer failure between the 2 groups.[24] Meta-analysis including the 2 studies[24,27] was done using OR. Moderate heterogeneity (I^2 = 45%) was noted. No statistically significant difference was noted in the retainer failure between the 2 retainers (OR = 2.28; *P* value = .23, 95% CI = 0.60 to 8.66) (Figure 3).

Patient Satisfaction

Two of the 5 included RCTs evaluated differences in patient satisfaction levels between the 2 retainers by using questionnaire surveys.[27] Perceived pain, discomfort, and speech difficulties were more in the patients with VFRs when compared to patients with LBRs (*P* value < .05).[27] Patients with VFRs reported soreness in mandibular arch when compared to patients with LBRs (*P* value < .05).[21] However, oral hygiene maintenance was easier in the patients with VFRs when compared to patients with LBRs.[27]

Table 3. Characteristics of selected studies

Study	Participants	Intervention/Comparison	Retention Protocol	Follow-Up Period	Outcomes and Parameters Assessed	Statistics Used	Result
O'Rouke et al.[23]	N = 82 (23 M, 59 F)	- VFR (n = 40, mean age: 16.95 ± 2.02 years) - 0.0175" stainless steel coaxial fixed retainer (n = 42, mean age: 18.47 ± 4.41 years)	-Full time wear: first 6 months -Night time wear: next 6 months - Alternate night time wear: next 6 months	T0: Debonding T1: 6 months T2: 12 months T3: 18 months	**Treatment Stability:** LII, ICW, IMW, AL, extraction space closure.	ICC, Mann–Whitney *U* test	LBR showed more stability than VFR at 6 months, which was statistically significant. No statistical significance at the end of 12 and 18 months.
Forde et al.[27] (Part I)	N = 60 (27 M, 33 F)	- VFR (n = 30) - 0.0195" 3-stranded twisted coaxial wire (n = 30)	-Night time wear	T0: Debonding T1: 3 months T2: 6 months T3: 12 months	**Treatment Stability:** LII, ICW, IMW, AL, OJ, OB. **Retainer survival:** Failure rate **Patient satisfaction:** Questionnaire survey	ICC, Mann–Whitney *U* test, Kaplan–Meier survival plot, log-rank test, and chi-square test	LBR showed more stability than VFR in mandibular labial segment at 12 months. LBR had more failure rate than VFR.
Storey et al.[22] (Part II)	N = 60 (27 M, 33 F)	- VFR (n = 30) - 0.0195" 3-stranded twisted coaxial wire (n = 30)	-Night time wear	T0: Debonding T1: 3 months T2: 6 months T3: 12 months	**Periodontal health outcomes:** GI, PI, CI	Shapiro–Wilk's test, *Q–Q* plots, Mann–Whitney *U* test, repeated-measure ANOVA, Bland–Altman plots, ICC	VFR group had statistically significant reduction in plaque and calculus accumulation when compared to LBR. Gingival inflammation decreased from baseline for both groups.
Krämer et al.[24] (Part I)	N = 104 (52 M, 52 F)	- Vacuum-formed Essix C retainers (n = 52) - 0.8" hard Remanium wire (n = 52)	-Full time wear: 7 days -Night only: 7 days to 12 months. -Every alternate night: 12-18 months -2 night per week: 18-24 months	T1: Debonding T2: 6 months T3: 18 months	**Retentive Capacity**: LII, ICW, IMW, AL, OJ, OB	Mann–Whitney *U* test, Wilcoxon signed-rank tests, Spearman's correlation coefficient test, chi-square test	VFR showed more changes in LII and OB compared to LBR. OJ, IMW, ICW were stable within both groups.
Krämer at al.[21] (Part II)	N = 104 (52 M, 52 F)	- Vacuum-formed Essix C retainers (n = 52) - 0.8" hard Remanium wire (n = 52)	-Full time wear: 7 days -Night only: 7 days to 12 months. -Every alternate night: 12-18 months -2 night per week: 18-24 months	T1: Debonding T2: 6 months T3: 18 months	**Patient Perception:** Questionnaire Survey	Mann–Whitney *U* test, Wilcoxon signed-rank tests, crosstabs and chi-square test, Spearman's correlation test	Patients were satisfied with the treatment outcome, quality of care, and attention.

(*Continued*)

Table 3. Characteristics of selected studies (Continued)

Study	Participants	Intervention/Comparison	Retention Protocol	Follow-Up Period	Outcomes and Parameters Assessed	Statistics Used	Result
Naraghi et al.[26]	N = 90 (54 M, 36 F)	- 0.0195" Penta-One Steel wire - Vacuum formed Essix retainer 1.5 mm	-22/24 hours wear: First 4 weeks -Night only: 12 months -Every alternate night: 1 year post debonding	T0: Pretreatment T1: Posttreatment T2: 2 years postretention	**Treatment Stability:** LII, ICW, IMW, AL, OJ, OB	Shapiro–Wilk's test, Levene's test, Kruskal–Wallis test, Dunn's test, chi-square test, Holm–Bonferroni correction.	No statistically significant difference in LII between groups. ICW showed a statistically significant increase in VFR group. No difference in IMW, OJ, OB, and AL.
Alrawas et al.[25]	N = 60 (17 M, 43 F)	- 0.012 × 0.018-in CAD/CAM NiTi lingual wire (Robofix) (n = 15) - 0.017-in multi-stranded stainless steel lingual wire (n = 15) - 0.027 × 0.011-in single strand Nickel-free Ti lingual wire (n = 15) - VFR 1 mm (Scheu-Dental) (n = 15)	-Full time wear for 6 months	T0: posttreatment T1: 3 months T2: 6 months	**Treatment Stability:** LII, ICW, IMW, anterior dental AL. **Periodontal Status:** PI, GI, BOP, PD.	Shapiro–Wilk's test, parametric hypothesis, one-way ANOVA, Tukey's HSD post hoc test, two-way RM ANOVA, Tukey's multiple comparison test, Cronbach's alpha coefficient	No statistically significant difference in LII and IMW between groups. ICW was decreased and AL was increased for MSLR group, which was statistically significant. No statistically significant difference in PDL status.

VFR, vacuum-formed retainer; LLI, Little's Irregularity Index; ICW, inter-canine width; IMW, inter-molar width; AL, arch length; ICC, intra-class correlation coefficient; OB, overbite; OJ, overjet; GI, gingival index; PI, plaque index; CI, calculus index; RM-ANOVA, repeated measures analysis of variance; BOP, bleeding on probing; PD, probing depth; HSD, honest significant test; MSLR, multi-stranded stainless steel lingual retainer.

DISCUSSION

The present systematic review was aimed to analyze the available literature and report on the comparison of treatment stability, periodontal status, retainer failure rate, and patients' satisfaction between subjects using VFRs and LBRs after completion of orthodontic treatment. Two out of the 5 included studies reported better stability of the corrected malocclusion with LBRs than VFRs, and the remaining studies showed no difference between the 2 types of retainers. Overall periodontal health was not affected by the type of retainer used. Data on patient satisfaction revealed that speech difficulties, discomfort, and soreness of the lower arch were more in patients using VFRs. Oral hygiene maintenance was better in patients with VFRs. Failure rate of retainers was more in patients with LBRs, but the quantitative analysis revealed no statistically significant difference between the 2 groups. Risk of bias assessment revealed that 2 of the 5 included studies had a high risk of bias, whereas the other 3 studies had some concerns about the risk of bias. Quantitative analysis for treatment stability involving the 2 included studies revealed no significant difference between the 2 retainers evaluated. A very low-grade certainty of evidence suggesting no difference in treatment stability between the 2 retainers was revealed by the GRADE approach. Random-effects meta-analysis involving 2 studies was done, and SMDs were computed because different methods of measuring the outcome parameters were used in the included studies. Odds ratio was used for quantitative assessment of the secondary outcome (retainer failure).

The available systematic reviews on retainers are an aggregation of prospective cohort studies, retrospective studies, RCTs, and non-RCTs comparing removable with fixed retainers.[16-19] Littlewood et al.[29] in their systematic review had compared the amount of relapse, adverse effects on oral health, retainer survival, and patient satisfaction between Hawleys retainers, bonded retainers, and clear overlay retainers but were unable to provide a definitive conclusion due to insufficient evidence.[29] Westerlund[18] in their systematic review compared removable and fixed retainers for treatment stability, periodontal, and dental outcomes and reported that fixed retainers provided better treatment stability with low certainty of evidence. The Cochrane review by Littlewood et al.[16] reported comprehensively on different types of retainers and had also revealed differences between removable and fixed retainers. However, they too remained inconclusive due to the lack of high-quality RCTs. Al-Moghrabi et al.[17] did not evaluate treatment stability in their systematic review. Instead, they reported on periodontal outcomes, survival and failure rates, patient-reported outcomes, and cost-effectiveness, and they were unable to perform a meta-analysis due to high heterogeneity among the included studies.[17] Bahije et al.[28] in their study had evaluated the effectiveness of treatment stability between removable and fixed retention appliances and reported better stability of incisal alignment with fixed retention than removable retention, but low-quality studies limit the findings of this systematic review.

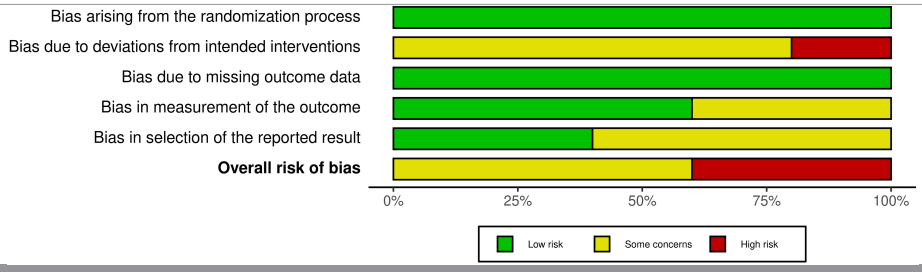

Figure 4. Risk of bias graph

The present review includes only RCTs specifically comparing VFRs and LBRs and is updated with 3 new RCTs that were not included by any previously conducted systematic reviews.[24-26] Both VFRs and LBRs are commonly used in practice even though they are indicated for specific retention requirements. A recent systematic review by Giudice et al.[30] compared removable and fixed retention appliances and came to a conclusion that fixed retention appliances provided better stability than removable retention appliances. On the contrary, the present review focused on comparing only VFRs and LBRs and the findings revealed no statistically significant difference between the 2 retainers. Inconsistencies of the findings could be attributed to the differences in the objectives and in the inclusion criteria of the 2 systematic reviews.

Treatment stability was assessed in all the included studies with the following parameters: LII, ICW, IMW, AL, OJ, and OB. Little's Irregularity Index scores increased in patients on VFRs as reported in 2 of the 5 included studies,[23,27] but when subjected to meta-analysis, there was no statistical significance (*P* value > .05). Naraghi et al.[26] reported an increase in the ICW of VFR group, which was attributed to poor adherence to VFR wear.[26] Alrawas et al.[25] reported a decrease in the ICW of the LBR group, which was attributed to width increase during treatment, leading to relapse. O'Rourke et al.[23] reported an increase in IMW of the LBR group which was due to the insufficient extent of LBRs, leading to relapse. However, when subjected to meta-analysis, no statistically significant ICW and IMW changes between the 2 retainers (*P* value > 0.001) were noted. Forde et al.[27] reported that mandibular AL had increased in patients with LBRs suggesting relapse, which was due to retainer failure. Krämer et al.[24] in their study had reported a decrease in the AL in both groups at 6 and 18 months but had not reported on intergroup comparison.[24] Alrawas et al.[25] reported an increase in the AL of the MSLR group.[25] The quantitative analysis of changes in AL, OJ, and OB revealed no statistically significant difference among patients receiving the 2 types of retainers (*P* value > .05).

The study by Krämer et al.[24] concluded that subjects using VFRs perceived more pain, discomfort, and speech difficulties in the mandibular arch than subjects using LBRs. Jäderberg et al.[31] had reported a similar finding in which the main complaint of the patients wearing VFR was soreness and speech difficulties. Incidentally, there was also an association between the wear time and pain experienced by patients in the VFR group. Oral hygiene maintenance was found to be easier in patients using VFRs. Sawhney[32] has also reported this finding in his study where patients found maintaining oral hygiene difficult with LBRs.

Periodontal status as assessed in this review was reported in studies by Storey et al.[22] and Alrawas et al.[25] Storey et al.[22] found better PI scores in patients receiving VFR than LBR, but no adverse periodontal effects were evident in both retainers.[22] Alrawas et al.[25] reported that there was no statistically significant intergroup difference for PI, GI, BOP, and PD scores. The findings of the present review for periodontal status are in consensus with the review by Arn et al.[33] in which they compared the effects of fixed retainers on the periodontal status and concluded that fixed retainers do not have any severe effect on the periodontium. Rody et al.[34] in his study had reported an increased incidence of plaque accumulation in fixed retainers than removable retainers. A retrospective study by Booth et al.[35] found a statistically significant increase in

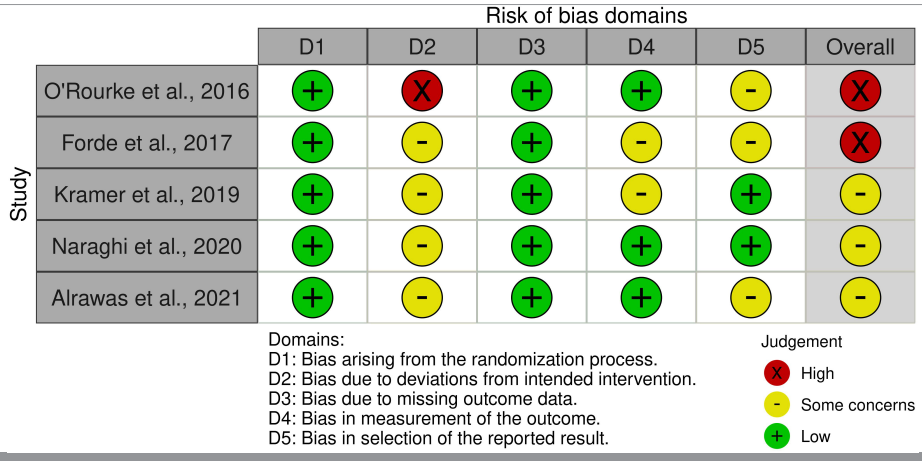

Figure 5. Risk of bias summary

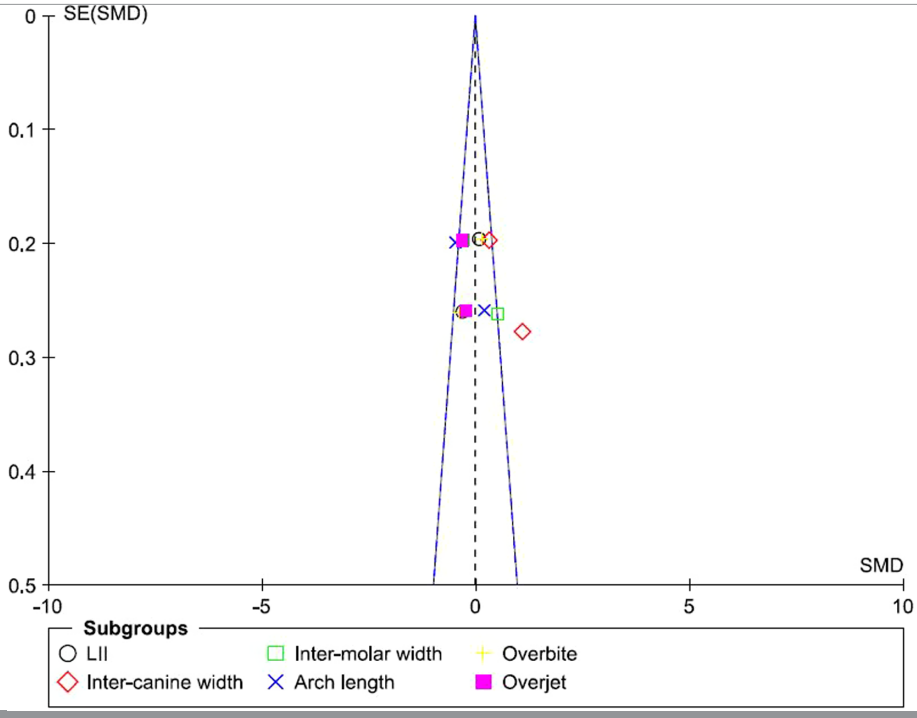

Figure 6. Funnel plot for publication bias assessment of treatment stability

PI scores near the inter-canine region of LBR as opposed to the VFR group.

Krämer et al.[24] reported that there was no difference between LBRs and VFRs in the retainer failure rate. Forde et al.[27] reported that retainer failure was more in the LBR group in the maxillary and mandibular arch than VFRs. However, the quantitative analysis revealed no difference in the retainer failure rate between VFRs and LBRs in the mandibular arch (*P* value > .05). Lingual-bonded retainers may be associated with failures because of operator experience as reported by a retrospective study conducted by Scheibe and Ruf.[36] Lingual-bonded retainer failures in the maxillary arch can be due to shearing forces as suggested by Dahl et al.[37] Krämer et al.[21] had a lower failure rate than the study by Forde et al.[27] in spite of following a night time wear-only protocol.

One of the limitations of this systematic review is the lack of sufficient number of high-quality studies. Differences in retainer dimensions and fabrication, arches involved, retainer wear protocols, outcome measurement methods, follow-up periods, and presence of inherent bias within the studies limits the scope of this review. Further high-quality trials following strict protocols

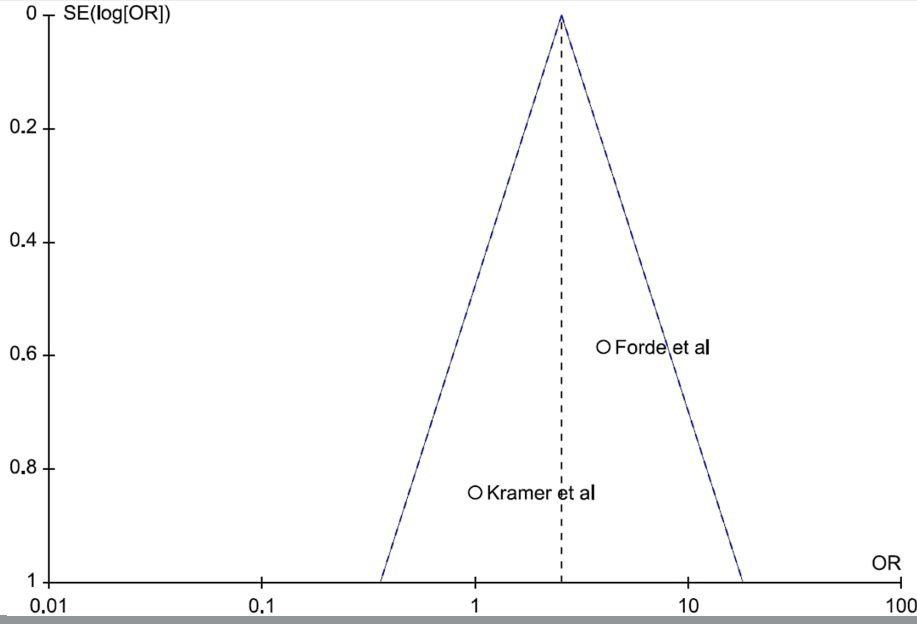

Figure 7. Funnel plot for publication bias assessment of retainer failure rate

Table 4. GRADE assessment for the level of certainty of evidence for the primary and secondary outcome parameters

Primary Outcome:

Comparison of Stability of Treatment Outcomes

Certainty Assessment							No. of Patients		Effect			
No. of Studies	Study Design	Risk of Bias	Inconsistency	Indirectness	Imprecision	Other Considerations	BR	VFR	Relative (95% CI)	Absolute (95% CI)	Certainty	Importance
Comparison of stability—Little's Irregularity Index												
2	Randomized trials	Serious[a]	Not serious	Not serious	Not serious	None	82	82	-	SMD **0.08 lower** (0.39 lower to 0.23 higher)	⨁⨁⨁◯ Moderate	CRITICAL
Comparison of stability—inter-canine width												
2	Randomized trials	Serious[a]	Serious[c]	Not serious	Not serious	Publication bias is strongly suspected	82	82	-	SMD **0.56 higher** (0.24 higher to 0.87 higher)	⨁◯◯◯ Very low	CRITICAL
Comparison of stability—inter-molar width												
2	Randomized trials	Serious[a]	Serious[c]	Not serious	Not serious	None	82	82	-	SMD **0.02 lower** (0.33 lower to 0.29 higher)	⨁⨁◯◯ Low	CRITICAL
Comparison of stability—arch length												
2	Randomized trials	Serious[a]	Not serious	Not serious	Not serious	None	82	82	-	SMD **0.24 lower** (0.55 lower to 0.07 higher)	⨁⨁⨁◯ Moderate	CRITICAL
Comparison of stability—overbite												
2	Randomized trials	Serious[a]	Not serious	Not serious	Not serious	None	82	82	-	SMD **0.07 lower** (0.37 lower to 0.24 higher)	⨁⨁⨁◯ Moderate	CRITICAL
Comparison of stability—overjet												
2	Randomized trials	Serious[a]	Not serious	Not serious	Not serious	None	82	82	-	SMD **0.3 lower** (0.61 lower to 0.01 higher)	⨁⨁⨁◯ Moderate	CRITICAL
Comparison of stability—total												
12	Randomized trials	Serious[a]	Serious[c]	Not serious	Not serious	Publication bias strongly suspected[b]	492	492	-	SMD **0.03 lower** (0.15 lower to 0.1 higher)	⨁◯◯◯ Very low	CRITICAL

SMD, standardized mean difference.

[a]Forde et al had some concerns for bias in 3 domains and Krämer et al. had some concerns for bias in 2 domains.

[b]Standard error was high and also Forde et al. was an outlier.

[c]Inconsistency in CI.

Table 4. GRADE assessment for the level of certainty of evidence for the primary and secondary outcome parameters (Continued)

Secondary Outcome:

Periodontal Status (Assessed with Plaque Index, Gingival Index, Calculus Index, Bleeding on Probing, Periodontal Pocket Depth)

Certainty Assessment							Impact	Certainty	Importance
No. of Studies	**Study Design**	**Risk of Bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other Considerations**			
2	Randomized trials	Serious[a]	Serious[b]	Not serious	Not serious[c]	All plausible residual confounding would reduce the demonstrated effect	There is an increase in the plaque index score in LBR compared to VFR at third month of assessment. No difference in gingival and calculus indices, bleeding on probing, and periodontal pocket depth	⨁⨁⨁◯ Moderate	NOT IMPORTANT

VFR, vacuum-formed retainer; LBR, lingual-bonded retainer.
[a]Storey et al. had some concerns for bias in 3 domains and Alrawas et al. has some concerns for bias in 2 domains.
[b]Inconsistency in reporting the measurements.

Table 4. GRADE assessment for the level of certainty of evidence for the primary and secondary outcome parameters (Continued)

Retainer Failure

Certainty Assessment							No. of Patients		Effect		Certainty	Importance
No. of Studies	**Study Design**	**Risk of Bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other Considerations**	**LBR**	**VFR**	**Relative (95% CI)**	**Absolute (95% CI)**		
2	Randomized trials	Serious[a]	Not serious	Not serious	Not serious	Publication bias strongly suspected all plausible residual confounding would reduce the demonstrated effect[b]	18/82 (22.0%)	9/82 (11.0%)	**OR** 2.28 (0.60 to 8.66)	**110 more per 1000** (from 41 fewer to 407 more)	⨁⨁⨁◯ Moderate	IMPORTANT

OR, odds ratio; VFR, vacuum-formed retainer; LBR, lingual-bonded retainer.
[a]Forde et al. had some concerns for bias in 3 domains and Krämer et al. had some concerns for bias in 2 domains.
[b]High standard error (log(OR)).

Table 4. GRADE assessment for the level of certainty of evidence for the primary and secondary outcome parameters (Continued)

Patient Satisfaction (Follow-Up: 12 Months; Assessed with Validated Questionnaire)

Certainty Assessment							Impact	Certainty	Importance
No. of Studies	**Study Design**	**Risk of Bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other Considerations**			
2	Randomized trials	Serious[a]	Serious[b]	Not serious	Not serious	All plausible residual confounding would suggest spurious effect, while no effect was observed	Pain, discomfort, and speech difficulties were more for VFR compared to LBR. However, oral hygiene maintenance was easier in VFR.	⨁⨁⨁◯ Moderate	NOT IMPORTANT

VFR, vacuum-formed retainer; LBR, lingual-bonded retainer.
[a]Forde et al had some concerns for bias in 3 domains, Krämer et al. has some concerns for bias in 2 domains.
[b]Inconsistency in measurement scale and domains to assess patient satisfaction.

and standard methodologies are required to evaluate the periodontal status and retainer survival rate of VFRs and LBRs as it could help establish its efficiency for long-term usage.

CONCLUSION

Within the limitations of this systematic review, very low certainty of evidence suggests that there is no difference in treatment stability following the use of either VFRs or LBRs after completion of orthodontic treatment. A moderate level of certainty of evidence suggests that there is no difference in periodontal status and retainer failure rate in patients receiving either of the 2 retainers. Also, VFRs are associated with more discomfort and soreness when compared with LBRs and oral hygiene maintenance was better in subjects receiving VFRs.

Both VFRs and LBRs are equally effective in maintaining treatment results and the choice of retainer depends on either operator preference or the patient's choice. Research implications include conducting well-planned, standardized, and long-term studies in the near future that will aid the clinician in making a more evidence-based decision on the choice of retainer.

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Appendix 1. Studies Excluded with Reasons (n = 5)

Reasons for Exclusion	Number of Studies
Studies not assessing treatment stability	3[14,38,39]
VFR and LBR in the same group	1[40]
Follow-up RCT	1[41]

RCT, randomized controlled trial; VFR, vacuum-formed retainer; LBR, lingual-bonded retainer.