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A Systematic Review of Efficiency of Retention and Periodontal Effects of the Lingual Bonded Retainers

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Abstract

Introduction: The fixed lingual bonded retainers have gained preference over removable retainers because they are more aesthetic, comfortable, convenient and free of patient compliance, but their periodontal effects, the incidences of breakages and failure to maintain incisor alignment are the some concerns. Therefore, this study aims to systematically evaluate the efficiency of retention and periodontal effects of lingual bonded retainers in orthodontically treated patients. **Materials and Methods:** The PRISMA guidelines were followed. The databases of Cochrane Library, PubMed and Google Scholar were systematically searched. All human, original research studies in English evaluating the fixed lingual bonded retainers, in orthodontically treated patients, in single group or in comparison with different fixed lingual bonded retainers, with or without control were included. All articles were subjected to assessment of risk of bias. **Results:** A total of 17 studies were selected meeting the inclusion criteria. These were divided into two Group 1 - addressing the periodontal status; Group 2 - addressing the lower incisor stability. The 7 selected studies for group 1, reported that periodontal effects like gingival inflammation, plaque and calculus accumulation are associated with all kinds of lingual bonded retainers, but more in multistranded retainer. The lower incisor stability and alignment during retention phase was shown to be very efficient with multistranded retainers compared to others, in the 14 selected studies for group 2. From the 17 selected studies, 8 studies had a high risk of bias, 5 studies had a medium of bias and 4 studies had a low risk of bias. **Conclusion:** Even though newer types of retainers are being introduced to improve the survival rate, the multistranded retainers still prove to be a good choice with respect to maintenance of incisor alignment.

Keywords: Lingual Bonded Retainer, Lower Incisor Stability, Periodontal Effects

1. Introduction

Following the soldered lingual retainers, used for post-orthodontic retention in the lower anterior segment, Dr. Knierim (1973) described the more aesthetic, direct bonding technique for lingual retainers[1]. The first generation of lingual bonded retainers, made of 0.8/0.9mm blue elgiloy, was introduced by Dr. Björn Zachrisson in 1977[2]. The second generation consisted of 0.032" multistranded wire for better retention[3]. In the third generation, 0.032" stainless steel or 0.030" gold-coated plain wire with sandblasted ends were used[4]. The fourth generation comprised of 0.0215" 5-stranded wires, and the fifth generation was of 0.032", blue elgiloy plain wires[5]. Only the 2nd and 4th generation retainers, with thinner wires, were bonded to all anterior teeth and the

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rest, with thicker wires, were bonded only to the canines and some means of increasing retention was employed.

The customized lingual bonded retainers found in the literature include, plain round wire[6,7,8] rectangular stainless steel[9] multistranded[6,10,11,12] or braided[13,14] or twisted[8] or flexible spiral wire[15,16] or Twistflex[17,18] retainer of different diameters, Glass fiber reinforced (GFR)[10,12] or polyethylene woven ribbon[16] retainer of different types, Australian wire V-loop[11] β-titanium (Titanium-Molybdenum-Alloy)[14] Nickel-Titanium[19] and titanium single stranded retainers[20]. Prefabricated canine-to-canine[21] or manufactured braided[7] lingual bonded retainers are also available. Recently, CAD-CAM (computer-aided design and computer-aided manufacturing) retainers like, the Sure Smile[22] retainer, and the Memotain[23] retainer, made of Nickel-Titanium wires are gaining popularity.

The fixed lingual bonded retainers have gained preference over removable retainers because they are more aesthetic, comfortable, convenient and free of patient compliance. But, their periodontal effects, the incidences of breakages and failure to maintain incisor alignment are the success-determining concerns. There are innumerable research articles covering this topic. Consolidated evidence assessing the effects of lingual bonded retainers is essential for the Orthodontist to successfully retain their treatment and avoid detrimental periodontal complications.

Therefore, this study aims to systematically evaluate the periodontal status and efficiency of retention of the lingual bonded retainers in orthodontically treated patients.

2. Materials and Methods

2.1 Protocol

This review was performed in compliance with the PRISMA guidelines for systematic reviews.

2.2 Eligibility Criteria

The study was aimed at systematically evaluating the efficiency of retention and periodontal effects of the lingual bonded retainers in orthodontically treated patients. The Population, Intervention, Comparison, and Outcome (PICO) format was used to formulate the question as follows:

Population/Patients: Orthodontically treated human population.

Intervention: Lingual bonder retainer on lower anteriors.

Comparison: Within different types of lingual bonded retainer, with or without control.

Outcome: Periodontal status and efficacy of retention.

Original research studies, published in English, conducted on humans, evaluating the mandibular lingual bonded retainer in a single group or in comparison with other fixed retainers, with or without control were considered. Case reports, literature or systematic reviews, comments, editorials, pearls, clinical tips, unpublished dissertations and thesis were excluded. Studies evaluating removable retainers, bonding material and bonding procedure were excluded. Articles with unavailable text or in languages other than English were also excluded.

2.3 Information Sources and Search

Specific keywords were searched (Table 1) in the different databases. Searches were first conducted for the Cochrane library, followed by PubMed and lastly, for Google Scholar (Figure 1). All the results on the first two databases were evaluated. While searching on Google Scholar, a huge database, only the first 10 result pages were screened, as it was manually impossible to screen the vast number of results obtained. The duplicates from Cochrane Library and PubMed were immediately excluded upon identification in Google Scholar and only a limited number of articles were subjected for in-depth assessment.

Table 1. Search dates and strategies

Databases searched (from 1989 to 2020)	Search strategy
Cochrane Library PubMed/MEDLINE Google Scholar	'lingual bonded retainer' or 'long term lingual bonded retainer' or 'stability of lingual bonded retainer'

2.4 Study Selection

The selection of studies was performed by a single reviewer. After screening the titles, the abstracts of the relevant titles were then evaluated. Once the abstracts were selected, their full texts were obtained to screen for eligibility.

2.5 Data Items and Collection

For periodontal evaluation, parameters like bleeding on probing, gingival index, plaque index and calculus index were collected. Lower incisor stability was assessed by collecting parameters like, Little's irregularity index, intercanine width, survival rate, success rate, and failure rate, detachment rate, bonding failure, breakage rate and fractures for efficacy of the lingual bonded retainer.

2.6 Risk of Bias in Individual Studies

The studies were labelled high, medium or low risk based on the score obtained in accordance with the methodological quality scoring system[24] (Table 2). Scores assigned for each of the criteria (0-not met, 0.5-partially met, 1-met) were added to give a total score for each study. The studies that had randomization and recorded intra-rater and inter-rater reliability were considered as low risk. High risk studies were those which did not include either inter-rater reliability or randomization. Rest of the studies was denoted as medium for risk of bias.

Table 2. Methodological quality scoring system[24]

1. Objective clearly formulated[√]
2. Appropriate sample size estimation[√]
3. Similar baseline characteristics[√]
4. Co-interventions[√]
5. Random sampling [√] and allocation[√]
6. Objective oriented measurement method[√]
7. Blinding[examiner √, statistician √]
8. Intra[√] and Inter-rate reliability[√]
9. Appropriate statistical analysis—for data[√]
10. Subgroup analysis[√]
11. Confounders[co-interventions]—confounders included in analysis[√]
12. Statistical significance level—*P* value stated[√]; confidence intervals[√]
13. Clinical significance[√]
Maximum number of √s = 17

2.7 Data Extraction and Data Synthesis

The data extracted for every study included: the author, year and month of publication, study type, quality of study, statistical analysis, duration of retention, mean age, sample size, number of groups formed, types of retainers used, parameters evaluated and the conclusion of the authors.

3. Results

3.1 Study Selection

A total of 17 articles (Figure 1 & 2) were finally selected after assessing the titles, abstracts and complete texts with respect to the inclusion and exclusion criteria. They were divided into two groups:

1. Group 1: Periodontal status - This includes studies evaluating periodontal effects of the lingual bonded retainer.
2. Group 2: Lower Incisor stability - This includes the studies evaluating the efficacy of the lingual bonded retainer with respect to maintenance of lower incisor alignment.

From the 17 selected studies, 4 studies belong to both the groups. Thus, group 1 and 2, have 7 and 14 studies respectively.

3.2 Study Characteristics

Group 1: Periodontal status (Table 3)

Stormann *et al.*[21] and Tacken *et al.*[10] showed no difference between plaque accumulations in different retainer types whereas, Al Nimri *et al.*[6] reported greater plaque retention in multistranded retainer group. Pandis *et al.*[13] reported no statistical difference in plaque accumulation with long term or short term retention. Gingival changes were found to be significant by Tacken *et al.*[10] with more gingival inflammation in Glass Fiber Reinforced (GFR) group and rest of the studies found insignificant results. Ferreira *et al.* found that the conventional retainers, bonded only to canines, had less periodontal effects. Juloski *et al.*[25] proved that lingual bonded retainers result in more calculus accumulation than control group without retainers.

Group 2: Lower incisor stability (Table 4)

Liesamfoek *et al.*[9], Lee *et al.*[11], Tacken *et al.*[10], AlNimri *et al.*[6], Renkema *et al.*[15], Bolla *et al.*[12], Salehi *et al.*[16], Fransson *et al.*[17], Maddalone *et al.*[8] and Kocher *et al.*[14] have all reported breakages and bond failures, but reasonable alignment could still be maintained. Stormann *et al.*[21] reported that the conventional canine-only retainer showed greater

Table 3. Summary characteristics of Group 1: Periodontal status

Study (according to year of publication)	Study duration (Y-years/ M-months)	Mean Age (years)	Sample size	Number of groups	Types of retainer used	Para-meters evalu-ated	Conclusion
1. Stormann *et al.*[21] (2001)	2 Y	13-17	103	3 based on types of retainers	2 Customized types (0.0195" & 0.0215") and 1 pre-fabricated canine-to-canine retainer.	-Bleeding on probing, -Plaque Index	Plaque accumulation similar for all.
2. Pandis *et al.*[13] (2007)	9.65 Y (Group 1) 3-6 M (Group 2)	25	64	2 (Long-term, Short term)	Braided 0.0195"	-Plaque Index, -Gingival Index	Statistically insignificant differences.
3. Tacken *et al.*[10] (2009)	2 Y	14	274	4 (3 retainer types and control)	GFR500, GFR1000, Multistranded retainer.	-Modi-fied gingival Index, -Bleeding on probing, -Plaque Index	More gingival inflammation in GFR. Same plaque levels for all.
4. Al Nimri *et al.*[6] (2009)	1 Y	20.23 Y and 19.97Y	62	2	Round wire retainer, Multistranded retainer	-Oral Hygiene Index, -Plaque Index, -Gingival Index	Multistranded retainer- More plaque retention
5. Juloski *et al.*[25] (2017)	5 Y	12.78 ±1.36 to21.18 ± 0.46	144	3 (With retainer, without retainer, untreated control)	Fixed lingual retainer (type unspecified)	-Gingival recession -calculus accumulation	Calculus accumulation increased in retainer group
6. Maddalone *et al.*[8] (2017)	12 Y	Not mentioned	50	1	Twisted multistranded stainless steel canine to canine retainer	-Gingival Index	No change in gingival Index
7. Ferreira *et al.*[7] (2019)	6 M	18-25	15	2	Conventional 3 × 3 plain retainer (0.8mm), Manufactured braided retainer (0.2 x 0.7-mm)	-Gingival Index -Dental plaque Index -Dental calculus Index	Conventional retainer showed better periodontal indexes than braided retainer

GFR- Glass fiber reinforced retainer

relapse. The multistranded retainer showed successful maintenance of incisor alignment in spite of a number of breakages[6,8,15,17,21,25]. The Glass fiber reinforced retainers were found to have inferior survival with respect to the multistranded retainers by Tacken *et al.*[10] and Salehi *et al.*[16] but Bolla *et al.*[12] reported otherwise. Lee *et al.*[11] concluded that the survival of V-loop retainer was inferior to multistranded retainer. According to Kocher *et al.*[14] and Arash *et al.*[20] the Titanium-Molybdenum-Alloy retainer[14] and Titanium single stranded retainer[20] respectively, had superior survival compared to multistranded retainer. Arash *et al.*[20] also reported that the Titanium retainer had clinical effects similar to multistranded retainer. The prefabricated retainer showed higher relapse[21]. Sadowsky

Table 4. Summary characteristics of Group 2: Lower Incisor stability

Study (according to year of publication)	Study dura-tion (Y-years/ M-month)	Mean Age (years)	Sample size	No. of groups	Types of retainer used	Para-meters evaluated	Conclusion
1. Sadowsky *et al.*[26] (1994)	8.4 Y	10.9	22	1	Mandibular fixed lingual retainer (Type unspecified)	-Irregularity Index -Intercanine, width	Incisor irregularity increased slightly postretention, intermolar width, displayed long-term stability.
2. Stormann *et al.*[21] (2001)	2 Y	13-17	103	3	Customized 0.0195" & 0.0215", 1 pre-fabricated canine-to-canine retainer.	-Irregularity Index -Intercanine distance	Canine-to-canine retainer had highest relapse, less with 0.0215", no relapse with 0.0195"
3. Liesamfoek *et al.*[9] (2008)	42 M	14.8-Females, 15.3-Males	277	1	Flexible, Braided, rectangular bonded stainless-steel lingual retainers	-Failure rate-debonding, fractures	Survival rate was 68.4%
4. Lee *et al.*[11] (2009)	6 M	Mode- 15 and 14 years for the 2 groups	300	2	0.0175 multistranded stainless steel retainer, 0.016 Australian wire V-loop retainer	-Detachment rate	Detachment rates were higher in V-loop retainer but statistically insignificant
5. Tacken *et al.*[10] (2009)	2 Y	14	274	4 (3 retainer types and control)	GFR500, GFR1000, Multistranded retainer.	-Success rate (intact for 2 years= success)	GFR- higher failure rate compared to Multistranded retainer.
6. AlNimri *et al.*[6] (2009)	1 Y	20.23 and 19.97	62	2	Round wire retainer, Multistranded retainer	-Irregularity Index, -Number of breakages	Multistranded retainer- better at maintaining tooth alignment
7. Renkema *et al.*[15] (2011)	5 Y	16.3- end of treatment	221	1	Flexible spiral wire (FSW) canine-to-canine lingual retainer	-Irregularity Index -Intercanine distance -Failure rate	Very effective in maintaining the alignment of the mandibular anterior region
8. Bolla *et al.*[12] (2012)	6 Y	Males- 24.1, females- 22.6 years	85	2 (based on types of retainer)	GFR and .0175" multistranded (MST) stainless steel retainer	-Detachment rate -Breakage rate	Detachment and breakages were higher in MST but statistically insignificant.

9. Salehi *et al.*[16] (2013)	18 M	14-28	142	2	Polyethylene Woven ribbon retainer, 0.0175-in flexible spiral wire retainer	-Failure rate -Survival rate	Polyethylene woven ribbon retainer has higher failure and lower survival rate but statistically insignificant
10. Fransson *et al.*[17] (2016)	9.3 Y	12.5- 22.4	64	2	Canine-to-canine retainer, Bonded Twistflex retainer	-Irregularity Index -Bond failures	Both equally efficient
11. Maddalone *et al.*[8] (2017)	12 Y	Not mentioned	50	1	Twisted mutistranded stainless steel canine-to-canine retainer	-Loss of retainer -Breakage of retainer	Incisor alignment maintained
12. Fransson *et al.*[18] (2018)	6-12 Y	12.9-27	105	2 (with retainer and un-treated)	Canine-to-canine retainer or Bonded Twistflex retainer	-Irregularity Index	Retention for 2-3 years gave suboptimal incisor stability
13. Kocher *et al.*[14] (2019)	10-15 Y	27.8	88	2	0.016" × 0.022" braided stainless steel retainers, 0.027" β-titanium (TMA) canine-only retainers	-Failure rate	TMA (Titanium molybdenum alloy) retainers had higher survival percentage than braided retainers
14. Arash *et al.*[20] (2020)	2 Y	20 ± 4.35	260	2	Twisted wire splint, Single stranded Titanium ribbon retainer	-Detachment rate	Titanium ribbon retainer showed less failure rate. Clinical effects were similar for both

GFR- Glass fiber reinforced retainer

et al.[26] and Fransson *et al.*[18] claim that, post-retention the irregularity in the incisor alignment increases.

3.3 Risk of Bias of Individual Studies (Table 5)

Based on the criteria mentioned earlier a total of eight studies had a low risk of bias,[6,10,15-18,25,26] five has a medium risk[7,9,12,14,21] and four had a high risk of bias[8,11,13,20].

4. Discussion

Lingual bonded retainers are an inevitable part of post-orthodontic retention. With the advent of newer types of retainers, and the availability of various research papers, inconsistent effects of the lingual bonded retainers have been reported by different authors. Therefore, this systematic review was undertaken, to provide consolidated evidence for the orthodontist to plan the retention phase of treatment.

To avoid excessive heterogeneity, the eligibility criteria included only the fixed lingual retainer and excluded removable retainers and studies comparing bonding materials and bonding procedures. Due to the variety of articles obtained, all the relevant parameters were accepted.

Table 5. Methodological scores for the selected articles

Study	Objective	Sample size	Baseline	No co-interventions	Random sampling	Random allocation	Measurement method	Examiner blinding	Statistician blinding	Intra-rater reliability	Inter-rater reliability	Statistical analysis	Subgroup analysis	Confounders included	P value	Confidence interval	Clinical significance	Total score	Risk of bias
Sadowsky *et al.*[26]	√	/	×	√	/	-	√	√	-	√	-	√	×	-	√	√	-	9	L
Stormann *et al.*[21]	√	/	×	√	×	√	√	×	×	×	×	√	×	-	√	×	√	7.5	M
Pandis *et al.*[13]	√	/	×	√	×	×	√	×	×	×	×	√	×	-	√	×	√	6.5	H
Liesamfoek *et al.*[9]	√	/	×	√	/	-	√	×	×	×	×	√	×	-	√	×	√	7	M
Lee *et al.*[11]	√	×	×	√	/	×	/	×	×	×	×	√	×	/	/	×	/	5.5	H
Tacken *et al.*[10]	√	×	×	√	/	√	√	×	×	√	-	√	×	-	√	×	√	8.5	L
AlNimri *et al.*[6]	√	×	×	√	/	√	√	√	×	√	√	√	×	-	√	×	/	10	L
Renkema *et al.*[15]	√	×	×	√	-	-	√	×	×	√	√	√	×	-	√	-	√	8	L
Bolla *et al.*[12]	√	×	×	√	√	√	√	×	×	×	×	√	×	-	√	-	√	8	M
Salehi *et al.*[16]	√	√	×	√	√	√	√	×	√	×	×	√	×	-	√	√	√	11	L
Fransson *et al.*[17]	√	√	×	√	√	√	√	√	×	√	-	√	×	-	√	√	√	12	L
Juloski *et al.*[25]	√	√	×	√	√	√	√	×	×	√	√	√	×	-	√	√	√	12	L
Maddalone *et al.*[8]	√	/	×	√	×	×	√	×	×	×	×	×	×	-	×	×	×	3.5	H
Fransson *et al.*[18]	√	/	×	√	-	-	√	√	×	√	√	√	×	-	√	√	√	10.5	L
Kocher *et al.*[14]	√	×	×	√	×	×	√	√	×	×	√	√	×	-	√	×	√	8	M
Ferreira *et al.*[7]	√	×	√	√	×	/	√	×	×	√	-	√	×	-	√	×	√	8.5	M
Arash *et al.*[20]	√	×	×	√	×	√	√	×	√	×	-	√	×	-	√	×	√	8	H

√ = met; × = not met; / = partially met, - = Not applicable, L= low risk of bias, M= medium risk of bias, H= High risk of bias

The multistranded retainers[6,8,10-18] being the first type of lingual bonded retainers to be used, were found to be the most commonly used among the selected articles. But they also had higher plaque retention[6,7]. The rationale behind these findings could be the rough surface of the multistranded retainer which attracts more food particles, leading to difficulty in cleaning.

Least used were the prefabricated retainers and they also showed higher relapse rate[7,21]. The canine-only retainers were found to have either similar[21] or lesser periodontal effects[7] better survival rate[14] but higher relapse rate[21]. The canine-only retainers are bonded only to the canines and the retainer wire only touches the lingual surface of the incisors. Even though, this simplifies hygiene maintenance, it also allows some mobility of the incisors, resulting in a greater possibility of relapse.

The studies with Glass reinforced retainers, showed contradictory findings regarding survival rate[10,12]. The Titanium-Molybdenum-Alloy retainers[14] and titanium retainers[20] showed higher survival rate compared to multistranded retainer. The clinical efficiency of titanium retainers[20] was similar to multistranded retainers, whereas, that of Titanium-Molybdenum-Alloy retainers was not mentioned[14]. These newer types require further evaluation to form conclusive evidence.

Also once the retainer is removed the post-retention incisor alignment stability is still questionable[18,26]. This may indicate toward the possibility of lifelong use of the lingual bonded retainer to avoid any relapse and re-treatments.

From the selected 17 articles, eight had a low risk of bias[6,10,15-18,25,26] and five had a medium risk of bias[7,9,12,14,21]

suggesting a good study design, which increases their authenticity. The findings of the four high risk studies[8,11,13,20] have to be questioned.

This review only aimed to conclusively bring forward the desirable effects as well as inadvertent side-effects of the lingual bonded retainer that the orthodontist must be aware of before planning the retention phase of orthodontic treatment.

5. Limitations of the Study

Due to variety in the types of retainers used, a meta-analysis and forest-plotting of the data was not possible. There are many studies addressing the effects of bonding materials and bonding procedures, which also affect the survival of the lingual bonded retainers, but these were beyond the scope of the study.

6. Recommendations

The newer types of lingual bonded retainers, like the glass reinforced retainer, Titanium-Molybdenum-Alloy retainer and Titanium retainer still need further research. The effects of bonding technique, procedure and materials were out of the scope of this systematic review, but may be of interest for future research.

7. Conclusion

The lingual bonded retainers are widely used and studied. Periodontal effects like plaque and calculus accumulation and gingival inflammation are to be expected and hygiene maintenance has to be enforced. The incidences of breakage of the lingual bonded retainers is a concern, which may be overcome by employing appropriate bonding technique and procedure, with standard bonding materials. Even though newer types of retainers are being introduced to try and improve the survival rate, the multistranded retainers still prove to be a good choice with respect to maintenance of incisor alignment.

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