TREATMENT STABILITY WITH BONDED VERSUS VACUUM-FORMED RETAINERS: A SYSTEMATIC REVIEW OF RANDOMIZED CLINICAL TRIALS

SUMMARY

Background: In orthodontics, the retention phase can be considered challenging and unpredictable. Therefore, evidence obtained from different retention protocols is important to facilitate clinical decision-making.

Objectives: This systematic review aimed to compare the clinical effectiveness of bonded versus vacuum-formed retainers (VFRs) regarding their capacity to maintain treatment stability, periodontal effects, and failure rates.

Search methods and eligibility criteria: Ten databases comprising published and unpublished literature were systematically searched up to August 2021. Randomized clinical trials (RCTs) comparing both retainers were included.

Data collection and analysis: The Risk of Bias (RoB) evaluation was performed with the Cochrane Collaboration RoB tool 2.0. All steps of the screening phase and RoB assessment were performed independently by two reviewers. The Grade of Recommendations, Assessment, Development and Evaluation (GRADE) was used to evaluate the certainty of the evidence.

Results: Initial database search yielded 923 studies. After duplicates removal and full-text assessment, five RCTs remained. Overall, the studies presented Low RoB, except one study judged with “Some concerns”. Based on the included studies, on a short-term (3-6 months) and long-term (4 years) basis, bonded retainers (BR) were more effective to maintain treatment stability than VFRs in the lower arch. However, from 12 to 24 months both retainers presented the same efficacy. In the upper arch, the retainers were equally effective. BRs were associated with greater plaque and calculus accumulation than VFRs after 12 months. The retainers’ failure rates were similar in the upper arch on the first year of retention; however, after 2 years VFRs showed significantly greater failure rates. Contrarily, BRs presented greater failure rates in the lower arch than VFRs.

Conclusions: Most of the evidence generated in this systematic review derived from a moderate level of certainty. In the lower arch, BRs are more effective than

VFRs to maintain treatment stability in the initial 6 months of retention and in the long term. In the upper arch, both retention protocols are equally effective.
Registration: Registration number: PROSPERO CRD42020199392.

Keywords: Orthodontics; Orthodontic Retainers; Systematic Review.

INTRODUCTION

In orthodontics, the possibility of relapse after treatment should always be taken into account (1). Although an accurate diagnosis and adequate mechanics are performed, the results obtained with orthodontic treatment may not be completely stable over time (2). The unpredictable nature of relapse inspired many researchers to investigate the most clinically effective retention protocol to enhance treatment stability. Nonetheless, the ideal retention protocol remains unclear (3,4).

The retention phase is recognized as the best attempt to maintain teeth in the correct position in the short- and long-terms (5). The most frequently used retention appliances are Hawley retainers, bonded retainers, and vacuum-formed retainers (3). Moreover, the decision-making for each one of them seems to be influenced by a different range of factors such as initial malocclusion, treatment applied, patients' assumptions, and orthodontists' experience (6,7).

Bonded retainers (BRs) were firstly described in 1973 (8). Basically, this type of retainer consists of solid or braided wires bonded to the lingual surface of the anterior teeth to maintain their alignment (9). Some variations of the retainer exist and its effectiveness is well-established in the literature (10,11). The main advantage of the technique is the minimum requirement of patient compliance when compared to the removable retainers (3). Notwithstanding, BRs have been related to greater plaque and calculus accumulation (12).

Regarding removable retainers, vacuum-formed retainers (VFR) are currently gaining popularity among patients and orthodontists owing to their ease of production and comfort (13). Interestingly, these plastic retainers were introduced in the same decade as BRs (14). The effectiveness of this kind of retainer has also been proved and is speculated their minor periodontal complications (12). Logically, the greater disadvantage of VFR resides in the entire need for patient compliance.

Previous systematic reviews evaluated the abovementioned retainers individually (10,11,15). Nonetheless, a direct systematic comparison between them has not yet been carried out. Recent clinical research compared the retention capacity of both retainers (2,3,16-18). However, their findings were controversial. Some of them suggest that BRs are more effective to maintain treatment stability compared to VFRs (3,16), while others state that no differences between retainers exist (17,18). Inconsistent evidence is also reported regarding the retainers' survival rates and retention wear time (4,9). A synthesis of the available evidence from randomized controlled trials (RCTs) would provide relevant information regarding both retainers and improve the orthodontist's decision-making of which retainer is more suitable for each individualized case.

Therefore, the primary aim of this systematic review was to compare the effectiveness of bonded versus vacuum-formed retainers regarding their capacity to maintain treatment stability. The secondary aim was to compare the retainers regarding their periodontal effects and failure rates.

MATERIAL AND METHODS

Protocol and Registration

The present review was conducted following the Cochrane Handbook for Systematic Reviews of Interventions (19) and was reported according to the PRISMA statement (20). Furthermore, a pre-existing protocol was registered on PROSPERO (CRD42020199392).

Eligibility criteria

The selection criteria were based on the PICOS strategy:

1. Participants: patients of any age and sex who underwent orthodontic treatment and followed a retention protocol.

2. Intervention: VFRs after active orthodontic treatment.

3. Comparator: BRs after active orthodontic treatment.

4. Outcome: treatment stability evaluated in millimeters with different occlusal variables at any available follow-up. Periodontal changes and failure rates were considered secondary outcomes.

5. Study Design: randomized clinical trials.

In summary, RCTs comparing the effectiveness of bonded versus VFRs in maintaining the results obtained with orthodontic treatment were included. Studies were excluded if they not exclusively compared VFRs and BRs; if the patients included presented an initial malocclusion requiring extensive transverse corrections (rapid maxillary expansion or surgical expansion); tooth anomalies of number/form; and craniofacial syndromes.

Information sources, search strategy and study selection

Seven electronic databases (Pubmed, Scopus, Web of Science, The Cochrane Library, Lilacs, Embase, and Livivo) were searched up to August 2021. Grey literature search included Google Scholar, OpenGrey, and ClinicalTrials (www.clinicaltrials.gov). Overall, 10 databases comprising published and unpublished literature were searched without limitations regarding language, publication year, and status. Detailed search strategies of each database are shown in Supplementary Table 1. Additionally, hand-search was performed in Orthodontic journals to identify any potential article loss.

The search was performed in two phases. Initially, two reviewers (S.A.B.P. and A.A.D.C) screened the titles and abstracts of all retrieved studies. Duplicate records were removed with the reference management software Endnote (Clarivate Analytics, Philadelphia, USA). The remaining studies were transferred for the second phase, where both reviewers assessed the full report of publications and applied the eligibility criteria. Both screening phases were performed independently and any disagreement was resolved by discussion or consulting with a third reviewer (C.C.O.S.). Finally, the reference lists of the included studies were searched for additional studies.

Data items and collection

The following qualitative and quantitative data were extracted from the included studies in a piloted electronic spreadsheet (Excel, Microsoft Corporation 2019): Authors; publication year; sample characteristics (sample size, patients' sex, age, type of retainer); stability assessment and outcomes; follow-ups; retention protocol; failure rates and main findings). During the process, if unreported relevant data was noticed, the trial investigators were contacted by e-mail for clarification.

Risk of bias in individual studies

The risk of bias (RoB) of the selected RCTs was assessed with the Cochrane Collaboration RoB Tool 2.0 (21). The tool considers five domains and results in an overall RoB judgment of “Low RoB” (low risk for all domains), “Some concerns” (some concerns in at least one domain, but no high risk for any domain), and “High RoB” (high risk for at least one domain, or some concerns in multiple domains).

Equally to the screening phase (study selection and data extraction), the RoB assessment was performed independently by both reviewers, and the third reviewer acted as a judge to resolve disagreements, if necessary.

Summary measures and approach to synthesis

A qualitative summary of the findings focusing on treatment stability was decided a priori. Moreover, due to the anticipated continuous nature of the outcomes, mean differences and 95% confidence intervals were planned for quantitative synthesis, if possible. Meta-analysis was planned if the included studies presented acceptable homogeneity and reported similar outcomes with appropriate statistical forms. In such case, a random-effects meta-analysis was deemed more suitable considering the possible differences among patients and implementation of interventions (22).

Risk of bias across studies and additional analysis

If feasible, publication bias would be evaluated through the inspection of the contour-enhanced funnel plots (23). The certainty of the evidence was judged with the Grading of Recommendation, Assessment, Development, and Evaluation (GRADE) approach (24) for each outcome and time-point evaluated.

RESULTS

Study selection and characteristics

The database search identified 923 studies. After duplicates removal, 511 studies remained. Grey literature search did not identify any potential study following the eligibility criteria. Moreover, the titles and abstracts were screened

and 500 studies were discarded. During the first phase, disagreements were rare between reviewers. Of the 511 titles and abstracts reviewed only 8 presented different judgments and were discussed with the third reviewer. The second phase included 11 studies for full-text evaluation. Of these, 6 were excluded with reasons (Supplementary Table 2). Finally, 5 studies were included in the qualitative synthesis. Second phase screening was performed with no disagreements between reviewers. The process of identification, screening, and exclusion of studies is described in the PRISMA flow diagram (20) (Figure 1).

The 5 included studies involved 348 patients (60% female / 40% male). They presented a two-arm (2,3,16,17) or three-arm (18) RCT design comparing bonded versus VFRs. The mean average age of the patients ranged between 13.8 ± 1.5 and 21.5 ± 3.0 years. Overall, the studies evaluated treatment stability with the following variables: Little Irregularity Index (LII), intercanine and intermolar width, and arch length. Additionally, extraction site opening was assessed in two studies (2,16), overbite and overjet were evaluated in the other three studies (3,17,18). These variables were assessed in digitized (3,17,18) or plaster models (2,16). Only two studies evaluated the upper arch (3,18).

The outcomes were assessed at debonding and at different follow-ups, which varied among studies. The maximum follow-ups evaluated were 12 (3), 18 (2,17), 24 (18), and 48 (16) months. In three studies it was possible to extract data at debonding and the longest follow-up (3,16,17), while in two studies only the treatment changes between periods were provided (2,18).

The retention protocol with VFRs differed among studies. Some authors suggested full-time use for 1 week (17), 4 weeks (18), or 6 months (2,16), followed by nights-only use for 1 year. Then, intermittent use after this period. Other authors instructed patients to wear the retainers only at night since debonding (3).

The overall retainer failure rates ranged from 5.8% to 50% for both retainers but differed in the upper and lower arches. A detailed description of the study's characteristics can be observed in Table 1.

Risk of bias within studies

In general, all the included studies in this systematic review were well-designed and followed the CONSORT guidelines (25). Thus, 4 included studies

(2,3,17,18) presented Low RoB and only one study (16) was judged with “Some concerns” (Figure 2). The randomization process involving random sequence generation, allocation concealment, and implementation was adequate. Likewise, no signs of deviations from intended interventions were noticed in all studies.

One study (2) presented a great number of drop-outs; therefore, possible bias due to missing outcome data was speculated. Even though the drop-outs were clearly reported and explained, it was decided to judge the study with “Some concerns” for this domain. The authors reported a considerable drop-out rate of 36% and 48% in the bonded and vacuum-formed groups respectively.

Two studies (17,18) presented the trial protocol registration and permitted a direct evaluation of bias in the selection of the reported result. In the remaining studies, the authors were contacted for clarifications and no evidence or suggestion of selection bias were noticed leading to a Low RoB judgment. The risk of bias assessment occasionally resulted in disagreements between reviewers in two studies (2,16). However, an agreement was obtained after discussion and contacting the study’s authors.

Results of individual studies, meta-analysis, and additional analysis

Initially, the performance of meta-analysis was expected; however, due to the substantial clinical and methodological heterogeneity between studies quantitative analysis was not feasible. Then, for descriptive reasons, findings will be presented regarding treatment stability at 3 to 6, 12 to 24, and 48 months to ease understanding. These were the follow-up times during retention provided in the included studies.

3 to 6 months follow-up: On a short-term basis, two studies (2,3) stated that BRs were more effective to maintain treatment stability in the lower arch compared to VFRs. Contrarily, one study (17) showed that the retention capacity of both retainers was similar during this period. Concerning the upper arch, no differences were found between retainers in the study of Forde et al. (3).

12 to 24 months follow-up: After 1-year, two studies (2,17) observed the same retention capacity between retainers; however, one study (3) suggested that BRs were more effective in the lower arch. Again, no differences were exhibited in the upper arch (3,18).

48 months follow-up: On a long-term basis BRs were more effective in maintaining treatment stability in the lower arch when compared to VFRs, although some relapse was observed in both groups (16). None of the included studies presented long-term data regarding the upper arch.

Two studies assessed the patient's periodontal health. The first study described that after one year BRs were associated with greater plaque and calculus accumulation and gingival inflammation than VFRs (3). Moreover, after 4 years both retainers were associated with plaque accumulation and gingival inflammation without significant differences (16).

Concerning the retainers' failure rates, in the upper arch, both retainers presented similar rates after 1-year in one study (3); however, another study (18) showed significantly greater failure rates with VFRs (50%) compared to BRs (23%) after 2 years (Table 1). In the lower arch, two studies reported significantly greater failure rates with BRs compared to VFRs (2,3). The study from Kramer et al. (17) did not find significant differences between the retainers' failure rates.

The certainty of evidence evaluated through the GRADE approach is described in Table 2. The overall certainty of evidence ranged from low to moderate for the outcomes assessed. In case of low certainty, the confidence in the effect estimated is limited and may be substantially different. Moreover, a moderate judgment suggests that the estimated effect is likely to be close to the true effect. This was the case for the great majority of outcomes. Publication bias was not evaluated because meta-analysis was not undertaken.

DISCUSSION

Summary of evidence

The present systematic review included 5 RCTs exclusively comparing BRs and VFRs. A broader Cochrane review (4) performed this comparison indirectly, and previous reviews were performed with different retainers (26,27). However, this is the first systematic review to directly compare these types of retainers.

The study from Al-Moghrabi et al. (16) was the long-term (4-year) evaluation of the RCT from O'Rourke et al. (2). Nonetheless, they were considered independent studies in this systematic review because different

research teams performed the outcomes evaluation, and both short- and long-term data would provide clinically relevant findings for the present review.

Overall, during the first 6 months of retention evidence of moderate certainty suggests that BRs are more effective in maintaining treatment stability than VFRs in the lower arch. It could be speculated that the worse performance of VFRs on a short-term basis compared to BRs might be related to the non-compliance of patients regarding the retention regimen rather than a proper failure of the retainer (2). In accordance, the RCT that found no differences between retainers reported minimum failure rates and great patient adherence with the VFR (17). Curiously, in this study, the VFRs were made up to the first premolars. Again, it seems that the possible short-term failure of VFRs in maintaining lower incisors alignment might be more related to the patients' non-compliance than the retainer itself. If the patient is unwilling or unable to wear the retainer as prescribed, some degree of relapse should be expected (1).

Orthodontic studies comparing fixed versus removable appliances are susceptible to this kind of shortcoming because researchers do not know the true amount of time the appliance was wear during the observational period. In this regard, short-term retention remains a controversial topic. Nonetheless, the evidence generated in this review reiterates the greater effectiveness of BRs compared to VFRs in the short term.

The retention capacity of both retainers in the lower arch was similar after 1 and 2 years in most of the included studies (2,17). This was an interesting finding and may be explained by different aspects of retention. Firstly, the literature describes that relapse mainly occurs in the first 6 to 12 months of retention; therefore, after this period it should be less expected (17,28). Additionally, the failure rates of the retainers are also greater in the short-term corroborating with a greater chance of relapse (2,3,17). In this regard, the first 12 months of retention are critical. It could be speculated that after this period the chance of relapse might be reduced enhancing the retainers' effectiveness.

The longest follow-up assessed was 4 years. Evidence suggested that BRs were more effective than VFRs to maintain treatment stability in the lower arch in the long term. Nonetheless, these findings are supported by only one study (16), and therefore, represent a low level of certainty. In this study, the authors were contacted for clarifications and confirmed that approximately 70%

of the patients in the VFR group stopped wearing the retainers at the 4-year follow-up, probably explaining the greater effectiveness of BRs. Once more, the greater disadvantage of VFRs compared to BRs is the entire need for patient compliance. Although it could be suggested that both retainers present the same retention capacity in the lower arch in the long term, it seems that the patients' responsibility decreases progressively over time, which may lead to relapse. Retention clinical studies are difficult to undertake from a practical and financial perspective, but further long-term studies should be performed for more robust information regarding this subject.

It was possible to gather evidence from two studies regarding the effect of the retainers in the upper arch. In this case, both RCTs indicated that the retainers present the same retention capacity after 1 and 2 years (3,18). The literature shows considerably smaller relapse in the upper arch when compared to the lower arch in both short- and long-terms (29). These findings are in accordance with previous retrospective studies that showed minimum relapse in the upper arch after 5 and 7 years (29,30). That reduced tendency of relapse in the upper arch might explain the effectiveness of different maxillary retention protocols (3,18,29). Overall, there is a lack of sufficient evidence to affirm that one retainer is better than the other on a long-term basis.

The periodontal effects and failure rates of the retainers were secondary outcomes of this systematic review. In this regard, there seems to be a consensus that BRs present greater plaque and calculus accumulation, and consequently cause greater gingival inflammation than VFRs in the short term (3). Logically, these effects are restricted to the canine-to-canine area. Moreover, on a long-term basis, both retainers were related to plaque accumulation and negative periodontal effects. Nonetheless, these effects were not strong enough to be clinically significant (12). It is reasonable to state that orthodontists must follow their patients and control their periodontal health in the long term as part of overall orthodontic treatment.

The survivability of the retainers might be influenced by a different range of factors. Especially when different studies and populations are considered. Likewise, a previous systematic review showed that the failure rate of BRs could range from 11% to 71% (9). Similarly, VFRs can reach important failure rates of 50% to 70% (16,18). It seems clear that both retainers are susceptible to failure

and require great care from the patient and orthodontist. Based on the RCTs included in this review, it could be considered that after 18 months of retention VFRs present greater failure rates in the upper arch compared to BRs. Contrarily, BRs showed greater failures rates in the lower arch after this period (Table 1). It should be emphasized that these findings are based on a moderate level of certainty, and further studies are required to confirm them.

To date, there is no standardized retention protocol for VFRs. However, high-quality evidence included in this systematic review indicates that VFRs part-time wear is equally effective compared to full-time wear (3,4,17). Thus, it is reasonable to affirm that these retainers could be prescribed for night-only use. The part-time wear of the VFR might also be related to the increased longevity of the material. On the contrary, full-time wear could be associated with greater failure rates (31).

From a clinical perspective, the decision-making regarding BRs and VFRs might consider other variables, such as cost-benefit, the differences between upper and lower arches, orthodontist's preferences, quality of life, but more importantly the level of patient compliance/motivation (9). Post-orthodontic appointments for treatment stability assessments are also part of orthodontic treatment. The patient should be followed up regularly after fixed appliances removal independently of the retainer of choice.

Limitations

The results of this review should be interpreted with caution. Even though the studies included were well conducted in a methodological perspective, it should be highlighted that their findings may be influenced by different initial malocclusions included, amounts of tooth movement, the patients' age, the true amount of VFRs wear time, the different materials of BRs, among other factors that are related to the unpredictability of relapse (4). However, these factors are beyond the objectives of this review.

CONCLUSIONS

According to the existing evidence found in this systematic review, the following can be concluded based on Low to Moderate level of certainty:

- In the lower arch, BRs are more effective to maintain treatment stability during the initial 6 months of retention compared to VFRs. After 12 months there is a tendency for both retention protocols to be equally effective. Nonetheless, in the long term, BRs seem to prevail over the VFRs regarding their retention capacity.
- In the upper arch, both retainers are an effective retention protocol to maintain the results obtained with orthodontic treatment.
- Bonded retainers are related to greater plaque and calculus accumulation than VFRs in the short term. In the long-term, both retainers are associated with negative periodontal effects highlighting the importance of post-orthodontic periodontal control.
- Both retainers present similar failure rates in the upper arch during the first year of retention; however, after this period VFRs present greater failure rates in the upper arch than BRs. In contrast, BRs present greater failure rates in the lower arch when compared to VFRs.

Acknowledgments

We thank the authors' Ama Johal (Queen Mary University of London, London, UK), Dalya Al-Moghrabi (Queen Mary University of London, London, UK), Padhraig Fleming (Queen Mary University of London, London, UK), Simon Littlewood (St Luke's Hospital, Bradford, UK) for providing clarifications and/or additional data for this systematic review.

Funding

This work was supported by the Coordination for the Improvement of Higher Educational Personnel (CAPES, Process code – 001).

Conflict of interest statement

None to declare.

Data availability statement

The data underlying this article will be shared on reasonable request to the corresponding author.

REFERENCES

1. Littlewood, S., Kandasamy, S., Huang, G. (2017) Retention and relapse in clinical practice. *Australian Dental Journal*, 62, 51-57.
2. O'Rourke, N., Albeedh, H., Sharma, P., Johal, A. (2016) Effectiveness of bonded and vacuum-formed retainers: a prospective randomized controlled clinical trial. *American Journal of Orthodontics and Dentofacial Orthopedics*, 150, 406-415.
3. Forde, K., Storey, M., Littlewood, S.J., Scott, P., Luther, F., Kang, J. (2018) Bonded versus vacuum-formed retainers: a randomized controlled trial. Part 1: stability, retainer survival, and patient satisfaction outcomes after 12 months. *European Journal of Orthodontics*, 40, 387-398.
4. Littlewood, S.J., Millett, D.T., Doubleday, B., Bearn, D.R., Worthington, H.V. (2016) Retention procedures for stabilising tooth position after treatment with orthodontic braces. *Cochrane Database of Systematic Reviews*.
5. Little, R.M., Riedel, R.A., Artun, J. (1988) An evaluation of changes in mandibular anterior alignment from 10 to 20 years postretention. *American Journal of Orthodontics and Dentofacial Orthopedics*, 93, 423-428.
6. Andriekute, A., Vasiliauskas, A., Sidlauskas, A. (2017) A survey of protocols and trends in orthodontic retention. *Progress in Orthodontics*, 18, 1-8.
7. Padmos, J.A.D., Fudalej, P.S., Renkema, A.M. (2018) Epidemiologic study of orthodontic retention procedures. *American Journal of Orthodontics and Dentofacial Orthopedics,* 153, 496-504.
8. Knierim, R.W. (1973) Invisible lower cuspid to cuspid retainer. *The Angle Orthodontist*, 43, 218-220.
9. Iliadi, A., Kloukos, D., Gkantidis, N., Katsaros, C., Pandis, N. (2015) Failure of fixed orthodontic retainers: a systematic review. *Journal of Dentistry*, 43, 876-896.
10. Buzatta, L.N., Shimizu, R.H., Shimizu, I.A., Pachêco-Pereira, C., Flores-Mir, C., Taba Jr, M., Porporatti, A.L., De Luca Canto, G. (2017) Gingival condition associated with two types of orthodontic fixed retainers: a meta-analysis. *European Journal of Orthodontics*, 39, 446-452.

11. Moda, L.B., da Silva Barros, A.L.C., Fagundes, N.C.F., Normando, D., Maia, L.C., dos Anjos Mendes, S.M. (2020) Lower fixed retainers: bonded on all teeth or only on canines? A systematic review. *The Angle Orthodontist*, 90,125-143.
12. Storey, M., Forde, K., Littlewood, S.J., Scott, P., Luther, F., Kang, J. (2018) Bonded versus vacuum-formed retainers: a randomized controlled trial. Part 2: periodontal health outcomes after 12 months. *European Journal of Orthodontics*, 40, 399-408.
13. Bondemark, L., Holm, A.K., Hansen, K., Axelsson, S., Mohlin, B., Brattstrom, V., Paulin, G., Pietila, T. (2007) Long-term stability of orthodontic treatment and patient satisfaction. A systematic review. *The Angle Orthodontist*, 77, 181-191.
14. Ponitz, R.J. (1971) Invisible retainers. *American Journal of Orthodontics*, 59, 266-272.
15. Kaklamanos, E.G., Kourakou, M., Kloukos, D., Doulis, I., Kavvadia, S. (2017) Performance of clear vacuum-formed thermoplastic retainers depending on retention protocol: a systematic review. *Odontology*, 105, 237-247.
16. Al-Moghrabi, D., Johal, A., O'Rourke, N., Donos, N., Pandis, N., Gonzales-Marin, C., Fleming, P.S. (2018) Effects of fixed vs removable orthodontic retainers on stability and periodontal health: 4-year follow-up of a randomized controlled trial. *American Journal of Orthodontics and Dentofacial Orthopedics*, 154, 167-174.
17. Krämer, A., Sjöström, M., Hallman, M., Feldmann, I. (2019) Vacuum-formed retainer versus bonded retainer for dental stabilization in the mandible - a randomized controlled trial. Part I: retentive capacity 6 and 18 months after orthodontic treatment. *European Journal of Orthodontics*, 45, 551-558.
18. Naraghi, S., Ganzer, N., Bondemark, L., Sonesson, M. (2020) Stability of maxillary anterior teeth after 2 years of retention in adolescents: a randomized controlled trial comparing two bonded and a vacuum-formed retainer. *European Journal of Orthodontics*, 43, 152-158.
19. Higgins JPT, T.J., Chandler J, Cumpston M, Li T, Page MJ, Welch VA. (2019) Cochrane Handbook for Systematic Reviews of Interventions version 6.0 (updated July 2019). *Cochrane*.

20. Page, M.J.*, et al.* (2021) The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*, 372.
21. Sterne, J.A.*, et al.* (2019) RoB 2: a revised tool for assessing risk of bias in randomised trials. *BMJ*, 366.
22. Spineli, L.M., Pandis, N. (2020) The importance of careful selection between fixed-effect and random-effects models. *American Journal of Orthodontics and Dentofacial Orthopedics*, 157,432-433.
23. Peters, J.L., Sutton, A.J., Jones, D.R., Abrams, K.R., Rushton, L. (2008) Contour-enhanced meta-analysis funnel plots help distinguish publication bias from other causes of asymmetry. *Journal of Clinical Epidemiology*, 61, 991-996.
24. Guyatt, G.H., Oxman, A.D., Vist, G.E., Kunz, R., Falck-Ytter, Y., Alonso-Coello, P., Schünemann, H.J. (2008) GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. *BMJ,* 336, 924-926.
25. Schulz, K.F., Altman, D.G., Moher, D. (2010) CONSORT 2010 statement: updated guidelines for reporting parallel group randomised trials. *BMJ,* 340.
26. Al-Moghrabi, D., Pandis, N., Fleming, P.S. (2016) The effects of fixed and removable orthodontic retainers: a systematic review. *Progress in Orthodontics*, 17, 1-22.
27. Mai, W., Meng, H., Jiang, Y., Huang, C., Li, M., Yuan, K., Kang, N. (2014) Comparison of vacuum-formed and Hawley retainers: a systematic review. *American Journal of Orthodontics and Dentofacial Orthopedics*, 145, 720-727.
28. Edman Tynelius, G., Bondemark, L., Lilja-Karlander, E. (2013) A randomized controlled trial of three orthodontic retention methods in C lass I four premolar extraction cases–stability after 2 years in retention. *Orthodontics & Craniofacial Research*, 16, 105-115.
29. Bjering, R., Birkeland, K., Vandevska-Radunovic, V. (2015) Anterior tooth alignment: a comparison of orthodontic retention regimens 5 years posttreatment. *The Angle Orthodontist*, 85,353-359.

30. Andrén, A., Naraghi, S., Mohlin, B.O., Kjellberg, H. (2010) Pattern and amount of change after orthodontic correction of upper front teeth 7 years postretention. *The Angle Orthodontist*, 80, 620-625.
31. Sun, J.*, et al.* (2011) Survival time comparison between Hawley and clear overlay retainers: a randomized trial. *Journal of Dental Research*, 90, 1197-1201.

FIGURE LEGENDS

Figure 1. Modified PRISMA flow diagram.

Figure 2. Cochrane Risk of Bias Tool 2.0 summary.

TABLE LEGENDS

Table 1. Characteristics of the 5 randomized clinical trials included in the qualitative assessment.

Table 2. GRADE Summary of Findings Table.

SUPPLEMENTARY MATERIAL

Supplementary Table 1. Databases and search strategy.

Supplementary Table 2. List of excluded studies with reasons for exclusion (n=6).

Fig. 1

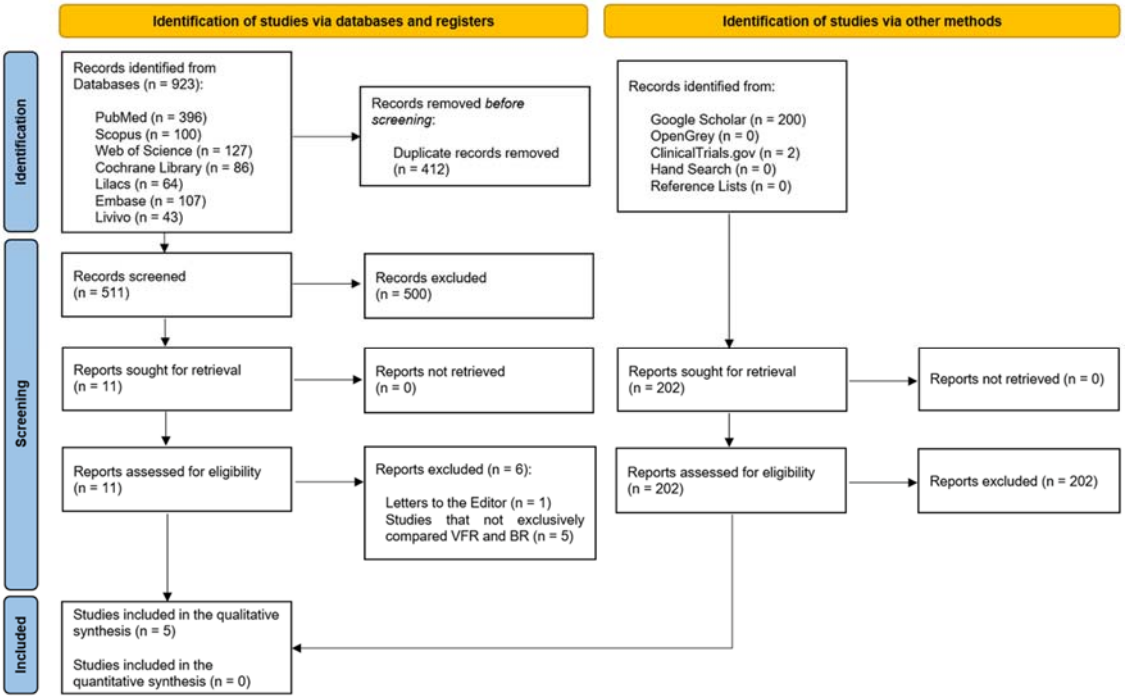
Identification of studies via databases and registers
Identification of studies via other methods
Identification
Screening
Included
Records identified from Databases (n = 923):
PubMed (n = 396)
Scopus (n = 100)
Web of Science (n = 127)
Cochrane Library (n = 86)
Lilacs (n = 64)
Embase (n = 107)
Livivo (n = 43)
Records removed before screening:
Duplicate records removed (n = 412)
Records identified from:
Google Scholar (n = 200)
OpenGrey (n = 0)
ClinicalTrials.gov (n = 2)
Hand Search (n = 0)
Reference Lists (n = 0)
Records screened (n = 511)
Records excluded (n = 500)
Reports sought for retrieval (n = 11)
Reports not retrieved (n = 0)
Reports sought for retrieval (n = 202)
Reports not retrieved (n = 0)
Reports assessed for eligibility (n = 11)
Reports excluded (n = 6):
Letters to the Editor (n = 1)
Studies that not exclusively compared VFR and BR (n = 5)
Reports assessed for eligibility (n = 202)
Reports excluded (n = 202)
Studies included in the qualitative synthesis (n = 5)
Studies included in the quantitative synthesis (n = 0)

Fig. 2

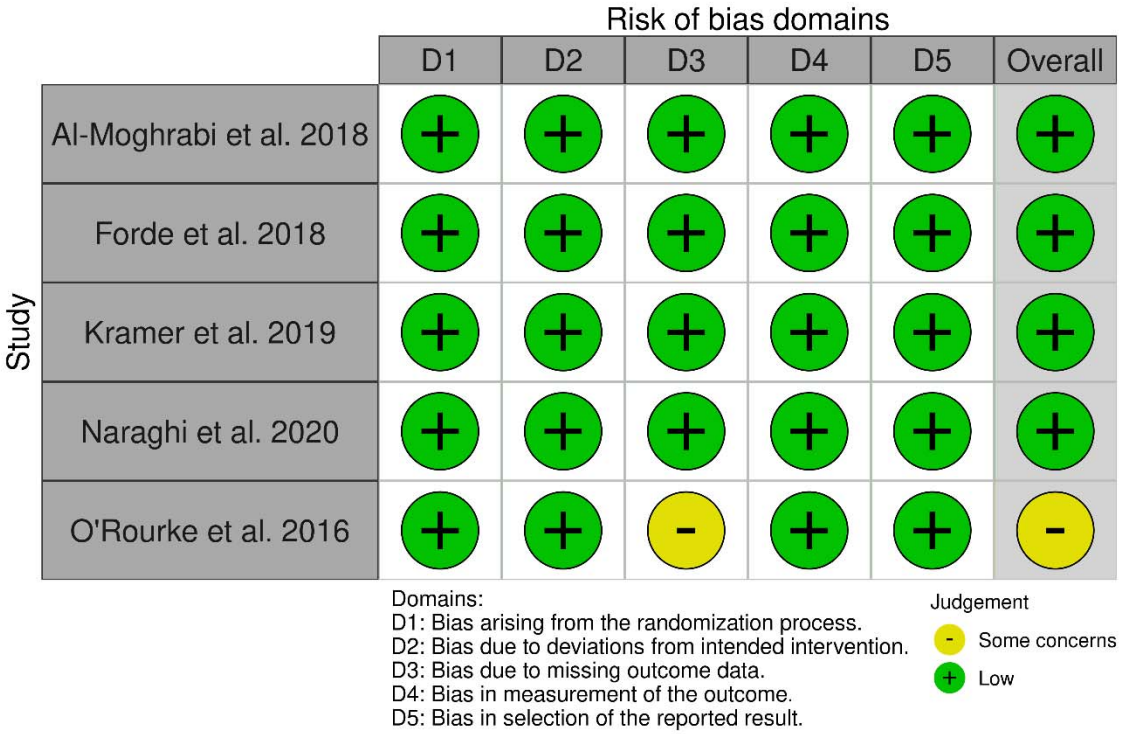
Risk of bias domains
D1
D2
D3
D4
D5
Overall
Study
Al-Moghrabi et al. 2018
Forde et al. 2018
Kramer et al. 2019
Naraghi et al. 2020
O'Rourke et al. 2016
Domains:
D1: Bias arising from the randomization process.
D2: Bias due to deviations from intended intervention.
D3: Bias due to missing outcome data.
D4: Bias in measurement of the outcome.
D5: Bias in selection of the reported result.
Judgement
Some concerns
Low

Table 1. Characteristics of the 5 randomized clinical trials included in the qualitative assessment.

Authors / Publication Year	Groups (N/sex/age)	Stability assessment	Outcome measures		Retention protocol (Vacuum-formed retainers)	Retainers' failure rates	Main findings
			Debond	Longest follow-up			
Al-Moghrabi et al. 2018	G1 Bonded retainers Coaxial SS wire 21 (18F / 3M) 21.54 years (3.06) G2 Vacuum-formed retainers Essix™ 21 (14F / 7M) 20.77 years (1.49)	Outcomes evaluated: LII, ICW, IMW, AL, extraction site opening Measurements were performed in the lower arches on gypsum study models with a digital caliper at debond and after 48 months	G1 – Lower arch LII: 0.25 (0.47) ICW: 26.90 (1.89) IMW: 42.80 (3.96) AL: 24.45 (3.83) Extraction opening: 0.00 (0.19) G2 – Lower arch LII: 0.42 (0.84) ICW: 26.77 (2.29) IMW: 41.77 (4.03) AL: 22.15 (2.96) Extraction opening: 1.37 (0.72)	G1 – Lower arch LII: 1.23 (1.27) ICW: 26.74 (1.84) IMW: 42.23 (5.82) AL: 25.84 (7.04) Extraction opening: 0.00 (0.00) G2 – Lower arch LII: 3.16 (2.74) ICW: 25.62 (2.51) IMW: 42.66 (4.93) AL: 20.81 (8.33) Extraction opening: 1.65 (1.57)	Full-time basis for the first 6 months, nights only for the following 6 months, and alternate nights from 12-18 months. Thereafter, intermittent nights-only wear (1 to 2 night weekly)	After 48 months: G1 – Lower arch 24% G2 – Lower arch n.r. %	After 48 months, BRs were more effective in retaining lower incisors alignment compared with VFRs (P = 0.02), although some relapse was observed in both groups
Forde et al. 2018	G1 Bonded retainers 3-stranded twistflex SS wire 30 (15F / 15M) 16 years (2) G2 Vacuum-formed retainers Essix™ 30 (18F / 12M) 17 years (4)	Outcomes evaluated: LII, ICW, IMW, AL, overjet and overbite Measurements were performed in the upper and lower arches on digitized study models at debond, 3, 6, and 12 months	G1 – Upper arch / Lower arch LII: 0.00 (0.93) / 0.29 (1.02) ICW: 35.20 (2.83) / 27.53 (1.68) IMW: 50.11 (3.96) / 44.05 (4.64) AL: 73.94 (12.74) / 66.74 (6.00) Overjet: 2.37 (0.70) Overbite: 1.29 (1.22) G2 – Upper arch / Lower arch LII: 0.23 (0.66) / 0.06 (1.23) ICW: 34.09 (2.22) / 26.17 (1.13) IMW: 48.46 (4.24) / 41.34 (5.72) AL: 71.23 (9.67) / 65.53 (12.94) Overjet: 2.38 (2.40) Overbite: 2.00 (1.21)	G1 – Upper arch / Lower arch LII: 1.35 (1.98) / 1.01 (1.28) ICW: 35.08 (2.31) / 27.31 (2.21) IMW: 49.47 (3.88) / 43.90 (4.32) AL: 76.70 (10.81) / 66.97 (8.21) Overjet: 2.26 (1.07) Overbite: 1.59 (0.78) G2 – Upper arch / Lower arch LII: 0.97 (1.68) / 1.73 (2.77) ICW: 33.21 (2.36) / 25.56 (1.39) IMW: 47.70 (3.80) / 41.32 (4.61) AL: 68.86 (10.26) / 62.57 (9.50) Overjet: 2.59 (0.94) Overbite: 2.01 (1.00)	Only at night, every night	After 12 months: G1 – Upper arch / Lower arch 36.7% / 50% G2 – Upper arch / Lower arch 26.7% / 20%	After 12 months, there is no evidence of a significant differences regarding stability (P = 0.61) or retainer survival (P = 0.34) in the upper arch. Nonetheless, in the lower arch, BRs were more effective at maintaining incisors alignment (P = 0.008), but with the cost of a higher failure rate (P = 0.01)

Kramer et al. 2019	G1 Vacuum-formed retainers Essix™ 52 (26F / 26M) 17.1 years (2.4) G2 Bonded retainers Remanium® wire 52 (26F / 26M) 17.1 years (1.9)	Outcomes evaluated: LII, ICW, IMW, AL, overjet and overbite Measurements were performed in the lower arches on digitized study models at debond, 6, and 18 months	G1 – Lower arch LII: 1.33 (0.65) ICW: 26.77 (1.89) IMW: 42.85 (2.96) AL: 58.82 (10.23) Overjet: 3.23 (1.63) Overbite: 1.68 (1.04) G2 – Lower arch LII: 1.53 (1.03) ICW: 27.33 (2.11) IMW: 42.57 (3.10) AL: 54.25 (8.31) Overjet: 3.13 (1.57) Overbite: 1.85 (0.97)	G1 – Lower arch LII: 2.06 (1.52) ICW: 26.63 (1.96) IMW: 43.30 (2.56) AL: 58.48 (9.74) Overjet: 3.12 (1.09) Overbite: 2.17 (1.55) G2 – Lower arch LII: 2.03 (1.40) ICW: 27.28 (1.95) IMW: 42.48 (2.89) AL: 53.22 (7.21) Overjet: 3.03 (1.24) Overbite: 2.06 (1.45)	Full-time the first week and thereafter at night only until 12 months. 12-18 months: intermittent nights 18-24 months: 2 nights per week	After 18 months: G1 – Lower arch 5.8% G2 – Lower arch 5.8%	After 18 months, VFRs and BRs presented the same retention capacity and failure rates in the lower arch
Naraghi et al. 2020	G1 Bonded retainers Penta-One 0.0195 SS wires 30 (17F / 13M) 13.8 years (1.5) G2 Vacuum-formed retainers Essix™ 30 (17F / 13M) 13.9 years (1.9)	Outcomes evaluated: LII, ICW, IMW, AL, overjet, overbite and maximum rotation Measurements were performed in the upper arches on digitized models with the software OnyxCeph™ before treatment, at debond (T1), and after 24 months (T2)	G1 – Upper arch (T2-T1) LII: 0.30 (CI: 0.10; 0.50) ICW: -0.30 (CI: -0.50; -0.10) IMW: -0.30 (CI: -0.70; 0.10) AL: 0.10 (CI: -0.10; 0.30) Overjet: 0.1 (CI: -0.10; 0.30) Overbite: 0.20 (CI: 0.00; 0.40) G2 – Upper arch (T2-T1) LII: 1.00 (CI: 0.40; 1.60) ICW: 0.20 (CI: 0.00; 0.40) IMW: -0.40 (CI: -0.60; -0.20) AL: 0.00 (CI: -0.20; 0.20) Overjet: 0.0 (CI: -0.40; 0.40) Overbite: 0.30 (CI: -0.10; 0.70)		Full-time basis for the first 4 weeks, then every night, and alternate nights from 12-24 months	After 24 months: G1 – Upper arch 23.3% G2 – Upper arch 50%	Both retention methods showed equally effective retention capacity after 2 years and can be recommended as retention methods in the upper arch (P = 0.138)

O'Rourke et al. 2016	G1 Bonded retainers Coaxial SS wire 42 (33F / 9M) 18.47 years (4.41) G2 Vacuum-formed retainers Essix™ 40 (26F / 14M) 16.95 years (2.02)	Outcomes evaluated: LII, ICW, IMW, AL, extraction site opening Measurements were performed in the lower arches on gypsum study models with a digital caliper at debond (T0), 6 (T1), 12 (T2) and 18 (T3) months	G1 – Lower arch LII: (T1-T0) 0.03 / (T2-T1) 0.03 / (T3-T2) 0.03 ICW: (T1-T0) 0.11 / (T2-T1) 0.17 / (T3-T2) 0.17 IMW: (T1-T0) 0.26 / (T2-T1) 0.38 / (T3-T2) 0.18 AL: (T1-T0) 0.19 / (T2-T1) 0.20 / (T3-T2) 0.18 Extraction opening: (T1-T0) 0.00 / (T2-T1) 0.00 / (T3-T2) 0.00 G2 – Lower arch LII: (T1-T0) 0.08 / (T2-T1) 0.08 / (T3-T2) 0.08 ICW: (T1-T0) 0.23 / (T2-T1) 0.20 / (T3-T2) 0.26 IMW: (T1-T0) 0.16 / (T2-T1) 0.25 / (T3-T2) 0.25 AL: (T1-T0) 0.23 / (T2-T1) 0.19 / (T3-T2) 0.19 Extraction opening: (T1-T0) 0.00 / (T2-T1) 0.00 / (T3-T2) 0.00	Full-time basis for the first 6 months, nights only for the second 6 months, and alternate nights from 12-18 months. Thereafter, intermittent nights-only wear (1 to 2 night weekly)	After 18 months: G1 – Lower arch 7.15% G2 – Lower arch 0%	BRs were more effective in their ability to maintain incisor alignment in the lower arch in the first 6 months after debond when compared to VFR (P = 0.008). Nonetheless, some minimal relapse is likely after fixed appliances therapy irrespective of retainer choice. The retention capacity between retainers was similar at 12 and 18 months (P = 0.195 and P = 0.300, respectively)

G1: Group 1; G2: Group 2; SS: Stainless steel; F: Female; M: Male; LII: Little Irregularity Index; ICW: Inter-canine width; IMW: Inter-molar width; AL: Arch length; BR: Bonded retainer; VFR: Vacuum-formed retainer; n.r.: Not reported.

Note: All outcomes were evaluated in millimeters and were presented with the median and interquartile range. Except the study from Naraghi et al. 2020 which presented their results with the mean and 95% confidence intervals (CI).

Table 2. GRADE Summary of Findings Table.

Certainty assessment							Summary of findings	Certainty
N° of studies (Patients)	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication Bias		
3 to 6 Months Stability								
3 (246)	RCTs	Not serious	Serious[†]	Not serious	Not serious	Not suspected	During the initial 6 months of retention, BRs are more effective than VFRs to maintain the lower incisors alignment. In the upper arch there is no difference between retainers.	⊕⊕⊕◯ MODERATE
12 to 24 Months Stability								
4 (306)	RCTs	Not serious	Serious[†]	Not serious	Not serious	Not suspected	After 12 to 24 months of retention, BRs and VFRs present the same retention capacity in the upper and lower arches.	⊕⊕⊕◯ MODERATE
48-Month Stability								
1 (42)	RCT	Not serious	Not serious	Serious[‡]	Serious[€]	Not suspected	BRs are more effective than VFRs in the long-term (after 48 months).	⊕⊕◯◯ LOW
Periodontal Health Changes								
2 (102)	RCTs	Not serious	Not serious	Not serious	Serious[€]	Not suspected	BRs are associated with greater plaque and calculus accumulation than VFRs during the initial 12 months of retention. After 48 months both retainers are related to negative periodontal effects. Nonetheless, these effects did not appear to produce any periodontal problem of clinical significance.	⊕⊕⊕◯ MODERATE
Failure Rates (Upper arch)								
2 (120)	RCT	Not serious	Not serious	Not serious	Serious[€]	Not suspected	BRs and VFRs present similar failure rates after 12 months. Nonetheless, after this period, VFRs present significantly greater failure rates compared to BRs.	⊕⊕⊕◯ MODERATE
Failure Rates (Lower arch)								
3 (246)	RCTs	Not serious	Serious[†]	Not serious	Not serious	Not suspected	BRs present significantly greater failure rates compared to VFRs after an 18-month period.	⊕⊕⊕◯ MODERATE

Note: for publication purposes the individual GRADE summary of the primary and secondary outcomes evaluated in this systematic review were collated into this single table.
RCT: randomized controlled trial; BRs: bonded retainers; VFRs: vacuum-formed retainers.
[†]The evidence was downgraded by 1 level because of unexplained heterogeneity in the results of the included RCTs; [‡]The evidence was downgraded by 1 level because of the difference in populations and applicability of the results; [€]The evidence was downgraded by 1 level because the results derived from small studies and few numbers of patients.

Supplementary Table 1. Databases and search strategy.

Database	Keywords
1. PUBMED 2. SCOPUS 3. EMBASE 4. COCHRANE LIBRARY (CENTRAL) 5. LIVIVO	(orthodontics OR orthodontic patients) AND (canine-to-canine retainer OR cuspid-to-cuspid retainer OR lingual retainer OR orthodontic fixed retainer OR 3x3 OR bonded retainer OR fixed retainer OR retention OR contention OR mandibular retainer) AND (removable retainer OR Essix OR vacuum-formed retainer OR thermoplastic retainer OR Vivera OR clear retainer OR plastic retainer)
6. WEB OF SCIENCE	TS=(orthodontics OR orthodontic Patients) AND (canine-to-canine retainer OR cuspid-to-cuspid retainer OR lingual retainer OR orthodontic fixed retainer OR 3x3 OR bonded retainer OR fixed retainer OR retention OR contention OR mandibular retainer) AND (removable retainer OR Essix OR vacuum-formed retainer OR thermoplastic retainer OR Vivera OR clear retainer OR plastic retainer)
7. LILACS (Latin American and Caribbean Health Sciences Literature Resource)	(orthodontics OR ortodontia OR Ortodontia) AND (canine-to-canine retainer OR contenção canino-a-canino OR contencíon de canino-a-canino OR orthodontic fixed retainer OR 3x3 OR bonded retainer OR fixed retainer OR contenção fixa OR contencíon fija OR thermoplastic retainer)
8. GOOGLE SCHOLAR (Grey Literature)	orthodontics AND canine-to-canine retainer OR cuspid-to-cuspid retainer OR 3x3 OR bonded retainer OR fixed retainer AND Essix OR vacuum-formed retainer OR thermoplastic retainer OR Vivera OR clear retainer OR plastic retainer
9. OPEN GREY 10. CLINICALTRIALS.GOV (Grey Literature)	bonded retainer AND vacuum-formed retainer

Supplementary Table 2. List of excluded studies with reasons for exclusion (n=6).

Reasons for Exclusion	Studies
Letters to the Editor	1
Studies that not exclusively compared VFR and BR	2,3,4,5,6

References

1. Brignardello-Petersen R. (2018) No evidence of differences important to patients between bonded and vacuum-formed retainers after 1 year of use. *Journal of the American Dental Association*, 149:e71.
2. Edman Tynelius G, Bondemark L, Lilja-Karlander E. (2010) Evaluation of orthodontic treatment after 1 year of retention - A randomized controlled trial. *European Journal of Orthodontics*, 32, 542-547.
3. Edman Tynelius G, Bondemark L, Lilja-Karlander E. (2013) A randomized controlled trial of three orthodontic retention methods in Class I four premolar extraction cases - stability after 2 years in retention. *Orthodontics and Craniofacial Research,* 16, 105-115.
4. Edman Tynelius G, Petrén S, Bondemark L, Lilja-Karlander E. (2015) Five-year postretention outcomes of three retention methods - A randomized controlled trial. *European Journal of Orthodontics*, 37, 345-353.
5. Cope JF, Lamont T. (2016) Orthodontic retention--three methods trialed. *Evidence Based Dentistry*, 17, 29-30.
6. Dias VAP, França EDC, Neves LS, Lombardi MDA, César CC, Drummond AF. (2019) Effectiveness of fixed and removable retainers in preventing lower anterior crowding relapse. *Revista Clinica de Ortodontia Dental Press*,18, 132-140.