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Systematic Review

Orthodontic Relapse after Fixed or Removable Retention Devices: A Systematic Review

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Abstract: Retention constitutes a fundamental phase of orthodontic treatment, of which the patient must be made aware from the outset. Retention, which can be fixed or movable, has the task of maintaining over time and stabilising the results obtained during treatment. This study assessed the efficacy of using removable restraints versus fixed solutions for maintaining long-term outcomes. A comprehensive search across major databases—Pubmed, Web of Science, Scopus—used 'relapse' and 'orthodontic' as keywords to gather articles on relapse discussions. The primary focus was relapsed cases in post-fixed orthodontic therapy. Both fixed and removable retainer systems prove effective in preserving orthodontic achievements. While fixed devices require regular wire integrity checks, mobile devices require patient compliance, proper usage, and a recommended wear time. Studies indicate that fixed retainers are generally successful, with relapse rates varying based on the retainer type. Full-time use of removable devices surpasses night-only wear. Vacuum-formed and Hawley retainers offer similar effectiveness. Fixed retainers excel in long-term alignment stability, whereas removable ones have higher failure rates yet remain beneficial.

Keywords: dentistry; orthodontics; orthodontic retainers; orthodontic appliances; removable; dental technology

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1. Introduction

1.1. Rationale

One of the most challenging aspects of an orthodontic treatment plan is keeping teeth in their corrected final position at the end of treatment [1]. In 1934, Oppenheim affirmed: "Maintaining the result obtained after orthodontic treatment is one of the most difficult aspects of the entire treatment: retention is the most difficult problem in orthodontics, in fact, it is the problem!" [2]. Almost everyone who receives an orthodontic treatment will need some retention to stabilise results and keep teeth aligned. Without retention, teeth tend to return to their original position, a condition called relapse [3]. Orthodontists must be able to manage the different methods and assess which would be best for each patient to minimise relapse [4–6].

The tendency for relapse depends on the time it takes for supragingival and transseptal periodontal fibres to stabilise [7]. When teeth are repositioned, the periodontal ligament and gingivae tissues change to accommodate the new tooth position [2]. These tissues tend to move the teeth back toward their original position until they have had

time to reorganise. The elastic fibres surrounding the teeth and the dental–gingival and interdental fibres take the longest to remodel, even up to 8 months [8]. The orthodontic movement causes remodelling and disorganisation of the collagen fibres of the extracellular matrix of the periodontal ligament, with a specific increase in immature collagen fibres, especially in the apical region of the tooth (area of greatest load) [9]. Applying orthodontic force releases inflammatory mediators and other molecules, such as interleukins, leptins, aspartate aminotransferase, etc., that support the inflammatory reaction underlying tissue remodelling [10]. Therefore, the teeth must be kept in place for enough time to allow these fibres to adapt. An alternative strategy involves using a straightforward surgical operation (perincision) to cut these gingival fibres [11].

Some studies have established that a stable occlusion is related to proper dental gearing between the arches: occlusal interference, displaced tooth contacts, and occlusal overload could result in increased tooth mobility and increased risk of relapse [12].

The orthodontic treatment should aim at positioning the teeth in the so-called "neutral zone". The neutral zone is an area in which the centrifugal forces of the tongue and the centripetal forces of the perioral soft tissues are balanced [13]. The more the teeth are outside the neutral zone due to excessive proclination or retroclination, the greater their instability and risk of recurrence [14].

Furthermore, when planning an arch form variation, the clinician should consider the increased risk of recurrence due to soft tissue forces on the teeth [15].

The dentition is in a phase of dynamic equilibrium that is constantly changing and readjusting: it has been widely demonstrated that there is a minimal residual growth of facial tissues even in adulthood, a variation in inter-arch ratios and a variation in the pressure exerted by the soft tissues [16]. These variations affect tooth balance and alignment. Therefore, a small amount of recurrence is considered physiological [17].

Removable or fixed, active, or passive retainer devices are used to achieve stability of orthodontic therapy over time. Schematically, the most used devices can be classified into

- Passive removable: resin plates, with or without a vestibular arch, Hawley, and vacuum-formed retainers (Figure 1), such as Essix, etc. [18].

Figure 1. Passive thermoformed upper and lower arch splints.

- Active removable: plates with added springs, grids, elastic hooks, spring aligners, thermoformed with set-up, and digitally customised elastomers.
- Passive fixed: from classic systems (lingual arches, Maryland bridges, etc.) to all types of bonded retainers (Figure 2).
- Fixed active: cemented grids in the upper jaw and lingual arches with active insertion.

Hawley's plate was introduced in 1919, and since then, its design has mostly stayed the same, except for some variations at the level of the labial arch. Thermally formed plastic retainers are the main removable alternative to the Hawley plate. These were first introduced by Ponitz in the early 1970s and found great popularity from the 1990s,

thanks to Sheridan and colleagues under the name of Essix® retainers. An Essix is a thin thermoplastic copolyester plate [19].

Figure 2. Fixed passive lingual lower canine–canine retainer (Stainless-Steel Ortho—Flextech®).

On the contrary, fixed retainers generally consist of segments of wire or multiple wires twisted together, with different diameters and cross sections, bonded most often from canine to canine [20]. The most common complications of fixed retainers are detachments, fractures, periodontal problems, and unwanted movements. Detachments can occur between composite-tooth or wire-composite. The causes of retainer detachment depend on errors in the placement technique, incorrect bonding or the design/material choice. Based on the currently available evidence, braided stainless-steel wire retainers, it can be stated that passive bonded retainers are certainly an effective means of preventing posttreatment relapses but should be checked regularly by the orthodontist [21]. Braided wires, especially small-diameter bonded retainers on each anterior tooth, are at the highest risk of creating unwanted movement and complications. In recent years, more and more retainers constructed using digital technology (Computer Aided Design CAD or Computer Aided Design/Computer Aided Manufacturing CAD/CAM) have been presented [22]. The materials mainly used are nickel–titanium alloys, titanium–molybdenum, chrome–cobalt, zirconium, glass fibre reinforced or new materials such as peek [23].

1.2. Objectives

This systematic review aims to assess whether fixed retainers and removable retention devices provide a good response in maintaining tooth position while reducing orthodontic relapse, trying to provide the reader with the best possible solution.

2. Materials and Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were used in this systematic review [24]. The information flow across the several stages of a systematic review is shown in the flow diagram. It illustrates how many records were found, how many were included, how many were excluded, and why. The article was structured following the main points of the PRISMA checklist and the division into paragraphs. This paper has been submitted to the international database of registered systematic reviews in health PROSPERO and was assigned the ID 459047.

2.1. Eligibility Criteria

This research studies the use of retainer/splint or other retainer devices and the failure rate. Articles that met several criteria were included:

1. Study design: Randomized Clinical Trials (RCT), case series with more than 5 case reports (CS), clinical trials (CT), retrospective studies (RS), prospective studies (PS), and observational study (O).
2. Human participants in permanent dentition of any age.
3. Mobile or fixed retainer.

4. English language.
5. Only full text is available.

Studies characterised by one of the following exclusion criteria were excluded:

1. Study design: reviews, letters, comments, and case series with less than 5 case reports; case reports.
2. In vivo and in vitro studies;
3. Animal models or dry skulls.
4. Interceptive treatments or palatal expansion.

2.2. Information Sources and Search Strategy

On 9 May 2023, L.R. and V.C. performed an online search to set the topic. Before conducting the search, the authors brainstormed to look for a combination of words that could generate an adequate and valid number of articles for the search itself. We used Pubmed, Scopus and Web of Science as online databases, in which we manually searched for publications that matched the topic of the review. The authors did not consider grey literature. The search method was developed by analysing articles that referred to fixed and mobile appliances used after orthodontic treatment and the occurrence of relapse after their use. After several searches, the final search referred to a range of time from May 2013 to May 2023 using the keywords "relapse" and "orthodontic" and the Boolean variable "AND" (Table 1).

Table 1. Database search indicator.

Articles screening strategy	Keywords: "relapse" and "orthodontic" Boolean Indicators: ("A" AND "B") Timespan: 10 years (2013–2023) Electronic Database: Pubmed, Web of Science, Scopus

2.3. Selection and Data Collection Process

We excluded articles that did not fit the topic by reading the manuscript's titles and abstracts. The full text of the remaining articles was read to assess the relevance based on the inclusion criteria. The study data were selected by analysing the study design, number of patients, average age, intervention, type of retainer and outcome. Disagreements between authors on article selection were discussed and resolved.

A standardized form was used to capture research design and location data, population characteristics (e.g., sex, age), type of intervention and comparison, baseline measurements, and reported results. Each study was also evaluated for handling missing data and effect measurements. For extraction accuracy, two reviewers (S.C. and M.G.) worked separately; consensus resolved divergences. Because of the substantial variability in the treatments and outcomes reported, meta-analysis was impossible; consequently, papers were synthesised qualitatively.

The fixed effect model was used for homogeneous research, whereas the random effect model was used for heterogeneous studies. All analyses calculated the effect size using the standardised means difference.

Table 2 depicts the PICOS (Population, Intervention, Comparison, Outcome, Study Design) criteria components, which include population, intervention, comparison, outcomes, and research design and their use in this evaluation.

Table 2. PICOS criteria.

Criteria	Application in the Present Study
Population	patients after fixed orthodontic therapy that received removable retention devices or fixed retainers
Intervention	analysis of the retention device

Table 2. *Cont.*

Criteria	Application in the Present Study
Comparison	comparison between the various types of devices, whether mobile or stationary and the degree of reception with each of them
Outcomes	stability over time or relapse
Study design	Randomised Clinical Trials (RCT), case series with more than 5 case reports (CS), clinical trials (CT), retrospective studies (RS), prospective studies (PS); observational study (O)

2.4. Quality Assessment

The quality of the included papers was assessed by two reviewers, RF and EI, using the reputable Cochrane risk-of-bias assessment for randomized trials (RoB 2). Although the tool is suitable for randomised studies, the observational studies analysed had one study group and one control group, such that the use of RoB 2 was appropriate to encompass all studies. The following six areas of possible bias are evaluated by this tool: random sequence generation, allocation concealment, participant and staff blinding, outcome assessment blinding, inadequate outcome data, and selective reporting. A third reviewer (FI) was consulted in the event of a disagreement until an agreement was reached.

3. Results

3.1. Study Selection

The electronic database search generated 1989 results by entering the keywords "relapse" and "orthodontic" in three databases, including Pubmed (917), Scopus (564) and Web of Science (508). Following duplication elimination (764), 1225 studies were screened, reading title and abstract. After the abstract screening, 1118 papers were rejected (50 reviews, 3 in vitro, 47 on animals, 4 were not in English, and 1014 were off-topic). A total of 9 texts were not retrieved from the 107 articles selected, so 98 articles were chosen for the eligibility evaluation. Following the full-text examination, 64 manuscripts were eliminated: 25 were off-topic, 8 were wrong settings, 13 were unavailable in full-text, and 18 had no outcome of interest. Finally, 34 papers were chosen for the systematic review. Figure 3 summarises the selection procedure.

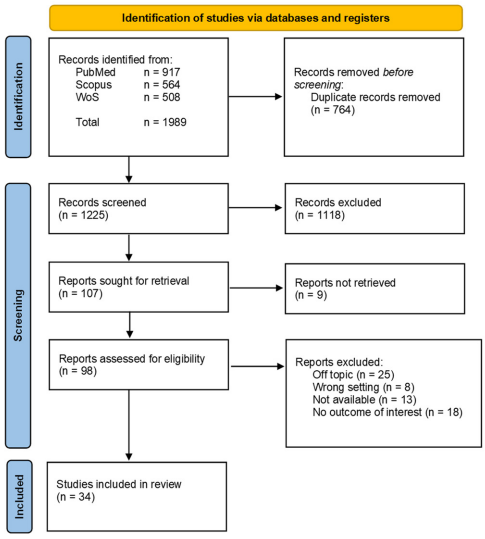


Figure 3. Literature search Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram.

3.2. Study Characteristics

The study data were selected by analysing the study design, number of patients, average age, intervention, type of retainer, and outcomes (Table 3).

Table 3. Summary table with the main points of the included studies in the review.

Author(s) and Year	Study Design	Number of Patients	Average Age (Years)	Retainer Type	Follow Up	Outcomes
Sinha, A. et al. (2021) [25]	PRCT	40	15.61 ± 1.13 and 5.83 ± 1.07	Flexible spiral wire versus ceramic interlocking bonded	Not available	Both retainers maintained their results at the end of treatment, although with a slight relapse in both groups.
Tynelius, G.E. et al. (2013) [26]	RCT	75 (45F and 30M)	14.4	Removable vacuum-formed retainer (covering palate and the upper teeth from 3-3); bonded 3-3 retainer; Ortho-Tain positioner	24 months	All devices maintained the orthodontic results achieved, with minimal and acceptable relapse.
Forde, K. et al. (2017) [27]	RCT	30	16 and 17	Bonded versus vacuum-formed retainers	12 months	There was no significant difference in stability or retainer survival in the maxilla. In the mandible, bonded retainers are more effective at maintaining mandibular labial segment alignment but have a higher failure rate.
Jowett, A.C. et al. (2022) [28]	RCCT	68	Not available	CAD/CAM Memotain® retainer versus Ortho-Flextech™	6 months	A high number of failures were recorded with the CAD/CAM retainer (50%) on the upper arch compared to the other
Arash, V. et al. (2020) [29]	PS	250 (99 M and 151 F)	13–30	Stainless-steel twisted wire (G&H) versus titanium ribbon (Retainium®)	24 months	It has the same clinical effect, but the ribbon retainer has less failure in terms of detachment
Shim, H. et al. (2022) [30]	RCT	46 (18 M and 28 F)	CAD/CAM 16.5 (median 15.3), Lab 15.8 (median 13.6), Traditional 15.2 (median 13.6)	CAD/CAM stainless-steel Dentaflex retainer (Dentaurum) versus Dentaflex retainer manually bent versus Ortho-FlexTech (Reliance)	3–6 months	The CAD/CAM group showed the slightest variation in the inter-canine distance between T3 and T1 and the minor variation, together with the traditional group, in the frontal group. The CAD/CAM group had the highest failure rate, and the traditional group had the lowest.

Table 3. *Cont.*

Author(s) and Year	Study Design	Number of Patients	Average Age (Years)	Retainer Type	Follow Up	Outcomes
Armstrong, A.W. et al. (2017) [31]	CS	80	Not Available	Magnetic retainer versus canine–canine bonded retainer (0.0195-inch twist flex wire)	Not available	There are no significant differences in the efficacy of canine-to-canine retainers bonded to each tooth and the magnetic retainer.
Alrawas, M.B. et al. (2020) [32]	RCT	60	20	CAD/CAM NiTi, multi-stranded stainless steel, single-stranded titanium and vacuum-formed removable retainer	6 months	All retainers showed some relapse in the mandibular anterior teeth and had the same clinical failure rate in maintaining teeth alignment.
Garcia-Nunez, W. et al. (2023) [33]	CS	34	18.3 ± 6.6 and 18.6 ± 5.7	Vacuum-formed retainer wear part-time versus full-time	6 months	Some relapses occurred with both protocols at the end of the 1st month. Part-time wear was less effective in maintaining results during the 1st and the 6th month after debonding.
Naraghi, S. et al. (2021) [34]	RCT	63 (39 F and 24 M)	12.9	Mainly vacuum-formed retainers. Bonded retainers only in patients who had spaces before orthodontic treatment	12 months	The two groups had no clinically significant difference; however, the irregularity difference was statistically significant (0.4 versus 1.3 mm). Retainers are not necessary in these cases.
Devi, S. et al. (2022) [18]	RCT	46	>18	Clear bow Hawley versus Vacuum-formed retainer	12 months	No difference was found between the two devices so they can be used equally.
Kaya, Y. et al. (2019) [35]	RCT	30	17.53 ± 3.89 (Essix) and 16.54 ± 2.24 (Hawley)	Essix versus Hawley retainers	12 months	No statistically significant differences were found in the two groups, although irregularity increased. The clinical effectiveness of the two devices was similar.

Table 3. *Cont.*

Author(s) and Year	Study Design	Number of Patients	Average Age (Years)	Retainer Type	Follow Up	Outcomes
Gera, A. et al. (2021) [36]	RS	287	18.3 ± 10.2	Fixed retainer (0.021 in 6-filament round stainless steel) on the upper and lower arch and upper mobile	24 months	Stability was good during this evaluation period.
Nasreen Iqbal Nagani and Imtiaz Ahmed (2020) [37]	RCT	54	14–30	Fibre-reinforced composite retainers (INOD, U.P. Fiber Splint, 2 mm) versus 0.0175″ stainless steel wire (All Star Orthodontics)	12 months	Fibre-reinforced retainers are more effective in preventing mandibular incisor relapse.
Rabia Adanur-Atmaca et al. (2021) [38]	RCT	132	16	0.0160″ × 0.022″ dead-soft eight-braided stainless-steel wire, 0.0215″ 5-strand stainless-steel wire, 0.014″ CAD/CAM nitinol retainer (Memotain®), connected bonding pads	12 months	There was no clinically significant relapse in any groups after one year.
Dalya Al-Moghrabi et al. (2018) [1]	RCT	82	21	Fixed retainer versus removable retainer	4 years	Fixed retention offers the potential benefit of improved preservation of the mandibular labial segment's alignment.
Eduar Radu Cernei et al. (2022) [39]	RS	150	11–15	Bonded upper retainers	12 months	Splinx retainer group reported almost twice as many relapses as Ortho Flextech Group, but not statistically significant.
Adam Johannes Hoybjerg et al. (2013) [40]	RS	90	15.2	Fixed versus removable retainers (Essix and Hawley)	Not available	The upper Hawley/lower bonded showed the most significant amount of settling, and the upper Essix/lower related had the least settling, but these differences were statistically insignificant
Mansi Radia et al. (2021) [41]	RCT	20	18 ± 2	Fixed retainer; Removable retainer	12 months	occlusal coverage of the Essix retainer does not allow any extrusion and retains the curve of Spee.

Table 3. *Cont.*

Author(s) and Year	Study Design	Number of Patients	Average Age (Years)	Retainer Type	Follow Up	Outcomes
Sait Ishakoglu et Serpil Cokakoglu (2022) [42]	SP	42	17.83–18.15	Essix retainer	12 months	A wear time of at least nine h/d is recommended to maintain mandibular anterior alignment.
Gudrun Edman Tynelius et al. (2014) [43]	RCT	49	Not Available	Removable retainer covering the palate and anterior teeth; Fixed retainer; Prefabricated positioner	5 years	The three retention methods (removable vacuum-formed retainer covering the palate and the anterior maxillary teeth from canine-to-canine and bonded canine-to-canine retainer in the lower arch; maxillary removable vacuum-formed retainer combined with the stripping of the lower anterior teeth; and prefabricated positioner had similar clinical results.
Katharina, E. Kocher et al. (2020) [44]	RS	80	12–28	Fixed retainers: 0.016″ × 0.022″ eight-strand braided SS wire (Ormco) bonded to all six anterior teeth and 0.027″ round β-titanium (Ormco)	Not Available	Mandibular 0.016″× 0.022″ braided SS retainers bonded to all six anterior teeth are more effective in maintaining anterior alignment than 0.027″ round β-titanium retainers bonded only to the canines. Both retainers maintain inter-canine width. In the maxilla, 0.016″ × 0.022″ braided SS retainers hold the anterior alignment.
Gonçalves Canuto et al. (2013) [45]	RS	23	13.6	Upper Hawley retainer and lower bonded retainer canine–canine.	4.92 years	The maxillary incisors irregularity increased significantly (1.52 mm) during long-term posttreatment.

Table 3. *Cont.*

Author(s) and Year	Study Design	Number of Patients	Average Age (Years)	Retainer Type	Follow Up	Outcomes
Freitas et al. (2017) [46]	RS	28 (9 M and 19 F)	12.72	Hawley plate in the maxillary arch; Fixed bonded retainer canine–canine in the mandibular arc	33 years	In the short term (within three years), relapse occurred in both the upper (2.18 mm according to the Little irregularity index) and lower arch (1.58 mm). In the long term, only mandibular incisors showed relapse (3.86 mm)
Wolf et al. (2016) [47]	RS	30	Not available	Twistflex retainer Dentaflex 0.45 mm three-strand twisted steel wire bonded from lower canine to canine	6 months	Superimposition of the models immediately after debonding and six months later showed changes in the three planes of space, especially for the canines. Increased inter-canine diameter and reduced OVJ during treatment are risk factors for relapse.
Schutz-Fransson et al. (2019) [48]	RS	105	Not available	Canine-to-canine retainer (0.028″ spring hard wire) or a Twist flex retainer (0.0195″)	12 years	No significant differences were shown in patients who wore a retainer and those who did not wear a retainer in the long term, as recurrence occurred in both cases. To maintain good stability of the results, patients should wear the retainer lifelong.
Morais et al. (2014) [49]	O	30 (17 F and 13 M)	Not available	Hawley retainer	5.6 years	After orthodontic treatment and Hawley retainer, lateral diastemas are very stable; central diastemas, on the other hand, in 60% of cases, have recurrences.
Guirro et al. (2016) [50]	O	103	13.06	Hawley	7.52 years	Although relapse occurred in the maxillary arch, both in extraction and non-extraction cases, the results were not statistically significant.

Table 3. *Cont.*

Author(s) and Year	Study Design	Number of Patients	Average Age (Years)	Retainer Type	Follow Up	Outcomes
Zafarmand et al. (2014) [51]	RS	40 (non-extraction group: 4 M and 15 F) (Extraction group: 6 M and 15 F)	Non-extraction group: 16.2 Extraction group: 14.9	Hawley retainer	4 years	Relapse values were not statistically significant in the group subjected to extractions (2.11 mm according to the Irregularity Index) and in the group not subjected to extractions (1.65 mm); in both cases, the phenomenon occurred within four years after retention.
Danz, J.C. et al. (2014) [52]	RS	61	11–29	Lower bonded retainer and an upper removable bite plate	11.9 years	10% of the patients showed relapse equal to or more significant than 50% incisor overlap, and their overbite increase was low.
Bjering, R. et al. (2017) [53]	CS	51	12–26	Relapse fixed and mobile	10 years	Long-term outcome ten years after retention and the possible influence of treatment-related factors on posttreatment stability of the dental arches. Patients with extraction had LII scores 1.0 mm lower than patients treated without extraction.
Steinnes, J. et al. (2017) [54]	CS	67	20–50	Relapse fixed and mobile	8 years	Evaluates the stability of orthodontic treatment outcome and retention status seven or more years after active treatment. Anterior LII in the total study sample after treatment was only about 1 mm in both arches.
Abdulraheem, S. et al. (2020) [55]	RS	92	12–27	Lower lingual bonded retainer versus no retainer	12 years	The LII showed equal values before treatment and at the follow-up registrations. A certain percentage of incisors is due to growth and not orthodontic relapse.

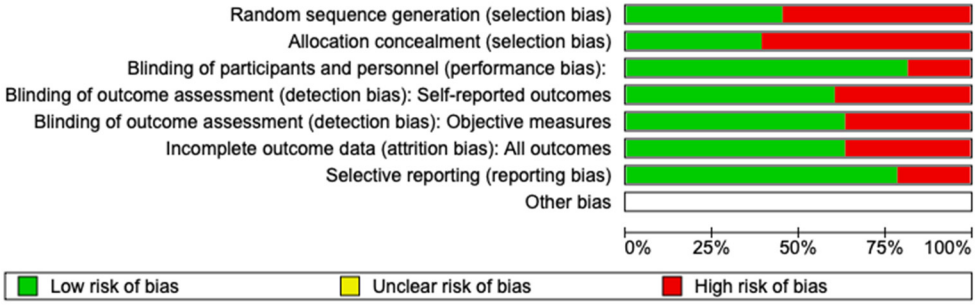
Table 3. *Cont.*

Author(s) and Year	Study Design	Number of Patients	Average Age (Years)	Retainer Type	Follow Up	Outcomes
Vaida et al. (2020) [56]	RS	618	11–17	Removable retainers	6–12 months	Evaluate the behaviour of two types of removable retainers. A total of 9.1% of the patients presented mild recurrences, mainly in the first six months (58.9%), while 2.6% presented severe recurrences, mainly in the first six months (62.5%).

Prospective Randomized Clinical Trials (PRCT), Randomized Clinical Trials (RCT), case series with more than 5 case reports (CS), clinical trials (CT), retrospective studies (RS), prospective studies (PS); observational study (O); Little Irregularity Index (LII).

3.3. Quality Assessment and Risk of Bias

The risk of bias in the included studies is reported in Figure 4. Regarding the randomization process, 50% of the studies present a high risk of bias and allocation concealment. All other studies ensure a low risk of bias. A total of 75% of the studies exclude performance; half of the studies confirm an increased risk of detection bias (self-reported outcome), and 75% of the included studies present a low detection bias (objective measures) (Figure 4). A total of 75% of studies ensure a low risk regarding attrition and reporting bias. The reason for the high bias in the randomisation process lies in the lack of double-blinding in the articles analysed. Furthermore, the patients were already reported in orthodontic treatment and not taken from a large sample that included all patients in orthodontic treatment with different braces systems.



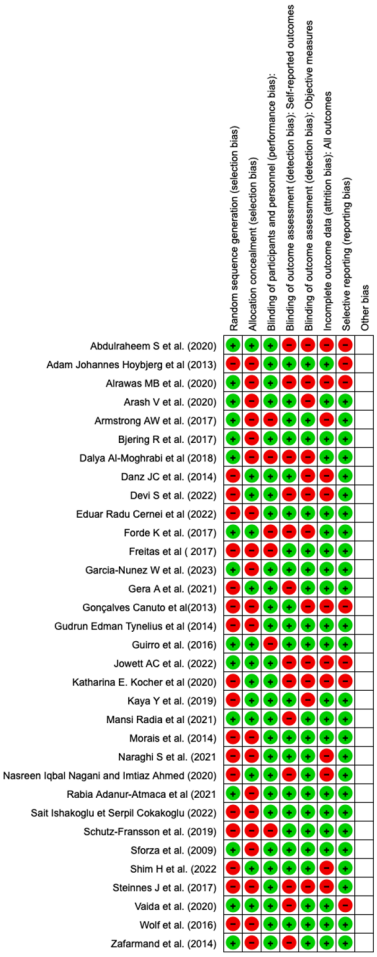


Figure 4. Risk of bias; red (-) indicates high risk, and green (+) indicates low risk of bias.

4. Discussion

4.1. Bonded Retainers Compared

Sinha et al. [25] conducted a trial comparing flexible spiral wire and ceramic interlocking retainers, finding that both retainers effectively maintained treatment results with slight relapse. Jowett et al. [28] compared CAD/CAM (Memotain®) and wire-based retainers (Ortho-Flextech™), observing a high failure rate with the CAD/CAM retainer (50%) on the upper arch compared to the other [57,58]. Although not statistically significant, the failure of the former is three times higher than the latter. Arash et al. [29] evaluated twisted stainless-steel wire (G&H orthodontics) and titanium ribbon retainers (Retainium®), reporting similar clinical effects but lower failure rates with the titanium ribbon retainer. Shim et al. [30] compared stainless-steel CAD/CAM (manually and machine-bent wires) and conventional retainers, highlighting better stability with the CAD/CAM machine-bent group. Armstrong et al. [31] found no significant differences between magnetic and cemented canine-to-canine retainers. Nagani and Ahmed [37] demonstrated that fibre-reinforced composite retainers exhibited less relapse tendency than stainless steel wire retainers due to their increased rigidity, which allows limited physiological tooth movement. Rabia Adanur-Atmaca et al. [38] investigated the stability of lingual retainers and reported no clinically significant worsening of periodontal health or relapse in any group. Eduard Radu Cernei et al. [39] compared two upper-bonded retainer systems (Splinx and Ortho-FlexTech) and found a lower relapse rate with the Ortho-FlexTech retainer. Kocher et al. [44] evaluated different lingual retainers and one upper retainer type. They determined that the retainer bonded to the lower six teeth was more effective in maintaining lower alignment over time than the retainer bonded to the canines alone. Additionally, movement in the lower arch was associated with active forces generated during retainer application. Both inferior retainers were effective in maintaining inter-canine distance. The upper retainer was effective in maintaining upper alignment. The upper inter-canine length remains stable even though the retainer was not extended to the upper canines. Abdulrahem et al. [55] investigated the movement of lower incisors in relation to orthodontic therapy recurrence or natural growth. One group had a retainer bonded to all lower anterior teeth, another had a wire bonded only to the two canines, and a third group was the control. Incisor movement occurred in 25% of the patients due to natural growth, but the measured LII of 1.5 mm at the 12-month follow-up was considered clinically irrelevant and showed different distribution patterns. The superimposition of plaster models revealed rotational movement, tipping, and slight extrusion of the canines. The canines experienced the most changes and recurrences. A subset of patients (13.32%) experienced severe recurrence characterised by significant expansion of the inter-canine diameter and notable overjet reduction during treatment phases [44]. Schutz-Fransson's long-term study [48] showed that using retainers prevented more significant increases in the Little Irregularity Index (LII) compared to the untreated group. However, long-term recurrence was still observed, indicating the need for lifelong retention to limit alterations from normal development. Tynelius et al. [26] showed that most changes occur within the first year, mainly caused by the "memory" of fibres.

4.2. Removable Retention Devices Compared

In a study by Garcia-Nunez et al. [33], two protocols for using vacuum thermoformed retainers were compared to maintain dental element position after orthodontic treatment. The study found that wearing the retainer part-time was less efficient in maintaining tooth position, especially in the first month and six months after appliance removal. Devi et al. [18] conducted a randomised clinical trial comparing two devices, Clear bow Hawley and vacuum-formed splints, for maintaining orthodontic results. The study found no difference between the two devices, indicating they can be used equally. Kaya et al. [35] compared the clinical effectiveness of Hawley and Essix retainers for maintaining orthodontic results. The study found no statistically significant differences between the two groups, although irregularity increased over time. Sait Ishakoglu and Serpil Cokakoglu [42] evalu-

ated the alignment relapse in patients wearing removable thermoformed retainers. The study found that wearing the retainer for less than 9 h per day negatively affected the alignment stability in the mandibular anterior teeth. Cast analysis [45] of patients who received non-extractive orthodontic treatment showed a worsening of alignment in maxillary incisors in the long term. Little's maxillary irregularity in the Class I non-extraction group was substantially higher than in the Class II non-extraction group in the long-term posttreatment stage [50]. A major recurrence occurred in the maxillary region, probably because the starting conditions were worse in the group with a higher relapse. Zafarmand's study [51] indicated that relapse is possible in both extraction and non-extraction cases, with no statistically significant differences in recurrence values. Vaida et al. [56] conducted a retrospective study evaluating two removable retention devices in the upper arch. The study found that Hawley and thermoformed Essix-type retainers were effective, with slightly higher recurrence in patients treated with Hawley's plate after the first year. Overall, these studies highlight the importance of retention protocols and the potential for relapse in maintaining orthodontic treatment results.

4.3. Bonded Retainers versus Removable Retention Devices

Tynelius et al. [26] conducted a randomised controlled trial comparing three retention methods over two years. All methods effectively maintained orthodontic results, with minimal relapse in the lower anterior teeth. Forde et al. [27] compared fixed upper and lower retainers to thermoformed mobile splints over 12 months. Both methods were equally effective in maintaining stability at the maxillary level, but the cemented retainer was more efficient in the mandibular arch. Alrawas et al. [32] compared different types of retainers and found that all retainers had a similar rate of maintaining alignment. CAD/CAM retainers had a better fit. Naraghi et al. [34] evaluated the significance of upper retainers in patients with impacted or unerupted maxillary incisors. They found no clinically significant differences in the maintenance of results between the group with no retainer and the group with a retainer. However, differences in lower incisor inclination were statistically significant. Gera et al. [36] conducted a retrospective study and found that stability was good two years after orthodontic treatment, with less than 2% experiencing undesirable changes. Dalya Al-Moghrabi et al. [1] found that fixed retainers were more effective than vacuum-formed retainers in maintaining mandibular anterior segment alignment at a 4-year follow-up. Periodontal health was similar between the two groups. Hoybjerg et al. [40] evaluated different retention strategies and found improvements in various occlusal variables after one year of retention. However, some variables deteriorated over time. Mansi Radia et al. [41] compared fixed lingual retainers to Essix-type retainers and found that Essix retainers were most effective in preventing extrusion of lower incisors. Tynelius et al. [43] performed a randomised clinical trial over five years and found that all three retention methods were clinically valid. Freitas et al. [46] observed a significant recurrence of alignment and crowding after three years but stabilisation in the upper arch after 33 years. Prolonged use of retainers improved outcomes. Danz et al. [52] followed up on patients with deep bites and found a recurrence of incisor position in 10% of cases, with causes unidentified. Bjering et al. [53] evaluated patients treated with fixed orthodontics and found higher recurrence with more significant initial tooth crowding. Occlusal stability decreased after ten years of retention. Steinnes et al. [54] evaluated patients seven years after orthodontic therapy and found small, clinically insignificant changes, indicating the presence of recurrence regardless of retention methods. The findings suggest that retention methods can effectively maintain orthodontic results, but some relapse may occur over time, particularly in the mandibular arch. Fixed retainers tend to be more effective than removable ones, and prolonged use of retainers improves stability.

Mummolo et al., as a result of their analysis, suggested the use of a fixed retainer in the lower arch, bonded from canine to canine or from premolar to premolar [59]. However, suppose significant bodily movements of the teeth have been performed (distalization or mesialization). In that case, it is recommended to use a simultaneous lower thermoformed

splint that accommodates the space for the fixed retainer. A simple thermoformed splint is recommended for the upper arch, discouraging using a fixed retainer that could interfere with the patient's protrusive movements and potentially cause temporomandibular joint issues.

The limitations of this study were related to the wide range of restraint devices on the market and the variables associated with the different types of treatment that can be adopted. The devices can be fixed or removable, or a combination of the two. The restraints can then be handmade, digitally designed and folded by machines. Articles were selected in which the cases treated were only fixed orthodontics in permanent dentition patients. There is also a whole range of interceptive treatments that were not considered as they were outside the inclusion criteria of the research. Individual skeletal growth is an essential and challenging variable to consider. In order to make the chosen group of articles as homogeneous as possible, we decided to focus on those of fixed therapy in adults or adolescents without deciduous teeth.

On the contrary, the strong points of this work are

- Broad coverage of studies: The discussion provides a wide range of studies comparing different types of retainers, including bonded and removable retention devices, allowing readers to gain an overview of the current literature on this topic.
- Mention various outcomes assessed in the studies, such as relapse, stability, alignment, and periodontal health. This provides a comprehensive understanding of the factors associated with orthodontic treatment maintenance.
- Comparison of different retainer types such as flexible spiral wire, ceramic interlocking retainers, CAD/CAM retainers, twisted stainless-steel wire, titanium ribbon retainers, magnetic retainers, cemented retainers, Hawley retainers, Essix retainers, etc., allowing readers to compare the strengths and weaknesses of different retainer options.
- Discussion of long-term effects: The text includes studies that evaluate the long-term effects of retention, with very wide follow-up periods providing insights into the stability of orthodontic results over time.
- Mention compliance and maintenance requirements: The text highlights the importance of patient compliance in correctly wearing removable retention devices and for the prescribed duration. It also emphasised the need for periodic checks of fixed retainers to ensure their integrity and adhesion. This information is crucial for orthodontic practitioners and patients to understand the responsibilities and maintenance required for different retainer types.

5. Conclusions

Both fixed and removable retention devices have proven valuable in maintaining orthodontically achieved clinical results. Mobile devices require, precisely because of their nature, an adequate level of compliance because patients must wear them correctly and for the prescribed number of hours (at least 9 h). On the other hand, fixed devices do not present this type of risk but still require a periodic check of the integrity of the wire and its correct adhesion to the tooth surfaces (at least every six months). The risk of recurrence with removable retention devices is approximately 40% after two years of treatment. Fixed retainers are more reliable in maintaining tooth position at the end of therapy.

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Abbreviations

CS	Case Series
CT	Clinical Trials
LII	Little Irregularity Index
O	Observational Studies
PAR	Peer Assessment Rating Index
PRCT	Prospective Randomized Clinical Trials
PSRoB	Prospective StudiesRisk-of-bias
RS	Retrospective Studies
SS	Stainless-Steel
VFR	Vacuum-performed retainer

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