

Stability and Side Effects of Orthodontic Retainers - A Systematic Review

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Abstract

Background: The role of orthodontic retainers in maintaining stability after orthodontic treatment, and side effects associated with orthodontic retainers have not been well established.

Objective: To investigate whether fixed retainers improve stability after orthodontic treatment, or increase the risk of side effects on the teeth and periodontium in comparison with removable retainers, no retainer, or fiberotomy.

Methods: A systematic literature search was conducted in PubMed, Embase, the Cochrane Library, HTA-databases of NHS Centre for Reviews and Dissemination, Swedish Council on Health Technology Assessment (SBU), Norwegian Knowledge Centre for the Health Services (NOKC), Danish Health and Medicines Authority, and reference lists. Data extraction was verified by at least two authors. The quality of evidence was rated. Meta-analysis was not suitable.

Results: Two systematic reviews (SR), two randomized controlled trials (RCT), four non-randomized controlled studies (CT), and five case series were included. The SRs were well reported, but addressed issues that differed from the addressed question, or did not add to the identified primary studies. Both RCTs and CTs had study limitations, and problems with directness and/or precision. None of the studies compared fixed retainers to fiberotomy.

Conclusion: According to the literature there is only low quality of evidence, that treatment stability may be improved by a fixed retainer after orthodontic treatment in comparison with a removable retainer, or no retainer (GRADE ⊕⊕○○). Furthermore, there is very low quality of evidence, whether periodontal outcomes, dental caries prevalence, or presence of calculus differ between the various types of retainer regimens (GRADE ⊕○○○).

Keywords: Orthodontic retainers; Post treatment; Post retention; Systematic review

Abbreviations: CT: Non-randomized Controlled Studies; GRADE: Grading of Recommendations, Assessment, Development and Evaluation; PICO: Population, Intervention, Comparators, outcomes; RCT: Randomized Controlled Trial; SR: Systematic Review

Introduction

Orthodontic treatment in general accomplish well-aligned teeth and a good occlusion. After the teeth have been orthodontically moved into the new position, it takes approximately a year for the surrounding tissues to adapt [1]. If the teeth are not retained during this period a relapse usually occurs, meaning that the teeth return towards their original position. Studies have demonstrated that most of the irregularities appear during the first two years post treatment [2,3].

In addition to the relapse after orthodontic treatment there is a continuous risk that the teeth change position throughout life due to inheritance/genetics and aging processes [4]. The ongoing mesial migration of teeth usually results in a gradual crowding especially for the lower front teeth. Many studies have tried to find predictors of stability without success. A review article from 2006 concludes that most malocclusions are unstable after treatment in the long-term and that stability is unpredictable at the individual level [5].

It is often of great importance for the patient to achieve long-term conservation of the orthodontic treatment result. The orthodontic treatment takes up to two years and is often associated with a substantial cost. These two years are demanding for the patient with regular visits to the orthodontist, pain, discomfort, problems to maintain oral hygiene, and difficulties to eat certain types of food. Furthermore, the patient is exposed to potential side effects including root resorption/shortening and increased a risk of caries.

Patients often receive retainers after the fixed appliance is removed

since it is difficult to predict stability on an individual level and because it is important for the patient to maintain the treatment results.

Retainers can be produced chair side or by a dental technician after a dental impression, and they can be fixed or removable. The fixed retainers are custom made of metal and are bonded to the teeth on the lingual side with composite resin. Fixed retainers usually span the six front teeth, although the extension varies. The removable retainers, usually covers all the teeth and can be vacuum formed or in the form of an acrylic splint with clasps. While the vacuum formed splints can be made chair side on casts the acrylic splints need to be constructed by a dental technician. The fixed retainers and the removable retainers can be used separately or together and the protocols vary. The choice of retainers is a matter of preference and tradition. For the patients there are both pros and cons. The bonded lingual retainer is invisible, but requires proper oral hygiene and often maintenance by the dentist. With the removable retainer there is no oral hygiene problem, but patient compliance is important since the patient must remember to use the retainer, and not to lose it.

Fiberotomy, i.e. cutting the gingival fibers after finishing orthodontic treatment, is another retention approach aiming to shorten the adaption time of the surrounding tissues, in order to prevent relapse.

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This systematic review was initiated to investigate whether fixed retainers improve stability after orthodontic treatment, or increase the risk of side effects on the teeth and periodontium in comparison with removable retainers, no retainer, or fiberotomy.

Materials and Methods

The predefined focused question was: ‘do fixed retainers improve stability after orthodontic treatment, and do they increase the risk of side effects on the teeth and periodontium in comparison with removable retainers, no retainer, or fiberotomy?’

To be included the studies had to concur with the predefined focused question from which the PICO (population, intervention, comparators, outcomes), was derived, and be within the predefined limitations (see below). After the protocol was set (27 September 2013) the focused question or the PICO were not changed.

Population

Patients treated with fixed appliance due to malocclusion of teeth (excluding malocclusion caused by periodontitis or trauma).

Intervention

Fixed retainer for more than two years, after orthodontic treatment.

Comparators

Removable retainer(-s) for more than two years, or no retainer, or fiberotomy.

Outcomes

Treatment stability (of teeth alignment measured by validated

index); periodontal outcomes (i.e. alveolar bone level, attachment loss, gingival recession); dental caries; dental plaque (i.e. biofilm); calculus; gingivitis; complications (e.g. retainer failure).

Limitations Study design

systematic review (SR); randomized controlled trials (RCT); non-randomized, controlled study (CT); case series if ≥ 60 patients (only regarding retainer complications); no case reports or narrative reviews.

Languages

English, Swedish, Norwegian, Danish.

Publication date: Year 1977-, except for the outcome ‘treatment stability’, for which the limit was set at year 2005-, when a comprehensive systematic review from The Swedish Council on Technology Assessment in Health Care was published [6].

Literature searches

Systematic literature searches were conducted (30 September 2013) in PubMed, Embase, the Cochrane Library, and the HTA-databases of NHS Centre for Reviews and Dissemination, the Swedish Council on Health Technology Assessment (SBU), Norwegian Knowledge Centre for the Health Services (NOKC) and Danish Health and Medicines Authority, by two of the authors (ELD, AL), specially trained for search strategies in health technology assessment and SRs. Reference lists of relevant articles were scrutinized for additional references. Detailed search strategies are accounted for in the Appendix, and a graphic presentation of the selection process is presented in Figure 1. Two authors (ELD, AL) selected studies and independently assessed the obtained abstracts

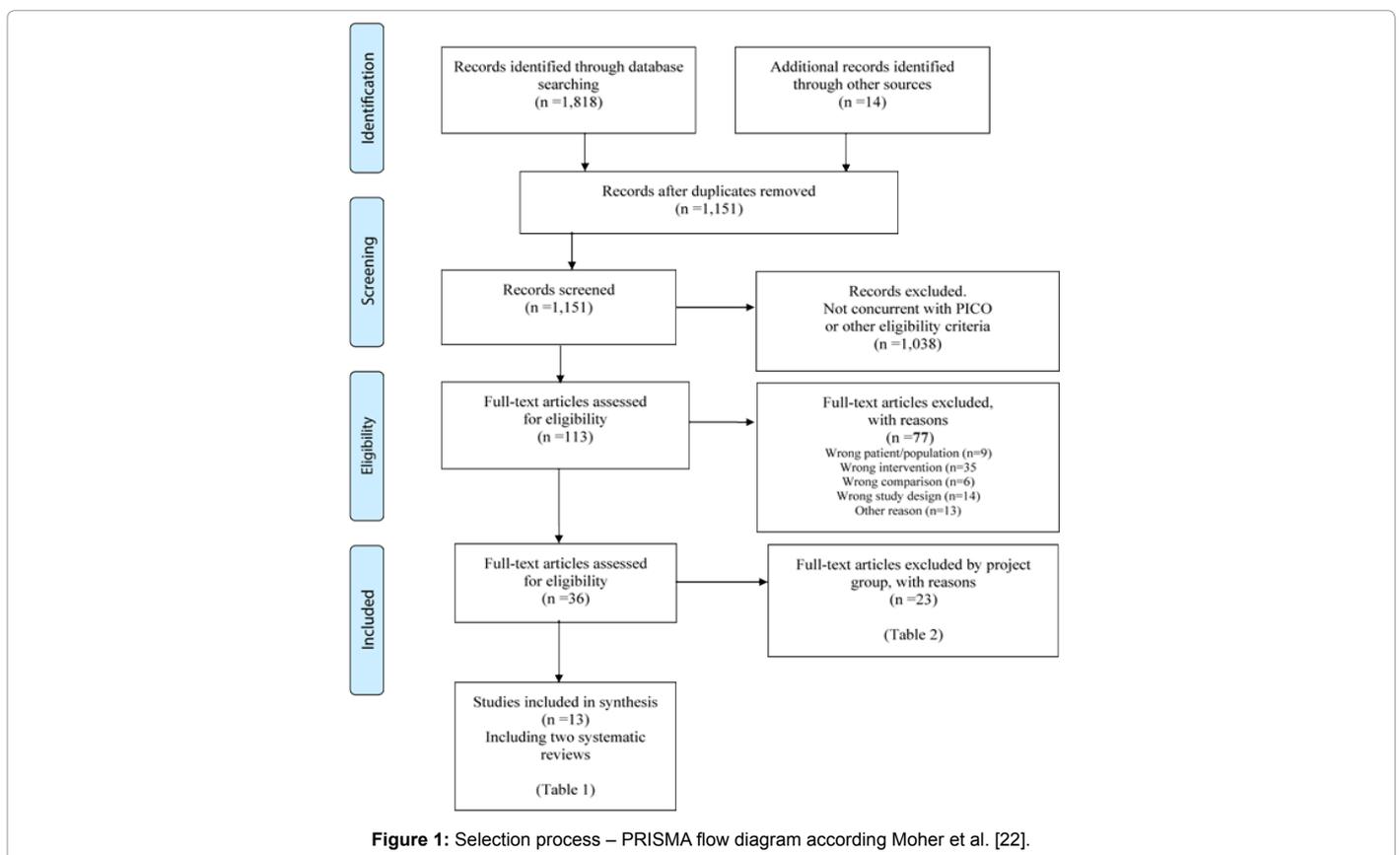


Figure 1: Selection process – PRISMA flow diagram according Moher et al. [22].

for initial selection of full-text articles for inclusion or exclusion. Any disagreements were resolved in consensus.

Study appraisal and rating of evidence

Two of the authors with previous experience in conducting SRs (OS, PS) trained the other authors in study appraisal and rating of the evidence. All included studies were critically appraised. The appraisal of RCTs, and CTs was based on checklists from The Swedish Council on Health Technology Assessment (SBU) [7,8], and the SRs were appraised using the AMSTAR checklist [9]. Case-series were not critically appraised or included in the rating of the quality of evidence. Data extraction from the included studies was verified by at least two authors, for each outcome. In a separate meeting the quality of evidence was rated, for all the studied outcomes separately, across the studies, according to the GRADE approach [10]. Since only two RCTs were available, no meta-analysis was attempted.

Results

Study selection

The literature search identified a total of 1,151 articles, after

removal of duplicates (Figure 1). Two authors (ELD, AL) then excluded 1,038 articles after reading the abstracts. Additionally 77 articles were excluded after reading the articles in full text. The remaining 36 articles were sent to all the authors, who read the articles independently. In a consensus meeting 13 articles were included in the systematic review.

There were two SRs, two RCTs, and four CTs that had studied the effect of a fixed retainer compared to a removable retainer, or to no retainer, after orthodontic treatment.

None of the included studies had compared fixed retainer with fibrotomy.

Five case series were included with regard to complications. Study characteristics of the included articles are presented in Table 1, and excluded articles in Table 2.

Methodological quality

The SRs were well reported, but addressed issues that differed from the here addressed question, or did not add to the included primary studies. Littlewood et al. included only one of the studies included in the present SR [2], whereas Bondemark et al. evaluated morphologic

Article	Study Design ^a	Follow-up period (years)	Study Groups; Intervention vs control	Patients (n)	Mean Age (years)	Men/women	Outcome variables
Bondemark <i>et al.</i> (2007) [5]	Systematic review	≥ 5 years	Various different	38 studies ^b	nr	nr	Treatment stability
Littlewood <i>et al.</i> (2006a) [2]	Systematic review	> 3 months	Various different	5 studies 442	nr	nr	Treatment stability Retainer failure
Edman Tynelius <i>et al.</i> (2013) [13]	RCT	2 years	Removable upper retainer and fixed lower retainer	25	14	30/45	Treatment stability Retainer failure
			Removable upper retainer and stripping lower anterior teeth	25			
			Removable upper and lower retainer (positioner)	25			
Artun <i>et al.</i> (1997) [11]	RCT	3 years	Fixed retainer	35	nr	nr	Calculus Dental caries Gingivitis Incisor irregularity Loss of attachment Plaque Retainer failure
			Removable retainer	14			
Cerny <i>et al.</i> (2010) [12]	CT	> 15 years	Fixed retainer (mixed groups)	41	nr	nr	Treatment stability Alveolar bone level Calculus Dental caries Periodontitis (Gingival recession) Gingivitis Plaque Retainer failure
		≤ 2 years	Removable retainer	18			
Levin <i>et al.</i> (2008) [16]	CT	4.6 years	Fixed retainer No retainer	48 arches 72 arches	21	46/46	Gingival pocket depth Gingival recession Gingivitis Plaque
Rody <i>et al.</i> (2011) [15]	CT	≥ 4 years	Fixed retainer	10	28	7-Mar	Gingivitis
			Removable lower retainer	11	24	2-Sep	Periodontitis (Gingival pocket depth)
			No retainer	10	27	5-May	Plaque
Artun (1984) [14]	CT	Approx.	Fixed 3-3 retainer	49	17-19	nr	Calculus
			No 3-3 retainer	25	17		Dental caries
		1-9 years	Fixed maxillary retainer	14	22		Gingivitis
			Removable maxillary retainer	20	16		Periodontitis (Gingival pocket depth) Plaque
Andrén <i>et al.</i> (1998) [18]	Case-series	≥ 5 years	Fixed retainer	103	35	22/81	Complications

Dahl and Zachrisson (1991) [17]	Case-series	3-6 years	Fixed retainer	142	nr	nr	Retainer failure
Renkema <i>et al.</i> (2011) [21]	Case-series	5 years	Fixed retainer	221	nr	146/75	Other complications Retainer failure
Störmann and Ehmer (2002) [19]	Case-series	2 years	Fixed retainer	103	13-17		Patient discomfort Retainer failure
Tacken <i>et al.</i> (2010) [20]	Case-series ^c	2 years	Fixed retainer	184	14	90/94	Gingivitis Plaque Retainer failure

^a Case-series were only used to record complications. ^b Number of included patients, not reported. ^c CT, in this context considered as case-series regarding fixed retainer (control group without orthodontic treatment). CT = non-randomised, controlled study. nr = not reported.

Table 1: Included studies and patient characteristics (alphabetically, according to study design).

Articles	Reason for exclusion
Al Yami <i>et al.</i> (1999) [23]	Stability after orthodontic treatment, published before year 2005
Booth <i>et al.</i> (2008) [24]	Wrong comparison (time point when retainer was lost was not stated)
Danz <i>et al.</i> (2012) [25]	Wrong patient groups (data not extractable for different types of retainers)
Devreese <i>et al.</i> (2007) [26]	Wrong outcome (case-series, no complications reported)
Freitas <i>et al.</i> (2013) [27]	Wrong intervention and comparison (compares other interventions)
Johnsson <i>et al.</i> (2007) [28]	Wrong intervention and comparison (compares two clinics)
Kuijpers <i>et al.</i> (2009) [29]	Wrong outcome (studies occlusal wear)
Lagerström <i>et al.</i> (2011) [30]	Wrong comparison (time point when retainer was lost was not stated)
Lagravere <i>et al.</i> (2005) [31]	Wrong intervention (studies rapid maxillary expansion)
Lang <i>et al.</i> (2002) [32]	Stability after orthodontic treatment, published before year 2005
Littlewood <i>et al.</i> (2006b) [3]	Same data as in Littlewood <i>et al.</i> , 2006a
Maia <i>et al.</i> (2010) [33]	Wrong outcome (case-series, no complications reported)
McNamara <i>et al.</i> (2003) [34]	Wrong intervention (studies rapid maxillary expansion vs. no orthodontics)
Millet <i>et al.</i> (2012) [35]	Wrong Intervention studied in systematic review
Morton and Panherz (2009) [36]	Wrong outcome (case-series, no complications reported)
Myser <i>et al.</i> (2013) [37]	Case-series with too few patients (included 25 out of 66 eligible)
Renkema <i>et al.</i> (2008) [38]	Data not extractable
Renkema <i>et al.</i> (2013a) [39]	Wrong outcome (case-series does not study complications)
Renkema <i>et al.</i> (2013b) [40]	Wrong intervention (does not study retainer)
Renkema <i>et al.</i> (2013c) [41]	Wrong intervention (does not study retainer)
Sari <i>et al.</i> (2009) [42]	Wrong intervention (too short follow-up)
SBU (2005) [6]	Data presented in Bondemark <i>et al.</i> , 2007
Tofeldt <i>et al.</i> (2007) [43]	Wrong intervention and comparison (compares two clinics)

Table 2: Excluded articles (alphabetically, with reasons for exclusion).

stability and patient satisfaction after at least five years of orthodontic treatment [5]. Thus, the SRs were only commented on.

The RCTs had some, or major study limitations (risk of bias), mainly regarding randomization and blinding, and had problems with directness and/or precision (Table 3).

None of the four CTs were blinded, and all had some, or major problems regarding directness and precision (Table 3).

Summary of findings and quality of evidence

Fixed orthodontic retainer versus removable retainer -

Article / Study design	Random sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Selective reporting	Other bias	Directness	Precision
Edman Tynelius <i>et al.</i> (2013) [13] / RCT	+	+	-	-	+	+	+	?	+
Artun <i>et al.</i> (1997) [11] / RCT	?	?	-	-	+	+	+	-	?
Cerny <i>et al.</i> (2010) [12] / CT	Na	Na	-	-	+	+	?	-	-
Levin <i>et al.</i> (2008) [16] / CT	Na	Na	-	-	+	+	?	?	-
Rody <i>et al.</i> (2011) [15] / CT	Na	Na	-	-	+	+	?	-	-
Artun (1984) [14] / CT	Na	Na	-	-	+	+	?	-	-

+ = low risk/no problems; ? = unclear risk/some problems; -= high risk/major problems; CT = non-randomised controlled study; Na=Not applicable; RCT = Randomised controlled trial

Table 3: Study limitations in controlled studies.

Treatment stability: The SRs did not report comparisons of different types of retainers [2,5]. Two RCTs and one CT compared treatment stability with fixed retainer and removable retainer [11-13] (Table 4). The RCT by Edman Tynelius et al., reported significantly better

treatment stability after two years of retention in the lower dental for a fixed retainer (change in Little's irregularity index, LII: 0.6) compared to removable retainers (Δ LII: 1.6) [13]. There was also a significant difference regarding other measurements of dental alignment between

Author, year	Country	Study design	Number of patients (n)	With drawsals - dropouts	Results		Comments
					Intervention Fixed retainer	Control Removable retainer	
Edman Tynelius, 2013 [13]	Sweden	RCT	n=75 Group 1 n=25 Group 2 n=25 Group 3 n=25	n=6	Maxilla	Maxilla	Little's Irregularity Index (LII)= the linear distance from anatomic contact point to adjacent anatomic contact point of mandibular anterior teeth (sum of five measurements) Group 1= upper removable retainer (vacuum formed) and lower fixed retainer. Group 2= upper removable retainer (vacuum formed) and lower stripping. Group 3= removable retainer upper and lower (positioner).
					Group 1 at 2 years: Δ LII 0.5 (sd 0.8)	Group 2 at 2 years: Δ LII 0.9 (sd 1.1)	
						Group 3 at 2 years: Δ LII 1.1 (sd 1.4) ns.	
					Mandible	Mandible	
					Group 1 at 2 years: Δ LII 0.6 (sd 0.7)	Group 2 at 2 years: Δ LII 0.9 (sd 0.8)	
						Group 3 at 2 years: Δ LII 1.6 (sd 1.4) p<0.001 between group 1 and 3	
					Overjet	Overjet	
					Group 1 at 2 years: Δ -0.3 mm (sd 1.1)	Group 2 at 2 years: Δ 0.5 mm (sd 1.1)	
						Group 3 at 2 years: Δ 0.4 mm (sd 1.0) p< 0.05 between group 1 and 2	
						Overbite	
	Group 2 at 2 years: Δ 0.4mm (sd 0.9)						
	Group 3 at 2 years: Δ 0.2mm (sd 1.3) ns.						
Overbite	Inter canine width maxilla	Occlusal traits					
Group 1 at 2 years: Δ -0.4mm (sd 1.1)	Group 2 at 2 years: Δ -0.9 mm (sd 0.9)						
	Inter canine width maxilla	Occlusal traits					
	Group 3 at 2 years: Δ -1.8 mm (sd 1.5) p<0.01 group 1 & 2 vs. group 3						
	Inter canine width maxilla	Occlusal traits					
Group 1 at 2 years: Δ -1.0 mm (sd 0.8)	Group 2 at 2 years: Δ -1.0 mm (sd 1.0)						
	Inter canine width mandible	Occlusal traits					
Group 1 at 2 years: Δ 0.2 mm (sd 0.5)	Group 3 at 2 years Δ -1.1 mm (sd 1.2) p<0.001 group 1 vs. group2 & 3						

Artun, 1997 [11]	USA	RCT	n=49 Group 1 n=11 Group 2 n=13 Group 3 n=11 Group 4 n=14	? ^a	Group 1 Baseline: 0.65 (se 0.24) At 3 years: 1.19 (se 0.27) Group 2 Baseline: 0.20 (se 0.08) At 3 years: 0.36 (se 0.12) Group 3 Baseline: 0.30 (se 0.16) At 3 years: 0.30 (se 0.16)	Group 4 Baseline: 0.36 (se 0.13) At 3 years: 0.66 (se 0.25) ns.	Little's Irregularity Index Group 1= Mandibular cuspid retainer .032 plain wire Group 2= Mandibular cuspid retainer.032 spiral wire Group 3= Mandibular 3-3 retainer .0205 flexible spiral wire Group 4= Removable lower retainer Cuspid retainer- bonded only to cuspids 3-3 retainer- bonded to each tooth Little's Irregularity Index= the linear distance from anatomic contact point to adjacent anatomic contact point of mandibular anterior teeth (sum of five measurements)
Cerny, 2010 [12]	UK	CT	n=61 Group 1 n=46 Group 2 n=43	? ^a	At 15 years follow up: No relapse: 89.0% Mild relapse: 11% Moderate relapse: 0.0% Severe relapse: 0.0% Totals: 26 mm Mean: 0.26mm	At 15 years follow up: No relapse: 7.0% p<0.001 Mild relapse: 40% p<0.001 Moderate relapse: 42% p<0.001 Severe relapse: 11% ns. Mean: 3.37 mm	Little's Irregularity Index Group 1= Permanent bonded retainer (PBR) (upper or lower). Group 2= Removable retainer (RR). Proportion individuals with relapse in the anterior teeth according to Little's Irregularity Index relapse category: No relapse: 0-1 mm Mild relapse: 1-3 mm Moderate relapse: 3-6 mm Severe relapse: (>6 mm) The retainers were used different times for different individuals, after treatment. The groups were analyzed according to retainer type used for each dental arch. Not for each individual. Smokers and those >50 years were excluded from analysis.

^a Withdrawals and drop-outs not explicitly stated. CT = non-randomised, controlled study. ns = not significant

Table 4: Fixed orthodontic retainer versus removable retainer - Treatment stability (alphabetically, according to study design).

the three study groups, but the interventions were mixed between upper and lower arch, which made it difficult to draw clinically meaningful conclusions. The other RCT did not report significant differences regarding treatment stability [11].

The CT reported a significantly higher proportion of relapse in the removable retainer group [12]. However, the outcome was not reported on the individual patient level, but on the dental arch level. Furthermore, there was no information of baseline characteristics of the study groups.

Conclusion: Treatment stability may be improved by fixed retainer compared to removable retainer. Low quality of evidence (GRADE ⊕○○○).

Fixed orthodontic retainer versus removable retainer - Periodontal outcomes: One RCT and three CTs reported on periodontal outcomes after treatment with fixed retainer and removable retainer [11,12,14,15]. One CT reported statistically significant (0.27 mm), but not clinically important, deeper gingival crevices in the fixed retainer group than in the removable retainer group [14]. There were no significant differences between study groups group in any other periodontal outcomes, across the studies (Table 5).

Conclusion: It is uncertain whether periodontal outcomes differ between fixed retainer and removable retainer. Very low quality of evidence (GRADE ⊕○○○).

Fixed orthodontic retainer versus removable retainer - Dental caries: One RCT and two CTs reported on caries prevalence after

treatment with fixed retainer and removable retainer [11,12,14]. No dental caries was detected in the study groups (Table 6).

Conclusion: It is uncertain whether the prevalence of dental caries differs between individuals with fixed retainer or removable retainer. Very low quality of evidence (GRADE ⊕○○○).

Fixed orthodontic retainer versus removable retainer - Dental plaque: One RCT and three CTs reported on accumulation of dental plaque after treatment with fixed retainer and removable retainer [11,12,14,15]. There were no significant differences between the study groups (Table 7).

Conclusion: It is uncertain whether accumulation of dental plaque differs between individuals with fixed retainer or removable retainer. Very low quality of evidence (GRADE ⊕○○○).

Fixed orthodontic retainer versus removable retainer - Calculus: One RCT and two CTs reported on presence of calculus after treatment with fixed retainer and removable retainer [11,12,14]. There were no significant differences between the study groups (Table 8).

Conclusion: It is uncertain whether presence of calculus differs between individuals with fixed retainer or removable retainer. Very low quality of evidence (GRADE ⊕○○○).

Fixed orthodontic retainer versus removable retainer - Gingivitis: One RCT and three CTs reported prevalence of gingivitis after treatment with fixed retainer versus removable retainer [11,12,14,15]. None of the studies reported significant difference between individuals with fixed or removable retainers (Table 9).

Author, year	Country	Study design	Number of patients (n)	With draws - dropouts	Result		Comments
					Intervention Fixed retainer	Control Removable retainer	
Artun, 1997 [11]	USA	RCT	n=49 Group 1: n=11 Group 2: n=13 Group 3: n=11 Group 4: n=14	? ^a	Group 1: 0.85mm (sd 0.55) Group 2: 0.63mm (sd 0.20) Group 3: 0.62mm (sd 0.25)	Group 4: 0.72mm (sd 0.33) ns.	Attachment loss (i.e. probing attachment level from cement-enamel junction to the bottom of the gingival pocket). Group 1= Mandibular cuspid retainer .032 plain wire. Group 2= Mandibular cuspid retainer .032 spiral wire. Group 3= Mandibular 3-3 retainer .0205 flexible spiral wire. Group 4= Removable lower retainer. Cuspid retainer- bonded only to cuspids. 3-3 retainer- bonded to each tooth.
Cerny, 2010 [12]	UK	CT	n=61 Group 1: n=46 Group 2: n=43	? ^a	No gingival recession Alveolar bone level Group 1: maxilla: Good or very good: 85% Group 1, mandible: Good or very good: 100%	No gingival recession Alveolar bone level Group 2, maxilla: Good or very good: 90% Group 2, mandible: Good or very good: 90% ns.	Gingival recession Alveolar bone level rating: Very good, good, fair, poor, very poor. Group 1= Permanent bonded retainer (PBR) (upper or lower). Group 2= Removable retainer (RR). Smokers and those >50 years were excluded from analysis.
Rody, 2011 [15]	Canada	CT	n=31 Group 1: n=10 Group 2: n=11 (Group 3: n=10)	? ^a	Group 1 Incisor: 1.85 mm (sd 0.81) Premolar: 2.15 mm (sd 0.94)	Group 2 Incisor: 1.68 mm (sd 0.46) Premolar: 2.04 mm (sd 0.56) ns.	Probing depth Group 1= 3-3 fixed lower retainer Group 2= Removable lower retainer (Group 3= No retainer).
Artun, 1984 [14]	Norway	CT	n=108 Group 1: n= 31 Group 2: n=18 Group 3: n=14 Group 4: n=20 (Group 5: n= 25)	? ^a	Group 3 1.87mm (sd 0.44)	Group 4 1.60mm (sd 0.31) p<0.05	Crevice depth Group 1= Mandibular cuspid retainer .032 spiral wire. Group 2= Mandibular cuspid retainer .032 plain wire. Group 3= Maxillary .0195 flexible spiral wire retainer. Group 4= Maxillary retainer plate. (Group 5= No retainer). Cuspid retainer = bonded only to cuspids. 3-3- retainer = bonded to each tooth.

^a Withdrawals and drop-out not explicitly stated. CT = non-randomised, controlled study. ns = not significant

Table 5: Fixed orthodontic retainer versus removable retainer - Periodontal outcomes (alphabetically, according to study design).

Conclusion: It is uncertain whether prevalence of gingivitis differs between individuals with fixed retainer or removable retainer. Very low quality of evidence (GRADE ⊕○○○).

Fixed orthodontic retainer versus no retainer - Treatment stability: None of the included studies reported this outcome.

Fixed orthodontic retainer versus no retainer - Periodontal outcomes: Three CTs compared periodontal outcomes in subjects with fixed retainer or without any type of retainer [14-16]. Only Levin et al., reported significantly less lingual gingival retraction in the removable

retainer group, but the difference was not clinically important (0.08 mm) [16] (Table 10).

Conclusion: It is uncertain whether periodontal outcomes differ between individuals with fixed retainer or no retainer. Very low quality of evidence (GRADE ⊕○○○).

Fixed orthodontic retainer versus no retainer - Dental caries: One CT reported on caries prevalence after treatment with fixed retainer or with no retainer [14]. No caries was detected on the lingual surfaces in the two study groups (Table 11).

Author, year	Country	Study design	Number of patients (n)	With draws - dropouts	Result		Comments
					Intervention Fixed retainer	Control Removable retainer	
Artun, 1997 [11]	USA	RCT	n=49 Group 1: n=11 Group 2: n=13 Group 3: n=11 Group 4: n=14	? ^a	No caries	No caries	Group 1= Mandibular cuspid retainer .032 plain wire Group 2= Mandibular cuspid retainer .032 spiral wire Group 3= Mandibular 3-3 retainer .0205 flexible spiral wire Group 4= Removable lower retainer Cuspid retainer- bonded only to cuspids. 3-3 retainer- bonded to each tooth
Cerny, 2010 [12]	UK	CT	n=61 Group 1: n=46 Group 2: n=43	? ^a	No caries	No caries	Group 1= Permanent bonded retainer (PBR) (upper or lower) Group 2= Removable retainer (RR) Smokers and those >50 years were excluded from analysis.
Artun, 1984 [14]	Norway	CT	n=108 Group 1: n= 31 Group 2: n=18 Group 3: n=14 Group 4: n=20 (Group 5: n= 25)	? ^a	No caries	No caries	Group 1= Mandibular cuspid retainer .032 spiral wire. Group 2= Mandibular cuspid retainer .032 plain wire. Group 3= Maxillary .0195 flexible spiral wire retainer. Group 4= Maxillary retainer plate. (Group 5= No retainer). Cuspid retainer = bonded only to cuspids. 3-3- retainer = bonded to each tooth.

^a Withdrawals and drop-outs not explicitly stated. CT = non-randomised, controlled study. ns = not significant

Table 6 Fixed orthodontic retainer versus removable retainer - Dental caries (alphabetically, according to study design).

Author, year	Country	Study design	Number of patients (n)	With draws - dropouts	Result		Comments
					Intervention Fixed retainer	Control Removable retainer	
Artun, 1997 [11]	USA	RCT	n=49 Group 1: n=11 Group 2: n=13 Group 3: n=11 Group 4: n=14	? ^a	Group 1 Baseline: 0.32 (se 0.20) At 3 years: 0.06 (se 0.02) Group 2 Baseline: 0.17 (se 0.08) At 3 years: 0.10 (se 0.03) Group 3 Baseline: 0.26 (se 0.2) At 3 years: 0.13 (se 0.07)	Group 4 Baseline: 0.31 (se 0.11) At 3 years: 0.13 (se 0.06) ns.	Plaque index Group 1= Mandibular cuspid retainer .032 plain wire. Group 2= Mandibular cuspid retainer .032 spiral wire. Group 3= Mandibular 3-3 retainer .0205 flexible spiral wire. Group 4= Removable lower retainer. Cuspid retainer- bonded only to cuspids. 3-3 retainer- bonded to each tooth.
Cerny, 2010 [12]	UK	CT	n=61 Group 1: n=46 Group 2: n=43	? ^a	Group 1 Mandibular lingual Good or very good 40%	Group 2 Mandibular lingual Good or very good 80% ns.	Group 1= Permanent bonded retainer (upper or lower). Group 2 = Removable retainer. Dental plaque accumulation rating: Very good, good, fair, poor, very poor. Smokers and those >50 years were excluded from analysis.
Rody, 2011 [15]	Canada	CT	n=31 Group 1: n=10 Group 2: n=11 (Group 3: n=10)	? ^a	Group 1, incisors: 60 % (sd 52) Group 1, premolars: 10 % (sd 31.6)	Group 2, incisors: 18.18% (sd 40) p<0.05 Group 2, premolars: 9.1% (sd 30) ns.	Group 1= 3-3 fixed lower retainer. Group 2= Removable lower retainer. (Group 3= No retainer). Proportion of tooth surfaces with dental plaque.

Artun, 1984 [14]	Norway	CT	n=108 Group 1: n=31 Group 2: n=18 Group 3: n=14 Group 4: n=20 (Group 5: n=25)	? ^a	Gingival margin: Group 3 Interprox: 0.83 (sd 0.41) Lingual: 0.49 (sd 0.47) Gingivally along wire: Group 1 Lingual: 0.17 (sd 0.23) Group 2 Lingual: 0.32 (sd 0.29) p<0.05 Between group 1 and 2 Gingivally along wire Interproximal: Group 1 versus Group 2 ns. Incisally along wire: Group 1 versus Group 2 ns. Gingival margin: Group 1 versus Group 2 ns.	Gingival margin: Group 4 Interprox: 0.64 (sd 0.43) Lingual: 0.38 (sd 0.40) ns.	Group 1= Mandibular cuspid retainer .032 spiral wire. Group 2= Mandibular cuspid retainer .032 plain wire. Group 3= Maxillary .0195 flexible spiral wire retainer. Group 4= Maxillary retainer plate. (Group 5= No retainer). Cuspid retainer = bonded only to cuspids. 3-3- retainer = bonded to each tooth.
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^a Withdrawals and drop-outs not explicitly stated. CT = non-randomised, controlled study. ns = not significant

Table 7: Fixed orthodontic retainer versus removable retainer - Dental plaque (alphabetically, according to study design).

Conclusion: It is uncertain whether caries prevalence differs between individuals with fixed retainer or no retainer. Very low quality of evidence (GRADE ⊕○○○○).

Fixed orthodontic retainer versus no retainer - Dental plaque: Three CTs reported on dental plaque accumulation after treatment with fixed retainer or with no retainer [14-16]. Two of them reported a significantly higher accumulation of plaque on the tooth surfaces adjacent to the fixed retainer compared to same tooth surfaces in individuals without a retainer, 82% vs. 52%, and 60% vs. 10%, respectively [14, 16] (Table 12).

Conclusion: It is uncertain whether fixed retainer contributes to

increased accumulation of dental plaque compared to no retainer. Very low quality of evidence (GRADE ⊕○○○○) (Table 12).

Fixed orthodontic retainer versus no retainer – Calculus: One CT reported on the presence of calculus after treatment with fixed retainer or with no retainer [14]. There was no significant difference between the study groups (Table 13).

Conclusion: It is uncertain whether presence of calculus differs between individuals with fixed retainer or no retainer. Very low quality of evidence (GRADE ⊕○○○○).

Fixed orthodontic retainer versus no retainer – Gingivitis: Three CTs reported prevalence of gingivitis after treatment with fixed retainer

Author, year	Country	Study design	Number of patients (n)	With draws - dropouts	Results		Comments
					Intervention Fixed retainer	Control Removable retainer	
Artun, 1997 [11]	USA	RCT	n=49 Group 1: n=11 Group 2: n=13 Group 3: n=11 Group 4: n=14	? ^a	Group 1 Baseline: 16.67 (se 8.03) At 3 years: 3.33 (se 2.22) Group 2 Baseline: 8.64 (se 4.45) At 3 years: 3.09 (se 3.09) Group 3 Baseline: 17.36 (se 6.84) At 3 years: 17.36 (se 8.87)	Group 4 Baseline: 9.52 (se 5.45) At 3 years: 8.33 (se 5.61) ns.	Calculus index Group 1= Mandibular cuspid retainer .032 plain wire. Group 2= Mandibular cuspid retainer .032 spiral wire. Group 3= Mandibular 3-3 retainer .0205 flexible spiral wire. Group 4= Removable lower retainer. Cuspid retainer- bonded only to cuspids. 3-3 retainer- bonded to each tooth.
Cerny, 2010 [12]	UK	CT	n=61 Group 1: n=46 Group 2: n=43	? ^a	Group 1 Mandible Good or very good: 80% Maxilla No calculus	Group 2 Mandible Good or very good: 100% ns. Maxilla No calculus	Calculus index Group 1= Permanent bonded retainer (PBR) (upper or lower). Group 2= Removable retainer (RR). Smokers and those >50 years were excluded from analysis.

Artun, 1984 [14]	Norway	CT	n=108 Group 1: n= 31 Group 2: n=18 Group 3: n=14 Group 4: n=20 (Group 5: n= 25)	? ^a	<p><u>Gingivally along wire:</u></p> <p>Group 1 Interproximal: 0.22 (sd 0.37) Lingual: 0.15 (sd 0.28)</p> <p>Group 2 Interproximal: 0.54 (sd 0.53) Lingual: 0.37 (sd 0.43)</p> <p>p<0.05 (group 1 vs. 2)</p> <p><u>Incisally along wire:</u></p> <p>Group 1 Interproximal: 0.07 (sd 0.21) Lingual: 0.06 (sd 0.18)</p> <p>Group 2 Interproximal: 0.05 (sd 0.12) Lingual: 0 (sd 0)</p> <p>ns. (group 1 vs. 2)</p> <p><u>Gingival margin</u></p> <p>Group 1 Interproximal: 0.29 (sd 0.35) Lingual: 0.18 (sd 0.28)</p> <p>Group 2 Interproximal: 0.49 (sd 0.43) Lingual: 0.30 (sd 0.30)</p> <p>ns. (group 1 vs. 2)</p> <p><u>Gingival margin:</u></p> <p>Group 3 Interproximal: 0 (sd 0) Lingual: 0 (sd 0)</p>	<p><u>Gingival margin:</u></p> <p>Group 4 Interproximal: 0 (sd 0) Lingual: 0.01 (sd 0.04)</p> <p>ns. (group 3 vs. 4)</p>	<p>Presence of calculus at different locations (different calculus indices)</p> <p>Group 1= Mandibular cuspid retainer .032 spiral wire. Group 2= Mandibular cuspid retainer .032 plain wire. Group 3= Maxillary .0195 flexible spiral wire retainer. Group 4= Maxillary retainer plate (Group 5= No retainer).</p> <p>Cuspid retainer = bonded only to cuspids. 3-3- retainer = bonded to each tooth.</p>
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^a Withdrawals and drop-outs not explicitly stated. CT = non-randomised, controlled study. ns = not significant

Table 8: Fixed orthodontic retainer versus removable retainer – Calculus (alphabetically, according to study design).

Author, year	Country	Study design	Number of patients (n)	With draws - dropouts	Result		Comments
					Intervention Fixed retainer	Control Removable retainer	
Artun, 1997 [11]	USA	RCT	n=49 Group1: n=11 Group 2: n=13 Group 3: n=11 Group 4: n=14	? ^a	Group 3 Baseline: 1.14 (se 0.07) At 3 years: 0.39 (se 0.15)	Group 4 Baseline: 1.08 (se 0.07) At 3 years: 0.77 (se 0.11) ns.	Gingivitis Group 1 = Mandibular cuspid retainer .032 plain wire. Group 2 = Mandibular cuspid retainer .032 spiral wire. Group 3 = Mandibular 3-3 retainer .0205 flexible spiral wire. Group 4 = Removable lower retainer. Cuspid retainer- bonded only to cuspids. 3-3 retainer- bonded to each tooth.

Cerny, 2010 [12]	UK	CT	n=61 Group 1: n=46 Group 2: n=43	? ^a	<u>Maxilla</u> Good or very good 100% <u>Mandible</u> Good or very good 80%	<u>Maxilla</u> Good or very good 100% <u>Mandible</u> Good or very good 95% ns.	Modified gingival index. Group 1 = Permanent bonded retainer (PBR), upper or lower. Group 2 = Removable retainer (RR). * Smokers and those >50 years were excluded from analysis.
Rody, 2011 [15]	Canada	CT	n=31 Group 1. n=10 Group 2. n=11 (Group 3: n=10)	? ^a	Group 1 Incisor: 30% (sd 48.3) Premolar: 20%(sd 42.16)	Group 2 Incisor: 0% Premolar: 18.18% (sd 40.45) ns.	Bleeding on probing BOP Group 1 = 3-3 fixed lower retainer. Group 2 = Removable lower retainer. (Group 3 = No retainer)
Artun, 1984 [14]	Norway	CT	n=108 Group 1: n= 31 Group 2: n=18 Group 3: n=14 Group 4: n=20 (Group 5: n= 25)	? ^a	Group 1 GI Interproximal: 1.34 (sd 0.29) Lingual: 1.05 (sd 0.10) Group 2 GI Interproximal: 1.26 (sd 0.25) Lingual: 1.08 (sd 0.17) ns. (group 1 vs. 2) Group 3 GI: Interproximal: 1.20 (sd 0.23) Lingual: 1.04 (sd 0.13) Group 1 NBP interproximal: 0.75 (sd 0.28) Group 2 NBP interproximal: 0.67 (sd 0.27) ns. (group 1 vs. 2) Group 3 NBP interproximal: 0.52 (sd 0.34)	Group 4 GI: Interproximal: 1.23 (sd 0.23) Lingual: 1.05 (sd 0.13) ns. (group 3 vs. 4) Group 4 NBP interproximal: 0.58 (sd 0.31) ns. (group 3 vs. 4)	GI = Gingival index. NBP =Non bleeding papilla. Group 1= Mandibular cuspid retainer .032 spiral wire. Group 2= Mandibular cuspid retainer .032 plain wire. Group 3= Maxillary .0195 flexible spiral wire retainer Group 4= Maxillary retainer plate (Group 5= No retainer) Cuspid retainer = bonded only to cuspids. 3-3- retainer = bonded to each tooth.

^a Withdrawals and drop-outs not explicitly stated. CT = non-randomised, controlled study. ns = not significant

Table 9: Fixed orthodontic retainer versus removable retainer – Gingivitis (alphabetically, according to study design).

or with no retainer [14-16]. In two of the studies, there was significantly more gingivitis in areas adjacent to the fixed retainer compared to same areas in individuals without retainer [14,16] (Table 14).

Conclusion: It is uncertain whether the prevalence of gingivitis is higher among individuals with fixed retainer compared to those with no retainer. Very low quality of evidence (GRADE ⊕○○○).

Fixed orthodontic retainer versus removable retainer, or no retainer – Complications: Complications were reported in two RCTs [11, 13], one CT [12], and in five case series [17-21]. The most common complication reported in the studies was retainer failure. The incidence varied substantially across the studies with a range from 0% to 100%

of the retainers. In the SR by Littlewood et al., there were no reported differences in the technical survival rates of fixed or removable retainers over three years follow-up [2]. This conclusion was based on data from Årtun et al. [11]. However, in the more recently published RCT failures were significantly more common for fixed retainers [13] (Table 15).

Fixed orthodontic retainer versus fiberotomy: No studies were identified in which fixed retainer was compared with fiberotomy. The ratings of the quality of evidence (GRADE) for different outcomes regarding fixed orthodontic retainer versus removable retainer are presented in Table 16, and regarding fixed orthodontic retainer versus no retainer in Table 17.

Author, year	Country	Study design	Number of patients (n)	With draws - dropouts	Results		Comments
					Intervention	Control	
					Fixed retainer	No retainer	
Levin, 2008 [16]	Israel	CT	n=92 Group 1: n=48 dental arches Group 2: n=72 dental arches	n=0	Group 1 GR lingual 0.09 mm (sd 0.18) GR labial: 0.14 mm (sd 0.24) PD 1.88 mm (sd 0.24)	Group 2 GR lingual 0.01 mm (sd 0.08) p=0.005 GR labial: 0.13 mm (sd 0.29) ns. PD 1.87 mm (sd 0.23) ns.	Gingival recession (GR). Probing depth (PD). Group 1 = One or two fixed retainers. Group 2 = No fixed retainer.
Rody, 2011 [15]	Canada	CT	n=31 Group 1. n=10 Group 2. n=11** Group 3: n=10	? ^a	Group 1 Incisors: Mean: 1.85 mm (sd 0.81) Premolars: Mean: 2.15 mm (sd 0.94)	Group 3 Incisors: Mean: 1.7 mm (sd 0.63) ns. Premolars: Mean: 2.05 mm (sd 0.59) ns.	Probing depths. Group 1 = 3-3 fixed lower retainer. Group 2 = Removable lower retainer. Group 3 = No retainer.
Artun, 1984 [14]	Norway	CT	n=108 Group 1: n= 31 Group 2: n=18 Group 3: n=14 (Group 4: n=20) Group 5: n= 25	? ^a	Groups 1 and 2 Interproximal Mean: 1.46 (sd 0.30) Lingual Mean: 1.07 (sd 0.15)	Group 5 Interproximal Mean: 1.42 (sd 0.32) ns. Lingual Mean: 1.11 (sd 0.16) ns.	Crevice depth Group 1 = Mandibular cuspid retainer .032 spiral wire. Group 2 = Mandibular cuspid retainer .032 plain wire Group 3 = Maxillary .0195 flexible spiral wire retainer. (Group 4 = Maxillary retainer plate). Group 5 = No retainer. Cuspid retainer = bonded only to cuspids. 3-3- retainer = bonded to each tooth.

^a Withdrawals and drop-outs not explicitly stated. CT = non-randomised, controlled study. ns = not significant

Table 10: Fixed orthodontic retainer versus no retainer - Periodontal outcomes (alphabetically, according to study design).

Author, year	Country	Study design	Number of patients (n)	With draws - dropouts	Results		Comments
					Intervention Fixed retainer	Control No retainer	
Artun, 1984 [14]	Norway	CT	n=108 Group 1: n= 31 Group 2: n=18 Group 3: n=14 (Group 4: n=20) Group 5: n= 25	? ^a	No caries	No caries	Dental caries on lingual surfaces Group 1 = Mandibular cuspid retainer .032 spiral wire. Group 2 = Mandibular cuspid retainer .032 plain wire. Group 3 = Maxillary .0195 flexible spiral wire. Group 4 = Maxillary retainer plate Group 5 = No retainer. Cuspid retainer = bonded only to cuspids. 3-3- retainer = bonded to each tooth.

^a Withdrawals and drop-outs not explicitly stated. CT = non-randomised, controlled study. ns = not significant

Table 11: Fixed orthodontic retainer versus no retainer - Dental caries (alphabetically, according to study design).

Discussion

The objective was to systematically review and estimate whether fixed retainers improve stability after orthodontic treatment, or increase the risk of side effects on the teeth and periodontium in comparison with removable retainers, no retainer, or fiberotomy.

The literature search was comprehensive, and included several databases, as well as hand search in the reference lists of relevant articles. Throughout the study conduct the PRISMA recommendations were followed [22], and the rating of evidence was performed according to the GRADE approach [10]. We consider the summary of findings representative for the addressed question: 'do fixed retainers improve stability after orthodontic treatment, and do they increase the risk of side effects on the teeth and periodontium in comparison with removable retainers, no retainer, or fiberotomy?'

Two RCTs were identified [11,13], both of which had study limitations, mainly regarding randomization and blinding, as well as problems with directness and/or precision. None of the CTs were blinded, and all had problems regarding directness and precision. Altogether, these aspects reduced the confidence in the effect estimates for different outcomes, reported across the studies. Therefore, the quality of evidence was low, or very low for all the studied outcomes.

It was very difficult to estimate effects of different outcomes across the studies, since the studies were heterogeneous in their design (only two were RCT), in the methodological aspects, methods for outcome measurements, as well as the studied interventions, and follow-up periods. Thus, a meta-analysis was not deemed suitable.

The main findings were that, based on low quality of evidence (GRADE ⊕⊕○○), treatment stability may be improved by a fixed

Author, year	Country	Study design	Number of patients (n)	With draws - dropouts	Results		Comments
					Intervention Fixed retainer	Control No retainer	
Levin, 2008 [16]	Israel	CT	n=92 Group 1: n=48 dental arches Group 2: n=72 dental arches	n=0	Group 1 Lingual 82.4%	Group 2 Lingual 51.6% p<0.0001, between groups	Group 1 = One or two fixed retainers. Group 2 = No retainer.
Rody, 2011 [15]	Canada	CT	n=31 Group 1: n=10 (Group 2: n=11) Group 3: n=10	? ^a	Group 1 Incisors: 60% (sd 51.6) Premolars: 10% (sd 31.6)	Group 3 Incisors: 10% (sd 31.6) p=0.03, between groups Premolars: 0% (sd 0) ns. between groups	Group 1 = 3-3 fixed lower retainer. Group 2 = Removable lower retainer. Group 3 = No retainer.
Artun, 1984 [14]	Norway	CT	n=108 Group 1: n= 31 Group 2: n=18 Group 3: n=14 (Group 4: n=20) Group 5: n= 25	? ^a	Group 1 and Group 2 Interproximal Mean: 0.94 (sd 0.57) Lingual Mean: 0.59 (sd 0.48) Group 3 Interproximal Mean: 0.20 (sd 0.25) Lingual Mean: 0 (sd 0)	Group 5 Interproximal Mean: 1.12 (sd 0.59) ns. between groups Lingual Mean: 0.62 (sd 0.48) ns. between groups Group 3 was not compared to group 5	Plaque along the gingival margin Group 1 = Mandibular cuspid retainer .032 spiral wire. Group 2 = Mandibular cuspid retainer .032 plain wire. Group 3 = Maxillary .0195 flexible spiral wire retainer. Group 4 = Maxillary retainer plate Group 5 = No retainer Cuspid retainer = bonded only to cuspids 3-3- retainer = bonded to each tooth.

^a Withdrawals and drop-outs not explicitly stated. CT = non-randomised, controlled study. ns = not significant

Table 12: Fixed orthodontic retainer versus no retainer - Dental plaque (alphabetically, according to study design).

Author, year	Country	Study design	Number of patients (n)	With draws - dropouts	Result		Comments
					Intervention Fixed retainer	Control No retainer	
Artun, 1984 [14]	Norway	CT	n=108 Group 1: n= 31 Group 2: n=18 Group 3: n=14 (Group 4: n=20) Group 5: n= 25	? ^a	Groups 1 and 2 Interproximal: Mean: 0.37 (sd 0.39) Lingual: Mean: 0.22 (sd 0.29)	Group 5 Interproximal: Mean: 0.38 (sd 0.36) ns. Lingual: Mean: 0.14 (sd 0.20) ns.	Group 1= Mandibular cuspid retainer .032 spiral wire. Group 2= Mandibular cuspid retainer .032 plain wire. Group 3= Maxillary .0195 flexible spiral wire retainer. Group 4= Maxillary retainer plate Group 5= No retainer. Cuspid retainer = bonded only to cuspids. 3-3- retainer = bonded to each tooth.

^a Withdrawals and drop-outs not explicitly stated. CT = non-randomised, controlled study. ns = not significant

Table 13: Fixed orthodontic retainer versus no retainer – Calculus (alphabetically, according to study design).

retainer after orthodontic treatment in comparison with a removable retainer or in comparison with no retainer. In addition, based on very low quality of evidence (GRADE ⊕○○○), it is uncertain whether periodontal outcomes, dental caries prevalence, or presence of calculus differ between the various types of retainer regimens. It was also evident that technical retainer failures are a relatively common.

As the results from this study indicate, there is only weak evidence

that treatment stability increase with retainers. Although the ‘retainer or not retainer’ discussion is considered ‘parachute-research’ for an orthodontist, especially for those with long experience, the reality is different. Theoretically, by keeping the teeth together the retainer prevents them from moving. However, not all the teeth are fixed with the retainer. Furthermore, there is always a risk that the retainer fractures or loosens without the patient being aware of or noticing it.

Author, year	Country	Study design	Number of patients (n)	With draws - dropouts	Result		Comments
					Intervention Fixed retainer	Control No retainer	
Levin, 2008 [16]	Israel	CT	n= 92 Group1: n= 48 Group 2: n= 72	n=0	Group 1 Lingual: 53.9%	Group 2 Lingual: 37.8% p<0.012	Bleeding on probing Group 1= One or two fixed retainers Group 2= No retainer
Rody, 2011 [15]	Canada	CT	n=31 Group 1: n= 10 (Group 2: n= 11) Group 3: n= 10	? ^a	Group 1 Incisor: 30% (sd 48.3) Premolar: 20% (sd 42.16)	Group 3 Incisor: 20% (sd 42.16) ns. Premolar: 20% (sd 42.16) ns.	Bleeding on probing Group 1= 3-3 fixed lower retainer. Group 2= Removable lower retainer. Group 3= No retainer.
Artun, 1984 [14]	Norway	CT	n=108 Group 1: n= 31 Group 2: n= 18 Group 3: n= 14 (Group 4: n= 20) Group 5: n= 25	? ^a	Groups 1 and 2 GI Lingual: Mean: 1.06 (sd 0.13) GI Interproximal: Mean: 1.31 (sd 0.28) NBP Interproximal: Mean: 0.63 (sd 0.27)	Group 5 GI Lingual: Mean: 1.13 (sd 0.15) p<0.05 GI Interproximal: Mean: 1.35 (sd 0.27) ns. NBP Interproximal: Mean: 0.68 (sd 0.23) ns.	Gingival index (GI) Non bleeding papilla (NBP) Group 1= Mandibular cuspid retainer .032 spiral wire. Group 2= Mandibular cuspid retainer .032 plain wire. Group 3= Maxillary .0195 flexible spiral wire retainer. Group 4= Maxillary retainer plate. Group 5= No retainer. Cuspid retainer = bonded only to cuspids 3-3- retainer = bonded to each tooth.

^a Withdrawals and drop-outs not explicitly stated. CT = non-randomised, controlled study. ns = not significant

Table 14: Fixed orthodontic retainer versus no retainer – Gingivitis (alphabetically, according to study design).

Thus, it is still unknown to what extent, or to what net gain, long-term retention contributes to maintain the orthodontic treatment results.

maintenance problems, especially with the fixed retainers since they frequently fail or fracture. This contributes to an additional workload for the dentist and orthodontist, as well as to a cost increase for the

This systematic review also indicate that there are a lots of

Author, year	Country	Study design	Number of patients (n)	With draws - dropouts	Results		Comments
					Intervention Fixed retainer	Control Removable retainer	
Edman Tynelius, 2013 [13]	Sweden	RCT	n=75 Group 1: n=25 Group 2: n=25 Group 3: n=25	n=6	Failure During 24-months: Group 1 7/25 (28%) In 3 patients one failure. In 3 patients two failures. In 1 patient four failures.	Lost appliance During (24-months): Group 1 and 2 5/50 (10%) Group 3 0/25 (0%) p<0.01 (group 1 vs. 3) ns. (group 1 & 2 vs. 3)	Failure rate (retainer loosening) Lost appliance Group 1= upper removable retainer (vacuum formed) and lower fixed retainer. Group 2= upper removable retainer (vacuum formed) and lower stripping. Group 3= removable retainer upper and lower (positioner). p-values calculated from study data (Fisher's exact test).
Artun, 1997 [11]	USA	RCT	n=49 Group 1 n=11 Group 2: n=13 Group 3: n=11 Group 4: n=14	? ^a	All fixed 8/35 (22.9%) Group 1: 1/11 (9.1%) Group 2: 4/13 (30.8%) Group 3: 3/11 (27.3%)	Group 4: 2/14 (14.3%) ns.	Failure rate Group 1= Mandibular cuspid retainer .032 plain wire. Group 2= Mandibular cuspid retainer .032 spiral wire. Group 3= Mandibular 3-3 retainer .0205 flexible spiral wire. Group 4= Removable lower retainer. Cuspid retainer- bonded only to cuspids. 3-3 retainer- bonded to each tooth
Cerny, 2010 [12]	UK	CT	n=61 Group 1: n=46 Group 2: n=43	? ^a	<u>Clinical examination</u> 6/46 (13%) patients with: 3 bond failures, 5 broken wires <u>Anamnesis (recall)</u> PBR fracture rate: 3.15%/year. Bond/wire fracture rate: 0.58%/year	-	Failure rate (loosening or broken retainer). Group 1 = Permanent bonded retainer (PBR) (upper or lower). Group 2 = Removable retainer (RR).
Andrén, 1998 [18]	Sweden	Case-series	n=103	n=11	<u>Loosening</u> Maxilla: 25/67 (37%) retainers Mandible: 18/52 (35%) retainers <u>Wire fracture</u> Maxilla: 11 occasions Mandible: 1 occasion	-	Failure rate (loosening or wire fracture). Bonded lingual retainers maxilla and/or mandible (during 5 years of observation) 16 both arches, 41 maxillary retainers, 36 mandibular retainers.

Dahl, 1991 [17]	Sweden	Case-series	n=153 Group 1: n=81	n=11 (Group 1)	<p><u>Loosening (n=retainers)</u> Group 1 Maxilla: 14/56 (25.0%) Mandible: 3/29 (10.3%)</p> <p>Group 2 Maxilla: 5/64 (7.8%) Mandible: 1/17 (5.9%)</p> <p><u>Wire fracture (n=retainers)</u> Group 1 Maxilla: 13/56 (23.2%) Mandible: 3/29 (10.3%)</p> <p>Group 2 Maxilla: 2/64 (3.1%) Mandible: 0/17 (0.0%)</p> <p><u>Opening of small spaces</u> Group 1 and 2: In 7 patients with retainer loosening In 4 patients with intact retainers</p>	-	<p>Failure rate (loosening or wire fracture). Other side effects.</p> <p>Group 1 = Lingual bonded retainers (.0195" or .0215" three-stranded spiral wire). (45 maxillary retainers, 14 mandibular retainers, 15 both arches). Group 2 = Lingual bonded retainers (.0215 five-stranded spiral wire). (55 maxillary retainers, 8 mandibular retainers, 9 both arches).</p> <p>Mean period between orthodontic treatment and examination was 4.57±2.2 years</p> <p>Small spaces = 0.5-1mm openings between teeth within the retained segments</p>
Renkema, 2011 [21]	Netherlands	Case-series	n=221	n=0	<p>At least one bonding failure 70/221 (31.7%)</p> <p>Less failures in incisors than canines p<0.001</p> <p>Central vs. lateral incisors ns.</p>	-	<p>Failure rate</p> <p>Bonded lingual mandibular retainer (.0195" 3-strand, heat-treated twist wire).</p> <p>Observation period 5 years</p>
Störmann, 2002 [19]	Germany	Case-series	n=103 Group 1: n=31 Group 2: n=38 Group 3: n=34	n=5	<p>Failure (% retainers) Group 1: 29% Group 2: 53% Group 3: 18%</p> <p>Increased patient discomfort with cuspid retainer</p>	-	<p>Failure rate</p> <p>Group 1 = Bonded retainer .0195".</p> <p>Group 2 = Bonded retainer .0215".</p> <p>Group 3 = Cuspid retainer.</p> <p>Cuspid retainer= bonded only to cuspids.</p>
Tacken, 2010 [20]	Belgium	Case-series	n=275 Group 1: n=45 Group 2 n=48 Group 3 n=91 Group 4: n= 90	n=15	<p>Success rate (n=retainers) Group 1 and 2: (92/186) 49%</p> <p>Group 3 161/182 (88%) p<0.001</p> <p><u>Failure</u> Group 1 and 2: Maxilla: Broken retainer 37/48 (77%) of all failures</p> <p>Mandible: Loosening 34/46 (74%) of all failures</p> <p>Group 3 Maxilla: Loosening 10/13 (77%) of all failures.</p> <p>Mandible: Loosening 8/8 (100%) of all failures.</p>	-	<p>Success rate</p> <p>Failure (loosening or broken retainer)</p> <p>Group 1 = Glass fiber reinforced bonded retainer 500 fibres. Group 2 = Glass fiber reinforced bonded retainer 1000 fibres. Group 3 = Multi-stranded bonded retainer. Group 4 = No retainer no treatment.</p>

^a Withdrawals and drop-outs not explicitly stated. CT = non-randomised, controlled study. ns = not significant

Table 15: Fixed orthodontic retainer versus removable retainer, or no retainer - Complications (alphabetically, according to study design).

Outcome variable	Number of studies and study design	Study limitations	Consistency	Directness	Precision	Publication bias	Magnitude of effect	Absolute effect I=fixed retainer C=removable retainer	Quality of evidence GRADE
Treatment stability	2 RCT 1 Cohort	Some limitations (?) ^a	No inconsistency	Serious indirectness (-1) ^b	Some imprecision (?) ^c	Unlikely	Not relevant	I= Δ LII: 0.6 ° C=Δ LII: 1.6	⊕○○
Periodontal outcomes	1 RCT 3 Cohort	Serious limitations (-1) ^a	No inconsistency	Serious indirectness (-1) ^d	Serious imprecision (-1) ^e	Unlikely	Not relevant	Not applicable ^f	⊕○○○
Dental Caries	1 RCT 2 Cohort	Serious limitations (-1) ^a	No inconsistency	Serious indirectness (-1) ^d	Serious imprecision (-1) ^e	Unlikely	Not relevant	I=0 C=0	⊕○○○
Dental plaque	1 RCT 3 Cohort	Serious limitations (-1) ^a	No inconsistency	Serious indirectness (-1) ^b	Serious imprecision (-1) ^e	Unlikely	Not relevant	Not applicable ^f	⊕○○○
Calculus	1 RCT 2 Cohort	Serious limitations (-1) ^a	No inconsistency	Serious indirectness (-1) ^d	Serious imprecision (-1) ^e	Unlikely	Not relevant	Not applicable ^f	⊕○○○
Gingivitis	1 RCT 3 Cohort	Serious limitations (-1) ^a	No inconsistency	Serious indirectness (-1) ^d	Serious imprecision (-1) ^e	Unlikely	Not relevant	Not applicable ^f	⊕○○○

⊕⊕⊕⊕ = high quality of evidence, ⊕⊕⊕○ = moderate quality of evidence, ⊕⊕○○ = Low quality of evidence, ⊕○○○ = Very low quality of evidence.[10]

^a Limitations in randomization procedure, and no blinding.

^b Study population strictly defined in one RCT, and undefined patient characteristics in the other RCT.

^c Small groups in some studies, and no 95%CI presented.

^d Patient characteristics not clearly described.

^e Data from Edman Tynelius *et al.*, 2013. LII=Little's irregularity index.

^f No pooled effect estimates, due to different outcomes across the studies.

Table 16: Summary of Findings - Fixed retainer versus removable retainer.

Outcome variable	Number of studies and study design	Study limitations	Consistency	Directness	Precision	Publication bias	Magnitude of effect	Absolute effect I=fixed retainer C=no retainer	Quality of evidence GRADE
Periodontal outcomes	3 Cohort	Serious limitations (-1) ^c	No inconsistency	Serious indirectness (-1) ^b	Serious imprecision (-1) ^a	Unlikely	Not relevant	Not applicable ^f	⊕○○○
Dental Caries	1 Cohort	Serious limitations (-1) ^c	No inconsistency	Serious indirectness (-1) ^b	Serious imprecision (-1) ^e	Unlikely	Not relevant	I=0 C=0	⊕○○○
Dental plaque	3 Cohort	Serious limitations (-1) ^c	No inconsistency	Serious indirectness (-1) ^d	Serious imprecision (-1) ^a	Unlikely	Large effect (+1)	Not applicable ^f	⊕○○○
Calculus	1 Cohort	Serious limitations (-1) ^c	No inconsistency	Serious indirectness (-1) ^b	Serious imprecision (-1) ^e	Unlikely	Not relevant	Lingual: I=0.22 C=0.14	⊕○○○
Gingivitis	3 Cohort	Serious limitations (-1) ^c	No inconsistency	Serious indirectness (-1) ^b	Serious imprecision (-1) ^e	Unlikely	Not relevant	Not applicable ^f	⊕○○○

⊕⊕⊕⊕ = high quality of evidence, ⊕⊕⊕○ = moderate quality of evidence, ⊕⊕○○ = Low quality of evidence, ⊕○○○ = Very low quality of evidence.[10] ^a Small groups in some studies, and no 95%CI presented. ^b Patient characteristics not clearly described. ^c Unclear patient selection. No blinding. ^d Patients from a different setting. ^e No CI 95% presented. ^f No pooled effect estimates, due to different outcomes across the studies.

Table 17: Summary of Findings - Fixed retainer versus no retainer.

patient and/or the dental care provider, depending on the health care system. An alternative to the use of fixed retainers is to lay the full responsibility on the patients by providing them with removable retainers, or to remove the bonded retainers after a few years and allow for natural aging of the occlusion.

Taken together, many patients receive retainers after orthodontic treatment that are kept for extended periods up to 10-20 years or even longer. This is time consuming and costly, and requires a lot of resources. It is therefore of important, not only for the patient but also health care providers and decision makers, to have high quality of evidence on; to what extent the retainers contribute to maintain treatment stability, which retainers are most effective, and what side effects can be expected of retainers in the long term. Therefore clinical studies need to be undertaken to answer these questions.

Conclusion

According to the literature there is only low quality of evidence,

that treatment stability may be improved by a fixed retainer after orthodontic treatment in comparison with a removable retainer, or no retainer (GRADE ⊕⊕○○). Furthermore, there is very low quality of evidence, whether periodontal outcomes, dental caries prevalence, or presence of calculus differ between the various types of retainer regimens (GRADE ⊕○○○).

Adequately designed long-term studies on the effects and risks of different retainer regimens after orthodontic treatment are needed.

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