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Keeping the teeth in line: Exploring the necessity of bonded retainers in orthodontics: A narrative review

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Abstract

In most recent studies, long-term retention after orthodontic treatment has been hypothesized that may be necessary to maintain the stability of the dentition and avoid post-treatment changes. The bonded fixed retainer is characterized by its clinical effectiveness, patient acceptance, and lack of patient complaints as compared with a removable retainer. An electronic database (such as PubMed, PubMed Central, Web of Science, Science Direct, Cochrane Library, Scopus, and ResearchGate) has been collected using specific keywords. Of the 152 articles, only randomized clinical trials that investigated different types of fixed retainers or compared fixed with removable retainers were illustrated in tables and included in this review. The present review has gone some way towards enhancing our understanding of the bonded fixed retainer, types, material, bonding methods, and how to improve its the success rate, besides the importance of new technology in fixed orthodontic retention.

Keywords:

Bonded retainer, fixed retainer, orthodontic retention, retention, stability

Introduction

During orthodontic treatment, teeth are moved away from their original position, and in their new position, they are exposed to forces from the soft tissues as well as from occlusion, periodontal fibers, and ligaments.[1,2] This explains the necessity for retention, which is considered an integral part of orthodontic treatment.[3-5]

Different retention approaches are available,[6] and many retention scenarios are advocated to prevent relapse and maintain long-term stability.[7,8] The available retention methods involved removable and fixed retainers.[9-11]

The importance of retention has been studied for decades, and it has been the subject of many systematic reviews.[4,12,13]

Up to date, fixed retention has been an essential topic for research. Therefore, this review aimed to evaluate the effectiveness of various bonded retainers in comparison to alternative removable types.

Materials and Methods

From January to March 2023, a comprehensive online search was conducted across several databases such as PubMed, PubMed Central, Web of Science, Science Direct, the Cochrane Library, Scopus, and ResearchGate. The search was conducted using specific keywords like "Retention", "Fixed retainer", "Bonded retainer", "Orthodontic retention", and "Fixed orthodontic retention". After screening the full text of 152 articles, this review includes only randomized clinical trials that compared different bonded retainer types or fixed retainers with removable retainers.

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Results

Out of the 152 articles obtained through the search process, only 22 articles met the inclusion criteria. Clinical trials that explored the different types of fixed bonded retainers are presented in Table 1, while those trials that compared fixed with removable retainers are presented in Table 2.

History

The advent of modern resin-based adhesive systems has facilitated the development of bonded retainers to improve clinical effectiveness and patient satisfaction and to overcome the drawbacks of patient complaints with removable retainers and potential demineralization with banded lingual bars.[5]

The first bonded retainer was a 0.028″ plain round wire.[36] In 1977, Zachrisson described the results of using 0.8 mm or 0.9 mm Blue Elgiloy plain wires with a follow-up period exceeding 2 years.[37]

Shortly after, Årtun and Zachrisson[38] proposed the use of a thick multi-stranded wire as a fixed retainer on canines only without retention loops. In the same year, thin, multi-stranded, flexible retainers were reported. They were fixed to all six anterior teeth as published by Zachrisson. The flexibility of the wire allowed physiological movement of the teeth while providing stability.[39] Furthermore, a few years later, the clinical performance of resin-reinforced fiberglass bonded retainers was reported.[40]

In the past decade, spanning from 2010 to 2020, there has been extensive evaluation of the different retention methods. Numerous clinical trial studies were conducted to investigate the effectiveness of different approaches, including bonded versus removable retainers, direct versus indirect bonding techniques, and round twisted versus braided rectangular bonded retainers.[9,27,30]

In recent years, computer-aided design–computer-aided manufacturing (CAD-CAM) technology has been used to improve the precision and fitness of fabricated bonded retainers.[41]

Types of fixed retainers

A fixed retainer can either be bonded to the lingual or palatal surfaces of the anterior teeth, which is described as canine to canine,[42] or be bonded to canines only, which is described as canine and canine.[24] A systematic review in 2020 concluded that the former provided more stability than the latter.[4]

Fixed retainers are available now in a wide array of material types, dimensions, and shapes.[42-46] Therefore, when selecting the most appropriate type of retainer, for a specific patient, several factors should be considered, including patient compliance, dental hygiene, pre-operative malocclusion, and patient expectations.[19] Fixed retainers can be classified in different ways:

I. According to material type:

The bonded fixed retainer can be classified into the following:

1. Metallic retainer

A- Stainless-steel retainer

(i) Multi-stranded wires are the most used type of bonded retainer. They are available in round or rectangular cross-sections and are made of 3 to 8 fine strands that can be braided, twisted, or coaxial.[5] These strands permit the bonded teeth to undergo physiological movement by enhancing the flexibility of the wire. These wires are available in different dimensions, 0.015″, 0.0175″, 0.0195″, and 0.0215″, can be employed for direct and indirect bonding techniques,[47] and are mostly used for mandibular arch.[48]

(ii) Plain wires: These wires are more rigid, with a diameter ranging from 0.025″ to 0.032″. The reduced flexibility decreases the possibility of wire fracture but increases the rate of bond failure.[16] It is indicated for canine-and-canine retention, which is characterized as being more hygienic, fail-safe, and superior in maintaining the inter-canine width.[4] This type of retainer may also provide a bite plane effect and maintain deep bite correction.[49]

(iii) Chains: These chains are rectangular in cross-section (0.039″x0.014″). They are mostly made from stainless steel. This type of retainer has good chairside adaptability and is used for direct bonding, which explains its recent use.[50]

B- Other metals:

(i) Single-strand ribbon titanium retainer: This type of retainer is made from dead-soft titanium and used for canine-to-canine direct bonding. It has a low failure rate.[44]

(ii) Memotain: This retainer was first introduced in 2012. The name is derived from "memory" and "retainer". It is a Ni-Ti wire that is fabricated by CAD/CAM with a diameter of 0.014″. It has excellent adaptation to the lingual surface of the anterior teeth.[51]

(iii) Chains: These are like stainless-steel chains but are fabricated from 14-carat white gold.[52]

2. Non-metallic retainers

Although the metallic multi-stranded stainless-steel wire is considered the gold standard of fixed retainers, the concerns regarding esthetics,

Table 1: The RCTs that investigated different types of fixed bonded retainer

Authors	Aim of study	Fixed retainer	Sample size	Duration	Conclusion
Störmann I, Ehmer 2002[14]	To assess the difference of lower fixed retainers, debonding rate, relapse, oral hygiene problems (periodontal), and participant discomfort.	0.0195-inch and 0.0215-inch stainless-steel retainers (canine-to-canine), prefabricated canine-and-canine retainer	103	24 months	The retainers bonded on lower anterior anterior teeth (canine-to-canine) showed a better stability, while the retainers bonded only on canines show frequent relapse.
Rose *et al*. 2002[15]	Plasma-treated woven polyethylene ribbon retainers compared with multi-stranded retainers in their efficacy to maintain canine-to-canine retention.	Plasma-treated woven polyethylene ribbons retainers and multi-stranded stainless-steel retainers (0.0175-inch).	20	3 months	Multi-stranded stainless-steel retainers are more effective than plasma-treated polyethylene-woven ribbon in stability of dentition.
Salehi *et al*. 2013[16]	Evaluate the reliability and failure rates of polyethylene woven ribbon retainers versus 0.0175-inch flexible spiral wire retainer.	Polyethylene woven ribbon retainer and flexible spiral wire retainer (0.0175-inch).	142	18 months	The differences between polyethylene woven ribbon and flexible spiral (0.0175-inch) retainers had limited clinical significance with no statistically significant differences.
Pandis *et al*. 2013[17]	Comparing the survival rates of mandibular bonded retainers chemically cured or light-cured adhesive.	0.022-inch soft bonded lingual retainer (Tru-Chrome multi-stranded wire; Rocky Mountain Orthodontics) that bonded directly.	220	6 months	There is no proof that the survival rate of mandibular lingual retainers bonded with chemically or light-cured adhesives is varied.
Torkan *et al*. 2014[18]	The purpose of the research was to assess the clinical and radiographic impact on the periodontium of dentition by two widely used bonded retainers.	Fiber-reinforced composite bonded retainer and spiral wire retainer.	30	6 months	In comparison of fiber-reinforced composite retainers with spiral wire retainers, less harmful periodontal effect in the short-term follow-up was found in spiral wire retainers.
Sfondrini *et al*. 2014[19]	Assessment the clinical reliability of two different kinds of bonded orthodontic retainers	Glass fiber-reinforced resin composite and multistranded stainless-steel wire.	87	12 months	Over a 1-year follow-up, single bond failure rates of multistranded metallic wires and glass fiber-reinforced resin composite retainers did not significantly differ.
Sobouti *et al*. 2016[20]	To compare the success rate of canine-to-canine mandibular retainers made of fiber-reinforced composite, spiral flexible wire, and twisted wire	Twisted wire, flexible spiral wire, and fiber-reinforced composite retainers.	150	24 months	Twisted wire had a failure rate that was two times lower than the FRC retainer.
Egli *et al*. 2017[21]	To compare the percentages of mandibular fixed retainers that fail when bonded using indirect and direct procedures and to look at posttreatment changes 2 years after insertion.	A 0.0215-inch multistrand stainless-steel wire	64	24 months	The risks of failure for mandibular retainers bonded using direct and indirect techniques were the same. Inter-canine and inter-premolar distances can be effectively maintained with bonded retainers.
Węgrodzka *et al*. 2021[22]	To examine the survival rates and periodontal health in individuals who had fixed retainers attached to mandibular anterior teeth in either a 3-strand round twisted or an 8-strand rectangular braided configuration.	A 0.0215-inch stainless-steel (3-strand) and 0.0265x 0.0106-inch (8-strand) bonded retainer	133	24 months	There was no difference between the analyzed retainers in terms of survival or periodontal health, and the total probability for first-time failure was considerable at 52.3%.
Gera *et al*. 2023[23]	The objective of this RCT was to evaluate and compare the clinical efficacy of nitinol CAD/CAM with traditional MS-FRs in terms of the stability of the teeth after treatment.	0.014 X 0.014-inch rectangular Nitinol CAD/CAM, and 0.0215-inch six-stranded stainless steel	181	6 months	After a duration of 6 months, there were no notable variations in LII, arch widths, and lengths between CAD/CAM and conventional retainers that had any clinical significance. There was no disparity in the rates of failures and patient satisfaction between the two types of FRs.

Table 2: The RCTs that compare removable retainers with fixed bonded retainers

Authors	Aim of study	Fixed retainer	Sample size	Duration	Conclusion
Årtun *et al*. 1997[24]	To determine which bonded orthodontic retainer types are most likely to accumulate plaque and calculus along the wire.	Canine and canine plain thick wire, canine and canine thick spiral wire, canine-to-canine flexible spiral wire, and removable retainer	49	3 years	After 3 years in retention, gingival irritation and plaque formation were scored less frequently than they were at the time of debonding.
Edman Tynelius *et al*. 2013[25]	To compare the effectiveness of distinct retention strategies in compliant patients after (2 years) retention.	Vacuum-formed retainer, bonded retainer, positioner	75	2 years	The stability to a clinically acceptable level could be accomplished with all three types of retention techniques.
Edman Tynelius *et al*. 2015[9]	Comparison of three different retention strategies within 5 years or more.	Vacuum-formed retainer, bonded retainer, positioner	49	5 years	The three retention techniques revealed similar positive clinical outcomes.
O'rourke *et al*. 2016[26]	Compare the clinical efficacy of bonded retainers with vacuum-formed retainers, in terms of stability	A 0.0175-inch coaxial archwire, vacuum-formed retainer	82	18 months	In the first 6 months following treatment, vacuum-formed retainers are less effective in maintaining the stability of the lower incisors than bonded retainers are.
Forde *et al*. 2018[27]	Compare upper and lower vacuum-formed retainers to upper and lower bonded retainers concerning the stability, survival, and patient satisfaction during a 12-month period.	A 0.0195-inch (3 strands) twist-flex stainless-steel wire, and vacuum-formed retainer	60	12 months	In terms of stability or survival in the maxilla after a year, there is no evidence of a substantial difference. BRs are more successful at preserving the alignment of the mandibular labial segments in the mandible.
Al-Moghrabi *et al*. 2018[28]	Assess the stability and periodontal health of lower anterior teeth bonded with fixed bonded retainer versus removable orthodontic retainers within 4-year follow-up.	Vacuum-formed retainer and 0.0175-inch coaxial arch-wire	42	4 years	The lower labial segment's alignment is better preserved over time with fixed retention, which is an advantage. However, increased plaque scores and gingival irritation were linked to both types of retainers.
Alkan *et al*. 2020[29]	To assess force distribution and occlusal changes between vacuum-formed, Hawley, and bonded retainers.	Vacuum-formed retainer. Hawley retainer, bonded fixed retainer	60	6 months	The occlusal force distribution significantly differs between the Hawley retainer and bonded retainer groups.
Krämer *et al*. 2020[30]	To compare the efficacy of vacuum-formed retainers and bonded canine-to-canine retainers after 6- and 18-month retention.	Vacuum-formed retainer, canine and canine 0.8 hard Remanium-bonded retainer.	104	18 months	Essix retainer and bonded retainer have the same retention efficacy after 6- and 18-month retention. Most relapses happen in the first 6 months.
Alrawas *et al*. 2021[31]	To assess, in comparison to existing retainers, how a CAD/CAM nickel-titanium retainer affects the stability and periodontal health of mandibular anterior teeth.	CAD/CAM NiTi, multi-stranded stainless steel, single-stranded nickel-free titanium and vacuum-formed retainers.	60	6 months	There was no statistically significant difference in the clinical survival rate between the CAD/CAM retainer and conventional retainers. In addition, less plaque buildup and gingival irritation were seen.
Naraghi *et al*. 2021[32]	To assess the effects of different retention strategies on the irregularity of the six maxillary anterior teeth after treatment.	A 0.0195-inch bonded retainer and removable vacuum-formed retainer.	90	2 years	All the alterations reported in the groups were clinically minor, and all three retention techniques demonstrated similarly effective retention ability.
Sonesson *et al*. 2022[33]	To assess the expenses of three different maxillary retention techniques.	A 0.0195-inch multistranded stainless-steel retainer and removable vacuum-formed retainer.	90	2 years	When expenses and retention capability are considered, all three retention techniques might be suggested.
Shim *et al*. 2022[34]	To compare the relapse and failure rates of typical fixed retainers versus CAD/CAM	CAD/CAM retainer, Ortho-FlexTech wires, and multistranded stainless-steel wire	46	6 months	Compared with conventional chairside retainers, the CAD/CAM fixed retainers showed less relapse and fewer failures.

Contd...

Table 2: Contd...

Authors	Aim of study	Fixed retainer	Sample size	Duration	Conclusion
Krämer *et al.* 2023[35]	Comparing the removable vacuum-formed retainers with bonded canine-to-canine retainers within 5 years of retention.	Vacuum-formed retainer and 0.8 hard, Remanium canine and canine retainer	104	5 years	Anterior alignment of anterior teeth was more stable with bonded retainers compared to removable vacuum-formed retainer after 5 years of retention

corrosion, and potential allergies[53] have led to the development of alternatives.

A- Fiber-reinforced composites:
This type of retainer is composed of glass fibers mixed with a thermoplastic polymer and light-cured resin matrix for bolstering of a dental polymer.[54] It has a large cross-sectional diameter, which increases the rigidity and shear strength.[45]

B- Polyethylene ribbon-reinforced retainer:
It is constructed using ultra-high-molecular-weight polyethylene fibers, typically consisting of 500 – 1000 fibers or ribbons.[55] These fibers are treated with cold gas plasma to enhance their adhesion to restorative material. The unique fiber network enables efficient force transmission. It can easily conform to the tooth surface and offers excellent esthetics due to its translucent nature.[49]

Table 1 displays an overview of clinical studies that investigated different types of bonded fixed retainers.

II. According to fabrication and bonding methods:

Fixed retainers are fabricated with two known methods:

I. Direct bonding method
This method involves chairside fabrication directly in the mouth.[56] The process includes measuring the appropriate length of the retainer using dental floss, isolating the teeth, and preparing for bonding by polishing, etching, and drying. The retainer is fixed in position with the aid of dental floss, ligature wire, or elastic.[57] A thin layer of unfilled resin is applied on the surfaces of the teeth and then cured with light for 10 seconds, followed by adding a thin band of filled composite on the retainer. Light curing is performed, and final polishing is achieved with a finishing bur.[15]

II. Indirect bonding method
This method is preferred when a shorter appointment time is desired by the patient; it involves the fabrication of a retainer on the patient's cast. A template for retainer bonding can be fabricated from clear vinyl polysiloxane[57,58] or a hard resin material with a 3D digital printer.[59] A randomized controlled trial (RCT) found that mandibular retainers bonded using direct and indirect methods had similar failure risks.[21] However, it was found that the difference in chairside time was statistically significant, with the indirect bonding technique requiring less chairside time than the direct bonding technique.[59]

Increasing the success rate of bonded fixed retainers

Many factors should be considered to increase the survival rate of bonded fixed retainers, including:

1. *Retainer type*:

Multi-stranded retainers are more effective than plane round retainers in maintaining incisors' alignment since they allow physiological movement of the teeth with sufficient splinting at the same time.[60] Therefore, a bonded fixed retainer to all six anterior teeth is preferable to the canine-and-canine retainer.[4,35] However, it should be kept in mind that canine and canine retainers are more hygienic, which may favor their selection for some patients due to the prolonged retention period.[61]

2. *Retainer material:*

Multi-stranded stainless-steel bonded retainers exhibit higher survival rates in comparison to fiber-reinforced composite retainers, primarily due to the rigidity and lack of flexibility of the latter. Although dead-soft stainless steel has good formability, which makes it suitable for direct bonding, it is prone to deformation by masticatory forces.[62,63]

3. *Bonding technique*:

This involves many aspects:

- Adhesive type

Since retention is required for a long duration, the composite needs to be examined regularly because it is subjected to long-term abrasion by dental brushing and masticatory forces.[64] However, clinicians prefer flowable hybrid composite resin due to its ease of application, curing, and polishing. But in light of their low filler particles, they are more susceptible to wear.[65]

- Isolation

Moisture contamination is the most common cause of bond failure; this is because of the hydrophobic characteristics of the adhesive systems. Ideally, a completely dry and isolated field is needed to achieve clinically acceptable bonding strengths, yet a variety of clinical factors make optimal isolation impossible.[37] Minimal contamination from saliva can negatively impact the bond strength as saliva creates an organic adhesive

layer that is not easily washed away.[66] For that reason, it is recommended to use a rubber dam during the bonding of orthodontic retainers to ensure complete isolation from moisture and saliva.[16]

- Curing time

To ensure optimal physical properties of the resin adhesive, it is crucial to achieve proper polymerization. This can be achieved by providing a radiant exposure within the range of 16–24 J/cm^2, which is calculated by multiplying the irradiance level with curing time. If the curing light device power was 800 mW/cm^2, a minimum of 20 seconds is needed.[67] It has been suggested to extend the curing time beyond the recommendations of the manufacturer to enhance the polymerization and microhardness of the composite.[68] High-power light-emitting diode units with an output of over 5000 mW/cm^2 are available, which can significantly reduce the curing time by as little as 3 seconds.[69]

- Curing system

The method of curing has evolved. The first report of the light-curing substance used was ultraviolet light. Four types of light curing units are available today for clinical applications: quartz tungsten halogen lamps, light-emitting diode units, plasma-arc lamps, and argon-ion laser.[70]

The light-emitting diode was invented in 1995.[12] It has a narrow wavelength band (400–500 nm), but it is within the polymerization range of the resin, making it more efficient with reduced generated heat and no need for filtration, and it can be operated on battery power which provides convenience and flexibility during clinical procedures.[71]

Light-curing units are utilized to induce polymerization in restorative materials by activating photo-initiators. When photo-initiators absorb photons, they alter the restorative material's molecular structure, converting monomers to a polymer network.[72]

The concentration of the photo-initiator within the material determines how much of it is activated, along with the number of photons to which the material is exposed and the energy of the photons.[72] The wavelength of the light emitted must coincide with the photo-initiator's amount of absorption. The currently available initiators are camphorquinone, phenylpropanedione, and lucirin. The most prevalent photo-initiator found in dental materials is camphorquinone, which reaches its greatest activity at 470 nm, while phenylpropanedione and lucirin have absorption levels closer to ultraviolet light (less than 400 nm).[73]

Why is the fixed bonded retainer important?

It has long been agreed that the strained gingival fibers need a long period to remodel; therefore, retaining the teeth in the post-treatment position is necessary.[74] It was shown that the relapse of lower anterior teeth was more common in patients without retainers than in controls.[75,76]

Various randomized clinical studies compared the clinical effectiveness of fixed bonded retainers with removable types, as illustrated in Table 2.

The fixed bonded retainer is superior to and mandatory over a removable retainer in cases of median diastema, dental spacing, palatal impacted canines, periodontally compromised patients, or mandibular extracted incisors.[39] It has been found to be more effective in maintaining the alignment of mandibular anterior teeth than the removable retainers, and the patients have reported less discomfort and less speech difficulties and required less compliance with bonded retainers.[27]

While bonded retainers may experience debonding, the removable retainers could be fractured or lost. Research suggests that the removable Hawley retainer and lingual bonded retainer have the longest survival rates, followed by the clear plastic retainer.[77] Additionally, settling of occlusion is better achieved with upper Hawley and lower bonded retainers than with the removable retainer in both jaws.[78]

Dual retention is a recommended approach for patients at high risk of relapse. In addition to the bonded retainer, a removable retainer can be used during nighttime to provide additional support and maintain the teeth in position.[61]

The role of technology in fixed retention

The introduction of CAD/CAM technology in dentistry facilitated the fabrication of a custom lingual retainer.[79] With this technology, precise fitness of the retainer is ensured, and interference is avoided since it allows visualization of the retainer in relation to soft tissue and occlusal contacts in the patient's mouth.[80]

Different approaches were used, including subtractive manufacturing, 3D printing, and robotic wire bending for the fabrication of bonded retainers from different materials including NiTi block, zirconia, and experimental resin. Several case reports, clinical studies, and RCTs described and investigated the effectiveness of these CAD/CAM-fabricated bonded retainers to conventional ones.[31,34,41,80-83]

Conclusion

This narrative review has aimed to provide a comprehensive understanding of the importance of bonded retainers in maintaining the stability of dentition following active

orthodontic treatment. The significance of this concept cannot be overstated, particularly when considering the patient's desire to preserve their beautiful smile. It is crucial for orthodontic practitioners to effectively communicate and educate patients about the role and benefits of bonded retainers prior to initiating orthodontic treatment. This essay highlighted the following points:

1. Retention has been investigated for decades and has been subjected to many clinical studies.
2. The bonded retainer was first described by Knierim in 1973 using a 0.028″ plain round wire.
3. Fixed bonded retainers classify according to materials, fabrication, and bonding methods.
4. Many criteria are necessary to improve the success rate of bonded retainers; these criteria include retainer types, material, and bonding technique.
5. Today, technology plays a role in retainer fabrication due to its importance.
6. Here is still a need for more evidence to assess the clinical efficacy of various retainer types.

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There are no conflicts of interest.

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