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Original Article

Pre-fabricated chain retainers as an alternative to traditional retainers

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Abstract *Background/purpose:* Preserving the outcome of orthodontic treatment is both important and challenging. However, there is insufficient evidence regarding the best way to ensure long-term treatment outcome. The aim of this study was to evaluate a pre-fabricated chain retainer (PFCR) in terms of: ability to maintain satisfactory treatment outcomes; periodontal and dental health; complications; and patient satisfaction.
Materials and methods: Overall, 130 patients who had completed orthodontic treatment with a fixed appliance during the period 2016–2019 (follow-up time range, 24–55 months) at a specialist orthodontic clinic in Varberg, Sweden and who had a PFCR in the lower jaw were invited to take part in the study. Little's irregularity index (LII) was recorded on dental casts. Caries, gingivitis, calculus, probing pocket depth, and gingival retractions were registered during clinical examinations. Patient satisfaction and retainer complications were evaluated using a questionnaire.
Results: In total, 76 patients (58.5%) agreed to participate. All patients, except for one, had their retainer still in place, and the complication rate was 40%. The LII scores were in the range of 0–4 mm (mean, 1.42 mm). At the retainer site, 82% had calculus, 74% had gingivitis, 1% had pocket depth >4 mm, 10.5% had gingival retractions >2 mm, and 0% had caries. All the patients expressed satisfaction with their retainer.
Conclusion: PFCRs exhibit characteristics similar to those of traditional bonded retainers in terms of complications, stability, side-effects and patient experience. Therefore, they can be considered a viable alternative to traditional retainers installed in the lower anterior teeth.

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Introduction

Maintaining the treatment outcome is an important and challenging part of orthodontic treatment. The causes of relapse, i.e., the tendency of teeth to return to their pre-treatment positions, are still not fully understood and there is insufficient high-quality evidence to formulate recommendations regarding retention procedures for stabilising tooth positions after orthodontic treatment.[1] Long-term changes can also be expected due to growth and long-term physiological changes, especially in the lower jaw.[2] Therefore, some form of retention device is needed. In this context, bonded retainers are widely used to ensure long-term retention.[3]

The ideal retainer is stable, easy to handle, cost-effective, comfortable and has no side-effects. Bonded retainers, which are the most-commonly used forms, comprise flexible spiral wire retainers that are bonded to each tooth from canine to canine, and a cuspid retainer in the form of a round steel wire that is bonded only to the cuspids. The performances of these two types of retainers have been extensively studied, and they have their weaknesses in terms of sensitivity of the technique and needs for maintenance.[4] Systematic reviews have shown that technical failures are relatively common for these types of retainers,[5] and that relapse shows a strong correlation to bonding failures.[6] The occurrence of unexpected post-treatment changes, such as the torque changes to the incisors and the canines observed with bonded flexible spiral retainers, has also been reported in the literature.[6] Therefore, retainer stability is crucial for maintaining the treatment outcome in the long term. Previous studies have also investigated the side-effects of bonded retainers. However, the quality of the evidence as to whether periodontal outcomes, prevalence of dental caries, presence of calculus, and prevalence of gingivitis differ between patients with fixed retainers and patients without a retainer is very poor.[5]

A pre-fabricated bonded chain retainer is available in the orthodontic field (Fig. 1). According to the manufacturer, this retainer secures stable, long-term passive retention, and it will not take an active bend. Furthermore, the retainer is claimed to have the ability to resist breakage and bond failures, and the bonding procedure is claimed to be efficient because there is no need for bending or burnishing, no need for models or impressions, reduced chair-side time, and reduced laboratory costs.[7] To our knowledge, no study to date has reported on the long-term effectiveness of pre-fabricated chain retainers (PFCRs), e.g., the Ortho FlexTech®. The aim of this study was to assess a PFCR regarding: the maintenance of treatment outcome; periodontal and dental health status; complications; and levels of satisfaction for patients who had worn the retainer for at least 24 months.

Materials and methods

Design

This descriptive study has a cross-sectional design. The Regional Ethical Committee (Gothenburg, Sweden) approved the study protocol (Dnr. 2020-04860).

Patients

The study was conducted at the Orthodontic Clinic in the National Health Service, Varberg, Sweden. The mean age of the patients upon initial examination was 20.1 years (range, 14.9—39.3 years).

Inclusion criteria

Patients who had completed orthodontic treatment with a full fixed appliance (straight wire technique 0.022) and had received a pre-fabricated, bonded, stainless steel chain retainer (Ortho FlexTech®; Reliance Orthodontic Products, Itasca, IL, US) (Fig. 1), which was bonded to all the anterior teeth canine-to-canine in the lower jaw, in the period of 2016—2019 were invited to take part in the study, regardless of the type of malocclusion at baseline (N = 130). Time in retention was set to at least 24 months.

Exclusion criteria

Patients who had any other type of retention device in the lower anterior teeth or who had moved away from the region were excluded from the study.

Each patient, or for those patients younger than 15 years of age, a parent, was provided with study information both verbally and in written form. All participants had to sign a consent form before being included in the trial. One experienced orthodontist treated all the patients included in the study. The distributions of patients according to sex, Angle class, crowding/no crowding, and extraction/non-

Figure 1 A pre-fabricated chain retainer.

Table 1 Baseline (before start of the treatment) characteristics of the study patients. Shown are the distributions of the patients according to sex, Angle class, crowding/no crowding, and extraction/non-extraction therapy at baseline. Two patients are excluded from this table due to incomplete baseline imaging/journal data. Both of these patients were treated with extraction.

Sex (N = 76)	Female (N = 39)	Male (N = 37)
Angle Cl (N = 74)		
Cl I (N = 28)	17	11
Cl II (N = 46)	19	27
Extraction (N = 43)	24	19
Non-extraction (N = 31)	13	18
Crowding (N = 58)	34	24
No crowding (N = 16)	5	11

extraction therapy at baseline are presented in Table 1. All retainers were bonded with 3M™ Transbond™ Supreme LV Adhesive (3 M Inc., Saint Paul, MN, US).

Methods

For each participant, a clinical examination was performed (SW, JQ), a dental cast of the mandible was made, and five intra-oral photos were acquired. The following variables were registered during the clinical examination:

- Complications: bonding failures, fractures;
- Side-effects: periodontal health of the lower front teeth, evaluated as calculus, gingivitis, probing pocket depth (PPD), gingival recessions and caries; and
- Patient satisfaction level: the patients were asked if they were satisfied with the retainer (answer yes/no).

The following study variable was registered on the dental casts:

- Alignment of the lower front teeth: Little's irregularity index (LII)[8] was evaluated from the study casts by one of the authors (SW) using a ruler (Gestenco International AB, Gothenburg, Sweden), with a precision of 1 mm and with the measurements rounded to the closest 0.5 mm.

Baseline alignment (de-bonding) was evaluated by one author (JQ) on intra-oral photographs (Fig. 1) due to the lack of baseline data, e.g., study casts/digital scans. Alignment during follow-up measurements was performed on study casts.

A patient questionnaire, which included questions about patient experience and satisfaction with the PFCR, was implemented at the same appointment as the clinical examination. When the patient did not know the answer to a specific question but the answer could be found in the patient's journal, the answer from the patient's journal was used. Complications were also registered from the information in the dental journal. Patients with retainer bonding failures received treatment to re-bond the same retainer, while patients with calculus were treated using depuration in the lower jaw after the clinical examination.

Statistical analyses

Descriptive statistics were used to describe the LII and patient satisfaction scores. Spearman's rank correlation was used to identify correlations between the LII score and length of the retention period, and between the LII score and number of adjustments. Frequency distributions were used to evaluate the periodontal parameters.

Error of the method

The LII score, which was assessed twice by the same author (SW) for 20 randomly selected casts at an interval of 1 month, was evaluated with the error of method formula according to the Dahlberg formula: $\sqrt{\sum d2/2n}$, where $\sum d2$ is the sum of the squared differences of repeated measurements and n is the number of repeated measurements. The intra-observer correlation coefficient (ICC) was used to assess the level of agreement between repeated measurements.

Results

Complications

The follow-up periods for the retainers were in the range of 24–55 months.

Of the invited patients, 76 (58.5%) agreed to participate. All patients, except for one, had their retainers in full dimension still in place. The retainers were bonded to the six anterior teeth in the lower jaw, except in those cases (N = 7) where one lower incisor was extracted, in which instances the retainer was bonded to the five anterior incisors/canines.

In 48 (63.2%) of the patients, no adjustment had been made to the retainer, and it had been in place without any problems since de-bonding of the orthodontic appliance. Overall, 26 patients (34.2%) had undergone one adjustment, and 2 patients (2.6%) had needed two adjustments. The adjustments mainly entailed re-bonding of the wire to one tooth.

Alignment

The LII scores ranged from 0 mm to 4 mm. The LII scores for the patients with their retainer still in place ranged from 0 mm to 3 mm. Most of the patients (72.4%) had an LII score of $\leq$1.5 mm and a few had a score of $>$2 mm; the mean LII score was 1.42 mm (Fig. 2). However, there was no significant correlation between the LII score and the time that the retainer had been in place or between the LII score and the number of adjustments made to the retainer.

Side-effects

Calculus and gingivitis in contact with the retainer were seen in 82% and 74%, respectively, of the patients (Table 2). One patient had one PPD that was 4 mm, whereas all the other PPD measurements were $<$4 mm. Overall, 89.5% of

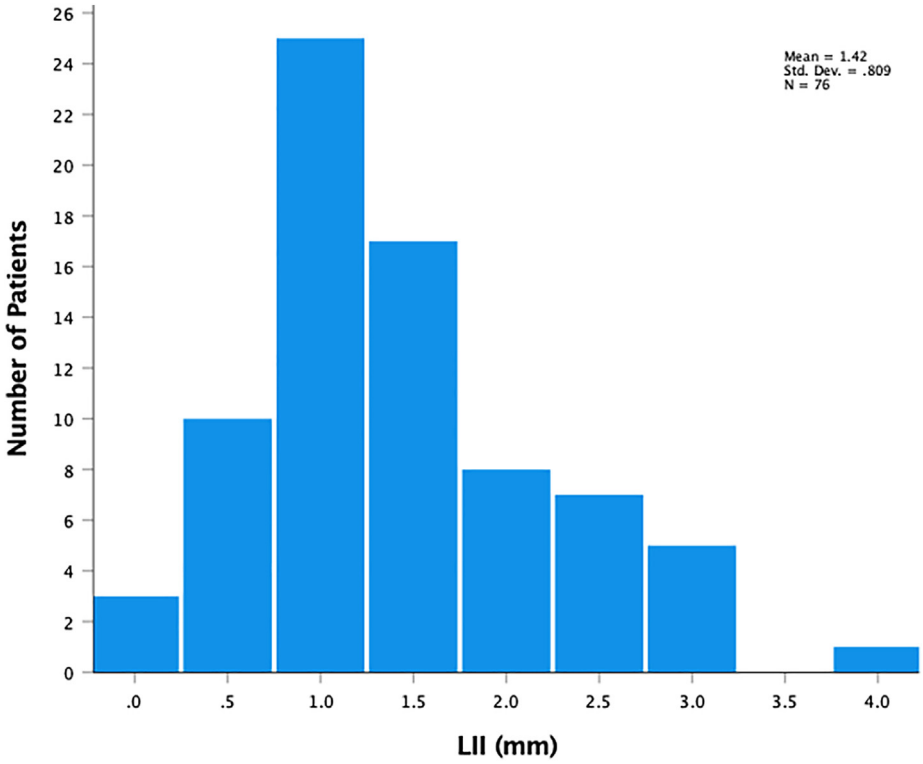

Figure 2 Frequency of the degree of irregularity according to Little's irregularity index (LII) at the recall examination.

Table 2 Numbers (N) and percentages (%) of patients with calculus or gingivitis, and of patients with different levels of gingival retractions.

	Frequency (N)	Frequency (%)	Gingival retractions (mm)	Gingival retractions (N)	Gingival retractions (%)
Calculus – no	14	18	0–1	52	68.4
Calculus – yes	62	82	1–2	16	21.1
Gingivitis – no	20	26	2–3	5	6.6
Gingivitis – yes	56	74	3–4	3	3.9

the patients had gingival retractions of ≤2 mm (Table 2). None of the patients had any caries on the affected teeth.

Patient satisfaction

All the patients (100%) who had their retainer still in place reported that they were satisfied with their PFCR. Some patients commented that they had experienced an increased amount of calculus.

Error of the method

The average error for the LII was 0.38 mm, and the ICC was 0.75, according to the Dahlberg formula.

Discussion

The PFCRs maintained the alignment of the lower incisors and caused no side-effects, with the exceptions of gingivitis and calculus. Moreover, the technical complication rate was relatively low, and all the patients expressed satisfaction with their retainer.

The stability of the alignment of the lower incisors noted in the present study is in agreement with that reported in some previous studies,[9] while other studies have shown a greater degree of alignment.[10] However, the clinical significance of this difference in LII score (1 mm) is debatable. In the present study, most of the patients did not show perfect alignment (LII = 0) at baseline.

We found no correlation between the LII score and the time of retention, and no significant correlation between the LII score and the number of adjustments. This might be explained by the follow-up time and the low number of adjustments. In other studies, lower incisor irregularity has been strongly correlated to bonding failures of the retainer.[6]

The degrees of gingivitis and calculus in this study were generally higher than those found in previous studies.[10] Since the present study lacked controls, it cannot be ruled out that these patients had poorer oral hygiene than patients in general. However, a more likely explanation is

that the physical form of the chain-like PFCR resulted in an increased incidence of calculus retention sites, as compared to traditional spiral wires, resulting in gingivitis due to increased difficulties with tooth brushing. This topic warrants further investigation.

A previous study[11] showed higher prevalence rates of marginal recessions, calculus, and PPD in patients who had had long-term (9 years) retention with a lingual fixed retainer, as compared with a group with short-term wearing of retainers (3–6 months). The patients in our study had undergone retention for at least 24 months, which is similar to the previous results for the group with long-term retention. In our study, only one patient had a periodontal pocket >4 mm, and most of the patients had gingival recessions of <2 mm. The mean attachment losses reported in other studies have been both lower and higher, ranging from 0.62 mm to 3 mm.[12,13] In similarity to a previous study,[10] no signs of caries were observed adjacent to the wire in any of the patients.

All but one patient had their retainer still in place at follow-up, and few patients reported a need for adjustment. On the one hand, this is a low failure rate compared to a previous study, which reported a failure rate of approximately 50% at 2 years.[13] On the other hand, it matches the failure rate in another study.[6] The relatively low frequency of retainer failures in our study accords with that seen in a previous study that showed that the PFCR possesses sufficient bond strength for clinical application.[7]

There have been some reports of unexpected movements of the mandibular anterior teeth that are retained with flexible spiral wire retainers. One study presented a 3%–5% prevalence of unexpected post-treatment complications, such as torque changes to the incisors and increased buccal inclination of the canines, when using a 0.0195-inch, 3-strand, heat-treated flexible spiral wire.[6] While the reason for this is not clear, one hypothesis is that the wire is deformed when exposed to the mastication load, due to the twisted component of the wire.[6,14] The PFCR is not a twisted type of retainer and it is claimed by the manufacturer that it does not cause unwanted torque changes to the teeth.

All the patients in the present study expressed satisfaction with their retainer. However, some patients experienced increased levels of calculus.

Approximately 60% of the invited patients were eventually enrolled in the study. The reasons for non-participation may have included the need for an extra dental appointment during working hours. As a further complication, the study was conducted during the COVID-19 pandemic.

The limitations of this study were its retrospective design, a lack of controls, and the fact that the degree of crowding at baseline was assessed from clinical photographs. In addition, the lack of periodontal baseline data means that the periodontal outcomes are only comparable to healthy/unhealthy periodontal conditions, so it is not possible to see the exact effects that could be caused by the retainers. However, since there is a scarcity of data regarding this type of retainer, this study provides valuable information for clinicians who wish to start installing such retainers in their patients. The main strengths of the present study are the high number of patients and the relatively long follow-up time.

The promising results obtained in the present study in relation to retainer stability, side-effects and patient satisfaction suggest that PFCRs represent a cost-effective alternative to conventional bonded retainers, which require extra visits for impressions and dental casts and extra demands on terms of laboratory work. PFCRs can, therefore, be beneficial to use in daily orthodontic practice due to saving chair-time and having properties similar to those of conventional bonded retainers. Prospective randomised clinical trials with more-controlled baseline data and fewer drop-outs are needed to confirm the clinical value of PFCRs.

According to the results of this study, the PFCR shows a similar stability and no more side-effects or complications than other, more-extensively investigated bonded retainers and can be a good alternative for retention in the lower anterior teeth following orthodontic treatment.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

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