ORIGINAL ARTICLE

FAILURE ANALYSIS OF MAXILLARY AND MANDIBULAR BONDED SPIRAL WIRE RETAINERS

Sarah Irfan, Mubassar Fida, Attiya Shaikh*

Aga Khan University Hospitals, Karachi, *Liaquat College of Medicine and Dentistry-Karachi-Pakistan

Background: Most of the orthodontic cases require a long period of retention which is usually carried out with the help of fixed retainers (FR). One of the downsides of FR is that these are prone to breakages. The aim of the present study was to identify the frequency and factors associated with failure of fixed spiral wire retainers. **Methods:** A retrospective cross-sectional study was conducted using orthodontic files and dental casts of 126 patients from dental clinics of a tertiary care hospital. Descriptive statistics were applied to calculate the frequency and most common site of breakages. Chi-square test was applied to compare the frequency of breakages among age groups and different retainer spans. Independent sample *t*-test was used to compare the mean overbite in retainer breakage and retainer intact groups. A *p*-value ≤0.05 was considered as statistically significant. **Results:** The frequency of retainer breakage was found to be 53.1%. Maxillary retainer breakages were found in 41.3% subjects whereas mandibular retainer failed in 22.2% subjects. The mean survival time of retainer was 8.91±4.57 months. The detachment of the retainer from the tooth surface was the most common occurrence (86%). The most common site of retainer breakage was maxillary canine (32.5%) and mandibular central incisor (12.7%). All the subjects who had retainers extending till maxillary molars encountered breakages. **Conclusions:** A longer retainer span is associated with a greater risk of breakage. Failure rate in the maxillary arch was higher than the mandibular arch. The most common sites were the maxillary canine and mandibular central incisor. The most common pattern was wire detachment.

Keywords: Orthodontic retention; Fixed retainers; Spiral wire

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INTRODUCTION

Removal of orthodontic appliances at the completion of treatment is followed by an important stage of retention. The primary goal of this phase is to maintain the correction achieved through orthodontic treatment. Remaining growth at the end of orthodontic treatment may lead to the reversal of the achieved correction.[1] Retention is required to allow the gingival and periodontal fibres to reorganize and acquire equilibrium. Soft tissue pressures can result in relapse if the teeth are placed in an unstable position at the end of the treatment. Most of the orthodontic cases require a long period of retention which is best carried out with the help of fixed retainers (FR).

Initially, Zachrisson[2] promoted the use of bonded retainers for long term retention. FR are employed in cases where lower incisors' position is to be maintained, when extraction spaces and diastemas are closed or where orthodontically achieved space for an implant or pontic has to be maintained[3]. However, over the last couple of decades, a gradual trend has been noticed towards the use of fixed retainer in all types of cases as these are inconspicuous, do not depend on patients' compliance, cause any soft tissue irritation or affect speech.[3]

Various types of FR have been implicated in recent years; multi-stranded and glass fibre reinforced retainers being the most popular ones.[4] One of the downsides of FR is that these are prone to breakages. Different factors can be related to the survival or failure of the retainer. Technique-related problems can lead to frequent bond failures e.g. using too little adhesive, moisture contamination or retainer movement during the curing of adhesive.[5] Other possible factors discussed in the literature are mainly the quality of the retainer wire, the type of adhesive used for bonding, isolation protocol, operator efficiency, occlusal characteristics and occlusal trauma to the wire.[6,7–13] In young patients, non-compliance during the procedure might have a negative effect on bonding. Successful clinical outcomes were reported in an adult population who are expected to be compliant to the given instructions.[14]

The retainer failures can be classified as (1) Total loss: when all bonding sites of the retainer become detached (2) Detachment: when one or more bonding sites become detached but the retainer is still in place. Detachment can either be

at the composite-tooth interface or composite-wire interface; and (3) Retainer fracture: when the retainer wire breaks at any point along the retainer span.[5,6] This may be due to heavy biting forces or fatigue of the wire.[15]

Fixed retainers can be bonded in different spans in either arch according to the patient's age, periodontal health, treatment plan being followed, patients' initial malocclusion and anticipated relapse.[16] Bond failures mostly occur within the first 6–12 months;[2] and in patients with retainers that bond all anterior teeth, any detachment may go unnoticed.[17] FR can be successfully used for permanent and semi-permanent retention; however, these can only be dependable if they remain failure-free.[18] Therefore it's important for patients to have frequent check-ups with their orthodontists especially in this period.

According to pertinent literature survey, there is scarcity of data reporting retainer failure in longer spans and any relation between the overbite and retainer failure. The aim of the present study was to identify the frequency of failure of both maxillary and mandibular fixed spiral wire retainers of different spans and to identify the factors associated with it.

MATERIAL AND METHODS

A cross-sectional study was conducted at the dental clinics of the Aga Khan University Hospital for a period of 3 months from June-August 2016. The sample size was calculated using the findings of Cerny[19] who reported the failure rate of 9% in canine to canine retainers. The precision was set at 5% and the confidence level was set at 95% which showed that we need at least 126 subjects in this study. Retrospective data of 1500 patients who presented for treatment between January 2005–June 2016 were evaluated. One hundred & twenty-six patients based on our inclusion criteria were included in the study, A non-probability consecutive sampling technique was used. An ethical review committee exemption was obtained prior to conducting the study (4391-Sur-ERC-16)

Patients with upper and lower fixed spiral wire retainers which extended from canine to canine, premolar to the contralateral premolar or from molar to the contralateral molar, patients who had at least one year of follow-up and those who were given FR using the direct bonding technique were included in the study. Patients whose retainers were removed purposefully, those who received other retainers in combination with the spiral wire retainers and those given asymmetric/atypical retainer span were also excluded.

Alginate impressions of the patients were taken one appointment prior to the debonding. The retainer was prepared on plaster casts with a 17.5 mil multistranded stainless steel wire. Fabrication of retainer on casts is a recommended method rather than intraoral fabrication.[17] After debonding, the lingual surfaces of the teeth were pumiced, rinsed with water, and dried with compressed air. The surfaces were then acid etched with 37% phosphoric acid (DenFil Etchant -37), rinsed thoroughly and dried. Then the bonding adhesive primer (3M) was applied and light cured. Floss was placed between the teeth to aid in the placement of the retainer wire and the retainer was then bonded to the teeth using light cure composite material (3M ESPE - Filtek^{TM} Z250 XT) and cured with LED curing light (Power Pen Type, 5W blue LED) producing light of wavelength 440–480 nm for 20 seconds per tooth. On the completion of bonding, floss holding the retainer wire were removed. Any occlusal interference was checked and composite was finished with a high speed hand-piece. All the retainers were bonded by postgraduate students.

Data were collected using the patients' orthodontic files and dental casts on a customized proforma. Details recorded from the patients' orthodontic files were the date of retainer placement and first retainer breakage, span of the retainers and the site of the breakage. The overbite was calculated from the patients' dental casts with the help of a Vernier calliper.

Data were analysed using SPSS-19.0; IBM, Armonk, NY) Descriptive statistics were used to calculate the mean age of patients, follow-up period, survival time of the retainer in the mouth before breakage, the frequency of breakage and the site of breakage. Chi-Square test was used to compare the breakages among different age groups, retainer span groups and gender. Independent sample t-test was used to compare the mean overbite in the retainer breakage and retainer intact groups. A p-value ≤ 0.05 was considered to be statistically significant.

RESULTS

The sample consisted of 77 female and 49 male subjects. The mean age of the subjects was 16.50±6.82 years. The mean duration of follow-up after placement of the retainer was 2.86±1.34 years. Retainer failure occurred in 67 out of a total of 126 patients at some point in time. The mean survival time of retainers in these 67 patients was 8.91±4.57 months. The frequency of failure of maxillary retainers was found to be 41.26% which

was higher than that of mandibular arch which had a failure rate of 22.22%.

When the retainer breakages were compared between the genders, males and females showed comparable failure rates. Both genders showed greater rate of failure in the maxillary arch as compared to mandibular; however, these findings were statistically insignificant (Table-1).

Detachment of the retainer from the tooth surface was the most common pattern of the retainer failure followed by the fracture of the retainer wire. The frequency of different patterns of retainer failure is shown in table-2.

The frequency and total number of breakages at each tooth in the maxillary and mandibular arch was calculated separately (Table 3 and 4). Maxillary canines and the mandibular incisors were identified as the most common sites of failure of FR.

The retainer breakages of the maxillary and mandibular arches were then compared in different age groups (Table 5), which showed insignificant intergroup differences for both arches.

The frequency distribution of retainer span was calculated for both arches separately (Figure-1). The frequency of retainer failure according to different retainer spans was compared using Chi-square test. A longer retainer span in the maxillary arch was found to be significantly associated (p=0.007) with a greater risk of failure. All five molar to molar retainers in the maxillary arch in current sample failed at some point in time (Table-6).

The degree of overbite was compared in the retainer failure and retainer intact groups using the independent sample t-test which showed insignificant differences (p >0.05) in both arches (Table-7).

Table-1: Gender dimorphism in retainer breakage

	Gender	Total	Breakage	Intact	*p*-value
Maxillary Retainers	Males	49	19	30	0.712
	Females	77	33	44	
Mandibular Retainers	Males	49	12	37	0.664
	Females	77	16	61	

Total subjects n =126. $p \leq 0.05$; Chi-square Test

Table-2: Pattern of retainer failure

Pattern	Frequency
Detachment from tooth	58
Wire fracture	6
Detachment along with wire fracture	2
Loss of wire	1
Total	67

Total subjects (n) = 126. Breakage (n) = 67

Table-3: Frequency and total number of breakages at each tooth in maxillary arch

	Maxillary Central Incisor	Maxillary Lateral Incisor	Maxillary Canine	Maxillary Second Premolar	Maxillary Molar
Subjects	21/126 (16.6%)	34/126 (26.9%)	41/126 (32.5%)	10/51 (19.6%)	0/5 (0%)
Total no. of Breakages	32	63	55	16	0

Total subjects (n)=126

Table 4: Frequency and total number of breakages at each tooth in mandibular arch

	Mandibular Central Incisor	Mandibular Lateral Incisor	Mandibular canine	Mandibular Second Premolar	Mandibular Molar
Subjects	16/126 (12.7%)	12/126 (9.5%)	11/126 (8.7%)	3/40 (7.5%)	1/16 (6.2%)
Total no. of Breakages	24	18	15	5	1

Total subjects (n) = 126

Table-5: Retainer breakages in different age groups

	Age Groups (Years)	Breakage	Intact	Percentage of Breakage	*p*-value
Maxillary Retainers	10–20	44	62	41.5	0.841
	20–30	3	6	33.3	
	>30	5	6	45.4	
Mandibular Retainers	10–20	26	80	24.5	0.381
	20–30	0	9	0	
	>30	2	9	18.1	

Total subjects n=126; $p \leq 0.05$; Chi-square Test

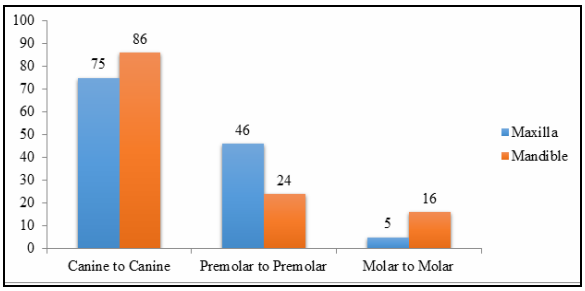

Figure-1: Distribution of retainer spans in maxillary and mandibular arch

Table-6: Retainer breakages in different retainer span group

	Retainer Span	Total	Breakage	Intact	*p*-value
Maxillary Retainers	Canine to Canine	75	25	50	0.007*
	Premolar to Premolar	46	22	24	
	Molar to Molar	5	5	0	
Mandibular Retainers	Canine to Canine	86	18	68	0.649
	Premolar to Premolar	24	5	19	
	Molar to Molar	16	5	11	

n =126. *$p < 0.05$; Chi-square Test

Table-7: Relationship between overbite and frequency of retainer breakage.

	Overbite (mm)		*p*-value
	Breakage (Mean±SD)	Intact (Mean±SD)	
Maxillary Retainers	3.96±2.50	3.25±2.61	0.129
Mandibular Retainers	3.03±2.44	3.68±2.61	0.240

n =126, SD – Standard Deviation. $p < 0.05$; Independent sample t-test

DISCUSSION

The bonded spiral wire retainers are one of most commonly used form of retention owing to the patients' acceptance for a longer period of time. These retainers do have certain disadvantages such as, they are prone to breakages and have increased susceptibility to plaque and calculus accumulation, which may lead to gingivitis and compromised periodontal health.[6,20] Various studies have tested the retentive efficiency and reliability of multi-stranded wire retainers bonded to the lingual sides of canines and incisors.[11,21,22]

The survival duration of those retainers that eventually broke was calculated to be 8.9±4.57 months in the present study. This is comparable to a mean survival time of 7.6 months reported by Ardeshna.[24] However, Segner and Heinrici[25] in Germany, reported the mean survival duration for FR to be 22.3 months, which is far greater than the survival duration in our subjects. Although the same technique was used, this difference could be attributed to the fact that in contrast to our study, all procedures were done by the consultants. The difference in skill and experience could account for the difference in the results. As most of the breakages were encountered during the first 12 months, frequent follow-up visits initially and subsequently 6-monthly visits should be scheduled so that unnoticed breakages or problems can be catered at the earliest.

The retrospective nature of the present study was associated with certain limitations. A number of operators having different levels of skill might have affected the results. Schneider and Ruf[5] reported the frequency of retainer breakage in the maxillary arch to be 58.2%. In the present study, we had a 41.26% breakage in maxillary retainers. Taner and Aksu[18] reported the mandibular retainer breakage in 46.9% of their subjects; whereas, it was found to be 22.2% in the current study.

The most common pattern of retainer failure in our study was the detachment of the retainer wire from teeth surfaces at one or more sites which is in concordance with other studies.[2,5,11,26] A shortcoming of this retrospective study is that the type of retainer detachment (wire-adhesive interface or adhesive-tooth interface) could not be determined from the orthodontic files.

The most frequent sites of failure in literature are lower central incisors followed by upper central incisors and upper lateral incisors.[27] In the present study, the most affected tooth in the mandibular arch was found to be central incisor which is in concordance with other studies.[27] However, the most frequent site of breakage in the maxillary arch was found to be the maxillary canine in the current study followed by upper incisors. According to Taner and Aksu,[18] the anatomy of the lingual surface of the maxillary incisors can cause an inadequate bonding of the adhesive with the lingual tooth surface, leading to failure. Moreover, debonding of retainers at maxillary anterior teeth could also be related to patients' biting forces and habits.[26]

In the present study, it was noted that mandibular retainer breakages were frequent in 10–20 years age group whereas maxillary retainer breakage was more common in patients 30 years or older. In young patients, non-compliance during the procedure can have a negative effect on bonding.

According to the literature survey, FR is mostly given in the mandibular arch from canine to canine. In the maxillary arch, FR are bonded usually to either central incisors or extend till lateral incisors.[5,6] In the present study, longer retainer spans were studied. Subjects who were treated with a non-extraction fixed mechanotherapy were given FR till canines in both arches. Those treated with first premolar extractions were given retainers extending

till second premolars whereas subjects with second premolar or first molar extractions had retainers extending till first and second molars respectively.

In various studies with retainers bonded to each anterior tooth (usually canine to canine), bond failures ranged from 5.3[26] to 71%,[24] whereas those retainers bonded only to canines, the bond failures rate ranged from 3.5 to 37.7%.[26,28,29] This can be attributed to the fact that internal stresses can be incorporated at several focal points as the retainer involves more teeth.[4] Similarly in our study, a significant relationship was noticed between retainer breakage and number of teeth bonded. All the maxillary retainers extending from one molar to contralateral molar encountered breakage in our study sample. Therefore, patients should be properly counselled about the aftercare and advised to return to dental clinics in case of any breakage.

Higher failure rate in the maxillary as compared to the mandibular retainers may be attributed to occlusal interferences or change in the overbite after the treatment. In a study conducted by Sadowsky,[30] 16% subjects exhibit increase in overbite on long term follow-up after orthodontic treatments. In the present study, orthodontic treatment in all subjects was finished within a normal range of overbite (2–4 mm).[3] Overbite at the time of retainer breakage cannot be determined to affirm any relapse in overbite that may have caused the retainer breakage. However, retainer breakage was compared to the pre-treatment overbite of the patients to check whether any association exists between breakage and excessive pre-treatment overbite. A weak trend of greater overbite was noticed in the retainer breakage group as compared to retainer intact group; however, the difference was not significant. This can be because of the fact that the maximum follows up period in the present study is 6 years and any deepening of overbite, would be very minimal in this period. Follow up studies for a longer period would be required to report any significant relation between retainer breakages and post-treatment relapse in overbite.

There were certain limitations in our study that includes retrospective study design due to which certain details could not be retrieved e.g. the type of detachment (adhesive or cohesive failure) of the retainer, overbite at the time of retainer breakage and effects of fixed retainer on periodontal health. Furthermore, as the study was conducted in a university hospital, retainers were bonded by different operators; the difference in clinical skills may affect the results.

We recommend a prospective clinical trial in which the detachment type and any increase in overbite at the time of breakage can be evaluated. Skill levels can also be standardized by evaluating the fixed retainers bonded by the same clinician. Moreover, periodontal health can be assessed in prospective trials as studies have reported varying effects of fixed retainers on periodontal appratus.[31–33] From our study results, it can be recommended to use hybrid retention (fixed retainer plus removable retainer for night time wear) especially in cases where permanent retention is required. Also, regular follow up appointments should be scheduled so that any breakage can be repaired at the earliest reducing the chances of relapse.

CONCLUSIONS

The success of orthodontic therapy lies in stability of the achieved results in the long term. The identification of factors which may lead to the failure of fixed retainers is of utmost importance. A high frequency of retainer breakage in our study indicates the importance of following the standard bonding protocols, passivity of the retainer against the lingual surfaces of the teeth, eliminating occlusal interferences and regular follow up visits. Also, greater failure rate in long span maxillary retainers suggests careful planning of either the span of the fixed retainer or the type of retention (removable or hybrid) based on pre-treatment malocclusion. The control of these factors is essential to prevent breakages and hence relapse of the ideal occlusal relationships achieved at the end of orthodontic treatment.

AUTHORS' CONTRIBUTION

All authors were involved in study conception, design and planning. SI performed data collection and analysis. Manuscript was approved by all the authors.

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Address for Correspondence:

Mubassar Fida, Section of Dentistry, Department of Surgery, The Aga Khan University Hospital, P.O Box-3500, Stadium Road, Karachi 74800-Pakistan
Email: mubassar.fida@aku.edu