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Risk factors for orthodontic fixed retention failure: A retrospective controlled study

Kaat Verschueren
Amit Arvind Rajbhoj
Giacomo Begnoni
Guy Willems
Anna Verdonck
Maria Cadenas de Llano-Pérula

Department of Oral Health Sciences-Orthodontics, KU Leuven and Dentistry, University Hospitals Leuven, Leuven, Belgium

Objective: To investigate the potential correlation between fixed orthodontic retention failure and several patient- and treatment-related factors. **Methods:** Patients finishing treatment with fixed appliances between 2016 and 2017 were retrospectively included in this study. Those not showing fixed retention failure were considered as control group. Patients with fixed retention failure were considered as the experimental group. Additionally, patients with failure of fixed retainers in the period of June 2019 to March 2021 were prospectively identified and included in the experimental group. The location of the first retention failure, sex, pretreatment dental occlusion, facial characteristics, posttreatment dental occlusion, treatment approach and presence of oral habits were compared between groups before and after treatment separately by using a Fisher exact test and a Mann–Whitney *U* test. **Results:** 206 patients with fixed retention failure were included, 169 in the mandibular and 74 in the maxillary jaws. Significant correlations were observed between retention failure in the mandibular jaws and mandibular arch length discrepancy (P = 0.010), post-treatment growth pattern (P = 0.041), nail biting (P < 0.001) and abnormal tongue function (P = 0.002). Retention failure in the maxillary jaws was more frequent in patients with IPR in the mandibular jaws (P = 0.005) and abnormal tongue function (P = 0.021). **Conclusions:** This study suggests a correlation between fixed retention failure and parafunctional habits, such as nail biting and abnormal tongue function. Prospective studies with larger study populations could further confirm these results.

Key words: Relapse, Orthodontic retainer, Malocclusion, Humans

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Corresponding author: Maria Cadenas de Llano-Pérula.
Assistant Professor, Department of Oral Health Sciences-Orthodontics, KU Leuven, Kapucijnenvoer 7, 3000 Leuven, Belgium.
Tel +32-16-33-20-17 **e-mail** maria.cadenas@uzleuven.be

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INTRODUCTION

The prevalence of fixed retention failure varies significantly with values ranging from 5.3 to 71%.[1,2] Bonding failure has been reported to occur mostly in the first 3 to 6 months of retention.[3] Rebonding after failure can increase the risk of repeated failure. When the canines are included, the retention wires in the maxillary jaws seem to be more prone to detachment than those in the mandibular jaws, possibly due to occlusal contact.[4-8]

Retention failure is potentially multifactorial; however, literature regarding the role of patient- or treatment-related factors in retention failure is limited. Gerami et al.[9] reported that more labially tilted incisors with a fixed lingual retainer experience more stress in the periodontal ligament and greater incisal movement because the forces are less parallel to the more vertical masticatory force direction. From this point of view, mandibular incisors with a normal inclination in individuals with open growth pattern would also experience more horizontally directed occlusal forces, thereby potentially affecting fixed retainer failure. In addition, interproximal reduction (IPR) has been found to be as successful at reducing relapse as using a retainer.[10] This can raise the question of whether teeth with retention wires and IPR are less likely to suffer from retention failure owing to their stabilizing effect. The same could be assumed in patients with good post-treatment interdigitation, although there is not enough evidence to support this.[11] The factors involved in orthodontic relapse may probably not exceed the bond strength of the fixed retainers and cause them to fail[12]; however, no research has been performed regarding this topic either.

Some studies suggest a link between the increased tooth mobility observed after treatment with fixed appliances and higher failure rates in the first months after bonding with a retention wire.[3,13] The extra jiggling forces produced by oral habits, such as bruxism or nail biting, have also been suggested to cause tooth mobility and displacement, respectively.[14,15] Additionally, abnormal tongue position during swallowing or at rest is known to affect the incisor position, leading to an increase in tooth mobility in periodontal patients.[16,17] Uneven masticatory load or muscle imbalance could also lead to higher occlusal load on certain teeth, which could create higher elastic deflection of the retention wire, resulting in higher chance of retention failure. Retention failure is not cost-effective for patients or practitioners and can lead to treatment relapse, which is an important clinical problem.

This study aims to investigate the possible correlation between fixed orthodontic retention failure and several patient- and treatment-related factors, such as pretreatment occlusal parameters, facial characteristics, treatment approach, stability of occlusion, and presence of oral habits. These findings could ideally be integrated into orthodontic treatment planning and post-treatment follow-up to help practitioners minimize retention failure.

MATERIALS AND METHODS

This study was registered and approved ethics committee of KU Leuven and University Hospitals Leuven (MP011223).

Patient selection

The experimental group consisted of (I) patients treated with fixed orthodontic appliances in the Department of Oral Health Sciences-Orthodontics, with fixed retainer failure between June 2019 to March 2021, who were prospectively included, and (II) patients who completed treatment with fixed appliances between 2016 and 2017, received fixed retainers, and had at least one fixed retention failure in the period until March 2021, who were retrospectively included. The control group consisted of consecutive patients who completed treatment during the same period (2016–2017) and did not show any failure or relapse for at least 1 year after debonding. The patients treated between 2016 and 2017 were treated by the same 3 orthodontists. Patients with retention failure due to dental restorations were excluded. Only the first failures were included in the statistical analysis, and patients could only be included in one of the 2 groups.

Retention protocol

According to the standard protocol of our Department, retainers (either removable, fixed, or a combination) are placed in all patients after the completion of active orthodontic treatment. Patients are advised to return for follow-up appointments 1 month, 3 months, 6 months, 1 year, 2 years, and 5 years after the debonding of fixed appliances. In this study, patients with removable retainers were excluded and only patients with fixed retainers were included.

In all cases, a stainless steel 6-strand twisted retention wire (Forestadent GmbH, Pforzheim, Germany) was bonded to all anterior teeth from canine to canine. All retainers were fabricated on dental casts in the same orthodontic laboratory using the same wire type, as described above. The wires were delivered by the dental technicians in silicone templates to determine their exact positions on the lingual surfaces of the teeth. All retainers were placed according to the same bonding protocol as follows: after debonding of the fixed appliances, the lingual surfaces were first cleaned and then isolated to start the bonding procedure. Each tooth was treated according to the manufacturer's instructions,

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including etching with phosphoric acid gel (K-etchant Syringe; Kuraray Noritake, Kurashiki, Japan), rinsing, drying, and bonding with a light-curing primer and adhesive (Transbond™ LR Primer; 3M Unitek, St. Paul, MN, USA). Subsequently, pieces of dental floss were placed in each interproximal space from canine to canine. The wire was then placed onto the teeth with the template and secured with floss. The wire was then bonded to the lingual surfaces of the teeth using Transbond™ LR Adhesive (3M Unitek). Finally, the smoothness of the surface was checked, and possible premature contacts were removed, particularly when the wire was placed in the maxillary jaws.

Data collection

Data from the included patients were collected from records before and after treatment, including digital casts, lateral cephalograms, and clinical photographs. In the experimental group, the following data were collected regarding retention failure: number of involved teeth, recurrence (yes/no), and associated relapse (yes/no).

For the comparison of the characteristics of patients with (experimental group) and without retention failure (control group), the following data were extracted from the records if present: sex, pretreatment occlusal parameters (overjet, overbite, and arch length discrepancy [ALD]), facial characteristics (growth pattern and skeletal relationship before and after treatment), post-treatment dental occlusion (proclination of maxillary and mandibular incisors, stability of the occlusion [yes/no]), treatment approach (dental extractions, IPR) and presence of oral habits (oral breathing, abnormal tongue function, pen or nail biting). Mixed dentition analysis was not included in the statistical analysis.

Additionally, cephalometric analysis was performed on pre- and posttreatment lateral cephalograms using VistaDent AT 3.1 software (Dentsply Sirona GAC International OC Orthodontic Imaging, Islandia, NY, USA). The growth pattern was determined using the gonion-gnathion to sella-nasion angle.[18] The A point-nasion-B point (ANB) angle was used to determine the skeletal relationship. The incisor angulation was determined after the treatment using the angle between the longitudinal axis of the front teeth and NA or NB lines for the maxillary and mandibular teeth, respectively.

Statistical analysis

Pre- and posttreatment variables were cross-sectionally compared between the groups with and without retention failure. Group comparisons of categorical variables were performed using Fisher's exact test, while the Mann–Whitney *U* test was used for ordinal or continuous variables. All tests were performed at a two-sided 95% confidence interval, and analyses were performed using SAS software version 9.4, SAS System for Windows (SAS Institute, Cary, NC, USA).

Table 1. Demographic data of the included patients and retention failures

Variable	Patient	Female	Male	*P* value
Total patients with retention failure	206	112	94	-
Retention failure maxillary jaws	74	40	34	> 0.999
Control group maxillary jaws	23	13	10	
Retention failure mandibular jaws	169	91	78	0.877
Control group mandibular jaws	56	29	27	
Retention failure maxillary + mandibular jaws	37	19	18	-
1 tooth involved	128 (62.14)	-	-	-
2 teeth involved	49 (23.79)	-	-	-
3 teeth involved	16 (7.77)	-	-	-
More than 3 teeth involved	13 (6.31)	-	-	-
Displacements due to bonding failure	27 (13.11)	-	-	-
Right quadrants	193 (57.27)	-	-	-
Left quadrants	144 (42.73)	-	-	-
Patients with follow-up of > 1 consults	188	-	-	-
Recurrence of retention failure	113 (60.11)	-	-	-
Recurrence on the same tooth	53 (28.19)	-	-	-

Values are presented as number only or number (%).
–, not available.

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RESULTS

The demographic details of the sample and retention failures are shown in Table 1. A post hoc power analysis performed using G*power (v. 3.1) with an effect size derived from the mandibular ALD revealed a power of 75.45% in the current sample. No association was observed between retention failure and sex. Figures 1 and 2 show that retention failure occurred more often in the mandibular jaws, closer to the midline, whereas the sites were more spread over the 6 anterior teeth in the maxillary jaws. The first retention failure mostly involved 1 tooth (62.14%), and in 37.9% of cases, 2 or more teeth. On further follow-up, retention failure recurred in 60.11% of the cases and 28.19% in the same tooth.

The data on the first retention failure were analyzed separately for the maxillary and mandibular jaws. A comparison of the different studied variables between the control and retention failure groups for both jaws is presented in Tables 2 (at the start of treatment) and 3 (after treatment). No association was found between retention failure and dentofacial characteristics in any of the jaws, except for ALD and open growth patterns. Patients with retention failure in the mandibular jaws presented with a slightly more open growth pattern at the end of treatment than those in the control group (P = 0.041). Additionally, in the mandibular jaws, significantly more crowding was observed in the control group than in the retention failure group (P = 0.010) at the start of treatment.

A strong association was found between nail-biting, abnormal tongue function, and retention failure in the mandibular jaws (P < 0.001 and P = 0.002, respectively). A significant relationship was also found in the maxillary jaws for abnormal tongue function (P = 0.021) but not for nail biting (P = 0.088). Finally, IPR of the mandibular front teeth was performed significantly more often in the control group than in the group with retention failure in the maxillary jaws (P = 0.005).

DISCUSSION

Our findings confirm that mandibular incisors that are closer to the midline are more susceptible to retention failure, as described in the literature,[5] possibly due to their concave lingual surfaces, the manner they receive biting forces, and their proximity to the sublingual gland. Furthermore, mandibular incisors are the most prone to relapse immediately after completion of orthodontic treatment.[5] In the maxillary jaws, canines are relatively more affected than incisors due to the possible occlusal interferences of the mandibular canines with the wire, which has also been mentioned in the literature.[6,7] Furthermore, the recurrence of retention failure on the same tooth was observed in 28.19% of our sample, which is comparable to the 28% reported by Taner and Aksu.[5] The difficulty of properly removing the remnants of the composite could partly explain this finding, since it has been shown that bonding to preexisting composite surfaces results in inferior bonding strength.[19] Meanwhile, 60.11% of patients presented several retention failures in different teeth, which could suggest possible patient-related factors behind multiple retention failures, although confirming this would require further research. Therefore, the close monitoring of patients with a history of retention failure is recommended.

Retention failure was not significantly related to most of the studied pretreatment occlusal factors, except for ALD in the mandibular jaws. This could be because our study focuses on the first retention failure, which happens mostly within the first 6 months after debonding. This period may be too short to detect retention failure

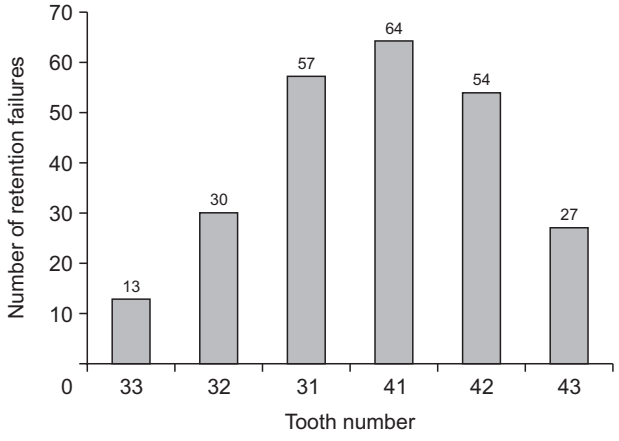

Figure 1. Number of failures according to tooth type in the mandibular jaws.

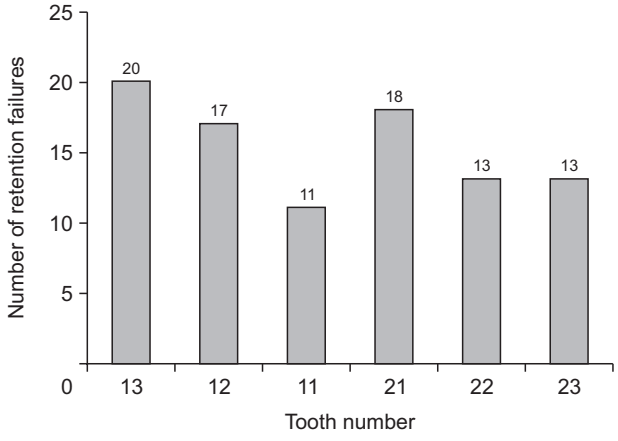

Figure 2. Number of failures according to tooth type in the maxillary jaws.

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Table 2. Retention failure vs. controls at the start of treatment

Variable	Statistic value	Mandibular jaws			Maxillary jaws		
		Failure	Control	*P* value	Failure	Control	*P* value
Overjet	N	169	56	0.722	74	23	0.104
	Mean	4.17	4.11		4.35	3.30	
	SD	2.476	3.043		2.625	2.382	
	Median	4.00	3.00		4.00	3.00	
	IQR	3.00 to 6.00	2.00 to 6.00		3.00 to 6.00	2.00 to 5.00	
	Range	−3.00 to 12.00	−4.00 to 12.00		−3.00 to 12.00	−3.00 to 9.00	
Overbite	N	169	56	0.283	74	23	0.911
	Mean	3.14	3.63		3.01	3.04	
	SD	2.270	1.893		2.407	1.796	
	Median	3.00	4.00		3.00	3.00	
	IQR	2.00 to 5.00	3.00 to 5.00		2.00 to 5.00	2.00 to 4.00	
	Range	−6.00 to 8.00	−1.00 to 10.00		−4.00 to 9.00	−1.00 to 7.00	
Deep palatal bite	n/N (%)	22/169 (13.02)	8/56 (14.29)	0.822	16/74 (21.62)	2/23 (8.70)	0.226
Anterior open bite	n/N (%)	24/169 (14.20)	3/56 (5.36)	0.097	10/74 (13.51)	2/23 (8.70)	0.725
ALD maxillary jaws	N	139	49	0.132	56	18	0.281
	Mean	−0.76	−1.91		−0.09	−2.12	
	SD	4.802	3.674		6.047	3.206	
	Median	−0.77	−1.61		−0.74	−1.43	
	IQR	−4.01 to 2.06	−3.12 to −0.17		−4.88 to 4.40	−3.21 to −0.67	
	Range	−12.00 to 13.16	−14.00 to 4.91		−13.81 to 14.28	−11.33 to 2.77	
ALD mandibular jaws	N	139	49	0.010*	54	19	0.177
	Mean	−0.44	−2.17		−1.05	−2.01	
	SD	3.688	3.500		3.883	2.652	
	Median	−0.86	−2.10		−1.08	−2.21	
	IQR	−2.82 to 2.10	−4.19 to 0.05		−2.50 to 1.09	−4.68 to 0.51	
	Range	−10.04 to 12.50	−14.00 to 4.19		−10.04 to 7.91	−7.06 to 2.01	
SN-GoGn	N	168	56	0.111	73	23	0.460
	Mean	33.55	31.47		33.82	32.12	
	SD	6.335	5.578		6.409	6.333	
	Median	33.00	32.20		33.40	33.40	
	IQR	29.05 to 37.15	27.50 to 34.95		29.00 to 37.50	27.50 to 37.50	
	Range	19.40 to 51.00	17.70 to 40.90		21.80 to 50.30	17.70 to 40.60	
ANB	N	168	56	0.422	73	23	0.264
	Mean	4.22	3.66		3.85	3.04	
	SD	2.535	2.874		2.813	2.636	
	Median	4.00	3.90		3.70	3.50	
	IQR	2.60 to 5.80	2.10 to 5.60		2.20 to 5.30	1.90 to 4.40	
	Range	−2.10 to 11.00	−4.20 to 9.40		−2.00 to 12.00	−2.30 to 9.00	
Oral habits							
Oral breathing	n/N (%)	11/169 (6.51)	3/56 (5.36)	> 0.999	4/74 (5.41)	0/23 (0.00)	0.570
Clenching	n/N (%)	14/169 (8.28)	2/56 (3.57)	0.369	7/74 (9.46)	1/23 (4.35)	0.676
Abnormal tongue function	n/N (%)	44/169 (26.04)	4/56 (7.14)	0.002*	20/74 (27.03)	1/23 (4.35)	0.021*
Nail biting	n/N (%)	60/169 (35.50)	4/56 (7.14)	< 0.001*	20/74 (27.03)	2/23 (8.70)	0.088

ALD, arch length discrepancy; SN, sella-nasion; GoGn, gonion-gnathion; ANB, A point-nasion-B point; N, sample size; SD, standard deviation; IQR, interquartile range; n, number of subjects with the variable.
*$P < 0.05$ (significance level).

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Table 3. Retention failure vs. controls after the treatment

Variable	Statistic value	Mandibular jaws			Maxillary jaws		
		Failure	Control	*P* value	Failure	Control	*P* value
Stable occlusion	n/N (%)	133/169 (78.70)	43/56 (76.79)	0.852	54/74 (72.97)	17/23 (73.91)	> 0.999
SN-GoGn	N	147	48	0.041*	59	17	0.116
	Mean	33.00	30.00		33.64	29.55	
	SD	7.188	6.584		7.844	8.965	
	Median	32.20	29.70		32.40	28.10	
	IQR	27.80 to 37.00	26.45 to 34.45		27.80 to 39.90	25.20 to 36.30	
	Range	16.60 to 51.70	8.40 to 42.70		19.40 to 51.70	8.40 to 42.70	
ANB	N	147	48	0.310	59	17	0.184
	Mean	3.79	3.84		3.81	4.36	
	SD	2.256	4.895		2.446	7.970	
	Median	3.70	3.75		3.70	2.30	
	IQR	2.20 to 5.20	1.95 to 4.75		2.20 to 5.20	1.70 to 4.30	
	Range	–1.50 to 10.70	–2.70 to 33.80		–3.20 to 10.70	–2.70 to 33.80	
Angulation maxillary incisors	N	147	48	0.164	59	17	0.111
	Mean	27.73	31.84		26.67	37.70	
	SD	7.293	19.842		8.519	32.470	
	Median	28.30	29.50		29.00	30.40	
	IQR	23.00 to 31.90	26.05 to 32.65		23.20 to 31.40	26.30 to 35.20	
	Range	–11.20 to 43.10	17.00 to 162.00		–11.20 to 42.90	19.00 to 162.00	
Angulation mandibular incisors	N	147	48	0.310	59	17	0.310
	Mean	32.10	32.59		32.45	30.78	
	SD	11.374	6.281		6.358	6.128	
	Median	31.00	32.65		32.50	30.30	
	IQR	27.00 to 36.40	27.55 to 35.90		28.00 to 36.40	26.40 to 35.20	
	Range	14.30 to 46.00	19.40 to 47.50		9.90 to 45.00	19.40 to 41.20	
Interincisal angle	N	147	48	0.623	59	17	0.579
	Mean	117.23	116.23		117.17	117.53	
	SD	9.187	6.914		10.356	6.848	
	Median	118.00	116.00		115.00	118.00	
	IQR	111.00 to 124.00	112.00 to 120.50		111.0 to 122.0	113.00 to 122.00	
	Range	99.30 to 147.00	103.00 to 136.00		97.80 to 147.0	106.00 to 136.00	
Treatment approach (maxillary jaws)							
Closing spaces	n/N (%)	28/169 (16.57)	9/56 (16.07)	> 0.999	18/74 (24.32)	2/23 (8.70)	0.143
IPR	n/N (%)	42/169 (24.85)	14/56 (25.00)	> 0.999	20/74 (27.03)	5/23 (21.74)	0.787
Treatment approach (mandibular jaws)							
Closing spaces mandibular jaws	n/N (%)	20/169 (11.83)	7/56 (12.50)	> 0.999	12/74 (16.22)	2/23 (8.70)	0.508
IPR mandibular incisors	n/N (%)	59/169 (34.91)	25/56 (44.64)	0.205	20/74 (27.03)	14/23 (60.87)	0.005*

SN, sella-nasion; GoGn, gonion-gnathion; ANB, A point-nasion-B point; IPR, interproximal reduction; N, sample size; SD, standard deviation; IQR, interquartile range; n, number of subjects with the variable.
*$P < 0.05$ (significance level).

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due to relapse, as expected in patients with retention failure in the maxillary jaws and pretreatment deep bite. Patients with retention failure in the mandibular jaws presented significantly less pretreatment crowding than controls (mean ALD, −0.44 mm vs. −2.17 mm). A possible reason for this is the fact that IPR was performed more often in the control group, which has been linked to the stability of incisor alignment.[10] Although a negative ALD may indicate anterior crowding in some cases, it may also indicate inadequate space in the premolar region. IPR reduces the arch length, possibly quenches the contacts between the maxillary and mandibular front teeth, and minimally increases the overjet, which could explain less retention failure in the maxillary jaws.

Retention failure in the mandibular jaws was also found to be substantially correlated with the post-treatment values of the angle between the sella-nasion and the gonion-gnathion, which indicates the growth pattern of the patient. Although the mean values (33° and 30°, respectively) were not significantly different from Steiner's norm values (32°), the range indicated a distinct trend toward more patients with an open growth pattern in the retention failure group than in the control group, which is likely due to the outliers of more extreme open growth patterns in the retention failure group.

The most remarkable finding of the present study is related to oral habits. A strong association between abnormal tongue function and retention failure was found in the maxillary (P = 0.021) and mandibular jaws (P = 0.002). Tongue-thrusting habits have also been suggested to create jiggling forces and influence incisor position, which could explain the increased susceptibility to retention failure in these patients.[16] In our sample, other oral habits such as pen or nail biting were also correlated with retention failure in the mandibular jaws. The fact that this association could not be confirmed for retention failures in the maxillary jaws may be due to the larger contact surface between the composite and the enamel.

The link between oral habits and retention failure is of high clinical relevance, because patients with habits such as tongue thrusting are more susceptible to undesired tooth displacement after retention failure. The literature shows that forces induced by tongue pressure or nail biting could cause malocclusion,[20] particularly regarding changes in incisor angulation.[16] Parafunctional habits alone would probably not lead to retention failure, but should rather be seen as one of many related factors. Poor moisture control during bonding or extreme biting forces could also have a cumulative effect, increasing the risk of retention failure.[21,22] Because of the increased risk of retention failure and associated tooth displacements in these patients, re-evaluation of the follow-up intervals is advised.

The present study has some limitations. The first is its retrospective nature and the fact that it was performed in a university setting. Data were retrospectively collected from the measurements taken by different orthodontic residents who also placed most of the retention wires. Some studies state that the number and experience of operators may play a role in retention failure,[1,4,23,24] while other have found no significant influence of the operator on retention failure.[12] Although operator experience may have influenced the prevalence of failure, all the operators in our study had comparable experience. Therefore, this should not have a direct effect on the other factors such as oral habits.

Second, no distinction could be made between failures at the adhesive-enamel interface or between the wire and composite. Some studies report the second type to be quite rare,[4-6,25] while others state that loosening mostly occurs at the wire-composite layer.[7] However, this type of failure is usually the result of abrasion, which increases over time.[6] Since this study concerns the first retention failures that mainly occur in the first months, and it could be assumed that most failures occurred at the composite-adhesive interface.

Lastly, oral habits were diagnosed during pretreatment record taking, and data after treatment was not available. In addition, the average follow-up period of the control group was 1 year, and the patients in the experimental group experienced the first retention failure mostly within the first 6 months after debonding. As mentioned previously, this does not allow exploration of retention failure due to relapse. Nevertheless, the literature suggests that 1 year after fixed retainer placement, the chance of loss of retention is only a fraction of the initial probability.[3,7] Owing to its multifactorial etiology, fixed retention failure is challenging to investigate. Further prospective research with larger study populations could help increase our knowledge of the underlying causes of retention failure.

CONCLUSIONS

The findings of this retrospective study suggest that retention failure and parafunctional habits, such as nail biting and abnormal tongue function, are associated. Therefore, close post-treatment monitoring is recommended in these patients. Significant differences were found between the group with retention failure in the mandibular jaws and the control group regarding pretreatment ALD and after treatment growth pattern along with IPR in maxillary jaws. No associations were observed with other patient- or treatment-dependent factors. Further prospective studies with larger study populations are required to confirm these findings.

AUTHOR CONTRIBUTIONS

Conceptualization: KV, MCLP. Data curation: KV. Formal analysis: KV, AAR, GB, GW, AV, MCLP. Investigation: KV. Methodology: KV. Resources: KV. Supervision: GW, AV, MCLP. Visualization: AAR, GB. Writing–original draft: KV. Writing–review & editing: KV, AAR, GB, GW, AV, MCLP.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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None to declare.

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