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Anterior tooth wear and retention type until 5 years after orthodontic treatment

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Abstract

Objectives. To study occlusal wear of anterior teeth in orthodontic patients retained with different retainers until 5 years post-treatment, and to investigate whether type of retention influences occlusal wear. ***Material and methods.*** Orthodontic patients ($n = 222$), aged 15 years maximally at the start of treatment, were followed until 5 years post-treatment. In the maxilla, a retainer bonded on all six teeth or a removable retainer was used; in the mandible, a lingual retainer was bonded on all anterior teeth or on canines only. Dental casts were analyzed before treatment (T_0), after treatment (T_1), and 5 years post-treatment (T_5). Incisal and canine wear were scored by applying a grading scale. Intercanine width, overjet, and overbite were measured with an electronic caliper. Statistics used were: Paired samples *t*-test for differences over time; Pearson correlation coefficients for associations between wear and retention type; and backward linear regression for influence of retention type on wear. ***Results.*** There was an increase in wear during all time periods and for all teeth. From T_0 to T_5 an increase in maxillary intercanine width and maxillary retention had an effect on changes in canine wear. Incisal wear was associated with an increase in upper intercanine width (T_1–T_5). For both arches, an increase in maxillary intercanine width during treatment was associated with less progression of canine and incisal wear, but the explained variance was low, 13.4% and 19.3%, respectively. ***Conclusions.*** Retention type and, occasionally, an increase in intercanine width influence anterior teeth wear post-treatment. However, the clinical significance and impact of the examined retention methods on occlusal wear are small.

Key Words: *Orthodontics, retention, tooth wear, treatment outcome*

Introduction

Maintenance of orthodontic treatment and prevention of relapse are important aspects of orthodontic treatment. To prevent teeth from returning to their original position, retainers are placed and/or "adjunctive" procedures are carried out, i.e. procedures such as stripping to reduce the mesio-distal width of the lower anterior teeth [1] or circumferential supracrestal fiberotomy [2]. It is common practice to place a fixed retainer bonded either on the canines only or on all six anterior teeth in the lower arch and to use either a bonded retainer to 4 or 6 anterior teeth and/or a removable retention device for a certain period of time in the upper arch.

Unfortunately, despite the application of retainers, the literature shows that lower anterior alignment, in particular, is difficult to maintain [3–5]. Al Yami et al. [6] found that about 67% of the achieved orthodontic result was still maintained after 10 years. However, a fast and continuous increased irregularity of the lower front teeth, as measured with the PAR score, was seen even exceeding the initial score 10 years after treatment. The presence of a bonded retainer had a positive effect on the stability [6,7]. Though there is no consensus among orthodontists to the duration of retention, these results, as well as clinical experience, have brought orthodontists to the conclusion that it is necessary to inform patients that they should expect to get fixed retainers after

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treatment either to prevent relapse or to counteract age-related changes in tooth position.

Because more and more permanent retention is given this way, effectiveness and adverse effects have to be studied, especially in relation to long-term use of fixed retainers. Present studies on the use of fixed retainers mainly concern the effectiveness, success and failure rate of a bonded retainer and oral hygiene aspects of different types of fixed retention. In the literature, there is one Cochrane review available summarizing the results of randomized and quasi-randomized controlled trials on this topic [8]. The quality of trials on retention was not thorough enough for a true conclusion to be drawn. Moreover, it was concluded that adverse effects, especially long-term effects, on dental and periodontal tissues, have not been adequately investigated.

A possible adverse effect of keeping teeth in a fixed position could be an increase of occlusal wear of anterior teeth after treatment. It can be hypothesized that teeth fixed in their position by a bonded retainer might have more wear, since physiological movements during function are impaired. To our knowledge, there is no study dealing with post-treatment wear of teeth, in particular anterior tooth wear, in patients with fixed retainers.

The aim of this research was to study the relationship between type of retention and occlusal wear of maxillary and mandibular incisors and canines in patients up to 5 years post-treatment.

The null hypothesis is that the type of retention has no effect on anterior tooth wear.

Material and methods

Subjects

For this retrospective clinical study, 222 patients (80 M, 142 F) were selected from the Nijmegen Treatment Outcome Archive of the Department of Orthodontics and Oral Biology of the Radboud University Nijmegen Medical Centre, The Netherlands. Mean age (SD) at T_0 was 11.65 (1.30) years (range 8.04–15.00), at T_1 14.49 (1.42) (range 11.08–19.02), and at T_5 20.58 (1.86) (range 17.03–25.11).

The following inclusion criteria were applied: no cleft or other craniofacial anomaly present; no agenesis or absence of any of the incisors; no developmental dental malformations; no combined ortho-surgery cases or ortho-perio cases; maximum 15 years of age at the start of treatment; no damaged or broken incisors; no prosthetic replacements or crowns; dental casts available at three time-points (see below) until 5 years post-treatment; treated with full fixed appliances; bonded retainer in the lower arch, either on canines only (C-C bar) or on six anterior teeth (FSW = flexible spiral wire); removable retention or FSW on all six anterior teeth in the maxilla.

The C-C bar was made of 0.0215×0.027 in stainless steel rounded rectangular wire bonded on the canines only. The FSW was fabricated of 0.0195 in three-strand heat-treated twist flex wire. The removable maxillary retainer had a labial bow and two anchors on the last molars. Patients were instructed to wear the retainer for 3 months for 24 h followed by 9 months only at night.

In the maxilla, 85 patients had removable retention (40 M, 45 F) and 137 a FSW (40 M, 97 F). In the mandible, 72 patients had a C-C bar (31 M, 41 F) and 150 patients had a FSW (49 M, 101 F). The distribution of the retention patterns was as follows: Maxilla removable retention, mandible C-C bar ($n = 49$); maxilla removable retention, mandible FSW ($n = 36$); maxilla FSW, mandible C-C bar ($n = 23$); maxilla FSW, mandible FSW ($n = 114$).

Methods

The degree of wear of upper and lower incisors, as well as the amount of wear of the canines, was assessed on dental casts. The dental casts of the following time-points were scored: T_0 = before treatment; T_1 = end of treatment; T_5 = 5 years after treatment.

The amount of incisal wear was assessed by applying a grading scale as described by Silness et al. [9] and as given in Table I. The amount of canine wear was determined according to the scale in Table II [10,11]. When in doubt for either incisor or canine, the lower score was given for the amount of wear. Only permanent teeth were measured.

The scores for all upper and lower incisors were averaged to obtain one value for incisor wear. The same was done for the scores of the canines. Furthermore, upper and lower intercanine width, overjet, overbite, and lower incisor alignment were measured with an electronic caliper (MAUSER

Table I. Grading scale for incisal wear according to Silness et al. [9]

Score	Amount of incisal wear
0	Incisal notches present
1	Incisal notches disappeared
2	Clearly outlined smooth incisal wear facets
3	Loss of substance with excavation along the incisal edge ('ditching'), more than half of the incisal edge
4	Ditching and crown height reduction with buccal lingual width of the incisal edge >1 mm for lower incisors or >1.5 mm for upper incisors

Table II. Grading scale for canine wear according to Carlsson et al. [10] and Bauer et al. [11].

	Amount of canine wear	
Score	Enamel	Crown length
0	No visible wear facets	–
1	Marked wear facets	No noticeable reduction
2	Distinct wear facets	Slight reduction
3	Extensive wear facets At least 2/3 of incisal edge gone	Marked reduction

digital 6 capa μ system®, Switzerland) with an accuracy of two decimals. The beaks of the electronic caliper were sharpened to a fine edge to permit access and accurate measurements.

The Irregularity Index, calculated to describe the contact point displacement of the lower anterior teeth, is defined as the sum (in millimetres) of the five distances between the anatomic contact areas from the mesial of the left canine through the mesial of the right canine [12]. The Little index was measured in a previous study by one observer (A.R.) with an electronic caliper [7]. All other measurements were taken by one observer (M.K.) calibrated against two experienced observers at the start of the study. To assess the intra-observer measurement error, 60 dental casts of 20 randomly selected patients at the three different time periods were measured twice by the same observer with a time interval of 3 weeks.

Statistical analyses

Kappa statistics were applied to express intra-observer reliability for incisal and canine wear grading. Descriptive statistics presenting means and standard deviations were used to report treatment findings at T_0, T_1, and T_5. Paired samples *t*-test was used for analyzing the increments of the intercanine width, incisal and canine wear, and the Irregularity Index over time.

Pearson correlation coefficients (Pearson's r) were used for associations between wear and retention type. Backward linear regression was applied to assess the effects of Irregularity Index, retention type, gender, and change of intercanine width on incisal and canine wear. In the backward linear regression procedure, the threshold for removal was set at $p = 0.10$.

Results

Error of the method

The intra-observer reliability for incisor and canine wear showed kappa values ranging from 0.53 to 0.71, meaning moderate to substantial agreement.

General treatment variables

Descriptive statistics of the general treatment variables are given in Table III. The Irregularity Index for the lower anterior teeth decreased significantly between T_0 and T_1, but increased again significantly between T_1 and T_5. As a result of the orthodontic treatment, both in the maxilla and the mandible, the mean (SD) intercanine distance increased significantly, 2.49 (2.49) mm and 1.31 (2.04) mm, respectively, but remained stable thereafter.

Table III. Descriptive statistics of general treatment variables and results of paired samples *t*-test for differences between time-points. Means and SD (range) are given in mm.

	T_0		T_1		T_5	T_0–T_1	T_1–T_5	T_0–T_5
Variable	*n*	Mean (SD) Range	*n*	Mean (SD) range	*n*	Mean (SD) range	*p*-value	*p*-value	*p*-value
Little Index LA	181	5.77 (3.79) *0.50–18.80*	181	0.10 (0.27) *0–1.74*	181	0.26 (0.57) *0–4.32*	<0.001	<0.001	<0.001
Overjet	222	6.36 (2.92) *−0.52–13.88*	221	2.39 (0.78) *0–5.81*	219	2.84 (0.99) *0–6.77*	<0.001	<0.001	<0.001
Overbite	222	3.88 (2.0) *−3.81–8.57*	221	1.44 (0.98) *−3.22–4.26*	219	1.79 (1.42) *−7.14–5.05*	<0.001	<0.001	<0.001
C-C width UA	222	33.05 (2.54) *25.24–40.31*	222	35.59 (1.83) *31.24–40.46*	222	35.64 (1.82) *31.36–41.49*	<0.001	0.448	<0.001
C-C width LA	222	25.62 (2.04) *19.18–30.97*	222	26.90 (1.45) *23.76–31.38*	221	26.94 (1.48) *23.47–31.33*	<0.001	0.083	<0.001

T_0 = start of treatment; T_1 = end of treatment; T_5 = 5 years after treatment; LA = lower arch; UA = upper arch.

Incisal wear

There was a significant increase in incisal wear during all time periods (Table IV). No gender differences were found.

Backward linear regression for the effect on incisal wear (Table V) showed an influence of increased intercanine width in the maxilla. Increase of maxillary intercanine width during (T_0–T_1) and after treatment (T_1–T_5) was associated with less increase of incisal wear. However, the explained variance for these variables was low, namely 13.4%. Retention type had no effect on incisal wear.

Canine wear

The paired samples *t*-test showed an increase in canine wear during all time periods (Table IV). No gender differences were found for the amount of wear.

Backward linear regression analysis for canine wear (Table VI) showed an influence of type of retention in the maxilla (patients with a removable plate had more wear for T_0–T_5). An increase of maxillary intercanine width during (T_0–T_1) and after treatment (T_1–T_5) was associated with less increase of canine wear. However, the explained variance was 19.3%. Retention type in the mandible had no effect on canine wear.

Discussion

In this study, we investigated anterior tooth wear in relation to post-treatment variables, including retention until 5 years after orthodontic treatment. Therefore we compared groups of patients with different retention protocols. The study was not designed to answer the question whether orthodontic and non-orthodontic subjects show the same amount of anterior tooth wear or whether orthodontic treatment might have a protective effect on tooth wear. To answer these questions, a non-treated control group with comparable malocclusion would be needed and this would be more applicable in a prospective study. The retrospective nature of this study makes it inevitable that some data were not available. Dietary habits were not taken into account because this information was not present in the patient files and cannot be reliably recalled in a retrospective manner. We were also unable to identify the presence of bruxism from the patient files. Therefore, we excluded patients who showed signs of extensive tooth wear at T_0 and T_1 dental casts and intra-oral pictures, but we cannot rule out that bruxism might have occurred after treatment.

The methods employed for measuring tooth wear are still controversial [13]. Many indices found in the literature stem from the Index for Dental Erosion of non-industrial origin of Eccles [14] and the Tooth Wear Index (TWI) proposed by Smith & Knight [15]. The latter has the advantage that tooth wear, irrespective of its cause, can be measured and monitored. The scoring method used in this study was a derivate of the TWI using simplified grading criteria [9–11] for use on large numbers of serial dental casts. However, despite calibration and training, difficulties were experienced in validating incisor wear. Nevertheless, Kappa values for intra-observer reliability were moderate to substantial, although the reproducibility of measurements on study casts in other studies was slightly better [16,17].

Another problem is the definition of tooth wear and what causes it. The diagnosis is primarily made from its lesion characteristics and anamnesis, and definitions are not quite clear [18]. Tooth wear in the present study means attrition of vertical forces by the antagonist during function. It could be that attrition of occlusal and incisal surfaces of the teeth could affect tooth position, positively or negatively, and change the result of orthodontic treatment. It is known that wear is a common phenomenon in aging dentition [9,10], but Könönen et al. [19] found most tooth wear in young individuals between the ages of 18 to 25 years. The mean age of our patients 5 years after treatment was 20.6 years, which is within the period mentioned by Könönen et al. [19] in which young people show more wear. This might have influenced the result. Wear could also have been influenced by the dietary habits of the patient or bruxism. To distinguish between patients with erosion and wear, cupping of the cusps of the molars was used as a criterion, although this might still be an uncertain factor because the diagnostic criteria

Table IV. Descriptive statistics of incisal and canine wear and results of paired samples *t*-test for differences between time-points. Means and SD (range) are given in mm.

	T_0		T_1		T_5		T_0–T_1	T_1–T_5	T_0–T_5
Variable	*n*	Mean (SD) Range	*n*	Mean (SD) range	*n*	Mean (SD) range	*p*-value	*p*-value	*p*-value
Incisor wear	222	1.18 (0.54) *0–2.8*	222	2.0 (0.57) *0.1–3.3*	222	2.5 (0.58) *0.3–3.7*	<0.001	<0.001	<0.001
Canine wear	212	0.42 (0.54) *0–2.75*	222	1.52 (0.6) *0–3.0*	222	2.11 (0.57) *0.5–3.0*	<0.001	<0.001	<0.001

T_0 = start of treatment; T_1 = end of treatment; T_5 = 5 years after treatment; LA = lower arch; UA = upper arch.

Table V. Backward linear regression analysis for the effect on incisal wear at three different time intervals (T_0–T_1; T_1–T_5; T_0–T_5). In the backward linear regression procedure, the threshold for removal was set at $p = 0.10$.

		Effect on increment of incisal wear		
Time period	Remaining variable	*p*-value	Unstandardized coefficient B	95% CI for B
T_0–T_1	Increase C-C distance	<0.001	−0.896	−1.24 ... −0.55
$R^2 = 0.106$	UA from T_0 to T_1			
T_1–T_5	No variables remained in			
$R^2 = 0.000$	the model			
T_0–T_5	Increase C-C distance	<0.001	−1.152	−1.54 ... −0.76
	UA from T_0 to T_1			
$R^2 = 0.134$	Increase C-C distance	0.027	−1.189	−2.24 ... −0.14
	UA T_1 tot T_5			

R^2 = explained variance; LA = lower arch; UA = upper arch.

for erosion do not seem to be that clear either [18] and might be signs of bruxism. Therefore, if the models showed signs of extensive wear, wearing of cusps and cupping of the occlusal surfaces of molars already before treatment or just at T_1 were excluded from the study.

In the present study we found an increase in wear during all time periods and for all anterior teeth. There were no gender differences. Increased upper intercanine width during and after treatment had an influence on incisal and canine wear (T_0–T_1 and T_1–T_5) and was associated with less increase in wear. In this sample, the intercanine distance increased about 1.3 mm in the mandible and 2.5 mm in the maxilla during treatment and remained more or less constant thereafter. Although in the backward analysis for incisal wear (Table IV) the increased upper intercanine width played a more prominent role, but the explained variance for the regression models for the three time periods was only 13.4% at the highest (Table V). To our surprise, there was no association between the degree of irregularity of the lower front teeth and the amount of anterior tooth wear and therefore the Irregularity Index did not show up in the regression models. This is different from what Berge et al. [17] found on measuring a relationship between alignment and anterior wear. They found less wear when teeth were less aligned.

The effect of retention on the amount of anterior teeth wear appeared to be limited to the use of a removable retainer in the upper jaw. Patients who were retained with a removable retainer showed more canine wear. No other effects of retention type could be found. Başciftçi et al. [20] studied occlusal contacts after orthodontic treatment during a one-year follow-up period using two different retention procedures: a maxillary removable plate plus a mandibular canine-to-canine fixed retainer ($n = 20$) versus maxillary and mandibular wraparound Hawley retainers ($n = 20$). In both groups, posterior occlusal contacts increased during the retention period. In the group retained with a maxillary removable plate and a mandibular C-C bar, the canines also showed a significant increase in actual occlusal contacts, which might account for a higher degree of canine wear as found in the present study.

Settling of the occlusion during the retention stage that increases the number of occlusal contacts might be facilitated by using removable retainers and this could be another explanation for increased

Table VI. Backward linear regression analysis for the effect on canine wear at three different time intervals (T_0–T_1; T_1–T_5; T_0–T_5). In the backward linear regression procedure, the threshold for removal was set at $p = 0.10$.

		Effect on increment of canine wear		
Time period	Remaining variable	*p*-value	Unstandardized coefficient B	95% CI for B
T_0–T_1	Increase C-C distance	<0.01	−4.434	−5.79 ... −3.08
$R^2 = 0.159$	UA from T_0 to T_1			
T_1–T_5	No variables remained in			
$R^2 = 0.000$	the model			
	Increase C-C distance	<0.001	−5.074	−6.57 ... −3.58
	UA from T_0 to T_1			
T_0–T_5	Increase C-C distance	0.024	−4.684	−8.74 ... −0.62
	UA T_1–T_5			
$R^2 = 0.193$	Retention maxilla *0 = removable 1 = CC all six*	0.088	−6.104	−13.12 ... 0.91

R^2 = explained variance; LA = lower arch; UA upper arch.

wear when removable retention devices are used. Sauget et al. [21] showed that there was a significantly increased number of occlusal contacts after 3 months with the Hawley retainer, though it should be noted that this study dealt with upper retention only. Although there are many studies showing an increased number of occlusal contacts after orthodontic treatment, they are all short term and, to our knowledge, there are no studies in the literature dealing with occlusal contact changes during fixed retention. Fixed retention might hamper settling to occlusal contacts in the anterior region because the teeth are fixed. The protocol for retention with the removable plate was one year, after which no further retention was given. One might wonder whether wearing a removable retainer gives more wear over a shorter period of time than a (life-long worn) FSW, but it is possible that the situation might equalize over time (for example, 10 years post-retention).

The scores for anterior teeth in this patient group increased from 1.18 to 2.5 for incisal wear and 0.42 to 2.11 for canine wear over a 9-year period, i.e. the period from T_0 to T_5. The scores obtained indicate that wear facets are visible for the incisors, while canines show some loss of crown length, but the question remains whether or not this is a pathological condition [22]. If we consider reduction of crown length as a clinically relevant feature, then a wear score of 3 for incisors and 2 for canines would be clinically significant. The present study shows that the effect of type of retention on the amount of wear was negligible. No differences were expected, but there was a small effect of increased wear when a removable plate was used. Therefore the null hypothesis was partly rejected.

However, with the increase of life-long retention it remains to be investigated whether this might cause an additional risk of tooth wear and whether a specific type of retention causes more wear than other types. Long-term prospective studies over a 10 to 20 years post-treatment period are needed to answer these questions. A prospective randomized clinical trial would be the preferred design to investigate this.

Conclusion

Retention type and, occasionally, increased intercanine width during and after treatment influence occlusal wear of anterior teeth after orthodontic treatment. However, the clinical significance and impact of the examined retention methods on occlusal wear are small.

Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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