Original Article
Caries outcomes after orthodontic treatment with fixed appliances: a longitudinal prospective study

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Abstract: Objectives: The aim of this study was to assess the relationship between orthodontic and the development of dental caries in the same patients who received single jaw orthodontic treatment. Material and methods: A consecutive sample consisted of 60 subjects who required single upper jaw orthodontic were recruited consecutively from the Department of Orthodontic at the Stomatology Hospital of Wenzhou Medical University. The dental examinations were routinely carried out by one dentists at the following stages: pre-treatment (T1); post-treatment (T2); more than 7 years after T1 (T3). The DMFS count which reflect the caries experience was recorded. Results: There was no significant difference between the treated groups and untreated groups for the DMFS before received fixed orthodontic treatment. The same result was found after orthodontic treatment. However, the average number of DMFS in the treatment jaw after fixed orthodontic treatment was lower than in the without treatment jaw after long-term follow-up period. Conclusions: Fixed orthodontic appliances significant decrease the patients caries risk after orthodontic treatment.

Keywords: Caries, orthodontic, fixed appliance

Introduction

The assumption that orthodontic treatment with fixed appliances is a risk factor for dental caries has long been made. Bands and brackets change the oral environment lead to increase of the retention of plaque and food on smooth tooth surfaces [1, 2]. It is therefore intuitive suppose that orthodontic treatment with fixed appliances will increase the incidence of dental caries. However, this belief has not always been supported by the literatures [3-5].

Studies evaluating the relationship between orthodontic treatment and dental caries have shown contradictory results. Some authors [6, 7] have reported a positive correlation between orthodontic treatment and the incidence of caries. Alqarni [8] failed to find a association between fixed orthodontic treatment and caries experience. Others [9, 10] have even reported a negative relationship between fixed orthodontic and caries, with a lower incidence of decay in subjects with orthodontic patients.

Moreover, dental caries is a multi-factorial disease and the outcome of a dynamic interplay between microorganisms and dietary carbohydrates is complex. Plaque is a necessary precursor of caries and for this reason sites on teeth which favor plaque retention are particularly prone to decay. It differs not only between the maxilla and mandible but also in individual teeth. Previous studies focused on the controversy based on the common method of different individual, which was limited by the individual variation, differ from the caries susceptibility, oral hygiene, gender, age, diets, socio-economic status and other factors influence the occurrence of caries. Therefore, it is hard to come to a conclusion that whether orthodontic treatment could reduce the incidence of dental caries or not.

Thus, the aim of this study was to assess the relationship between orthodontic and the development of dental caries in the same patients who received single jaw orthodontic treatment.

Table 1. Base-line of subjects' characteristics

	Total		Treated group		Untreated group		P value (chi-square test)
	%	(n)	%	(n)	%	(n)	
Total	100	120	50	60	50	60	
Baseline Croweding							
minor	100	93	49	45	51	48	
moderate	100	24	50	12	50	12	
severe	100	3	100	3	47	0	0.785
Sex							
Female	100	64	50	32	50	32	
Male	100	56	50	28	50	28	0.68
malocclusion							
Class I	100	100	50	50	50	50	
Class II	100	20	50	10	50	10	0.726
Age (y)							
11-13	100	120	50	60	50	60	
Social-economic class							
high	100	110	50	55	50	55	
low	100	10	50	5	50	5	0.897

Material and methods

This study was conducted as a prospective longitudinal study, investigating the prevalence of caries in received orthodontic jaw and an untreated jaw in the same subjects at four point of time. To make the two groups comparable, they were matched according to age, social status, gender, malocclusion, oral hygiene and DMFS (**Table 1**).

Subjects

This study was approved by the Ethics Committee of the Wenzhou Medical University.

The sample size for each group was calculated based on an alpha significance level of 0.05 and a beta of 0.1 to achieve 90% power to detect a clinically meaningful difference of DMFS between the orthodontic group and untreatment group. The power analysis showed that 25 patients in each group were needed, and to compensate for dropouts during the trial, it was judged to enroll at least 35 patients.

All subjects underwent the caries examination before the start of active orthodontic treatment. However, five subjects dropped out, three did not come regularly to our hospital for orthodontic treatment and eight had smoked when they grow up were excluded. Eventually, a consecutive sample consisted of 60 subjects who required single upper jaw orthodontic were recruited consecutively from three profession orthodontists who had the same concept of treatment philosophy and been familiar with each other at the Department of Orthodontic at the Stomatology Hospital of Wenzhou Medical University. Subjects included in the study satisfied the following selection criteria:

Patients must be (1) patients aged between 15 and 16.25 years at the end of active treatment; (2) Hawley retainer was used in upper dental arch approximately 2 years; (3) present similar crowding in both jaw and more than 4 mm; (4) follow-up at least more than 7 years, (5) permanent dentition, (6) treatment included 0.022-in slot brackets with similar wire sequences (3M Unitek, Monrovia, Calif), (7) received orthodontic treatment with fixed appliance in upper jaw, (8) similar oral hygiene and social status.

Patients with hypodontia, oligodontia, hypothyroidism, cleft-lip/palate, syndromes, smoking were excluded. The upper and lower first premolars were also excluded as they were frequently removed for orthodontic reasons. Participants who met these inclusion criteria were recruited. At the time of recruitment, it was routine practice to informed about the examination procedures and obtain written consent for participation in the trial.

Table 2. Decayed, missing and filled surfaces (DMFS) in treated group and untreated group before treatment

Teeth	Treated group						Untreated group						$P_{(DS)}$	$P_{(FS)}$	$P_{(Intact surface)}$	$P_{(DMFS)}$
	Total No of surfaces	Intact surfaces	DS	MS	FS	DMFS	Total No of surfaces	Intact surfaces	DS	MS	FS	DMFS				
7+7	600	567	10	0	22	32	600	525	12	0	25	37	0.667	0.655	0.542	0.535
6+6	600	556	14	0	30	44	600	550	16	0	34	50	0.712	0.607	0.812	0.591
5+5	600	582	8	0	10	18	600	579	9	0	12	21	0.807	0.667	0.625	0.625
3+3	480	477	2	0	1	3	480	476	3	0	1	4	1.000	1.000	1.000	1.000
2+2	480	462	6	0	12	18	480	462	8	0	10	18	0.590	0.666	1.000	1.000
1+1	480	456	6	0	18	24	480	452	8	0	20	28	0.590	0.741	0.952	0.568

DS-decayed surfaces; MS-missing surfaces; FS-filled surfaces. DMFS=DS+MS+FS.

Table 3. Decayed, missing and filled surfaces (DMFS) in treated group and untreated group after treatment

Teeth	Treated group						Untreated group						$P_{(DS)}$	$P_{(FS)}$	$P_{(Intact surface)}$	$P_{(DMFS)}$
	Total No of surfaces	Intact surfaces	DS	MS	FS	DMFS	Total No of surfaces	Intact surfaces	DS	MS	FS	DMFS				
7+7	600	560	11	0	24	35	600	515	14	0	27	41	0.614	0.621	0.215	0.684
6+6	600	550	15	0	32	47	600	540	18	0	36	54	0.642	0.615	0.758	0.602
5+5	600	575	8	0	12	20	600	578	10	0	15	25	0.792	0.598	0.910	0.624
3+3	480	475	2	0	1	3	480	475	3	0	1	4	0.920	0.965	0.930	0.956
2+2	480	455	7	0	12	19	480	450	8	0	12	20	0.684	0.762	0.584	0.991
1+1	480	450	6	0	19	25	480	449	8	0	22	30	0.612	0.697	0.735	0.452

DS-decayed surfaces; MS-missing surfaces; FS-filled surfaces. DMFS=DS+MS+FS.

Table 4. Decayed, missing and filled surfaces (DMFS) in treated group and untreated group after long-term follow-up time

Teeth	Treated group						Untreated group						$P_{(DS)}$	$P_{(FS)}$	$P_{(Intact surface)}$	$P_{(DMFS)}$
	Total No of surfaces	Intact surfaces	DS	MS	FS	DMFS	Total No of surfaces	Intact surfaces	DS	MS	FS	DMFS				
7+7	600	552	18	0	30	48	600	493	36	1	70	107	0.012	0.000	0..004	0.000
6+6	600	534	20	1	45	66	600	503	40	2	55	97	0.008	0.296	0.012	0.009
5+5	600	565	14	2	19	35	600	522	30	2	46	78	0.014	0.001	0.051	0.000
3+3	480	474	4	0	2	6	480	472	5	0	3	8	1.000	1.000	0.784	0.590
2+2	480	447	12	1	20	33	480	446	16	2	16	34	0.443	0.497	0.256	0.889
1+1	480	442	12	0	26	38	480	438	14	0	28	42	0.691	0.779	0.456	0.640

DS-decayed surfaces; MS-missing surfaces; FS-filled surfaces. DMFS=DS+MS+FS. P<0.05

Methods

The patients' pre-orthodontic examination charts, panoramic radiographs, and intra-oral photos were examined. Before bonding, the records, intra-oral photos, and the panoramic radiographs were checked carefully for caries lesions.

The dental examinations were routinely carried out by one dentists at the following stages: pre-treatment (T1); post-treatment (T2); more than 7 years after T1 (T3). The DMFS count which reflect the caries experience was recorded.

Three examiners were incorporated in this study. To determine the measurement error in the DMFS count and assess the intra-observer and inter-observer agreement, 18 randomly selected patients were evaluated by the three observers. The dental casts at TP and at T5 were re-measured for these patients. The time interval between two intra-observer assessments was at least 1 week.

After each examination, information about the oral hygiene status and how to improve it was given to subjects. Subjects were instructed to brush their teeth with fluoride-containing toothpaste at least three times a day with a modified Bass technique as demonstrated with a model for a minimum of 5 minutes each time, while using inter-dental brushing and flossing as well. They were instructed about dietary habits to restrict sugary food and drink consumption. Their oral hygiene was checked during routine appointments every 4th or 5th week and, if necessary, instructions were repeated, and patients were referred to the Department of Periodontology or additional evaluation of their oral hygiene.

Statistical analysis

Descriptive data were presented in univariate tables and evaluated with the chi-square test and the Fisher exact test when appropriate.

Systematic differences between observers were tested by the paired t test. Inter-observer and intra-observer reliability was expressed as Pearson's correlation coefficients between re-measurements. The magnitude of the intra-observers and inter-observers measurement error in the DMFS count was calculated.

The statistical analysis was performed using a chi-square test comparison of orthodontic treated and untreated jaw. The level of statistical significance was established at $P<.05$. All analytical statistical analyses were performed with SPSS software (release 18.0, SPSS for Windows).

Result

No significant systematic differences were found between examiners. The measurement errors were 0.9. The intra-observer correlation ranged over the two periods from 0.98 to 0.99 and the inter-observer correlation from 0.96 to 0.99, indicating a high level of reliability. No significant difference was detected in ages, gender, follow up period, and social status before treatment (**Table 1**).

The present prospective study sample comprised 60 young adults (28 men, 32 women) from aged 11 to 13 years follow-up more than 7 years (mean age of the total sample, 11.2 ± 1.8 years), divided into 2 groups: maxillary and mandible. The mean treatment time was 18.6 month in treated jaw.

At baseline, the two groups were comparable with respect to age, gender, and crowding and malocclusion and Socio-economic status, see **Table 1**.

Descriptive statistics indicated no significant differences between the treated groups and untreated groups for the Baseline.

There was also no significant difference between the treated groups and untreated groups for the DMFS before received fixed orthodontic treatment, see **Table 2**.

After about 2 year treatment time, there was also no significant difference between the treated groups and untreated groups for the DMFS, see **Table 3**.

The total DMFS counts for the different teeth were generally somewhat higher in the untreated than in the treated groups after long-term follow-up (**Table 4**). A chisquare test demonstrated significantly more undestructed surfaces in the maxillary first molars, second molars, second premolars in the treated groups. There were no significant differences between the treated and untreated group in canine, incisors.

Table 5. Comparison of the decayed, missing and filled surfaces (DMFS) for the different tooth surfaces in orthodonticly treated and untreated children. DS-decayed surfaces. FS-filled surfaces. MS-missing surfaces

Teeth	Treated group						Untreated group						$P_{(DS)}$	$P_{(FS)}$	$P_{(Intact\ surface)}$	$P_{(DMFS)}$
	Total No of surfaces	Intact surfaces	DS	MS	FS	DMFS	Total No of surfaces	Intact surfaces	DS	MS	FS	DMFS				
Mesial	720	677	15	4	24	43	720	632	33	3	48	84	0.008	0.004	0.045	0.000
Distal	720	679	15	0	26	41	720	630	32	4	54	90	0.012	0.001	0.012	0.000
occlusal	360	276	65	0	50	115	360	188	60	0	62	122	0.564	0.325	0.086	0.501
buccal	720	694	8	0	18	26	720	661	19	0	40	59	0.033	0.003	0.054	0.000
lingual	720	698	8	0	14	22	720	670	17	0	33	50	0.069	0.005	0.124	0.001
Mesial	720	677	15	4	24	43	720	632	33	3	48	84	0.008	0.004	0.006	0.000

DS-decayed surfaces; MS-missing surfaces; FS-filled surfaces. DMFS=DS+MS+FS. $P<0.05$.

The distribution of destructed surfaces for each of the tooth surfaces after long-term follow-up (see **Table 5**) showed significantly more intact surfaces including mesial and distal surfaces in the untreated than in the treated groups. The number of undestructed surfaces was no significantly higher on the buccal and lingual surfaces of incisors in the untreated group. Also, there was no significant difference between the treated group and the untreated group in the occlusal surfaces.

Discussion

The present study results clearly indicate that significant changes are occurring in the DMFS between the treated and untreated group after long-term observation period. The data showed that orthodontic treatment greatly reduced the caries occured, especially in molars and premolars which teeth easily decayed. At the same time, orthodontic treatment reduces the rate of maxillary anterior teeth caries, There is no statistical differences with mandibular anterior teeth, which considered to be the easiest to decay. And disagrees with previous investigations showing that orthodontic increased the incidence of dental caries [6, 7].

We should be interpreted with caution according to the previous studies. Not only small sample and short follow-up time, but also inability to exclude facts which contribute to the occurrence of caries: individual susceptibility, dietary, oral hygiene [11, 12]. Oral health education must be given before appliance placement as well as any treatment must be postponed until optimum oral hygiene achievement. In addition, oral hygiene procedures should be regularly checked during the treatment. Therefore, in this study, as a prospective longitudinal study, we follow up the subjects who received single jaw orthodontic more than 7 years after completed orthodontic treatment. As subjects live in the same area with the same school system, participants were matched concerning oral habit and social status. Furthermore, both groups had equal fluoride exposure. This method exclude the interference of oral hygiene, salivary infact, quality of enamel, oral microflora, and dietary factors and other systemic disease. Thus, owing to adopt strict inclusion criteria and follow up relatively long-term observation time, results in present study could be more accurately response to the influence of orthodontic treatment on the incidence of caries disease.

The outcome of the present study showed that orthodontic treatment with a fixed appliance decreased the risk of caries. This finding is in agreement with results of several studies [13, 14]. However, others [15-17] argued that incidence of caries increased because of the irregular surfaces of brackets, bands, wires, and other attachments, which created stagnation areas for plaque, rendered tooth cleaning and limited naturally occurring self-cleansing mechanisms, such as the movement of the oral musculature and saliva. Dental caries is influenced by numerous factors. Malocclusion and orthodontic treatment may have only a limited effect compared to behavioral influences (smoking, oral hygiene, diet) and genetic conditions. It may not be possible to detect this effect. And it is also possible that the effects of orthodontic treatment on caries are so detrimental that they outweigh the positive effects of eliminating a malocclusion.

A high prevalence of caries was also observed on the mandibular premolars and molar supporting previous studies [18-20]. The most likely reason for this observation is that crowding segment mainly concentrated in the posterior teeth. Plaque retention is thus increased and plaque removal is more difficult to accomplish along the gingival margin. Although there is no strong relationship between crowding and dental caries in untreated persons [21], Studies [22, 23] have shown an association between increase caries incidence and crowding, aligned teeth by orthodontic treatment, which may reduce plaque accumulation and facilitate plaque removal. Meanwhile, we found that there was high incidence of caries in the mandibular compared with maxillary which receive orthodontic therapy. This is because of the patients were informed and made aware of the cariogenic potential of foods and bad eating habits such as snacking, and be taught to eat sensibly, this kind of health education and oral health instruction during the orthodontic treatment process making the patient's oral health is better than the average patient, thereby reducing the occurrence of the caries. The results are consistent with others' reports [24, 25].

This study was the first to analyze the caries changes in the same person who received sin-

gle jaw orthodontic therapy. The subjects were reasonably comparable, since there were no significant differences between them at baseline regard to the dental component, sex, age and growth. Nevertheless, some limitations should be addressed. First, the sample size was still small. The subjects were collected at Wenzhou medical university in east China, accounts for only a proportion of the population of China. Thus, the results might not be generalizable to the Chinese adolescents. Second, a randomized controlled trial is the highest level of evidence, but we hard to conduct a random trail for ethical reasons.

In the future, large sample and randomized research should be carried out which provided a more accurate impact of orthodontic on the incidence of dental caries.

Conclusion

Fewer carious lesions were detected in the treatment jaw than without orthodontic treatment jaw after long-term follow-up time.

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Disclosure of conflict of interest

None.

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