Radiographic oral health evaluation after orthodontic therapy

A 6-year longitudinal study

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Summary

The purpose of this study was to evaluate radiographically the oral health status in young adults (range 14–21 years) following completion of orthodontic treatment.
Bitewing radiographs were taken at the completion of orthodontic treatment and three and six years later. Of the 184 individuals included in the study, 49 subjects had readable radiographs at all three examinations, 80 subjects at baseline and at 6 years examinations and 55 subjects at baseline only. All the radiographs were obtained by using a long-cone paralleling technique and the Rinn® system. Tooth loss, bone loss at teeth in presence or absence of adjacent teeth, initial and open caries lesions, frequency of root canal treatments and the periodontal impact of restorations with overhanging margins were evaluated.
After the baseline examination, no further tooth loss was observed. The distance between the cemento-enamel junction to the alveolar bone crest increased continuously over the observation period of 6 years. Sites adjacent to extracted neighbor teeth first demonstrated a faster, then a slower rate of bone loss similar to that of control teeth. After orthodontic therapy, there was a low prevalence of tooth decay and root canal treatments. There was no correlation between restorations with overhanging margins and alveolar bone loss levels.
Over all, no significant negative influences to the oral health status as a result of orthodontic treatment could be demonstrated in a population of young adults in Switzerland.

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Introduction

Over the last 20 years, the oral health status of the younger Swiss population was studied (Menghini 1993). Epidemiological surveys in school children showed in a period of 20 years a 80% reduction of occlusal and a 90% reduction of approximal decayed surfaces in posterior teeth. Interestingly, 80% of the DFS lesions (Decayed-Filled-Surfaces) were found in only 25% of the 12-year old children. Caries was not only concentrated in these high risk subjects, but also its localization predominantly affected the fissures of the teeth. In 1991, 7% of the school children examined showed approximal dentinal lesions (0.17 approximal DFS corresponded to 12% of the total DFS rate), and in 34%, fissural dentinal caries was diagnosed (1.18 DFS corresponded to 82% of the total DFS rate). Caries lesions in front teeth were rarely seen. In 1989, about 40% of the 14-year-old children were free of caries (Menghini 1993). Between 1970 and 1985, also in Swiss Army recruits, a caries reduction of 46% could be detected (Menghini et al. 1991). Above all, the rate of unfilled dentinal caries had dramatically decreased in the group of subjects with high caries activity: Less than 8% of all recruits showed more than 16 DMFT (Decayed-Missed-Filled-Teeth) corresponding to the mean DMFT value obtained in the survey of 1970. Also, the statistically expected doubling of the number of caries lesions within 5 years after completing compulsory school was confirmed in that study (Menghini et al.1991). Steiner et al. (1987) observed in school children a considerable increase in caries prevalence (1.21 DFS/year to 1.55 DFS/year) from the age of 15 to 20 years. This progression was mainly due to radiographically diagnosed interproximal dentinal lesions in posterior teeth. Interestingly, the occlusal caries lesions predominantly detected during the school age progressed only at half rate.

The periodontal situation in the Swiss Army recruits during the same observation period improved significantly and reached satisfactory oral hygiene standards. While in 1970, 96% of all recruits showed different degrees of gingivitis, only 44% of the recruits scored < 0.5 for a mean Sulcus Bleeding Index (SBI) and 17% showed a mean SBI value of < 0.25 indicating a clinically acceptable situation. Proximal and oral tooth surfaces, especially in the molar areas, yielded the highest mean SBI values (Joss et al.1992). In Switzerland, as in many other countries, all children up to the age of 16 are under continuous surveillance in a well organized dental school system. Out of that dental care program the population's oral health status is expected to deteriorate after the compulsory school education and into adult age with respect to both prevalence of caries and periodontitis.

People with malocclusions represent a particular group of patients. So far, several epidemiological studies were related to caries prevalence and periodontal implications of orthodontic treatment. It is not definitely proven, however, that the long-term oral health status may be improved or aggravated due to orthodontic alignment of teeth. Likewise, in the 1985 Swiss Army recruits study only a weak correlation between malocclusion and the periodontal status (Probing depth, probing attachment loss) in 757 subjects (18 to 24 years old) could be recorded. However, plaque and bleeding indices were strongly correlated with probing depth values (Graf & Leuenberger 1993). Other studies showed a changed subgingival flora and clinical signs of inflammation at banded teeth (Diamanti-Kipioti et al. 1987, Miethke & Bernimoulin 1988).

In patients with advanced adult periodontitis (mean age 42.6 years), the teeth in segments treated with fixed orthodontic devices, showed significantly higher bone loss (5%) than teeth in untreated control sections (2.7%). Before orthodontic therapy was started these 24 periodontally compromised patients were prepared by scaling and root planing only. Periodontal surgery was performed later (Årtun & Urbye 1988).

Zachrisson (1976) evaluated 173 patients (mean age 16 years) 2 years after orthodontic treatment for caries, attachment loss, apical root resorption and oral hygiene status. In comparison to untreated youngsters, there were no significant disadvantages detected which could be attributed to orthodontic therapy. Over 10 years, no differences in the periodontal parameters were found in 112 orthodontic patients (at least 10 years after completion of orthodontic therapy; mean age 29.3 years) compared with a control group of 111 subjects (mean age 32.9 years) with untreated malocclusions (Polson et al. 1988).

The aim of this study was to evaluate radiographically the oral health status in young adults after completion of orthodontic treatment as well as three and six years later. Tooth loss, periodontal attachment loss and dental caries as well as restorative and endodontic aspects were of special interest.

Material and methods

The analyzed radiographs originated from 184 patients treated consecutively at the University of Berne, School of Dental Medicine, Department of Orthodontics. Three and six years following completion of orthodontic treatment, the patients were examined clinically and radiographically. At baseline, i.e. at the completion of orthodontic therapy, the young adolescents had a mean age of 17.5 years (range 14–21 years), and 80% of them ranged between 16 to 19 years of age.

Of the 184 individuals included in the study, 49 subjects had readable radiographs obtained at all three examinations, while readable radiographs at the baseline and at the six year-examinations were available from 80 subjects. For 55 subjects, readable radiographs were only obtained at baseline. A total of 748 bitewing radiographs taken between 1983 and 1991 were evaluated.

The bitewing radiographs were obtained by using a Philips Radiographic Equipment (Oralix 655: 65 KV; 7.5 mA) in combination with a Dens-O-Mat exposure control (0.50s). Ultra speed films (Kodak 42×31 mm) were orientated by means of the Rinn® device and a rectangular long-cone tube (13.5 cm) for correct exposure geometry.

For each examination and every patient, all the data obtained were recorded on a specially created form. Tooth loss and root canal treatments during the postorthodontic therapy period were registered.

The radiographic bone level at teeth was measured in relation to the cemento-enamel junction from an area distally of the canine to the sites mesially of the first molar. Under a threefold magnification glass (Eschenbach, Nürnberg, Germany), measurements were made by using a 0.5 mm calibrated scale (Rotring Art. 801030, Hamburg, Germany).

The loss of dental hard tissue was diagnosed by using the extended Caries Index System (Marthaler 1966). In brief, to obtain reproducible measurements, the six original caries categories were converted into four classes: a) free of caries *(Category 0),* b) initial lesion/enamel caries *(Categories 1, 2),* c) unfilled dentinal caries *(Categories 3, 4, 6)* and d) treated caries/filling *(Category 5).* For mesial and distal tooth aspects radiographic hard tissue loss was recorded. Since it is not possible to differentiate caries free occlusal surfaces from initial occlusal caries on bitewing radiographs, only a limited occlusal caries evaluation was possible in the present study. Furthermore, overhanging margins of restorations were also registered and classified according to Lang et al. (1988).

The statistical analysis was done using a software program of SAS Institute Inc. (Cary, NC USA). Different statistical tests were applied and are indicated separately for each table or figure.

To determine intraexaminer reproducibility (R.S.), double evaluations of the radiographs of 10 patients yielded a reproducibility for radiographic bone level measurements of 97% within 1 mm and for caries of 93% with identical diagnoses.

Results

At the baseline examination, 60% of the patients showed a complete dentition from premolars to molars (with the exception of third molars), while in 30% four, and in the remaining 10% one to three posterior teeth were missing. From the first to the third examination, there was no tooth loss.

The degree of alveolar bone loss was significantly higher on distal (0.095–0.157 mm) than on mesial sites and was increasing over time (from 0.10 mm mesially to 0.15 mm distally in 6 years). This increase was statistically significant ($p<0.05$). The intermaxillary comparison of mesial bone loss revealed a statistically significantly greater loss (0.05–0.06 mm) in the maxilla than in the mandible at the mesial aspects ($p<0.05$) both at the second and at the third visit. The annual mesial bone loss amounted to 0.020 mm for the maxilla and 0.013 mm for the mandible, respectively (Table I). At the distal aspects, however, the bone loss did not differ significantly between the maxillary and mandibular aspects. The distal annual bone loss amounted to 0.028 mm for the maxilla and 0.025 mm for the mandible, respectively (Table I).

Tab. I Mesial and distal alveolar bone levels for maxillary (upper) and mandibular (lower) jaws.

		Examination 1		Examination 2		Examination 3	
		m	d	m	d	m	d
Bone Level	n	1292	1287	904	899	347	350
Upper Jaw	mean	0.512	0.598	0.582*Δ	0.675*	0.629*Δ	0.764*
	S.D.	0.09	0.09	0.08	0.09	0.10	0.12
Bone Level	n	1289	1274	903	890	351	341
Lower Jaw	mean	0.495	0.599	0.529*	0.687*	0.571*	0.750*
	S.D.	0.08	0.10	0.09	0.09	0.09	0.13

n Number of measurements, S.D. Standard deviation, * Statistically significant difference to (baseline) examination 1 (paired t-Test; $p<0.05$), Δ Statistically significant difference to lower jaw (Wilcoxon matched pairs signed rank test; $p<0.05$)

In case of the loss of an adjacent tooth prior to baseline a greater mesial bone loss was observed at baseline which did not increase over 6 years, however (Fig. 1). When the distally adjacent tooth was missing, bone loss at distal sites was higher at baseline when compared to control sites (Fig. 2). While distal sites with adjacent teeth present showed an increasing bone loss over the three examinations, the distal bone level adjacent to missing teeth remained unchanged.

Regarding the loss of hard dental structures, mesial and distal aspects yielded similar findings. At the baseline evaluation, nearly 90% of the patients were caries-free. 4–5% of the subjects showed fillings and 4–5% initial carious lesions, while the remaining 1–2% of the patients showed tooth decay with cavity formation. Secondary caries was only diagnosed in very few single cases. The occlusal aspects showed almost 70% of the surfaces being caries-free. 30% of the occlusal surfaces of the posterior teeth (n=2682) had fillings. Mostly, the first (55–60%) and the second (30–40%) molars were filled (Fig. 3).

The prevalence of initial carious lesions and of decayed sites with cavitation remained unchanged over time (Fig. 4). From the baseline examination the prevalence of approximal fillings increased steadily, however. Also, the prevalence of occlusal fillings increased, but only over the first three years of the survey and remained unchanged in the latter three years. No statistically significant differences between the right and left or upper

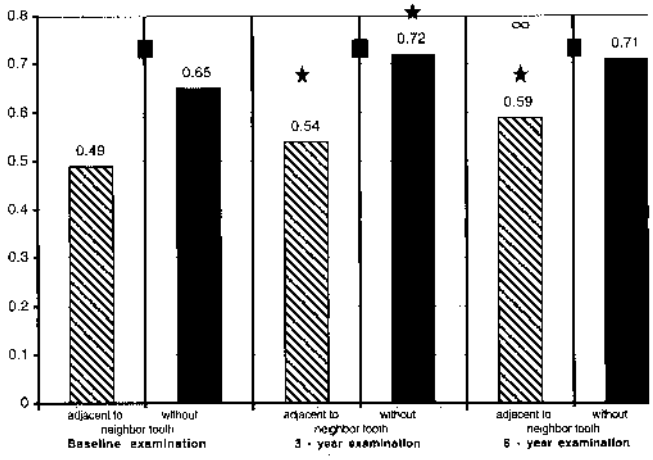

*Fig. 1 Mean mesial alveolar bone level changes in relation to the cemento-enamel-junction with and without the presence of a mesial neighboring tooth at all examinations. ■ Statistically significant difference between groups (Mann-Whitney-U-Test), * Statistically significant difference to baseline (examination 1) (Chi²-Test), ∞ Statistically significant difference to 3-year examination (2) (Chi²-Test), p<0.05*

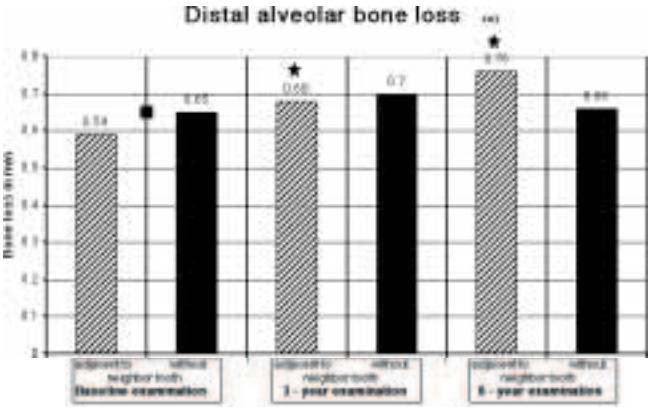

*Fig. 2 Mean distal alveolar bone level changes in relation to cemento-enamel-junction with and without the presence of a distal neighboring tooth at all examinations. ■ Statistically significant difference between groups (Mann-Whitney-U-Test), * Statistically significant difference to baseline (examination 1) (Chi²-Test), ∞ Statistically significant difference to 3-year examination (2) (Chi²-Test), P<0.05*

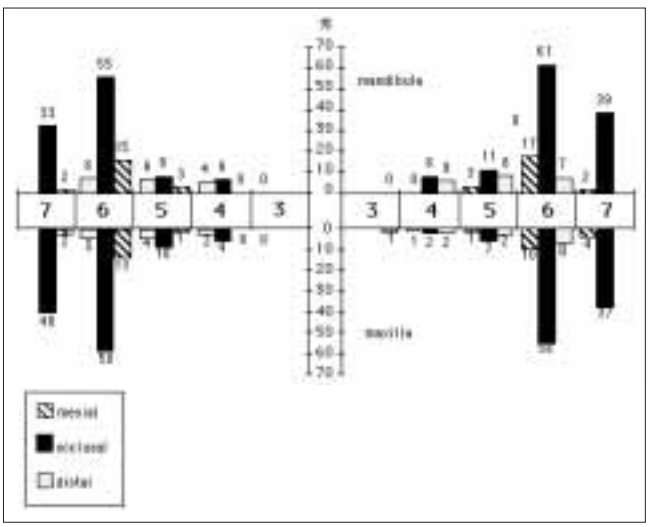

Fig. 3 Percentage of mesial, occlusal and distal tooth surfaces filled for all teeth distal of the canines to occlusal of the second molars in the maxilla and the mandible at the baseline examination.

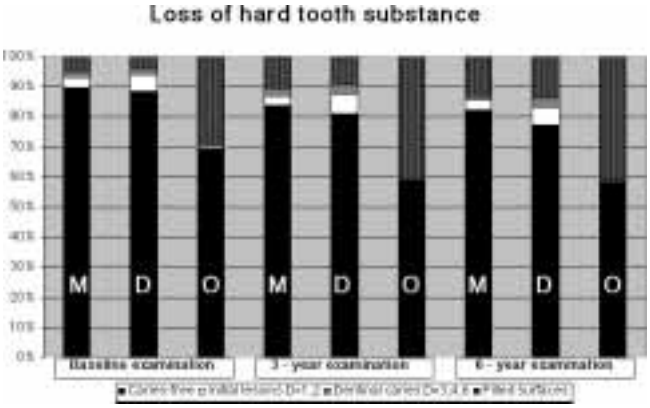

Fig. 4 Distribution of the loss of hard tooth substance due to caries for mesial, distal and occlusal aspects at the completion of orthodontic treatment and 3 and 6 years thereafter.

and lower jaw could be detected indicating a homogenous distribution of caries prevalence within the dentition.
At the baseline examination, 1% (n=2) of the patients showed one tooth with a root canal treatment. The prevalence of root canal treatments increased up to 10% (n=16) of the subjects, mostly in molars at the subsequent visits.
Over 90% of the approximal fillings showed no or minimal overhanging margins, whereas 5–10% demonstrated overhangs of 0.4 to 0.8 mm (LANG et al. 1988). No correlation was found between the alveolar bone level in relation to cemento-enamel junction and the size of the overhanging margin over time.

Discussion

Bitewing radiographs taken by means of the long-cone parallel technique are widely used for caries diagnosis (MARTHALER 1966, BERKEY et al. 1988) and for the localization and classification of restorations with overhanging margins (LANG et al. 1988). Furthermore, this technique provides radiographic evidence for alveolar bone loss in the progression of periodontal disease (GOODSON et al. 1984, HIRSCHMANN 1987). Repeated bone loss measurements of different radiographs from the same site and the comparison of radiographic measurements with clinical probing demonstrated high correlations for small and moderate osseous destruction (KELLY et al. 1975, CLEREHUGH et al. 1986, HÄMMERLE et al. 1990, ÅKESSON et al. 1992). However, there are limitations in interpretations due to horizontal and vertical distortion leading to interproximal overlapping (STASSINAKIS et al. 1996) as well as to shortening and lengthening of projection distances (SEWERIN et al. 1987). The radiographic image of the periodontal ligament space is dependent on the presence of root concavities, the diameter of the root, the horizontal inclination of the central x-ray beam and the subjective judgment of different radiographic contrasts rendering correct radiographic interpretation difficult at times (VAN DER LINDEN & VAN AKEN 1970). Furthermore, the two-dimensional image affects caries and periodontal diagnoses on approximal aspects (KELLY et al. 1975, HIRSCHMANN 1987). Also, the radiographic interpretation is subject to intra-individual variation (KARJALAINEN & HANNULA 1988, ÅKESSON et al. 1992). In the present study, however, the intra-examiner reproducibility based on double evaluations yielded was very high (97%) for bone level measurements within one millimeter and 93% for caries diagnosis.

Tooth loss: No further teeth were lost between the baseline and the follow-up visits. This indicated that most of the missing teeth had been extracted due to orthodontic therapy while attempting to create and/or maintain space. Approximately 35% of the patients were orthodontic patients with symmetrically performed tooth extractions and about 60% were non-extraction orthodontic patients. In the remaining percentage asymmetric extractions had been performed as a result of congenitally missing teeth *(anodontia partialis).* With respect to tooth loss in young adults, similar results were obtained from a study in Swiss Army recruits (MENGHINI et al. 1991).
Periodontal conditions: The distance from the cemento-enamel junction to the alveolar bone level was continuously increasing over the 6 years. Similar results of an early bone loss from age 14 and onwards were described in earlier studies. LENNON & DAVIES (1974) reported that out of 590 schoolchildren (mean age 15.1 years) 46% had a loss of probing attachment (PAL) $\geqslant$ 1 mm, including 11% showing PAL $\geqslant$ 2 mm on at least one tooth. Differences in ethnic and educational status could be identified and children of non-European origin were twice as likely to display alveolar bone loss of $\geqslant$ 1mm and five times as likely to show alveolar bone loss $\geqslant$ 2 mm than their European counterparts. Another study (AL-KUFAISHI et al. 1984) evaluated bitewing radiographs taken annually in 11–14 year-old children. At the age of 14, a mean net crestal alveolar bone loss of 0.28 mm could be demonstrated and was statistically significantly different from baseline. These studies revealed substantially higher alveolar bone loss in adolescents than the results of the present study. The annual bone loss of 0.020 mm for the maxilla and 0.015 mm for the mandible are in agreement with adult population samples with high standards for preventive dentistry (AXELSSON et al. 1991, HUGOSON et al. 1998).
Most of the epidemiological studies report on mean scores of alveolar bone loss. It is evident that such figures only reflect the general trend of a population. Similarly, the low mean annual losses of alveolar bone in this patient cohort represent the general trend in a periodontally stable adolescent population following orthodontic therapy. However, this does not preclude the possibility of single tooth sites having lost a considerable amount of alveolar bone which would be masked by the analysis.
In the present study, the distal value of alveolar bone loss was significantly higher than the mesial one at any time. This may be explained as a result of the radiographic-projection (SEWERIN et al. 1987) and the biologic tooth development. In general, this study confirmed results of other authors where no negative middle- and long-term periodontal effects of orthodontic therapy could be demonstrated (POLSON et al. 1988). An eventual slightly higher bone loss with fixed orthodontics may be compensated by intensified oral hygiene practices (ZACHRISSON 1976).
The initially accelerated bone loss at sites with extracted neighbor teeth encountered in the present study confirmed results of other studies (ZACHRISSON 1976). With time the alveolar bone loss showed similar rates as at the control sites where teeth had not been extracted. In adults, bone loss at sites neighboring to extracted teeth has also been shown to be more pronounced than at contralateral sites with no extractions (GRASSI et al. 1987).
Dental Caries: In molars, there was a striking difference in the prevalence of approximally and occlusally filled tooth surfaces. Since these are the first and the last teeth erupting, the time factor for plaque accumulation may be less important than the fact that posterior regions are more difficult to be cleaned efficiently. Also,

the morphology of fissures of molars may give rise to more frequently encountered tooth decay than in premolars. At no examination time the prevalence of approximally decayed or unfilled surfaces differed from that of occlusal surfaces. This fact suggested false positive diagnoses of fissural caries (MARTHALER et al. 1988). Clinically, this may result in overtreatment, a fact which had already been discussed in previous studies (MENGHINI 1993). The influences of plaque retention by orthodontic treatment may evidently be compensated by intensified efforts for higher standards of oral hygiene and hence, not result in a higher caries prevalence or incidence.

Well known epidemiological studies performed in Switzerland by MARTHALER et al. (1988) and MENGHINI (1993) examined either twelve-year old children or twenty-year old recruits and may be compared to patients of the present study with a mean age of 17.5 years. In the present study, only the mesial surfaces of the molars showed at the baseline examination an equally high caries value (about 16%) to that presented in the study of the Swiss Army recruits (MENGHINI et al. 1991). Based on that comparison, no negative influence of orthodontic treatment on the development of dental caries can be postulated. This, in turn, corroborates results obtained by ZACHRISSON (1976).

With respect to periodontal prophylaxis, 90% of all approximal fillings were of good marginal adaptation. This represents a further improvement of quality of approximal fillings when compared to previous surveys (LANG et al. 1998).

Conclusions

Within the limits of the present study, it may be concluded that

1. Posterior tooth loss in young adolescents represents the sequellae of orthodontic therapy rather than dental caries or other reasons.
2. Alveolar bone is lost continuously after orthodontic therapy, but at a slow rate of 0.015–0.020 mm per annum and resulting in a total alveolar bone loss of approximately 0.2 mm at the age of entering adulthood. However, when comparing rates of alveolar bone loss of other populations alveolar bone loss did not appear to be related to orthodontic therapy.
3. After tooth extraction for orthodontic reasons the alveolar bone loss on neighboring sites tends to be minimal and relatively stable over the years.
4. Based on adequate oral hygiene practices, no increased risk for dental caries development is to be expected following orthodontic therapy.

Acknowledgments

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Zusammenfassung

Ziel dieser Arbeit war die radiologische Beurteilung des oralen Gesundheitszustands bei Jugendlichen im Anschluss an eine kieferorthopädische Behandlung.

Bissflügelaufnahmen wurden bei einer Basisuntersuchung kurz nach Abschluss der kieferorthopädischen Behandlung sowie 3 und 6 Jahre danach unter Anwendung der Long-cone-Technik sowie des Rinn® Positionierungssystems gewonnen. Aus einem Patientengut der Klinik für Kieferorthopädie der Universität Bern von 184 konsekutiv aufgenommenen Patienten wiesen 49 Jugendliche für alle drei Untersuchungsperioden lesbare Röntgenaufnahmen auf. Dazu kamen 80 Patienten mit lesbaren Aufnahmen der Basis- und der 6-Jahr-Untersuchung und 55 Jugendliche, bei denen nur für die Basisuntersuchung lesbare Röntgenbilder zur Verfügung standen. Es wurden Zahnverlust der Seitenzähne sowie alveolärer Knochenverlust bei vorhandenen und extrahierten Nachbarzähnen, initiale und offene kariöse Läsionen, die Häufigkeit endodontischer Behandlung sowie der Einfluss von Restaurationen mit überstehenden Rändern auf das Parodont beurteilt. Die Röntgenbilder wurden unter dreifacher Vergrösserung und mittels eines Rastersystems von 0,5 mm ausgewertet.

Nach der Basisuntersuchung kam es zu keinem weiteren Zahnverlust, so dass allfällig fehlende Seitenzähne als direktes Resultat der kieferorthopädischen Behandlung angesehen werden müssen. Die Distanz zwischen der Schmelz-Zementgrenze und der *Crista alveolaris* nahm über die Beobachtungszeit von 6 Jahren kontinuierlich zu, hielt sich jedoch im Vergleich zu anderen jugendlichen Populationen in einem bescheidenen Ausmass (0,015–0,020 mm *per annum*). Stellen, bei denen der Nachbarzahn entfernt worden war, zeigten in den ersten drei Jahren eine etwas stärkere und danach eine schwächere Knochenresorptionsrate, welche mit derjenigen von Kontrollzähnen ohne benachbarte Extraktionen übereinstimmte. Nach der durchgeführten kieferorthopädischen Behandlung bestand eine niedrige Kariesprävalenz. Auch diejenige der Wurzelbehandlungen war gering. Nur 10% der Approximalfüllungen zeigten eine ungenügende Qualität. Aufgrund der kleinen Patientenzahl mit solch inadäquaten Füllungen konnte jedoch keine Korrelation zwischen Füllungsüberschüssen und alveolärem Knochenverlust nachgewiesen werden.

Als Konklusion darf festgestellt werden, dass in einem Patientengut von jungen Schweizern aus der kieferorthopädischen Behandlung keine negativen Einflüsse auf die orale Gesundheit resultierten.

Résumé

Le but de l'étude était d'évaluer, à l'aide de radiographies, l'état de santé buccale, chez un collectif de jeunes adultes (âgés de 14 à 21 ans) ayant subi un traitement orthodontique. Des radiographies de type «bitewing» ont été prises à la fin du traitement orthodontique, ainsi que trois et six ans plus tard. Parmi les 184 individus participant à l'étude, 49 possédaient des radiographies lisibles des trois moments de l'examen. 80 en disposaient pour la fin du traitement (examen de base) et six ans plus tard, tandis que chez 55 sujets seulement les radiographies lisibles réalisées à la fin de la thérapie orthodontique étaient disponibles. L'ensemble des radiographies sont prises à l'aide de la technique du tube long avec le système de positionnement Rinn®. Les paramètres suivants ont été évalués: perte de dents, perte d'os alvéolaire au niveau de dents avec ou sans dents adjacentes, présence de caries initiales ou ouvertes, fréquence de traitements endodontiques, ainsi que l'effet sur le parodonte de restaurations débordantes.

A partir de l'examen de base, aucune perte ultérieure de dents n'a été observée. La distance entre la jonction cément-émail et la crête alvéolaire a augmenté continuellement tout au long de la période d'observation de six ans. Les sites adjacents à des dents extraites ont montré initialement un taux de perte osseuse plus rapide, puis similaire à celle des dents témoins. Après traitement orthodontique, une faible prévalence de caries dentaires et de soins endodontiques a été constatée. En outre, il

n'existait pas de corrélation entre restaurations avec marges débordantes et perte osseuse. Globalement, aucune influence négative significative sur la santé buccale n'a pu être démontrée chez ce collectif de jeunes adultes suisses suite à un traitement orthodontique.

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