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Gingival recessions and the change of inclination of mandibular incisors during orthodontic treatment

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SUMMARY A recent systematic review demonstrated that, overall, orthodontic treatment might result in a small worsening of periodontal status. The aim of this retrospective study was to test the hypothesis that a change of mandibular incisor inclination promotes development of labial gingival recessions.

One hundred and seventy-nine subjects who met the following inclusion criteria were selected: age 11–14 years at start of orthodontic treatment (T_S), bonded retainer placed immediately after treatment (T_0), dental casts and lateral cephalograms available pre-treatment (T_S), post-treatment (T_0), 2 years post-treatment (T_2), and 5 years post-treatment (T_5). Depending on the change of lower incisor inclination during treatment (ΔInc_Incl), the sample was divided into three groups: *Retro* (*N* = 34; ΔInc_Incl ≤ –1 degree), *Stable* (*N* = 22; ΔInc_Incl > –1 degree and ≤1 degree), and *Pro* (*N* = 123; ΔInc_Incl > 1 degree). Clinical crown heights of mandibular incisors and the presence of gingival recessions in this region were assessed on plaster models. Fisher's exact tests, one-way analysis of variance, and regression models were used for analysis of inter-group differences.

The mean increase of clinical crown heights (T_0 to T_5) of mandibular incisors ranged from 0.6 to 0.91 mm in the *Retro*, *Stable*, and *Pro* groups, respectively; the difference was not significant (*P* = 0.534). At T_5, gingival recessions were present in 8.8, 4.5, and 16.3 per cent patients from the *Retro*, *Stable*, and *Pro* groups, respectively. The difference was not significant (*P* = 0.265).

The change of lower incisors inclination during treatment did not affect development of labial gingival recessions in this patient group.

Introduction

A 'gingival recession' (Figure 1a and 1b) is defined as the displacement of the marginal tissue apical to the cemento-enamel junction (Camargo et al., 2001). Recessions are relatively common in Caucasian populations and their development is age-dependent—they are more prevalent in older than in younger persons. Furthermore, they are more frequently observed in mandibular than in maxillary teeth. The gingival recessions negatively affect the appearance of dentition and may cause tooth hypersensitivity and lead to root caries (Löe *et al*., 1992; Susin *et al*., 2004).

Orthodontic treatment may promote development of recessions (Bollen *et al*., 2008; Slutzkey and Levin, 2008). Slutzkey and Levin (2008) observed that the prevalence and extent of recessions correlated with past orthodontic treatment. For example, young adults (18–22 years old) who had been treated orthodontically many years before showed twice as high risk of developing gingival recessions than their untreated peers (22.9 versus 11.4 per cent, respectively). Also, Bollen *et al*. (2008) concluded in their review that the evidence suggested a small mean worsening of periodontal status after orthodontic therapy.

The precise mechanism by which orthodontic treatment influences the occurrence of recessions remains unclear. Nonetheless, it has been assumed that the presence of bony dehiscence is a prerequisite for the development of gingival recession (Wennström, 1996). Because a bony dehiscence does not always lead to recession (Thilander *et al*., 1983), other factors such as thin gingival biotype, prolonged gingivitis, or mechanical trauma during tooth brushing must coincide (Wennström, 1996). From the orthodontic perspective, however, a possibility of formation of alveolar bone dehiscences during treatment and the presence of gingivitis during and after therapy is most important.

Animal experiments with labial movement of lower incisors in monkeys (Batenhorst *et al*., 1974; Steiner *et al*., 1981) demonstrated the development of bone dehiscences and subsequent loss of periodontal attachment.

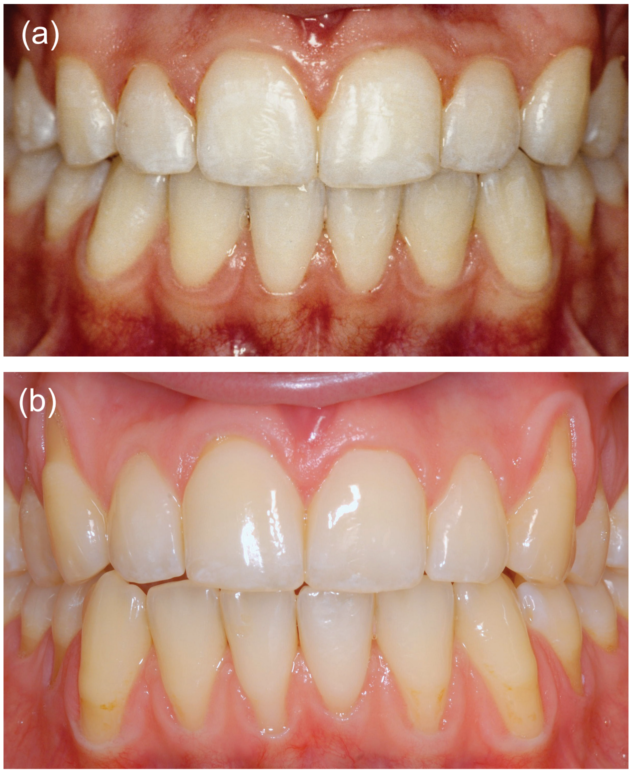

Figure 1 Development of labial gingival recessions after orthodontic treatment: (a) immediately post-treatment and (b) 5 years later.

Although other experiments were less unequivocal (Nyman *et al*., 1982), it seems possible that labial movement of incisors in humans may be a risk factor for gingival recessions. Several studies addressed this problem, but their conclusions were contradictory. Some publications showed association between incisor proclination and development of recessions (Årtun and Krogstad, 1987; Allais and Melsen, 2003; Yared *et al*., 2006) and others demonstrated the lack of such correlation (Ruf *et al*., 1998; Djeu *et al*., 2002). Most of them, however, assessed periodontal status immediately or within a few months after orthodontic therapy.

Orthodontic treatment is followed by a period of retention. Fixed retainers, a common type of retention devices (Renkema *et al*., 2009), are associated with increased accumulation of bacterial plaque (Pandis *et al*., 2007). Observations that teeth with loss of periodontal attachment showed signs of gingival inflammation (Steiner *et al*., 1981; Wennström *et al*., 1987) suggest the association between a plaque-induced gingivitis and development of recessions. The objective of this study was to test the research hypothesis that an increase or decrease of inclination of lower incisors during treatment followed by a permanent retention with fixed retainers results in an increase of the clinical crown heights and development of gingival recessions.

Materials and methods

Materials

The post-treatment archive in the Department of Orthodontics and Craniofacial Biology, Radboud University Nijmegen Medical Centre, Nijmegen, The Netherlands, was searched to identify all subjects meeting the following inclusion criteria: 1. from 11 to 14 years of age at start of orthodontic treatment (T_S), 2. presence of four fully erupted lower incisors before and after treatment, 3. a bonded canine-to-canine retainer placed directly after active orthodontic treatment with full fixed appliances, 4. no visible wear of lower incisal edges, 5. no retreatment, and 6. dental casts and lateral cephalometric radiographs available before treatment (T_S), after treatment (T_0), 2 years after treatment (T_2), and 5 years after treatment (T_5).

One hundred and seventy-nine subjects (77 males and 102 females) met the inclusion criteria. Based on the amount of change of the lower incisor inclination during treatment (ΔInc_Incl from T_S to T_0), the sample was divided into three groups:

1. *Retro* group (N = 34); ΔInc_Incl ≤ –1 degree (range –15 to –1 degree)
2. *Stable* group (N = 22); ΔInc_Incl > –1 degree and ≤1 degree (range –0.5 to 1 degree)
3. *Pro* group (N = 123); ΔInc_Incl > 1 degree (range 1.5–22.5 degree)

Methods

The distances between the incisal edges and the deepest points of the curvature of the vestibulo-gingival margin of all four mandibular incisors (Figure 2), corresponding with the 'clinical crown heights', were measured on the plaster models made at T_S, T_0, T_2, and T_5. The measurements were made by one investigator (AMR) with an electronic calliper (Digital 6, Mauser, Winterthur, Switzerland) with an accuracy of 0.01 mm.

Pre-existing gingival recessions may indicate high individual susceptibility to development of recessions. Therefore, the presence of pre-treatment (T_S) recessions in all teeth was

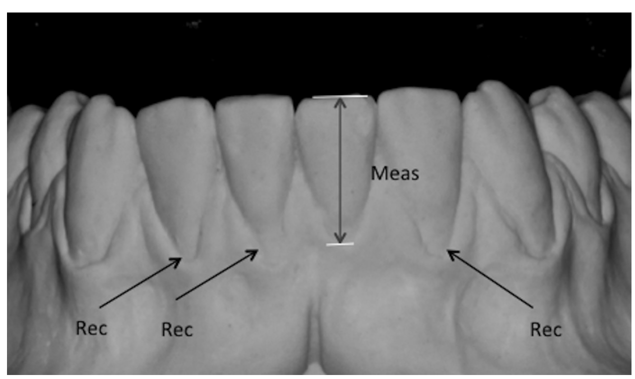

Figure 2 Example of measurement of the clinical crown height (*Meas*) and gingival recession (*Rec*) scored as present.

scored as *Yes*/*No* on the plaster models (Figure 2) independently by two calibrated observers (AMR and AR). The presence of gingival recessions 5 years after treatment (at T_5) was scored only for the lower incisors. A recession was noted (scored *Yes*) if the labial cementoenamel junction was exposed.

The validity of measuring clinical crown heights and identification of gingival recession on plaster models was assessed in a 'pilot study' that was performed in 30 randomly selected adult patients [mean age 42.0; standard deviation (SD) = 10.4; range 18.1–54.8 years]. First, an observer (AMR) measured with the electronic calliper clinical crown heights of the four lower incisors in a patient sitting in the dental chair. Then, during this clinical examination, the presence of gingival recessions in all regions of the dental arch was scored as *Yes* or *No*. Finally, upper and lower alginate impressions were taken to make plaster casts. After 3 months, the same assessment—measurement of clinical crown heights and scoring the presence of gingival recessions—was performed on the plaster casts by the same observer (AMR).

The following landmarks were identified and traced on the lateral cephalometric radiographs taken at T_S, T_0, T_2, and T_5: incisal edge (*ie*) and apex (*ap*) of the lower incisor, *menton* (the lowest point of the mandibular symphysis), and *gonion* (the most inferior posterior point of the mandibular angle). The 'inclination of the incisors' was determined at all time points as the angle between the line connecting *ie* and *ap* and the line connecting *menton* and *gonion* landmarks.

Information on gender, age at T_S, T_0, T_2, and T_5, and extraction versus non-extraction treatment type was obtained from the patient files.

Method error

To determine the inter- and intra-observer agreement for the clinical crown height, inclination of the lower incisors, and presence of gingival recessions, 80 dental casts and 20 lateral cephalograms of 20 randomly selected subjects were re-evaluated by two observers (AMR and AR) after more than 1 month.

Spearman's correlation coefficients, duplicate measurement error (DME), and paired *t*-tests were computed to evaluate error of determination of clinical crown heights and lower incisor inclination. The DME was calculated as the SD of the difference between paired scores, divided by $\sqrt{2}$. The kappa statistics was calculated to assess the strength of agreement for scoring of the presence of recessions.

Statistical analysis

In the pilot study, Spearman's correlation coefficients and paired *t*-tests were used to analyse the difference between the clinical and model measurements; the kappa statistic was used to express the agreement between the clinical and model assessments for the gingival recessions.

Descriptive statistics (means and SDs) were calculated. Fisher's exact tests were computed to evaluate the inter-group difference in distribution of gender, extraction versus non-extraction treatment type, and presence of recessions. One-way analysis of variance was used to assess the inter-group differences regarding age at T_S, T_0, T_2, and T_5, incisal inclination at T_S, T_0, T_2, and T_5, treatment time, and post-treatment time (from T_0 to T_2 and from T_0 to T_5).

Regression analysis was performed to investigate an association between the change of clinical crown heights from T_0 to T_5 (dependent variable) and age at T_0, group (*Retro*, *Stable*, and *Pro*), and gender (independent variables).

Results

The pilot study

The correlation between the measurements of crown heights performed clinically and on plaster models was 0.986. However, statistically significant differences between clinical and model measurements were found—the crown heights of lower incisors measured clinically were approximately 0.1 mm larger than when measured on plaster models.

The level of agreement between scoring recessions clinically and on plaster models was very good. Clinically, 147 recessions in various regions of the dental arch were found in 20 of 30 patients, whereas on plaster models 137 recessions were found. The kappa was >0.800 suggesting a very good concordance.

Method error

For the clinical crown height, the coefficients of reliability ranged between 0.973 and 0.995. One statistically significant difference of the clinical crown height measurements between the both observers was found at T_S (tooth 42). No differences were found at T_0, whereas seven differences were identified at T_2 and T_5. All these differences were small, with a maximum of 0.04 mm. The DME for the clinical crown height ranged between 0.07 and 0.17 mm.

Regarding the Inc_Incl at the four points in time, the reliability between the two observers ranged between 0.985 and 0.988. The difference between the two observers was statistically significant at all points in time, with the mean difference between the observers ranging between 0.23 and 0.46 degree. The DME for the inclination ranged between 0.81 and 0.91 degree.

Sample

The proportion of males in the *Pro* group (62.6 per cent) was higher than in the *Retro* and *Stable* groups (44.1 and 40.9 per cent, respectively; P = 0.046). The proportion of extraction versus non-extraction treatment was comparable in the groups (P = 0.229). The *Retro*, *Stable*, and *Pro* groups were also well-matched regarding age at T_S (mean 12.4 years), age at T_0 (mean 15 years), treatment time (T_S to T_0, 2.8 years), and post-treatment time (T_0 to T_2, 2.4 years; T_0 to T_5, 5.4 years). Other demographic data of the sample are presented in Table 1.

Table 1 Characteristics of the *Retro*, *Stable*, and *Pro* groups.

	Retro	*Stable*	*Pro*	*P* value	Paired differences
Age at T_S	12.52 (0.88)	12.38 (0.86)	12.32 (0.74)	0.415	–
Age at T_0	15.31 (1.26)	14.83 (1.24)	14.99 (0.99)	0.193	–
Treatment time (T_S to T_0)	2.79 (0.75)	2.45 (1.03)	2.67 (0.73)	0.453	–
Time from T_0 to T_2	2.46 (0.49)	2.68 (0.59)	2.40 (0.51)	0.070	–
Time from T_0 to T_5	5.56 (0.43)	5.59 (0.44)	5.39 (0.41)	0.024	–
Inc_Incl at T_S	98.32 (6.2)	97.23 (6.18)	91.33 (6.18)	<0.001	R versus P; S versus P
Inc_Incl at T_0	94.35 (6.48)	97.36 (5.96)	99.09 6.21)	0.001	R versus P
Inc_Incl at T_2	94.66 (6.75)	99.05 (6.45)	99.5 (6.49)	<0.001	R versus S; R versus P
Inc_Incl at T_5	94.47 (7.04)	99.34 (6.64)	99.91 (6.73)	0.001	R versus S; R versus P

All values are in years or degrees. Standard deviations are given within parenthesis. Inter-group differences are analysed with analysis of variance tests; paired comparisons are made with *post hoc* Tukey's tests.

Table 2 The mean increase (mm) of clinical crown height of lower incisors after treatment (from T_0 to T_5).

					95% CI		
Tooth number	*Retro*	*Stable*	*Pro*	*P* value	R versus S	R versus P	S versus P
32	0.81 (0.76)	0.92 (0.50)	1.05 (0.88)	0.274	[−0.64 to 0.42]	[−0.62 to 0.12]	[−0.59 to 0.31]
31	0.58 (0.61)	0.57 (0.70)	0.79 (0.86)	0.244	[−0.51 to 0.53]	[−0.58 to 0.15]	[−0.66 to 0.21]
41	0.43 (0.71)	0.63 (0.76)	0.83 (0.91)	0.049	[−0.75 to 0.36]	[−0.80 to −0.01]	[−0.68 to 0.27]
42	0.79 (0.67)	0.95 (0.85)	0.97 (0.71)	0.439	[−0.63 to 0.31]	[−0.51 to 0.15]	[−0.41 to 0.38]
Mean	0.60 (0.69)	0.88 (0.80)	0.91 (0.84)	0.103	[−0.54 to 0.31]	[−0.56 to 0.04]	[−0.50 to 0.21]

Standard deviations are given within parenthesis. CI, confidence interval; R, *Retro*; S, *Stable*; P, *Pro*.

Table 3 Results of regression analysis.

	Coefficients (*B*)	*P* value	Lower limit of 95% CI	Upper limit of 95% CI
(Constant)	64.23	<0.001	27.97	100.5
Age at T_S*	−3.44	0.612	−16.81	9.93
Gender (female = 0; male = 1)	12.82	0.236	−8.45	34.09
Retro group	–6.25	0.744	−44.04	31.53
Pro group	22.32	0.174	−9.93	54.57

The *Stable* group was used as a reference group in the regression model.
CI, confidence interval.
*Age above 11 years.

Pre-treatment Inc_Incl was largest in the *Retro* group (98.3 degree) and smallest in the *Pro* group (91.3 degree), whereas end-of-treatment (T_0) Inc_Incl was largest in the *Pro* group (99.1 degree) and smallest in the *Retro* group (94.4 degree). From T_0 to T_5, Inc_Incl did not change in the *Retro* and *Pro* groups, and increased by 2 degree in the *Stable* group.

Gingival recessions

No gingival recessions were found before treatment (T_S) in any of the subjects from the *Retro*, *Stable*, and *Pro* groups. Five years after treatment (T_5), gingival recessions were present in 3 (8.8 per cent), 1 (4.5 per cent), and 20 (16.3 per cent) patients from the *Retro*, *Stable*, and *Pro* groups, respectively. The difference, however, was not statistically significant (P = 0.265).

Clinical crown height

The mean increase of clinical crown heights of the lower incisors ranged from 0.6 to 0.91 mm in the *Retro* and *Pro* groups, respectively (Table 2). The only statistically significant inter-group difference was a larger increase of the clinical crown height of tooth # 41 in the *Pro* group in comparison with the *Retro* group—0.83 mm in the former and 0.43 mm in the latter group (P = 0.049; 95 per cent confidence interval: –0.80 to –0.01).

The regression analysis (Table 3) showed that none of the independent variables had an effect on the change of clinical crown heights of lower incisors.

Discussion

Orthodontic treatment is frequently an elective procedure performed mostly for aesthetic reasons (Wedrychowska-Szulc and Syrynska, 2010). Gingival recessions may compromise therapeutical outcome because they may adversely affect dentofacial aesthetics or cause tooth hypersensitivity. Although their aetiology is not clear, occurrence of gingival recessions may be associated with past orthodontic treatment (Slutzkey and Levin, 2008). Given that a gingival recession may be the unwanted effect of orthodontic therapy, identification of factors conducive to development of recessions is of great importance. In this study, we searched for a relationship between the change of inclination of lower incisors during treatment (ΔInc_Incl) and development of gingival recessions in the area of mandibular incisors.

Our results show that despite the difference in the amount and direction of lower incisor inclination during treatment, the increase of clinical crown heights was similar in our study groups. Neither proclination nor retroclination of the lower incisors nor maintaining them in the original positions affected development of recessions 5 years after orthodontic treatment. Although we found that the increase of the clinical crown height in tooth # 41 in the *Pro* group was larger than in the *Retro* group (Table 2), the difference was limited to only one tooth and the change of clinical crown heights of the remaining incisors was comparable. Moreover, the inter-group difference for tooth # 41 resulted from less increase of the clinical crown height in the *Retro* group rather than larger increase in the *Pro* group. Thus, the current findings seem to be in agreement with the results of Ruf *et al*. (1998), Årtun and Grobéty (2001), and Djeu *et al*. (2002). Ruf and associates analysed the changes in mandibular incisor inclination in teenagers treated with the Herbst appliance and development of gingival recessions 6 months after treatment. They found that the mean proclination of lower incisors by 8.9 degree did not increase the risk of recessions. Also, the comparison of patients with maximal proclination (mean = 16.4 degree) and minimal proclination (mean = 2.7 degree) did not reveal any significant differences for crown height or for the incidence of recession between the subgroups. Djeu *et al*. (2002) made a similar finding in adolescent and post-adolescent patients treated with fixed appliances in whom lower incisors had been proclined by 5 degree. They reported that proclination of mandibular incisors was not correlated to gingival recessions. Årtun and Grobéty (2001), in turn, followed the group of 10-year olds with Class II malocclusion, who had been treated with reverse headgear to the mandibular dentition, until 22 years. They reported no difference in the increase in clinical crown height from after treatment to follow-up.

Several other studies, however, found the association between a change of inclination of lower incisors and increased risk of gingival recessions. Sperry *et al*. (1977) investigated Class III patients who had been treated only orthodontically 9.2 years earlier. They found more gingival recessions in their group than in a combined Class I/Class II control group. Unfortunately, the large difference in the mean age in both groups (9.5 years) makes their finding difficult to interpret. Ngan *et al*. (1991) observed that retroclination of mandibular incisors in patients, who already had labial recessions, resulted in a decrease of severity of recessions. Årtun and Krogstad (1987) found that excessive proclination of lower incisors during the combined orthodontic/surgical treatment of Class III subjects led to retraction of the gingival margin during 3 years post-treatment; only minimal changes were noted after the next 5 years. Also, Allais and Melsen (2003) observed that at the end of orthodontic treatment of adult patients, lower incisors demonstrated more gingival recessions than untreated controls. The discrepancy between our findings and the results of other authors can be explained by inclusion of subjects with recessions to the study group (Ngan *et al*., 1991) or evaluation of patients with Class III malocclusion (Sperry *et al*., 1977; Årtun and Krogstad, 1987) who might have had thinner gingiva, more prone to recessions. Allais and Melsen (2003), in turn, found only minimal (<0.2 mm) differences in crown heights between treated and untreated individuals, which were within the error of measurement.

All subjects in our sample had fixed lower retainers during the whole 5-year post-treatment period. We selected patients with bonded canine-to-canine retainers because it is a popular type of retention of the mandibular dental arch. Furthermore, a growing trend among clinicians is to use compliance-free permanent retainers (Wong and Freer, 2004; Renkema *et al*., 2009; Valiathan and Hughes, 2010). This makes that the evaluation of this group provided clinically relevant information. Increased plaque retention is one of the disadvantages of fixed retainers. This may result in prolonged gingival inflammation and bleeding on probing (Levin *et al*., 2008). Although we did not measure periodontal parameters (indices) in this study, it is likely that many patients had calculus accumulation as shown by Pandis *et al*. (2007). How an accumulation of calculus around retainer promotes gingival recessions is unclear because recessions develop primarily labially, whereas the retainer is bonded lingually. Nonetheless, it has been hypothesized (Pandis *et al*., 2007) that, if mandibular incisors retained with a bonded appliance for long periods of time are proclined, this may cause attachment loss, leading to gingival recessions. Our findings do not confirm this hypothesis. The increase of clinical crown heights was similar irrespective of their post-treatment inclination. However, it cannot be ruled out that it would be possible to identify an association between incisor inclination and development of gingival recessions if the observation period were longer.

Previous researches used intraoral photographs for evaluation of periodontal status (Årtun and Grobéty, 2001; Allais and Melsen, 2003). For example, Allais and Melsen (2003) utilized colour slides and found that the number of unreadable teeth was larger when the assessment was performed on casts than when done on slides. They considered intraoral images as a better medium for analysis of gingival recessions. However, we noticed that relatively many of our intraoral photographs were unreadable, usually due to the lip retractor covering the gingiva. Consequently, after validation of the use of plaster models for analysis of development of recessions in the pilot study, we only used dental cast.

Presence of gingival inflammation, baseline recession, a gingival biotype, and a narrow width of keratinized gingiva were found to affect development of gingival recessions (Joss-Vassalli *et al.*, 2010). Particularly, a delicate (thin) gingiva and on-going gingivitis are considered as the crucial factors promoting development of recessions (Wennström, 1996). Wennström (1996) stated that labial tooth movement *per se* would not cause recession, but the thin gingiva that would be the consequence of the facial tooth movement might serve as a 'locus minoris resistentia', i.e. a recession might develop in case of improper tooth brushing or bacterial plaque accumulation leading to gingival inflammation. The limitation of this investigation is that the above-mentioned periodontal parameters were not assessed and that we only evaluated the presence of baseline (pre-treatment, T_S) recessions. Due to the retrospective nature of this study, it is possible that periodontal variables, unequally distributed in the groups, overrode the effect of the change of incisor inclination on occurrence of recessions.

Our results indicate the necessity of a prospective study with clinical examination before, during and after treatment, stratification for gingival biotype and various types of malocclusion, and a long follow-up. The recent systematic review identified only studies that provided a low or moderate level of scientific evidence (Joss-Vassalli *et al.*, 2010). Most publications included in the review suffered from retrospective design and the examinations of clinical data like gingival height, gingival biotype, or width of attached gingiva on the intraoral photographs or plaster casts. Minority of trials included clinical measurements of the gingival parameters but only at the follow-up examination. Because smoking and inadequate hygiene resulting in gingival inflammation are associated with gingival recessions (Wennström, 1996), these parameters should also be monitored during treatment. Furthermore, the sample composition and length of follow-up are of importance. Årtun and Krogstad (1987) found that recessions induced by orthodontic treatment developed primarily during the first 3 years after treatment with little progress afterwards. However, they assessed periodontal status in patients treated surgically for Class III malocclusion. Patients with this type of malocclusion and treatment modality are not representative for a typical orthodontic patient population, which comprises subjects with Class I/Class II malocclusion. Extending observation period over 3 years post-treatment also seems justified in the light of findings that, overall, orthodontic therapy increases the risk of gingival recessions (Slutzkey and Levin, 2008).

It should be stressed that orthodontic treatment *per se* may be conducive to development of gingival recessions irrespective of the direction of tooth movement. Elucidation of this issue would require a control group comprising subjects not treated orthodontically and, unfortunately, it was beyond the scope of our study.

Conclusions

Based on the findings of this study, we conclude that the change of inclination of lower incisors during *orthodontic* treatment did not affect development of labial recessions in this patient group.

Also, we would like to emphasize that a prospective study that takes into consideration additional factors which could influence the development of gingival recessions is needed to elucidate the role of change of inclination of lower incisors on the development of gingival recessions during orthodontic treatment and permanent retention. The design of the study should include: clinical examination - before, during, and after treatment - stratification for gingival biotype, various types of malocclusion, and a long observation period.

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