A retrospective study of orthodontic treatment with pre-treatment gingival recessions

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Research article

Keywords: gingival recession, orthodontic treatment

Posted Date: June 30th, 2020

DOI: <https://doi.org/10.21203/rs.2.22064/v4>

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Abstract

Background: The development of gingival recessions (GR) after orthodontic treatment (OT) is well described in the literature. However, there is a lack of information about the changes in pre-existing GR during OT.

Methods: This retrospective study aimed to examine the change of GR before and after OT. Intraoral photographs of 993 patients treated with fixed appliances between 2005 and 2017 were evaluated. Patients who had at least one GR on the vestibular surface of maxillary/mandibular teeth mesial to first molars were included. GR was measured on good quality plaster models before and after OT. The change of GR (T0-T1) was categorised into the three groups: worsened, did not change and improved (this group consisted of GR, which became better but did not disappear, and fully healed, which disappeared after OT)). The change of GR by ≥ 0.5 mm was recorded. Statistical analysis was performed using SPSS Statistics (Version 22.0. Armonk, NY, USA).

Results: Fifty-one (5.1%) patient had ≥ 1 GR before OT. Of them, 37 (72.5%) patients were included in the final analysis according to the inclusion criteria. GR before OT was found on 114 buccal/labial surfaces.

Significant improvement of mean GR at patient level was found between T0 and T1 (0.45 mm, 95% CI: 0.28, 0.62) ($p < 0.001$). At tooth level the median GR improvement was 0.55 (Q1; Q3: 0.12; 0.96) mm ($p < 0.001$). GR improved in 67 teeth (58.7%), did not change in 41 (36.0%), and worsened in 6 (5.3%). Of the 67 GR, which improved, full healing was observed in 15 (22.4%) teeth. There was a lower chance for GR improvement in cases with pre-treatment open bite (OR 3.35; 95% CI: 1.14, 9.84; $p = 0.03$) and dental Class III patients (OR 2.20; 95% CI: 0.92, 5.28; $p = 0.03$).

Conclusions: There was an improvement of GR after orthodontic treatment in most cases. Class III malocclusion and reduced pre-treatment overbite had a negative impact on GR improvement.

Background

Gingival recession (GR) is defined as the apical shift of the gingival margin with respect to the cement-enamel junction. It is also associated with attachment loss and exposure of the root surface to the oral environment [1, 2]. The consequences of GR include tooth sensitivity, root caries, hypermobility of the affected tooth and poor aesthetics [3, 4].

Several GR classifications are available in the literature, with Miller's four categories of GR being the most widely used in orthodontics: Class I, where marginal tissue recession does not extend to the mucogingival junction (MGJ); Class II, where marginal tissue recession extends to or beyond the MGJ, but with no interdental periodontal attachment loss; Class III, where marginal tissue recession extends to or beyond the MGJ, with interdental bone or soft tissue loss or malpositioning of teeth, and, finally, Class IV, where marginal tissue recession extends to or beyond MGJ, with severe interdental bone or soft tissue loss and/or severe malpositioning of teeth [5]. In 2018 a new classification was introduced, in which GR is described by three categories based upon the interdental clinical attachment loss and predictability of root coverage outcomes [4, 6]. Literature about the prevalence of different extent of GR is scarce, but GR of Miller class III and IV with interdental attachment loss is usually associated with the inflammatory periodontal disease and therefore is often not included in orthodontic research of periodontally healthy subjects [7].

The overall prevalence of GR affecting at least one tooth ranges from 11% to 90% in the adult population, being more frequent in adults aged 50 years and above [8-10]. The severity of GR has been observed to increase with age [8, 11]. GR is more prevalent on vestibular surfaces and in mandibular teeth [9]. It is usually observed on one or several teeth; however, GR can be more widespread when the gingiva of multiple teeth is affected [12].

Although the pathogenesis of gingival recession remains unclear, there are several predisposing and precipitating factors, e.g. coronally attached frenulum and muscles, abnormal tooth position, overhanging restorations, proclination of teeth, fenestration, dehiscence, thin mandibular alveolar bone or mechanical trauma [13]. It has been observed that GRs greater than 3 mm are associated with facially aligned roots extending beyond the alveolar bony envelope [14]. Thin periodontal/gingival biotype, absence of attached gingiva and reduced thickness of the alveolar bone due to abnormal tooth position are considered as the main risk factors for the development of GR [2, 13]. As labial bone and crestal soft tissue thickness are highly associated, they may also influence the outcome of GR during different kinds of orthodontic movements [15, 16]. To sum up, usually the main factors for GR development are presence of gingival retraction before orthodontic movement, poor oral hygiene, gingivitis and/or a thin gingival/bone biotype together with proclination of incisors [17].

Several clinical characteristics have been described for defining gingival biotype: crown width and length ratio, the width of keratinised tissue, papilla height and gingival thickness, which may be assessed by transgingival probing, ultrasonic measurement or probe visibility test [18]. However, method of visual inspection of the probe transparency through the gingiva is mostly recommended [19]. Studies have shown that subjects with a thin biotype are more prone to gingival marginal alterations, irrespective of the type of orthodontic movement. Thin periodontal biotype and proclination of teeth have been shown to correlate with loss of keratinised tissue [16]. It has also been found that the risk for the development of GR grows by 9.7% with each year after orthodontic treatment (OT) [20]. Canines, first premolars and first molars are most prone to GR after OT in the maxilla, while the highest risk of GR in the mandible was observed for the central incisors and first premolars [20].

The management of GR involves the elimination of aetiological and predisposing factors and, if needed, surgical root coverage [3, 13]. As untreated malocclusions have also been found to influence gingival problems (including GR), orthodontic therapy may favour tooth positions and be advantageous in the interdisciplinary treatment plan of GR management [21]. It has been described in the literature that moving a facially positioned tooth or its root in the lingual direction to a more centred position within the alveolar process, the apico-coronal dimension of gingival tissue will increase in width [2, 22].

In the face of an increasing number of adult patients in orthodontic practice and the scarcity of the literature discussing recession changes, the investigation of the possible advantages of OT in the interdisciplinary management of pre-existing GR becomes essential. The literature up to date mainly focuses on the development of new GR after OT and mainly in patients before adulthood.

The present retrospective study aimed to examine changes (improvement, worsening or no change) in pre-existing GRs after orthodontic treatment.

Null hypothesis: No change in GRs may be observed after orthodontic tooth movement.

Methods

Selection

The present study was a retrospective clinical study. Ethical approval for the study was obtained (No. BEC-OF-67).

Intraoral photographs of 993 patients treated between January 2005 and November 2017 were analysed. Flowchart of included patients is presented in Figure 1. Patients were treated by two orthodontists (authors EZ and DS) in the Department of Orthodontics, Faculty of Odontology at Lithuanian University of Health Sciences (LUHS) and the private practice in Kaunas, Lithuania. The presence of GR was identified on frontal, right and left buccal intraoral photographs (in occlusion) by one investigator, who was blinded (GA). The diagnosis was confirmed in patients' records and then measured on the plaster models (Figure 2). The presence of gingival recession was confirmed if the marginal border of the gingiva was apical to the cement-enamel junction. Patients with ≥ 1 GR before OT were selected and included in the study. Inclusion criteria were: 1) ≥ 1 GR before OT on labial surfaces of maxillary/mandibular teeth mesial to first molars; 2) dual arch OT with fixed orthodontic appliances; and 3) good quality plaster models available before and after OT. Exclusion criteria were: 1) periodontal disease; OT without fixed orthodontic appliances; 3) systemic disease or medication that could influence the treatment outcome; 4) combined orthodontic-orthognathic treatment; and 5) surgical treatment of GR during OT. Only patients with the records of good oral hygiene without bleeding on probing (BoP) were included. Professional oral hygiene was performed every 3-6 months during OT for all patients.

Measurements

Patient records

- General data: age (years), gender (male, female), duration of orthodontic treatment (months).
- Tooth extraction (no extraction, extractions in the maxillary or mandibular dental arch, or extractions in both dental arches).

Plaster models

All measurements were performed on plaster models before (T0) and after (T1) orthodontic treatment (the day of bracket debond) by the blinded calibrated observer (GA). No gingival enlargement at T1 was noted in patient records.

- The extent of gingival recession was measured in millimetres, using a digital calliper (Fino, Germany) before (T0) and after (T1) OT. Measurements were recorded to the nearest 0.01 mm (Figure 2). The change of GR (T0-T1) was categorised into three groups (worsened, did not change, improved (this group consists of healed GR, which became better but did not disappear, and fully healed-which disappeared after OT). Recession change of ≥ 0.5 mm was recorded as improvement or worsening [23, 24].
- Overbite (OB), measured in millimetres before OT. OB values were categorised into three groups (<1 mm; 1–3 mm; >3 mm) [25].
- Overjet (OJ) was measured in millimetres before OT. Data were categorised into two groups (<4 mm; ≥ 4 mm) [25].

- Sagittal relationship (between maxillary and mandibular canines). Class I was considered when upper canine displacement from the ideal position was less than 1 mm.
- Crowding (yes/no) was determined according to the plaster models before OT.
- Position of teeth with GRs in the dental arch was assessed and classified to: 1) labial tooth position due to crowding, 2) labial/buccal root inclination, and 3) unfavourable occlusal contacts with antagonist teeth (cusp-to cusp or deep overbite).

Intraoral photographs

Gingival biotype (normal/thick or thin) was determined blindly by two authors (NB and GA) according to intraoral photographs before OT based on tooth crown morphology and capillary transparency (Figure 3). Kappa value between the investigators was 0.88. The gingiva was identified as thin when triangular crowns and interproximal contacts close to the incisal edge were present, and the contours of tooth roots and the capillary network were easily visible [26, 27]. The gingiva was recorded as thick/normal when square-shaped tooth crowns, large interproximal contact located more apically, and the contours of tooth roots and the capillary network were not visible [18, 26].

The primary outcome variable was the change in the extent of GR in relation to the cement-enamel junction (CEJ) from before to after OT (T0–T1).

As the outcome of fixed appliance orthodontic treatment may be influenced by some specific treatment (e.g. duration of orthodontic treatment, extraction of teeth) or patient-related factors (e.g. age, sex, gingival biotype, crowding), they were also analysed ([28, 29].

Data preparation

Firstly, analyses were performed on the patient as the unit of measure. Measurement analysis included all GRs at patient (cluster) level. GR change T0–T1 was evaluated by the mean millimetre change. Later, the analysis was performed at tooth (individual) level, taking into account possible clustering effects, to find out whether the number of teeth with GR changed within the patient during the treatment [30].

Also, analyses were performed at the tooth level. Three groups were created according to the change of GR: 1) improved - when the most apical point of GR approached cement-enamel junction (the distance between the most apical point of GR and cement-enamel junction decreased (recession change was ≥ 0.5 mm and T0-T1 was positive); 2) did not change - when the distance between the most apical point of GR and cement-enamel junction changed by less than 0.5 mm; 3) worsened - when the distance between the most apical point of GR and cement-enamel junction increased (change was ≥ 0.5 mm and T0-T1 was negative).

Statistical analysis

Statistical analysis was performed using SPSS Statistics (Version 22.0. Armonk, NY, USA).

The interdependence of qualitative characteristics was evaluated using the chi-squared (χ^2) criterion. The Kolmogorov-Smirnov test was used to determine the normality of the parameter distribution. If variable distribution met the normality assumption, the Student's (t) criterion was applied to compare the quantitative sizes of two independent groups. When the variable did not meet the distribution normality condition, a significance level was verified by the Mann-Whitney U nonparametric method. For quantitative dependent variables, we used the paired test when distribution was normal, and the Wilcoxon nonparametric test when the test of normality of the investigated variables was denied.

The probability of the event given a certain risk factor was calculated using univariate and multivariate logistic regression analysis, including an odds ratio (OR) and its confidence interval (95% CI).

The difference between groups was considered statistically significant when $p < 0.05$.

The intra-examiner error was estimated by performing gingival recession measurements twice with 1-week interval on plaster models before (T0) and after (T1) OT. Measurement error ranged between 0.16 and 0.37 mm. For the assessment of the reproducibility of the measurements made by two investigators (GA and EZ), the inter-class correlation coefficient (ICC) was calculated. ICC revealed high agreement between 2 investigators (0.98; 95% CI: 0.97; 0.99, $p = 0.0001$).

Results

Baseline data

Fifty-one (5.1%) patient of the 993 assessed treated by two orthodontists during 12 years had at least one vestibular GR before OT. Of those, 37 (72.5%) patients, eight males (21.6%) and 29 females (78.4%) were included in the final analysis according to the inclusion criteria. The mean age of the included patients was 28.7 (95% CI: 26.01, 31.40) years, and most of them were adults ($n=33$). Orthodontic treatment lasted for a mean of 21.4 (95% CI: 18.99, 23.82) months. The characteristics of the included patients are presented in Table 1.

Gingival recession change at the patient level: Median GR before OT was 1.47 mm (Q1; Q3: 1.13; 1.69); the number of teeth with GR within 37 patients before OT is shown in Figure 4. Most of the GRs were Miller

class I ($N=110$) and only four teeth with Miller class II. Median GR after OT reduced to 0.98 mm (0.66; 1.33). Significant improvement of mean GR was found between T0 and T1 (0.45 mm, 95% CI: 0.28, 0.62) ($p < 0.001$).

10 patients had no improved GR, 9 patients had 1 improved GR, 9 patients had 2 improved GRs, 3 patients had 3 improved GRs, 2 patients had 4 improved GRs, 3 patients had 5 improved GRs and one patient had 8 improved GRs.

Gingival recession change at tooth level: 718 teeth mesial to molars in 37 patients were evaluated before and after OT; of these, 114 (15.9%) teeth had GR on the vestibular surfaces. The prevalence of GRs before orthodontic treatment in different groups of teeth is presented in Figure 5. The median GR improvement was 0.55 mm (Q1; Q3: 0.12; 0.96) ($p < 0.001$), with 67 (58.7%) gingival recessions improved by ≥ 0.5 mm and 25 (21.9%) GR improved by ≥ 1 mm. Of the 67 GRs that improved, full healing was observed in 22.4% ($n=15$) teeth

(Figure 6: a-c; g-j), GR did not change in 36.0% (n=41), and worsened in 5.3% (n=6) teeth. None of Miller class II gingival recessions healed. Numbers and different groups of teeth with GR change is presented in Table 2. Median GR change in the different groups of teeth is presented in Figure 7. The percentage of improved GR was highest on maxillary canines (84.6%); however, the highest amount of GR improvement in millimetres was observed on maxillary premolars and mandibular premolars ($p<0.001$). Healing of GR was mostly observed on maxillary incisors (46.7%). No recession was completely healed on mandibular incisors.

Median GR change in relation to different pre-treatment factors could be seen in Table 3. A statistically significant difference in median GR change was found between dental Angle I and III. The smallest median change of GR was found in Angle III ($p=0.004$) and open bite cases ($p=0.001$). Teeth with thin gingival biotype were the least prone to GR improvement compared to thick/normal gingival biotype ($p=0.01$).

As significant changes in GR were found, the influence of specific patient and treatment factors were analysed.

Patient-related factors

- Sagittal relationship: Significant median GR improvement was found in subjects with dental Angle I (0.48 mm, Q1; Q3: 0.39; 0.95) ($p=0.01$) and Angle II (0.63 mm, Q1; Q3: 0.04; 0.81) ($p=0.01$), however, median GR change in Angle III subjects was not significant (0.25 mm, Q1; Q3: -0.35; 0.64) ($p=0.44$).
- Overbite: Pre-treatment overbite had an impact on recession change after OT. Median GR improvement was significantly lower in patients with pre-treatment open bite tendency (<1 mm) in comparison to normal (1-3 mm) or deep (>3 mm) overbite ($p=0.03$). Significant median GR improvement was found in patients with normal or deep pre-treatment overbite (0.59 mm, Q1; Q3: 0.28; 0.93) ($p=0.001$). No median GR improvement in subjects with a reduced overbite, rather a tendency to median recession worsening was observed (0.002 mm, Q1; Q3: -0.49; 0.36) ($p=0.75$).
- Biotype: Significant median improvement T0-T1 was found in subjects with both thin ((36 mm, Q1; Q3: 0.03; 0.45) ($p=0.02$); n=15) and normal/thick ((0.69 mm, Q1; Q3: 0.20; 0.98) ($p=0.001$); n=22) gingival biotype. However, difference of median GR change between these two groups was not significant ($p=0.095$).
- Overjet: No difference of median GR change at patient level was found in different (<4 ; ≥ 4 mm) pre-treatment overjet groups ($p=0.22$);
- Crowding: No difference of median GR change at patient level was found between patients with pre-treatment crowding (n=28) in comparison to no crowding (n=9) ($p=0.37$);
- Sex: No difference of median GR change was found between males and females ($p=0.57$);
- Age: No difference of median GR change at patient level was found between GR change in adults and subjects <18 years ($p=0.56$).

Univariate binary logistic regression analysis revealed a statistically significant association between GR improvement and overbites in different Angle classes. Multilevel regression analysis showed a lower chance for GR improvement in cases with pre-treatment OB <1 (OR 3.35; 95% CI: 1.14, 9.84; $p=0.03$) and dental Class III patients (OR 2.20; 95% CI: 0.92, 5.28; $p=0.03$).

1. Overbite (OB): A significant change in GR (median 1.0 mm; Q1, Q3: 0, 1.0), as well as the percentage of recession improvement (83.3%), was found in cases with normal or deep bite (OB >1mm), compared to overbite <1mm (median 0 mm; Q1, Q3: 0, 0.5) ($p<0.001$). The odds ratio for the GR improvement was 3.89 (95% CI: 1.35, 11.16; $p=0.008$) greater if the pre-treatment overbite was >1mm in comparison to OB $\leq$
2. Sagittal dental discrepancy: GR showed less tendency for healing in dental Angle Class III patients on one or both sides ($p=0.006$). Also, the odds ratio for the GR improvement was 2.6 times less (95% CI: 1.11, 6.00, $p=0.026$) in cases with dental Class III.

Treatment-related factors

No difference of median GR change at patient level was found for different orthodontic treatment duration groups (<18 vs >18 months) ($p=0.43$), or extraction and non-extraction cases ($p=0.89$).

Since 58.8% ($n=67$) of GRs improved, and 22.4% ($n=15$) of them were completely healed, the null hypothesis was rejected.

Discussion

The present retrospective study aimed to evaluate the change of GRs, which were present before OT. As the focus on mucogingival factors is increasing in the orthodontic literature due to the increasing number of adult subjects in orthodontic practice, it is essential to analyse whether the improvement in GR may be influenced by OT. The present study is one of the very few studies in the field to assess changes of pre-treatment GRs and related factors retrospectively. The available literature is more focused on the factors inducing GR after OT rather than changes [20, 31, 32].

In the present study, only 5.1% of patients with pre-existing GR were identified from the 12-year clinical material of 2 orthodontists showing rather low prevalence. The included patients were different in the type of dental malocclusion, the number of gingival recessions and other variables, partly explaining the current scarcity of the prospective studies (Table 1, Figure 4). Most of the included cases were adult patients ($n=33$), showing that GRs are more prevalent in adult patients and confirming findings in the literature [11]. GRs in teenagers have been described to be associated with atypical tooth position; however, there were very few subjects <18 years in the present study ($n=4$) [33].

The measurements of 114 GRs in 37 patients were performed calculating the distance between the most apical marginal gingival contour and cement-enamel junction using a digital calliper, which is more accurate than using a periodontal probe. In the recent article, authors found that measurements on digital models were the most accurate; however, their calliper was not digital, and this could influence the results [34]. Other authors compared pre-treatment and post-treatment clinical crown heights; however, this kind of measurement in adults could be affected by incisal wear and/or restorations during OT [20, 35]. At tooth level, due to the small numbers of recession measurements, we performed qualitative analysis and classified improvement only when it was clinically significant (change from T0 to T1 was ≥ 0.5), so actual percentage with GR improvement could be higher. Changes of clinical periodontal variables are usually small and are in line with the findings of the present study [36].

The results of the present study revealed a positive impact of OT on the change in GR (58.8% GRs improved). The mean change of GRs was similar at the patient (0.45 mm) and tooth (0.55 mm) levels confirming the positive impact of OT. A high percentage of improved GRs could be influenced by gingival enlargement during OT. However, gingival enlargement is mostly prevalent in teenagers with compromised oral hygiene; this study comprised mostly of adults with good oral hygiene, so the influence of this factor is not discussed. Tooth group was found to be important in GR changes. The present study showed the most significant GR improvement in millimetres in maxillary premolars and mandibular premolars (Figure 7). The study by Melsen et al. (2005) showed equal amounts of improved and worsened GRs (42.3%) [31]. It is worth mentioning that these authors examined recessions only on mandibular incisors, which improved in more than half in our study; however, none of them fully healed. Mandibular incisors might be described most frequently because of the highest prevalence of new GRs after OT on their labial surfaces. The incomplete healing of GRs in the mandibular incisors revealed in the present study may be explained by the fact that the labial alveolar bone is anatomically very thin already before OT, and may predispose the development of dehiscences after the orthodontic movement of these teeth [37]. The percentage of improved GRs in the present study was the largest on maxillary canines (84.6%), which is in contrast to the results of Boke et al. (2014), where GRs worsened after orthodontic treatment [26]. That could be influenced by negative torque, usual in Roth prescription of canine brackets, leading to more significant labial movement of the canine root. In the present study, all patients were treated with maxillary canine torque of 0° or +7°. Careful selection of torque for GR treatment, bearing in mind the position of the root in the alveolus, could have influenced our results. However, this is only a speculation, as the present study had a retrospective design.

As the study patients had different malocclusions, we found it essential to analyse patient-related factors, which could have influenced GR change. Pre-treatment overbite had an impact on GR change: patients with reduced overbite had a tendency for GR worsening in comparison to normal/deep overbite cases, where improvement of GR was found. The results are in line with the results by Zimmer et al. (2007), where an average improvement of 2 mm in GRs was observed in maxillary incisors [35]. The sample of this study consisted mainly of patients with a traumatic deep bite. Therefore, a significant improvement in GR was related to the elimination of the causative factor - mechanical load. Based on the results of the present study and earlier studies, it may be expected that the treatment of deep overbite may favour the improvement of GR (Figure 6: a-c). Enhos et al. (2012) also found that patients with hypo-divergent vertical growth pattern (deep bite) have a lower prevalence of dehiscence than those with a normo-divergent or hyper-divergent (open bite) growth pattern [38].

GR improvement in the present study was similar in pre-treatment increased and decreased overjet at the patient level and tooth level (Table 3). However, in the study by Boke et al. (2014), a decreased incisor proclination had a positive effect on the improvement of GR. Later studies by Kamak et al. (2015) and Morris et al. (2017) did not find such an association, suggesting that correction of increased overjet does not influence GR change [39, 40].

Gingival biotype at patient level did not result in significantly different GR change; however, at tooth level, a smaller improvement was found in cases with thin biotype. Some authors suggest that GRs are less likely to improve after OT in cases with thin biotype [41]. However, in the study by Boke et al. (2014), no association

between GR change and gingival biotype was reported suggesting that gingival thickness is not the most critical factor [26].

The sagittal dental relationship has also been found to influence GR change. The literature mostly describes Angle class III cases as risk factors to GR worsening after OT, mainly due to retroclination of lower incisors to camouflage malocclusion [32]. Sperry et al. observed that Class III patients with excessive dental compensations had more than three times as many teeth with labial GRs after OT in comparison to patients with Class I or Class II [42]. The results of the present study support these findings: no significant GR improvement was found in Angle III patients. Patients with a Class III canine relationship had 2.6-times less chance of GR improvement than those with Class I or II. This observation can be explained by the anatomically thin buccal cortical plate, and the presence of dehiscences and fenestrations in the mandibular incisor region found in all types of untreated sagittal malocclusions [37]. Therefore, lingual movement of the lower incisor crowns, in order to compensate Class III malocclusion, may result in labial movement of incisor roots thereby causing or worsening GR [32]. Maxillary anterior teeth usually undergo proclination due to dentoalveolar compensation in Class III patients, which has also been found to induce the development or worsening of GR [41]. Therefore, the net effect is that Class III patients have a risk of GR worsening during OT.

Even if a small percentage (5.3%), most of the worsened GRs were in Class III patients with small OB and OJ before OT, and conversely patients with improved GRs were mostly with thick/normal gingival biotype and normal or deep bite.

An etiologic factor of the recession was classified to labial tooth position due to crowding, labial/buccal root inclination and unfavourable occlusal contacts with antagonist teeth (Table 3) [12]. Interestingly, GR improvements were somewhat similar despite etiologic factor suggesting that recession improvement may be due to correction of malocclusion, the better position of tooth roots in the alveolar envelope by lingually moving labially positioned teeth, or tooth roots (by changing inclination) and also resolving unfavourable occlusal contacts [12, 22]. Therefore orthodontic movements should be carefully planned before the orthodontic treatment to reach the aforementioned results, knowing that the main key is trying to retain the roots within the alveolar bony envelope [28, 43].

Possible confounding factors such as surgical treatment of GR during OT, periodontal disease and systemic disease or medication that could influence treatment outcome were excluded from the study. There were also no influences of sex, age or treatment duration on GR change.

The clinical relevance of the present study is that orthodontic movements, together with some related factors, may induce GR change. The results of the present article show the merit of OT in adult patients with pre-treatment GRs therefore confirming the necessity of interdisciplinary collaboration. The tendency of GRs to be improved may be expected in the normal/deep overbite cases, however more in maxillary teeth. However, GRs in open bite and Class III cases, also on mandibular anterior teeth, if present before OT, may need soft tissue augmentation, especially when planning unfavourable camouflage movements in relation to the alveolar bone envelope. This decision is more critical in thin gingival biotype cases [22].

Limitations

The present study was of the retrospective design, and the measurements were made on plaster models, which were performed directly after bracket debonding, and this could influence the results. Using plaster models can be problematic as they can be damaged and result in inaccurate measurements. Also we can not guarantee that during 12 years exactly the same materials were used for impressions. However, only good quality plaster models were included in the present study, and GR measurements were performed with a digital calliper. In the prospective study, we would recommend to wait 3-6 months after OT and perform direct measurements of GR or to perform measurements using digital models [34].

Another limitation is that gingival biotype evaluation was performed on intraoral photographs. In the prospective design, it could be performed clinically [34].

The sample size was small, however many years would be needed to collect clinically uniform groups for comparison.

The need for prospective and follow up studies is warranted to confirm the results of the present study.

Conclusions

Based on the findings of the present retrospective study, it may be concluded that orthodontic treatment induces changes in gingival recessions. In more than half of the teeth, the improvement in gingival recession was observed. Class III malocclusion and reduced pre-treatment overbite had a negative impact on GR improvement.

List Of Abbreviations

GR - gingival recession

MGJ – mucogingival junction

OT – orthodontic treatment

OB – overbite

OJ – overjet

Declarations

Ethics approval and consent to participate

Ethical approval for the study was received by Bioethics Center at Lithuanian University of Health Sciences (No. BEC-OF-67).

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare no competing interests.

Funding

No funding.

Authors' contributions

All authors were involved in manuscript preparation. Author EZ was responsible for the project. Authors EZ and DS treated patients. Measurements were made by two investigators (GA and EZ). Author NB consulted and assessed periodontology aspects of the manuscript. All authors read and approved the final manuscript.

Acknowledgements

Authors acknowledge help and support of colleagues in private dental centres "Odontologijos praktikos centras", "Lazerinės odontologijos centras" and "& SMILE" while collecting data for this study. Authors also acknowledge university statistician Irena Nedzelskiene for help with statistical analysis.

References

1. Manson JD, Eley BM: **Mucogingival problems and their treatment**. In: *Outline of Periodontics*. edn. Edited by Manson JD, Eley BM: Wright; 2000.
2. Cortellini P, Bissada NF: **Mucogingival conditions in the natural dentition: Narrative review, case definitions, and diagnostic considerations**. *J Periodontol* 2018, **89 Suppl 1**:S204-S213.
3. Tugnait A, Clerehugh V: **Gingival recession-its significance and management**. *J Dent* 2001, **29**(6):381-394.
4. Jepsen S, Caton JG, Albandar JM, Bissada NF, Bouchard P, Cortellini P, Demirel K, de Sanctis M, Ercoli C, Fan J *et al*: **Periodontal manifestations of systemic diseases and developmental and acquired conditions: Consensus report of workgroup 3 of the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions**. *J Clin Periodontol* 2018, **45 Suppl 20**:S219-S229.
5. Miller PD, Jr.: **A classification of marginal tissue recession**. *Int J Periodontics Restorative Dent* 1985, **5**(2):8-13.
6. Cairo F, Nieri M, Cincinelli S, Mervelt J, Pagliaro U: **The interproximal clinical attachment level to classify gingival recessions and predict root coverage outcomes: an explorative and reliability study**. *J Clin Periodontol* 2011, **38**(7):661-666.
7. Pini-Prato G: **The Miller classification of gingival recession: limits and drawbacks**. *J Clin Periodontol* 2011, **38**(3):243-245.
8. Loe H, Anerud A, Boysen H: **The natural history of periodontal disease in man: prevalence, severity, and extent of gingival recession**. *J Periodontol* 1992, **63**(6):489-495.

9. Marini MG, Gregghi SL, Passanezi E, Sant'ana AC: **Gingival recession: prevalence, extension and severity in adults.** *J Appl Oral Sci* 2004, **12**(3):250-255.
10. Sarfati A, Bourgeois D, Katsahian S, Mora F, Bouchard P: **Risk assessment for buccal gingival recession defects in an adult population.** *J Periodontol* 2010, **81**(10):1419-1425.
11. Mythri S, Arunkumar SM, Hegde S, Rajesh SK, Munaz M, Ashwin D: **Etiology and occurrence of gingival recession - An epidemiological study.** *J Indian Soc Periodontol* 2015, **19**(6):671-675.
12. Jati AS, Furquim LZ, Consolaro A: **Gingival recession: its causes and types, and the importance of orthodontic treatment.** *Dental Press J Orthod* 2016, **21**(3):18-29.
13. Kassab MM, Cohen RE: **The etiology and prevalence of gingival recession.** *J Am Dent Assoc* 2003, **134**(2):220-225.
14. Richman C: **Is gingival recession a consequence of an orthodontic tooth size and/or tooth position discrepancy? "A paradigm shift".** *Compend Contin Educ Dent* 2011, **32**(4):e73-79.
15. Le BT, Borzabadi-Farahani A: **Labial bone thickness in area of anterior maxillary implants associated with crestal labial soft tissue thickness.** *Implant Dent* 2012, **21**(5):406-410.
16. Rasperini G, Acunzo R, Cannalire P, Farronato G: **Influence of Periodontal Biotype on Root Surface Exposure During Orthodontic Treatment: A Preliminary Study.** *Int J Periodontics Restorative Dent* 2015, **35**(5):665-675.
17. Flores-Mir C: **Does orthodontic treatment lead to gingival recession?** *Evid Based Dent* 2011, **12**(1):20.
18. Zweers J, Thomas RZ, Slot DE, Weisgold AS, Van der Weijden FG: **Characteristics of periodontal biotype, its dimensions, associations and prevalence: a systematic review.** *J Clin Periodontol* 2014, **41**(10):958-971.
19. Cosgarea R, Kloukos D, Katsaros C, Sculean A: **Etiology and Treatment of Gingival Recessions in Orthodontically Treated Patients.** In: Eliades, T., Katsaros, C.eds. *The Ortho-Perio Patient. Clinical Evidence & Therapeutic Guidelines.*: Quintessence Publishing Co Inc USA; 1st Edition edition (October 1, 2019); 2019.
20. Renkema AM, Fudalej PS, Renkema A, Kiekens R, Katsaros C: **Development of labial gingival recessions in orthodontically treated patients.** *Am J Orthod Dentofacial Orthop* 2013, **143**(2):206-212.
21. Renkema AM, Fudalej PS, Renkema AA, Abbas F, Bronkhorst E, Katsaros C: **Gingival labial recessions in orthodontically treated and untreated individuals: a case - control study.** *J Clin Periodontol* 2013, **40**(6):631-637.
22. Gorbunkova A, Pagni G, Brizhak A, Farronato G, Rasperini G: **Impact of Orthodontic Treatment on Periodontal Tissues: A Narrative Review of Multidisciplinary Literature.** *Int J Dent* 2016, **2016**:4723589.
23. Cesar Neto JB, Cavalcanti MC, Sekiguchi RT, Pannuti CM, Romito GA, Tatakis DN: **Root Coverage for Single Deep Gingival Recessions: Outcomes Based on a Decision-Making Algorithm.** *Int J Dent* 2019, **2019**:1830765.
24. Goodson JM, Haffajee AD, Socransky SS, Kent R, Teles R, Hasturk H, Bogren A, Van Dyke T, Wennstrom J, Lindhe J: **Control of periodontal infections: a randomized controlled trial I. The primary outcome attachment gain and pocket depth reduction at treated sites.** *J Clin Periodontol* 2012, **39**(6):526-536.
25. Proffit WR: **Malocclusion and Dentofacial Deformity in Contemporary Society.** In: *Contemporary Orthodontics - E-Book.* edn. Edited by Proffit WR, Fields HW, Larson B, Sarver DM: Elsevier Health Sciences; 2018.

26. Boke F, Gazioglu C, Akkaya S, Akkaya M: **Relationship between orthodontic treatment and gingival health: A retrospective study.** *Eur J Dent* 2014, **8**(3):373-380.
27. Esfahrood ZR, Kadkhodazadeh M, Talebi Ardakani MR: **Gingival biotype: a review.** *Gen Dent* 2013, **61**(4):14-17.
28. Johal A, Katsaros C, Kiliaridis S, Leitao P, Rosa M, Sculean A, Weiland F, Zachrisson B: **State of the science on controversial topics: orthodontic therapy and gingival recession (a report of the Angle Society of Europe 2013 meeting).** *Prog Orthod* 2013, **14**:16.
29. Wishney M: **Potential risks of orthodontic therapy: a critical review and conceptual framework.** *Aust Dent J* 2017, **62 Suppl 1**:86-96.
30. Koletsi D, Pandis N, Polychronopoulou A, Eliades T: **Does published orthodontic research account for clustering effects during statistical data analysis?** *Eur J Orthod* 2012, **34**(3):287-292.
31. Melsen B, Allais D: **Factors of importance for the development of dehiscences during labial movement of mandibular incisors: a retrospective study of adult orthodontic patients.** *Am J Orthod Dentofacial Orthop* 2005, **127**(5):552-561; quiz 625.
32. Vasconcelos G, Kjellsen K, Preus H, Vandeyska-Radunovic V, Hansen BF: **Prevalence and severity of vestibular recession in mandibular incisors after orthodontic treatment.** *Angle Orthod* 2012, **82**(1):42-47.
33. Chrysanthakopoulos NA: **Gingival recession: prevalence and risk indicators among young greek adults.** *J Clin Exp Dent* 2014, **6**(3):e243-249.
34. Fageeh HN, Meshni AA, Jamal HA, Preethanath RS, Halboub E: **The accuracy and reliability of digital measurements of gingival recession versus conventional methods.** *BMC Oral Health* 2019, **19**(1):154.
35. Zimmer B, Seifi-Shirvandeh N: **Changes in gingival recession related to orthodontic treatment of traumatic deep bites in adults.** *J Orofac Orthop* 2007, **68**(3):232-244.
36. Papageorgiou SN, Papadelli AA, Eliades T: **Effect of orthodontic treatment on periodontal clinical attachment: a systematic review and meta-analysis.** *Eur J Orthod* 2018, **40**(2):176-194.
37. Yagci A, Veli I, Uysal T, Ucar FI, Ozer T, Enhos S: **Dehiscence and fenestration in skeletal Class I, II, and III malocclusions assessed with cone-beam computed tomography.** *Angle Orthod* 2012, **82**(1):67-74.
38. Enhos S, Uysal T, Yagci A, Veli I, Ucar FI, Ozer T: **Dehiscence and fenestration in patients with different vertical growth patterns assessed with cone-beam computed tomography.** *Angle Orthod* 2012, **82**(5):868-874.
39. Kamak G, Kamak H, Keklik H, Gurel HG: **The effect of changes in lower incisor inclination on gingival recession.** *ScientificWorldJournal* 2015, **2015**:193206.
40. Morris JW, Campbell PM, Tadlock LP, Boley J, Buschang PH: **Prevalence of gingival recession after orthodontic tooth movements.** *Am J Orthod Dentofacial Orthop* 2017, **151**(5):851-859.
41. Joss-Vassalli I, Grebenstein C, Topouzelis N, Sculean A, Katsaros C: **Orthodontic therapy and gingival recession: a systematic review.** *Orthod Craniofac Res* 2010, **13**(3):127-141.
42. Sperry TP, Speidel TM, Isaacson RJ, Worms FW: **The role of dental compensations in the orthodontic treatment of mandibular prognathism.** *Angle Orthod* 1977, **47**(4):293-299.
43. Wennstrom JL: **Mucogingival considerations in orthodontic treatment.** *Semin Orthod* 1996, **2**(1):46-54.

Tables

Table 1. Characteristics of included patients at baseline.

Variable	
Age at T0 (years),	
Mean (SD):	28.7 (8.1)
<18 n (%)	4 (10.8)
>18 n (%)	33 (89.2)
Gender, n (%)	
male	8 (21.6)
female	29 (78.4)
Duration of orthodontic treatment, (months)	
Mean (SD)	21.41 (7.23)
<18 months, n (%)	14 (37.8)
≥18months, n (%)	23 (62.2)
Gingival biotype, n (%)	
normal/thick	22 (59.5)
thin	15 (40.5)
Overjet, n (%)	
<4 mm	30 (81.1)
≥4 mm	7 (18.9)
Overbite, n (%)	
<1 mm	6 (16.2)
1-3 mm	25 (67.6)
>3 mm	6 (16.2)
Angle class of canines at T0, n (%)	
I	14 (37.8)
II	14 (37.8)
III	9 (24.4)
Pre-treatment crowding, n (%)	28 (75.7)
Crowding maxillary arch, n (%)	4 (10.8)
Crowding mandibular arch, n (%)	9 (24.3)
Crowding both arches, n (%)	15 (40.5)
No pre-treatment crowding, n (%)	9 (24.3)
Extraction treatment, n (%)	
Maxillary dental arch	2 (5.4)

Mandibular dental arch	2 (5.4)
Both arches	15 (40.5)
Non-extraction	18 (48.7)

Table 2. Change of gingival recession in different groups of teeth.

Tooth group	Change of gingival recession			
	Improved	No change	Became worse	Total
	n (%)	n (%)	n (%)	n (100%)
Maxillary incisors	10 (62.5)	5 (31.3)	1 (6.3)	16
Maxillary canines	11 (84.6)	2 (15.4)	0 (0.0)	13
Maxillary premolars	16 (53.3)	13 (43.3)	1 (3.3)	30
Mandibular incisors	7 (58.3)	5 (41.7)	0 (0.0)	12
Mandibular canines	10 (52.6)	8 (42.1)	1 (5.3)	19
Mandibular premolars	13 (54.2)	8 (33.3)	3 (12.5)	24
Total	67 (58.8)	41 (36.0)	6 (5.3)	114

$p=0.01$.

Table 3. Pre-treatment variables and gingival recessions before (T0) and after (T1) orthodontic treatment and recession change T0-T1 at tooth level.

		Gingival recessions at tooth level (mm)			
		Median (Q1; Q3)			
		T0	T1	Change T0-T1	
Pre-treatment variable	N				p
-	114				
		1.48 (1.02; 2.03)	0.65 (0; 1.30)	0.55 (0.12; 0.96)	0.001
Dental Angle I	50				
		1.52 (1.02; 2.02)	0.95 (0.54; 1.13)	0.59* (0.19; 1.11)	0.001
Dental Angle II	36				0.001
		1.40 (0.98; 2.06)	1.04 (0.60; 1.35)	0.66 (0.15; 0.90)	
Dental Angle III	28				
		1.36 (0.99; 2.21)	1.09 (0.92; 1.44)	0.20* (-0.08; 0.59)	0.016
Normal overbite	77	1.36 (1.04; 1.97)	0.95 (0.54; 1.27)	0.55 ^a (0.18; 0.92)	0.001
Open bite or edge to edge	19	1.16 (0.95; 1.56)	1.03 (0.95; 1.57)	0.11 ^{ab} (-0.12; 0.52)	0.40
Deep overbite	18	2.08 (1.07; 2.81)	1.17 (0.60; 1.95)	0.86 ^b (0.49; 1.14)	0.001
Overjet <4mm	82	1.34 (1.05; 1.91)	1.02 (0.60; 1.31)	0.51 (0.10; 0.87)	0.001
Overjet ≥4mm	32	1.86 (0.98; 2.33)	1.08 (0.71; 1.53)	0.76 (0.27; 1.11)	0.001
Labial tooth position due to crowding	38				
		1.56 (1.00; 2.32)	0.99 (0.49; 1.95)	0.57 (0.09; 0.97)	0.001
Labial/buccal root inclination	48				
		1.36 (1.00; 2.02)	1.01 (0.80; 1.23)	0.54 (0.14; 1.02)	0.001
Unfavourable occlusal contact with antagonist	28				
		1.31 (1.05; 2.13)	1.08 (0.58; 1.55)	0.52 (0.08; 0.98)	0.001
Thin biotype	39				
		1.17 (0.94; 1.64)	0.95 (0.61; 1.21)	0.43* (0; 0.57)	0.017
Normal/thick biotype	75	1.63 (1.14; 2.12)	1.05 (0.66; 1.42)	0.74* (0.13; 1.08)	0.001

p by Wilcoxon signed ranks test; * p<0.05 by Mann-Whitney U test difference between recession change in Angle I and I patients, between thin and normal/thick biotypes; ^{ab} p<0.05 by Mann-Whitney U test: a = comparison between open-nor

overbite; b = comparison open-deep overbite.

Figures

Figure 1

Flowchart of included patients.

Figure 2

Example of measurement of gingival recession (GR) on the plaster model. a – measurement of tooth 23 GR with digital caliper ; b – good quality of the plaster model.

Figure 3

Example of biotype assessment from digital photographs. a, b, c – the gingiva was identified as thin when triangular crowns and interproximal contacts close to the incisal edge were present, and the contours of tooth roots and the capillary network were easily visible; d, e, f – The gingiva was recorded as thick/normal when square-shaped tooth crowns, long interproximal contact located more apically, and the contours of tooth roots and the capillary network were not visible.

Figure 4

Number of teeth with pre-treatment gingival recessions in 37 patients.

Figure 5

The prevalence of pre-treatment gingival recessions in different groups of teeth.

Figure 6

a-c: change of gingival recession when deep overbite of tooth 23 is corrected; d-f: no significant change of gingival recession of tooth 23 before, during and after orthodontic treatment; g-j: change of gingival recessions before and after orthodontic treatment of teeth 13, 31, 33 and 43 due to better position in the alveolar bone.

Figure 7

Median gingival recession change in the different groups of teeth.