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REVIEW ARTICLE

Orthodontic therapy and gingival recession: a systematic review

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Abstract

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To perform a systematic review on the effect of changes in incisor inclination owing to orthodontic treatment and the occurrence of gingival recession. PubMed, EMBASE Excerpta Medica and CENTRAL of the Cochrane Library were searched and a hand search was performed. From 1925 articles identified, 17 articles were finally included: six experimental animal studies and 11 retrospective clinical studies in humans. More proclined teeth compared with less proclined teeth or untreated teeth had in most studies a higher occurrence or severity of gingival recession. Contradictory results were found regarding a possible statistically significant correlation between the extent of gingival recession and the amount of incisor proclination during treatment, width of attached gingiva, hygiene, periodontal condition or thickness of the symphysis. There are no high quality animal or clinical studies on this topic. Movement of the incisors out of the osseous envelope of the alveolar process may be associated with a higher tendency for developing gingival recessions. The amount of recession found in studies with statistically significant differences between proclined and non-proclined incisors is small and the clinical consequence questionable. Because of the low level of evidence of the included studies, the results should be considered with caution. Further randomized clinical studies including clinical examination of hygiene and gingival condition before, during and after treatment are needed to clarify the effect of orthodontic changes in incisor inclination and the occurrence of gingival recession.

Key words: gingival disease; gingival recession; incisor inclination; orthodontics; periodontium; tooth movement

Introduction

The gingiva is defined as 'the part of the masticatory mucosa which covers the alveolar process and surrounds the cervical portion of the teeth' (1). According to the 'International Workshop for a Classification of Periodontal Diseases and Conditions', the gingival/soft tissue recessions on the facial or lingual surfaces or interproximal (papillary) areas are classified in the group of 'Development or Acquired Mucogingival Deformities and Conditions Around Teeth' (2) and are defined as the displacement of the marginal tissue apical to the cemento-enamel

junction (AAP 1992). The resulting root exposure is not esthetically pleasing and may lead to sensitivity and root caries (3).

Data from a long-term epidemiological study have shown that in a Western European population receiving regular dental care with a reasonable level of oral hygiene, gingival recessions were found in more than 60% of the younger population (i.e. up to 20 years of age) and in more than 90% of the older population (>50 years) (4). However, the occurrence of gingival recessions was significantly higher in a population without any dental care (4).

Gingival recessions are more frequently observed in mandibular than in maxillary teeth. With increasing age, they are more frequent at facial than on lingual surfaces (5). The main causes for the occurrence of gingival recessions are related to mechanical factors or periodontal factors or to inflammatory periodontal disease (4, 6). Traumatic tooth brushing is one of the most often factor associated with gingival recessions (3, 5–8). An aggressive cleaning technique may lead to mechanical destruction, which is influenced by horizontal scrubbing with excessive force and the use of hard tooth brushes (5). Intra- and perioral piercings may be further causes for the development of recessions because of the traumatizing effect upon the tissues (9, 10). Frontolateral bruxism has been associated with the initiation and/or enhancement of the development of gingival recessions (11). Gingival recession has also been related to microbially induced inflammation in periodontal connective tissue (8).

A further possible etiological factor for gingival recession is the orthodontic movement of teeth, specially the movement of teeth to positions outside the labial or lingual alveolar plate, which could lead to dehiscence formation (12). Whether orthodontic tooth movement really can cause a gingival recession or whether the alveolar bone and gingiva adapt to the new position of the tooth in the absence of other traumatic factors like vigorous tooth brushing is a controversial issue. Contradictory statements can be found in the literature.

The aim of this study was to perform a systematic review to assess the effect of changes in incisor inclination owing to orthodontic treatment and the occurrence of gingival recession.

Material and methods

Literature search

A literature search was performed independently by two reviewers (the first author and the last author) using the following databases:

- PubMed (from 1948 to week 3 of February 2009),
- EMBASE Excerpta Medica (from 1980 to week 3 of February 2009),
- CENTRAL of the Cochrane Library (to week 3 of February 2009).

To identify articles reporting the appearance of gingiva recessions and changes of crown length in the incisor region related to orthodontic tooth movements. All articles were found using MeSH searches with the MeSH terms ‘gingival recession’ and ‘orthodontics’ for PubMed, ‘gingival disease’ and ‘orthodontics’ for EMBASE, ‘gingival recession’ and ‘orthodontics’ for CENTRAL of the Cochrane Library, further ‘tooth movement’ and ‘periodontium’ for PubMed. Articles in any language were considered. To complete the search, references of each selected publication were handsearched.

Selection criteria

The following inclusion criteria were chosen initially to select potential articles from the published abstract results:

- Human controlled or randomized clinical trials and animal studies.
- Studies reporting occurrence of gingival recessions and crown length changes in the anterior region of the lower and upper arch in the context of orthodontic labial or palatal tooth movement.

The exclusion criteria were as follows:

- Studies concerning impacted teeth or injured anterior teeth.
- Studies dealing with pre-orthodontic treatment for dental restoration.
- Medically compromised patients or test animals.
- Studies restricting the population to patients or test animals with severe periodontal diseases or craniofacial anomalies.

- Case reports, descriptive studies, review articles, opinion articles.

In case of duplicate publications in more languages, the publication in English language was used.

Data extraction

Data were recorded on specially designed data extraction forms. First abstracts were reviewed without considering the number of patients reported. Articles that apparently fulfilled the inclusion criteria and articles of which the title or abstract did not present enough relevant information were obtained in full text. Secondly, the following data were extracted (if reported) from full-text articles: year of publication; study design; method to measure gingiva recession; error analysis; time since end of orthodontic treatment at outcome assessment; number, gender and mean age of patients; ethnical background of patients; orthodontic intervention; treatment duration; existence of a control group and their description; outcomes regarding gingiva recessions; correlations between extent or presence of gingiva recession and different variables such as age, gender, hygiene, degree of labial or palatinal movement of the incisors.

Quality assessment

The quality of methodology, statistics, and performance of each study were assessed, and the studies were graded with a score of A–C (Grade A: high value of evidence, Grade C: low value of evidence) according to predeterminded criteria using the system of Bondemark (13). They described the criteria for grading the studies as follows:

- Grade A: high value of evidence (all criteria should be met):
  - Randomized clinical study or a prospective study with a well-defined control group.
  - Defined diagnosis and endpoints.
  - Diagnostic reliability tests and reproducibility tests described.
  - Blinded outcome assessment.
- Grade B: moderate value of evidence (all criteria should be met):
  - Cohort study or retrospective cases series with defined control or reference group.
  - Defined diagnosis and endpoints.
  - Diagnostic reliability tests and reproducibility tests described.
- Grade C: low value of evidence (one or more of the following conditions):
  - Large attrition.
  - Unclear diagnosis and endpoints.
  - Poorly defined patient material.

Results

Results of search

The search strategy resulted in 1559 articles. The QUORUM-flow diagram gives an overview of the selection process (Fig. 1). Hand search of the references revealed 366 studies, from which nine were selected and studied together with the 105 full-text articles derived from the electronic search. Finally, a total of 17 suitable studies (16 articles from the electronic database search and one article from the hand search) were included.

The 17 articles that met the inclusion criteria were divided into two groups based on the study design: animal studies (six studies) and human clinical trials (11 studies).

Animal studies

Quality assessment

The six included animal studies were graded as low value of evidence (Grade C). The reason was the absence of diagnostic reliability tests.

Study settings

An overview of the experimental set-up of the included animal studies is given in Table 1. Five of the studies used a split mouth design (12, 14–17) comparing experimental teeth that were moved labially with not moved control teeth. One study (18) had three orthodontically treated animals as experimental group and three untreated animals as control group. Engelking and Zachrisson (17) utilized the same animals that were used before in the study of Steiner et al. (15). The lower as well as the upper incisors that were proclined in the latter study were retracted and relocated toward their original position in the arches (17).

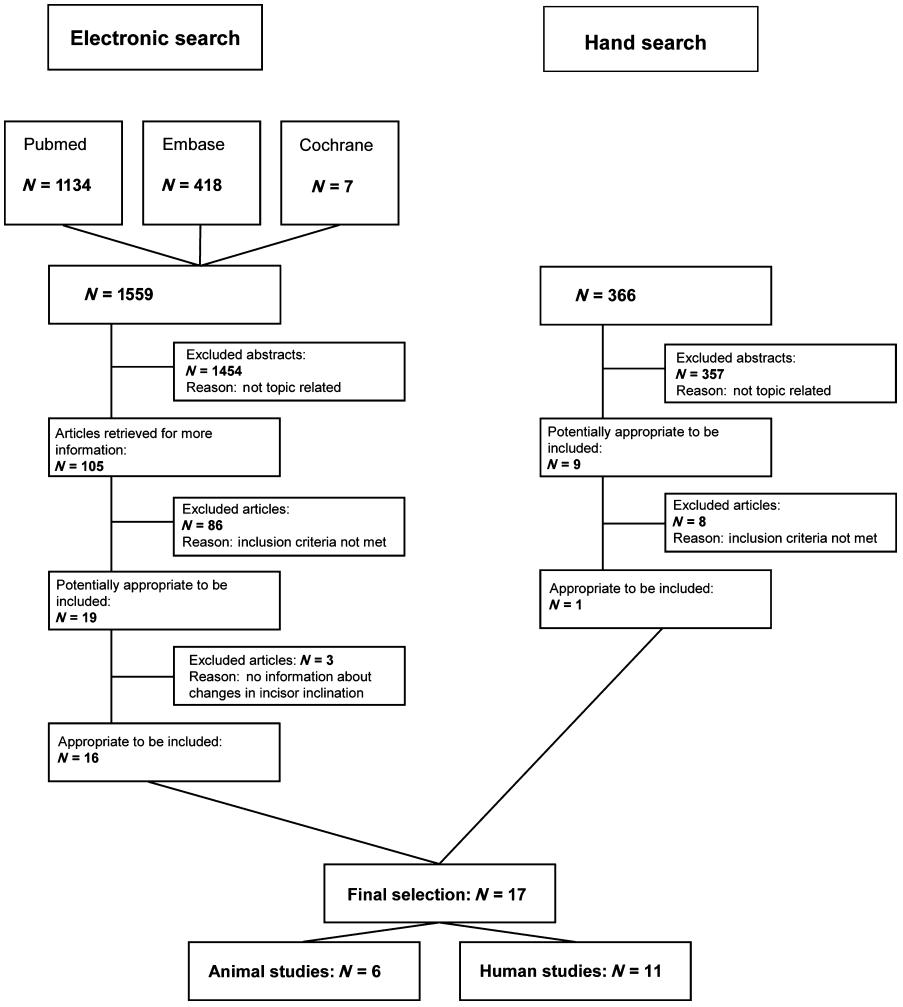

Fig. 1. Selection process.

All animals in the six selected studies received a meticulous plaque control, and in two studies additionally (14, 16) Bicillin (benzathine penicillin G) was administered monthly to minimize plaque formation.

The measurements of gingival recession were made directly on the teeth in all animal studies. No error of the method was reported for any of the animal studies.

Clinical findings

Table 2 gives an overview of the results of the animal studies regarding gingival recessions.

One study could find neither bone dehiscence nor gingival recession of the labially moved incisors (16). Two of the studies (14, 15) diagnosed significantly more gingival recession on the labial side of the orthodontically proclined teeth than on the control teeth. The gingival recessions were accompanied by a significant bone dehiscence. Wennström et al. (12) histologically determined the apical termination of the junctional epithelium. They could show that bodily tooth movement resulting in deep and wide dehiscences was not necessarily accompanied by loss of attachment and recession. In fact, in eight out of the 10 test teeth the apical termination of the junctional epithelium was located at the cemento-enamel junction. The gingival margin however had been apically displaced at five out of the 10 test teeth. Batenhorst et al. (14) measured in the experimental teeth a change of 3.0–3.4 mm between the location of the free gingival margin before and after labial movement. Steiner et al. (15) noticed in the experimental teeth a lowering of the gingival margin of 0.3–1.6 mm. The study (15), in which both upper and lower incisors were moved labially, reported a significantly higher amount of recession in the lower arch. After the experiment, the incisors were held in their exaggerated labioversion position for a period of 8 months, then the animals were used for the study of

Table 1. **Overview of the experimental design of included animal studies**

Author	Year	Species	Gender	N	Age	Teeth moved	Force per tooth	Treatment duration	Time since end of active treatment at outcome assessment
Wennström et al. (12)	1987	Monkey	†	5	Adult	11, 21, 14, 24	Incisors: 50 cN Premolars: 30 cN	3–4 months	1 month
Thilander et al. (18)	1983	Dog	†	6	≈12 months	12, 11, 21, 22	50 cN	450 days	150 days
Engelking and Zachrisson (17)	1982	Monkey	Female	5	Adult	11, 21, 31, 41	50–100 cN	112 days proclination 8 months break 2 months retraction	4–6 months
Steiner et al. (15)	1981	Monkey	Female	5	Adult	11, 21, 31, 41	50 cN	112 days	3 weeks
Wingard and Bowers (16)	1976	Monkey	Male	4	Adult	31, 41	Max. 170 cN	36–95 days proclination	0, 30, 60, 120 days respectively
Batenhorst et al. (14)	1974	Monkey	†	2	Corresponding 12–20 years old humans	32, 31 or 41, 42	Max. 35 cN	54–64 days proclination	240 days

†Not reported.

Engelking and Zachrisson (17) and the incisors were relocated towards their original position. During the 8-month interim period, the recessions continued to develop and several teeth showed areas of 2–3 mm of recession. On the average, the monkeys showed another 1.01 mm of recession before starting the retraction of the incisors. During the retraction and relocation of the incisors as close as possible towards their original position, the overall bone gain was 2.52 mm for maxillary and 3.11 mm for mandibular incisors, which corresponded to 50% recovery. The changes in the soft tissues were, in contrast, negligible. The gingival margin moved coronally 0.09 mm. There was no sign of repair of the gingival recessions that had developed because of the extreme labial advancement. The amount of gingival recession and bone dehiscence, the location of the mucogingival junction, and the connective tissue level were not statistically significantly related to the amount of tooth movement (15). During the follow-up study in which the incisors were retracted, Engelking and Zachrisson (17) found a highly significant relationship between the amount of tooth movement and increase in marginal bone level. With regard to changes in the level of gingival margin, there were no statistically significant relationships to the amount of tooth movement. No statistically significant relationship existed between tooth movement and position of the mucogingival junction or width of the keratinized gingiva (17).

One study (18) compared the situation between facially moved teeth, teeth that following facial displacement were moved back in their original position, and teeth not moved at all. Dehiscences developed in the buccal alveolar bone by moving the teeth in a facial direction, so that after facial displacement the marginal bone crest was located at approximately mid-root level. The bone dehiscences of the teeth that were moved back to their original position recovered completely. The apical termination of the epithelial junction was in all test and control teeth at the cemento-enamel junction. This implies that no gingival recession arose during treatment neither for the facially displaced and moved back incisors nor for incisors that were moved only facially.

Three studies compared the width of the keratinized respectively attached gingiva between the displaced teeth and the control teeth. No difference was found in the width of the keratinized gingiva between

Table 2. **Results of included animal studies**

Author	Degree of proclination (+) or retroclination (−) of incisors	Gingiva recession +: increase of recession −: decrease of recession	Extend/occurrence of recession is statistically related to…	Extend/occurrence of recession is not statistically related to…
Wennström et al. (12)	Ø + 3.3 mm	Ø + 0.40 mm Range: 0–1.5 mm	†	Initial width of keratinized gingiva
Thilander et al. (18)	†	No recession	†	†
Engelking and Zachrisson (17)	−1.83 ± 0.88 mm	−0.09 ± 0.40 mm (no signs of repair of prior developed gingival recessions)	†	Amount of tooth movement
Steiner et al. (15)	+3.05 ± 0.8 mm	+1.01 ± 0.4 mm*	Proclination of the incisors versus no movement, Arch (lower arch more recessions than upper)	Amount of tooth movement, Pre-experimental exploratory surgery
Wingard and Bowers (16)	Ø + 3.35 mm Range: 2.1–5 mm	No recession	†	†
Batenhorst et al. (14)	+6 mm	Ø + 1.9 mm* Range: 1.8–1.9 mm	Proclination of the incisors versus no movement	†

Ø, average.
†Not reported.
*Statistically significant more gingival recession in displaced incisors than in control teeth (Steiner et al., 15, Batenhorst et al., 14).

displaced and control teeth (12, 15), whereas Batenhorst et al. (14) found that the width of the attached gingiva increased on the facial surfaces of all experimental teeth, but it remained about the same on the controls.

Human studies

Quality assessment

Three included human studies were graded as low value of evidence (Grade C). The reason was the absence of diagnostic reliability tests (19–21) and unclear endpoints (19). The remaining eight studies were graded as moderate value of evidence (Grade B).

Study settings

An overview of the experimental set-up of the included human studies is given in Table 3. Two studies used untreated persons as control group (20, 22). Five of the included studies compared groups with different degrees of inclination of the lower or upper incisors as result of the orthodontic treatment (21, 23–26). Two studies had no control group (27, 28). For better understanding, it should be added that the study of Allais and Melsen (22) as well as the study of Melsen and Allais (27) is based on the same test group of 150 treated patients. Dorfman (19) selected 24 patients after evaluation of 1150 patients. The 24 selected patients had at the beginning of treatment a height of keratinized gingiva smaller than 2 mm in the lower incisor region. These 24 patients were divided in two groups: the one group showed an increase in the width of keratinized gingiva, the second group showed a decrease in the width of keratinized gingiva during treatment. Dorfman (19) compared the two groups. Ngan et al. (29) divided their 20 patients with more than 1 mm labial recession on one or more mandibular central incisor before treatment in two groups: one group received autogenous gingival graft in the area of recession prior orthodontics, the second group (control group) had no graft before orthodontics (in both groups the incisors were retroclined during treatment).

Pearson (20), Dorfman (19) and Sperry (21) did not mention anything about the oral situation of their probands. Djeu et al. (25) excluded the variable 'hygiene' because it was not consistently reported in the records. In the studies of Allais and Melsen (22, 27), the visible plaque accumulation and gingival inflammation on intraoral slides were recorded.

Ruf et al. (24) described the oral hygiene of all subjects as good throughout the treatment without specifying how they came to this conclusion.

In the study of Ngan et al. (29), the oral hygiene was determined for each selected tooth before and after treatment; fair to poor hygiene was maintained by the patients. In three studies, the hygiene condition was scored at the clinical follow-up (23, 26, 28).

In all but one study the gingival recessions were determined from intraoral slides. If the linear changes in gingival recession were searched, the approach was as follows: Measurements of the recessions were made on the projected image of intraoral slides at the midline of the facial surface of the selected tooth. Afterwards, to determine the actual linear changes in gingival recession, extrapolation was performed by dividing the measured length of the clinical crown from the study cast by the measured length of the clinical crown from the projected slide. In the study of Pearson (20), the gingival recessions were identified only on plaster casts.

Several studies had also clinical measurements at follow-up (21, 23, 26, 28).

In all studies, except the three older studies (19–21), the error of the method was assessed.

Clinical findings

Table 4 gives an overview of the results of the human studies regarding gingival recessions.

The two studies concerning orthodontic labial movement of lower incisors and occurrence of gingival recession comparing treated and untreated persons found out that significant greater recession was demonstrated in the treated cases (20), and the prevalence of individuals with gingival recession was significant higher in treated cases (22).

The four studies comparing patient groups of more or less proclination of the lower incisors during treatment (23–26) showed that more proclined teeth had generally bigger gingival recession or the development of new recession was more frequent relative to the non-proclined or less proclined teeth, and in one of these studies the difference was statistically significant (26). Sperry et al. (21) compared a test group of orthodontically treated cases of mandibular prognathism by dental compensation with a control-group of Class I

Table 3. **Overview of the experimental design of included human studies**

Author	Year	Race	Gender	N	Age	Teeth analysed	Force per tooth	Treatment duration	Time since end of active treatment at outcome assessment
Yared et al. (28)	2006	†	†	34	18–33 years	31, 41	†	†	7–47 months
Melsen and Allais (27)	2005	White	Male N = 36 Female N = 114	150	33.7 ± 9.5 years	32, 31, 41, 42	15–25 g	†	≈1 month
Allais and Melsen (22)	2003	White	T: Male N = 36 Female N = 114 C:†	T: 150 C: 150	T: 33.7 ± 9.5 years C:†	32, 31, 41, 42	T: 15–25 g C: 0 g	†	≈1 month
Djeu et al. (25)	2002	African Americans N = 7 Asian Americans N = 4 White N = 56	T+C: Male N = 28 Female N = 39	T: 40 C: 27	T + C: Ø 16.4 years	31, 41	†	Ø 33.2 months	Immediately after treatment
Årtun and Grobety (23)	2001	†	T: Male N = 15 Female N = 30 C: Male N = 9 Female N = 21	T: 45 C: 30	≈10 years	32, 31, 41, 42	†	≈4 years	T: Ø 7.83 years C: Ø 9.38 years
Ruf et al. (24)	1998	†	First part: Male N = 67 Female N = 31 Second part:†	First part: 98 Second part: T: 16 C: 17	12.8 ± 1.4 years	32, 31, 41, 42	†	Ø 7 months Herbst (+ fixed appliance)	Immediately after Herbst (incisor inclination); 6 months after Herbst (gingiva recession)
Ngan et al. (29)	1991	†	Male N = 8 Female N = 12	T: 10 C: 10	≈12 years	31, 41	†	Ø 24 months	Immediately after treatment
Årtun and Krogstad (26)	1987	†	†	T: 29 C: 33	T: 28.8 ± 5.9 years C: 27.9 ± 4.6 years (3 years postoperative)	32, 31, 41, 42	†	†	T: Ø 7.8 years C: Ø 8.1 years (post surgery)

***Table 3.* Continued**

Author	Year	Race	Gender	N	Age	Teeth analysed	Force per tooth	Treatment duration	Time since end of active treatment at outcome assessment
Dorfman (19)	1978	†	†	T: 16 C: 8	10–15 years	32, 31, 41, 42	†	Ø 28 months	Immediately after treatment
Sperry et al. (21)	1977	†	†	T: 36 C: 32	T: Ø 26.7 years C: Ø 17.1 years	13, 12, 11, 21, 22, 23, 33, 32, 31, 41, 42, 43	†	†	T: Ø 9.2 years C: Ø 2.1 years
Pearson (20)	1968	†	†	T: 45 C: 27	≈12 years	31, 41	†	†	Immediately after treatment

Ø, average; T, test group; C, control group.
†Not reported.

and II orthodontically treated patients. The test group had compared with the control-group more proclined upper incisors and retroclined lower incisors. The test group had significant more teeth with gingival recession, particularly in the lower arch.

Two studies had no control group:

Yared et al. (28) observed that patients with final inclination of more than 95° between mandibular plane and long axis of incisors showed greater and more severe recessions of the mandibular incisors (for the mandibular right central incisor, this behavior reached statistical significance). They concluded that the final inclination of the mandibular central incisors is a much more important factor than the total amount of proclination of these teeth.

Melsen and Allais (27) comparing the gingival situation of their patients before and after treatment with fixed appliance and proclination of lower incisors demonstrated that the increase in the prevalence of gingival recession during treatment was significant, but the increase in the mean gingival recession was not significant.

Dorfman (19) described in his study that the 16 patients with decrease in the width of keratinized gingiva demonstrated marked gingival recession. Their incisors moved either negligibly or somewhat labially during treatment. However, the eight patients with increase in keratinized gingiva exhibited a significant amount of lingual tooth movement. Ngan et al. (29) found out that teeth presenting true gingival recession had statistically less gingival recession after being retroclined (with no difference between grafted and ungrafted recessions). A further important finding between the relation of lower incisor proclination and gingival recession is that no statistically significant difference was observed during the period from 3-year-post-operative control to time of follow-up examination (about 8 years post-surgery) (26).

Melsen and Allais (27) found out that the presence of gingival inflammation correlated significantly with development or increase in gingival recession, but it was not the case for the presence of plaque. Yared et al. (28) on the other hand, affirmed that no correlation could be found between the variables of general and mandibular central incisor periodontal condition at the follow-up examination (plaque index, gingival bleeding index and probing pocket depth) with gingival recession in this area.

Table 4. **Results of included human studies**

Author	Degree of proclination (+) or retroclination (−) of incisors	Total amount of recession or change in gingiva recession/crown length +: increase −: decrease	Extend/occurrence of recession is statistically related to…	Extend/occurrence of recession is not statistically related to…
Yared et al. (28)	+5.85 ± 3.92°	Total amount: 0–2.48 mm Median: 0 mm (pretreatment, median: 0 mm)	Free gingival margin <0.5 mm Height of keratinized tissue <2 mm Final inclination >95°	Amount of labial movement Plaque index Gingival bleeding index Probing pocket depth
Melsen and Allais (27)	Ø + 3.4 mm Range: 0.5–12 mm	Total amount: 0.34 ± 0.69 mm (pretreatment: 0.20 ± 0.68 mm)	Presence of baseline recession Pretreatment gingival biotype Pretreatment width of keratinized gingiva Pretreatment gingival inflammation	Amount of change in arch length Age Sex Skeletal or dental relationship Plaque
Allais and Melsen (22)	T: +3.4 ± 2.6 mm C: 0 mm	Total amount: Tooth 42: T: 0.3 ± 0.83 mm C: 0.2 ± 0.62 mm Tooth 41*: T: 0.4 ± 0.86 mm C: 0.3 ± 0.8 mm Tooth 31: T: 0.3 ± 0.81 mm C: 0.3 ± 0.83 mm Tooth 32*: T: 0.4 ± 0.86 mm C: 0.2 ± 0.71 mm	Proclination of lower incisors (compared with no treatment)	†
Djeu et al. (25)	T: +5.03 ± 6.37° C: −4.37 ± 6.21°	Change in gingival recession: Tooth 31: T: +0.04 ± 0.17 mm C: +0.02 ± 0.11 mm Tooth 41: T: +0.10 ± 0.32 mm C: +0.07 ± 0.28 mm	†	Amount of proclination Age Sex Race Treatment duration Extraction Treatment type Angle classification

Table 4. **Continued**

Author	Degree of proclination (+) or retroclination (−) of incisors	Total amount of recession or change in gingiva recession/crown length +: increase −: decrease	Extend/occurrence of recession is statistically related to…	Extend/occurrence of recession is not statistically related to…
Årtun and Grobety (23)	T: +9.98 ± 5.56° C: +1.67 ± 3.42°	Total amount: T: 0.27 ± 0.52 mm C: 0.17 ± 0.32 mm	Width of symphysis in C-group	Width of symphysis in T-group, Amount of proclination
Ruf et al. (24)	First part: Ø + 8.9° Range: 0.5–19.5° Second part: T: +16.4 ± 1.9° C: +2.7 ± 1.7°	Crown length changes: First part: Tooth 32: −0.1 ± 0.6 mm Tooth 31 + 41: +0.1 ± 0.5 mm Tooth 42: −0.1 ± 0.5 mm Second part: Tooth 32: T: +0.2 ± 1 mm C: −0.1 ± 0.6 mm Tooth 31: T: +0.1 ± 0.6 mm C: +0.1 ± 0.5 mm Tooth 41: T: +0.3 ± 0.6 mm C: +0.2 ± 0.4 mm Tooth 42: T: +0.1 ± 0.5 mm C: −0.1 ± 0.6 mm	†	Gender Amount of proclination
Ngan et al. (29)	Retroclination (extent not reported)	Change in gingival recession: T: Ø −1.03 mm‡ C: Ø −0.96 mm‡	Retroclination of lower incisors -> less recession	Preorthodontic gingival grafting
Årtun and Krogstad (26)	T: >10° C: <2°	Crown length changes: T: +0.76 ± 0.62 mm§ C: +0.31 ± 0.35 mm§ (after 3 years)	More proclination T-group (vs. less proclination C-group) Width of symphysis in T-group	†

Table 4. **Continued**

Author	Degree of proclination (+) or retroclination (−) of incisors	Total amount of recession or change in gingiva recession/crown length +: increase −: decrease	Extend/occurrence of recession is statistically related to…	Extend/occurrence of recession is not statistically related to…
Dorfman (19)	T: Ø + 1.4° Range: −13° to +14° C: Ø−1° Range: −11° to +7°	T: marked gingival recession, amount not reported	†	†
Sperry et al. (21)	T: Maxillary incisors: +4.9 ± 6.8° Mandibular incisors: −3.5 ± 5.2° C:†	T: Ø 1.9 teeth with labial gingival recession per patient¶ C: Ø 0.6 teeth with labial gingival recession per patient¶	Dental compensation in Kl.III patients (proclination upper incisors, retroclination lower incisors)	†
Pearson (20)	T: 71% had labial movement of apex C: 52% had labial movement of apex (extent not reported)	T: significantly greater recession, amount not reported*	Orthodontic treatment (versus no treatment)	Amount of root apex advancement or retraction Different types of incisal movements (tipping, torque, translation) Overbite

T, test group; C, control group.
*T-group had significantly greater recession than C-group [Allais and Melsen (22), Pearson (20)].
†Not reported.
‡Significantly less gingival recession in both groups after retroclination, but no difference between T-group and C-group Ngan et al. (29).
§Significantly more increase in clinical crown length in T-group than in C-group (Årtun and Krogstad, 26).
¶T-group had significantly more teeth with recessions than C-group (Sperry et al. (21).

The presence of baseline recession correlated significantly with development or increase in gingival recession (27).

Yared et al. (28) noted that recession was more frequent when the height of keratinized tissue was <2 mm, and 93% of the incisors that developed recession had thicknesses of the free gingival margin <0.5 mm at the follow-up examination. Thickness had greater relevance to recession than final inclination of the incisors.

Melsen and Allais (27) found a significant correlation between the pre-treatment width of keratinized gingiva and gingival biotype and the development or increase in the ginigval recession.

Discussion

A notable finding was that none of the selected studies were graded A (high value of evidence). All the animal studies and four human studies were graded as a low value of evidence (Grade C), seven human studies had a moderate value of evidence (Grade B). Summary of the scientific value of the included studies is limited.

The major weak point of the included human studies compared with the animal studies is related to the retrospective study design used. The examinations of clinical data like gingival height, gingival biotype, gingival recession or width of attached gingiva could only be carried out on intraoral slides or plaster casts. McComb (30) questioned the results of studies that measured clinical crown height on study casts to evaluate periodontal recession because of the reduced tooth height of the cast caused by attrition or fractures. Just four human trials included also clinical measurements of the gingival parameters but only at the follow-up examination (21, 23, 26, 28). It is quite difficult to draw conclusions based on these findings. A prospective study design with clinical examinations before, during and after treatment would give more precise information about the interaction of orthodontic tooth proclination and the development of gingival recession.

A further weakness of most included studies is the short time period between the end of active treatment and the evaluation of the outcomes. If the records are taken immediately after debanding, the periodontal measurements may be affected, by often observed gingival inflammation and swelling, because of difficulty in oral hygiene during treatment (31). On the other hand, if the observation period is too long, cumulative treatment-independent periodontal problems may arise, which in turn may also affect the results. Årtun and Krogstad (26) suggested an observation time of 3 years, because up to 3 years the clinical crown height increased significantly more in the patients with excessive proclination than in the patients with minimal change in incisors inclination after the first 3 years the difference between the groups were not more significant.

The selected studies had quite different study settings and they focused on different aspects of the relation between incisor inclination and recession. The treatment durations, the forces applied, the control groups, or the degree of movement varied highly. The different results reported from the 17 studies cannot be pooled or compared directly.

Most studies investigated the correlation between the change in incisor inclination and the development of gingival recession in a patient group or they compared two patient groups with more or less proclination during treatment regarding recession. Two animal studies found statistically significant more gingival recession in displaced incisors than in control teeth (14, 15). Five human studies found statistically significant differences in the extension of recessions or the number of teeth with recession after changing the inclination of the incisors or comparing the T-group with the C-group (20–22, 26, 29). It seems possible that orthodontic therapy involving movement of the incisors out of the osseous envelope of the alveolar process constitutes a risk that recession of the gingiva may result.

More proclination during treatment may be accepted for a low initial inclination than for a high initial inclination. Indeed, Yared et al. (28) showed that a final lower incisor inclination of more than 95° in relation to the mandibular plane was directly related to more frequent and more severe recession in the mandibular central incisors; the amount of proclination was not important but the final inclination. Future studies should consider both the amount of proclination during treatment and the final inclination.

Treatment duration, treatment type, the skeletal or dental relationship, age, sex or race did not have an

influence on the development of recessions during treatment. Presence of gingival inflammation and baseline recession (27), a thin gingival biotype (27, 28), a narrow width of keratinized gingiva (19, 27, 28) or a thin symphysis (26) were found to correlate significantly with the development or increase in gingival recession.

Conclusion

There are no high-quality animal or clinical studies on this topic. The major reason for the low level of evidence in the animal as well as in the human studies is the lack of diagnostic reliability tests. Animal studies tend to suggest more gingival recession in displaced incisors than in control teeth. Clinical studies showed that more proclined teeth compared with less proclined teeth or untreated teeth and movement of the incisors out of the osseous envelope of the alveolar process may be associated with a higher tendency for developing gingival recessions. Because of the low level of evidence of the included studies, the results should be considered with caution. In addition, the amount of recession found in studies with statistically significant differences between proclined and not proclined incisors is small and the clinical consequence questionable.

Further prospective, randomized clinical studies including clinical examination of hygiene and gingival condition before, during and after treatment are needed to clarify the effect of orthodontic changes in incisor inclination and the occurrence of gingival recession.

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