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Does labial movement of lower incisors influence the level of the gingival margin? A case–control study of adult orthodontic patients

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SUMMARY It has been suggested that proclination of the lower incisors results in gingival recession. Proclination is, however, a valuable alternative to extraction especially when considering facial aesthetics in adult patients.

The aim of this study was to evaluate the association between the extent of labial movement of the lower incisors and the prevalence and severity of gingival recession in orthodontically treated adult patients. A retrospective case–control study based on the analysis of study-casts and intra-oral slides of 300 adult patients was carried out. One hundred and fifty pairs matched by age and sex were selected using simple random sampling. Recordings of gingival recession were made using casts as well as intra-oral slides. Dental displacement was measured on casts comparing the measurements before and after treatment.

The intra-oral slide recordings of gingival recession were more reliable than the cast recordings. Although the difference in prevalence of individuals with gingival recession among cases and controls was statistically significant ($P < 0.001$), no significant difference in the mean recession value could be found between cases and controls ($P > 0.10$). The mean value of the extent of recession of the four lower incisors amounted to 0.36 mm for treated subjects and 0.22 mm for the controls. This mean difference of 0.14 mm between members of a pair was not clinically relevant. Faced with the alternative between extraction and labial movement of lower incisors the present study indicates that the latter is a valuable alternative leading to no clinically relevant deterioration of the periodontium.

Introduction

The position of lower incisors has received much attention in the orthodontic literature and represent a key-point in deciding the treatment objectives.

A large variation in the incisor inclination has been reported among individuals representing a Scandinavian population without any orthodontic experience (Björk, 1947) and among individuals sampled on the basis of facial attractiveness (Steiner, 1953; Tweed, 1954; Downs, 1956). As incisor inclination is closely related to both the sagittal and vertical jaw relationship it can only provide guidelines and not play a determining role in relation to the definition of the treatment goal (Björk, 1963; Hasund and Böe, 1980; Janson and Hasund, 1981; Lundström and Woodside, 1981).

Several authors, nevertheless, maintain that the position of the incisors is the key to the achievement of good facial aesthetics (Margolis, 1943; Wylie, 1955; Downs, 1956; Holdaway, 1956; Ricketts, 1960). According to these authors, labial dental movement or sagittal expansion is advisable only when the mandibular incisors are behind the ideal position. Where the incisors are proclined and space is needed, dental units have to be sacrificed to obtain treatment goals. An increased overjet in adult patients has therefore traditionally been corrected by retraction of the upper incisors often in combination with extraction of the upper premolars in cases where surgical advancement has not been considered a valid alternative. Unfortunately, correction of an overjet by incisor retraction does not always lead to improvement or even maintenance, of facial aesthetics especially in adult patients. Transverse expansion and/or proclination of the teeth are valid alternatives to extraction in cases of crowding, but both lack of stability and the development of bone dehiscences have been demonstrated as side-effects subsequent to anterior displacement of the lower incisors (Ten Hoeve and Mülie, 1976; Boyd, 1978; Geiger, 1980; Steiner *et al*., 1987; Little and Riedel, 1989). Mills (1966) claimed that only in particular situations is it possible to move the teeth out of the 'alveolar housing', and Wennström *et al*. (1987, 1993) stated that 'teeth can not be moved out of the dento-alveolar envelope'. Proffit and White (1991) described an 'envelope of discrepancies' for the maxillary and mandibular arches in three planes of space beyond which the above-mentioned morphological side-effects are likely to occur. None of these authors, however, gives any clear definition of the rather abstract concept that has been described as a limit.

The lack of difference in the long-term stability among extraction (Gardner and Chaconas, 1976; Little *et al*., 1981, 1988) and non-extraction cases (Walter, 1953; Mills, 1966; Glen *et al*., 1987; Little and Riedel, 1989) and the fact that clinical measurements undertaken in groups of adult surgical patients show no association between incisor inclination and long-term incisor irregularity has further weakened the argument against proclination (Årtun *et al*., 1990).

It seems as if 'the envelope' is only defined when side-effects resulting from orthodontic treatment have occurred. In these cases the teeth are said to have been moved 'out of the dento-alveolar envelope' (Proffit and Fields, 2000).

The aim of the present study was therefore to investigate the association between orthodontic labial movement of the lower incisors and the prevalence and severity of labial gingival recession, and to describe and compare the reliability of recordings of gingival recession using orthodontic dental casts and intra-oral slides, respectively. The null hypothesis was that labial movement of the lower incisors could be considered a risk for the development of gingival recessions.

Materials and methods

Subjects

The sample comprised 150 adult patients (114 female, 36 male) with Class I and Class II malocclusions treated with fixed orthodontic appliances and labial movement of the lower incisors. The mean age was 33 years, ranging from 22 to 65 years (Table 1). The control group included 150 patients waiting for orthodontic treatment. The target sample size was determined by a power analysis carried out on the basis of results from a pilot study of the pre-treatment casts of 390 adults with malocclusion seeking orthodontic treatment. The requirements were to be able to detect a difference in bone dehiscence of more than 0.5 mm at the 5 per cent confidence level. Both groups represented the same population. Pairs that matched with respect to sex and age, deviating by no more than 1 year when comparing the post-treatment record-age of the samples with the pre-treatment record-age of the controls, were selected using simple random sampling. The pairs were numbered consecutively from 1 to *N* (total number of pairs available), using a random number table; 150 (rounded up sample size) numbers were drawn which indicated the pairs to be included in the study.

Table 1 Age and sex distribution of the individual pairs included in the study.

Sex	*N* (%)	Mean age	SD	Range
Females	114 (76)	33.6	9.5	22–65
Males	36 (24)	33.9	7.4	23–50

All subjects had been examined clinically and periodontal status had been assessed. All patients had received hygiene instructions before orthodontic treatment and had been routinely checked throughout treatment.

The changes in mandibular arch length during treatment were measured on casts as the difference between the post-treatment distance from the mesial contact point of the first mandibular molars to the inter-incisal point of the lower central incisors, and the same measurements performed on the pre-treatment casts.

The periodontal status, including recording of gingival recessions, was made on intra-oral slides and dental casts. Registration of visual plaque, gingival inflammation, and biotype of the gingiva was undertaken exclusively on the slides.

All cast recordings were made using an electronic calliper [Mitutoyo Digimatic®, Mitutoyo (UK) Ltd, Telford, Shropshire, UK] with a scale, which included hundredths of millimetres (0.01 mm).

The intra-oral colour slides were taken with a Nikon medical camera with a ×0.39 lens and a 100 ASA Ektacrome film. Each intra-oral slide (frontal view) was projected on to a screen at a distance of 2 metres and read in a dark room. The measurements on the enlarged image were carried out to the nearest millimetre. The enlargement correction for the slide analysis was achieved by comparing the crown width of the upper left central incisor, recorded on the slide, with the same dimensions of the same tooth as recorded on the cast.

Gingival recession was measured at the mid-labial site of each of the four lower incisors as the distance between the gingival margin and the cemento–enamel junction (CEJ). When the CEJ was not visible a 0 mm recording was assigned.

The investigation was designed as a matched case–control study with respect to gender and age. The comparability with respect to morphological variables assessed on the lateral head films and study casts, and gingival health registered on intra-oral slides, was evaluated by comparing pre-treatment records of the test samples with the before-treatment records of the matched controls (Table 2a–c).

In order to obtain an unbiased evaluation, an examiner who was not an orthodontist and was not informed on the design of the study performed the recordings of gingival recession. Prior to the investigation the examiner was calibrated with an orthodontist and a periodontologist. Casts and slides were recorded separately and samples and controls were mixed in a random sequence unknown to the observer (Table 3).

Table 2a Morphological and gingival parameters characterizing the two groups.

Variables	Sample at baseline			Control		
	X	SD	Range	X	SD	Range
Skeletal and dental parameters						
Vertical jaw relationship NL/NIL (degrees)	22.0	7.7	7 – 45	23.0	8.1	5 – 45
Incisor to A–PG (mm)	0.6	3.2	–9 – +8	0.8	3.5	–9 – +12
Incisor inclination Il/ML (degrees)	94.0	8.4	77 – 122	94.0	8.5	78 – 122
Overjet (mm)	4.5	3.5	0 – 14	4.0	3.3	0 – 14
Overbite (mm)	4.0	2.5	–2 – +10	3.4	2.5	–2 – +9
Lack of space	–2.0	2.3	–8 – +5	–1.5	2.4	–8 – +9
Gingival parameters						
Width of keratinized gingiva (mm)						
42	4.0	1.2	1 – 7.0	4.0	1.2	2 – 7.5
41	3.0	1.1	0 – 7.0	3.5	1.1	1.5 – 6.0
31	3.0	1.1	0 – 6.0	3.0	1.1	1.5 – 6.0
32	4.0	1.3	0 – 8.5	4.0	1.1	2.0 – 7.0
Gingival recession						
42	0.2	0.8	0 – 6	0.2	0.6	0 – 5.0
41	0.2	0.7	0 – 4	0.3	0.8	0 – 4.0
31	0.2	0.8	0 – 5	0.3	0.8	0 – 5.0
32	0.3	0.8	0 – 5	0.2	0.7	0 – 4.0

Test of H_0: $P_{\text{Sample}} \neq P_{\text{Control}}$: $P > 0.05$.

Table 2b Description of the frequency of tooth rotation, gingival recession, and occlusal relationship among samples and controls.

Status at base line valid pairs 595 teeth, 150 patients	Sample baseline		Control	
	Number	Percentage	Number	Percentage
Rotation of single teeth	36	6	63	11
Distal canine relationship right	84	56	92	61
Distal canine relationship left	88	59	107	71

Chi-square test of H_0: $P_{\text{Sample}} \neq P_{\text{Control}}$: $P > 0.05$.

Error of the method

The reproducibility of the assessment of gingival recession on the intra-oral slides and dental study casts was estimated through double registration of the slides and casts from 52 randomly selected individuals among the orthodontically treated sample and the control individuals. The recordings of the casts and slides were kept separate. The mean value, standard deviation (SD), and range of the differences between the two sets of measurements are shown in Table 4. The mean difference between the second and first measurements was 0.01 mm for both slides and casts. Between 75 and 80 per cent of the measurements had no difference and only differences

Table 2c Morphological data and gingival status of the two groups of patients at baseline.

Tooth type	42 (N = 150)		41 (N = 150)		31 (N = 150)		32 (N = 145)	
	Sample	Control	Sample	Control	Sample	Control	Sample	Control
Tooth rotation								
Number of rotated teeth	4	11	10	20	12	18	10	14
Percentage	3	7	7	14	8	12	7	10
Gingival recession								
Number of teeth with recession	17	15	17	19	16	21	21	15
Percentage	12	11	12	13	11	14	15	10
Gingival bio-type								
Number of teeth with thin gingiva	39	55	56	66	56	69	37	50
Percentage	36	37	38	44	38	46	26	35
Visual gingival inflammation								
Number of teeth with inflamed gingiva	16	14	13	20	6	17	11	7
Percentage	11	8	8	13	11	11	8	5
Visual plaque								
Number of teeth with plaque	4	11	9	20	12	18	10	14
Percentage	3	7	6	13	8	12	7	10

Chi-square test of H_0: $P_{\text{Sample}} \neq P_{\text{Control}}$: $P > 0.05$.

Table 3 Results of slide and cast recordings of gingival recession according to individual analysis performed. Parameters characterizing the dentition of the two samples.

	Slides		Casts	
	Sample	Control	Sample	Control
Number of individuals recorded	150	150	150	150
Number of teeth recorded	579	586	507	544
Missing teeth (percentage)	11 (2)	9 (2)	11 (2)	9 (2)
Unreadable teeth* (percentage)	10 (2)	5 (1)	82 (14)	47 (8)

*Chi-square test of H_0: $P_{\text{Sample}} \neq P_{\text{Control}}$: $P < 0.05$.

Table 4 Error of the method determined by double measurements of the slides and casts, respectively.

	Slides	Casts
Number of valid measurements	206	182
Missing value	2	26
Mean difference (mm)	0.01	0.01
Standard deviation (mm)	0.16	0.18
Range (mm)	–0.9 – +0.75	–1.6 – +0.6

Test of H_0: $P_{\text{Sample}} \neq P_{\text{Control}}$: $P > 0.05$.

between 0 and 1 mm were registered both on the slide and cast recordings (Figure 1).

Statistical analysis

Statistical analysis of data was performed using the SPSS (Statistical Package for Social Sciences, SPSS Inc., Chicago, Ill, USA).

The recordings were analysed twice using teeth as well as individuals as units. When individuals were considered the mean values of gingival recession for the four mandibular incisors were the outcome variables of interest. The data analysis was performed in two steps:

1. Description of the pre-treatment characteristics of the samples and controls. Demographic, skeletal, dento-alveolar, occlusal, and soft tissue characteristics were analysed (Table 2a–c).
2. Analysis of gingival recession among samples (post-treatment) and controls, on slides and casts (individual and tooth-based analysis) (Tables 5–7).

For the different variables the arithmetic mean, standard deviation, and maximum and minimum value were calculated. The z-test for comparing proportions and the t-test for comparing mean values were used.

Results

The two groups were matched with respect to age and sex but comparison of the independent variables obtained from head films, casts, and slides confirmed the validity of the design of the study as the two groups did not differ significantly with respect to any of the variables (Table 2a–c).

Analysis of the dependent variable and gingival recessions among the orthodontically treated and untreated matched controls was carried out on slides and casts. A total of 579 lower incisors from the 150 orthodontically treated individuals were considered on slides and 507 on casts. The corresponding figures for the 150 non-treated control individuals were 586 and 544 teeth, respectively. Eleven teeth were missing from the treated and nine from the non-treated individuals. On the slides 10 and 5 teeth were considered unreadable, whereas 82 (14 per cent) and 47 (8 per cent) teeth, respectively, were unreadable on the casts (Table 3).

As the number of unreadable teeth was larger when performed on casts than when assessed on slides, and as the variation in the error of the method was smaller for the slide than the cast analysis (Table 4), comparison of gingival recession was based on slide analysis.

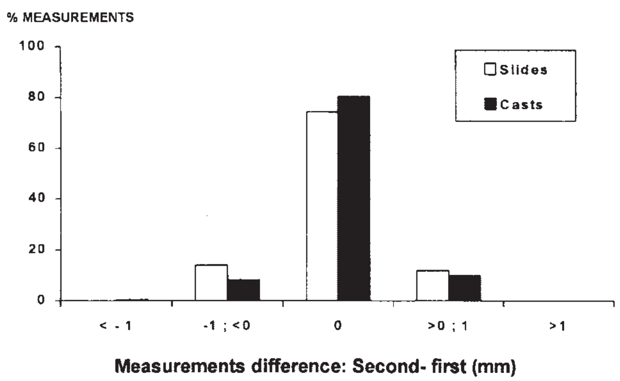

Figure 1 Distribution of differences between first and second measurements performed on slides.

Table 5 Description of the prevalence of individuals having gingival recession in at least one lower incisor. Subjects who had undergone treatment were compared with those awaiting treatment.

	Slide	
	Sample	Control
Individuals without recession	98	124
Individuals with recession	52	26
Percentage	35*	17

*Chi-square test of H_0: $P_{\text{Sample}} \neq P_{\text{Control}}$: $P < 0.05$.

Table 6 Results of slide recordings of the mean value of gingival recession according to tooth type for samples and controls.

	Tooth type							
	42		41*		31		32*	
	Sample	Control	Sample	Control	Sample	Control	Sample	Control
Number of teeth recorded	148	149	149	149	147	147	135	141
Mean recession value (mm)	0.3	0.2	0.4	0.3	0.3	0.3	0.4	0.2
Standard deviation	(0.83)	(0.62)	(0.86)	(0.80)	(0.81)	(0.83)	(0.86)	(0.71)
Range	[0–5.45]	[0–4.94]	[0–3.95]	[0–4.13]	[0–4.26]	[0–4.48]	[0–4.26]	[0–3.86]

*Test of H_0: $d = 0$. $P < 0.05$.

Table 7 Description of the prevalence of gingival recession according to tooth type in the treatment and control groups.

	Tooth type							
	42		41*		31		32*	
	Sample	Control	Sample	Control	Sample	Control	Sample	Control
Teeth without recession	122	134	117	130	118	126	102	126
Teeth with recession	26	15	32	19	29	21	33	15
Percentage	(18)	(10)	(22)	(13)	(20)	(14)	(24)	(10)

*Chi-square test of H_0: $P_{Sample} \neq P_{Control}$: $P < 0.05$.

At baseline the number of teeth exhibiting gingival recession was slightly, although not significantly, higher among the treated than the control group. When measured in 0.1 mm the two groups, however, did not differ.

The proclination of the incisors increased the arch length by an average of 3.4 mm (SD 2.6 mm). This tooth movement had an impact on the gingival level. Among the orthodontically treated individuals 52 (35 per cent) had at least one lower incisor with gingival recession ≥0.1 mm, in contrast to 26 (17 per cent) of the controls (Table 5). This difference was significant. More detailed information on the distribution of the differences between the two members of a pair of their individual mean recession values is shown graphically in Figure 2. Seventy per cent of the pairs did not show any difference among orthodontically treated and non-treated individuals. Less than 10 per cent of the pairs exhibited a difference of more than 2 mm.

The mean paired difference in gingival recession between treated and non-treated individuals for each of the four lower incisors can be seen in Tables 6 and 7. In the case of tooth 32 the number of valid pairs was reduced as missing incisors were conventionally recorded as the left lower lateral incisor (tooth 32). The prevalence of recessions on single teeth was significantly

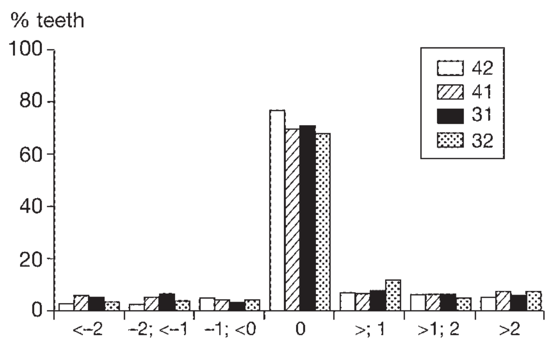

Figure 2 Distribution of difference in gingival recession between the orthodontically treated and control sample.

increased for teeth 32 and 41. This was corroborated by the fact that the mean paired recession difference was positive for all teeth (Table 8). The mean difference in recession values for the four incisors in the treated and control individuals varied between 0.04 and 0.17 mm (Table 8). Based on slide assessments the mean value of the extent of the recession for the four lower incisors amounted to 0.36 mm for orthodontically treated individuals and 0.22 mm for the controls. The difference of 0.14 mm was not statistically significant.

Table 8 Analysis of the paired difference, *d*, between subjects after orthodontic treatment and controls.

	Tooth number				
	42	41*	31	32*	Total
Mean difference (mm)	0.15	0.11	0.04	0.17	0.14
Standard deviation	0.92	1.10	1.00	1.08	0.90

*Test of $H_0: d = 0$. $P > 0.10$.

The difference in recession among treated and non-treated individuals was related to tooth type (Table 7, Figure 2). Based on slide registration the occurrence of recession varied from 18 to 24 per cent for treated subjects and from 10 to 14 per cent for the controls. This indicated that the occurrence of recession was statistically significantly higher for treated than for non-treated individuals for teeth 41 and teeth 32, but not for 42 and 31. All differences however were within the error of the method.

Discussion

A case–control investigation was performed in order to evaluate the risk of developing gingival recession as a result of a labial movement of the lower incisors. The relevance of the study is high as labial movement of incisors is the only valid alternative to extraction in the upper or surgical advancement of the lower arch for correction of an increased overjet.

Although warnings against labial movement of lower incisors have referred to both lack of stability (Walter, 1953; Mills, 1966; Glen *et al*., 1987; Little and Riedel, 1988) and dehiscence (Vanarsdall and Corn, 1977; Coatoam *et al*., 1981; Foushee *et al*., 1985; Shiloah *et al*., 1987; Ngan *et al*., 1991) the literature has, however, only rarely been evidence-based (Shields *et al*., 1985; Årtun *et al*., 1990).

The present investigation was designed as a case–control study with respect to sex and age but the comparison of the variables reflecting facial morphology, occlusion, gingival quality, and status revealed the two groups studied were also compatible with respect to these variables. The number of individuals investigated was determined on the basis of a pilot study in which the prevalence, mean value, and variation of gingival recession in an adult population was determined. If the wish was to establish a difference of 0.5 mm with a type one error of 0.5 per cent, the study had to comprise 142 individuals in each group. A sample size of 150 was therefore chosen.

Incisor proclination was assessed through the increase in arch length. The reason for not measuring the change in inclination of the incisors on the head films was that the question addressed concerned an increase in arch length and several of the patients exhibited a marked degree of crowding at the start of treatment, making measurement of the change in inclination imprecise.

The recession could be studied on both intra-oral slides standardized for differences in magnification and on study casts. Since both the number of unreadable teeth, due to poor impressions, and the variation in the error of the method due to bad quality of the casts, was larger for study casts the assessment of the intra-oral slides was considered preferable. A possible bias of the slide measurements due to differences in orientation of the photographs caused by inclination could be excluded as no significant difference has been established between the cast and the slide measurements (Allais, 2000).

The present study did not relate to treatment stability as the result in most adult patients would be maintained with a premolar to premolar or a canine to canine retainer whether or not the treatment included proclination of the incisors. The question raised was to what extent the periodontium would suffer from proclination in borderline cases where proclination was considered an alternative to extraction either in the upper or in both arches. The patients studied represented a population where sagittal expansion was used for reduction of the overjet as an alternative to retraction of maxillary teeth. An example of a treated subject is shown in Figure 3.

The proclination undertaken was expressed as an increase in arch length and this parameter could in theory also express a distal displacement of the molars. According to the three-dimensional treatment objective made by a combination of the tracing of the head film and the occlusogram, the treatments were planned and performed as labial displacement by means of controlled tipping with the centre of rotation of the total displacement localized below the apex. Forces ranging from 15 to 25 g per tooth were applied and the loss of anchorage, i.e. displacement of the molars, could not be verified. Teeth can be moved with or through bone depending on the strain generated in the surrounding periodontium (Baron, 1975; Melsen, 2001). The force system applied attempted to generate a maximum distribution of low forces, thus avoiding local necrosis and ischaemia of the periodontal ligament. It is likely that this regimen differed from that applied in the cases referred to as generating recessions (Steiner *et al*., 1981). In addition it can be assumed that the patients' oral hygiene was maintained during treatment. Nevertheless, a certain swelling of the gingiva immediately after removal and cleansing can be anticipated. The intra-oral slides and the cast were, therefore, taken approximately one month after removal of the appliance (Figure 3).

It is well known that gingival recession is an age-related problem (Baelum *et al*., 1997). The influence

Figure 3 Example of a patient treated for a large overjet with incisor proclination. (a–d) Frontal view of the patient, relaxed and when smiling before and after treatment. (e–h) Profile before and after treatment at rest and smiling. (i and j) Intra-oral frontal view of the occlusion before and after treatment. (k and l) Gingival status before and after treatment. Note the improvement of 41. (m–t) Intra-oral illustration of the patient before and after treatment.

of age was, however, eliminated through the design of the present investigation as a case–control study. The influence of ethnicity was likewise taken into consideration since all the patients were white Caucasians. The target population further represented the typical malocclusion prevalent in northern European countries; namely, Class I and II malocclusions. Surgical cases and subjects with a Class III malocclusion were excluded.

Figure 3 Continued.

The effect of incisor proclination in the latter type of patient has been studied longitudinally by Årtun and Krogstad (1987), who found that proclination generated modest recessions, but these had no influence on gingival measurement either in the short- or long-term.

The present study demonstrated a significant increase in the prevalence of individuals exhibiting dehiscence. When measured quantitatively the clinical significance could, however, not be confirmed. The difference was on an average 0.14 mm, which was not considered clinically relevant since it was below the standard deviation of the error of the method.

Conclusions

Controlled proclination under maintenance of good oral hygiene can be carried out in most patients without risk to the periodontium. It should, however, be underlined that new recessions developed in 10 per cent of the investigated teeth but improved in 5 per cent. In 85 per cent there was no change. The task remains to analyse whether contributing risk factors can be identified.

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