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Original Article

Some factors associated with open gingival embrasures following orthodontic treatment

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Open gingival embrasures or "black triangles" can be an undesirable outcome of adult orthodontic treatment. The aims of the present study were to determine the prevalence of open gingival embrasures in a group of orthodontic patients, and to determine if open gingival embrasures were related to: age at the start of treatment, the severity of pretreatment crowding of the mandibular incisors, the duration of treatment or changes in alveolar bone height. The subjects were 80 orthodontic patients (33 males, 47 females) between 15 and 31 years of age. Open gingival embrasures were found in 43.7 per cent of all subjects, while in subjects over 20 years of age the prevalence was 66.7 per cent. In relation to the amount of crowding 42.8 per cent of the subjects with less than 4 mm crowding had open gingival embrasures, 41.2 per cent of those with between 4 and 8 mm crowding had open gingival embrasures, and 50 per cent of those with more than 8 mm crowding had open gingival embrasures. The groups were not significantly different. Approximately 42 per cent of the subjects in the shorter treatment group had open gingival embrasures, and 44.4 per cent of those whose treatment took longer than 3 years had open gingival embrasures. This difference was not statistically significant. Cephalometric measurements of mandibular alveolar bone height indicate that open gingival embrasures were more likely to be due to resorption of the alveolar crest rather than extrusion of the mandibular incisors. In conclusion, open gingival embrasures were more frequently found in patients over 20 years of age than in younger patients, and were associated with resorption of the alveolar crest.

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Introduction

In some orthodontic clinics up to 40 per cent of the patients under treatment are adults, and some of these patients may have underlying periodontal conditions that can worsen with orthodontic treatment.[1,2] Gingival spaces or open gingival embrasures are one of the aesthetic concerns of orthodontic treatment that can develop when crowded maxillary and mandibular incisors are aligned. These spaces, which appear as unsightly dark triangles below the contact points, are a relatively common occurrence in adults following orthodontic treatment. For example, Burke *et al.*[1] reported that approximately 42 per cent of their patients had a black triangular gingival space between the maxillary central incisors following orthodontic treatment. In addition to being unsightly these spaces may contribute to the retention of food debris and adversely affect the health of the periodontal tissues.

Various theories have been advanced to account for open gingival embrasures following orthodontic treatment. One proposal implicates shortening of the interdental papillae due to stretching of the interdental gingival fibres as crowded incisors are aligned.[1] However, this hypothesis fails to take into account possible contributions made by crown form, severity of pretreatment crowding, alveolar bone loss, gingival fibres other than the interdental fibres, and aging of the gingival tissues. Some support for a multifactorial explanation of open gingival embrasures can be found in reports that loss of gingival attachment increases with age[3], and that the progression of periodontal disease is associated with the severity of crowding.[4]



Figures 1a and b. Pretreatment and post-treatment views of the same patient showing dark triangles between the mandibular incisors.

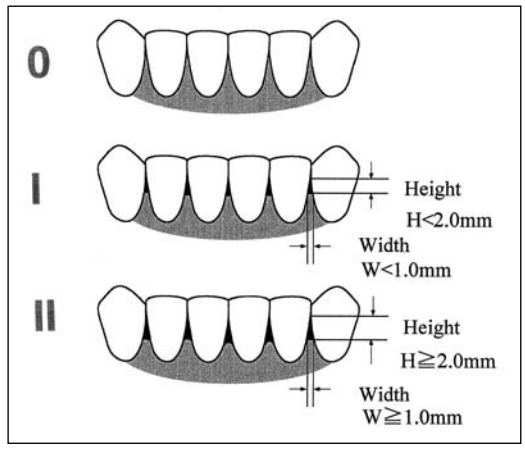


Figure 2. Classification of embrasures (After Burke S, Burch JG, Tetz JA[1]). Degree O: papilla filling; Degree I: pinpoint; Degree II: black triangle.

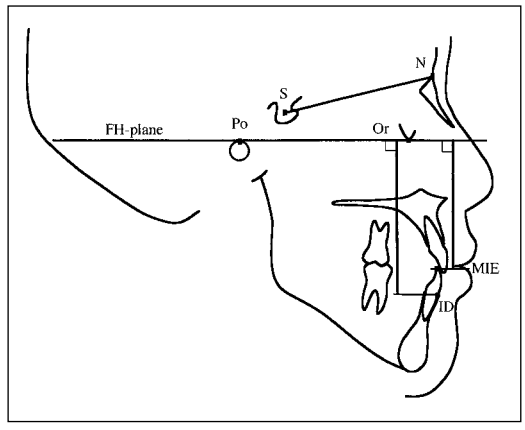


Figure 3. Cephalometric measurements: FH-MIE, FH-ID.

The aims of this study were, firstly, to determine the prevalence of open gingival embrasures in a group of orthodontic patients and, secondly, to determine if open gingival embrasures are related to pretreatment age, the severity of mandibular incisor crowding, duration of treatment, and/or changes in alveolar bone height.

Materials and methods

The subjects in this investigation were 80 patients (33 males, 47 females) with Class I malocclusion who attended the Department of Orthodontics, Nihon University School of Dentistry at Matsudo. All subjects were treated with multi-bracket appliances following extraction of the first premolars. The duration of treatment was recorded in months. At the start of treatment 38 patients (19 female, 19 male) were between 15 and 20 years of age and 42 patients (28 female, 14 male) were over 20 years of age.

Using study casts and intra-oral photographs taken at the start and end of treatment the heights and widths of the five gingival embrasures, from the mesial surface of one mandibular canine to the mesial surface of the contralateral canine, were measured with dial calipers (Max-Cal, Japan) to the nearest 0.01 mm. The height of a gingival embrasure (H) was the distance from the midpoint of the line joining the contact point(s) to the uppermost margin of the interdental papilla. The width of a gingival embrasure (W) was the interproximal distance at the level of the uppermost margin of the interdental papilla. The gingival embrasures were then graded into Degree 0 ("papilla filling"), Degree I ("pinpoint", width < 1.0 mm, height < 2.0 mm), and Degree II ("black triangle", width ≥1.0 mm, height ≥2.0 mm) (Figures 1 and 2).[1]

The crowding present between the mandibular canines at the start of treatment was measured with a dial caliper and assessed as "slight" (less than 4 mm of crowding),

Table I. Classification of embrasures, classified after Burke S, Burch JG, Tetz JA.[1]

Degree	N	Per cent
O	14	17.5
I	31	38.7
II	35	43.7
Total	80	100

Chi -square, I versus O, $p < 0.01$; II versus O, $p < 0.01$

Table II. Comparison of gingival embrasures, by age group.

Age (years)	O N	I N	II N	Total
15-20	7 (18.4)	24 (63.1)	7 (18.4)	38 (100)
>20	7 (16.7)	7 (16.7)	28 (66.7)	42 (100)
Total	14	31	35	80

Percentages in parentheses
Chi-square, Degree II, 15–20 year-olds versus >20 year-olds, $p < 0.001$

"moderate" (between 4 and 8 mm of crowding) and "severe" (more than 8 mm crowding).

To determine changes in the heights of the incisors and their bony support the pre- and post-treatment cephalometric radiographs were traced, and the following perpendicular distances measured with a dial caliper: Frankfort plane to the incisal edge of the most prominent mandibular incisor (FH-MIE), Frankfort plane to the mandibular alveolar crest (FH-ID) (Figure 3).

The Chi-square test was used to test for differences in the distributions of open gingival embrasures in the age groups, in the groups with varying amounts of crowding, and the duration of treatment. The pretreatment and post-treatment bone heights were compared with the *t*-test for paired data. The statistical package used was Statistica (Statistica, version 5.5, StatSoft, Japan). The cephalometric measurements were repeated and tested for significant differences with the paired *t*-test. There were no significant differences between the duplicate measurements taken on different occasions.

Results

The results are given in Tables I to V. At the end of treatment 17.5 per cent of the subjects had Degree 0 embrasures, 38.7 per cent had Degree I embrasures, and 43.7 per cent had Degree II embrasures (Table I). There were significantly more subjects with Degree I and Degree II embrasures than Degree 0 embrasures ($p < 0.01$).

Significantly more patients had open gingival embrasures (66.7 per cent) in the group over 20 years of age than in the 15 to 20 year-old group (18.4 per cent) (Table II).

When the subjects were grouped according to the severity of crowding 42.8 per cent of those with less than 4 mm crowding had open gingival embrasures, 41.2 per cent of the subjects with 4-8 mm crowding had open gingival embrasures, and 50 per cent of those with more than 8 mm crowding had open gingival embrasures (Table III). These differences were not statistically significant. The majority of the subjects with open gingival embrasures were in the group with less than 4 mm crowding (60 per cent).

Table III. Comparison of gingival embrasures, by severity of crowding.

Group	Crowding (mm)	O N	I N	II N	Total
Slight	<4	4 (8.2)	24 (49.0)	21 (42.8)	49 (100)
Moderate	4 to 8	3 (17.6)	7 (41.2)	7 (41.2)	17 (100)
Severe	>8	7 (50.0)	0 (0)	7 (50.0)	14 (100)
Total		14	31	35	80

Percentages in parentheses
Chi-square, Degree II, no significant difference

Table IV. Comparison of gingival embrasures, by duration of treatment.

Group	Duration (years)	O N	I N	II N	Total
A	<3	4 (15.4)	11 (42.3)	11 (42.3)	26 (100)
B	>3	10 18.5)	20 (37.0)	24 (44.4)	54 (100)
Total		14	31	35	80

Percentages in parentheses
Chi-square, Degree II, no significant difference

Table V. Comparison of lower incisor and alveolar bone heights pre- and post-treatment.

		Pretreatment (mm)		Post-treatment (mm)				
Variable	N	Mean	SD	Mean	SD	Mean diff	SD diff	*p*
FH-MIE	80	54.9	4.65	56.4	4.97	-1.47	0.23	ns
FH-ID	80	65.3	5.72	68.7	5.5	-3.43	0.15	0.001

Paired *t*-test; ns, not significant

The percentages of subjects with open gingival embrasures were not related to treatment duration: 42.3 per cent of the patients with the shorter treatment time (less than 3 years) had open gingival embrasures, and 44.4 per cent of the patients with the longer treatment time (3 years or more) had open gingival embrasures (Table IV). The difference was not statistically significant.

There was no statistically significant difference between the pre- and post-treatment measurements of FH-MIE. In contrast, FH-ID distance increased significantly ($p < 0.001$) during treatment (Table V).

Discussion

The prevalence of open gingival embrasures in the present study is comparable to that reported by Burke *et al.*[1] They suggested that open gingival embrasures could be closed by torquing the central incisor roots mesially as the proximal contacts were maintained.[1] Removing enamel from the proximal contacts before approximating the roots will enable an open gingival embrasure to be reduced further. Although these procedures may be used to close small spaces they may not be effective in closing a larger space, particularly when alveolar bone has been lost (Figure 1).

In the present study open gingival embrasures were more prevalent in patients over 20 years of age: 66.7 per cent of the patients in the older group had open embrasures whereas 18.4 per cent of the patients between 15 and 20 years of age had open embrasures.

Periodontal disease occurs in all age groups, but is more prevalent in older age groups. For example, Eger *et al*.[5] reported that about 11 per cent of a sample of 201 male recruits, aged 18 to 25 years, had moderately advanced periodontitis. Anerud *et al*.[3] investigated attachment loss in young adults from 19 to 30 years of age and reported that the prevalence increased markedly around the maxillary first molar, maxillary and mandibular first premolars and, particularly, in the mandibular incisor region with increasing age. Hugoson *et al*.[6] reported significantly deeper periodontal pockets occurred around the upper and lower incisors in 20 year-old patients than in 15 year-old patients. If periodontal disease is found to act as a "trigger" early orthodontic treatment may prevent open gingival embrasures from developing. It has been reported also that the interdental papilla is frequently lost in patients with periodontal disease, particularly where there has been destruction of the alveolar bone.[5] Loss of the interdental papillae is a conspicuous finding in patients with open gingival embrasures.

In the present study severe incisor crowding did not appear to contribute to open gingival embrasures (Table III). A recent study by Kawauchi and Mitani[8] supports this view. They reported that prior to orthodontic treatment the prevalence of open gingival embrasures was 31 per cent in patients with well-aligned arches and 48 per cent in patients with crowding, and concluded that open gingival embrasures were not always associated with crowding.

Further studies will be needed to determine if a relationship exists between anterior crowding, periodontal health and open gingival embrasures. Although plaque and gingival indices may be significantly higher in individuals with more than 4 mm mandibular crowding,[9] and anterior crowding may progress to periodontal disease,[4] other factors appear to play a part in the appearance of open gingival embrasures.

Orthodontic treatment may be one of these factors. Although the duration of treatment had no effect on the prevalence of open gingival embrasures there was significantly less alveolar bone around the lower incisors at the end of treatment (Table V). Orthodontic treatment can accelerate loss of alveolar bone in dogs[10] and adolescents.[11,12] In the latter, the distance between the cemento-enamel junction and alveolar crest was greater in those who had received orthodontic treatment, as compared to untreated controls.[11] The prevalence of open gingival embrasures has also been reported to increase as the distance from the alveolar crest to the contact points increases. When this distance was 6 mm the prevalence of open gingival embrasures was 44 per cent, and it was 73 per cent when the bone-tooth distance was 7 mm.[13] Thus, open gingival embrasures may be due, in part, to alveolar bone loss during orthodontic treatment. It could be postulated that the sequence leading to open gingival embrasures is: appliance-induced periodontal inflammation leading to alveolar bone resorption, and finally gingival recession involving the interdental papillae.

The form of the teeth, particularly the crowns, may also play a part in open gingival embrasures. It has been reported that patients with open gingival embrasures have more divergent roots, and more divergent or triangular-shaped crowns, than individuals with normal gingival embrasures.[13]

Conclusion

The aims of the present study were to determine the prevalence of open gingival embrasures in a group of orthodontic patients, and to determine if open gingival embrasures were related to: age at the start of treatment, the severity of pretreatment crowding of the mandibular incisors, the duration of treatment, or changes in alveolar bone height.

The subjects were 80 orthodontic patients (33 males, 47 females) between 15 and 31 years of age.

Open gingival embrasures were found in approximately 43.7 per cent of the subjects, and the majority of the subjects with open gingival embrasures (66.7 per cent) were more than 20 years of age.

In the group with open gingival embrasures there were no statistically significant differences between the subjects with slight, moderate and severe mandibular incisor crowding.

Similar percentages of subjects with open gingival embrasures were found in both treatment duration groups.

The cephalometric measurements indicate that open gingival embrasures were associated with resorption of the alveolar crest rather than extrusion of the mandibular incisors.

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