

Incidence of open gingival embrasures after mandibular incisor extractions: A clinical photographic evaluation

Flavio Uribe,^a Brett Holliday,^b and Ravindra Nanda^c
Farmington, Conn

Introduction: The purposes of this study were to determine the incidence of open gingival embrasures after a single mandibular incisor extraction and to investigate whether age, sex, interproximal pretreatment and post-treatment contact location, or the type of mandibular incisor were predictors of the incidence and magnitude of open gingival embrasures. **Methods:** Pretreatment and posttreatment intraoral frontal photos of 51 adults who had 1 mandibular incisor extracted were evaluated to determine the incidence and magnitude of open gingival embrasures. **Results:** The incidence of open gingival embrasures was 68%; the embrasures were moderately noticeable to very noticeable in 52% of those patients. Age, sex, incisor type, and location of interproximal contact before treatment were not predictors of open gingival embrasures after mandibular incisor extractions. An interproximal contact in the incisal third at the end of treatment was associated with the formation of an open gingival embrasure. **Conclusions:** Open gingival embrasures are a common finding after the extraction of a mandibular incisor, and the magnitude of this embrasure is clinically noticeable. (*Am J Orthod Dentofacial Orthop* 2011;139:49-54)

Mandibular incisor extraction therapy has been used as a treatment option since the early 1900s to relieve tooth size-arch length discrepancies in the anterior segment of the mandible. The advantages of this therapy include potential reduction in treatment time,¹ possibility of achieving better long-term stability in the mandibular anterior segment since intercanine width is not increased,^{2,3} and maintenance of the soft-tissue profile because retraction of the mandibular incisors is less compared with mandibular premolar extractions.⁴⁻⁶

These advantages are counterbalanced, however, by some potential disadvantages. The most significant of these is the possibility of the space reopening in the long term,^{2,7,8} an occlusal result less than ideal because of a significant tooth-mass reduction in the

anterior mandibular region.¹ Another potential sequelae of this therapy is the development of an open gingival embrasure.^{7,9}

Open gingival embrasures after orthodontic treatment have been reported in up to 40% of adolescent patients with crowded maxillary central incisors.¹⁰ Some causes attributed to open embrasures are periodontal bone loss, high interproximal contact, triangular shape of the incisors, and divergent root angulations.¹¹ The interproximal papillae might be sacrificed with the extraction of a mandibular incisor, and an open embrasure can result; yet only anecdotal evidence has pointed to this outcome.

The objective of this study was to quantify the incidence and magnitude of an open gingival embrasure after mandibular incisor extraction. In addition, predictors of this unesthetic outcome were explored.

MATERIAL AND METHODS

The study sample comprised 51 patients (22 male, 29 female) in the permanent dentition with a treatment plan involving 1 mandibular incisor extraction. The mean age at the start of treatment was 26.8 years (range, 15-62 years). The majority had Class I crowding (41 patients), followed by Class II (6 patients) and Class III (4 patients) malocclusions. Edgewise appliances were used in treating all the patients, and all had 1

From the Department of Craniofacial Sciences, School of Dental Medicine, University of Connecticut, Farmington.

^aAssociate professor and program director, Division of Orthodontics.

^bPrivate Practice, Santa Fe, New Mexico.

^cProfessor and head; Alumni Endowed Chair.

The authors report no commercial, proprietary, or financial interest in the products or companies described in this article.

Reprint requests to: Flavio Uribe, Division of Orthodontics, University of Connecticut Health Center, 263 Farmington Ave, Farmington CT 06030; e-mail, FUribe@uchc.edu.

Submitted, November 2008; revised and accepted, March 2009.

0889-5406/\$36.00

Copyright © 2011 by the American Association of Orthodontists.

doi:10.1016/j.ajodo.2009.03.049

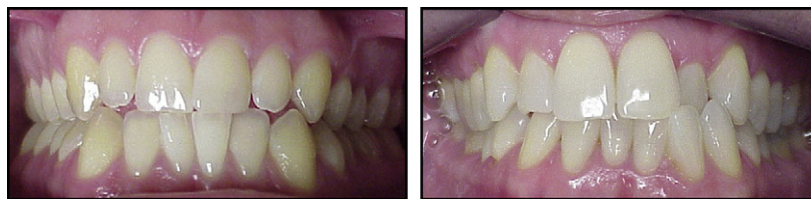


Fig 1. Pretreatment photographs. These photos correspond to the posttreatment photographs in Figure 2, C and D.

mandibular incisor extracted. The exclusion criteria were (1) evidence of periodontal bone loss or existing open gingival embrasures determined by the clinical and radiographic examinations; (2) mandibular incisors lost to trauma, caries, or periodontal disease; and (3) congenitally missing incisors.

Before and after intraoral frontal photographs were collected from the orthodontic graduate clinic and private offices of alumni and orthodontists in Connecticut (Fig 1). Posttreatment records were taken on average 2 months after appliance removal. Records were obtained as 35-mm slides and digital images. The slides were scanned (Expression 1640XL, Seiko Epson, Nagano, Japan) at a resolution 600 dpi and converted into digital images. Two evaluators (B.H. and M.L.) individually viewed and rated each variable in the before and after photographs 3 times, with a 2-week interval between evaluations. There was no limit on the viewing time period; each photograph was projected on a screen (height, 5 ft; width, 6 ft) from a computer projector (Pro Xtrax, Sanyo, Osaka, Japan) for as long as necessary to make a clear determination. All the above criteria were assessed by each evaluator individually, and the scores were established independently; the evaluators did not confer. The protocol was approved by the Institutional Review Board of the University of Connecticut.

Each pretreatment and posttreatment photograph was evaluated for (1) the initial interproximal contact location (upper, middle, or gingival third), (2) the presence or absence an open gingival embrasure after treatment, and (3) the severity of interdental gingival papillary loss by using an ordinal classification system developed by Nordland and Tarnow.¹² Accordingly, if present, the degree of the open gingival embrasure visible was classified as follows.

Normal: interdental papilla fills the embrasure space to the apical extent of the interdental contact point/area.

Class I: the tip of the interdental papilla lies between the interdental contact point and the most coronal extent of the interproximal cemento-enamel junction (CEJ) (space present but interproximal CEJ not visible).

Class II: the tip of the interdental papilla lies at or apical to the interproximal CEJ but coronal to the apical extent of the facial CEJ, and the interproximal CEJ is visible.

Class III: the tip of the interdental papilla is level or apical to the facial CEJ.

Additionally, the severity of each open gingival embrasure was measured on a 4-point scale (1, not noticeable; 2, barely noticeable; 3, moderately noticeable; and 4, very noticeable) (Fig 2). Photographs of patients where the contact and papillary height could not be visualized were excluded.

Statistical analysis

Intrarater and interrater reliability was analyzed by using Pearson and intraclass correlation coefficients. Descriptive statistics of the frequencies for the categorical variables were calculated. A point-biserial correlation coefficient was used to evaluate the relationship between age and presence and magnitude of an open gingival embrasure. A chi-square analysis was used to evaluate the relationship of the presence and magnitude of an open gingival embrasure, with sex, contact location before and after treatment, and the incisor extracted as the variables. The level of significance was set at $P < 0.05$.

RESULTS

More than 100 patients were screened, with 51 patients (22 male, 29 female) satisfying the inclusion and exclusion criteria. The measurements were made by 2 raters on 3 occasions. As a result, intrarater and interrater reliability analyses were conducted. Interrater reliabilities ranged from 0.9 to 0.98 for rater 1 and from 0.81 to 0.97 for rater 2 for the different measurements and time points. Interrater reliability was evaluated by using an average across the 3 measurement occasions and was calculated for each rater for each item measured. The correlations between the 2 raters ranged from 0.54 to 0.98. The raters strongly agreed on all but 2 items; contact before and contact after treatment had acceptable, although lower, reliability.



Fig 2. Classification of open gingival embrasure severity: **A**, no open gingival embrasure; **B**, barely noticeable; **C**, moderately noticeable; **D**, very noticeable.

Descriptive statistics for the sample on the categorical measurements obtained in the study are shown in Table I. Frequencies are based on measurements obtained by the first evaluator on the first measurement occasion.

The variables for the magnitude and level of open gingival embrasure were significantly correlated ($r = 0.76$, $P < 0.001$), indicating good correlation between the index of Nordland and Tarnow¹² and a clinical appraisal index of the open gingival embrasure.

A point-biserial correlation failed to find a significant correlation between age and presence or absence of an open gingival embrasure ($r = 0.034$, $P = 0.81$). A chi-square analysis was conducted to examine whether there was a relationship between which incisor was extracted (lateral vs central) and presence or absence of an open gingival embrasure (Table II).

The data suggested that more patients who had the central incisor extracted were likely to have an open gingival embrasure than those whose lateral incisor was extracted (41% vs 27%). However, the analysis yielded a nonsignificant result, showing no association between these 2 variables ($\chi^2(1) = 2.23$, $P = 0.13$).

A chi-square analysis was also conducted to examine the association between contact before treatment (incisal third, middle third, gingival third) and presence of an open gingival embrasure. The analysis excluded patients whose contact before treatment could not be determined to reduce error in the analysis. Nine patients were excluded in this analysis.

Table III shows that most patients (93%) had contact at the middle third at the beginning of treatment. Of those, 71.4% ended with an open gingival embrasure.

Table I. Descriptive statistics for the categorical variables

Clinical variable	Percentage
Tooth extracted	
Central incisor	52.9
Lateral incisor	47.1
Incidence of open gingival embrasure	
Absent	31.4
Present	68.6
Magnitude of open gingival embrasure	
Normal	31.4
Class II	68.6
Contact before treatment	
Not determined	17.6
Incisal third	2
Middle third	76.5
Gingival third	3.9
Contact after treatment	
Not determined	2
Incisal third	13.7
Middle third	82.4
Gingival third	2
Level of open gingival triangle	
Not noticeable	31.4
Barely noticeable	33.3
Moderately noticeable	13.7
Very noticeable	21.6

Few patients had a pretreatment contact location in the incisal or gingival third. The data were not significant ($\chi^2(2) = 1.08$, $P = 0.58$), suggesting that the contact location at the beginning of treatment is not associated with an open gingival embrasure.

A similar trend was found in the contact after treatment data (Table IV); only 1 subject was excluded in this analysis because the contact location was not visualized.

Table II. Patients classified by tooth extraction (central vs lateral incisor and absence of an open gingival embrasure)

Tooth extracted	Open gingival embrasure (%)	
	Absent	Present
Central incisor	11.8	41.2
Lateral incisor	19.6	27.5

Table III. Patients classified by contact before treatment and absence or presence of an open gingival embrasure

Contact location	Open gingival embrasure (%)	
	Absent	Present
Incisal third	0	2.4
Middle third	21.4	71.4
Gingival third	2.4	2.4

Most patients (84%) had contact at the middle third, and the majority of them (54%) also had an open gingival embrasure. Nevertheless, the analysis result was not significant, indicating no statistical evidence that these variables were associated ($\chi^2(2) = 4.08, P = 0.13$). Also of interest is that all patients who had contact at the incisal third exhibited an open gingival embrasure after treatment (all 7 patients, or 14% of the total sample); however, with the limited sample size in this category, this observation must be interpreted with some caution.

Separate chi-square analyses were conducted to examine the association between absence or presence of an open gingival embrasure by contact after treatment for only patients whose contact was at the incisal third compared with those whose contact was at the middle third, and for those whose contact was at the incisal third compared with those whose contact was at the gingival third. These analyses indicated no significant ($\chi^2(1) = 3.60, P = 0.058$) difference between contact point at the middle third and the incisal third. However, patients with contact at the incisal third were more likely to exhibit an open gingival embrasure (14%) than patients with contact at the gingival third (2%). The difference in percentages was statistically significant ($\chi^2(1) = 11.76, P = 0.001$). There was no significant difference in the percentages of patients with contact at the middle third compared with the gingival third and evidence of an open gingival embrasure after treatment ($P > 0.05$).

To examine the relationship between age and severity of an open gingival embrasure, a point-biserial correlation was calculated, yielding a nonsignificant result

Table IV. Patients classified by contact after treatment and Absence or presence of an open gingival embrasure

Contact location	Open gingival embrasure (%)	
	Absent	Present
Incisal third	0	14
Middle third	30	54
Gingival third	0	2

Table V. Open gingival embrasures according to sex

Sex	Open gingival embrasure (%)	
	Absent	Present
Female	37.9	62.1
Male	22.7	77.3

($r = 0.034, P = 0.81$). Chi-square analyses were also conducted to examine the association between sex and (1) an open gingival embrasure and (2) its magnitude. Table V presents the percentages of patients with open gingival embrasures. The relationship between sex and whether a patient had an open gingival embrasure was not significant.

DISCUSSION

Open gingival embrasures have been reported as potential sequelae after orthodontic treatment, especially in adults.¹¹ However, the incidence of this clinical finding after the extraction of a mandibular incisor has only anecdotal evidence. Our results indicate that 68% of the patients developed an open gingival embrasure after the extraction of a mandibular central or lateral incisor.

Only 1 clinical study reported the effects of mandibular incisor extraction and open gingival embrasure formation. Faerovig and Zachrisson⁷ evaluated this clinical approach in mild Class III malocclusions in adults with minimal incisor irregularity. They stated that the interdental papilla was well preserved at the end of orthodontic treatment. However, there was no adequate description of the method of assessment of the open gingival embrasure and no objective measurement of the interdental embrasure in the mandibular incisor region in this study.

It has been suggested that the presence of an open gingival embrasure is related to the patient's age.⁹ However, in this study, no correlation was found between the age and an open gingival embrasure. Since periodontal disease is more prevalent with age, and attachment loss can lead to an open gingival embrasure, we excluded patients with periodontal pathology.¹³

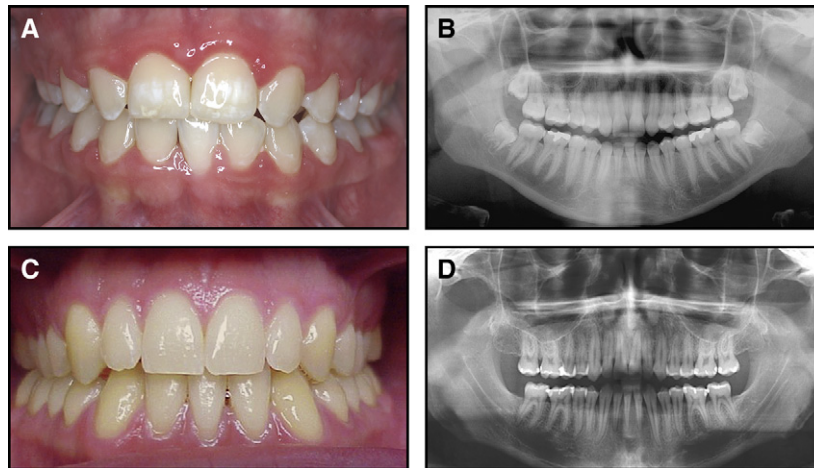


Fig 3. **A and B**, Patient with a barely noticeable open gingival embrasure; the panoramic radiograph shows root divergence between the mandibular right lateral and left central incisors, as well as an interproximal contact location at the incisal third. **C and D**, Patient with moderately noticeable open gingival embrasure; the panoramic radiograph shows adequate root parallelism between the mandibular right central and left lateral incisors, and a contact location in the incisal third.

Two indexes were used to evaluate the magnitude of open gingival embrasures. The index of Nordland and Tarnow¹² has been used in the periodontal literature to evaluate the severity of interproximal papillary loss. Since the most severe stage of this classification applies only to patients with periodontal disease, a scale that applied to periodontally healthy subjects was designed to evaluate the magnitude of open gingival embrasures. The analysis found that both indexes were highly correlated. Our results also showed that the magnitude of an open gingival embrasure was moderately to largely noticeable in 52% of the patients. However, as expected, sex had no impact on the presence or magnitude of open gingival embrasures.

It was reported that an open gingival embrasure is a common finding when the distance from the interproximal contact to the crestal bone is more than 5 mm.¹⁴ In this sample, the crest of the bone was expected to be located within 2 mm of the CEJ, since patients with periodontal disease were excluded. Therefore, in this sample, the only potential predictor of an open gingival embrasure would have been the interproximal contact before treatment. However, only 1 patient had an interproximal contact before treatment located on the incisal third. Interestingly, this patient developed an open gingival embrasure after incisor extraction. On the other hand, 2 patients had a contact on the gingival third before treatment; 1 developed an open gingival embrasure. The majority of patients had an initial contact on the middle third, and most of these (71%) developed an open gingival embrasure. Therefore, since there

were a limited number of patients in the other 2 categories, contact location before treatment could not be assumed to be a predictor of open gingival embrasure formation.

The interproximal contact location after treatment was to a certain degree a predictor of the development of an open gingival embrasure. Seven patients (14%) had the contact located in the incisal third after treatment, and all of them had an open gingival embrasure. This was statistically significant when compared with the patients with gingival contact, but not significant compared with patients with interproximal contact on the middle third after treatment. Altogether, these findings suggest that patients who end treatment with an interproximal contact location at the incisal interproximal third are at greater risk for developing an open gingival embrasure than those who ended with a contact at the gingival third. This is supported by the study of Kurth and Kokich,¹¹ who, in a similar age population (adults without periodontal disease), found no difference in the distance between the CEJ and crestal bone in patients with and without open gingival embrasures in the maxillary incisors after orthodontic treatment. Thus, an incisal contact location might be the most important variable associated with open gingival embrasures.

Other causes of open gingival embrasure formation that have been reported after orthodontic treatment are pretreatment crowding and root divergence.^{10,11} However, Kurth and Kokich¹¹ found no association between pretreatment maxillary incisor crowding and open gingival formation. On the other hand, they found

root divergence associated with an open gingival embrasure after treatment. However, these findings might be associated with an incisally displaced interproximal contact as a result of root divergence; thus, the alveolar bone-interproximal contact distance could explain this finding (Fig 3). To better address this relationship, a radiographic examination would be required.

Although there was a higher tendency for developing an open gingival embrasure associated with the extraction of a central incisor than a lateral incisor, it was not statistically significant. This trend could be associated with the photographic angle of an intraoral frontal picture; the interproximal space of a lateral incisor, particularly the distal portion, is more difficult to evaluate from a frontal photograph.

This study was an initial attempt to objectively examine the incidence of open gingival embrasures after mandibular incisor extractions. It was retrospective, and therefore a limitation of the study as standardization of the records was not possible, especially since our patient sample was obtained from various orthodontic offices. Additionally, it was based on photographs taken at the beginning and end of treatment. Although this is a limitation, it can be speculated that the incidence of open gingival embrasures after a clinical evaluation might be higher because saliva and specific photographic angles can preclude highlighting the less conspicuous open gingival embrasures.

CONCLUSIONS

1. More than two thirds of the patients who had a mandibular incisor extracted had an open gingival embrasure at the end of treatment.
2. The magnitude of an open gingival embrasure is moderately noticeable to very noticeable in 52% of these patients.
3. Extracting a lateral or central incisor did not make a statistically significant difference in the presence or absence of an open gingival embrasure.
4. Age is not a predictor of open gingival embrasure formation after mandibular incisor extraction.
5. Sex was not correlated with open gingival embrasures.

6. Most patients who had incisor extraction had an interproximal contact location in the middle third before and after treatment.
7. All patients who had a posttreatment interproximal contact location in the incisal third had an open gingival embrasure.

We thank Drs. Jeff Blasius, Jonathan Feldman, Robert Gange, Jennifer Lowney, Baliram Maraj, and Davis Witt for contributing their patient records for this study. We also like to thank Dr. Manuel Laborde for his contribution as a second examiner in this study.

REFERENCES

1. Kokich VG, Shapiro PA. Lower incisor extraction in orthodontic treatment. Four clinical reports. *Angle Orthod* 1984;54:139-53.
2. Riedel RA, Little RM, Bui TD. Mandibular incisor extraction—post-retention evaluation of stability and relapse. *Angle Orthod* 1992; 62:103-16.
3. Canut JA. Mandibular incisor extraction: indications and long-term evaluation. *Eur J Orthod* 1996;18:485-9.
4. Owen AH. Single lower incisor extractions. *J Clin Orthod* 1993;27: 153-60.
5. Miller RJ, Duong TT, Derakhshan M. Lower incisor extraction treatment with the Invisalign system. *J Clin Orthod* 2002;36: 95-102.
6. Valinoti JR. Mandibular incisor extraction therapy. *Am J Orthod Dentofacial Orthop* 1994;105:107-16.
7. Faerovig E, Zachrisson BU. Effects of mandibular incisor extraction on anterior occlusion in adults with Class III malocclusion and reduced overbite. *Am J Orthod Dentofacial Orthop* 1999;115:113-24.
8. Riedel RA, Brandt S. Dr. Richard A. Riedel on retention and relapse. *J Clin Orthod* 1976;10:454-72.
9. Sheridan JJ, Hastings J. Air-rotor stripping and lower incisor extraction treatment. *J Clin Orthod* 1992;26:18-22.
10. Burke S, Burch JG, Tetz JA. Incidence and size of pretreatment overlap and posttreatment gingival embrasure space between maxillary central incisors. *Am J Orthod Dentofacial Orthop* 1994;105:506-11.
11. Kurth JR, Kokich VG. Open gingival embrasures after orthodontic treatment in adults: prevalence and etiology. *Am J Orthod Dentofacial Orthop* 2001;120:116-23.
12. Nordland WP, Tamow DP. A classification system for loss of papillary height. *J Periodontol* 1998;69:1124-6.
13. Hugoson A, Norderyd O. Has the prevalence of periodontitis changed during the last 30 years? *J Clin Periodontol* 2008;35:338-45.
14. Tamow DP, Magner AW, Fletcher P. The effect of the distance from the contact point to the crest of bone on the presence or absence of the interproximal dental papilla. *J Periodontol* 1992;63:995-6.