sciendo

DOI: 10.2478/aoj-2007-0003

# Changes in interdental papillae heights following alignment of anterior teeth

Sanjivan Kandasamy,* Mithran Goonewardene* and Marc Tennant†

Dental School, The University of Western Australia* and the Centre for Rural and Remote Oral Health, The University of Western Australia,† Perth, Australia

*Background:* Orthodontic alignment of overlapped incisors can reduce the apparent heights of the interdental papillae leading to unsightly dark triangles or open gingival embrasures.

*Aim:* To determine if certain pretreatment contact point relationships between the maxillary anterior teeth were accompanied by changes in the heights of the interdental papillae after orthodontic alignment.

*Methods:* Pre- and post-treatment intra-oral 35 mm slides, lateral cephalometric radiographs and study casts of 143 patients (60 males, 83 females) between 13 and 16 years of age were used. The patients had diastamata closed, imbricated teeth aligned and palatally or labially placed teeth repositioned. A sample of 25 patients (12 males, 13 females) between 13 and 16 years of age who had well-aligned anterior teeth at the start of treatment acted as a control group. All patients were treated for approximately 18 months. The clinical crowns of the maxillary incisors and the heights of the interdental papilla between the incisors were measured on projected images of the slides. The percentage increases or reductions in the heights of the interdental papillae were compared.

*Results:* The heights of the interdental papillae increased following palatal movement of labially placed ($p < 0.05$) or imbricated ($p < 0.05$) incisors and the intrusion of one incisor relative to an adjacent incisor ($p < 0.01$). The heights of the interdental papillae reduced following labial movement of an imbricated ($p < 0.05$) or palatally placed ($p < 0.05$) incisor or closure of a diastema ($p < 0.01$). Before treatment the midline papillae in the diastema subgroup were of similar length to the midline papillae in the control group, but after treatment they were markedly shorter. The interdental papillae associated with crowded or imbricated incisors were shorter than the interdental papillae in the control group before and after treatment.

*Conclusions:* Dark triangles are less likely to develop following palatal movement of labially placed or imbricated teeth and the intrusion of one tooth relative to another. On the other hand, dark triangles are more likely to develop following labial movement of imbricated or palatally placed incisors and closure of a diastema. Clinicians should be alert to the possibility of dark triangles developing in the latter group, particularly in older patients.

(Aust Orthod J 2007; 23: 16–23)

Received for publication: July 2006
Accepted: January 2007

## Introduction

Orthodontic alignment of overlapped incisors can reduce the apparent heights of the interdental papillae leading to unsightly dark triangles or open gingival embrasures.[1–3] It has been suggested that as overlapped teeth are aligned the interdental papillae 'stretch', their heights reduce and open gingival embrasures develop.[1–3] Other factors, such as alveolar bone levels, crown form, contact relationships, pretreatment crowding,[4–6] age,[7] and orthodontic effects on the gingival fibres may also play a part in the causation of open gingival embrasures or dark triangles. Recently, Ko-Kimura et al.[8] and Ikeda et al.[9] reported that open gingival embrasures were associated with resorption of the alveolar crest, and were more frequently found in patients over 20 years of age.

Two factors believed to influence the form of the gingival tissues post-treatment are the direction of tooth movement and the faciolingual thickness of the supporting bone and soft tissue.[10] For example, during lingual or palatal tooth movement the gingival tissue on the facial aspect of a tooth thickens and migrates occlusally. The reverse may occur when teeth are moved labially.[11–13] Providing a tooth is moved within the alveolar process the risk of gingival recession is

Table I. Definitions.

| Relationship | Definition |
|---|---|
| Diastema | The horizontal space between adjacent incisors |
| Vertical discrepancy | Adjacent incisors in different vertical positions |
| Imbricated | Incisors arranged in an overlapping manner, one incisor may be palatally or labially placed relative to the other incisor |
| Labially or palatally placed incisors with no overlap | Labially or palatally placed incisors. Study models and lateral intraoral photographs were used to determine if an incisor was imbricated or labially/palatally placed. |

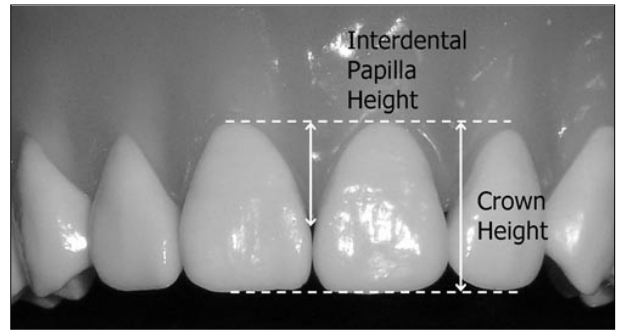



Figure 1. Crown height was measured from the incisal edge to the highest point on the gingival margin. Interdental papilla height was measured from the tip of an interdental papilla to the line joining the highest points on the gingival margins of adjacent incisors.

minimal, irrespective of the dimensions or quality of the gingival tissue.[14]

The aim of this study was to determine if certain pre-treatment contact point relationships between the maxillary anterior teeth were accompanied by changes in the heights of the interdental papillae after orthodontic alignment.

## Materials and methods

Ethical approval for this study was obtained from the Human Research Ethics Committee of the University of Western Australia. All assessments were carried out in accordance with the guidelines of the National Health and Medical Research Council of Australia.

All patients who commenced treatment in a private orthodontic practice in 1996 and required alignment of the upper anterior teeth were eligible for the study. Patients with poor oral hygiene exhibiting swollen, erythematous and/or hyperplastic gingivae, with incomplete records and when two or more of the contact relationships given in Table I were present, were excluded. Patients with the latter condition were excluded because the interdental papilla between the teeth could be influenced differently by the different tooth movements required to align the teeth. A total of 143 patients (60 males, 83 females) between 13 and 16 years of age (Mean age: 14 years 7 months) were available for the experimental group. A sample of 25 patients (12 males, 13 females) who received orthodontic treatment in the same practice, but who had well aligned anterior teeth at the start of treatment acted as a control group. These patients were also between 13 and 16 years of age (Mean age: 14 years 4 months).

Pre- and post-treatment intra-oral 35 mm slides, lateral cephalometric radiographs and study casts were used. The intra-oral frontal photographs were taken at the same magnification and standardised by positioning the upper midline in the centre of the view finder and sighting along the occlusal plane. All patients were treated for approximately 18 months and the post-treatment photographs were taken four weeks after appliance removal. The pre- and post-treatment lateral cephalometric radiographs were used to assess qualitatively the overall direction of maxillary incisor movement. The study models were used to determine the arrangement of the anterior teeth and allocation into the groups given in Table I.

The clinical crowns (incisal edge – lowest point on the gingival margin) of the central and lateral incisors and the heights of the interdental papillae between the incisors (tip of an interdental papilla to the line joining the lowest points on the gingival margins of adjacent incisors) were measured twice on standardised images of the slides projected onto a white background (Figure 1). The maxillary incisors in both experimental and control groups were measured.

Because it was not possible to measure the interdental and crown heights precisely if adjacent teeth were at different inclinations or displaced palatally/labially, and pretreatment measurements of the cemento-enamel junction – gingival margin distances

Table II. Pretreatment and post-treatment comparisons.

| Group | N | Mean pretreatment height (Per cent) | Pretreatment difference E minus C (Per cent) | *p* | Mean post-treatment height (Per cent) | Intra-group change (Per cent) | *p* | Post-treatment difference E minus C (Per cent) | *p* |
|---|---|---|---|---|---|---|---|---|---|
| Control | 25 | 56.6 (8.1) | – | – | 47.1 (8.1) | 1.5 | NS | – | – |
| Diastema | 28 | 48.5 (7.5) | 2.9 | NS | 38.0 (8.8) | -10.5 | **0.01** | -9.1 | **0.01** |
| Vertical discrepancy | 31 | 35.4 (8.6) | -10.2 | **0.01** | 43.5 (7.7) | 8.1 | **0.01** | -3.6 | NS |
| Labially overlapped | 11 | 34.6 (7.8) | -11.0 | **0.01** | 45.1 (9.6) | 10.5 | **0.01** | -2.0 | NS |
| Palatally overlapped | 25 | 43.3 (7.8) | -2.3 | NS | 41.0 (6.1) | -2.3 | NS | -6.1 | **0.01** |
| Labially placed | 10 | 31.0 (8.3) | -14.6 | **0.01** | 38.9 (8.6) | 7.9 | **0.01** | -8.2 | **0.05** |
| Palatally | 28 | 42.8 (7.4) | -2.8 | NS | 40.8 (6.5) | -2.0 | **0.05** | -6.3 | **0.01** |

E, experimental; C, control
NS, not significant
Standard deviations in brackets
Significant values in bold

were not available, the data were converted to percentages. The percentage loss or gain in the height of an interdental papilla(e) were obtained by dividing the mean height of the interdental papilla(e) by the mean length of the clinical crowns of the incisors on either side of the papilla(e) and converting the result to a percentage. The mean pre- and post-treatment percentage values were then used to obtain the percentage increases or reductions.

The statistical analyses were performed using the Intercooled Stata 8.0 statistical package (SPSS, Chicago, Illinois, USA). Values of $p$ less than 0.05 were considered significant. All measurements were repeated by the same examiner two weeks later. Results of the paired $t$-test showed there were no significant differences at the 5 per cent level of significance between the first and second sets of measurements. To improve the reliability of these measurements the means of both sets of measurements were used in all subsequent calculations.

## Results

The results are given in Table II and Figures 2–7.

### *Control group*

The mean pre- and post-treatment heights of the interdental papillae in the control group were 45.6 and 47.1 per cent respectively. The difference between the pre- and post-treatment heights was not statistically significant.

### *Experimental group*

#### *Diastema*

The diastemata were closed in 28 patients (Table II, Figure 2). Following closure of diastemata the interdental papillae between the central incisors were significantly shorter at the end of treatment (Mean difference: -10.5 per cent; $p < 0.01$). The post-treatment heights of the interdental papillae in the experimental sample were also significantly shorter than the post-treatment heights of the interdental papillae in the control group (Mean difference: -9.1 per cent; $p < 0.01$).

#### *Vertical discrepancy*

Before treatment the heights of the interdental papillae in this group were significantly shorter than the pretreatment heights of the interdental papillae in the control group (Mean difference: -10.2 per cent; $p < 0.01$). The control – experimental difference after treatment was not significant. Following correction of a vertical discrepancy the interdental papillae increased in height significantly (Mean difference: 8.1 per cent; $p < 0.01$). Pre- and post-treatment views of a typical case are shown in Figure 3.



(2a)



(2b)

Figure 2. Closure of a diastema.Pretreatment (a) and post-treatment (b) views.



(3a)



(3b)

Figure 3. Vertical discrepancy between the central and lateral incisors. Pretreatment (a) and post-treatment (b) views.

### *Imbrication – labially overlapped*

There were 11 subjects with labially overlapped teeth (Figure 4). The mean pre- and post-treatment heights of the interdental papillae were 34.6 and 45.1 per cent respectively. The pretreatment heights of the interdental papillae in the experimental group were 11.0 per cent shorter than the pretreatment papillae in the control group ($p < 0.01$). The interdental papillae were significantly longer at the end of treatment (Mean difference: 10.5 per cent; $p < 0.01$)

### *Imbrication – palatally overlapped*

At the start of treatment the heights of the interdental papillae in the 25 control and 25 experimental patients were similar. The mean heights of the interdental papillae pre- and post-treatment were also similar. But after treatment the heights of the interdental papillae in the experimental group were significantly shorter than the heights of the interdental papillae in the control group (Mean difference: 6.1 per cent; $p < 0.01$). Pre- and post-treatment views of a typical case are shown in Figure 5.

### *Labially placed*

Before treatment the heights of the interdental papillae in this group of 10 patients were significantly shorter than the interdental papillae in the 25 patients in the control group (Mean difference: -14.6 per cent; $p < 0.01$). During treatment the papillae increased in length significantly (Mean difference: 7.9 per cent; $p < 0.01$), but remained significantly shorter than the post-treatment papillae in the control group (Mean difference: -8.2 per cent; $p < 0.05$). Pre-



(4a)



(4b)

Figure 4. Imbricated tooth, tooth 21 overlapped labially by tooth 11. Pretreatment (a) and post-treatment (b) views.



(5a)



(5b)

Figure 5. Imbricated tooth, tooth 21 overlapped palatally by tooth 22. Pretreatment (a) and post treatment (b) views.

and post-treatment views of a typical arrangement in this group are shown in Figure 6.

### *Palatally placed*

Before treatment the heights of the interdental papillae in this group were similar to the heights of the interdental papillae in the control subjects. The interdental papillae were, however, significantly shorter post-treatment (Mean difference: –2.0 per cent; $p < 0.05$) and significantly shorter than the papillae in the control group post-treatment (Mean difference: -6.3 per cent; $p < 0.01$). A typical example is shown in Figure 7.

## Discussion

The present study confirms previous investigations that palatal movement of labially displaced or imbricated teeth and the intrusion of one tooth relative to another tooth increases the height(s) of the interdental papilla(e). It also confirms previous reports that the height(s) of the interdental papilla(e) reduce following labial movement of an imbricated or palatally placed incisor. The finding that the interdental papilla reduced substantially when a diastema was closed is puzzling: it may be a normal age change or it may have occurred because one or both central incisors were extruded or moved labially during closure of the diastema. Before treatment the papillae connected to the labial frenum were of similar length to the papillae in the control group, but after treatment they were markedly shorter. At the outset the papillae associated with labially overlapped incisors were shorter than papillae in the control group, but only the papillae associated with palatally overlapped incisors were shorter after treatment.



(6a)



(6b)

Figure 6. Labially placed tooth, tooth 12 is labially placed. Pretreatment (a) and post-treatment (b) views.



(7a)



(7b)

Figure 7. Palatally placed tooth, tooth 22 is palatally placed. Pretreatment (a) and post treatment (b) views.

In a study such as this there are some limitations that should be considered. We used intra-oral photographs to measure the lengths of structures that were not always viewed directly, the depth of the gingival crevice was not probed and standardised periapical radiographs were not available. Had the latter been available we could have measured the distance between the cemento-enamel junction and the gingival margin and obtained information on the height of the interproximal bone. A further limitation in our study is that it only covers 18 months (the period covered by treatment) and, as a result, the changes we observed may not be maintained in a longer study. Furthermore, gingival attachments change over time and during adolescence marked changes can occur in some individuals. Age changes in the interdental papillae could have been masked or enhanced by the type of tooth movement, particularly if the teeth on either side of an interdental papilla were intruded or extruded. This is a potential confounding variable that was not assessed. It was mainly because of these limitations that we used proportional changes. Although our control group was made up of patients that did not require alignment of the anterior teeth some unintentional tooth movement may have occurred. The possibility of this happening and possibility of confounding changes in the control group also must be acknowledged.

The pretreatment heights of interdental papillae were significantly shorter in groups with a vertical discrepancy, labially overlapped and labially placed incisors. The heights of the interdental papillae increased significantly when a vertical discrepancy was corrected.

During leveling one tooth may have been intruded and the adjacent tooth extruded. This is a potential confounding variable that was not assessed in this study. Following extrusion the height of the alveolar bone usually increases and there is a proportional increase in the attachment of the supra-alveolar connective tissues.[15] Whether the papilla between overlapped teeth increased or reduced in height during treatment was determined by the direction of tooth movement: a papilla shortened if the overlapped tooth was moved labially, and increased in height if the overlapped tooth was moved palatally. Similar findings occurred when labially or palatally placed teeth that were not overlapped were repositioned.

Labial movement of palatally placed or imbricated teeth may result in a number of unfavourable bone and soft tissue changes considered to predispose gingival recession following orthodontic treatment, such as a reduced height and thickness of the free gingivae and an increased clinical crown.[10,16] Gingival recession associated with labial tooth movement correlates with our findings of interdental recession. In comparison with marginal gingival recession, interdental recession can result in the characteristic open gingival space or 'dark triangle', particularly between incisors. Gingival recession is likely to be precipitated, firstly, by inflammation induced by bacterial plaque and, secondly, by trauma from tooth brushing.[9,16] Therefore, patients undergoing labial movement of palatally placed teeth should be warned of the likelihood of dark triangles and should use effective and non-traumatic plaque control measures.[14,17]

Palatal tooth movement, on the other hand, results in an increased labio-palatal thickness of the tissue at the labial aspect of the tooth. This often results in a reduced clinical crown and coronal migration of the soft tissue margin, which may require periodontal treatment.

Open gingival embrasures frequently follow alignment of crowded maxillary incisors and, as we have shown, closure of a diastema.[1] These findings disagree with Kurth et al.[15] who could not demonstrate any post-treatment difference in the form of the embrasures in patients with rotated or overlapped maxillary central incisors before treatment. It has been reported that following orthodontic treatment open gingival embrasures are more likely to be found in patients over 20 years of age than in younger patients.[7,8] In the present study the patients were between 13 and 16 years of age so it would be reasonable to expect greater changes in an older group of patients.

Periodontal assessment and warning of the likelihood of dark triangles is a sensible precaution for patients who present with diastemata, palatally overlapped and palatally placed incisors in the permanent dentition. Adult patients appear to be particularly prone to develop dark triangles, but other factors such as the form of the crowns, the position of the contact area and the height of the interproximal bone may also influence the position of the interdental papilla.[7,8,12,13,18] It may be possible to minimise complications by adopting procedures to locate the contact point further apically, place bonded restorations interproximally and/or by augmenting the gingival tissues.[12,13]

In the developing dentition, treatment strategies should be aimed at establishing favourable contact point relationships. Strategies such as early extraction of deciduous canines, reducing the interproximal surfaces of deciduous teeth, and/or arch expansion may allow early alignment of the permanent incisors and prevent unfavourable contact point relationships from developing later in life.[19] If teeth are moved beyond the biological limits of the alveolar bone it may be advantageous to allow the interdental papillae to reach their adult sizes before undertaking orthodontic tooth movement likely to reduce the heights of the interdental papillae.

## Conclusions

The results of this study indicate that the interdental papillae between the anterior teeth may lengthen following palatal movement of labially displaced or imbricated teeth and the intrusion of one tooth relative to another. In these cases dark triangles are less likely to develop. On the other hand, the heights of the interdental papillae are likely to reduce following labial movement of imbricated or palatally placed incisors and closure of a diastema and, as a result, dark triangles may develop. Clinicians should be alert to the possibility of dark triangles developing in the latter group, particularly in older patients.

## Acknowledgments

This research was supported by The University of Western Australia Orthodontic Research Fund.

## Corresponding author

Associate Professor Mithran Goonewardene
Program Director, Orthodontics
Dental School
The University of Western Australia
17 Monash Avenue
Nedlands WA 6009
Australia
Tel: (+61 8) 9346 7470
Fax: (+61 8) 9346 7666
Email: mithran.goonewardene@uwa.edu.au

## References

1. 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.
2. Atherton JD. The gingival response to orthodontic tooth movement. Am J Orthod 1970;58:179–86.
3. Atherton JD, Kerr NW. Effect of orthodontic tooth movement upon the gingivae. An investigation. Brit Dent J 1968; 124:555–60.
4. Diedrich PR. Orthodontic procedures improving periodontal prognosis. Dent Clin North Am 1996;40:875–87.
5. Waerhaug J. Eruption of teeth into crowded position, loss of attachment, and downgrowth of subgingival plaque. Am J Orthod 1980;78:453–9.
6. El-Mangoury NH, Gaafar SM, Mostafa YA. Mandibular anterior crowding and periodontal disease. Angle Orthod 1987;57:33–8.
7. Ainamo J, Paloheimo L, Norblad A, Murtomaa H. Gingival recession in school children at 7, 12 and 17 years of age in Espoo, Finland. Community Dent Oral Epidemiol 1986;14: 283–6.
8. Ko-Kimura N, Kimura-Hayashi M, Yamaguchi M, Ikeda T, Meguro D, Kanekawa M, Kasai K. Some factors associated with open gingival embrasures following orthodontic treatment. Aust Orthod J 2003;19:19–24.
9. Ikeda T, Yamaguchi M, Meguro D, Kasai K. Prediction and causes of open gingival embrasure spaces between the mandibular central incisors following orthodontic treatment. Aust Orthod J 2004;20:87–92.
10. Wennstrom JL. Mucogingival considerations in orthodontic treatment. Semin Orthod 1996;2:46–54.
11. Andlin-Sobocki A, Bodin L. Dimensional alterations of the gingiva related to changes of facial/lingual tooth position in permanent anterior teeth of children. A 2-year longitudinal study. J Clin Periodontol 1993;20:219–24.
12. Zachrisson BU. Orthodontics and Periodontics. In: Lindhe J, Karring T, Lang NP, editors. Clinical Periodontology and Implant Dentistry. Copenhagen: Munksgaard, 1998: 741–93.
13. Zachrisson BU. Interdental papilla reconstruction in adult orthodontics. World J Orthod 2004;5:67–73.
14. Wennstrom JL. The significance of the width and thickness of the gingiva in orthodontic treatment. Dtsche Zahnarztl Z 1990;45:136–41.
15. Maynard JG, Ochsenbein C. Mucogingival problems, prevalence and therapy in children. J Periodontol 1975;46: 543–52.
16. Ericsson I, Lindhe J. Recession in sites with inadequate width of the keratinized gingiva: an experimental study in the dog. J Clin Periodontol 1984;11:95–103.
17. Kurth JR, Kokich VG. Open gingival embrasures after orthodontic treatment in adults: prevalence and etiology. Am J Orthod Dentofacial Orthop 2001;120:116–23.
18. Lindhe J. Textbook of Clinical Periodontology. 2nd ed. Copenhagen: Munksgaard, 1997.
19. Rosa M, Cozzani M, Cozzani G. Sequential slicing of lower deciduous teeth to resolve incisor crowding. J Clin Orthod 1994;28,596–9.