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## RESEARCH ARTICLE

### Factors Affecting the Presence or Absence of Interdental Papilla; An *in-vivo* study. Part II: Influence of Different Parameters on the Presence or Absence of a Black Triangle

Joanne Cunliffe<sup>1</sup>, Michaela Goodwin<sup>2</sup>, Sari A. Mahasneh<sup>1,3,\*</sup> and Iain Pretty<sup>2</sup>

<sup>1</sup>Division of Dentistry, School of Medical Sciences, University of Manchester, Manchester, M13 9PL, UK

<sup>2</sup>The Dental Health Unit, Division of Dentistry, The University of Manchester, Williams House, Manchester Science Park, Manchester, M15 6SE, UK

<sup>3</sup>School of Dentistry, University of Jordan, Amman, 11942, Jordan

#### Abstract:

#### Background:

The distance from the crest of the bone to the contact point is crucial to the formation of a black triangle. This study looks into the influence of various clinical parameters on the absence of the interdental papilla.

#### Aim:

The aim of this study is to assess the different clinical parameters that can contribute to black triangle formation.

#### Objective:

The objective of this study is to determine the significance of various clinical parameters in the formation of black triangles.

#### Methods:

Patients included were those referred to the radiology department for periapical radiographs from the second premolars to the second premolars in both jaws. All the patients were clinically examined to assess the parameters investigated. Different Parameters were assessed which included tissue phenotype type, interproximal cleaning, and the presence of inflammation. The data was analysed using IBM SPSS version 19 and STATA.

#### Results:

It was found that the relative risk of patients who have a thin tissue phenotype is 1.20 times more likely to have a black triangle than patients with a thick tissue phenotype. Lack of interproximal cleaning resulted in 1.46 times more likely to have a black triangle. The presence of gingival inflammation caused 1.32 times more likelihood of having a black triangle.

#### Conclusion:

The parameters that had a significant association were tissue phenotype, interproximal cleaning, and gingival inflammation. The amount of inflammation, the cleaning habits, and the tissue phenotype of the patient need to be taken into consideration when planning restorative work and care needs to be taken in the treatment planning, consent, and execution.

**Keywords:** Dental esthetics, Black triangles, Interdental papilla, Recession, Open embrasure, Treatment outcome.

#### Article History

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## 1. INTRODUCTION

Gingival recession is defined as the displacement of the soft tissue from the cemento-enamel junction. It can be found

in populations with high standards of oral hygiene [1] and in populations with poor oral hygiene [2]. Where oral hygiene is optimal the recession appears mainly on the buccal surfaces [1, 3]. In patients with poor oral hygiene and untreated periodontal disease, the loss of soft tissue is from all the tooth surfaces [2, 4].

\* Address correspondence to this author at the School of Dentistry, University of Jordan, P.O. Box 13205, Amman, 11942, Jordan; Tel: +962791830073; E-mail: Sari.mahasneh@ju.edu.jo

The recession was first classified in 1968 [5] where it was divided into narrow, wide, shallow, and deep. These classifications were used to predict the success of the coverage, with shallow and narrow defects more likely to succeed. Subsequently, Miller developed four new classifications that related recession to the bone level and the mucogingival junction [6].

The prevalence of gingival recession increases with age. The Third National Health and Nutrition Examination Survey (NHANES) in the USA found that it increased from 0.5% in 18-24-year-olds who had one or more sites of recession greater than 3mm, to 45% in those older than 65 [7]. Other studies have confirmed this association with age [8 - 10] and also found that the prevalence of recession was higher in men [8, 10].

Recession plays a crucial role in the aetiology of black triangles. Anything that induces or increases the severity of the pre-existing gingival recession in interproximal areas is likely to lead to the possible formation of black triangles, due to the geometry of the root structure. As one goes more apical on the roots then the circumference becomes smaller and there is more space between the roots of adjacent teeth. If the bone support is lost then the gingiva will follow this apical migration, leading to space formed between the roots called the black triangle or open gingival embrasure. Nordland and Tarnow (1998) [11] proposed a classification to describe the papilla height (Table 1).

**Table 1. Classification of papillary height (Nordland and Tarnow 1998).**

|  |
|--|
| <b>Normal</b> Interdental papilla fills embrasure space to the apical extent of the interdental contact point/area   |
| <b>Class I</b> 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 is not visible) |
| <b>Class II</b> The tip of the interdental papilla lies at or apical to the Interproximal CEJ but coronal to the apical extent of the facial CEJ (interproximal CEJ visible)   |
| <b>Class III</b> The tip of the interdental papilla lies level with or apical to the facial CEJ  |

There are many factors that affect recession and therefore the possibility of a black triangle if the recession appears interproximally. The aim of this study is to assess the different parameters that can contribute to black triangle formation.

## 2. MATERIALS AND METHODS

For this *in-vivo* study ethical approval was granted by National Health services Manchester Foundation Trust (NHS MFT) (reference number: 08/H1011/49) and the aim was to get a sample of 288 interproximal sites (same number as Tarnow, Magner [12]) by using the data from 80 patients and 3-4 interproximal sites on each radiograph. The number of actual interproximal sites that were observed from 80 patients was 404. Subjects were randomly selected from patients referred to

the dental radiography department, following their periodontal consultation. The inclusion criteria was that the subject required radiographs of the second premolar to the second premolar in the upper and lower jaw, as this was deemed to be the esthetic zone. The patients were taken from the referrals for periapical radiographs of the 15 to the 25 and the 35 to the 45 using film holders. A clinical examination was carried out on the included patients to record the clinical parameters under investigation.

A proforma was used to record the parameters investigated visually, the parameters of interest included:

- The presence or the absence of a papilla.
- The tissue phenotype, *i.e.* thick or thin.
- The gingival condition and if there is any oedema or inflammation.
- The presence of a restoration.
- Pocket depths adjacent to the papilla using the WHO periodontal probe

The notes were also checked for a Community periodontal index of treatment needs (CPITN) and a diagnosis. A digital photograph of the subject's teeth was taken and used to assess the aesthetics and gingival condition.

Radiographs were scanned digitally using a slide scanner (Epson perfection V700 photo) and images were used in the digital format to measure the most apical point on the contact area to the crest of the bone interdental. Radiographs were used to measure the distance from the contact point to the crestal bone to assess whether bone resorption will contribute significantly to the risk of black triangle formation as it is well-known that the gingiva follows the bone. The distance was measured to determine the degree of bone resorption needed for black triangles to form.

The measurements were then calculated using Adobe Photoshop CS4<sup>®</sup> which measured the pixel numbers. The size of the radiograph was then determined in mm and the pixels were converted into mm by multiplying 0.045.

The observer was calibrated against 20 qualified dentists and 10 students, and any disagreements were solved by a maxillofacial radiologist. The observer then repeated the measurement two weeks later to verify the results. The data were first analysed using IBM SPSS version 19 to see if there was an agreement between the first and second attempts at the measurements of the 19 radiographs. This was done using the Interclass Correlation coefficient (ICC). The data were split into three subject groups of specialists, students, and GDPs. With only 10 subjects in each group, this test was more accurate than Pearson's correlation for smaller numbers. The statistical analysis assessed whether any of the variables assessed had a significant relation to black triangles formation. Descriptive statistics for the parameters investigated are described in Tables 2-4. Logistic regression was done to assess whether any of the parameters investigated are considered significant predictors.

Table 2. Tissue phenotype.

| -                            |             | Tissue Phenotype |       | Total                 |
|------------------------------|-------------|------------------|-------|-----------------------|
|                              |             | Thin             | Thick |                       |
| Black Triangle               | Count       | 31               | 76    | 107                   |
|                              | % within TT | 18.9%            | 31.7% | 26.5%                 |
| No                           | Count       | 132              | 158   | 290                   |
|                              | % within TT | 80.5%            | 65.8% | 71.8%                 |
| Yes                          | Count       | 1                | 6     | 7                     |
|                              | % within TT | 0.6%             | 2.5%  | 1.7%                  |
| Total                        |             | 100%             | 100%  | 100%                  |
| Chi-Square Tests             |             |                  |       |                       |
|                              |             | Value            | Df    | Asymp. Sig. (2 sided) |
| Pearson Chi-Square           |             | 10.917           | 2     | 0.004                 |
| Likelihood ratio             |             | 11.441           | 2     | 0.003                 |
| Linear-by-linear association |             | 5.202            | 1     | 0.023                 |
| N of valid cases             |             | 404              | -     | -                     |

Table 3. Interproximal cleaning.

| -                            |             | Interproximal Cleaning |       | Total                 |
|------------------------------|-------------|------------------------|-------|-----------------------|
|                              |             | No                     | Yes   |                       |
| Black Triangle               | Count       | 63                     | 44    | 107                   |
|                              | % within IC | 20.6%                  | 44.9% | 26.5%                 |
| No                           | Count       | 238                    | 52    | 290                   |
|                              | % within IC | 77.8%                  | 53.1% | 71.8%                 |
| Yes                          | Count       | 5                      | 2     | 7                     |
|                              | % within IC | 1.6%                   | 2%    | 1.7%                  |
| Total                        |             | -                      | 100%  | 100%                  |
| Chi-Square Tests             |             |                        |       |                       |
|                              |             | Value                  | Df    | Asymp. Sig. (2-sided) |
| Pearson Chi-square           |             | 22.95                  | 2     | 0.000                 |
| Likelihood ratio             |             | 21.53                  | 2     | 0.000                 |
| Linear-by-linear association |             | 19.15                  | 1     | 0.000                 |
| N of valid cases             |             | 404                    | -     | -                     |

Table 4. Gingival inflammation.

| -                            |             | Gingival Inflammation |       | Total                 |
|------------------------------|-------------|-----------------------|-------|-----------------------|
|                              |             | No                    | Yes   |                       |
| Black Triangle               | Count       | 144                   | 111   | 225                   |
|                              | % within GI | 57.8%                 | 44.9% | 47.9%                 |
| No                           | Count       | 99                    | 130   | 229                   |
|                              | % within GI | 39.7%                 | 52%   | 44.8%                 |
| Yes                          | Count       | 6                     | 9     | 15                    |
|                              | % within GI | 2.4%                  | 3.6%  | 3.1%                  |
| Total                        |             | -                     | 100%  | 100%                  |
| Chi-Square Tests             |             |                       |       |                       |
|                              |             | Value                 | Df    | Asymp. Sig. (2-sided) |
| Pearson Chi-square           |             | 2.800                 | 2     | .247                  |
| Likelihood ratio             |             | 2.803                 | 2     | .246                  |
| Linear-by-linear association |             | 2.714                 | 1     | .099                  |

(Table 4) contd.....

|                   |     |                       |     |       |
|-------------------|-----|-----------------------|-----|-------|
| -                 |     | Gingival Inflammation |     | Total |
|                   |     | No                    | Yes |       |
| No of valid cases | 469 | -                     | -   |       |

Table 5. Variables with a significant association.

| -                   | Tissue Phenotype    |       | Interproximal Cleaning |     | Gingival Inflammation |     |
|---------------------|---------------------|-------|------------------------|-----|-----------------------|-----|
|                     | Thin                | Thick | No                     | Yes | No                    | Yes |
| No                  | 31                  | 76    | 63                     | 44  | 144                   | 111 |
| Yes                 | 132                 | 158   | 238                    | 52  | 99                    | 130 |
| Risk ratio (95% CI) | 1.20 (1.07 to 1.35) |       | 1.46 (1.20 to 1.78)    |     | 1.32 (1.09 to 1.60)   |     |

Note: Logistic regression  
 Number of obs. = 397  
 Wald chi 2(4) = 47.91  
 Prob. > chi2 = 0.0000  
 Log pseudolikelihood = -63.904959 Pseudo R2 = 0.7238  
 (Std. Err. adjusted for 81 clusters in Particip).

Table 6. Results of STATA logistic regression clustered where 0 is the indicator.

| Black Triangle        | Z     | Std Error | P> z  | 95% CI Lower | Odds Ratio | 95% CI Upper |
|-----------------------|-------|-----------|-------|--------------|------------|--------------|
| Radiograph            | 6.53  | 13.50895  | 0.000 | 10.00472     | 26.83514   | 71.97855     |
| IPC                   | -2.61 | 0.1183958 | 0.009 | 0.0498493    | 0.1804114  | 0.65293      |
| Gingival inflammation | -1.48 | 0.2472944 | 0.138 | 0.1145488    | 0.393089   | 1.348935     |
| Tissue phenotype      | -6.09 | 0.0057761 | 0.000 | 0.0014473    | 0.0071112  | 0.0349408    |

3. RESULTS

Parameters were assessed to determine their significance in relation to the presence and absence of black triangles. Variables that had a significant association were tissue phenotype (Table 2), interproximal cleaning (Table 3), and gingival inflammation (Table 4).

From Table 5 it can be seen that subjects who have thin tissue types are 1.20 times more likely to have a black triangle than those subjects with thick tissue (p = 0.0001). Subjects that reported not undertaking interproximal cleaning were 1.46 times more likely to have a black triangle than those who did carry out interproximal cleaning (p = 0.006). If there is gingival inflammation present, the subjects were 1.32 times more likely to have a black triangle (p = 0.01).

The data were also analysed using logistic regression in STATA. This program can cluster the black triangles in the same mouth and hold all other predictors constant (Table 6). The results of the logistics show that interproximal cleaning and tissue thickness remain significant predictors (when all relevant predictors are entered into the regression) the odds of having a black triangle for interproximal cleaners was 0.18 times that of those who do not practice interproximal cleaning while the odds of having a black triangle for those with thick tissue type were 0.007 times that of those with a thin tissue type. Gingival inflammation had no significant effect when the other factors were entered into the regression.

4. DISCUSSION

Periodontal disease leads to the loss of the supporting alveolar bone which can lead to recession [13]. If the patient has lost the bone support around the tooth, then there may be a

movement or migration of the gingival soft tissues apically. When interdental bone is lost there may be remodelling of the buccal and lingual aspects that lead to the soft tissue migrating apically [3]. In the case of gingival inflammation, if there is inflammation, one is 1.32 times more likely to have a black triangle (p = 0.01). In the process of inflammation, the tissue will be swollen due to the infiltration of inflammatory cells and increased tissue fluid. As a consequence, the gingiva will be swollen which will further fill the space in the interproximal area. This effect of hyperplasia can be exaggerated by hormones and certain drugs [14]. These lesions can also be localised or general according to the reaction of plaque [15]. When one looks at interproximal cleaning, if one does not clean, the risk of having a black triangle is 1.46 times higher than for those who do clean (p = 0.006). Patients who do not clean interproximally will have inflammation in the interproximal area and therefore be more susceptible to periodontal disease which will lead to bone loss [13].

Plaque is an important aetiological aspect of periodontal disease [16]. If a patient does not clean interproximally the site will have hard and soft deposits [17]. This area is therefore the site that shows the most periodontal and gingival lesions [18]. Pocket depth is related to periodontal disease as well as the degree of inflammation. A common concern and complaint from patients following periodontal therapy is the recession and black triangles that may follow leading to concerns with the esthetics.

Muscle attachments and frenal pull usually make it difficult for patients to keep the area clean. Rarely is it the direct pull of the muscle attachment that causes the problem [19]. There is a variation in the results when the link between the fraenum and recession has been studied. In some studies,

there has been found to be a correlation [20, 21], whereas in others there was not [22].

The gingival phenotype has important implications in the presence of inflammation. If the tissue is thin then a larger proportion of the connective tissue is involved which can increase the likelihood of recession [23]. If the tissue is thick, then it is more able to resist recession. Patients who had thin tissue were 1.20 times more likely than those patients that have thick tissue of having a black triangle ( $p = 0.0001$ ). The reason for this is that patients with thin tissue are more likely to get a recession.

The presence of a restoration can be among the iatrogenic causes of the gingiva receding. During indirect restoration preparation, the interdental papilla is very delicate and the slightest damage to it can lead to an impingement of the supracrestal tissues. On occasion, the restoration is cemented and the margins appear to be merely intra-crevicular. This leads to the supracrestal tissues being impinged and the resultant recession. It is important that the fixed ratio of supracrestal tissues is maintained at 2.04mm [24]. This measurement is the sum of the connective tissue and epithelial measurements. If it is violated this leads to inflammation and possible recession. There have been studies to support this argument. When examining anterior crowns, Newcomb found that the nearer the crown margin was to the epithelial attachment the more likely the inflammation was severe [25]. The health of the periodontium is affected by the position of the crown margin and if placed supragingivally the health is better than subgingival margins [26, 27].

There are different types of gingival hyperplasia that can be fibrotic. They can be hereditary or drug-induced. The exact mechanism that causes drug-induced hyperplasia is unknown, but it is thought to be due to a change in the regulation of the fibroblasts which may be directly or indirectly linked with the production of collagen through changes in growth factors, cytokines, and matrix metalloproteinase. The drugs cause a change in the metabolism which is also dependent on age, sex, dose, and other medication taken [28]. In the case of the immunosuppressant Tacrolimus, it was found that there was an increase in the fibroblasts and collagen tissue [29].

The treatment for hyperplasia is either non-surgical or surgical depending on the cause. The more fibrous the tissue the more likely that a non-surgical treatment will not remove the overgrowth. The result is to reduce the pocket depth and therefore there will be a certain amount of recession. Recession can take place in non-surgical therapy but is very likely in surgical pocket reduction or crown lengthening [30].

Orthodontic treatment does not cause a recession but if the tooth is pushed beyond its bony envelope and dehiscence is created, then if the tissue type is thin or stretched around the new tooth position, this can lead to recession [31]. Dehiscences can be seen in the lower labial segment when there is crowding and there is thin bone. Also, the bone overlying the upper canines is thin and when the teeth are pushed labially, especially in Class III cases that are undergoing orthognathic surgery there may be dehiscence created that can lead to recession. There are debates in orthodontics literature about the

merit of treatments performed after orthodontics as opposed to before as measures of prevention. There appears to be a consensus that it is much more predictable if connective tissue surgery is undertaken after orthodontics [32]. If teeth are moved lingually there will tend to be a thickening of the gingival tissue and an apparent regrowth of the gingival tissue. The traumatic relationship of the incisor teeth can cause the gingiva to be damaged and stripped off. Akerly [1977], described four classifications of incisal relationships and what damage these relationships can do to the hard and soft tissue.

There are many other rare causes including Self-inflicted (Gingivitis Artifacta) [33], oral piercing causing recession [34] and drug-related (cocaine abuse) [35]. An interesting series of case reports discuss recession caused by mechanical factors such as piercings, partial dentures, and dental floss to chemical and heat trauma [36].

A theory as to why recession takes place is that the rete pegs from both the gingivae and the sulcular sides join. When the gingiva becomes chronically inflamed the rete pegs from the junctional epithelium elongate and contact the rete pegs from the opposite side when they contact there are epithelial bridges made and the gingiva recedes. The changes have been studied histologically in induced inflammation and it was found that there was a development of epithelial clefts in the gingiva as a result of inflammatory infiltration invading the connective tissue and the basal layer. The connective tissue and the basal layer then proliferate to maintain thickness, but the superficial layers of the epithelium desquamate [37]. There has also been an animal study [38] that looked at inflammation and gingival recession and concluded that there is a link.

The measurement of the distance from the crest of the bone to the contact point has an influence on the presence or absence of a filled interdental area. In Tarnow's study as the distance increased the percentage of the spaces with black triangles increased, so at 5mm there was a 100% presence of a papilla; at 6mm a 44% chance of a black triangle existing; and at 7mm or more than in 73% of cases a triangle will be formed [12]. It seems that the crucial point is between 6mm and 7mm [39].

## CONCLUSION

The radiographic measurement is an important factor to consider in the presence of a black triangle. This study has also shown that this is not the only factor to consider when planning restorations, treatments for periodontal disease, and cosmetic dentistry. The amount of inflammation, the cleaning habits of the patient, and the patient's tissue phenotype will have an influence on treatment choices and what messages of warning need to be given to the patient about expectations of treatment.

Patients with thin tissue need to be planned very carefully as these patients appear to be more susceptible to black triangles. Cleaning habits particularly interdental cleaning has a significant impact on the risk of developing black triangles. Also, in patients with inflammation or periodontal disease, this needs to be treated as gingival inflammation was found to have a significant effect on black triangles formation. Once treatment is completed for periodontal disease and oral hygiene improves including interdental cleaning, the planning for restorative treatment can be undertaken and the treatment for

potential or actual black triangles treatment planned.

## LIST OF ABBREVIATIONS

CPITN = Community periodontal index of treatment needs

ICC = Interclass Correlation coefficient

## ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study was approved by Oldham Research Ethics Committee to see eighty patients (08/H1011/49).

## HUMAN AND ANIMAL RIGHTS

No animals were used in this research. All human research procedures followed were in accordance with the ethical standards of the committee responsible for human experimentation (institutional and national), and with the Helsinki Declaration of 1975, as revised in 2013.

## CONSENT FOR PUBLICATION

Consent was obtained for each participant.

## STANDARDS OF REPORTING

STROBE guidelines were followed.

## AVAILABILITY OF DATA AND MATERIALS

Not applicable.

## CONFLICT OF INTEREST

All authors declare that there was no conflict of interest in this study.

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