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Black Triangles Causes and Management: A Review of Literature

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Authors' contributions

This work was carried out in collaboration between all authors. Author BKA designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript and managed literature searches. Authors MGS, WMA, HB, IT managed the analyses of the study and literature searches. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

Open gingival embrasures often pose complex functional and esthetic problems. Management of open embrasures requires careful evaluation of the underlying causes. A team approach comprising of general dentist, an orthodontist, and a periodontist is critical. The authors reviewed a total of 51 articles including review of the literature using the terms 'black triangle'; 'open gingival embrasure'; 'interdental papilla' and interproximal contact area'. These articles provided information regarding etiology, diagnosis, and management of black triangles. There are several risk factors leading to the development of black triangles. These factors include periodontal disease, loss of height of the alveolar bone relative to the interproximal contact, length of embrasure area, root angulations, interproximal contact position, triangular-shaped crowns and aging. Treatment of black triangles often requires an interdisciplinary approach, involving of periodontal; orthodontic and restorative treatment.

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1. INTRODUCTION

The field of aesthetic dentistry is governed by rules and values, and should be studied from both subjective and objective point of view. Perception varies between individuals and is controlled by social background and personal experience [1]. Aesthetics has been studied from different perspectives.

Aesthetic has been studied from different perspective to obtain an esthetically pleasing smile; many components should be in harmony and symmetry. These include gingival display; lips contour and outline; and tooth shape; color; size; and position [2]. Consequently, open gingival embrasures or black triangles are complex aesthetic and functional problems that are noticeably unaesthetic and negatively affect smile (Fig. 1). Open gingival embrasures “black triangles” are defined as the embrasures cervical to the interproximal contact that is not filled by gingival tissues [3] (Fig. 1). Consequently, Open gingival embrasures or black triangles are complex aesthetic and functional problems. Among these problems is that they are noticeably unaesthetic which negatively affects the smile, facilitate retention of food debris which can negatively affect the health of the periodontium [2]. Black triangles are present in more than one third of all adults but are more frequent in adult patients who suffer bone loss [4]. Treatment plan should be discussed with patients before starting dental treatment [3,5].

Fig. 1. Open gingival embrasures or black triangles

Amongst the main objectives of restorative and orthodontic treatment is preserving papilla and avoiding black triangles in the esthetic zone. The etiology of open embrasures is known to be multifactorial. Etiological factors include aging, periodontal disease, loss of height of the alveolar bone relative to the interproximal contact, length of embrasure area, root angulations, interproximal contact position, and triangular-shaped crowns. Its management varies depending on the etiological factor, but is favorably managed by a team work usually including restorative, orthodontic and periodontic treatment. In certain cases correction of these open embrasures is not straightforward and may increase both the complexity and duration of treatment. Sometimes, the decision to close the embrasures or not is difficult especially when the open embrasures are small.

Several studies have investigated the impact of open gingival embrasures. Kokich et al. [5] found that orthodontists considered a 2 mm open gingival embrasure as noticeably less attractive than an ideal smile with normal gingival embrasure. Open gingival embrasures slightly greater than 3 mm were considered less attractive by both general dentists and the general population. Cunliffe [6] found that interdental "black triangles" were rated as the third most disliked aesthetic problem below caries and crown margins.

In this review, the authors highlighted the important etiological factors that predispose to the occurrence of the black triangles. In addition to the common biological factors, dimensional changes of papilla during orthodontic alignment, the relevant consequences of periodontal disease treatment and iatrogenic treatment mishaps such as poor veneers and crowns are factors have also been discussed as factors that may lead to black triangles.

Prevalence and Patient Attitude

One third of adults have unaesthetic black triangles [5]. Other studies found that black triangles were found in 67% of the population over 20 years of age compared with 18% in the population under 20 years of age [3,7,8,9]. A recent study of patient attitudes found patient dissatisfaction with black triangles to rank quite high among aesthetic defects, ranking third following carious lesions and dark crown margins [8].

2. ETIOLOGICAL FACTORS AND MANAGEMENT

2.1 Black Triangles and Periodontal Diseases

Tarnow's study [4] has become a standard in calculation of crestal bone to contact area distance when predicting the stable papilla height. His study, based on 288 patients, showed that when the contact point was within 5.0 mm of the crestal bone, the papilla was present in 100% of samples. However, when the distance was 7.0 mm, the papilla was present in only 27% of samples (Table 1) [4]. Moreover, pocket depths greater than 3 mm will lead to increased plaque retention, inflammation, and possibly gingival recession [7]. Wu YJ also found that a distance of 5, 6, and 7 mm resulted in an open embrasure in 2, 44, and 73% of the cases respectively [10]. These observations indicates that papilla was present in almost 100% of the cases if the distance from the alveolar crest to the contact point was 5 mm or less. When the distance was more than 7 mm, most patients had an open gingival embrasure. Another study by Zetuhas reported similar results [7].

Table 1. Adopted from Tarnow et al. 1992 [4]

Bone-contact distance (mm)	% Full papilla
3	100
4	100
5	98
6	56
7	27
8	10
9	25
10	0

For those with periodontal diseases, it is the bone loss that increases the distance between the contact points and alveolar crest and eventually creates open gingival embrasures. Tarnow's 5.0 mm rule might be skewed in a favorable or unfavorable direction because there are many factors that determine the presence of black triangles such as the root angulations, teeth shape, occlusion and previous trauma. For square-shaped teeth with wide contact points, the chances of 'black triangles' is minimal compared with triangular teeth having narrow, more incisally positioned contact points. Furthermore, the degree of interproximal fill is also dependent on the periodontal biotype. A thick periodontal biotype encourages interdental fill, while a thinner tissue type creates un-aesthetic hollow gingival embrasures [8]. Interdental width seems to be critical in papilla presence. An increased interdental space results in wide papillae base that may be helpful in increasing blood supply to the papilla tip. However, too wide of an interdental distance can be detrimental, stretching and blunting the tip of the papillae and increasing the likelihood of the black triangle [9]. An extreme form of this is the absolute loss of papilla in periodontal disease that has been associated with loss of the interdental papilla because of alveolar bone loss. Chronic periodontitis and tooth brush trauma are other factors that may cause open embrasures. If interproximal tooth brushing is causing gingival recession, and loss of interdental papilla, it should be discontinued until the tissue recover [11,12]. Plaque accumulation and gingivitis are probably higher in people with crowding, but host susceptibility and other factors may also play a contributory role in the occurrence of open gingival embrasures, especially in patients who have been previously treated for periodontal disease [11]. Such patients need to increase their efforts to enhance periodontal maintenance and oral hygiene to avoid further bone loss and recession. The interdental papilla is a small fragile area with minor blood supply which seems to be the major limiting factor in all surgical reconstructive and augmentation techniques [10]. Most surgical techniques published involve gingival grafting, but show only limited success because of insufficient blood supply [10,11]. However, some case studies have reported some degree of success with the combination of sub-epithelial connective tissue grafts and orthodontic therapy [13,14]. A large number of techniques have been proposed to reconstruct the interdental tissues including a pedicle flap [15]; semilunar coronally repositioned flap [16,17]; envelop type flap [18]; autogenous osseous and connective tissue grafts [19] and microsurgery. However, pedicle flaps have provided better results than free gingival grafts as reported by WuYJ. [10]

2.2 Black Triangle and Orthodontic Management

Tooth morphology determines two aspects of gingival undulations. Firstly, the basic tooth forms: circular; square or triangular; determine the degree of gingival scallop. Circular (oval) or square teeth produce a shallower gingival scallop, while triangular teeth form the opposite

as pronounced scallop. The latter predisposes to the black triangles especially with a thin biotype which has a propensity for recession [5]. Furthermore, root divergence of adjacent teeth either occurs naturally or as a result of improper orthodontic treatment [20], triangular-shaped incisor crowns [21] long and narrow teeth [22] are all etiological factors for black triangles. Treatment should be designed to create parallelism of the roots and a favorable position of the proximal contact point of the crowns. In cases where incisors are malposed or overlapping they should be up-righted and moved mesially to correct the inclination of the roots. The mesial cementum enamel junctions of each incisor will then be closer to each other's causing the stretched transeptal fibers to relax. The same soft tissue will fill in the gingival embrasure, which has been narrower [23]. Kurth et al. [20] noticed that a mean root angulation of 3.65° in normal gingival embrasures and an increase in root divergence by 1° increased the probability of occurrence of an open gingival embrasure from 14 to 21%. Bracket repositioning can be performed to converge maxillary incisor roots to reduce or eliminate the open gingival embrasures as paralleling divergent roots decreases the severity of a black triangle. During orthodontic treatment bracket's slots should be bonded perpendicular with the long access of the tooth and not to the incisal edge. If brackets placement is done based on incisal edges, greater root divergence may result causing an open gingival embrasure [10]. In case where the crowns are triangular, interproximal reduction (IPR) of enamel between the triangular crowns will broaden the contact area and also move it gingivally leading to reduced open gingival embrasures. Typically, 0.5-0.75 mm of enamel is removed with IPR for correction of black triangles [10].

The severity of crowding does not influence the incidence of open embrasures as they were found to occur in a similar percentage in patients with incisor crowding of less than 4 mm and those with 4-8 mm of incisor crowding. It was found that when the crowding was more than 8 mm, the occurrence of black triangles increased by only 7% [20]. However, these results were not statistically significant. It was also found that the orthodontic treatment duration did not have any significant effect on the occurrence of open gingival embrasures [3].

2.3 Black Triangle and Restorative Management

Natural interproximal embrasures are constructed with a wide range of cervical shapes and varying root proximities. The gingival usually adapts to a wide range of teeth cervical area shapes. Clinicians can create convenient interproximal shapes if the restorations are smooth and without sharp margina ledge. Composite, porcelain laminate veneers; pink auto-cure and heat-cured acrylics, resins and thermoplastic acrylics, as well as silicone-based soft materials [24,25,26] are all treatment modalities for closure of open gingival embrasure space. Composite and porcelain laminate resin can be extended into the gingival sulcus, however, care must be taken not to impinge on the interdental tissue or violate the biological width [24].

Clark presented a feature case of management of open gingival spaces that includes restorative treatment followed by papilla regeneration [25]. He used flowable composite resin rather than composite paste for the first increment since paste composite would be nearly impossible to place in such "claustrophobic" area without voids and without disturbing the anatomically shaped matrices (Figs. 2a and 2b). In an attempt to reduce the interproximal space and improve esthetics and phonetics Barzilay [26] used two types of removable prosthesis; Molloplast B soft lining material and clear acrylic facing (Fig. 3). However, his type of prosthesis suffers from few limitations. Retention may be difficult, and because of the inherent porosity of the silicone-based material, staining and plaque accumulation may be a problem. Therefore, it would be better if it is made of heat-curd acrylic resin (Figs. 4a and 4b). Retention can be further enhanced by providing implant supported prosthesis when space is available.

Porcelain veneers are considered an excellent choice to eliminate or reduce the black triangle. Nevertheless, care must be taken when planning for anterior crowns or veneers in order to avoid occurrences of black triangles.

This complication can be avoided by proper planning and pre-operative periapical X-rays to carefully assess the level of the alveolar crest bone. The interproximal contact area can be extended apically to compensate for some bone resorption, and the contact area should be

Fig. 2a. Before treatment

Fig. 2b. After treatment with flowable composite

Fig. 3. Molloplast B soft lining material and clear acrylic facing

placed at a point within 5.0 mm of the crestal bone as stated by Tarnow [4].

In a complete denture wearer, knowledge of the ideal papilla location for optimal aesthetics originated from classic literature on prosthetic tooth selection and arrangement. Frush and Fisher [27] attempted to establish guidelines for proper papilla form to enhance denture aesthetics. They described the ideal papilla position and shape in relation to the interproximal contact location and morphology; it was thought that the papilla could enhance a youthful appearance as a complimentary factor in age interpretation.

2.4 Black Triangle and Implant

Close attention to both soft tissues and hard tissues around teeth and implants before, during, and after restorative procedures will greatly increase the probability of successful outcomes [28]. The presence of the dental papilla is critical in achieving an esthetic single tooth dental implant restoration. The vertical and horizontal distances from the implant to the natural teeth, and the distance from the restoration contact point to the bone level of the natural teeth are paramount criteria that could be utilized to predict the presence or absence of the papilla. These criteria are based on studies involved natural teeth and implant restorations [4,29,30].

To preserve the interdental papilla and allow for adequate oral hygiene, 1.5 - 2.0 mm of space is needed between the implant and the tooth on each side. Therefore, 7 mm of mesiodistal space must be created between the adjacent teeth [31]. After the appropriate amount of coronal space has been determined, it is necessary to evaluate the inter-radicular spacing. The minimum inter-radicular distance required is generally 5-7 mm for a single implant placement.

Grunder [32] reported an excellent papilla results for single tooth implant restoration even when the distance from contact point to the implant bone was 9 mm, whereas, Tarnow et al. [4] concluded that all papilla were present in the natural teeth when 5 mm or less was present from the contact point to the crestal bone and less than 50% when the distance was over 6mm. In another study by Tarnow et al. [29] crestal bone loss was evaluated in relation to horizontal inter-implant distance. In this study it was reported that increased crestal bone loss would occur if the inter-implant distance was less than 3 mm. Their findings lacked statistical analysis that examined significance at an acceptable level of confidence. In another study by Mark et al. [33] describing the relationship between horizontal implant-tooth distances and the presence of papilla,' they reported that the distance from the contact point to the implant increased the chance of loss of papilla significantly. They also found that there was no difference between delayed or immediate provisionalization and papilla scores.

Fig. 4a. Patient with black triangles as a result of periodontal disease

Fig. 4b. Same patient with a heat-cured acrylic prosthesis masking the black triangle

In cases where two implants are placed adjacent to each other, open gingival embrasures are more pronounced [34]. Selective utilization of implant with a smaller diameter at the implant-abutment interface may be beneficial when multiple implants are to be placed in the esthetic zone so that a minimum of 3 mm of bone can be retained between them at the implant-abutment level [29].

3. CONCLUSION

Open gingival embrasures or black triangles often pose complex aesthetic and functional problems that are noticeably unaesthetic and negatively affect the smile. A multidisciplinary approach must be considered mandatory if a successful clinical outcome is to be achieved. All etiological factors and treatment alternative must be discussed with the patient before starting the treatment

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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