







Minimally Invasive Cosmetic Restoration of Teeth Associated with Open Gingival Embrasures. Descriptive Case Series

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ABSTRACT

The aim of this study is to evaluate the performance of the restorations and soft tissues at 2 years using direct composite resin with injection molding technique to solve open gingival embrasures, also known as black triangles.

Materials and Method: An observational study of a case series was conducted for the treatment of black triangles. The criteria evaluated in each of the restorations were: color stability, polishing, maintenance of surface gloss, staining in the tooth/restoration margins, secondary caries, radiographic appearance of the restored emergence profile, probing depth and bleeding on probing (of the restored proximal surface), presence of plaque (of the restored proximal surface), detachment, delamination, and fracture of the restoration. The following patient satisfaction criteria were evaluated using the visual analog scale (VAS): aesthetic, functional and overall satisfaction.

Results: A total of 36 restorations were performed in the anterior aesthetic area between canines (24 upper and 12 lower). The mechanical and biological survival rate of restorations were both 100% (95%CI: 90.3–100%). Regarding mechanical complications, there were no restorations showing secondary caries, alteration of color, staining in the tooth/restoration interface, detachment, delimitation or fracture during the entire follow-up (0%; 95%CI: 0–9.7%). Regarding biological complications, there were no restorations measuring probing depth higher than 3 mm or showing an unusual radiographic appearance during the entire follow up (0%; 95%CI: 0–9.7%).

Conclusions: The composite injection technique using anatomical matrices is a cost-effective, minimally traumatic, predictable, and reproducible approach to achieve anterior black triangles closure and creation of pseudopapillas.

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Introduction

The treatment of open gingival embrasures areas, also known as black triangles, has always been a frequent reason for consultation in daily practice. It is undoubtedly one of the most important unaesthetic sequelae of periodontal disease.¹ Cunliffe et al. evaluated in 2009 the perception of 80 randomly selected patients in terms of the number of visible black triangles and their severity. They concluded that the presence of black triangles was the third most unpleasant aesthetic problem after caries and dark crown margins.²

The etiology of black triangles is multifactorial, depending on the interproximal space between the teeth, the distance between the position of the contact point and the bony ridge, the gingival biotype, the age of the patient, the severity of the periodontal disease, the presence of divergent roots and, finally, the morphology of the tooth and whether it is more or less predisposing

(triangular), or an inadequate contour of a prosthetic crown and/or restoration.³

One of the most frequent moments for the appearance of black triangles is after orthodontic treatment. Kurth and Kokich⁴ published a study in 2001 with 337 patients from their private practice to assess the prevalence of black triangles between the upper central incisors after orthodontic treatment. The study showed that the prevalence of incomplete papillae between the upper incisors was approximately one third of the population. Another classic study by Burke et al.⁵ in 1994 estimated that 15% of adolescent patients undergoing orthodontic treatment for crowding of the upper incisors could expect the presence of black triangles after treatment.

Surgical techniques such as platelet-rich fibrin (PRF) or connective tissue graft (CTG) in papilla reconstruction to treat

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these sequelae have a greater or lesser degree of recurrence over time.⁶ The limited blood supply to the papilla is a problem that determines the reaction of this tissue to any trauma or intervention, however minor. A recent review published in 2020 by Zhang et al.⁷ concludes that minimally invasive procedures, such as hyaluronic acid or low-power laser photobiomodulation, still require further observation to confirm their long-term efficacy.

The most reproducible and cost-effective alternative to solve the black triangles would be a restoration driven papilla regeneration⁸ using direct composite resin but in a particular way called “injection molding composite technique.” This technique is based on using simultaneously flowable composite and heated conventional composite (nanofiller/microhybrid) in combination with anatomical clear mylar matrices (Bioclear, Washington, USA). This is also applicable to class II restorations,⁹ diastemas and direct veneers.¹⁰ The injection molding technique has the advantages of making a homogeneous monolithic restoration, stronger compared to composite layering,¹¹ the result will be a restoration ultra-polished and without staining in contact with the matrix. The main disadvantage is the color, as it is recommended to use only the body or universal shade, it is impossible to achieve the translucency effects of layering.

The objective of this clinical research was to analyze, by means of a 2-year longitudinal descriptive case series, the periodontal and mechanical performance of composite resin restorations bonded in the interproximal areas of anterior teeth with absence of gingival papilla through injection molding technique to solve the black triangles.

Materials and Method

An observational study of a series of cases was carried out for the treatment of black triangles using the injection molding technique with composite resin in the Dental Clinic of the Faculty of Medicine and Dentistry of the University of Valencia through one operator, Antonio Mendoza Rodriguez. DDS. (A. M-R) between November 2020 and February 2021. The study protocol was approved by University of Valencia Ethics Committee for Research Involving Humans (procedure n°: 2404840/2022). The study protocol fulfilled guidelines established in the Declaration of Helsinki. All study participants received full information on the study objectives, the procedures involved, alternative treatment options, and the risks involved; all study participants gave their informed consent to participate in the study.

The inclusion criteria were the following: patients between 30 and 60 years of age, of any sex, in good general health, who presented black triangles in the aesthetic area between both upper and lower canines, regardless of the etiological factor. The selected patients signed a specific informed consent detailing the clinical procedure to be performed.

The exclusion criteria were: the tooth to be treated should not have a plaque index equal to or greater than 2, periodontal pocket, gingival hypertrophy and/or dental mobility grade II and III, presence of necrosis, fractures and prosthetic restorations. Patients who presented traumatic brushing, frequent

consumption of acidic foods or drinks, presence of diabetes, coagulopathies, hemostatic and hormonal alterations, gastroesophageal reflux, smoking habit of more than 10 cigarettes/day, patients being treated with drugs whose effects. secondary conditions provide for gingival hypertrophy (e.g. hydantoins) and the presence of any physical or psychological condition that prevents voluntarily giving informed consent to participate in the study.

Before starting the study, all patients received oral hygiene instructions, a basic periodontal examination, conventional scaling with ultrasound, and dietary advice focused on the prevention of non-cariou cervical lesions.

A clinical study was carried out analyzing criteria based on the restoration and its environment, as well as criteria based on patient satisfaction with the treatment received. The criteria evaluated in each of the restorations were: color stability, polishing, maintenance of surface gloss, staining in the tooth/restoration margins, secondary caries, radiographic appearance of the restored emergence profile, probing depth and bleeding on probing (of the restored proximal surface), presence of plaque (of the restored proximal surface), detachment, delamination, and fracture of the restoration. The following patient satisfaction criteria were evaluated using the visual analog scale (VAS) with a score of 1–10: aesthetic, functional and overall satisfaction.

Before beginning the restorative procedures, periapical radiographs (Carestream RVG 142, Atlanta, USA) of the area to be restored (anterior upper or lower) were performed, and the initial probing depth was determined. Local infiltrating anesthesia with epinephrine (Ultracain, Normon, Madrid, Spain) was applied in the treatment zone. The restorative protocol is known as a Bioclear method and was conducted according to the use of a patented matrix system (Bioclear, Washington, USA) by Clark, D,^{8–10} together with a refined technique that simultaneously uses flowable composite and heated conventional composite (nanofiller/microhybrid).

The clinical restorative procedure consists of 10 steps that must be performed in order.¹² (Figures 1–9). All the details (pictures, video and material references) are extensively described in the protocol recently published by us on the open access platform: <https://www.protocols.io/view/injection-molding-technique-correcting-the-dreaded-5qpvo35obv4o/v3>.

A control visit was made two weeks after the procedure, where new periapical radiographs of the restored area were taken to assess the new emergence profile created with the restoration, determining its physiological aspect and ruling out the presence of burrs or undercuts. Subsequently, patients were monitored at one and two years. In the control visit one year later, the parameters included in the restoration section and its environment described above were evaluated. Tissue health of the restored area was evaluated based on the presence of gingival displacement measured in millimeters using a periodontal probe (PCPUNC156; Hu-Friedy, Frankfurt, Germany), the presence of plaque (determined as present or absent by visual inspection), the presence of bleeding (determined as present or absent by visual inspec-

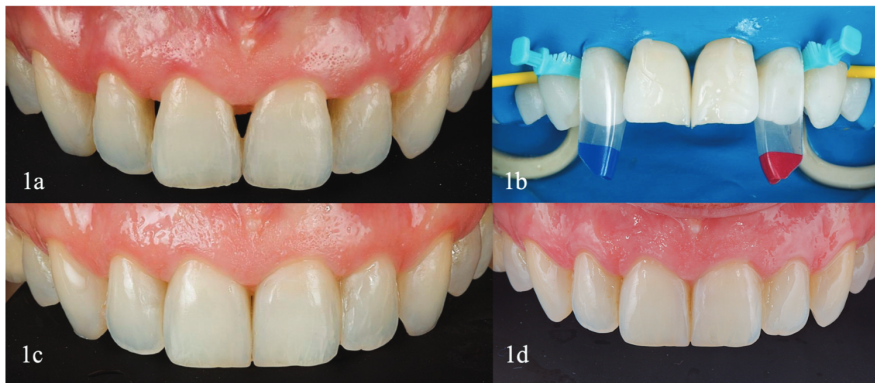


Figure 1. Clinical case 1. (a) Initial intraoral front view. (b) Detail of the isolated teeth. Anterior HD diastema closure upper mesial-distal. Bioclear matrix systems. Bioclear was used to treat the central black triangle. The specific matrices for black triangles installed on the sides (black triangle kit. Bioclear matrix systems. Bioclear) can be seen, they are color coded and the red one has a lower profile than the blue one, which allows us to close a larger area of the anterosuperior sector in which the black triangles can be seen. (c) Two weeks review. (d) Two years review, highlighting the periodontal health and restorations integrity.

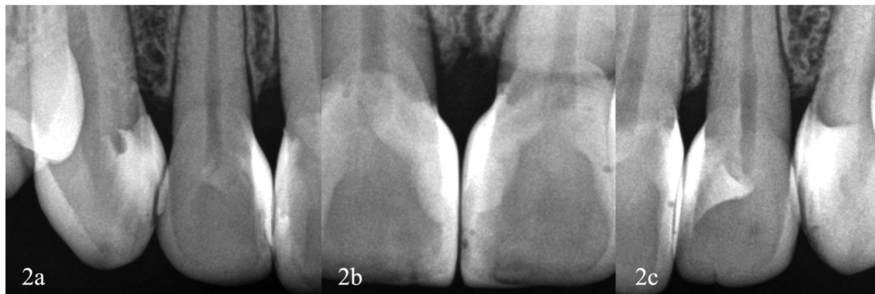


Figure 2. Clinical case 1. Two weeks radiographic control composition to check the adaptation and the absence of retentive areas, the radiopacity of the composite allows us to observe the new artificial amelocementary junctions proximally. (a) Adaptation of composite in the papilla area from right mesial upper canine to distal upper right central incisor. (b) Good composite adaptation between central incisors drawing the new natural emergence profiles. (c) Adaptation of composite in the papilla area from left distal upper central incisor to mesial upper left canine.



Figure 3. Clinical case II. (a) Initial intraoral front view. (b) It was performed a back triangles closure from canine to canine. Anterior HD an DC diastema closure upper mesial-distal. Bioclear matrix systems. Bioclear was used. (c) Two weeks review. (d) Two years review, highlighting gingivitis due to plaque accumulation and loss of polish because the patient never returned to maintenance.

tion) and the status of the restoration (color stability, polishing, maintenance of surface gloss, detachment, delamination and/or fracture of the restoration if present by visual inspection).

McNemar's test was used to assess changes in the presence of complications between 1-year and 2-years. Chi-squared independence and Fisher's exact test was used to assess the relationship between the different complications

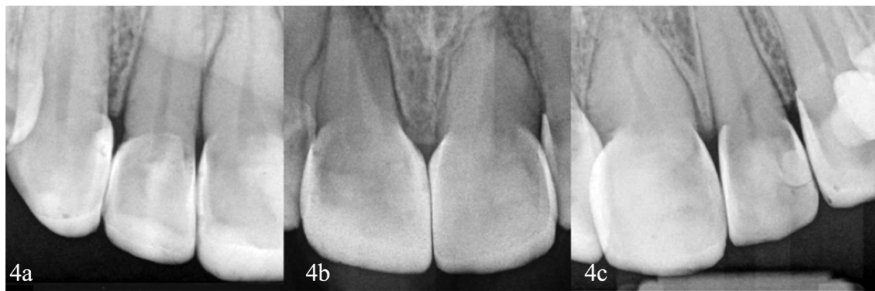


Figure 4. Clinical case II. Two weeks radiographic control composition to check the subgingival marginal composite integrity and the absence of gaps and retentive areas, the radiopacity of the composite allows us to notice the pores absence and the continuity of the restoration without undercuts. (a) Adaptation of composite in the papilla area from right mesial upper canine to distal upper right central incisor. (b) Excellent adaptation of the composite between the central incisors drawing the new natural and progressive emergence profiles. (c) Adaptation of composite in the papilla area from left distal upper central incisor to mesial upper left canine.

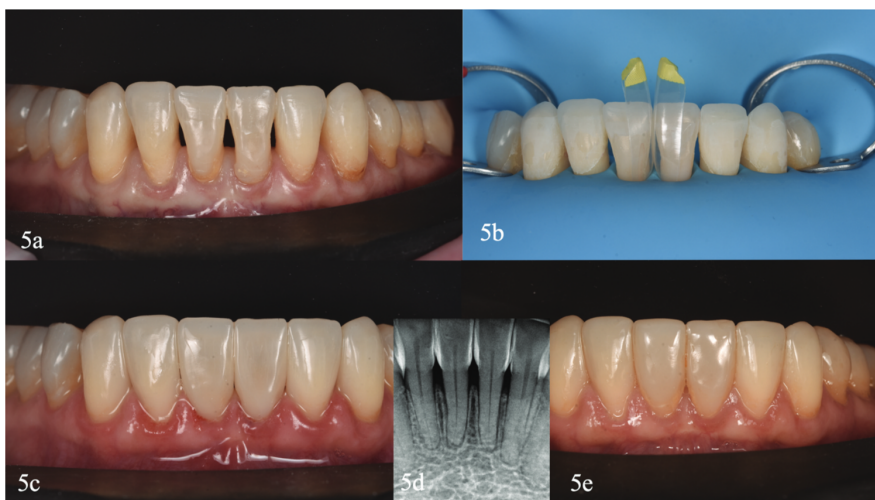


Figure 5. Clinical case III. (a) Initial lower intraoral front view. (b) Detail of the isolated teeth. The small yellow specific matrices for black triangles installed on the central black triangle (black triangle kit. Bioclear matrix systems. Bioclear) can be seen. (c) Immediate result just after removed the rubber dam. (d) Two weeks radiographic control (e) Two years review, highlighting the periodontal health and good polish of the restorations.

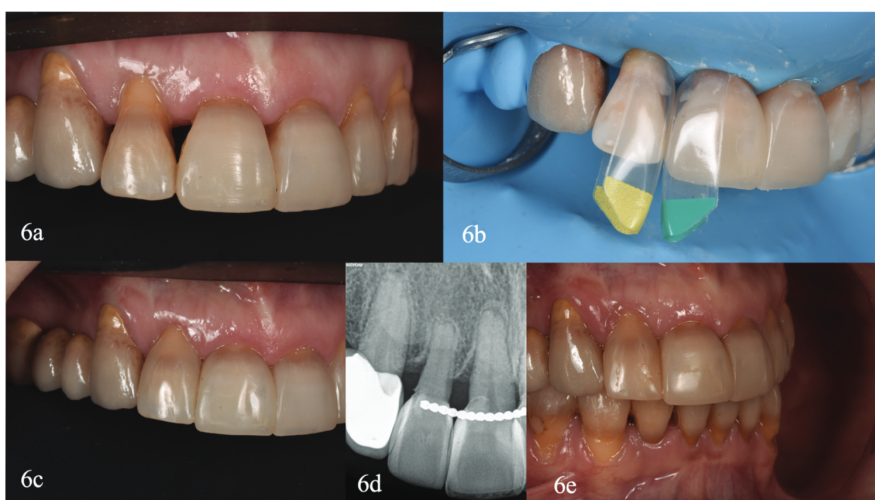


Figure 6. Clinical case IV. (a) Initial intraoral lateral view. (b) Detail of the isolated teeth. The largest yellow and green specific matrices for black triangles were selected (black triangle kit. Bioclear matrix systems. Bioclear). (c) Two weeks clinical control (d) Radiographic control at two weeks. (e) Two years review, highlighting the restoration integrity.



Figure 7. Clinical case V. (a) Detail of de initial intraoral lateral view. (b) Detail of the isolated teeth, the large red one can be seen in place, the distal right lateral embrasure. (c) Two weeks clinical control. (d) Radiographic control at two weeks. (e) Two years review, highlighting the restorations integrity.

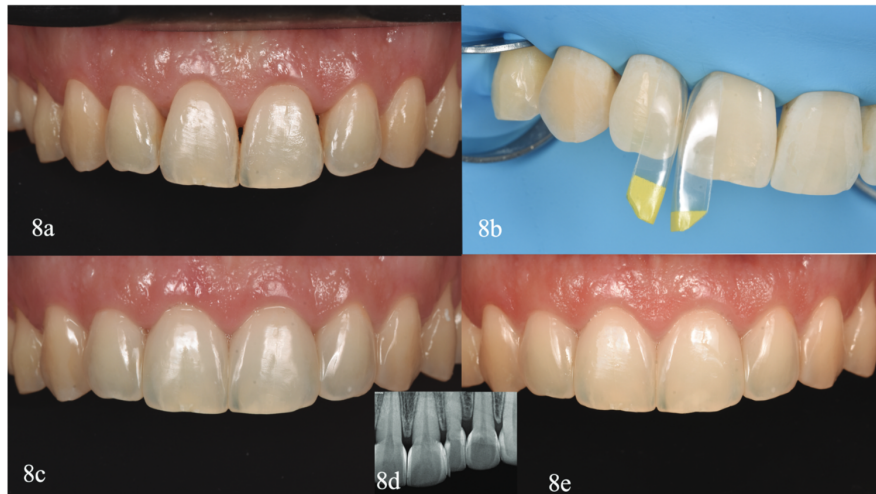


Figure 8. Case VI. (a) Initial intraoral front view. (b) Detail of the isolated teeth, example of two large yellow specific matrices for black triangles were selected (black triangle kit. Bioclear matrix systems. Bioclear) to closure the black triangle between mesial right upper lateral and distal right upper central incisor. (c) Two weeks clinical review. (d) Two weeks radiographic control composition to check the perfect adaptation of composite and the absence of retentive areas. (e) Two years review, highlighting the amazing periodontal condition and the integrity of the restorations.

at the same time point. The level of significance was set at 5% ($p < .05$).

Results

Seven patients (4 females and 3 males; mean age 52 ± 4 years) black triangles in the anterior area, were treated with composite resin using the injection molding technique. A total of 36 restorations were performed in the anterior aesthetic area between canines (24 upper and 12 lower). We considered one restoration for each tooth regardless of whether both proximal surfaces (mesial and distal) or only one of them (mesial or distal) were treated.

The mechanical and biological survival rate of the restorations were both 100% (95%CI: 90.3–100%). Regarding

mechanical complications, there were no restorations showing secondary caries, alteration of color, staining in the tooth/restoration interface, detachment, delimitation, or fracture during the entire follow-up (0%; 95%CI: 0–9.7%) (Table 1).

Seventeen restorations (47.2%; 95%CI: 30.9–63.5%) showed slight loss of surface gloss at 1 year. Overall, 18 restorations (50%; 95%CI: 33.7–66.3%) at 2 years (12 slight and 6 strong). Seventeen restorations (47.2%; 95%CI: 30.9–63.5%) needed polishing at 1 year, increasing to 18 (50%; 95%CI: 33.7–66.3%) at 2 years.

Regarding biological complications, there were no restorations measuring probing depth greater than 3 mm or showing an unusual radiographic appearance during the entire follow up (0%; 95%CI: 0–9.7%). Two restorations (5.5%; 95%CI: 0.7–18.7%) showed bleeding on probing at 1 year, increasing to 6 (16.7%; 95%CI: 4.5–28.8%) at 2 years. Seventeen restorations

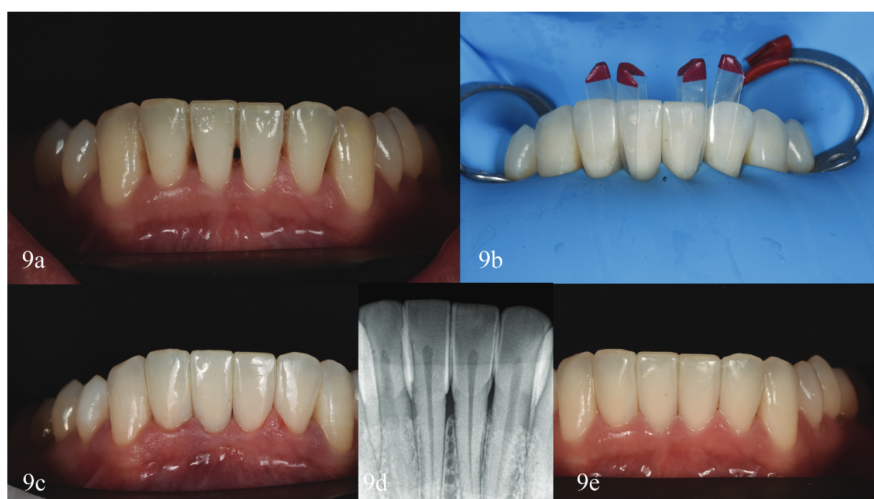


Figure 9. Clinical case VII. (a) Initial lower intraoral front view. (b) Detail of the isolated teeth, the small red specific matrices for black triangles installed can be seen, to do the injection molding procedure at the same time (black triangle kit. Bioclear matrix systems. Bioclear). (c) Two weeks clinical review. (d) Two weeks radiograph control, (e) Two years review, highlighting the stability of periodontal health and good polish.

Table 1. Restoration survival and outcomes (restorative parameters).

Location	N	Color stability	Polishing	Maintenance surface gloss	Secondary caries	Staining tooth/restoration interface	Detachment, delimitation, fracture
Maxilla (case 1) 1 year	6	Yes	Not necessary	Yes	No	No	No
Maxilla (case 1) 2 years	6	Yes	Not necessary	Yes	No	No	No
Maxilla (case 2) 1 year	6	Yes	At one year	No (small insignificant loss)	No	No	No
Maxilla (case 2) 2 years	6	Yes	At two years	No (loss of surface gloss)	No	No	No
Maxilla (case 3) 1 year	6	Yes	Not necessary	Yes	No	No	No
Maxilla (case 3) 2 years	6	Yes	Not necessary	Yes	No	No	No
Maxilla (case 4) 1 year	5	Yes	At one year	No (small insignificant loss)	No	No	No
Maxilla (case 4) 2 years	5	Yes	At one year	No (small insignificant loss)	No	Yes (one tooth of 5)	No
Maxilla (case 5) 1 year	1	Yes	Not necessary	Yes	No	No	No
Maxilla (case 5) 2 years	1	Yes	At two years	No (small insignificant loss)	No	No	No
Mandible (case 6) 1 year	6	Yes	At one year	No (small insignificant loss)	No	No	No
Mandible (case 6) 2 years	6	Yes	At two years	No (small insignificant loss)	No	No	No
Mandible (case 7) 1 year	6	Yes	Not necessary	Yes	No	No	No
Mandible (case 7) 2 years	6	Yes	Not necessary	Yes	No	No	No

Table 2. Restoration survival and outcomes (periodontal and radiographic parameters).

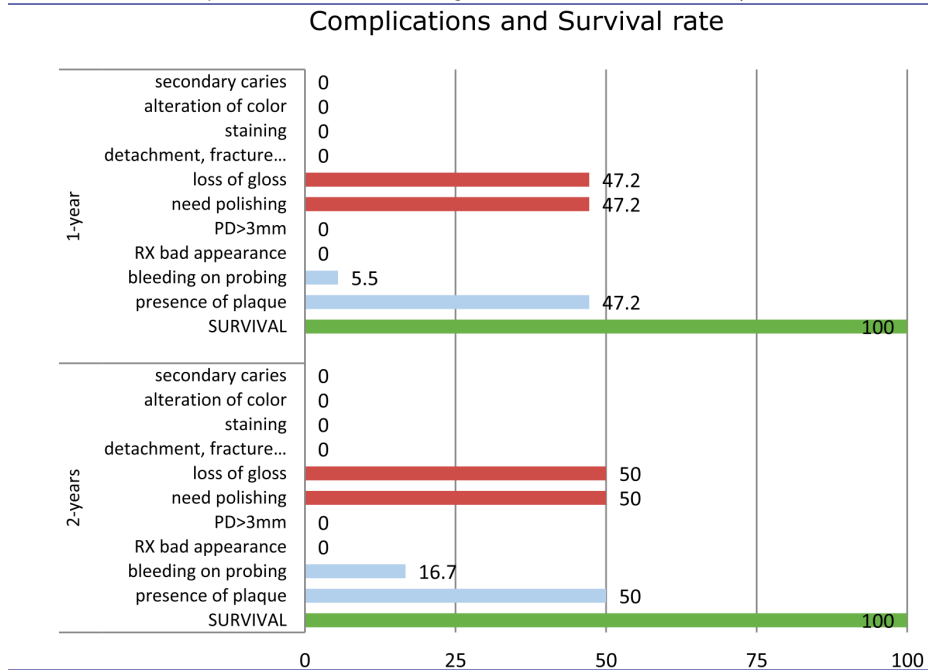
Location	N	Probing depth	Bleeding on probing	Presence of plaque	Radiographic appearance
Maxilla (case 1) 1 year	6	1-3 mm	No	No	Correct emergence profile
Maxilla (case 1) 2 years	6	1-3 mm	No	No	Correct emergence profile
Maxilla (case 2) 1 year	6	1-3 mm	No	Little on proximal surfaces	Correct emergence profile
Maxilla (case 2) 2 years	6	1-3 mm	Yes (2 tooth of 6)	Little on proximal surfaces	Correct emergence profile
Maxilla (case 3) 1 year	6	1-3 mm	No	No	Correct emergence profile
Maxilla (case 3) 2 years	6	1-3 mm	No	No	Correct emergence profile
Maxilla (case 4) 1 year	5	1-3 mm	No	Little on proximal surfaces	Correct emergence profile
Maxilla (case 4) 2 years	5	1-3 mm	Yes (1 tooth of 5)	Little on proximal surfaces	Correct emergence profile
Maxilla (case 5) 1 year	1	1-3 mm	No	No	Correct emergence profile
Maxilla (case 5) 2 years	1	1-3 mm	Yes (1 tooth of 1)	Little on proximal surfaces	Correct emergence profile
Mandible (case 6) 1 year	6	1-3 mm	Yes (2 tooth of 6)	Little on proximal surfaces	Correct emergence profile
Mandible (case 6) 2 years	6	1-3 mm	Yes (2 tooth of 6)	Little on proximal surfaces	Correct emergence profile
Mandible (case 7) 1 year	6	1-3 mm	No	No	Correct emergence profile
Mandible (case 7) 2 years	6	1-3 mm	No	No	Correct emergence profile

(47.2%; 95%CI: 30.9–63.5%) showed plaque at 1 year, increasing to 18 (50%; 95%CI: 33.7–66.3%) at 2 years. All complication rates did not change statistically from 1 year to 2 years. The most relevant increase was bleeding ($p = .125$) (Table 2).

At 1 year, no association was found between bleeding and other complications: loss of gloss ($p = .216$), need for polishing

($p = .216$) or presence of plaque ($p = .216$). Loss of gloss and polishing were always observed in the presence of plaque ($p < .001$). At 2 years, loss of gloss and polishing were significantly more frequent when bleeding ($p = .019$) or plaque ($p < .001$) were present. In addition, bleeding rate was 50% in teeth with plaque and absent in teeth without plaque ($p = .019$) (Table 3).

Table 3. Incidence of complications (mechanical and biological) and survival after one and two years of clinical behavior.



The degree of patient satisfaction was assessed by means of a VAS. Five patients (71.4%) scored 9 for aesthetic, functional and overall satisfaction and 2 patients (28.6%) scored 7. Therefore, the median VAS was estimated at 9 (IQR: 8–9) for all dimensions.

Discussion

Management of the open gingival embrasure area with direct composites should be a familiar tool in routine practice, especially when dealing with young patients. The classic technique of black triangles closure requires great skill on the part of the practitioner.^{13,14} If we want to achieve an optimal aesthetic result and at the same time respect soft tissue, the management of the contact point and emergence profile is essential.¹⁵ With straight acetate matrices and the incremental technique (e.g., Hawe Striproll. Kerr.), the procedure is complex and unpredictable for general or inexperienced dentists.

The injection molding technique with the new bioclear matrices, by providing different sizes and individualized shapes, allows us to directly establish the appropriate height of our contact zone as well as an emergence profile that will perfectly support the soft tissue.^{16,17}

In addition, when closing diastema, special care must be taken with the adaptation of the material in the intrasulcular area, to avoid leaving retentive areas that can become a niche for future lesions, both in hard and soft tissues. This aspect is also an advantage over the conventional techniques, which, although proven to be very effective, have certain aspects that could be improved. For example, transparent acetate strips do not offer sufficient rigidity to

form a progressive emergence profile. In addition, they must be adapted with a spatula, various types of wedges or a lot of manipulation, such as the “pull through technique.”^{18–21}

In the case of using metallic sectional posterior matrices,²² they also do not adapt perfectly to the anatomy of the tooth, especially due to the palatal aspect, and still require a lot of training to not leave excess in areas that are difficult to access for subsequent finishing/polishing. A final advantage of the injection molding technique is that the degree of composite resin conversion is higher compared to incremental techniques since heated composite is used.²³

The main disadvantage is that it does not allow layering; it is a monolithic approach that focuses much more on shape than color. Another issue is the periodontal maintenance, normally these patients use interproximal brushes for hygiene, but now, they must switch to a superfloss and increase the ability to keep the gingival area clean, especially in the new interproximal emergence profile to prevent future periodontal problems.

The presence of the black triangle can have a negative impact on dental aesthetics, as well as gingival health and phonation. Treatment should be considered with every proximal restoration and may include this noninvasive tooth recontouring in an additive manner. Of course, other traditional treatments are always available to solve this clinical dilemma, including orthodontic treatment with interproximal reduction or classic prosthetic intervention. These options are more invasive in terms of tooth structure and require more time and money for the patients and dentists.^{3,24}

Conclusions

Considering the limitations of our study, such as the inclusion of black triangles regardless of the etiological factor, the resin composite injection molding technique using anatomical matrices is a cost-effective, minimally traumatic, cosmetically predictable, and reproducible approach to achieve anterior black triangles closure and creation of pseudopapillas.

The technique also provides good biological and mechanical results in the mid-term, although more longitudinal clinical studies are required in the mid- to long-term to support its clinical predictability.

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