



Marginal Discoloration with Tooth Colored Restorations, Causes, Diagnosis, and Management

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Abstract

Periodontal disease is a major problem affecting human dentition. Early diagnosis and evaluation of the results of periodontal therapy is important for controlling the disease.

Purpose:

Material and Methods: S.

Results: Fs.

Conclusion:

Keywords: Plaque; Non-Surgical Periodontal Therapy; Modified Widman's Flap

Introduction

The longevity of restorations is dependent upon many factors, including operator skill, the materials and techniques used, the criteria for replacement, patient compliance with oral hygiene advice, the oral environment and its contribution to the patient's susceptibility to caries, and possibly, the means by which the treatment is funded [1].

Ideal restorative materials must have the ability to protect exposed dentine from bacteria and their toxins [2]. The interface between restoration and dental substrate is an area of clinical concern that can result in secondary decay, marginal discoloration, and pulpitis [3]. For that reason, perfect sealing should be the plan of each clinical performance [4].

Marginal Discoloration

As a result of colored molecules infiltration at the tooth-restoration interface, marginal staining will occur. Macroleakage and marginal staining are the end result of adherence breakdown after microleakage begins at the marginal surface [5].

Causes of Marginal Discoloration

Presence of excess filling material, a deficit of filling material at the margin and the formation of gaps can be considered as the primary factors of marginal discoloration [6,7].

Several factors can cause defects at the tooth-restoration interface and leads to marginal discoloration, such as unsatisfactory restoration placement and finishing technique, or by inadequate bonding and stress fatigue.

Resin based composites shrink on polymerization and can generate high stresses at bonded surfaces in confined cavity preparations [8]. Failure at the tooth-restoration interface can happen if the forces of polymerization contraction exceeded adhesive bond strength.

Diagnosis of marginal staining

To control the quality of restorations, the most commonly used direct method is the United States Public Health Service (USPHS) evaluation system [9].

When the USPHS criteria were used to evaluate bulk discoloration and cavosurface marginal discoloration, inter-examiner agreements were relatively poor varying between 68% to 78% and 54% to 72% respectively [10].

Color transparencies was used to evaluate bulk and cavosurface marginal discoloration indirectly, due to the need to develop standardized indirect techniques. The results of Color transparencies were compared to those obtained with the USPHS direct technique. The results indicated poor coloration between the two methods, and the USPHS was considered as the least sensitive [11].

However, several factors can influence the results of indirect evaluation. Such as, the differences in reflectance spectra between restorative materials and tooth structure [12]. As well as surface morphology and specimen thickness [13,14].

Furthermore, the differences in light scattering properties between microfilled and macrofilled composite resins can affect the results of reflectance spectra [15].

Due to the difficulty of performing the indirect method *in vivo*, the USPHS criteria for direct evaluation remains the preferred system for evaluating important characteristics of dental restorations like color matching, secondary caries, cavosurface margin discoloration and postoperative sensitivity [16].

Predicted outcomes from marginal staining

Marginal staining can lead to poor aesthetic, penetration of bacteria as a result of gap presence which can cause sensitivity and secondary caries [17].

Every plaque retention site is a possible site for secondary caries to occur [18].

The stability of tooth-restoration adhesive interface, can be compromised as a result of fluids along the interface, which can cause hydrolytic breakdown of the adhesive resin and the collagen within hybrid layer [19].

Kidd, *et al.* [20] Examined 56 cavity margins, and they found that caries lesions are more likely to be present in the outer enamel and enamel of the cavity wall where the margin was stained. Thus, marginal staining of restorations is likely indicating caries at the cavity walls.

Differential diagnosis in regards to marginal discoloration

Tooth colored restorations usually exhibits marginal staining in different appearance and each has different causes behind it. For example; White line: usually cause by a crack or fissure in the enamel. A white margin can be also a void in the interface space between the bond and the enamel (a brown line is formed after staining of this type void). Gray line: Typically, this discoloration is due to the background being visible through the bonding layer due to a too thick application of the bonding agent. And brown line: staining of the bond layer usually due to excess film thickness. A brown line can also result from micro-leakage at the interface between uncut enamel and the composite restoration where the composite “laps” over the margin [21].

Because of the importance traditionally attributed to microleakage for the occurrence of secondary caries [22], stains at the margins of tooth-colored restorations are prone to be misdiagnosed as recurrent carious lesions [23], leading to replacement of the restoration as preventive measure. However, a correlation between the width of a marginal discrepancy and the presence of recurrent caries only exists when frankly cavitated lesions are detected at the restoration margins [24,25]. As secondary carious lesions are known to be localized and delineated defects, a reconsideration of the conventional treatment approach has been recently recommended. In deciding whether to repair or to replace a defective restoration, a “minimal treatment” should be preferred. Simple re-contouring and re-polishing of small marginal defects should be performed as a first option [23], mainly in patients with a low caries-risk status [26]. Conversely, if any clinical doubt exists in areas prone to plaque accumulation, in presence of larger defects and higher caries risk, an exploratory preparation into the composite material at the tooth/resin composite interface may help in diagnosing the existence and the size of the lesion [23,27]. Being localized in nature, it rarely progress along the tooth/resin composite interface [25]. When sound tooth tissue is exposed, the exploratory cavity may be repaired using a conventional restorative technique [28].

Comparison of different materials regarding marginal discoloration

Packable composite has higher filler content in comparison to hybrid composite, which is essential in reducing shrinkage of the composite during polymerization. Theoretically, the high filler percentage will lead to minimal marginal defect and discoloration [29].

In contrast to this theory, a study done by L Shi, *et al.* [30] compared TPH Spectrum/XenoIII (TS) restorations and the Synergy Compact/One Coat (SC) restorations in regards to marginal discoloration, and found no difference in the results between the two groups. Which is in agreement with another study that compared TPH Spectrum and SureFil (Dentsply) [31].

To evaluate the efficiency of simplified bonding system, a study was conducted to evaluate the initial clinical performance of conventional hybrid resin composite (SpectrumTPH, Dentsply DeTrey GmbH), and packable composite (SureFil, Dentsply DeTrey GmbH, Konstanz, Germany), using a resin adhesive (Non-Rinse Conditioner and Prime & Bond NT, both manufactured by Dentsply DeTrey GmbH). Restorations were evaluated using U.S. Public Health Service-Ryge modified criteria and by using color transparencies and die stone replicas. The results showed Alfa rating (90 percent or higher) for both composites in regards to marginal discoloration, anatomical form, surface texture and surface staining [32].

That was in agreement with another study, where Alfa rating (80 percent or higher) was reported for both packable (SureFil, Dentsply DeTrey GmbH, Konstanz, Germany) and a conventional (SpectrumTPH, Dentsply DeTrey GmbH) resin-based composite [31].

The two-year performance of SureFil (Dentsply DeTrey GmbH, Konstanz, Germany) packable posterior resin-based composite in Class I and II restorations was studied by Turkun., *et al.* there were five Bravos for surface staining and three for marginal adaptation. One restoration had marginal discoloration at the one-year recall period and four others had marginal discoloration at the two-year recall period ($P < .05$) [33].

A Low shrinkage composite (Quixfil) was compared with a nano-hybrid composite (Grandio), in Class I and Class II restorations over 12 months period. Both groups reported no marginal discoloration or anatomical form loss [34].

In a two years *in vivo* study, 88 Class I and 32 Class II restorations were restored using either (Z100 (3M Dental Products Div.), Clearfil Ray-Posterior (Kuraray Co. Ltd.) or Prisma TPH (Caulk/Dentsply). At the end of the two years recall period, no changes were reported in regard to color match, secondary caries or marginal discoloration ($P \geq .05$) [35].

Class II restorations with Ariston PHC Composite (Vivadent, Schaan, Liechtenstein), reported significantly less marginal discoloration in comparison to Class II restorations with Tetric (Vivadent, Schaan, Liechtenstein) (10% against 38.5%), and there was no significant difference between the two materials regarding marginal adaptation or post-operative sensitivity. pooling of the self-etching adhesive that was used with Tetric restorations between the matrix and walls of proximal boxes, could be the cause of marginal discoloration in proximal margins of the restorations [36].

Dyract AP and F2000 reported best clinical performance in comparison to Heliomolar, over 24 months evaluation period. Regarding color match, secondary caries, marginal discoloration and marginal adaptation [37].

The sonic energy applied through hand piece during application of Sonicfill Bulk Fill composite will lead to ultra-sonic activation of specific modifiers that causes the viscosity to drop (up to 87%), increasing the flowability of the material which facilitate placement and adaptation to cavity walls [38]. Swapna., *et al.* compared conventional Bulk Fill composites (Tetric Evo Ceram, and X-tra fil) with SonicFill Bulk Fill composite. The results showed that SonicFill Bulk Fill composite reported less microleakage than the other materials [39]. Another clinical study also justify their result with the same previous reason, where they reported that Tetric N Ceram Bulk Fill exhibited 76% alpha scores after 12 months with regard to margin-

al discoloration and integrity, whereas Sonic Fill recorded 90-95% alpha scores in the same regard [40].

Comparison of different adhesive system regarding marginal discoloration

A three years clinical study was conducted to compare the performance of one- and two-bottle adhesive systems used to restore non-carious cervical lesions, in terms of sensitivity, marginal integrity, retention and marginal discoloration. They found that there is no statistically significant differences between the three adhesives, with an overall average of 34% of the restorations showed marginal discoloration [5]. Long-term marginal discoloration always has been a problem and may remain a significant problem even for the newer adhesives such as SB and OCB [41,42].

Better rates of no marginal discoloration of 88 to 90 percent after a three years period, was reported in another study for one-and-two bottle adhesives [43,44].

Hybrid resin-based composite was used in 99 Class V restorations using either a filled, ethanol-based adhesive (OptiBond Solo [OS], SDS Kerr, Orange, Calif.) or an unfilled, acetone-based adhesive (Prime and Bond 2.1 [PB] Dentsply Caulk, Milford, Del). The examiners evaluated the restorations at baseline and for as long as eight years after placement using modified USPHS criteria, marginal discoloration was reported on 55 % of the retained OS restorations and on 31% of the retained PB restorations, no secondary caries was detected around any of restorations [45].

A study done by Loguercio., *et al.* [46] Compared an experimental self-etch adhesive (Experimental EXM-618 Self-etch (3M ESPE)) with etch-and-rinse adhesive (Adper Single Bond (3M ESPE, St. Paul, Minn.)), over a period of 36 months. They reported Bravo ratings to 46.6 percent and 16.6 percent for each adhesive system respectively regarding marginal discoloration.

This discoloration occurred at the enamel margin for the majority of the restorations, which seems to be a common finding in clinical studies in which Prompt L-Pop was used [47-49].

That was also confirmed by a study that found restorations with Filtek Supreme and Scotchbond MP excel the restorations with Adper Prompt L-Pop with regard to the marginal discoloration and marginal adaptation over three years evaluation period. And they considered that as result from hydrolytic degradation of the bond [50]. Perhaps this is caused by the high molecular weight of the copolymer of the polyalkenoic acid, incorporated in the hybrid layer [51,52].

The inferior etching ability of one step self-etching adhesive systems could be reason behind the high marginal discoloration results, some studies suggested conditioning the enamel surface with 35% phosphoric acid prior to its placement, in order to improve the resin-enamel bond strength [53,54]. A clinical trial found lower percentage of marginal discoloration with using phosphoric acid prior to the application of a mild two-step self-etch adhesive system [55].

Another suggested technique to improve the performance of self-etch adhesive systems, is by increasing the application time of the primer twice as the recommendation by the manufacture. This technique has been shown reduction in enamel microleakage [56], as well as improvement in bond strength of some self-etch adhesives. But no improvement was reported for Adper Prompt L-Pop [57].

Comparison of different indirect restorations regarding marginal discoloration

A study was done to compare the clinical performance of three nanofilled composite restorative materials and two indirect inlay restorative materials, a total of 100 restorations were placed in molars of 54 patients. Restorations were evaluated using modified USPHS criteria at baseline, 6 months and 12 months period. In regards to marginal discoloration 85% of the indirect restorations received Alpha rating while it was 95% for direct composite restorations. None of the restorative materials received a Charlie rating in this study [58].

Another two-year clinical evaluation of (Filtek Supreme XT (FS), 3M ESPE) restorations reported similar marginal discoloration results as the previous study [59].

A prospective clinical trial evaluated 47 composite inlays (Tetric, blend-a-lux, Pertac) and 24 ceramic inlays (Empress) for clinical acceptability as restorative materials in posterior teeth and provided 2-year results. It was found that Ceramic inlays produced significantly better "anatomic form of the surface" ($P = 0.038$) and "integrity of the restoration" values ($P = 0.043$). Inlays in small cavities exhibited superior "marginal integrity" ($P = 0.026$) and "marginal discoloration" values ($P = 0.034$) [60].

Santos, *et al.* evaluated the clinical performance of two types of ceramics: a slurry-powder ceramic (Duceram Plus, Degussa) – D and a hot-pressed leucite-based glass-ceramic (IPS Empress, Ivoclar Vivadent) – IPS. Eighty-six restorations, 44 IPS and 42 D, were made by one operator. All restorations were cemented with the dual-resin cement (Variolink, Ivoclar-Vivadent) under rubber dam

and were evaluated using the modified USPHS criteria. After 6 months 100% of the restorations were analyzed and the following received Bravo rating: color match – IPS (4.55%) and D (9.52%); surface texture – IPS (2.27%) and D (11.9%); marginal discoloration – IPS (6.82%) and D (4.76%) and marginal integrity – IPS (4.55%) and D (7.14%) [61].

Another study done by the same author compared seventy-four restorations - 37 IPS and 37 D - cemented in 34 patients. Twenty-four premolars and 50 molars received Class II cavity preparations, totaling 28 onlays and 46 inlays. Their results showed that only the following received "Bravo" ratings: marginal discoloration: IPS (24.32%), D (13.51%); marginal integrity: IPS (10.81%), D (8.11%); color match: IPS (5.41%), D (5.41%); surface texture: IPS (2.70%), D (10.81%). No "Charlie" or "Delta" scores were given to the restorations. They concluded their results by that among the analyzed criteria, only marginal discoloration differed statistically significantly from the results of the baseline examination for IPS Empress ceramic restorations ($p = 0.008$). No significant differences were found between the two ceramics. The two ceramic systems demonstrated excellent clinical performance after a period of 1 year [62].

And after two years follow up they found that the following received Bravo ratings: marginal discoloration-IPS (31.82%), D (23.81%); marginal integrity-IPS (18.18%), D (11.9%), color match-IPS (4.55%), D (9.52%) and surface texture-IPS (2.27%); D (14.29%). No "Charlie" or "Delta" scores were attributed to the restorations [63].

Management of restorations exhibits marginal discoloration

Marginal staining can be a significant source of concern when esthetics is considered; however, another important consideration should be the significant amount of healthy tooth structure that is lost when the restoration is completely replaced. Furthermore, good marginal adaptation is important to reduce plaque accumulation.

When the dentist faces a particular restoration which deviated from ideal and doubts the need to replace it, a better alternative might be to monitor the restoration over a period of time. Certainly, caries risk assessment, patient oral hygiene profile, and preventive measures should be taken into consideration when this option is selected. If the questionable area has a particular influence on marginal adaptation and marginal staining, a better and equally predictable option might be to repair the affected area

of the restoration, this option will certainly be more conservative in the preservation of healthy tooth structure.

If the defective restoration has a Bravo rating for marginal adaptation and marginal staining, the restoration may need to be treated to avoid further deterioration. Repair and replacement would offer the most predictable results, and repair would be the most conservative option of treatment [64].

To investigate the effectiveness of alternative treatments to the replacement of resin based composite (RBC) restorations a prospective longitudinal cohort clinical study was done by Gordan, *et al.* Forty patients aged 27 to 77 years (mean = 55) with 88 RBC restorations, with one or more features that deviated from ideal, participated in the study. They were assigned to five treatment groups: repair (N = 25), sealing of defective margins (N = 13), resurfacing (N = 18), replacement (N = 16), and the no-treatment group (N = 16). The repair, sealant, and replacement groups presented significant improvement when compared with the no-treatment group for marginal adaptation and marginal staining. They concluded their results that RBC restorations that present less-than-ideal marginal adaptation and stained margins are better off being repaired. The clinical significance of their results is that repair of resin-based composite (RBC) restorations is a conservative option for treatment of RBC restorations with inadequate marginal adaptation and marginal staining [64].

In the same way, non-carious, degraded or ditched margins may be successfully restored by re-finishing and re-polishing methods [65]. Based on the same concepts, no replacement of any restoration with bulk discoloration in aesthetic areas should be planned without first evaluating that the unsatisfactory appearance can be treated and improved by resurfacing/veneering or refurbishing procedures. Similarly, clinical reports showed that bulk fractures limited to the composite material may be repaired by bonding a new resin composite to the old restoration [23].

Therefore, it has been suggested that in the temporary absence of evidence-based guidelines, the clinical choice of repair rather than replacement must be based on the individual caries-risk status assessment, the professional evaluation of benefits versus risks, and the conservative principles of cavity preparation [26,66,67].

A study was done with an aim to present a small cross-sectional survey of composite restoration clinical attributes associated with choices for replacement. Ninety-four composite fillings selected to be replaced were included in this study. A questionnaire was filled out after each procedure in order to assess the clinical conditions

that indicated the restoration replacement. The results showed that composite shade discoloration was the main cause of restoration replacement (63.8%). Marginal staining (50%), unsatisfactory restoration anatomy (50%), marginal fracture (14.9%), painful symptoms (8.5%), fractured restoration body (4.3%), dental fracture (1.1%) and total displacement of the restoration (1.1%) were conditions that could be associated [68]. In this study, when the clinical signs that were most frequently present in the replaced restoration were analyzed, caries lesions were observed in 79% of the restorations with marginal staining and 70% of the cases with material shade mismatch. Marginal staining is mentioned as a clinical sign of microleakage [5,22] and according to their results, its clinical presence is a good parameter for indicating esthetic restoration replacement.

Another survey found that replacement of resin composite due to marginal discoloration and marginal fracture/degradation together accounted for between 9 per cent (in molars) and 27 per cent (in anteriors). They suspected that the majority of marginal breakdown may have been at dentine/cementum margins. The highest rate for anteriors may reflect aesthetic requirement compared to that of molars, rather than the actual marginal status [69].

In an *in vivo* study in which composite restorations were followed up for a period of 36 months, a high retention rate was observed (86%), even when superficial marginal discoloration and marginal degradation were noted [68].

Ceherli and Altay [70], concluded that after 3 years, marginal discoloration significantly increased but it was still superficial and could be removed by polishing. In a five-year clinical study by Kohler, *et al.* [71] 12.5% failure of restoration had been due to marginal discoloration.

A study was done to test the hypothesis that marginal deterioration and cavo-marginal discoloration may be a predictor of the failure of posterior composite restorations. Longitudinal 5-yr data from the multicentre trial of Occlusion were analyzed, and it was found that restorations with cavo-marginal discoloration at 3 years were found to be 3.8 times more likely to have failed at 5 years than restorations with no cavo-marginal discoloration at 3 years. Moreover, restorations with both marginal deterioration and cavo-marginal discoloration at 3 years failed 8.7 times more frequently than restorations with sound margin at 3 years. It was concluded that clinical investigations of present-day materials for posterior composite should seek to determine if marginal deterioration and cavo-marginal discoloration is an important predictor

of the failure of posterior composites, especially when marginal deterioration and cavo-marginal discoloration occur simultaneously [72].

Conclusions

Marginal discoloration is an indirect indicator of the performance of a bonding technique [73]. Furthermore, the marginal discoloration may be a clinical sign of bond failure between the tooth and restoration interface [74].

The USPHS criteria for direct evaluation remains the preferred system for evaluating important characteristics of dental restorations like color matching, secondary caries, cavosurface margin discoloration and postoperative sensitivity [16].

In case restorations exhibits marginal discoloration with absence of evidence-based guidelines, the clinical choice of repair rather than replacement must be based on the individual caries-risk status assessment, the professional evaluation of benefits versus risks, and the conservative principles of cavity preparation.

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