Short Communication

Decision tree protocol for demineralized gingival margin extension in class II composite cavity preparations

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Summary This study proposed the development of a protocol for class-II preparations with demineralized gingival margins for the improvement of the longevity of restorations. Evidence sources such as location/color/surface hardness/width of demineralized gingival margin with enamel/demineralized enamel (DE)/dentin/cementum were reviewed based on methodological studies and systematic reviews. A decision tree protocol was developed with criteria (i) lesion location: demineralized gingival margins in enamel must be removed, but if close to cementoenamel-junction, color should be evaluated. (ii) Color: yellow/brown lesions must be removed, but if white/opaque, then the surface hardness should be evaluated. (iii) Surface hardness: soft/demineralized gingival margin must be removed, but if adequately hard, width should be evaluated. (iv) Width: lesions less than half-enamel thickness and impenetrable by an explorer, remineralization is possible and the lesion does not need to be removed. A decision tree protocol was set up with the current available literature. Further continued investigations will be needed for the appropriate protocol updates.
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Introduction

Resin-based composite (RC) restorations in Class-II preparations are one of the most common procedures in daily practice. However, they are also one of the most common categories to experience failures, mainly due to weaker adhesion caused by dental enamel at the gingival margin.[1] One possible way to alleviate this problem is to address caries detection tools and apply them to treat the disease. Several studies have reported different approaches to detect carious tissue, such as red fluorescence, infrared transillumination, detecting dies, chemo-mechanical caries removal, self-limiting polymer burs, fluorescence cameras, optical coherence tomography, and lasers.[2] However, to date, there is no diagnostic tool or established method enabling clear identification of the limit of a Class-II RC preparation at the gingival margin. This study proposes a management strategy for Class-II RC preparations at the gingival margin in order to assist dental professionals in clinical decision-making to ensure the longevity of restorations.

Clinical protocol

The International Caries Detection and Assessment System II has reliable reproducibility and high accuracy for *in-vivo* and *in-vitro* detection of carious lesions at all stages. However, subtle changes in demineralized lesions at the gingival margin of class-II preparations (Fig. 1) have not been described.

Decision tree

The decision-making process for the management of gingival margin in class-II cavity preparation was supported by recent scientific literature and/or clinical experience (Fig. 2).

Lesion location

The first criterion to evaluate is the location of the demineralized gingival margin (DGM) (Fig. 2-(A)). Bonding strength and marginal sealing abilities differ significantly in enamel, dentin, and cementum. The lowest microleakage is found when the gingival margin is located in enamel, followed by the cementoenamel-junction (CEJ), and the most occurs in cementum[3] as it does not allow for adequate micro-retention of adhesive materials. As far as bonding strength, the most reliable bonding occurs in restorations where the margin is in enamel.[1] If the DGM is completely in enamel, the lesion should be removed (Fig. 2-(Ai,)), but if DGM is close to CEJ (Fig. 2-(Aii)), the next criterion "tissue color" (Fig. 2-(B)) should be evaluated.

Tissue color

The enamel surface may change color from translucent to opaque or brown in both the cervical region and on smooth surfaces. If a lesion progresses to a moderate stage involving dentin, there may be additional signs of dark gray shadows and translucencies in enamel. The categorization of lesions based on color is often subtle, subjective, and varies with the age of the patient. Since visual and tactile detection methods are highly specific but subjective by nature,[4] additional indicators such as moisture (wet, moist, or dry), optical characteristics, and measures of different bacterial metabolic products (biofilm and acidity) are helpful. Using additional indicators besides visual/tactile methods provides a more accurate and consistent method to assess caries quantitatively.[4] If the demineralized lesion is more yellow or brown in color, and even if the margin is close to the CEJ, the lesion should be removed (Fig. 2-(Bi,②)). If the demineralized lesion is white/opaque, the next criterion "hardness" (Fig. 2-(C)) is evaluated.

Surface hardness

Lesions with the potential to remineralize are tactilely smooth and hard, while non-remineralizable enamel is rough and soft. Tactile perception is also subjective and depends on the operator's experience in performing this technique.[4] The application of pressure to estimate lesion hardness can lead to underpreparation or overpreparation. Underpreparation may either be noticed immediately or later as secondary caries. Overpreparation unnecessarily
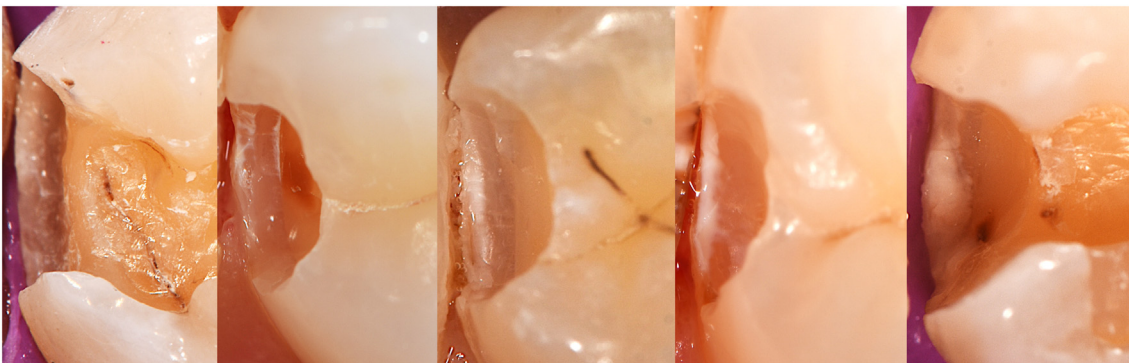

Figure 1 Demineralized gingival margin: variety of the location, severity, color and the width of demineralized gingival margin in class-II preparation. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)
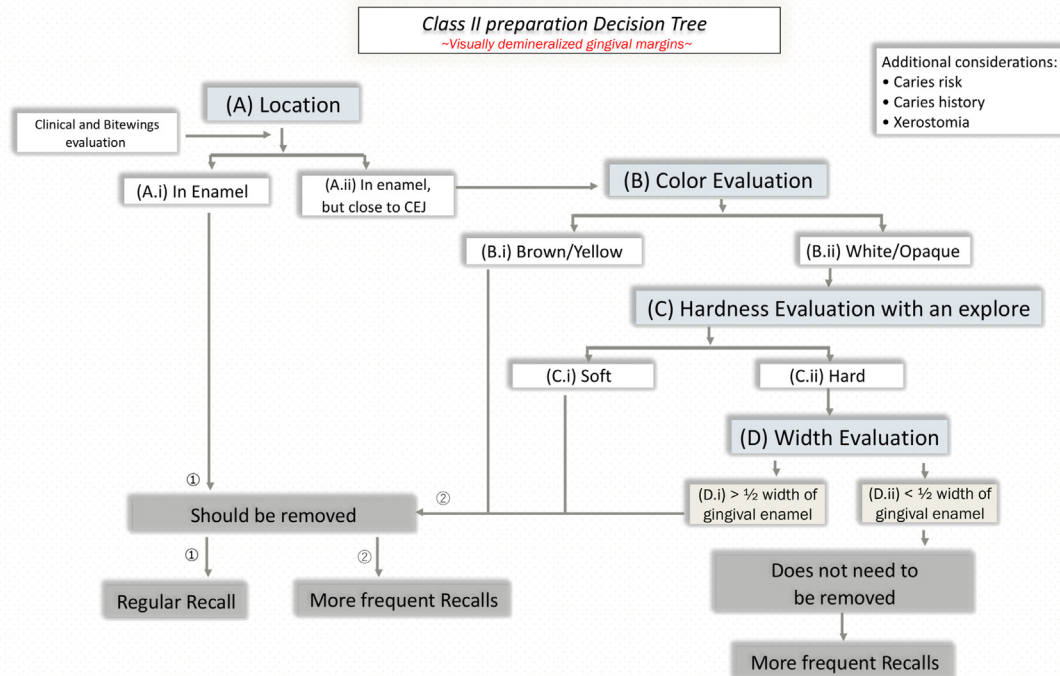
Figure 2 Decision tree protocol of a Class-II preparation.

results in loss of tooth structure.[4] Thus, the combination of tactile and visual examinations may produce higher specificity which is considered more important than sensitivity in decreasing overtreatment. If the demineralized area is soft at the gingival margin, the lesion should be removed (Fig. 2-(Ci,②)). If it is hard (Fig. 2-(Cii)), the next criteria "lesion width" (Fig. 2-(D)) should be evaluated.

Lesion width

Minimally invasive dentistry (MID) should be taken into consideration during treatment selection. Regarding lesion width at the gingival margin, the concept of MID has been applied in some US regional boards. If the lesion does not exceed half the thickness of the enamel and cannot be penetrated by an explorer, remineralization is possible and removal is not indicated (Fig. 2-(Dii)). Preserving the remaining DE at the gingival margin may have other benefits such as improved moisture control, better access during procedures, and early failure detection during subsequent appointments. Also, DE may retain the ability to be remineralized.[5]

Other factors (patient caries risk, caries history, xerostomia)

Clinicians must consider other factors when determining removal of DE, these include the presence of patient caries-risk factors, such as (i) previous caries experience; (ii) *Streptococcus mutans* sampled from saliva or plaque; (iii) lactobacilli sampled from saliva; (iv) buffer capacity; (v) salivary flow rate; (vi) dental plaque/oral hygiene; (vii) dietary habits; and (viii) sociodemographic variables.[6]

Recall system

The frequency of each patient's recall depends on various criteria such as location, presence, and width of DE at the gingival margin, and caries risk factors (Fig. 2).

Discussion

The DGM is one of the major clinical problems for dental professionals and may lead to failures in adhesive restorations. This study sought to propose a management strategy for Class-II preparations at the gingival margin in order to improve the success rate of restorations. The data that was extracted to determine the extent of preparation design in the decision tree comes from methodological studies and multiple systematic reviews testing bond strength in different substrates. To the best of our knowledge, this is the first paper discussing the most appropriate method to visualize the decision-making process of a class-II preparation design at the gingival margin.

One important factor influencing the durability of restorations in different dental substrates is the bonding strength. From the variety of dental adhesives currently available, multiple studies and systematic reviews have shown that etch-and-rinse (ER) adhesives and universal adhesives (UA) with an ER approach may achieve durable bonding strengths (BS) in enamel.[7] On the other hand, three-steps ER and two-steps self-etch (SE) adhesives, along with mild UA may be an appropriate strategy to improve dentin bonding strength.[7] For DE, both ER and UA adhesives with an ER or SE approach may produce a slightly better bonding strength,[8] and for cementum, ER and mild SE adhesives may promote higher bonding strength to cementum.[9] Once the steps in the decision tree have been followed, bitewings should be taken

periodically to look for signs of leakage or secondary infection not visible clinically.[10] Recalls every three months with bitewings every six months may be appropriate in high caries risk patients and for lesions near the CEJ.[10] For lesions being monitored or above the CEJ, a recall period of six months with bitewings yearly should suffice.

One challenge in designing this decision tree was the lack of literature support comparing the bonding strength between different substrates. There are no studies investigating the bonding strength of enamel, DE, dentin, and cementum within a single study. The lack of objective criteria in the studies also exposed differences in detection and treatment outcomes that may have led to a heterogeneity of results. Therefore, it is challenging to determine the optimal extent of the gingival margin in a Class-II preparation. Further research in caries detection methods, bonding strategies, and appropriate dental recall frequency may improve current treatment protocols.

Dentistry is moving in a conservative direction and finding novel methods of diagnosis and treatment for DE is essential for safer and more effective dentistry. A decision tree protocol of the DE margin in class-II composite resin preparations was synthesized with the current available literature. This protocol would provide an understanding of caries assessment, substrate bonding strength, and adhesive systems in order to remove the tooth structure conservatively and optimize the success rate of restorations. This would also be a good commence to visualize the decision-making process for DGM in class-II preparations. Further investigations are needed for appropriate updates of the decision tree protocol.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

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