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Discoloration of Orthodontic Adhesives –A Clinician's Review

Dr. Rathi Amey Jayant[1*], Dr. Varghese Ashwin Thomas[2]
[1]Department of Dentistry, MGM Medical College and Hospital, Aurangabad, Maharashtra, India
[2]Private Orthodontic Practitioner, Dubai

Review Article

***Corresponding author**
Dr. Rathi Amey Jayant

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Abstract: Discoloration of orthodontic adhesive during the length of orthodontic treatment and after debonding of brackets poses a difficult aesthetic situation for the clinician and the patient. A detailed review of the causes of the discoloration from a clinical perspective is detailed in the article. Demineralization of enamel and penetration of resin tags, enamel cracks, surface defects are the main causes. The type of composite used, its constituents and the curing process also affects the speed and extend of the discoloration of the enamel. Steps the clinician can take reduce the amount of discoloration of enamel like use of a slow speed tungsten carbide burs are explained. Even though some discoloration of enamel is inevitable, steps can be taken to minimize the problem to a negligible proportion.
Keywords: Discoloration, composite, Demineralization, Resin Tags, Tungsten carbide Bur, Adhesives.

INTRODUCTION

In orthodontics, direct bonding of orthodontic brackets to enamel is 'state of the art'. Since the basic investigations in etching tooth surfaces with phosphoric acid, satisfactory bonding between enamel and adhesive is achievable [1, 2]. There are a number of reports in the orthodontic literature on bond strength testing of brackets using various parameters, while colourstability of orthodontic adhesives has only been investigated in a few studies [3, 4].

Two reasons for enamel discolouration after debonding of orthodontic attachments are evident:

- The formation of white spots due to decalcification and
- The irreversible penetration of resin tags into the enamel structure

Orthodontic bracket bonding and debonding can lead to adverse effects on tooth enamel.
These effects can be identified

- As enamel loss caused by etching;
- Enamel alterations during fixed orthodontic treatment due to the inhibition of remineralization, leading to decalcification and, possibly, to caries development;
- Enamel microcracks, scratches, and abrasions induced by the adhesive debonding and cleaning procedures.
- Apart from the formation of structural and surface defects, the foregoing variables may affect the enamel color, inducing various alterations on the enamel surface, such as white spots.

Over the years, the evolution of orthodontic adhesives has encompassed several areas, including modifications of filler levels and filler components and inclusion of the polymeric part of the resins [6, 7].

Adhesive resin composites are multiple materials composed of

- Synthetic polymers,
- Particulate ceramic reinforcing fillers, and
- Silane coupling agents which bond the reinforcing fillers to the polymer matrix.

In addition, molecules which promote or modify the polymerization reaction are required [8]. There are external and internal causes for the discolouration of orthodontic adhesives.

External discolouration

External discolouration can be caused by food dyes, TEA and coloured mouth rinses [2]. The material, e.g. the polymeric structure or filler content, and surface roughness play a decisive role in the extent of discolouration caused by diverse substances [9].

- The amount of colour change can be influenced by a number of factors including oral hygiene, water absorption, and incomplete polymerization [10].

Internal Discoloration

- The reason for internal discolouration can be found in ultraviolet irradiation and thermal energy. The influence of ultraviolet light exposure on colour stability of orthodontic adhesives and the effect on tooth discolouration has been investigated.
- Ultraviolet light can induce physico-chemical reactions in the polymer, which cause irreversible colour changes.

One of the undesirabe effect of bonding of orthodontic attachments to enamel with the acid etching technique, is the formation of white spots due to decalcification [5]. The prevalence, methods of examination, and prevention and treatment of decalcification have been studied extensively.In general, orthodontic treatment–induced white spot lesion formation has been shown to take place even 5 yrs following orthodontic therapy.

Enamel color alterations due to resin tags may derive from two sources, ie,

The post-debonding resin removal protocols involving grinding with various rotary instruments. The specularly reflected light component, a surface roughness– dependent parameter, is highly sensitive to cleaning and polishing procedures influencing the L* values of the substrate [6]. Even though the dependence of color on surface texture and roughness has been clearly shown, it must be emphasized that the pattern of this relationship is currently unknown [15]. Omomo *et al*., found a direct relationship for opacity & L* in resin composite and resin modified glass ionomers. However, the correlation between opacity and roughness is as yet unknown. Inokoshi *et al*., found opacity depends partly on surface roughness, since rough surfaces demonstrate a white appearance due to the increased contribution of surface-localized random specular reflections. In addition excess resin is removed by a mechanical process, which can result in varying amounts of enamel being removed affecting reflectance of light [14].

Second, The penetration of resin tags into the enamel structure at depths reaching 50 µm. Because resin impregnation in the enamel structure cannot be reversed by debonding and cleaning procedures, enamel discoloration may occur by direct absorption of food colorants and products arising from the corrosion of the orthodontic appliances. The long-term presence of these resin residues in the enamel tags that extend over the middle third of the buccal surface may render the color stability of these materials critical for tooth color (Fig-1) [4].

Fig-1: Post debonding picture

Fig-2: Residual composite after bracket debonding

Fig-3: after use of tungsten carbide finishing bur

Fig-4: After use of polishing inverted cone tips

Discolouration can be differentiated by colourimeter or visually. Nevertheless, the sensitivity of the human eye in detecting small colour differences is limited and the interpretation of visual colour comparisons is subjective. For that reason colourimetric measurements are essential to obtain reproducible results of colour determination [16, 17]. Arthur *et al*., [10] stated that changes in optical properties within the polymer could be responsible for colour changes. Chemical discolouration has been attributed to the oxidation of unreacted double bonds in the matrix of the resin and the subsequent formation of degradation products from water diffusion or the oxidation of the polymer. Numerous tests have been used for artificial ageing of dental materials to investigate colour stability in vivo and in vitro [10, 14]. One of the investigation by M Behr *et al*., [13] have studied the exposure time to tomato ketchup, Coca Cola, tea, and ultraviolet light set to 72 hours because Stober *et al.*, reported that a period of 24 hours of artificial treatment was too short to investigate discolouration of dental composites [14].

Eldiwany *et al*., [15] found that not only the type but also the amount of filler affects colour stability of composites. They were able to establish a correlation between discolouration and the filler component in resin composites. According to Ruyter *et al*., [16], higher contents of inorganic filler in dental composites resulted in lesser discolouration than lower filled polymers. However, it should be borne in mind that the bonding procedure for GICs differs from that for composite resins. The initial low pH of the GIC induces a local dissolution of apatite on the enamel surface which is followed by a reversible hydrolytic molecular bond mechanism between ionized glass-ionomer carboxyl groups and enamel calcium. Therefore, no resin-infiltrated zone stays on the enamel after debonding and cleaning. Eliades *et al*., investigated the influence of enamel colour changes after bonding with resin and GIC. They stated that the main surface features following debonding and cleaning are those of polished enamel [5].

Most of the adhesives became ‘yellower’ after ultraviolet light treatment. The yellowing of the polymer is accompanied by a reduction in the quantity of residual unreacted double bonds in the resins [4]. It is suggested to use a good quality adhesive for bonding with adequate curing time as suggested by the manufacturer or by the curing machine. A possible explanation for the yellowing could be oxidation of the unreacted C=C to produce coloured peroxide compounds. As seen in Fig-2, 3 & 4; there is no yellowing of adhesive seen after debonding post treatment. This could be suggestive of adequate curing or polymer with higher inorganic filler content. We use a light cure with intensity of 1600mW/cm^{2}for 3 secs in two intervals. The polymeric structure and filler content, as well as the polymerization conversion, seem to be the most important factors that influence the colour stability of dental polymers [11].

Many variables could affect colour stability of orthodontic adhesives. Chemical differences among the resin components, such as residual monomers, polymeric structure, and the concentration of amines and diketones may influence colour stability. In addition, differences in both filler content and composition may explain the fact that composites with a higher content of inorganic filler show greater colour stability than polymers with low filler content [15].

Eliades *et al*., [12] stated that some alterations in enamel colour are unavoidable during bracket bonding because of microstructural modifications associated with enamel bonding and debonding procedures. Consequently, it is necessary to reduce the tendency of orthodontic adhesives to internal and external discolouration to a minimum to reduce the amount of enamel colour change.

CONCLUSION

In our opinion minimum damage to tooth surface and complete removal of composite post debonding and polishing of enamel surface can prevent post orthodontic tooth discoloration or yellowing of tooth. We suggest to use a finishing tungsten carbide bur of 12 flute with 10000-20000 rpm followed by polishing the enamel with polishing midi or Inverted cone [IC] with moderate to feather light pressure with 3000-10000 rpm under intermittent water spray. Also currently available color changing orthodontic adhesives should be preferred as the help in better cleaning and removal of flash around brackets thus preventing further decalcification and stains post debonding. Even though some discoloration of enamel is inevitable, steps can be taken to minimize the problem to a negligible proportion. Within the limitations of bonding and debonding procedures, it could be concluded that the orthodontic adhesives seem to be susceptible to both internal and external discolouration depending on its filler content and curing process.

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