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Effects of acidulated phosphate fluoride gel application on surface roughness, gloss and colour of different type resin composites

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ABSTRACT

Objective: Application of acidulated phosphate fluoride (APF) gel has been reported to cause deterioration of resin composites. This study investigated the effects of APF gel application on surface roughness, gloss and colour of resin composites.

Methods: A2-shade resin disks of 2 mm thickness polished with 180-grit and 3000-grit SiC papers were made with Estelite Σ Quick (EQ), Clearfil Majesty (CM) and Beautifil II (B2). Six disks were prepared for each group. APF gel was applied in a 3 mm thickness on the top surface of resin disks and left for 30 min followed by rinsing and ultrasonic washing. This procedure was repeated 4 times. The $L^*a^*b^*$ values, colour difference (ΔE^*ab), opacity, surface gloss and roughness of specimens before and after APF application were compared. Data were analysed ANOVA and Fisher's PLSD test with $\alpha = 0.05$.

Results: For the 3000-grit polishing groups, the order of influence of APF gel application on colour of resin composites was CM > B2 > EQ. Both in the 180- and 3000-grit polishing groups, colour difference before and after APF gel application was hard to detect (CM and B2) or impossible to detect (EQ) by naked eye. On the other hand, for all the resin composites, the gloss was significantly decreased by APF gel application. APF gel appeared to cause deterioration and dissolution of resin composites used in this study.

Significance: In this limited study, supra-nano spherical filled Estelite Σ Quick showed the least change on colour, gloss and surface roughness by APF gel application.

1. Introduction

Acidulated phosphate fluoride (APF) gel has been found to increase fluoride uptake by enamel to a greater extent and to more efficiently reduce the demineralization of enamel.[1] However, APF gel application can cause adverse effects on resin composite such as dissolution of inorganic fillers,[2] surface erosion,[3] increased surface roughness,[4] decreased wear resistance,[4] increased adherence of cariogenic bacteria,[5] influence on colour stability,[6] and reduced surface hardness.[7]

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The underlying mechanism of APF deterioration of resin composites has been postulated through three major interaction pathways[2]: interaction of fluoride with reinforcing fillers, filler-matrix coupling agents, or the organic matrix. Dissolution of composite filler particles has been ascribed to the presence of hydrogen and fluoride ions in APF gel that forms hydrofluoric acid and results in decrease surface hardness.[7] The severity of resin surface damage is related to the acidulated or neutral types of fluoride gel used, the composition and size of filler particles in the resin composite,[8,9] as well as the entanglement of the resin matrix and inorganic fillers.[10] Barium boroaluminosilicate glass-containing composites are the most susceptible to attack by APF agents,[7] whilst microfilled materials are the least sensitive to APF gel.[11] Other possible factors contributing to deterioration include the surface roughness of composite materials, which may increase the interfacial surface area, as well as the viscosity and thixotropic characteristics of fluoride gels, both of which can extend the reaction time of hydrofluoric acid with resin composites.[2]

Resin composites have been widely utilized for the restoration of carious lesions. Traditional hybrid and microfilled composites contain colloidal silica particles as inorganic fillers, however, these tiny colloidal silica particles tend to agglomerate and increase viscosity, thus producing undue thickening and limited clinical use. To increase filler loading and overcome the viscosity problem, prepolymerized fillers or organic fillers are blended with uncured material to enhance physical properties.[12] Recently, due to new filler technology, nanohybrid and nanofill resin composites have been developed. Nanohybrid resin composites contain conventional glass fillers and nonagglomerated discrete silica nanoparticles. The nanometer-sized particles can be dispersed in higher filler concentrations and polymerized into the resin system to increase filler loading of resin composites.[12] Nanofill composites consist of individual nanosilica particles and nanoclusters. Nanocluster fillers are agglomerates of nano-sized particles and act as a single unit to achieve higher filler loading and strength.[12] There is limited information on whether the nanohybrid and nanofill composite materials are more resistant to APF gel application.[13]

The purpose of this study was to investigate the effects of APF gel application on colour and gloss of three different type resin composites: supra-nano spherical filled resin composite (Estelite Σ Quick: EQ, Tokuyama Dental Co., Tokyo, Japan), surface reaction type pre-reacted glass ionomer (S-PRG) filled nano-hybrid resin composite (Beautifil II: B2, Shofu Co., Kyoto, Japan) and pre-polymerized organic filled hybrid resin composite (Clearfil Majesty: CM, Kuraray Co., Tokyo, Japan).

The null hypothesis tested was that APF application does not influence to surface roughness, gloss and colour of resin composites.

2. Materials and methods

2.1. *Specimen preparation*

The properties and type of the resin composites are shown in Table 1.

To make a standardized specimen, 3-mm thick acrylic round-box-shaped moulds with a 15-mm diameter hole were prepared. A2-shade resin composite was placed in the hole and clear plastic film was placed on top. Then, the specimen was light-activated for 20 s at 3 different areas (total time, 60 s) using a quartz–tungsten halogen light-curing unit (Hyperlight, Morita Co., Kyoto, Japan). The composite disc was removed from the mould, after which the bottom of the disc was also light-activated for 60 s. The top sides of the resin discs were polished with 180-, 600-, 800-, 1000-, 2000-, and 3000-grit SiC papers, in that order, and the bottom sides of the resin disks were polished with 800-grit SiC paper under copious water

Table 1 – Characteristics of resin composites tested (shade: A2).

Resin composite	Abbreviation	Composition	Type and filler loading
Estelite Σ Quick (Tokuyama Dental Co., Tokyo, Japan)	EQ	Matrix: bis-phenolA diglycidylmethacrylate (Bis-GMA), triethylene glycol dimethacrylate (TEGDMA)	Supra-nano spherical filled
		Filler: spherical silica–zirconia filler (100–300 nm, average: 200 nm)	71 vol% (82 wt%)
Clearfil Majesty (Kuraray Medical Co., Tokyo, Japan)	CM	Matrix: bis-GMA, hydrophobic aliphatic dimethacrylate, hydrophobic aromatic dimethacrylate	Hybrid
		Filler: silanated barium glass filler pre-polymerized organic filler including nano filler (filler: 0.2–100 μm, average; 0.7 μm)	66 vol% (78 wt%)
Beautifil II (Shofu Co., Kyoto, Japan)	B2	Matrix: bis-GMA, TEGDMA, urethane diacrylate (UDA)	Nano-hybrid
		Filler: surface reaction type pre-reacted glass-ionomer (S-PRG) and multi-functional (MF) glass fillers based on fluoroboroaluminosilicate glass (0.1–4.0 μm, average: 0.8 μm)	68.6 vol% (83.3 wt%)