Introduction. Cigarette smoke (CS) has been recognized as one of the factors causing stain and discoloration of teeth and restorative composite resin [3]. CS increases water sorption and volatilization of composite resins [2], which may lead to deposition of metal ions into the resin matrix [3] and increase their discoloration [4]. Smoking could also decrease the luminosity and increase the resin surface roughness [5] and affect the bonding strength of dental composite resins to dentin, which may compromise the long-term outcomes of the restorations [6]. CS affects also the surface properties, like microhardness, of dental hard tissues and restorations and causes discoloration of teeth [7]. The severity of smoke-related dental discoloration is largely dependent on the quantity of tar generated during the combustion of tobacco at various temperatures. Modified risk tobacco products (MRTP) is a promising alternative to continued smoking for people unwilling to quit. Some of these products, such as the Tobacco Heating System (THS® 2.2), a candid MRTP, heats tobacco instead of burning it and does not produce “tar” as that term is commonly defined and understood (i.e., the particulate residue from CS when a cigarette is burned). Accordingly, THS® 2.2 carries the potential to minimize the risk of tooth and dental composite discolouration (6).

Objectives. In this study, we investigated, for the first time, the effects of the aerosol generated by THS® 2.2 on color stability and surface roughness of premolar human teeth and composite resins, compared with that generated by CS.

Methods

Figure 1. Study design. The color of human premolar teeth and composite resins was assessed in the CIE Lab space to establish baseline values. Surface roughness was measured only for composite resins. After exposure in the Vitrotcor® 24/48 system (Vitrotcor® System GmbH, Waldkirch, Germany) to undiluted CS from reference cigarettes 3R4F (University of Kentucky, Kentucky Tobacco Research and Development Center) and THS® 2.2 (Philip Morris International) aerosol from 20 cigarettessticks per day for 4 days, samples were brushed with toothpaste and measured for color. The exposures and measurements were repeated through 3 weeks. Surface roughness was measured at the end of the 3 weeks of exposure. 1, aerosol inlet; 2, Vitrotcor plate well; 3, Vitrotcor insert.

Figure 2. At the baseline, TEC had a greater surface roughness than DVS and FSU (P = 0.08 vs. 0.00 and 0.09, respectively). Exposure to either 3R4F CS or THS® 2.2 aerosol did not affect the surface roughness of the composite resins used in the present study. Surface roughness was significantly associated with discoloration (ΔE) in the 3R4F group (Pearson’s r=0.54, p<0.05) but not in the THS® 2.2 group (Pearson’s r=0.36, p=0.05) [data not shown] [10].

Figure 3. There were significant differences in ΔE, the spectrophotometric score calculated based on the CIE Lab values, between THS® 2.2 and 3R4F groups for each composite resin at all timepoints. The THS® 2.2 aerosol affected the composite resins with a different pattern from 3R4F CS. While 3R4F CS caused greater dental discoloration in TEC (ΔE > 30) and FSU (ΔE > 28) than in DVS (ΔE < 23), the effects of the THS® 2.2 aerosol were more pronounced in DVS (ΔE > 40) and TEC (ΔE < 5) than in FSU (ΔE > 26) [14].

Table: ΔE values (Mean ± SD) of composite discs after 3 weeks of exposure to 3R4F CS and THS® 2.2 aerosol. *Student’s t-tests, THS® 2.2 vs. 3R4F, N = 10 per group.

<table>
<thead>
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<th>Treatment</th>
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<tr>
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ΔE values (Mean ± SD) of enamel, dentin, and composite resin after three-week exposure to 3R4F CS and THS® 2.2 aerosol. *Student’s t-tests, THS® 2.2 vs. 3R4F, N = 11 per group.

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Basic Science

Effects of 3R4F CS and THS® 2.2 aerosol exposures on surface roughness of composite disc resins

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Conclusions

• THS® 2.2 aerosol caused six- to ten-fold less discoloration of composite resin materials than 3R4F CS as measured by ΔE after 1 to 3 weeks of exposure.
• The effects of THS® 2.2 aerosol on dental tissue discoloration were four- to seven-fold lower than CS and were not clinically significant (ΔE < 3) after three weeks of exposure.
• CS but not THS® 2.2 aerosol caused color mismatch between enamel and composite resin restorations, which compromises the aesthetic outcome of restorative treatment.
• Surface roughness was not altered by either 3R4F CS or THS® 2.2 aerosol exposure.
• Brushing was limited to one at the end of each experimental week. This design was employed to maximize the potential staining of the dental materials/tissues by CS/THS® 2.2 aerosol in a limited time frame.
• In summary, aerosol derived from heating tobacco causes significantly lower 1) discoloration of enamel, 2) dentin and composite-resin restoration, and 3) color mismatch between dental hard tissues and restoration than CS. Reducing or eliminating the deposits derived from tobacco combustion may minimize the impact on tooth and composite resin restoration color stability.

Competing Financial Interest

F.Z. M., S.M., M.P., and J.H. are employees of Philip Morris International. Philip Morris International is the sole source of funding and sponsor of the research described in this paper.