Original Article
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Effect of Thai Wine on Surface Roughness and Corrosion of Various Tooth-Coloured Filling Materials

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Abstract

This study investigated the effect of Thai wines (red and white wines) on surface roughness and erosion of various tooth-coloured filling materials: glass ionomer cement, resin modified glass ionomer cement, giomer, compomer and resin composite. It also compared the difference of surface roughness and erosion of tooth-coloured filling materials after being soaked in the same type of wines and in different types of wines. Specimens (n=10) of each tooth-coloured filling materials were prepared. Surface roughness was evaluated by average surface roughness. Erosion was evaluated by the difference in volumes of holes and peaks using the surface Profilometer. Specimens were alternately immersed in wines for 25 min and in artificial saliva for 5 min in 4 cycles. After that, they were immersed in artificial saliva for 22 h. This process was repeated 5 times. Surface roughness and erosion measurements were performed again with the same method. The data were analyzed by the Paired t-test, One-way ANOVA and Independent t-test at alpha = .05. Surface roughness and erosion of each tooth-coloured filling material differed significantly when soaked in the same type of wines ($p < .05$), both red and white. This study showed that surface roughness and erosion of all tooth-coloured filling materials increased when exposed to Thai wines, especially glass ionomer cement.

Key words: erosion; surface roughness; tooth-coloured filling materials; wine

Introduction

Nowadays, tooth-coloured filling materials are widely used in restorative dentistry because of their good physical, mechanical and esthetic properties. However, consumption of acidic food, soft drinks, coffee, tea or wine, can result in surface damage and decrease hardness, esthetic quality, and other properties of these materials.[1-4]

Most of Thai people enjoy a glass of wine during their meal.[5] Several recent studies suggested that drinking wine in moderation can help maintain good health and reduce coronary heart disease.[5-9] Thailand now produces good standard, quality wines for domestic consumption and export.

Tests of the quality and taste of wine are performed by wine tasters.[10] Several studies have reported that wine tasters have dental erosion due to the frequency of tasting wine[11] and related to the acidity of wine.[10-12] Acidity of white and red wine ranges from pH 3.0-3.8,[10,12-14] with white wine having a lower pH than red wine.[10,14] The acidity of wine plays a major role in dental erosion. In addition, tasters were found to have stained teeth as a result of their work.[15] Some studies have indicated the effects of wine on surface degradation and the staining of tooth-coloured filling materials[4,16] which reduces esthetic properties.[3]

The success of tooth-coloured restorations depends on proper material selection. Erosive properties and surface degradation can predict the longevity of these materials.[17] When these materials are eroded, the teeth may present anatomical loss, marginal leakage, secondary caries[18] and increase in the surface roughness of restorations. Surface roughness of restoration results in plaque deposition, tissue irritation, gingivitis,[19] staining, and decreasing longevity of restorations.[1,20,21]

There are a number of studies reporting the erosive effects of wine on tooth structure,[10-14,22] but only a few of the studies reported effects of wine on surface roughness and erosion of tooth-coloured filling materials. The objective of this in vitro study was to investigate the effect of wine on surface roughness and erosion of various tooth-coloured filling materials after soaking in Thai red and white wine. After being soaked in various types of wine, the difference in surface roughness and erosion of these materials was also compared.

Materials and Methods

Specimens (n=10) of each tooth-coloured filling materials were prepared from 5 tooth-coloured filling materials; listed in Table 1. Each material was placed into a self-cured acrylic mould (5 mm wide and 6 mm long and 2 mm thick) and covered with a glass cover slip during the curing process. Giomer, compomer, and resin composite specimens were light cured for 40 second, using a dental curing unit (model 2500, 3M ESPE, St Paul, MN, USA). Specimens cured under the glass cover slip had mirror-smooth surfaces that did not require further grinding or polishing. Conventional glass ionomer cement and resin modified glass ionomer cement were mixed for 10 second. Resin modified glass ionomer cement specimens were light cured for 40 second, and conventional glass ionomer cement specimens were left in the mould for 6 minutes to harden. The excess of filling materials was removed using blade No.12. All specimens were kept in deionized water for 24 hours at room temperature and ultrasonically cleaned for 5 minutes before testing.

Each specimen was subjected to surface roughness and erosion measurements to obtain a baseline value. Surface roughness and erosion measurements were performed using a surface Profilometer (model TalyScan 150, Taylor Hobson Ltd., Leicester, England). The radius of the tracing diamond stylus tip was 2 μm. Surface roughness was evaluated by the average surface roughness value (Ra, μm). The cut-off value for surface roughness was 0.8 mm. Degree of erosion was evaluated by the differences in the volume of holes and peaks. The volume of holes and peaks was evaluated by size, i.e. 2 x 2 mm at the center of the specimens.

The acidity of the Thai red or white wine was measured with a pH meter (model 420A, Orion Research Inc, Boston, USA), every time a new bottle was opened. After baseline surface roughness, the volume of holes and of peaks was recorded, and the specimens were alternately immersed manually in 20 ml of wine (Table 2) for 25 min and in 20 ml of artificial saliva for 5 min for 4 cycles.

Then, the specimens were immersed in artificial saliva for 22 h. This process was repeated 5 times at room temperature. The specimen soaking protocol simulated a wine taster tasting wine in one trip. Total soaking time was 5 days. After the soaking sequence was completed, the specimen was rinsed with deionzed water, blotted dry, and subjected to post-immersion surface roughness, volume of holes, and volume of peaks testing.

Surface roughness and erosion numbers of the baseline and post-immersion measurements were compared, using paired *t*-test at $p = .05$. The differences in surface roughness and erosion after immersion in the same type of wine of 5 tooth-coloured materials were recorded using one-way ANOVA, followed by Turkey's multiple comparison at $p = .05$. The differences in surface roughness and erosion of same tooth-coloured filling material after immersion in the different types of wines were recorded using independent *t*-test at $p = .05$.

Results

The pH of red wine and white wines were shown in table 3. The average white wine pH was lower than the red. Mean average surface roughness (Ra) of these materials at the baseline and measurements after soaking in red wine and white wine were shown in Table 3. Average surface roughness of 5 tooth-coloured filling

Table 1 *Tooth-colored filling materials used in this study*

Materials	Products	Manufacturers	Composition		Average filler	Lot Number
			Matrix	Filler	particle (μm)	
GIC	Ketac Fil Plus Applicap	3M ESPE Dental Products, St.Paul , MN, USA	Polyacrylic acid, polymaleic acid, Tartaric acid	Calciumsodium Fluorophospho Aluminosilicate glass	Less than 10	142178
RMGIC	GC Fuji II LC Capsule	GC Corporation, Tokyo, Japan	Polyacrylic acid, HEMA[a], TEGDMA[b], UDMA[c], water, catalyst	Fluoroaluminosilicate glass Glass	4.5	0406228
Giomer	Beautifil	Shofu Dental Corporation, CA, USA	Bis-GMA[d], TEGDMA[b], catalyst	S-PRG[e], Fluoroboroalumino Silicate glass	1	020481
Compomer	F2000 Compomer	3M ESPE Dental Products , St.Paul , MN, USA	CDMA[f] oligomer, GDMA[g], High molecular weight hydrophilic Polymer, photoinitiator	Fluoroaluminosilicate Glass,colloidal silica	3	20041229
Resin composite	Filtek™ Z250	3M ESPE Dental Products , St.Paul , MN, USA	TEGDMA[b], UDMA[c], Bis-GMA[d], catalyst	Zirconia, silica	0.6	20041215

[a]HEMA, hydroxythyl methacrylate ; [b]TEGDMA, Triethyeneglycol dimethacrylate; [c]UDMA, Urethanethyl dimethacrylate; [d]Bis-GMA, Bisphenol-glycidyl methacrylate; [e]S-PRG, surface pre-reacted glass; [f]CDMA, citric acid dimethacrylate ; [g]GDMA, glyceryl dimethacylate

Table 2 *Wines used in this study*

Wine	Products	Manufacturer	Description
Red wine	PB Valley Khao Yai Reserve Red Wine 2001	B.B.Groups Trading Co.,Ltd.,Thailand	13.5% v/v alcohol
White wine	PB Valley Khao Yai Reserve White Wine 2003	B.B.Groups Trading Co.,Ltd.,Thailand	12.5% v/v alcohol

Table 3 *Mean (s.d.) average surface roughness (Ra) of materials at the baseline and after soaking in red and white wine*

Wine	Materials	Baseline	Ra (μm³)	Post-immersion	Ra (μm³)	*p*-value
		mean	s.d.	mean	s.d.	
Red (pH 3.8)	GIC	0.0364	0.0054	0.0606	0.0157	0.002*
	RMGIC	0.0433	0.0083	0.0571	0.0080	0.000*
	GM	0.0269	0.0042	0.0331	0.0059	0.002*
	CM	0.0401	0.0031	0.0534	0.0131	0.011*
	RC	0.0227	0.0035	0.0271	0.0040	0.000*
White (pH 3.45)	GIC	0.0348	0.0075	0.0991	0.0351	0.000*
	RMGIC	0.0408	0.0084	0.0865	0.0165	0.000*
	GM	0.0271	0.0058	0.0423	0.0132	0.002*
	CM	0.0401	0.0062	0.0551	0.0094	0.002*
	RC	0.0214	0.0027	0.0315	0.0075	0.001*

*statistically significant difference ($p < .05$) n=10

Table 4 *Mean (s.d.) volume of holes of these materials at the baseline and after soaking in red and white wine.*

Wine	Materials	Baseline volume of holes (µm³)		After immersion volume of holes (µm³)		*p*-value
		Mean	s.d.	Mean	s.d.	
Red	GIC	88,827.00	19,046.84	119,939.90	16,433.95	0.000*
	RMGIC	110,344.90	45,865.49	243,462.00	122,854.11	0.019*
	GM	33,829.70	2,476.70	50,731.80	13,098.97	0.002*
	CM	60,208.60	5,277.27	87,972.70	24,450.49	0.002*
	RC	33,939.80	2,920.85	37,315.40	3,349.67	0.001*
White	GIC	87,265.10	16,361.87	273,821.70	45,546.54	0.000*
	RMGIC	107,059.70	44,618.41	274,251.90	168,020.50	0.005*
	GM	32,674.90	6,376.59	53,992.70	11,960.40	0.000*
	CM	59,588.10	6,259.23	99,612.30	12,158.11	0.000*
	RC	32,791.90	2,983.12	38,224.70	7,316.22	0.010*

*statistically significant difference ($p < .05$).

Table 5 *Mean (s.d.) volume of peaks of these materials at the baseline and after soaking in red and white wine*

Wine	Materials	Baseline volume of peaks (µm³)		After immersion volume of peaks (µm³)		*p*-value
		Mean	s.d.	Mean	s.d.	
Red	GIC	88,827.00	19,046.84	119,939.90	16,433.95	0.000*
	RMGIC	110,344.90	45,865.49	243,462.00	122,854.11	0.019*
	GM	33,829.70	2,476.70	50,731.80	13,098.97	0.002*
	CM	60,208.60	5,277.27	87,972.70	24,450.49	0.002*
	RC	33,939.80	2,920.85	37,315.40	3,349.67	0.001*
White	GIC	87,265.10	16,361.87	273,821.70	45,546.54	0.000*
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	CM	59,588.10	6,259.23	99,612.30	12,158.11	0.000*
	RC	32,791.90	2,983.12	38,224.70	7,316.22	0.010*

*statistically significant difference ($p < .05$).

materials increased significantly ($p < .05$) after soaking in red and white wine.

Mean volume of holes of these materials at the baseline and measurements after soaking in red and white wine were shown in Table 4. Volume of holes of 5 tooth-coloured filling materials increased significantly ($p < .05$) after soaking in red and white wine.

Mean volume of peaks of these materials at the baseline and measurements after soaking in red and white wine were shown in Table 5. Volume of peaks of 5 tooth-coloured filling materials increased significantly ($p < .05$) after soaking in red and white wines.

Discussion

The wine tested was not at the body temperature (37°C), because red and white wine are drunk at different temperatures. Red wine is drunk at 19-21°C, but white wine is drunk at 9-11°C. This study was done at the room temperature (25 °C). This study indicates that wine's acidity has a pH ranging from 3.4-3.8, which is similar to previous studies.[13] The types of wine used contained 1-5 g/l tartaric acid,1-4 g/l maleic acid and other acids including: succinic acid, lactic acid, citric acid, and acetic acid.[24] White wine had a pH of 3.45 and 12.5% volume alcohol, red wine had a pH of 3.8 and 13.5% volume alcohol.

This study showed that soaking in red and white wines increased surface roughness and corrosion of all tooth-coloured filling materials significantly ($p < .05$), which is similar to previous studies.[16] Wine and 9% volume alcohol beverages cause significant increased in degree of corrosion because alcohol in beverages soften polymer matrixes and dislodge filler particles, resulting in a rapid increase in surface roughness and erosion. Yip, To, and Smale[25] reported that acidity in oral environment might change physical properties, including surface roughness and corrosion of tooth-coloured filling materials with differences in surface roughness in descending order as follows: from glass ionomer cement, resin modified glass ionomer cement, to resin composite. In addition, water absorption of the material was an important factor, changing the surface roughness and erosion of tooth-coloured filling materials.[26,27] Factors which influenced water absorption of polymer-based materials were types of resin. A hydrophobic resin like hydroxyethylmethacrylate absorbs water more than one like Bis-GMA. If tooth-coloured filling materials have a lot of filler particles, they are able to absorb more water.[28,29] The last factor which influenced water absorption of polymer-based, tooth-coloured filling materials is the presence of voids during the mixing or producing of these materials.[25] When these tooth-coloured filling materials absorb water, a coupling agent causes hydrolysis and loss of chemical bond between filler particle and resin matrix. Filler particles dislodge from the outer surface of the material, causing the surface roughness.[30]

This study showed that after being soaked in red wine: resin composite had the lowest difference in surface roughness and volume of holes; giomer had the lowest difference in volume of peaks; glass ionomer cement had the highest surface roughness; and resin modified glass ionomer cement had the highest volume of holes and peaks. The filler particle size has been shown to affect the surface roughness and erosion of tooth-coloured filling materials.[31-33]

Glass ionomer cement was composed of glass particles and hydrogel matrixes. Polymer materials were composed of filler particles and polymer resins. If hydrogel matrixes or polymer resins are removed and the glass particles and filler particles exposed, then the filling materials will have rougher surfaces. Furthermore, glass particles or filler particles, which lack of hydrogel matrixes or polymer resin surroundings would dislodge, resulting in rapid increased in corrosion of the materials.[18,31,32] Thus, tooth-coloured filling materials, which have large filler particles size showed more surface roughness and erosion than tooth-coloured filling materials which have smaller filler particles size.[31,34]

Brittleness of filler particles in materials is another factor for consideration. If materials composed of brittle filler particles are restored in a stress bearing area, filler particles break rapidly and erode.[34]

From this study, resin composite and giomer are recommended for use in dental restorations for wine tasters who tasted only red wine; however, glass ionomer cement and resin modified glass ionomer cement are not recommended. From this study, wine tasters who taste only white wine, are recommended to use only resin composite. In this case, glass ionomer cement and resin modified glass ionomer cement were not recommended for use in dental restoration. In fact, wine tasters taste both wines. Therefore, resin composites may be chosen in dental restorations, but they should not be restored with glass ionomer cement or resin modified glass ionomer cement. Because wine tasters have tendency to be high caries risk patients, glass ionomer cement and resin modified glass ionomer cement can be selected in dental restoration by using a sandwich technique, which combines glass ionomer cement, or resin modified glass ionomer cement, and resin composite.[30,35,36] Glass ionomer cement or resin modified glass ionomer cement can also release fluoride in high levels on enamel, dentin, and surrounding materials, so tooth structure may resist demineralization and prevent secondary caries.[37-39] Acidity has an influence in dissolution of glass ionomer cement. Glass ionomer cement will increasingly dissolve the matrix, along with any unstable glass particles in low pH value. This explains why there are so many holes in the surface of glass ionomer cement.[40,41]

Wine is a factor which affects dental erosion. Behavior and frequency of consumption, duration and quality of wine drink, salivary flow rate, buffer capacity and food taken with meals are other factors which affect dental erosion.[11,13] Wine tasters taste wine on a round trip which may last up to 5 days per week.[10] In wine tasting, the taster looks, smells, tastes, and swallows.[24] The tasting step is composed of swishing wine in the mouth for 15-60 min.[12] After that, swallowing a little of the wine in the mouth and then spitting out. This is enough time to erode teeth. Wine tasters should not eat acidic food when tasting wine because it is prone to erode teeth and disturb the quality of the wine's taste.[42]

The results of this study showed that the specimens were stained after being soaked in red wine. Patel *et al.*[43] reported that hybrid resin composite had stained significantly after being soaked in red wine for 7 days. Surface roughness was an important factor for acquiring stains and bacterial adhesion on filling materials.[44] If the surface roughness is more than 0.2 micron, it increases bacterial adhesion significantly.[44] In addition to increasing surface roughness, it also increases the degree of erosion of filling materials and enamel of opposing teeth.[34] Surface roughness alteration of 0.5 micron will change the perception of the tongue and cause discomfort in oral cavity. Therefore, filling material should have surface roughness of less than 0.5 micron.[45] This study showed that tooth-coloured filling materials with a surface roughness of less than 0.1 micron should not create any discomfort in the oral cavity.

Presently, there is no means of testing the quality and taste of wine except by a wine taster. Dentists should recommend that wine tasters swish water immediately after tasting wine in order to reduce acidity in the oral cavities.[13] They should not rinse their mouth with alkaline mouth wash in order to reduce acidity in the oral cavities because it will change the taste of food.[13] A wine taster should rinse his or her mouth with 0.05% sodium fluoride daily to reduce chance enamel dissolution.[13] Maintain good oral hygiene and brushing with a soft toothbrush and fluoride toothpaste should be performed. When the wine tasters require dental restoration, dentists should select the appropriate materials with the consideration of surface roughness, erosion, and material properties.

Conclusions

After being soaked in red and white wines, there was a significant increase in surface roughness and erosion of all tooth-coloured filling materials ($p < .05$). Surface roughness and erosion of each tooth-coloured filling material differed significantly when exposed to the same type of wines ($p < .05$).

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บทวิทยาการ

ผลของไวน์ไทยต่อความหยาบผิวและการสึกกร่อนของวัสดุบูรณะสีเหมือนฟัน

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บทคัดย่อ

การศึกษานี้มีวัตถุประสงค์เพื่อศึกษาผลของไวน์ไทย ได้แก่ ไวน์แดงและไวน์ขาว ต่อความหยาบผิวและการสึกกร่อนของวัสดุบูรณะสีเหมือนฟัน 5 ชนิด ได้แก่ กลาส-ไอโอโนเมอร์ซีเมนต์ เรซินโมดิฟายด์กลาส ไอโอโนเมอร์ซีเมนต์ ไจโอเมอร์ คอมโพเมอร์ และเรซินคอมโพสิต และเปรียบเทียบค่าความแตกต่างความหยาบผิวและการสึกกร่อนของวัสดุบูรณะสีเหมือนฟันเมื่อแช่ในไวน์ชนิดเดียวกันและต่างชนิดกัน โดยเตรียมชิ้นตัวอย่างวัสดุบูรณะสีเหมือนฟันกลุ่มละ 10 ชิ้น วัดความหยาบผิวของวัสดุโดยพิจารณาจากค่าความหยาบผิวเฉลี่ย ส่วนการสึกกร่อนของวัสดุพิจารณาจากความแตกต่างความขรุขระของพื้นผิวโดยดูจากปริมาตรหลุมและปริมาตรยอดด้วยเครื่องวัดความขรุขระผิว โดยนำชิ้นตัวอย่างแช่ไวน์ 25 นาที สลับกับแช่น้ำลายเทียม 5 นาที จนครบ 4 ครั้ง จากนั้นแช่ชิ้นตัวอย่างในน้ำลายเทียม 22 ชั่วโมง แล้วทำซ้ำจนครบ 5 รอบ วัดความหยาบผิว ปริมาตรหลุมและปริมาตรยอดของชิ้นตัวอย่างอีกครั้งด้วยวิธีเดียวกัน ทดสอบค่าที่ได้ด้วยสถิติการทดสอบทีสำหรับกลุ่มตัวอย่างสองกลุ่มที่สัมพันธ์กัน การวิเคราะห์ความแปรปรวนทางเดียว และสถิติการทดสอบที ผลการศึกษาพบว่าไวน์แดงและไวน์ขาวทำให้ความหยาบผิวและการสึกกร่อนของวัสดุทั้ง 5 ชนิดเพิ่มขึ้นอย่างมีนัยสำคัญทางสถิติ ($p < .05$) เมื่อแช่ในไวน์ชนิดเดียวกันทั้งในไวน์แดงและไวน์ขาว ผลการศึกษาสรุปว่าไวน์ไทยทำให้วัสดุบูรณะสีเหมือนฟันมีความหยาบผิวและการสึกกร่อนเพิ่มขึ้น โดยเฉพาะกลาสไอโอโนเมอร์ซีเมนต์