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RESEARCH ARTICLE

Effect of Liquefied Digestive Medicine on the Surface of Composite Resin

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Background: The purpose of this study is to investigate the effect of liquefied digestive medicines on the composite resin surface.
Methods: Three types of liquefied digestive medicines (Gashwalmyeongsu, Wicheongsu, and Saengrokcheon) were selected as experimental groups, Samdasoo and Chamisul as negative controls, and Trevi as positive controls were selected to measure pH and titratable acidity. The samples filled with resin at acrylic were made total 300, 50 per group. To evaluate the erosion risk of the composite resin, the specimens were immersed in a liquefied medicine for 1, 3, 5, 15, and 30 minutes, and then the surface microhardness was measured using the Vickers Hardness Number, and the surface change was observed with scanning electron microscope (SEM).
Results: The average pH of the three liquefied medicine was 3.75±0.30, the Saengrokcheon was the lowest at 3.45±0.01, and the Trevi was 4.66 and Samdasoo and Chamisul were 7.40 and 8.58, respectively. The amount of NaOH reaching pH 5.5 and 7.0 was the lowest in the order of Trevi, Gashwalmyeongsu, Wicheongsu, and Saengrokcheon. The largest surface hardness reduction value was shown in Gashwalmyeongsu (−11.85±3.73), followed by Saengrokcheon (−9.79±3.11) and Wicheongsu (−8.28±2.83), and Samdasoo (−0.84±1.56) and Chamisul (−6.24±0.42) had relatively low surface hardness reduction values. However, Trevi (−16.67±5.41), a positive control group containing carbonic acid, showed a higher decrease in surface hardness than the experimental group. As a result of observation with SEM, experimental group and positive control group, showed rough surfaces and irregular cracks, and negative control groups showed smooth patterns similar to before immersion.
Conclusion: The liquefied digestive medicine with low pH could weaken the composite resin surface, and the carbonic acid component could more effect on the physical properties of the composite resin than pH.

Key Words: Composite resins, Liquid digestive medicine, Hardness, Scanning electron microscopy

Introduction

Dyspepsia includes all symptoms of digestive disorders occurring mainly in the upper abdomen such as the stomach and duodenum. The symptoms appear as fullness after eating, early satiety, heartburn, nausea, upper abdominal bloating, pain or discomfort[1]. The number of individuals showing the symptoms of indigestion has increased due to westernized diet and stress, and to treat such symptoms, digestive medicines are administered as they are commercially available in various forms from tablets to powder and liquefied medicines.

The Notification System for Exempt Medicinal Products has been revised and notified by the Ministry of Health and Welfare on June 1, 2011. The revised notification views certain medicinal products of verified safety among the over-the-counter (OTC) products such as liquefied digestive medicines, probiotics and ointments as exempt medicinal products so as to increase consumer convenience. This allows the purchase of 15 types of liquefied digestive

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medicines including Saengrokcheon, Wicheongsu, and Gashwalmyeongsu with ease at convenience stores, for example[2], and with increased accessibility, the sales of liquefied digestive medicines have steadily increased[3].

While liquefied digestive medicines assist in the improvement of dyspepsia, their low pH has been reported to cause enamel erosion such as reduced microhardness of the enamel surface and surface cracks[4]. The causes of dental erosion vary in addition to liquefied digestive medicines and they are broadly categorized into intrinsic and extrinsic factors. The intrinsic factors include the gastric acid entering the oral cavity due to reflux or vomit, and the extrinsic factors include acidic foods, acidic drinks, acidic drugs and acidic mouthwash products. The increased intake of acidic foods has led to an increasing trend in dental erosion, so acidic foods are regarded as the main cause of dental erosion[4]. In line with this, the low pH of acidic drinks has been reported to cause dental erosion in the oral cavity[5], and the low pH of the kids' drinks, sports drinks, carbonated drinks, hangover drinks, and energy drinks has been shown to reduce the dental surface hardness to cause erosion[6]. The low pH acidic drinks have also been reported to affect the durability and longevity of the composite resins as well as teeth by inducing chemical degradation and reducing the physical properties[7]. In a previous study where resin specimens were repeatedly immersed in acidic medicines, demineralizing and remineralizing solutions every 24 hours for 12 days, the composite resin surface was shown to have been damaged[8].

Meanwhile, composite resins exhibit an outstanding ability to bind with the tooth structure with excellent mechanical strength and aesthetic impression, and the advantage of low heat conductivity has led to the recent marked increase in use across various clinical fields of dentistry[9]. The scope of use of resins has been widened to include the restoration of the posterior region where occlusal force is exerted as well as the anterior region. Notably, resins are now being applied as a restorative material to resolve aesthetic issues, recover the fractured enamel surfaces due to trauma and restore damaged teeth due to dental caries[10]. Composite resins have been verified as a filling material for permanent teeth that accounts for 60% of the use of filling materials as the most frequently used material across all age groups[11]. With the implementation of the insurance coverage for light-cured composite resins in 2019, which covers 30% of coinsurance for children under the age of 12 receiving the treatment of dental caries using light-cured composite resins, the use of composite resins has been predicted to show an accelerated increase[12].

Acidic foods and drinks have an effect on the teeth and composite resins, and previous studies have reported that the increased consumption of liquefied digestive medicines had influenced the enamel surfaces. These findings collectively indicate that the liquefied digestive medicines with low pH are likely to induce changes in the composite resin surface hardness. Various previous studies have reported on the effect of acidic drinks on dental restorative materials. Yanikoğlu et al.[13] reported that acidic foods, tea, coffee and drinks with low pH could reduce the surface hardness of resin-based composite materials. Erdemir et al.[14] reported that low pH sports drinks and energy drinks led to facilitated degradation of dental restorative materials and reduced the hardness to ultimately decrease the longevity of such materials. As can be seen, previous studies have shown the results of treating enamel or resin-based restorative materials with acidic foods or sports and energy drinks, while only a few studies have investigated the effects of liquefied digestive medicines with the recent steep increase in consumption on composite resins as dental restorative materials. In addition, erosion of the teeth and restorative materials may be influenced by gastric reflux in patients with functional dyspepsia, and liquefied digestive medicines have been predicted to further accelerate the erosion, which thus prompted this study.

This study thus aimed to investigate the effects of the three most popular and easily accessible liquefied digestive medicines among those commercially available in South Korea on the possibility of erosion and surface hardness of the composite resins commonly used in clinical practice. The study thereby provides the basic data to promote suitable ways of intake of liquefied digestive medicines for consumers.

Materials and Methods

1. Materials

Three types of liquefied digestive medicines (Wicheongsu, Kwangdong Pharmaceutical Co., Pyeongtaek, Korea; Gashwalmyeongsu, Donghwa Pharmaceutical Co., Chungju, Korea; and Saengrokcheon, Kwandong Pharmaceutical Co., Pyeongtaek, Korea) among those that can be purchased with ease at marts and convenience stores were selected. The negative control was Samdasoo (mineral water; Jeju Special Self-Governing Province Development, Jeju, Korea) and Chamisul (distilled liquor; Hitejinro, Icheon, Korea), and the positive control was Trevi (carbonated water; Lottechilsung, Anseong, Korea) (Table 1).

2. Methods

1) pH and buffer capacity

To measure the pH of the selected medicines and drinks, 10 ml of each was transferred to a beaker after standing in a room temperature at 25°C for six hours. The pH of each group was measured using a calibrated pH meter (S20K pH meter; Mettler-Toledo, Greifensee, Switzerland). For buffer capacity, 1M NaOH was added to each group by 0.05 ml until the pH reached 5.5 to 7.0, and the added amount of 1M NaOH was estimated. To ensure a uniform mixture during the pH measurement, each group was vortexed at 200 rpm. All measurements were taken using the same methods, and the mean of triplicate measurements was obtained.

2) Specimen preparation

The specimen was filled with resins (Filtek^{TM} Z350 XT; 3M ESPE, St Paul, MN, USA) in a spherical space of 5 mm diameter and 2 mm height using an acryl plate (20 mm×10 mm×4 mm) with subsequent 30-seconds light-curing using the LED light-curing device (L1660679D; Guilin Woodpecker Medical Instrument, Guilin, China). To ensure the specimen surface is flat, a stepwise grinding was performed using the Sic-paper #1200, #1500, #2000, and #4000, and the grinder (Struers LaboPol-5, Type 05206133; Struers, Ballerup, Denmark). Next, 300 specimens with the composite resin surface hardness in the 83～103 Vickers Hardness Number (VHN) range were selected, and 50 specimens were allocated to each of the six control and experiment groups.

3) Specimen surface hardness measurement

To estimate the surface hardness of each ground specimen, four areas (top, bottom, left, and right) of the specimen were positioned perpendicular to the direction of stamping using the surface microhardness tester (MMT-X7B; Matsuzawa, Akita, Japan) prior to liquid immersion, and after 10 seconds of stamping at 50 gm weight, the VHN was measured and the mean of four areas was obtained. The specimen retrieved after 1, 3, 5, 15, and 30 minutes of liquid immersion was washed with distilled water for 1 minute and the measurements were taken in the same methods as before from the areas close to those used in measuring the surface hardness before immersion.

4) Liquid immersion

Each of the selected medicines and drinks was opened immediately before the immersion of the specimen and 20 ml of each was transferred to an identical container for subsequent use. Each specimen was immersed in the liquid for 1, 3, 5, 15, and 30 minutes to induce the composite resin surface erosion. A fresh batch of medicines

Table 1. Liquefied Digestive Medicine Used in the Experiment

Group	Brand name	Manufacturer
Experiment (liquefied digestive medicine)	Wicheongsu	Kwangdong Pharmaceutical Co., Pyeongtaek, Korea
	Gashwalmyeongsu	Donghwa Pharmaceutical Co., Chungju, Korea
	Saengrokcheon	Kwandong Pharmaceutical Co., Pyeongtaek, Korea
Positive control	Trevi	Lottechilsung, Anseong, Korea
Negative control	Samdasoo	Jeju Special Self-Governing Province Development, Jeju, Korea
	Chamisul	Hitejinro, Icheon, Korea

and drinks was used for each measurement. The time of immersion was set based on the previous study reporting that the retention time of drink in the oral cavity was <1 minute upon a single intake[15], and on the study reporting that the pH of the plaque was maintained at <5.7 until 30 minutes after the intake[16].

5) Scanning electron microscopy

To examine the morphological changes in the composite resin surface, two specimens were randomly selected from each group. Each treated specimen was dehydrated in the order of increasing alcohol concentration then dried using the critical point dryer (HCP-2; Hitachi, Tokyo, Japan). Next, the specimen was fixed on an aluminum stub then coated with gold-palladium to 200 nm thickness using the ion sputter (E-1030; Hitachi) for the observation under the scanning electron microscope (SEM; S-4700; Hitachi) at 10 kV accelerating voltage and 2,000× magnitude.

6) Data analysis

To compare the variation of surface microhardness between each group, one-way ANOVA was used. To compare the surface microhardness according to the immersion time for each group, repeated measures ANOVA was used. The Tukey HSD was the post-hoc test, while the level of significance was set to 0.05. For all statistical analyses, the SPSS ver. 26 (IBM Corp., Armonk, NY, USA) was used.

Results

1. pH and buffer capacity

The pH of the three types of liquefied digestive medicines in this study fell in the range of 3.45 to 3.94. The mean pH was 3.75±0.30 with Saengrokcheon showing the lowest pH at 3.45±0.01, Gashwalmyeongsu showing pH at 3.86±0.01 and Wicheongsu showing pH at 3.94±0.00. For the negative control, Samdasoo showed pH at 7.40±0.05 and Chamisul showed pH at 8.58±0.03. For the positive control, Trevi showed pH at 4.66±0.00. The buffer capacity at pH 5.5 was the lowest for the positive control Trevi at 0.01±0.00 ml. For the experiment groups, the buffer capacity was the highest at 0.13±0.03 ml for Saengrokcheon, followed by Wicheongsu 0.07±0.01 ml and Gashwalmyeongsu 0.06±0.01 ml. The buffer capacity at pH 7.0 was the lowest for the positive control Trevi at 0.05±0.03 ml. For the experiment groups, the highest buffer capacity was at 0.18±0.03 ml for Saengrokcheon, followed by Wicheongsu 0.11±0.01 ml and Gashwalmyeongsu 0.10±0.01 ml (Table 2).

Table 2. The pH and Titratable Acidity of Liquefied Digestive Medicine

Group	pH	Titratable acidity (ml)	
		pH 5.5	pH 7.0
Wicheongsu	3.94±0.00	0.07±0.01	0.11±0.01
Gashwalmyeongsu	3.86±0.01	0.06±0.01	0.10±0.01
Saengrokcheon	3.45±0.01	0.13±0.03	0.18±0.01
Trevi	4.66±0.00	0.01±0.00	0.05±0.03
Samdasoo	7.40±0.05	-	-
Chamisul	8.58±0.03	-	-

Values are presented as mean±standard deviation.

2. Changes in composite resin surface hardness before and after the treatment with liquefied digestive medicines

1) The surface microhardness after the 30 minutes treatment with liquefied digestive medicines

The surface microhardness of composite resins before and after the treatment with liquefied digestive medicines was significantly different between groups with the exception of the negative control Samdasoo and Chamisul, before and after 30 minutes treatment ($p<0.05$). The

Table 3. Microhardness Change on Composite Resin Surface after Treatment for 30 Minutes (Unit: VHN)

Group	Treatment		Difference*
	Before (0 min)	After (30 min)	
Wicheongsu	93.00±2.57	84.72±3.96	−8.28±2.83[b]
Gashwalmyeongsu	94.24±3.60	82.39±7.33	−11.85±3.73[bc]
Saengrokcheon	93.48±2.46	83.69±5.57	−9.79±3.11[b]
Trevi	97.68±2.13	80.01±7.54	−16.67±5.41[c]
Samdasoo	94.32±2.55	93.48±4.11	−0.84±1.56[a]
Chamisul	91.57±3.11	85.76±2.69	−6.24±0.42[a]

Values are presented as mean±standard deviation.
[a,b,c]The same letter indicates no significant difference by Tukey test at α=0.05.
*$p<0.05$ by one way ANOVA.

positive control Trevi showed a significant difference from the experiment group Wicheongsu and Saengrokcheon, while Gashwalmyeongsu also showed a significant difference from Wicheongsu and Saengrokcheon ($p<0.05$, Table 3). The values obtained for the negative control Samdasoo and Chamisul were −0.84±1.56 and −6.24±0.42, respectively, and the value of −16.67±5.41 was obtained for the positive control Trevi with a significant difference from the three medicines in the experiment group ($p<0.05$).

The surface hardness of the experiment group was reduced to the greatest degree for Gashwalmyeongsu (−11.85±3.73), followed by Saengrokcheon (−9.79±3.11) and Wicheongsu (−8.28±2.83) (Table 3).

2) The surface microhardness according to time in each group

For the time-dependent changes in the surface hardness of composite resins after the treatment with liquefied digestive medicines, the negative control Samdasoo showed negligible changes, while Chamisul showed a slight fall until 15 minutes of immersion than a similar pattern after 30 minutes of immersion. The positive control Trevi showed a considerable fall in the surface hardness after 1 minute of immersion than a gradual fall after 3 minute of immersion. In the case of the experiment group, Wicheongsu showed a gradual fall until 5 minutes of immersion then negligible changes after 15 minutes of immersion; Gashwalmyeongsu also showed a gradual fall until 5 minutes of immersion then negligible changes after 15 minutes of immersion; Saengrokcheon showed a considerable fall in the surface hardness after 1 minutes of immersion which turned to a gradual fall after 3 minutes of immersion. The composite resin surface hardness was thus shown to have undergone significant changes according to the time of immersion ($p<0.05$) with significant between-group differences ($p<0.05$, Table 4).

3) The SEM results after the treatment with liquefied digestive medicines

The observation of the composite resin surface under the SEM showed that, except Samdasoo, all groups showed a change on the surface after 30 minutes of liquid immersion. The composite resins of the negative control Samdasoo exhibited smooth surfaces and clearly visible crystalline resin structures to indicate no change on the surface (Fig. 1A). The negative control Chamisul showed certain roughness of the surface but overall smooth surfaces in a similar way to Samdasoo (Fig. 1B). The positive control Trevi showed various forms of micropores of 1 to 4 μm size across the surfaces due to the loss of resin crystals (Fig. 1C). The experiment group Wicheongsu showed micropores of 1 to 3 μm size on some parts (Fig. 1D), while Gashwalmyeongsu showed numerous micropores of 4 to 5 μm size to exhibit a similar pattern to Trevi (Fig. 1E). Saengrokcheon mostly displayed smooth surfaces but micropores of 2 μm were observed on some parts (Fig. 1F).

Discussion

In modern society, the westernized diet and stress from work overload and environmental changes have increased the number of patients with dyspepsia, who consume

Table 4. Microhardness Change of Composite Resin up to 30 Minutes (Unit: VHN)

Group	Treatment (min)					
	Before	1	3	5	15	30
Wicheongsu[b]	93.00±2.57	91.46±4.09	86.51±2.72	85.73±5.40	84.40±2.13	84.72±3.96
Gashwalmyeongsu[bc]	94.24±3.60	90.09±6.64	87.15±2.79	84.03±4.30	82.05±5.31	82.39±7.33
Saengrokcheon[b]	93.48±2.46	87.13±4.15	87.13±3.18	86.85±6.74	85.59±1.80	83.69±5.57
Trevi[c]	97.68±2.13	89.79±6.71	87.04±6.30	85.75±3.29	84.80±2.75	80.01±7.54
Samdasoo[a]	94.32±2.55	91.28±4.90	94.81±4.20	89.32±1.48	89.71±2.94	93.48±4.11
Chamisul[a]	91.57±3.11	88.79±3.64	89.61±4.61	87.82±3.43	85.75±2.77	85.76±2.69

Values are presented as mean±standard deviation.
[a,b,c]The same letter indicates no significant difference by Tukey test at $\alpha=0.05$.

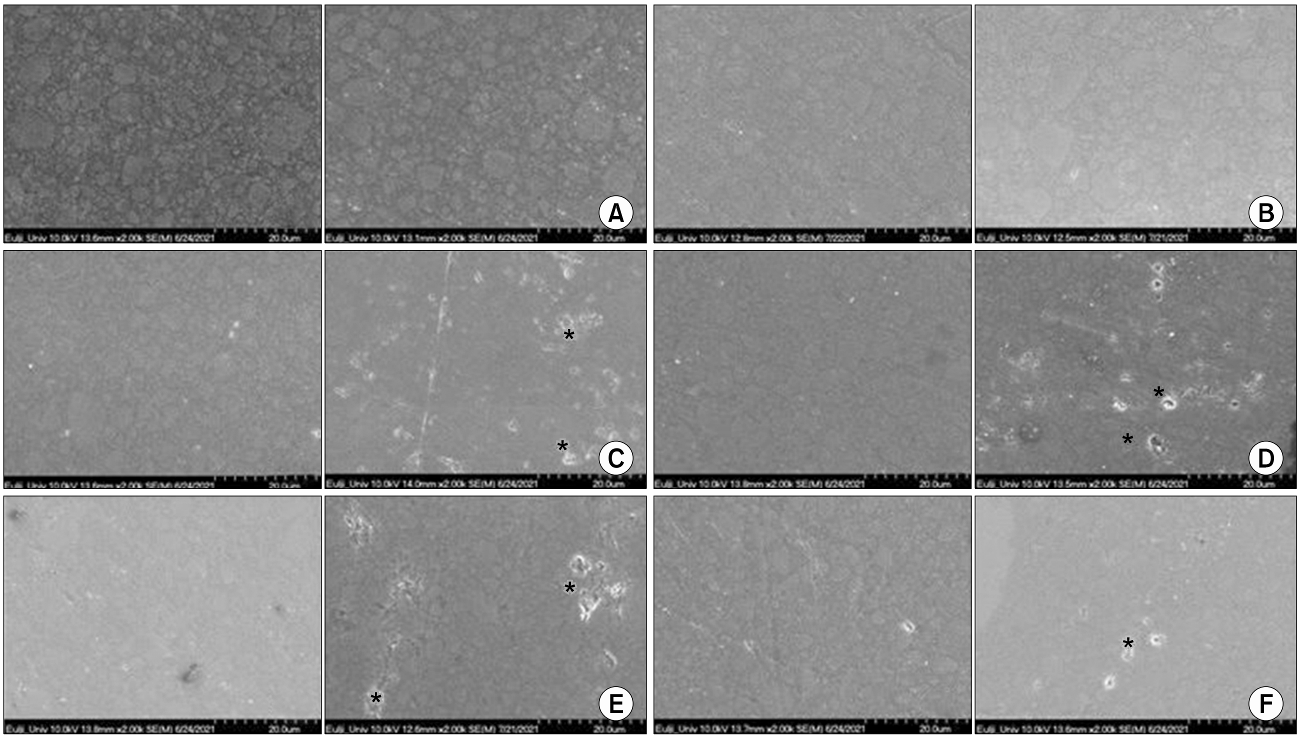

Fig. 1. Scanning electron microscope (SEM) image of composite resin surface after treatment after 1 minute and 30 minutes. This demineralization pattern was observed in all samples except the Samdasoo and Chamisul. In particular, erosion appeared severely in Trevi, a positive control, and Gashwalmyeongsu, an experimental group, followed by Wicheongsu and Saengrokcheon (A) Samdasoo. (B) Chamisul. (C) Trevi. (D) Wicheongsu. (E) Gashwalmyeongsu. (F) Saengrokcheon. Left: 1 minute, Right: 30 minutes. All magnification is ×2,000. *: micropore.

various types of digestive medicines for the improvement of related symptoms[17,18]. The digestive medicines are available in various forms from tablets to powder and liquefied types, and in line with the revision of the Notification System for Exempt Medicinal Products, the liquefied digestive medicines have become exempt medicinal products among the OTC products since June 1, 2011, so that they may be purchased easily at marts or convenience stores with the consequent trend of a steady increase in sales[2,3].

In Lee and Oh[4], a study on the commercially available liquefied digestive medicines, the examined medicines showed a positive effect on the improvement of dyspepsia but caused a fall in the enamel surface microhardness as time passed with the pH falling below 4.0 so as to induce cracks on the enamel and demineralization of the tooth structure. Previous studies have verified the low pH of liquefied digestive medicines, and in Murrell et al.[19], pH was shown to be a predictor of dental erosion. In addition, Larsen and Nyvad[20] reported a correlation between erosion and the pH of beverages, while Reddy et al.[21] reported that beverages of pH ≥4.0 might have a negligible effect on dental erosion but beverages of pH 3.0 to 3.9 might cause dental erosion with beverages of pH <3.0 causing severe cases of erosion. The mean pH of the three types of liquefied digestive medicines in this study was 3.75±0.30, with the lowest mean pH at 3.45 for Saengrokcheon, followed by Gashwalmyeongsu 3.86 and Wicheongsu 3.94. The mean pH of the positive control Trevi was 4.66, and the mean pH of the negative control Samdasoo and Chamisul was 7.40 and 8.58, respectively. The results agreed with the previous study on the commercially available liquefied digestive medicines whose pH fell in the range of 2.93 to 3.63, with mean pH of 3.30±0.29[4]. In addition, as in Reddy et al.[21], erosion was observed in the experiment group of liquefied digestive medicines after 30 minutes treatment in this study, in contrast to the negative control Samdasoo and

Chamisul.

In Hooper et al.[22] the main factors causing erosion were shown to be the pH, buffer capacity and exposure time of the beverages. Notably, the dissolution of enamel was reported to occur at pH $\leq$5.5 to indicate that the pH and buffer capacity were the two most important chemical determinants of the level of erosion caused by acidic beverages[23]. Song and Choi[24] investigated the effect of certain liquor products on dental erosion and reported that the effect was not significant for the common weak-alkaline distilled liquor products but the low-pH wine products containing citric acid had a significant effect on dental erosion. Park et al.[25] reported that, due to the contents of various acids in fruit extracts, the fruit-scented liquor products displayed low pH, and the wine products also had low pH, and a high level of 1M NaOH required for the titratable acidity. The study also showed that, in addition to pH, the buffer capacity was an important determinant of the level of erosion caused by the intake of beverages with a high buffer capacity indicating a high probability of erosion[20]. In this study, the buffer capacity at pH 5.5 was the lowest at 0.01±0.00 mL for the positive control Trevi, and for the three liquefied digestive medicines in the experiment group, Saengrokcheon showed the highest buffer capacity at 0.13±0.03 ml, followed by Wicheongsu 0.07±0.01 ml and Gashwalmyeongsu 0.06±0.01 ml. The buffer capacity at pH 7.0 was the lowest at 0.05±0.03 ml for the positive control Trevi, and for the three liquefied digestive medicines, the highest buffer capacity was shown by Saengrokcheon 0.18±0.03 ml, followed by Wicheongsu 0.11±0.01 ml and Gashwalmyeongsu 0.10±0.01 ml. The results in this study agreed with the previous studies to confirm that a higher buffer capacity indicated an increase in the severity of erosion. Nonetheless, Gashwalmyeongsu and Trevi containing carbonic acid were shown to have caused more severe erosion despite higher pH than Saengrokcheon and Wicheongsu. According to Lee et al.[26] the fall in the enamel surface hardness varied to a greater degree for the carbonated drink coke after vibration to increase the carbonation than the coke before vibration, to indicate that carbonation had a direct effect on the enamel surface hardness. In addition, in Kim et al.[27] where a specimen of the resin-based pit and fissure sealant was immersed in carbonated water, time-dependent changes in surface microhardness were observed, and it was thus reported that carbonic acid had the potential to reduce the physical properties of resin-based restorative materials by lowering the pH upon the artificial injection of carbon dioxide into beverages. In this study, likewise, the carbonated water Trevi was shown to have induced a higher level of changes in the surface hardness despite the higher pH compared to liquefied digestive medicines. Among the liquefied digestive medicines, Gashwalmyeongsu that contains carbonic acid was found to have led to a greater variation in surface hardness compared to Saengrokcheon and Wicheongsu, which indicated that, rather than pH, the content of carbonic acid had a greater deteriorating effect on surface hardness.

Meanwhile, acidic foods and drinks were reported as a crucial factor in reducing the performance and durability of the dental restorative materials as they caused surface degradation[7]. According to a previous study on the effect of beverages on dental restorative materials, acidic drinks such as coke and juice were reported to reduce the surface microhardness of dental restorative materials[28,29], while orange juice containing citric acid and apple juice containing malic acid had an effect on the changes in dental restorative materials[30]. Yanikoğlu et al.[13] also reported that, in addition to the type of the material, the surface treatment and immersion time had a considerable effect on the surface hardness of the material, moreover tea, coffee and coke had an influence on the surface hardness of composite resins. In addition, Kim[31] reported that, after the immersion in various types of liquor products, the resulting time-dependent changes were to a greater degree for those with a lower pH. In this study, likewise, the specimen treatment with 30 minutes immersion in liquefied digestive medicines was shown to have reduced the surface microhardness for all three medicines with the increase in immersion time. Trevi showed the highest level at −16.67±5.41, followed by Gashwalmyeongsu −11.85±3.73, Saengrokcheon −9.79±3.11, Wicheongsu −8.28±2.83, Chamisul −6.24±0.42 and Samdasoo −0.84±1.56. In addition, a greater effect on the microhardness of the composite resin surface was found in line with the increase in the time of liquid immersion.

Surface microhardness provides an effective method of measuring the minute changes on the surface of material after liquid immersion as it allows indirect measurement of demineralization in early lesions[32]. In addition, the SEM allows a high-resolution representation of the surface microstructures and the visualization of finer regions through the electron beam than the wavelength of the visible light[33]. According to a study by Kim et al.[34] using a SEM, after applying the bovine tooth specimens to a drink containing calamansi and observing the surface, Samdasoo showed a smooth surface, whereas Cola and Oranssi calamansi showed a rough surface and cracks. In Choi et al.[35] a study on the surface of restorative materials after the treatment with APF gel, the resin filler was shown to have exhibited a considerable level of loss. Yang et al.[36] also showed that the changes on the composite resin surface after the treatment with acidulated fluoride varied in accordance with the filler particle type in the composite resin. The surface roughness was also reported to vary according to the type of immersion solution and time when resin-based pit and fissure sealant was immersed in carbonated water[27], and the treatment with LAB- fermented milk was shown to have led to rough and cracked surfaces of composite resins in low pH beverages[9]. In this study, likewise, the level and pattern of erosion on the composite resin surface were analyzed using the surface microhardness tester and the SEM. The surfaces of composite resins after the treatment with liquefied digestive medicines showed notable changes across all groups except Samdasoo after 30 minutes of liquid immersion. For the negative control Samdasoo, the surfaces were smooth with clearly visible crystals of composite resins to indicate the lack of significant changes. For the negative control Chamisul, the roughness was observed on certain surfaces, but overall, similar smooth surfaces to Samdasoo were observed. For the positive control Trevi, the loss of resin crystals resulted in the detection of various forms of micropores of 1 to 4 μm size across overall surfaces. For the experiment group, Wicheongsu showed micropores of 1 to 3 μm size on certain parts, Gashwalmyeongsu showed numerous micropores of 4 to 5 μm size in a similar pattern to Trevi, and Saengrokcheon showed mostly smooth surfaces with micropores of 2 μm size appearing on certain parts. Such changes on the composite resin surface were in line with the changes in the surface microhardness.

Saliva has a critical role in preventing dental erosion by providing the minerals required in remineralization as well as ensuring pellicle formation and buffer capacity[37]. In addition, the saliva secretion rate and buffer capacity were shown to be the most primary factors to lower the level of dental erosion through the protection of teeth[38]. In this study, however, the oral cavity environment such as the saliva secretion rate and buffer capacity or the remineralization had not been taken into consideration. Future studies should conduct a more multidimensional investigation based on the reproduction of an environment resembling the oral cavity.

The results in this study collectively suggested that liquefied digestive medicines could cause the erosion of composite resins due to low pH, and those containing carbonic acid, in particular, were predicted to accelerate the rate of erosion. In light of this, consumers of liquefied digestive medicines should be recommended not to hold the liquid inside the mouth to minimize the contact time of acid and to rinse the mouth with water immediately after intake to remove the residual acidic components in the oral cavity.

Notes

Conflict of interest

No potential conflict of interest relevant to this article was reported.

Ethical approval

This article does not require for IRB screening because human origin is not used.

Author contributions

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