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다양한 색소에 대한 3D 프린팅 인공치의 색 안정성

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Color stability of three dimensional-printed denture teeth exposed to various colorants

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Purpose: This study evaluated color stability of Dentca 3D-printed denture teeth, in comparison to color stabilities of four conventional types of denture teeth, upon being immersed in various colorants. **Materials and methods:** Four types of conventional prefabricated denture teeth (Surpass, GC, Artic 6, Heraeus Kulzer, Premium 6, Heraeus Kulzer, Preference, Candulor), 3D-printed denture teeth (Dentca); and Z250 (Filtek Z250, 3M ESPE) were prepared for testing. The samples were immersed in erythrosine 3%, coffee, cola, and distilled water (DW) at 37°C. Color change (ΔE) was measured by spectrophotometer before immersion and at 7, 14, and 21 days after immersion. One-way analysis of variance was performed along with Tukey's honestly significant difference multiple comparisons test ($P<.05$). **Results:** No great difference was observed between the color change of Dentca denture teeth and that of conventional denture teeth in most cases ($P>.05$). The color change of Dentca denture teeth immersed in erythrosine 3% was greater than that of Surpass (ΔE = 0.67 ± 0.25) after 1 week; Artic 6 (ΔE = 1.44 ± 0.38) and Premium 6 (ΔE = 1.69 ± 0.35) after 2 weeks; and Surpass (ΔE = 1.79 ± 0.49), Artic 6 (ΔE = 2.07 ± 0.21), Premium 6 (ΔE = 2.03 ± 0.75), and Preference (ΔE = 2.01 ± 0.75) after 3 weeks ($P<.05$). **Conclusion:** A color change was observed in Dentca denture teeth when immersed in some colorants; however, the maximum value of ΔE for Dentca denture teeth was within the clinically acceptable range. *(J Korean Acad Prosthodont 2020;58:1-6)*

Keywords: 3-D printing; Colorants; Color stability; Denture teeth; Spectrophotometer

Introduction

When restoring teeth, color is one of the most important things to be considered.[1] It is also important that the color of restorations remains stable because, in the oral environment, they are prone to exposure to liquids and foods containing color agents.[2] Color stability is related directly to the esthetic aspect of the restorations.[1,3-5] However, discoloration of restorations is quite common, which causes esthetic problems for the patients.

With removable dentures, color stability of the artificial teeth is critical in esthetic terms.[6] Acrylic resin denture teeth are vulnerable to discoloration and are stainable because of their absorptivity. Poly-

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methyl methacrylate (PMMA), which acrylic denture teeth are made of, absorbs water slowly over time resulting in either oxidation of the amine accelerator or penetration of colored solutions.[1,7] The oral hygiene of patients, along with eating habits and demographic characteristics, also affect the color stability of acrylic denture teeth.[8]

Several *in vitro* studies have tested the color stability of acrylic resin teeth exposed to different colorants, beverages, and other potentially discoloring substances. In these studies, acrylic resin teeth exhibited degrees of color instability dependent on the types of teeth, types of solutions, and periods of immersion. Coffee, cola, tea, red wine, and curry solutions produced significant color changes in acrylic resin teeth.[1,7,9,10] *In vivo* studies have also assessed the color stability and staining of acrylic resin denture teeth. Their findings showed that the denture teeth exhibited color instability due to consumption of different solutions.[8]

Recently, with the development of digital equipment, machines, and technology, computer-aided design and computer-assisted manufacturing (CAD/CAM) have been used in various aspects of dentistry, including inlays, crowns, fixed partial dentures, and implant prostheses.[11] CAD/CAM technology can be also applied to removable prostheses, and Dentca 3D-printed denture (Dentca, Torrance, CA) is an example of CAD/CAM dentures. Dentca 3D-printed denture consists of a denture base and artificial teeth, produced through digitized modeling, computational optimization, and a 3D printing process. Dentca 3D printing process uses stereolithography, which polymerizes the liquid resin layer by layer through repeated exposure to a concentrated beam of ultraviolet light.[11-13] Dentca 3D-printed denture teeth consist of methacrylate-based photo-polymerized resin.[12] In the era of digital dentistry, 3D-printed dentures can be fabricated with great precision, and patient comfort is increased through minimizing the duration of their visit, therefore, the use of 3D-printed dentures is expected to increase.[14] However, there is a deficiency of studies of the color stability of 3D-printed denture teeth compared to that of conventional denture teeth.

The purpose of this *in vitro* study is to evaluate, via spectrophotometry, the color stability of Dentca 3D-printed denture teeth compared with that of four types of conventional denture teeth following immersion in various colorants. The null hypothesis is that there would be no significant difference in color stability between Dentca 3D-printed denture teeth and conventional denture teeth.

Materials and Methods

For color stability test Dentca 3D-printed denture teeth and four types of conventional denture teeth were prepared. Z250 (FiltekTM Z250, 3M ESPE, St. Paul, MN, USA) photopolymerizing composite resin was used as a control. A2 shade was selected in all specimens. Prefabricated maxillary central incisors were used without any treatment in the groups of conventional denture teeth. Each group was consisted of 20 specimens.

Dentca specimens were designed as a rectangular parallelepiped measuring 15 mm × 10 mm × 10 mm (length × width × height), and the digital specimen file was uploaded to 3D printer operation software to prepare the appropriate pre-processing to print. The specimens were printed via stereolithography (Zenith 3D printer, Dentis Cor., Daegue, South Korea), cleaned with isopropanol, and cured for 40 min to react with the remaining monomers in the post-curing oven (UV Honle Sol 500, Honle UV America, Inc., Marlborough, MA, USA) by immersion in glycerin.

Z250 specimens were fabricated in disk shapes of 3 mm thickness and 10 mm diameter by condensing in a cylindrical mold and light-cured. Z250 was condensed incrementally and light cured 3 times with light curing gun (Mini LED, SATELEC, Merignac, France) for 40 minutes at each thickness of 1 mm.

Both Dentca and Z250 specimens were kept dry at 37°C for one day. Subsequently, the specimens were polished and ground with silicon carbide papers of grain sizes 600 and 1200 grit on a rotary machine under water cooling. Table 1 shows the tested resin denture teeth and a control.

Four colorants-erythrosine 3%, coffee, cola, and distilled water-were used for testing. The specimens (5 samples in each group) were immersed in the respective colorants and then stored at 37°C in an

Table 1. Tested resin denture teeth and a control

Group	Product	Manufacturer	Mold	Material*
1	Z250	3M ESPE	10 mm round, 3 mm thickness	Composite
2	Surpass	GC	S6	PMMA
3	Artic 6	Heraeus Kulzer	S40	PMMA
4	Premium 6	Heraeus Kulzer	S8	MPM-PMMA
5	Preference	Candulor	040	PMMA
6	Dentca denture teeth	Dentca	15 × 10 × 10 mm	Methacrylate based photo-polymerized resin

PMMA, Polymethylmethacrylate; MPM, Multiplex-Polymer-Matrix; UDMA, Urethanedimethacrylate
*written following manufacturer's information.

incubator for 7, 14, and 21 days. The solutions were replaced every day. The coffee solution was made by placing 1.8 g of ground coffee powder (Nescafe Crema, Nestle, Vevey, Switzerland) in a cup and adding 200 mL of boiling water. The specimens in the cola group were stored in cola (Coca-Cola, Coca-Cola Co., Kwangju, Korea). All specimens were rinsed with distilled water before measurement. Excess water on the surfaces of the specimens was removed with tissue paper, and they were allowed to dry.

The color Commission Internationale d'Eclairage (CIE) Lab values were measured on three random areas via spectrophotometry (Color-Eye 7000A, GretagMacbeth, München, Germany) following different immersion times (before immersion, and at 1 week, 2 weeks, and 3 weeks after immersion).The color difference (ΔE) value was calculated for statistical analysis.

$$\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

$\Delta L^* = L2 - L1$,

L2 = value after immersion,

L1 = value before immersion (day 0)

$\Delta a^* = a2 - a1$,

a2 = value after immersion,

a1 = value before immersion (day 0)

$\Delta b^* = b2 - b1$,

b2 = value after immersion,

b1 = value before immersion (day 0)

Statistical analysis using SPSS (IBM Cop., New York, NY, USA) was performed to evaluate the values obtained for the different groups. One-way analysis of variance (ANOVA) was performed in conjunction with Tukey's honestly significant difference multiple comparisons test. The significance level was set at $P < .05$.

Results

The ΔE value is the combination of differences in the three dimensions of color space in the CIE LAB color system. Table 2 shows the ΔEs of the denture teeth. The results differ according to the immersion solutions and the duration of immersion. There was more color change in the Z250 control than in both Dentca and prefabricated denture teeth, both of which showed only minor color changes. Color change in Dentca denture teeth was greater following immersion in erythrosine 3% solution than after immersion in either coffee or cola solutions.

After immersion in erythrosine 3% for 1 week, the ΔE values of Dentca denture tooth material were lower than those of Z250 and higher than those of Surpass ($P < .05$). After immersion in coffee for 1 week, the ΔE values of Dentca denture tooth material were lower than those of Z250 ($P < .05$).

After immersion in DW for 2 weeks, the ΔE values of Dentca denture tooth material were lower than those of Premium 6 ($P < .05$). After immersion in erythrosine 3% for 2 weeks, the ΔE values of Dentca denture tooth material were lower than those of Z250 and higher than those of Artic 6 and Premium 6 ($P < .05$). After immersion in coffee for 2 weeks, ΔE values of Dentca denture tooth material were lower than those of Z250 ($P < .05$). After immersion in cola for 2 weeks, the ΔE values of Dentca denture tooth material were lower than those of Preference ($P < .05$).

After immersion in erythrosine 3% for 3 weeks, the ΔE values of Dentca denture tooth material were lower than those of Z250 and higher than those of Surpass, Artic 6, Premium 6, and Preference ($P < .05$). After immersion in coffee for 3 weeks, the ΔE values of Dentca denture tooth material were lower than those of Z250 ($P < .05$).

Table 2. Results of the color stability test (Mean and standard deviation of ΔE)

Period	Colorants	Materials					
		Z250	Surpass	Artic 6	Premium 6	Preference	Dentca denture teeth
One week	DW	0.39 (0.15)	0.25 (0.66)	0.61 (0.25)	0.49 (0.99)	0.54 (0.21)	0.30 (0.27)
	Erythrosine 3%	10.51 (0.77)	0.67 (0.25)	1.65 (0.89)	1.72 (0.48)	1.17 (0.61)	2.78 (0.27)
	Coffee	3.57 (0.86)	0.56 (0.39)	1.02 (0.69)	0.51 (0.17)	1.06 (0.77)	0.68 (0.13)
	Cola	0.80 (0.19)	0.67 (0.33)	0.31 (0.18)	0.89 (0.68)	0.73 (0.24)	0.66 (0.65)
Two weeks	DW	0.65 (0.31)	0.70 (0.23)	0.56 (0.64)	1.78 (0.43)	0.96 (0.76)	0.30 (0.17)
	Erythrosine 3%	11.65 (0.73)	2.19 (0.62)	1.44 (0.38)	1.69 (0.35)	1.77 (0.81)	2.62 (0.27)
	Coffee	4.99 (0.24)	1.89 (0.78)	0.57 (0.54)	1.80 (0.16)	1.51 (0.40)	0.82 (0.22)
	Cola	1.11 (0.22)	1.74 (0.56)	0.57 (1.88)	0.84 (0.84)	1.83 (0.17)	0.71 (0.41)
Three weeks	DW	0.67 (0.37)	0.49 (0.86)	0.58 (0.14)	0.79 (0.18)	0.62 (0.26)	0.44 (0.09)
	Erythrosine 3%	11.92 (0.54)	1.79 (0.49)	2.07 (0.21)	2.03 (0.75)	2.01 (0.75)	3.72 (0.30)
	Coffee	5.99 (0.50)	1.34 (1.24)	0.67 (0.53)	2.16 (0.62)	1.00 (0.52)	1.28 (0.17)
	Cola	1.19 (0.11)	1.66 (0.90)	0.45 (0.11)	0.59 (0.31)	1.14 (0.58)	1.02 (0.11)

Discussion

The color stability in dental prostheses is an important factor both in the longevity of prostheses and in patient satisfaction. Discoloration, esthetic disharmony, and the addition of colorants to prostheses are major reasons for remaking the prostheses.[15] The CIE Lab, which was introduced in 1976, provides a standard and approximately uniform color scale.[16]

In the present study, color change measurement was done using the CIE Lab. CIE Lab is used widely because its color values can show small differences in color change and can be compared easily. Color difference with CIE Lab is presented as ΔE. Douglas *et al*.[17] demonstrated that color difference of 2.6 ΔE is the visual threshold for 50/50 perceptibility, meaning that dentist observers can perceive a color difference, and that color difference of 5.5 ΔE is the clinically acceptable limit for denture teeth. This finding has been used to assess the color stability of dental materials, such as denture teeth.

The present study used erythrosine 3%, coffee, cola, and distilled water as colorants. Erythrosine is commonly used as food colorants, for example, in beverages, jellies, jams, candies, and ice cream. Since it is electrostatically charged, it can stain surfaces.[7] As reported by Jeong *et al*.[15] who measured the color stability of ceromers (Targis and Artglass system) upon exposure to different colorants, the greatest color change occurred with the red colorant compared with the yellow and blue colorants. Moreover, Hersek *et al*.[7] showed that there was a greater color change in Luciton, which is a heat-cured denture base acrylic resin, in erythrosine solution compared to yellow solutions. As erythrosine 3% solution can produce a detectable color change, it is a suitable colorant for comparing the color stability of denture teeth. As the other colorants used in this study, i.e., coffee and cola, are popular drinks, they can also play a great role in evaluating the color stability of denture teeth. Coffee contains tannin, which stains denture teeth. Moreover, the presence of sugar and filtering process of coffee also affect color change in denture teeth.[9,18] Cola has extremely low pH, and this acidity can contribute to changes in the color of materials.[19] Many studies have shown that coffee can produce a greater color change than other drinks, such as tea and cola.[9,10] However, other studies have shown a smaller color change with coffee than with other beverages.[1,20] Despite these conflicting findings, the fact that coffee and cola can stain materials are still an important aspect of the current study.

In this study, color change in Dentca 3D printed denture teeth was compared with that in the photopolymerizing composite resin Z250 and four types of conventional denture teeth. Z250 specimens used as a control group showed the maximum color change compared to Dentca denture teeth followed immersion in ether erythrosine 3% or coffee. However, the color of Dentca denture teeth did not differ statistically from that of Z250 after immersion in either DW or cola for all periods.

Dentca denture teeth showed no great color change compared to conventional denture teeth in most cases, including immersion in either DW or cola for periods of 1 week and 3 weeks, and immersion in coffee for periods of 1 week, 2 weeks, and 3 weeks. However, following immersion in erythrosine 3%, the color change in Dentca denture teeth was greater than that in Surpass after 1 week, Artic 6 and Premium 6 after 2 weeks, and all of the conventional denture teeth after 3 weeks. Conversely, the color change was more statistically obvious in the conventional denture teeth Premium 6 after 2 weeks' immersion in DW and Preference after 2 weeks' immersion in cola than in the Dentca denture teeth. Therefore, the null hypothesis was rejected for immersion in DW, erythrosine 3% solution, and cola, but it was accepted for immersion in coffee.

Within the results, even if there was some statistically different color change in the Dentca denture teeth compared with the conventional denture teeth, the maximum value of ΔE for Dentca denture teeth was 3.72 following 3 weeks' immersion in erythrosine 3%. Though this figure might exceed the 50/50 perceptibility level, it is still below the clinically acceptable range. The same results were obtained for the color change in the same solution for 1 and 2 weeks. These color changes were not noticed by the patients, and they should not constitute a reason to remake prostheses.

The increasing use of CAD/CAM technology enables the development of 3D printed dentures. Dentca 3D printed denture uses additive manufacturing in fabricating dentures.[21-23] The material used to make Dentca artificial teeth is methacrylate-based photo-polymerized resin, which consists of photo-curable organic compounds, surface modified nano-sized inorganic fillers, photo-initiator, colorants, and stabilizer.[24] The main disadvantages when fabricating conventional complete dentures are the number of visits, the length of time required for manufacture, and the complexity of the laboratory processes involved. Conversely, Dentca 3D printed denture can reduce the patient visit to complete the dentures, can be duplicated easily because all the 3D images and collected data can be saved digitally. Several recent studies have reported on clinically applied 3D printed complete dentures and demonstrated benefits such as patient satisfaction, higher retention, and fewer sore spots.[12,14,25-27] Moreover, Dentca 3D printed denture teeth have proven mechanical properties, such as chipping strength and indirect tensile fracture resistance, which are comparable to those of conventionally prefabricated denture teeth.[28] However, since there is no long-term experience and no sufficient data has been accumulated yet, more research is needed.

The limitation of the present *in vitro* study is the fact that it did not consider the oral cavity environment. In the oral cavity, the complete denture is exposed constantly to saliva and foods, which may affect

the color stability of denture teeth. Therefore, future *in vivo* research is required to evaluate the color stability of 3D-printed dentures.

Conclusion

In the present study, the color stability of Dentca artificial teeth was comparable to that of conventional denture teeth.

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References

1. Kurtulmus-Yilmaz S, Deniz ST. Evaluation of staining susceptibility of resin artificial teeth and stain removal efficacy of denture cleansers. Acta Odontol Scand 2014;72:811-8.
2. Piskin B, Sipahi C, Akin H. Effect of different chemical disinfectants on color stability of acrylic denture teeth. J Prosthodont 2014;23:476-83.
3. Ruyter IE, Nilner K, Moller B. Color stability of dental composite resin materials for crown and bridge veneers. Dent Mater 1987;3:246-51.
4. Vichi A, Corciolani G, Davidson CL, Ferrari M. Color and opacity variations in three different resin-based composite products after UV aging. Inter Dent SA 2007;9:58-66.
5. Gregorius WC, Kattadiyil MT, Goodacre CJ, Roggenkamp CL, Powers JM, Paravina RD. Effects of ageing and staining on color of acrylic resin denture teeth. J Dent 2012;40:e47-54.
6. Koksal T, Dikbas I. Color stability of different denture teeth materials against various staining agents. Dent Mater J 2008;27:139-44.
7. Hersek N, Canay S, Uzun G, Yildiz F. Color stability of denture base acrylic resins in three food colorants. J Prosthet Dent 1999;81:375-9.
8. Barão VA, Ogawa ES, Moreno A, Mesquita MF, Wee AG, Assunção WG. Long-term clinical evaluation of the color stability and stainability of acrylic resin denture teeth. J Prosthet Dent 2015;113:628-35.
9. Mousavi S, Narimani S, Hekmatfar S, Jafari K. Colour stability of various types of acrylic teeth exposed to coffee, tea and cola. J Dent Biomater 2016;3:335-40.
10. Mutlu-Sagesen L, Ergün G, Ozkan Y, Bek B. Color stability of different denture teeth materials: an in vitro study. J Oral Sci 2001;43:193-205.
11. Kattadiyil MT, Goodacre CJ, Baba NZ. CAD/CAM complete dentures: a review of two commercial fabrication systems. J Calif Dent Assoc 2013;41:407-16.
12. Kim TH, Varjao F. 3D printed complete dentures. 1st ed. Illinois; Quintessence Publishing Co. Inc.; 2016. p. 141-9.
13. van Noort R. The future of dental devices is digital. Dent Mater 2012;28:3-12.
14. Pereyra NM, Marano J, Subramanian G, Quek S, Leff D. Comparison of patient satisfaction in the fabrication of conventional dentures vs. DENTCA (CAD/CAM) dentures: A case report. J N J Dent Assoc 2015;86:26-33.
15. Jeong YJ, Lim JH, Cho IH, Lim HS. Color stability of ceromers in three food colorants. J Korean Acad Prosthodont 2003;41:136-47.
16. McGuire RG. Reporting of objective color measurements. HortScience 1992;27:1254-5.
17. Douglas RD, Steinhauer TJ, Wee AG. Intraoral determination of the tolerance of dentist for perceptibility and acceptability of shade mismatch. J Prosthet Dent 2007;97:200-8.
18. Guler AU, Yilmaz F, Kulunk T, Guler E, Kurt S. Effects of different drinks on stainability of resin composite provisional restorative materials. J Prosthet Dent 2005;94:118-24.
19. Gupta R, Parkash H, Shah N, Jain V. A spectrophotometric evaluation of color changes of various tooth colored veneering materials after exposure to commonly consumed beverages. J Indian Prosthodont Soc 2005;5:72-8.
20. Um CM, Ruyter IE. Staining of resin-based veneering materials with coffee and tea. Quintessence Int 1991;22:377-86.
21. Baba NZ, Goodacre CJ, Kattadiyil M. CAD/CAM removable prosthodontics. In: Masri R, Driscoll CF. Clinical applications of digital dental technology. Hoboken; John Wiley & Sohns, Inc.; 2015. p. 107-10.
22. Baba NZ. Materials and processes for CAD/CAM complete denture fabrication. Curr Oral Health Rep 2016;3:203-8.
23. Lin WS, Harris BT, Pellerito J, Morton D. Fabrication of an interim complete removable dental prosthesis with an in-office digital light processing three-dimensional printer: A proof-of-concept technique. J Prosthet Dent 2018;120:331-4.
24. Lee JS, inventor; DENTCA Inc, assignee. Photo-curable resin compositions and method of using the same in three-dimensional printing for manufacturing artificial teeth and denture base. United States patent US2014/0167300A1. 2014 Aug 28.
25. Kattadiyil MT, Al Helal A. An update on computer-engineered complete dentures: A systematic review on clinical outcomes. J Prosthet Dent 2017;117:478-85.
26. Park JH, Cho IH, Shin SY, Choi YS. The treatment of an edentulous patient with DENTCA™ CAD/CAM Denture. J Korean Acad Prosthodont 2015;53:19-25.
27. Chen J, Ahmad R, Suenaga H, Li W, Sasaki K, Swain M, Li Q. Shape optimization for additive manufacturing of removable partial dentures-a new paradigm for prosthetic CAD/CAM. PLoS One 2015;10:e0132552.
28. Chung YJ, Park JM, Kim TH, Ahn JS, Cha HS, Lee JH. 3D printing of resin material for denture artificial teeth: Chipping and indirect tensile fracture resistance. Materials (Basel) 2018;11:1798.

다양한 색소에 대한 3D 프린팅 인공치의 색 안정성

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목적: 본 연구는 다양한 색소에 침전된 Dentca 3D 프린팅 인공치의 색 안정성을 4가지 전통적인 인공치와 비교하여 평가하기 위함이다.

재료 및 방법: 4가지 전통적인 기성 인공치(Surpass, GC, Artic 6, Heraeus Kulzer, Premium 6, Heraeus Kulzer, Preference, Candulor), 3D 프린팅 인공치(Dentca), 그리고 Z250 (Filtek Z250, 3M ESPE)이 실험을 위하여 준비되었다. 시편은 37°C에서 에리스로신 3% 용액, 커피, 콜라, 그리고 증류수에 침전되었다. 색 변화량(ΔE)은 침전 전, 침전 7,14,21일 후에 분광광도계로 측정되었다. Tukey's honestly significant difference 다중 비교를 이용한 일원분산분석을 시행하였다($P < .05$).

결과: 대부분의 케이스에서 Dentca 인공치와 전통적인 인공치 사이의 색 변화량은 큰 차이를 보이지 않았다 ($P > .05$). Dentca는 에리스로신 3% 용액에 침전된 1주 뒤의 Surpass (ΔE = 0.67 ± 0.25), 2주 뒤의 Artic 6 (ΔE = 1.44 ± 0.38), Premium 6 (ΔE = 1.69 ± 0.35), 그리고 3주 뒤의 Surpass (ΔE = 1.79 ± 0.49), Artic 6 (ΔE = 2.07 ± 0.21), Premium 6 (ΔE = 2.03 ± 0.75), Preference (ΔE = 2.01 ± 0.75)와 비교했을 때 더 많은 색 변화를 보였다 ($P < .05$).

결론: 일부 색소에 침전된 Dentca 인공치에서 색 변화가 관찰되었으나, ΔE의 최대값은 임상적으로 받아들일 수 있는 범위 내에서 관찰되었다. *(대한치과보철학회지 2020;58:1-6)*

주요단어: 3D 프린팅; 색소; 색 안정성; 인공치; 분광광도계

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