Original Article

Color Change of Ceramill Zolid FX Following Abrasion with/without Toothpaste

Majid Abolhasani[1], Ehsan Ghasemi[2], Amir Hossein Fathi[3], Mohammad Javad Hayatizadeh[4]

[1] Assistant Professor, Dental Implants Research Center, Dental Prosthodontics Department, School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran
[2] Associate Professor, Dental Materials Research Center, Dental Prosthodontics Department, School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran
[3] Assistant Professor, Dental Materials Research Center, Dental Prosthodontics Department, School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran
[4] Dentist, Private Office, Yazd, Iran

Abstract

Background and Aim: Toothbrushing can potentially abrade the teeth and direct and indirect dental restorations, and may also affect their color. This study aimed to assess the color change (ΔE) of Ceramill Zolid FX following abrasion with/without toothpaste in two groups of simultaneous and separate staining and glazing.

Materials and Methods: This in vitro, experimental study was conducted on 40 cylindrical specimens measuring 2 x 10 mm fabricated from Ceramill Zolid FX by the computer-aided design/computer-aided manufacturing technology. The samples were randomly divided into four groups (simultaneous and separate staining and glazing) and subjected to simulation of 3, 6 and 9 years of toothbrushing in a cross-brushing machine with and without toothpaste. The ΔE of specimens was measured before and after the intervention by using Shade Pilot spectrophotometer, and compared using the Mann-Whitney and Friedman tests (alpha=0.05).

Results: Significant differences were noted in ΔE of simultaneous staining and glazing control (without toothpaste) and intervention (with toothpaste) groups over time (both P=0.000). Both the control and intervention subgroups in separate staining and glazing group also showed significant differences in ΔE over time (both P=0.000).

Conclusion: The results showed greater color change over time in simultaneous staining and glazing group due to the presence of one layer of stain and glaze, compared with separate staining and glazing. The effect of toothpaste on color change was only significant at 9 years in both simultaneous and separate staining and glazing groups.

Key Words: Toothpastes, Tooth Wear, Ceramics

Corresponding author:
Ehsan Ghasemi, Associate Professor, Dental Materials Research Center, Dental Prosthodontics Department, School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran

e_ghasemi@dnt.mui.ac.ir

Received: 17 April 2021
Accepted: 15 Aug 2021

➢ **Cite this article as:** Abolhasani M, Ghasemi E, Fathi A, Hayatizadeh M. Color Change of Ceramill Zolid FX Following Abrasion with/without Toothpaste. J Iran Dent Assoc. 2021; 33(3-4):51-57.

Introduction

Tooth-colored restorations have long been favored due to optimal esthetics. Dental ceramics have excellent esthetics, favorable biocompatibility, and high strength for dental restorations [1]. Use of dental porcelain is increasing due to favorable optical and esthetic properties [2]. In the past 40 years, metal-ceramic restorations have served as a reliable treatment option. However, advances in science and technology, increased demand for esthetics, and questionable biocompatibility of metals and alloys used in meta-ceramic restorations further led to growing popularity of all-ceramic dental restorations [3]. Dental ceramics inherently have high compressive strength and low tensile strength. Zirconia is used as a core material in some types of ceramic restorations. However, chipping of the porcelain veneering due to its weak bond is one drawback of this type of restorations. To overcome this shortcoming, some researchers suggested the use of full anatomic zirconia [4,5]. Zirconia has greater strength than other types of dental ceramics. The potential concerns regarding these restorations are mainly related to wear of the opposing or adjacent enamel, and/or their optimal and esthetic properties. Recently, some manufacturers marketed a high-translucency zirconia [6,7].

The favorable optical properties and color of these restorations are attributed to the use of intrinsic and extrinsic stains. However, since the stains are exposed to the oral environment, they may be worn over time due to the effect of environmental factors such as toothpastes. Abrasives are present in the composition of toothpastes, and several studies have evaluated the effects of toothbrushing on superficial stains of feldspathic porcelain [8,9]. Toothbrushing has several advantages including plaque removal, elimination of external stains, prevention of gingivitis and periodontitis, and prevention of dental caries [8,9]. Toothpastes also help mechanical plaque removal by toothbrushing due to the presence of abrasives and detergents in their composition. On the other hand, absence or inadequate amount of abrasives in toothpastes often leads to increased external staining of teeth and restorations. However, it has been accepted that some degree of abrasion by toothpaste is inevitable in teeth at the expense of their optimal cleaning.

All-ceramic restorations have gained wide acceptance in the recent years. Adequate strength of ceramic cores in combination with optimal esthetics of the veneers yield restorations with high biocompatibility and favorable esthetics [10]. The cores are often made of reinforced disilicate, leucite, or zirconia oxide crystals. At present, different manufacturers have introduced zirconia-based ceramic systems. High strength, dimensional stability, and a coefficient of elasticity comparable to that of stainless steel made zirconia a suitable alternative to metal cores [11,12].

This study aimed to assess the color change (ΔE) of Ceramill Zolid FX following abrasion with/without toothpaste by simulation of 3, 6, and 9 years of clinical service in two groups of simultaneous and separate staining and glazing. The ΔE was assessed using the CIE L*a*b* color space.

Materials and Methods

In this in vitro, experimental study, 40 cylindrical specimens measuring 2 x 10 mm were fabricated from Ceramill Zolid FX (Amann Girrbach, Germany) using computer-aided design/computer-aided manufacturing technology (imes-icore). The specimens were randomly divided into four groups as follows:

(I) Simultaneous staining and glazing of specimens followed by exposure to Puneh toothpaste (Tehran, Iran; RDA=68)

(II) Simultaneous staining and glazing of specimens with no exposure to toothpaste

(III) Separate staining and glazing followed by exposure to Puneh toothpaste

(IV) Separate staining and glazing with no exposure to toothpaste

A polisher machine (3M Perfect-It) was used to reduce 100 μm of the thickness of specimens. After sintering, C4 Vita stain was applied on the surface of specimens in 100 μm (±30) thickness and heated. Each specimen was then mounted in cold-cure acrylic resin and placed in a cross-brushing V8 machine, which used a medium toothbrush (GUM) with 1.96 N force and back and forth brushing motion at 90 rpm. The color parameters of specimens were measured before simulated toothbrushing and after simulation of 3, 6, and 9 years of toothbrushing (80,000, 160,000, and 240,000 cycles, respectively) [13] using Shade Pilot spectrophotometer (Degudent, Germany) according to the CIE

L*a*b* color space. The mean color change (ΔE) was calculated and the intervention and control groups were compared using the Mann-Whitney and Friedman tests. Data were analyzed using Excel 2010 and SPSS version 20 software programs. Level of significance was set at 0.05.

Results

According to the Friedman test, a significant difference was noted at different time points regarding ΔE in the control (no exposure to toothpaste) (P=0.000) and intervention (exposure to toothpaste) (P=0.000) subgroups of simultaneous staining and glazing group (Figure 1). Table 1 presents the mean ΔE of simultaneous staining and glazing subgroups (control and intervention), while Table 2 presents the mean ΔE of separate staining and glazing groups (control and intervention).

The Friedman test showed a significant difference in ΔE within the control (P=0.000) and intervention (P=0.000) groups over time (Figure 2).

Table 3 shows color change of simultaneous and separate staining and glazing groups at different time points.

Comparison of simultaneous and separate staining and glazing protocols showed significantly greater ΔE of specimens in simultaneous staining and glazing groups (Figure 3). Regarding the effect of toothpaste on color change, the results showed a significant change only at 9 years in the toothpaste groups of both simultaneous and separate staining and glazing (P=0.02). No significant change was noted in any other group (P>0.05).

The degree of abrasion and the resultant ΔE in the toothpaste groups was greater than that in the no-toothpaste groups over time. The color of specimens became lighter after tooth brushing with toothpaste. Wilcoxon test (Table 4) showed that the color change was maximum between 3-9 and minimum between 3-6 years.

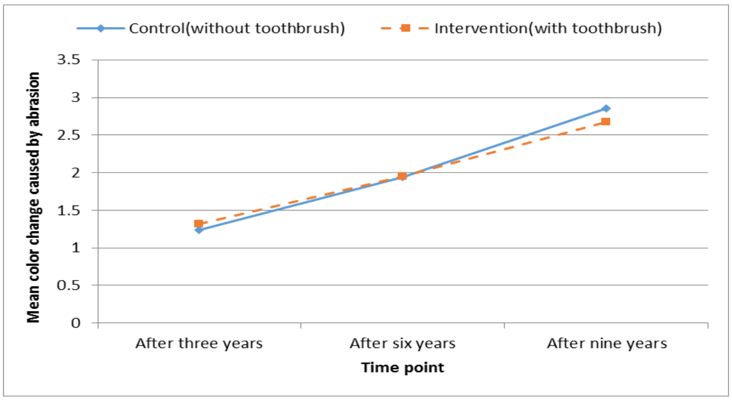

Figure 1. Color change of simultaneous staining and glazing groups at different time points

Table 1. Mean ΔE of simultaneous staining and glazing groups (control and intervention)

Time	Number	Control	Intervention	Mann-Whitney	
				Statistic	P value
3 years	10	1.0±24.12	1.0±32.26	44.50	0.68
6 years	10	1.0±94.11	1.0±95.22	44.00	0.68
9 years	10	2.0±86.08	2.0±67.19	19.50	0.01
Friedman test	Statistic	20.00	20.00		
	P value	0.000	0.000		

Table 2. Mean ΔE of separate staining and glazing groups (control and intervention)

Time	Number	Control	Intervention	Mann-Whitney	
				Statistic	P value
3 years	10	32.17±1.0	33.14±1.0	44.50	0.68
6 years	10	98.16±1.0	07.31±2.0	49.00	0.97
9 years	10	78.24±2.0	86.13±2.0	45.00	0.73
Friedman test	Statistic	020.00	19.53		
	P value	0.000	0.000		

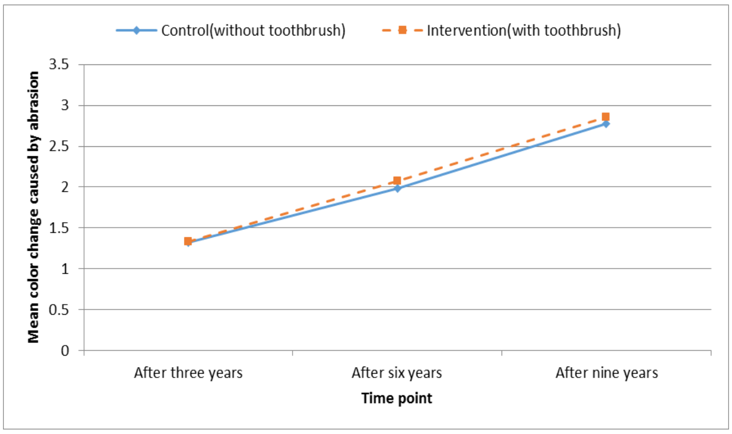

Figure 2. Color change of separate staining and glazing groups at different time points

Table 3. Color change of simultaneous and separate staining and glazing groups at different time points

Group	Number	Separate staining and glazing with toothpaste	Simultaneous staining and glazing with toothpaste	Mann-Whitney	
				Statistic	Statistic
	3 years	32.17±1.0	24.12±1.0	0.81	0.41
Control	6 years	98.16±1.0	94.11±1.0	1.01	0.30
	9 years	78.24±2.0	86.08±2.0	0.03	0.96
Friedman	Statistic	020.00	20.00		
	P value	0.000	0.000		
	3 years	33.14±1.0	32.26±1.0	0.65	0.51
Intervention	6 years	07.31±2.0	95.22±1.0	1.31	0.19
	9 years	86.13±2.0	67.19±2.0	2.22	0.02
Friedman	Statistic	19.53	20.00		
	P value	0.000	0.000		

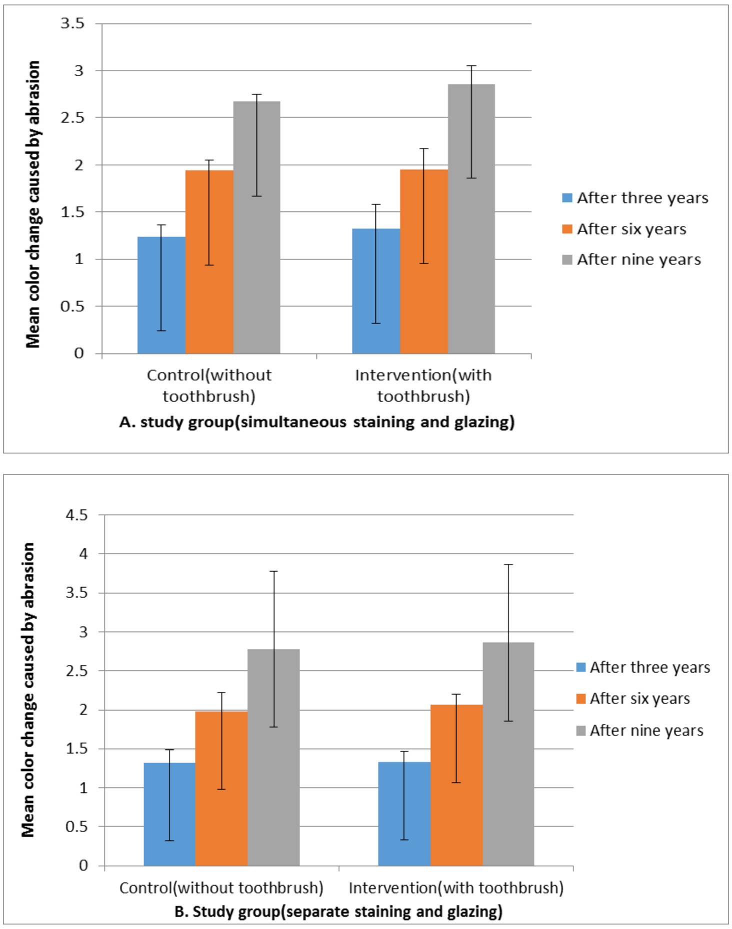

Figure 3. Effects of simultaneous (A) and separate (B) staining and glazing on color change at different time points

Table 4. Pairwise comparisons by the Wilcoxon test

Group		Mean difference	Test statistic	P value	Outcome
Simultaneous staining and glazing intervention group	3 and 6 years	0.63	2.80	0.005	Significant
	3 and 9 years	1.35	2.82	0.005	Significant
	6 and 9 years	0.72	2.82	0.005	Significant
Simultaneous staining and glazing control group	3 and 6 years	0.70	2.83	0.005	Significant
	3 and 9 years	1.62	2.82	0.005	Significant
	6 and 9 years	0.92	2.82	0.005	Significant

Discussion

Successful color match of dental restorations and the adjacent natural teeth is an important topic in dentistry. Traditionally, color selection is performed by using a shade guide. However, it is now known that this method is a subjective method and is influenced by a number of factors [14]. The composition of toothpastes has greatly changed since their introduction. Nonetheless, abrasives are a constant ingredient in the composition of almost all toothpastes. They account for 25% to 60% of the composition of toothpastes. Abrasives are used to clean the tooth surface [15]. Several factors can affect the level of abrasivity of toothpastes such as the inherent hardness of the abrasive components, their shape, size and percentage, technique of toothbrushing, pressure applied to toothbrush, hardness of the bristles, and direction and frequency of brushing movements [15,16]. Due to the fragile nature of dental porcelain, a suitable core is required to support the veneering porcelain in all-ceramic restorations. Zirconia has superior mechanical properties compared with other materials for use as a core in all-ceramic systems due to its transformation toughening mechanism. Thus, it is increasingly used for this purpose [17]. This study aimed to assess the color change of Ceramill Zolid FX following abrasion in a cross-brushing machine with and without using a toothpaste. Puneh toothpaste was used in this study. The results showed a significant difference in ΔE of both the intervention and control groups with simultaneous staining and glazing (P=0.000). This result was in agreement with the findings of Debra et al, [18] who showed that using a toothpaste caused significant ΔE and lightened the tooth shade (due to stain removal). Roselino et al. [19] evaluated the effect of toothbrushing with toothpaste on color change and surface roughness of composites and concluded that use of toothpaste and increased duration of toothbrushing caused color change of composites; however, these parameters had no significant effect on surface roughness of composites. Their results were in line with the present findings although they evaluated composite resins while we assessed zirconia ceramics. Garza et al. [20] evaluated the effects of toothbrushing on color and surface roughness of two different ceramics and found no significant change in color or surface roughness of Empress Esthetic ceramic irrespective of the staining technique. However, significant changes in color and surface roughness were noted in the IPS group (lithium disilicate-based ceramic) after 12 hours of simulated toothbrushing. The results in the latter group were in agreement with the present findings. A number of factors can affect the color of specimens in vitro. Heydari et al. [21] evaluated the effect of repeated baking of dental ceramics on their color stability following exposure to tea and coffee. They concluded that the color change of ceramics was influenced by the frequency of baking cycles (3, 5, and 7 times) and also the type of ceramic system. Tea and coffee had no significant effect on the ceramic color.

This study had some limitations including in vitro design, presence of confounding factors like environmental temperature alterations, and operator errors, which should be addressed in future studies.

Conclusion

The results showed greater color change over time in simultaneous staining and glazing due to the presence of one layer of stain and glaze, compared with separate staining and glazing. The effect of toothpaste on color change was only significant at 9 years in both simultaneous and separate staining and glazing groups.

References

1. Molin M, Karlsson S. A clinical evaluation of the Optec inlay system. Acta Odontologica Scandinavica. 1992 Jan 1;50(4):227-33.

2. Bergström J, Lavstedt S. An epidemiologic approach to toothbrushing and dental abrasion. Community dentistry and oral epidemiology. 1979 Feb;7(1):57-64.

3. Heath JR, Wilson HJ. Abrasion of restorative materials by toothpaste. Journal of Oral Rehabilitation. 1976 Apr;3(2):121-38.

4. Absi EG, Addy M, Adams D. Dentine hypersensitivity–the effect of toothbrushing and

dietary compounds on dentine in vitro: an SEM study. Journal of oral rehabilitation. 1992 Mar; 19(2):101-10.
5. Dyer D, MacDonald E, Newcombe RG, Scratcher C, Ley F, Addy M. Abrasion and stain removal by different manual toothbrushes and brush actions: studies in vitro. Journal of clinical periodontology. 2001 Feb;28(2):121-7.
6. Franzo D, Philpotts CJ, Cox TF, Joiner A. The effect of toothpaste concentration on enamel and dentine wear in vitro. Journal of dentistry. 2010 Dec 1;38(12):974-9.
7. Smith BG, Knight JK. A comparison of patterns of tooth wear with aetiological factors. British Dental Journal. 1984 Jul;157(1):16-9.
8. Joiner A, Weader E, Cox TF. The measurement of enamel wear of two toothpastes. Oral Health Prev Dent. 2004 Jan 1;2(4):383-8.
9. Kaidonis JA, Richards LC, Townsend GC, Tansley GD. Wear of human enamel: a quantitative in vitro assessment. Journal of dental research. 1998 Dec;77(12):1983-90.
10. Attin T, Wegehaupt FJ. Methods for assessment of dental erosion. Erosive Tooth Wear. 2014; 25:123-42.
11. Hooper S, West NX, Pickles MJ, Joiner A, Newcombe RG, Addy M. Investigation of erosion and abrasion on enamel and dentine: a model in situ using toothpastes of different abrasivity. Journal of clinical periodontology. 2003 Sep; 30 (9):802-8.
12. Gregg T, Mace S, West NX, Addy M. A study in vitro of the abrasive effect of the tongue on enamel and dentine softened by acid erosion. Caries research. 2004;38(6):557-60.
13. Kanik Ö, Turkun LS, Dasch W. In vitro abrasion of resin-coated highly viscous glass ionomer cements: a confocal laser scanning microscopy study. Clinical oral investigations. 2017 Apr 1;21(3):821-9.
14. Rosenstiel SF, Land MF, editors. Contemporary fixed prosthodontics-e-book. Elsevier Health Sciences; 2015 Jul 28.
15. Moghareabed A, Birang R. Oral and dental health promotion: jids. 2010;6(6):705-11. (Persian).
16. Kaidonis JA, Richards LC, Townsend GC, Tansley GD. Wear of human enamel: a quantitative in vitro assessment. Journal of dental research. 1998 Dec;77(12):1983-90.
17. Conrad HJ, Seong WJ, Pesun IJ. Current ceramic materials and systems with clinical recommendations: a systematic review. The Journal of prosthetic dentistry. 2007 Nov 1; 98 (5):389-404.
18. Aker DA, Aker JR, Sorensen SE. Toothbrush abrasion of color-corrective porcelain stains applied to porcelain-fused-to-metal restorations. The Journal of prosthetic dentistry. 1980 Aug 1;44(2):161-3.
19. Roselino LD, Chinelatti MA, Alandia-Román CC, Pires-de-Souza FD. Effect of brushing time and dentifrice abrasiveness on color change and surface roughness of resin composites. Brazilian dental journal. 2015; 26:507-13.
20. Garza LA, Thompson G, Cho SH, Berzins DW. Effect of toothbrushing on shade and surface roughness of extrinsically stained pressable ceramics. The Journal of prosthetic dentistry. 2016 Apr 1;115(4):489-94.
21. Heydari B, Vafaee F, Torkan A. The Effect of Repeated Firings on the Color of Dental Ceramics and Their Color Stability Submitted to Colored Solution. Avicenna Journal of Clinical Medicine. 2012 Sep 15;19(2):58-65.