Original Article

Scanning Electron Microscope Comparative Evaluation of Feldspathic Porcelain Surfaces under Irradiation by Different Powers of Neodymium-Doped Yttrium Aluminium Garnet (Nd:YAG) Laser

Mohammad Hashem Hosseini[1], Farhad Sobouti[2], Ardavan Etemadi[3], Nasim Chiniforush[3]
Stephane Ayoub Bouraima[4]

[1]Department of Orthodontics, School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran
[2]Orthodontic Department, Dental Faculty, Mazandaran university of medical sciences,Mazandaran,Iran
[3]Laser Research Center of Dentistry, School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran
[4]Laser Application in Medical Sciences Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran

Abstract:

Introduction: Recent use of lasers for porcelain surface treatment for adhesion of brackets to restorations has not only showed some promising results, but is also accompanied with less undesirable effects among other advantages. The purpose of this study is the comparative electron microscope evaluation of feldspathic porcelain surfaces under irradiation by Neodymium-Doped Yttrium Aluminium Garnet (Nd:YAG) with different powers (0.75, 1.5 and 2W) via the acid etching with hydrofluoric acid (HF) technique.
Methods: The glazed porcelain samples were obtained by duplicating labial surfaces of maxillary central incisor teeth. The specimens were randomly treated by 4 different methods. Group1 was etched with hydrofluoric acid 9.6%. Samples in group 2 to 4 were also irradiated by Nd:YAG laser with different powers: 0.75, 1.5 and 2W. Then the samples were prepared for evaluation by scanning electron microscope (SEM).
Results: Etching quality from a porosity point of view was similar for group2 and HF group. Laser with power of 0.75W has little potential to create mechanical porosity.
Conclusion: In regard of the results of this study, it is possible to benefit from Nd:YAG laser with appropriate parameters for surface conditioning.
Keywords: Nd:YAG; Porcelain; SEM

Please cite this article as follows:
Hosseini MH, Sobouti F, Etemadi A, Chiniforush N, Bouraima SA. Scanning Electron Microscope Comparative Evaluation of Feldspathic Porcelain Surfaces under Irradiation by Different Powers of Nd:YAG laser. J Lasers Med Sci 2013; 4(2):75-8

***Corresponding Author:** Nasim Chiniforush, DDS; Laser Research Center of Dentistry, School of Dentistry,Tehran University of Medical Sciences, Tehran, Iran. Tel: +98-2188015017; Fax: +98-2188687471; Email: n-chiniforush@farabi.tums.ac.ir

Introduction

Recent use of lasers for porcelain surface treatment for adhesion of brackets to restorations has not only showed some promising results, but is also accompanied with less undesirable effects among other advantages. Adhesion should have the potential to resist various stresses. Among various porcelain compounds, feldspathic porcelain in ceramic fused to metal restorations and considered strong and beautiful restorations, has many applications[1].

In ceramic restorations, an appropriate bond between ceramic surface and resin substance (Composite resin or resin cements) is usually created by use of micromechanical bonding mechanisms and by means of roughness creation with air abrasion, diamond burs, acid etching or application of silane coupling agents. Porcelain is not appropriate for adhesion to orthodontic attachments because of its physical properties and glazed surface as well as resin bonding chemical properties. Meanwhile, different methods have been suggested to overcome such problems like porcelain deglazing via surface roughness creation by diamond bur or micro etching with aluminum oxide particles, and then brackets bonds with or without adhesion factor[2]. In addition, chemical conditioning of deglazed porcelain surfaces with the use of orthophosphoric acid or hydrofluoric acid and brackets bonding with or without adhesion factor have also been introduced and used[3]. Though, it became clear that sandblasting or etching via orthophosphoric acid couldn't create enough bond strength for clinical applications[3-7].

Use of different lasers as replacement option in these treatments has been proposed, and has showed convenient results. It has been demonstrated that Neodymium-Doped Yttrium Aluminium Garnet (Nd:YAG) laser not only lessen the need to promote porcelain surface roughness, but also doesn't present potential damages to gingival tissues seen in the acid etching method with hydrofluoric acid (HF), and doesn't need porcelain re-polishing during the de-bonding stage as well[8]. Moreover, use of Nd:YAG laser in comparison to HF conventional method, needs little time (10 seconds compared to 3-5 minutes), and its advantages have been showed in some studies[9]. Li et al conditioned porcelain with application of Nd:YAG in 0.6, 0.9 and 1.2W powers and demonstrated that this type of laser in combination with light curing composite promotes acceptable bond strength to porcelain[10].

Considering that different powers of Nd:YAG laser are available and that the effects of these powers on the amount of strength of porcelain bond to composite have not been completely evaluated. The present study has been performed with the aim of scanning electron microscope comparative evaluation of feldsphatic porcelain surfaces under irradiation by different parameters of Nd:YAG laser (0.75, 1.5 and 2W) with the common acid etching technique with HF acid.

Methods

Glazed porcelain samples were obtained by duplication of labial surfaces of maxillary central incisor teeth by using rubber mold. Specimens were built via densification of Vita porcelain (Vita VMK Feldspathic Porcelain; Germany) and firing at 940°C in vacuum. Feldspathic porcelain samples were prepared with non precious alloy (nickel-chromium alloy) and at the size of maxillary central tooth (10×8mm). Finally, samples were randomly put under 4 different treatment methods.

In group 1, after porcelain surface roughness creation by carbide bur and deglazing, samples were etched for 2 minutes with 9.6% hydrofluoric acid (Bisco, USA). Then, the samples were washed under water for 60 sec and air dried.

In group 2 to 4, samples were put under Nd:YAG laser irradiation (Fotona, Slovenia) with wavelength of 1064nm (fiber of 300 µm), 0.75, 1.5 and 2W powers, frequency of 10 Hz and pulse duration of 100µs via sweeping motion at approximately 2mm distance from surface.

Scanned images of central part from electron microscope with ×1000 magnification of 0.75, 1.5, 2W and HF groups were obtained after etching.

For scanning electron microscope (SEM) analysis, samples were immersed in 2.5% gluteraldehyde for 12 hours at 4˚C for fixing; and after rinsing all of them in distilled water, they were dehydrated in ascending grades of ethanol (25%for 20min, 50% for 20min, 75% for 20min, 95% for 30min, 100% for 60min). And after that we had the final step: Samples were dried with absorbing paper and sputter-coated with gold, and finally the surfaces were analyzed by scanning electron microscope in magnification of ×1000

Results

Electron microscope images (Figures 1-4) showed etching quality among study groups. Figure 1 shows porcelain surface etched with 9.6% hydrofluoric

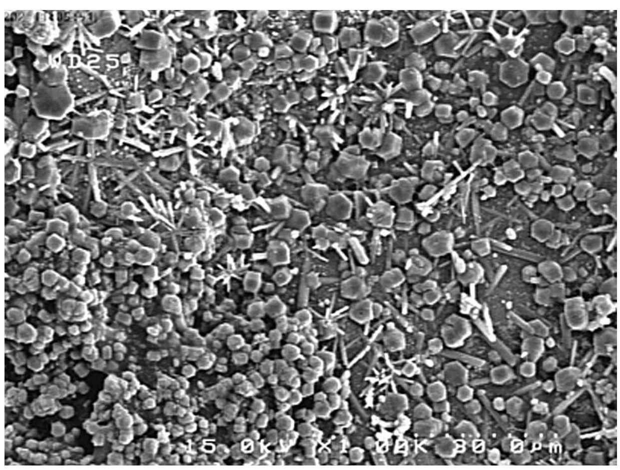

Figure 1. Feldspathic Porcelain surface after etching with HF (Magnification ×1000)

acid which had a complex surface with a relatively homogenous pattern. Figure 2 and 3 which were irradiated by Nd:YAG laser with power of 0.75, 1.5W

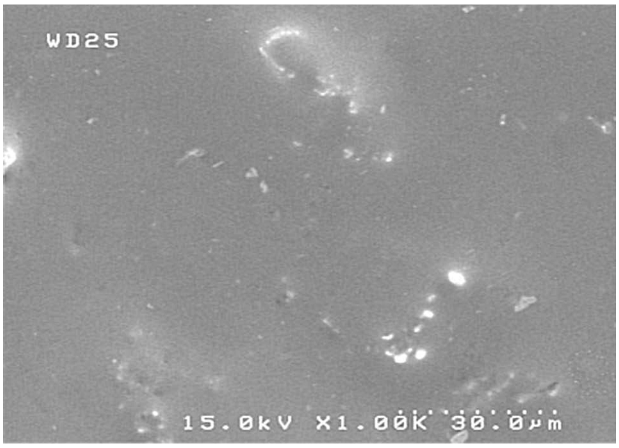

Figure 2. Feldspathic Porcelain surface after etching with Nd:YAG laser with power of 0.75W (Magnification ×1000)

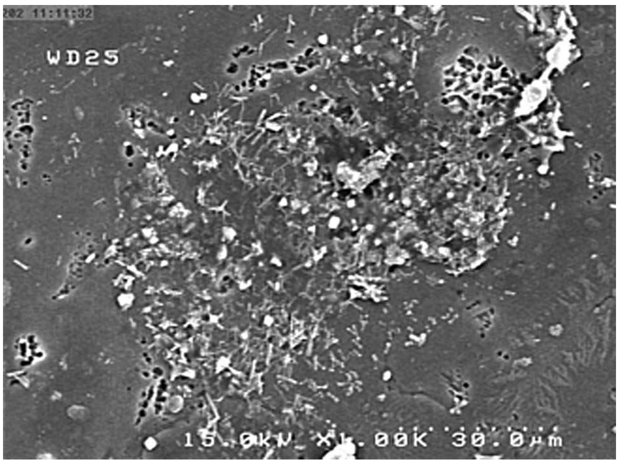

Figure 3. Feldspathic Porcelain surface after etching with Nd:YAG laser with power of 1.5W (Magnification ×1000)

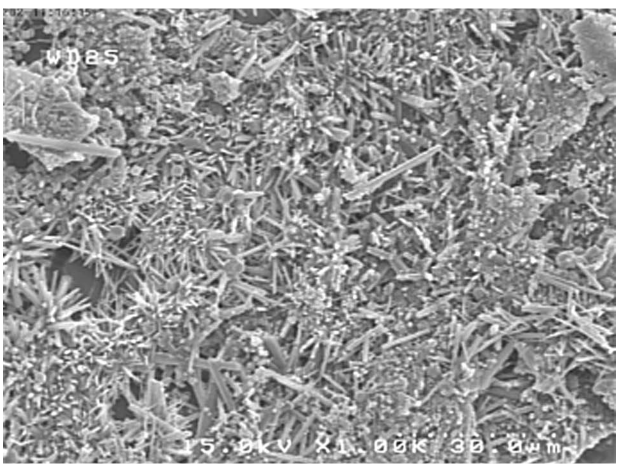

Figure 4. Feldspathic Porcelain surface after etching with Nd:YAG laser with power of 2W (Magnification ×1000)

show relatively smooth surface. In figure 4 which shows also Nd:YAG laser irradiation with power of 2W, exposition of feldspar crystals and regular porosity was seen on the surface.

Discussion

Considering the physical properties of glazed porcelain surfaces and bonding resins chemical characteristics and because of the importance of applying orthodontic forces without breaking the bond during the treatment, achieving adequate bonding between porcelain surfaces and orthodontic brackets is a concern for clinicians and researchers[7]. Besides, proposed porcelain surface treatment methods such as acid etching with HF or sandblasting takes time and can be damaging to oral soft tissues. Therefore, irradiation of different laser parameters or different types of laser in order to achieve adequate treatment of surfaces has been proposed. There is no doubt that conventional acid etching with HF is an appropriate technique for porcelain bonding to composite[11,12], but because of risks of burning and irritating oral tissues, a lot of precision is required. For this reason many orthodontists have some considerations regarding its use. With this in mind, in the present study effects of irradiation of 0.75, 1.5, 2W powers of Nd:YAG laser on feldspathic porcelain in combination with the application of conventional acid etching with HF were assessed via scanning electron microscope.

Advantages of Nd:YAG laser irradiation in conditioning of porcelain surfaces were reported by Poosti et al, and Kim and Cho study revealed improvement of bond strength of regions between ceramic and titanium[8-10]. Akova et al also demonstrated that increase in bond strength in samples under laser irradiation is related to creation of micromechanical retention on the surface[13].

Uşümez et al (2002) also showed that laser irradiation with 2W power resulted in creation of shear bond strength like with acid etching mechanism; although laser irradiation with 1W power created significantly less amount of bond strength compared to the application of acid[14].

Comparison of different studies in this field shows some conflicts. It appears that the difference in study method is the reason for occurrence of different findings and sometimes contradictory ones. It has been reported that porcelain structural changes resulting from laser irradiation depends on laser energy, duration of irradiation and distance between radiation sources to porcelain surface[15].

Although application of HF as an acidic factor increases micromechanical bond in porcelain surface; it should be considered that precipitations created from porcelain surface etching could weaken bond between resin and porcelain. Some evidences show that HF reaction results in formation of fluorosilicate products like Na, K, Al and Ca; presence of these products in the same time reduces bond strength. Perhaps it is possible to say that one of the reasons for low bond strength in previous studies is the same precipitations produced. Some suggested that after treatment with acid, application of ultrasound to clean porcelain surface from the precipitations can be beneficial[16]. In our study, scanning electron microscope (SEM) images showed that etching quality from a porosity point of view obtained in 2W group and HF group was almost similar. In samples etched with power of 2W and acid hydrofluoric there was a high depth penetration. Porosity resulting from exposure of feldspathic crystals can explain the desirable bond strength of these two groups. Based on the SEM images, it appears that laser with power of 1.5W creates more surface porosity and consequently more mechanical retention than with power of 0.75W. Laser irradiation with power of 0.75W has little potential to promote mechanical porosity. Low penetration depth just enough to remove the glazed layer and some amount of surface removal are observable. Furthermore, it seems that laser with 1.5W in comparison to HF and 2W groups also obtained inferior results in surface conditioning. Of course we should take into account that the evaluation of SEM images was performed qualitatively and there are different factors playing a role in it.

Conclusion

Considering the results of this study, Nd:YAG laser with appropriate parameters can be beneficial for surface conditioning. More studies are needed to determine the appropriate parameters in order to define a convenient protocol and a replacement method to the conventional methods, in regard to the potential damages to the pulp and dental surrounding tissues.

References

1. Schmage P, Nergiz I, Herrmann W, Ozcan M. Influence of various surface-conditioning methods on the bond strength of metal brackets to ceramic surfaces. Am J Orthod Dentofacial Orthop 2003; 123:540-6.
2. Eustaquio R, Garner LD, Moore BK. Comparative tensile strengths of brackets bonded to porcelain with orthodontic adhesive and porcelain repair systems. Am J Orthod Dentofacial Orthop 1988; 94:421-5.
3. Zachrisson BU, Buyukyilmaz T. Recent advances in bonding to gold, amalgam and porcelain. J Clin Orthod 1993; 27:661-75.
4. Gillis I, Redlich M. The effect of different porcelain conditioning techniques on shear bond strength of stainless steel brackets. Am J Orthod Dentofacial Orthop 1998; 114:387-92.
5. Shahverdi S, Canay S, Sahin E, Bilge A. Effects of different surface treatment methods on the bond strength of composite resin to porcelain. J Oral Rehabil 1998; 25:699-705.
6. Cochran D, O'Keefe KL, Turner DT, Powers JM. Bond strength of orthodontic composite cement to treated porcelain. Am J Orthod Dentofacial Orthop 1997; 111: 297-300.
7. Smith GA, McInnes-Ledoux P, Ledoux WR, Weinberg R. Orthodontic bonding to porcelain: bond strength and refinishing. Am J Orthod Dentofacial Orthop 1988; 94: 245-52.
8. Poosti M, Jahanbin A, Mahdavi P, Mehrnoush S. Porcelain conditioning with Nd:YAG and Er:YAG laser for bracket bonding in orthodontics. Lasers Med Sci 2012; 27(2): 321-4.
9. Kim JT, Cho SA. The effects of laser etching on shear bond strength at the titanium ceramic interface. J Prosthet Dent 2009; 101:101-6.
10. Li R, Ren Y, Han J. [Effects of pulsed Nd:YAG laser irradiation on shear bond strength of composite resin bonded to porcelain]. Hua Xi Kou Qiang Yi Xue Za Zhi 2000; 18:377–9. (Chinese)
11. Barbosa VLT, Almedia MA, Chevitarese O, Keith O. Direct bonding to porcelain. Am J Orthod Dentofacial Orthop 1995; 107:159-64.
12. Zachrisson YO, Zachrisson BU, Büyükyilmaz T. Surface preparation for orthodontic bonding to porcelain. Am J Orthod Dentofacial Orthop 1996; 109:420–30.
13. Akova T, Yoldas O, Toroglu S, Uysal H. Porcelain surface treatment by laser for bracket-porcelain bonding. Am J Orthod Dentofacial Othop 2005; 128:630-7.
14. Uşümez S, Orhan M, Uşümez A. Laser etching of enamel for direct bonding with an Er,Cr:YSGG hydrokinetic laser system. Am J Orthod Dentofacial Orthop 2002; 122: 649-56.
15. Rodríguez-Vilchis LE, Contreras-Bulnes R, Sánchez-Flores I, Samano EC. Acid resistance and structural changes of human dental enamel treated with Er:YAG laser. Photomed Laser Surg 2010;28:207-11.
16. Canay S, Hersek N, Etran A. Effect of different acid treatment on a porcelain surface. J Oral Rehabil 2001; 28:95-101.