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Intraoral Repair of Dental Ceramics Using Er,Cr:YSGG Laser: Review

Noor Bader Hassan, Basima Mohammed Ali Hussein*

Institute of Laser for Postgraduate Studies, University of Baghdad, Baghdad, Iraq.
**Email address of the Corresponding Author: basma.moh@ilps.uobaghdad.edu.iq*

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Abstract

Introduction: All-ceramic crowns are widely used in prosthodontics and cosmetic dentistry due to their good esthetic and proper physical properties. Chipping of ceramic is one of the most common post-insertion complications, that can be fixed either extraoral or intraorally. The latter is time time-effective alternative, less traumatic, and low-cost. A newer objective method of laser is a surface modification of ceramics to increase surface roughness. The aim of this study is to provide a review of Er,Cr;YSGG (2960nm) in intraoral repair and shear bond strength (SBS). **Method:** A thorough search considering Google Scholar and PubMed published data and ten articles found who published between 2018 to 2022. **Results**:Because of the variation in the material composition of all ceramic crowns (feldspathic porcelain, zirconia, lithium dislocate, hybrid ceramics) different surface treatment methods are required for strong composite ceramic interphase. The effect of Er,Cr:YSGG on porcelain was minimal and lower than hydrofluoric acid, while for zirconia surface can be acceptable compared to no treatment. **Conclusion**: intraoral repair is an effective and cost-effective treatment that does not require multiple appointments. However, the success and durability of the restoration are dependent on technical and clinical experience and a superior understanding of material composition.

Keywords: Intraoral repair, dental ceramics, ceramic chipping, Er,Cr:YSGG laser and shear bond strength (SBS).

1. Introduction

With the newest improvements in the sciences of materials construction processes and techniques, the demand for more aesthetic restoration has increased. The exceptional aesthetic properties and biocompatibility of all ceramic restorations permit their widespread usage in restorative dentistry. (Sousa et al. 2022). All-ceramic restorations, such as aluminum-based porcelains, zirconium oxide ceramics, and leucite or lithium-disilicate-reinforced glass ceramics, can be regarded as an alternative treatment option to porcelain fused to metal restorations. Because it is the most stable and high-strength ceramic material,

zirconium dioxide offers superior mechanical qualities when compared to traditional ceramics. It has a flexural strength of 900 MPa and a fracture toughness of 9 MPa/m1/2. But for the ideal esthetic results the zirconium dioxide does not have the best optical properties that mimic the natural teeth, so the solution was to add a translucent layer of porcelain to permit the light transmission as the natural teeth. Owning to the physical properties of the porcelain it chips easily when exposed to masticatory forces which may extend to 160 ibf upper limit or in cases of occlusal discrepancy, or improper design and construction considering the of masticatory force. (Kimmich and Stappert 2013),(Sailer et al. 2007) (Poli O et al, 2021). According to a systematic literature review, chipping of the veneering ceramic is one of the most frequent technical complications occurring at a rate of 12.7% following a three-year observation period (Pjetursson et al. 2015). Chipping of ceramic can cause esthetic and functional concerns that require repair, small chipping of ceramic can be repaired intraorally with resin composite, which is economically effective, less traumatic to the abutment structure, and pulp, and can be performed with a single session. While some etensive fractures may require replacement or extraoral repair of the crown (Rekow et al. 2011),(Ghavam et al. 2017). Dental composite resin can be used for ceramic repair with intraoral ceramics repair kits. The chemical interaction at this interface is essential for a strong and successful resin-porcelain bond. Surface-roughening treatments on ceramic material are necessary to improve micro-mechanical retention. In these techniques, the silan group could provide onding sites between the substrate and repair material following the etching procedure (Duzyol, Sagsoz, et al. 2016).

In such a circumstance, a number of different treatments can be applied, such as Al_2O_3 particle sandblasting, acid etching as hydrofluoric acid, diamond disc grinding, Cojet system (surface air blasting with silica particles and laser treatment (Ji-Young et al 2015). The increase in use of chairside laser applications such as carbon dioxide (CO_2), neodymium-doped yttrium garnet (Nd:YAG), and erbium chromium: yttrium scandium gallium garnet (Er,Cr:YSGG) lasers. (de Paula Eduardo et al. 2012) (Emre Tokar et al, 2019; Farhad et al. 2012). Er, Cr:YSGG (2780 nm) is effective for removing both hard and soft dental tissues. Erbium lasers eliminate hard dental material by using thermal ablation. This method eliminated explosive tissue via water. This occurs as a result of the fast warming of subsurface water within the structure of the hard tissue, which absorbs infrared laser light. Warming these water particles[molecules] increases their subatomic vibrations, hence increasing the subsurface pressure. Finally, a "blast" of tissue removes tooth material or other hard substances, such as zirconia or ceramics.(Mirhashemi et al. 2019).
This study aim is to review the efficiency of Er,Cr:YSGG in intraoral repair of the ceramic fixed prostheses from 2013 to 2023.

2. Method

2.1. Data source and search strategy

The literature search was performed by using Google Scholar and PubMed for studies about the intra-oral repair that used the Er,Cr:YSGG laser as a surface modification for fracture of ceramics. The studies collected from January 2018 to December 2022, all review studies were excluded from this study.

In this review, keywords such as" Intraoral repair", "ceramic", "porcelain", "zirconia", "Er,Cr:YSGG", "shear bond strength", "SBS" were used to collect data and, only the studies published or translated to English were included. All are in a full-text format and have the Er,Cr:YSGG laser as a main study group or sub-group. Preparing for this review was started first by the selection of sequenced articles which was performed by reading the abstract first and then data collection and arranging from the full text.

3. Results

In order to comprehend the intraoral repair strategies utilized for the treatment of ceramic fractures or chipping, Google Scholar and PubMed searches yielded 6 papers that were included in this review. Table 1 provides a summary of the findings of the listed studies. In regard to Er,Cr:YSGG laser, several surface

treatment methods such as diamond bur, sand blasting, Cojet, hydrofluoric acid, Nd:YAG laser and air ablation were included in this study in order to modify ceramic surface roughness, increase bond strength, and raise shear bond strength. In addition to that, a variety of types of ceramics, such as zirconia, lithium disilicate, and feldspathic porcelain, were taken into consideration for this review. Ceramics that are based on glass and are sensitive to acid were included, as well as ceramics that are not based on glass and are resistant to acid. The repair systems that have been reviewed in this article were Cimara, Cimara zirconia repair, Ceramic repair N, Clearfil repair, and Bisco intraoral repair systems The efficiency of Er,Cr:YSGG during the ceramic intra-oral repair was investigated by considering the shear bond strength. Most of the reviewed studies compared the new method "laser "with the traditional methods like acid etching, bur grinding, Cojet, and sandblasting.

3.1 Intraoral repair without zirconia exposure

For restorations that have been chipped but do not reveal the zirconia layer, surface adhesion between porcelain and composite resin may be achieved either by macro-mechanical, micromechanical, or chemical methods(Borges, Sophr, et al. 2003). Most of the included studies compared SBS of composite the studies review is listed in Table 1. Abdulla and Hassan, 2022 evaluated two repair systems bond strength to porcelain surface and 50% porcelain and 50% zirconia, surface treated by Er,Cr:YSGG, sandblasting, and control group with no treatment. The veneering porcelain surface treated with air abrasion had the highest mean value (13.74 MPa), while the mixed surface's highest value was in the laser group with (11.24 MPa) Lowest value was in the control group. In a similar study made by Polat, Tokar et al. 2021 they reported the highest bond strength for 100% porcelain and mixed were in the control group with diamond bur with 16.76 MPa and 16.6 Mpa respectively. Baiomy et al. 2020 , had four groups for surface treatment air abrasion, Cojet, Er,Cr:YSGG laser, and mixed group (Cojet and laser), in their study they revealed that there was a significant difference between the groups(SBS) highest bond strength was in Cojet group and the lowest value was in the laser group. These results are in accordance with a study made by Sarac et al. 2013. Four studies in the review measured the shear bond strength of composite to laser-treated Lithium disilicate.

In a study by M. Chaharom et al. who modified the lithium disilicate surface with three different methods HF 9,5%, Nd:YAG , Er,Cr:YSGG and compared to the control group with no treatment. The HF group showed the highest shear bond strength, while the laser group was similar to the control group. (Chaharom, Azar et al. 2018). These results disagree with Alkhudairy(Alkhudhairy, Naseem et al. 2019), K.Barutcigit and O.Kirmali (Barutcigil and Kirmali 2020)who Obtained that the Er,Cr:YSGG was efficient in lithium disilicate surface modification and shear bond strength improvement.Vohra et al. assessed the SBS and color stability of lithium disilicate by using three pretreatment methods, HF mean bond strength was comparable to Er,Cr;YSGG. In addition to that the bond strength increases as the power and the duration of the laser increase. For hybrid ceramics, one study performed by Oz (Oz et al. 2019) in 2019, when a comparison of two types of hybrid ceramics treated with sandblasting, acid etching (hydrofluoric acid 8% and phosphoric acid 37%), Er,Cr:YSGG laser (2W and 3W) and control group with no treatment. The lowest SBS was in the control group followed by phosphoric acid, while the highest SBS was at 3W followed by 2W, sandblasting, and hydrofluoric acid.

3.2 Intra-oral repair with zirconia exposure

Most of the reviewed studies used different surface treatment methods to repair exposed zirconia surfaces in full ceramic crowns. Polat et al. compared the efficiency of Er,Cr: YSGG lasers with short and long pulse durations to various surface roughening techniques for repairing zirconia ceramics with different surface configurations. They found that SBS for sandblasting and Er,Cr: YSGG laser treatments exhibited no noticeable differences. (Polat et al. 2021) .These results agree with a study made by Kiramli et al. (Kirmali, Barutcigil, et al. 2015), additionally, a combination group of sandblasting and laser obtained the highest SBS, especially with the Er.Cr:YSGG laser.

Table 1: Reviewed studies.

Author/date	Type of ceramic	Manufacturer	Surface treatment	Study design	repair system	Result /conclusion
Mohammed Abdulla and Radhwan H /2022	- 100% zirconia -100%porcelain -zirconia with a veneering ceramic	-Zirconia (DD BioZ Wiso, Dental Direkt - Ceramic (VITA VM® 9 VITA Zahnfabrik	-Er,Cr,YSGG, 3W, frequency 10Hz, puls duration 140µ - Air- abraded sandblasting	In vitro	- Cimara repair system. - Ceramic repair N system	- air abrasion yields a greater SBS than Er,Cr:YSGG laser -Ceramic repair N system demonstrated significantly higher SBS values for all surface-treated substrates than the Cimara repair system.
Polat et al /2021.	-100% zirconia -100% porcelain - 50% porcelain 50% zirconia	- Vita VMK Master- ICE Zirkon Translucent, , Germany	-Dimond bur grinding -Sand blasting -Er.Cr;YSGG frequency 20Hz, power 1.5W. •Long wavelength pulse duration 200 µs •short wavelength pulse duration 140µs.	In vitro	Clearfil Repair, Noritake, Kuraray, Japan	Grinding is most appropriate for both zirconia and porcelain. -Sand blasting and short pulse duration shoed no significant difference
Baiomy et al 2020.	-100% porcelain -100% zirconia	-Ceramco PFZ Dentsply Sirona, USA -Bio ZX2 Zirconium, dental direkt , germany .	-Air abrasion -Cojet -Er.Cr;YSGG - Cojet +Er,Cr;YSGG 3W, pulse duration140µs and frequency 50 Hz.	In vitro	Bisco intraoral repair kit)	Cojet treatment had the highest SBS for porcelain and zirconia while laser lowest.
Barutcigit and O. Kirmali /2020.	-Lithium disilicate -IPS. E.max press, Ivoclar	----	-No treatment (control) -HF 9.5% -Phosphoric acid 37%- -Er.Cr; YSGG 1,2,3 W Frequency 1-Hz, for 20s.	In vitro	Single bond universal adhesive 3M ESPE	HF and 3W laser treatment obtained comparable results with appropriate bond strength
Vohra et al/2019.	Lithium disilicate	IPS. E, max Ivoclar	-HF 9.6% (control) - Er.Cr;YSGG 3.75W,15HZ, 2 min and 4min - Er.Cr.YSGG 7W, 25HZ 2min and 4min.	In vitro	-Ceramic primer, Mono-bond N Ivoclar -Bonding system (Adhese Universal; Ivoclar	Specimens lased (Er,Cr:YSGG) with 3.75 W power and 15 Hz frequency for 4 min showed bond strength comparable with that of HF acids.

Alkhudairy et al /2019.	Lithium disilicate	IPS. E.max press Ivoclar	-HF + silane -HF + ultrasonic bath silane -Self etch ceramic primer -Er,Cr:YSGG + Silane. 4.5W, frequency 30 Hz, 60s.	In Vitro	-Silane, Ivoclar	Er,Cr:YSGG laser can be used as a surface conditioner for lithium disilicate repair.
OZ / 2019.	Hybrid ceramics	-Lva ultimate 3M -Cerasmart, GC	-No treatment -Phosphoric acid 37% -Hydrofluoric acid 6% -Sandblasting -Er,Cr:YSGG 2W, 3W , 10 Hz, 20s.	In vitro	Single bond universal adhesive 3M ESPE	Er,Cr:YSGG can be an alternative etching method for hybrid ceramic repair
Tokar et al 2019.	-100% zirconia -100% porcelain	-ICE zirkon tranlucent -Vita VMK-master	-Diamond bur. -Er.Cr.YSGG 6W, frequency 20Hz. •Long wave length pulse duration 200 µs •short wavelength 140µs	In vitro	Ceramic repair N, Ivoclar	SBS for 100% zirconia was highest in short pulse duration laser while the diamond bur group provided the highest SBS for 100% porcelain.
Chahrom et.al/2018.	Lithium disilicate	PS E,max Ivoclar	-Control(no treatment) - HF 9,5% -Nd;YAG Power 4.5W,15Hz - Nd;YAG 6W,20Hz -Er.Cr:YSGG 1.5W and 6W for 1min.	In vitro	Porcelain silane, ultradent -primer and adhesive, self-etch silorane system, 3M	HF group showed the highest SBS while all laser groups did not improve the bond strength of composite to ceramic
Kirmali et al/2015.	Zirconia	- Noritake Co. -Nagoya	-Bur grinding (control) - CoJet sandblasting -Nd:YAG 1W, 20Hz, -Er.Cr.YSGG 1.5W -Sandblasting +Nd:YAG -sandblasting + Er;Cr:YSGG	In vitro	Cimara repair system	Combination of sandblasting and laser treatment is effective in zirconia repair, especially the Er,Cr;YSGG

Tokar et al. discovered that the SBS between zirconia and composite resin may be strengthened by using (Er,Cr: YSGG) laser surface treatments, shorter pulse laser with 140µs irradiation was more effective than longer pulse duration 200µs but it was not significant from the diamond bur grinding (control)group (Tokar et al. 2019). In a vitro study by Abdulla and Hassan that applied laser, air ablation and no treatment on the zirconia surface the highest SBS value was at air ablation followed by laser treatment.(Abdulla and Hasan 2022) .

4. Discussion

This review aimed to summarize the effect of Er.Cr:YSGG laser in intraoral repair of all ceramic crowns and how the surface treatment can reflect on SBS in years between 2018- December 2022.

Chipping of veneering porcelain is the most common complication of ceramic crowns and the incidence of chipping is higher in all ceramic crowns than in porcelain fused to metal crowns (Molin and Karlsson 2008). Multiple factors can be the cause of ceramic chipping such as lack of support, parafunctional occlusion, or intra-ceramic defects (Pjetursson, Sailer et al. 2015). The first step of the repair is to understand the classification of ceramic failure and the material, its extension an of the framework material. The ceramic fracture can either be static, adhesive, or cohesive, and the material of the chipped part can determine the method of repair (Aslam, Hassan, et al. 2018). Composite resin is the material of choice for repairing the fracture, for successful repair, a strong bond between the composite and the ceramic must be established. Mechanical and chemical methods are usually used. A variety of techniques are applied to increase ceramic roughness like HF, sandblasting, silica embedding, air abrasion with aluminum oxide particles, and laser there after silane application and resin bond before the repair composite(Swain 2009). In the current review adherence to glassy matrix ceramics is well-established by the application of HF, salinization, and adhesive resin, while the Er,Cr.YSGG did not improve repair bond strength alone. For lithium disilicate in one study, the laser had comparable results to HF.

Surface treatment processes such as acid etching and silane application have no effect on the adhesion between the zirconia framework and the composite material since zirconia is chemically inert and does not contain any silica(Qeblawi et al. 2010). To form a chemical bond with silane, Z-prime is used to create a chemical link with zirconia because it includes 10-MDP phosphate ester monomer, which chemically binds with the oxide layer of zirconia and increases bond strength.(El-Ashkar and Nabil 2022)

Other published research, however, has shown that the use of a laser does not improve the adhesion of composite resins and zirconia.

4. Conclusions

On the basis and the limitations of our review regarding the Er,Cr;YSGG laser effect on all ceramic repair the following conclusions could be drawn:

1- Er, Cr;YSGG laser does not improve the composite repair bond strength to porcelain in different powers, frequency, and energy. For lithium disilicate ceramic can be improved. The HF is the best surface treatment method for silica-based ceramics followed by silane and resin bonds.

2- The zirconia surface roughness was increased after laser treatment and even the shear bond strength compared to no treatment surface .

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استخدام ليزر Er:Cr;YSGG في اصلاح السيراميك داخل الفم: دراسة استطلاعية

نور بدر حسن ، باسمة محمد علي حسين*

معهد الليزر للدراسات العليا، جامعة بغداد، بغداد، العراق.

*البريد الالكتروني للباحث: basma.moh@ilps.uobaghdad.edu.iq

الخلاصة

مقدمة: تستخدم التيجان الخزفية على نطاق واسع في التعويضات الاصطناعية السنية في طب الاسنان نظرًا لخواصها الجمالية والفيزيائية المناسبة. يعد تكسر السيراميك أحد أكثر مضاعفات ما بعد تركيب التعويضات شيوعًا ، ويمكن إصلاحه إما خارج الفم أو داخل الفم, هذا الأخير يعد هو بديل أقل تكلفة وأقل تاثيرا على السن والتركيب وفعالة اكثرمن حيث الوقت. تتمثل إحدى طرق المعالجة بالليزر في معالجة لسطح السيراميك لزيادة خشونة السطح (Er,Cr,YSGG 2780 nm). الهدف من هذه الدراسة هو تقديم مراجعة لتاثير هذا النوع من الليزر في اصلاح السيراميك في السنوات وتاثيره في قوة الربط بين السيراميك والحشوه التجميلية . بحثنا في الطريقة Google, PubMed Scholar وتم العثور على 10 مقالات من سنه2013 الى 2023. **النتائج**: بسبب الاختلاف في تركيب المواد لجميع التيجان الخزفية (الخزف الفلدسباثي والزركونيا وثاني سيليكات الليثيوم والسيراميك الهجين) ، فإن طرق المعالجة السطحية مختلفه حسب نوع السيراميك . وجد ان تاثير الليزر على البورسلين كان اقل كفاءة من أجل زيادة قوة الربط .ولكن الليزر كان افضل تأثير بينما بالنسبة لسطح الزركونيا اة يمكن أن يكون مقبولاً مقارنة بعدم المعالجة .**خلاصة الدراسة:** الإصلاح داخل الفم علاج ناجح وفعال من حيث التكلفة وقلة المضاعفات ولا يتطلب عدة مواعيد. ومع ذلك ، فإن نجاح واستمرارية الترميم يعتمدان على الخبرة الفنية والسريرية والفهم الفائق لتركيب المواد.