BULLETIN OF STOMATOLOGY AND MAXILLOFACIAL SURGERY
Volume 21, Issue 8

DOI: 10.58240/1829006X-2025.21.8-65

ORIGINAL ARTICALE

COMPARATIVE EVALUATION OF THE EFFECT OF ER, CR: YSGG LASER DEBONDING OF DIFFERENT TRANSLUCENT CERAMIC MATERIALS ON MODE OF FAILURE IN VITRO STUDY

Bassam Karem Amin[1], Hemn Muhssin Suleman[2]
[1]Professor, Dean of College of Dentistry, Hawler Medical University, Erbil, Iraq bassam.amin@hmu.edu.krd
[2]Assistant Professor, Vice Dean of College of Dentistry, Hawler Medical University, Erbil, Iraq hemn.suleman@hmu.edu.krd
***Corresponding Author:** Bassam Karem Amin Professor, Dean of College of Dentistry, Hawler Medical University, Erbil, Iraq bassam.amin@hmu.edu.krd
Received: *JuL 10. 2025;* ***Accepted:*** *Aug 8, 2025;* ***Published:*** *Aug 30, 2025*

ABSTRACT

Background: In recent years, ceramic materials have been developed to offer both the mechanical strength and aesthetic qualities required for contemporary dental restorations. Among these, lithium disilicate glass-matrix ceramics have gained significant popularity for applications.
Objectives: This study aimed to evaluate the efficacy of the Er,Cr:YSGG laser as a non-destructive tool for debonding lithium disilicate laminate veneers of varying thicknesses and to determine the associated failure modes.
Materials and Methods: Thirty extracted human maxillary first premolars of comparable dimensions were selected and randomly allocated into two groups (n = 15 each). Group 1 received high-translucency lithium disilicate glass-ceramic veneers, while Group 2 received low-translucency lithium disilicate glass-ceramic restorations. All veneers were bonded using RelyX Veneer resin cement (shade A1, 3M ESPE, USA). Following cementation, the specimens were stored in distilled water at 37 °C for 24 hours to simulate intraoral conditions. Debonding was performed using an Er,Cr:YSGG laser (Waterlase iPlus, Biolase, USA) equipped with a turbo handpiece and MX7 sapphire tip.
Results: The longest debonding time was recorded for veneers with a thickness of 1.0 mm (5.960 ± 0.723 minutes), while the shortest time was observed for 0.5 mm thick veneers (5.653 ± 0.875 minutes). However, the differences in debonding times between groups were not statistically significant. Failure analysis revealed that debonding predominantly occurred at the veneer–cement interface, with minimal impact on the underlying enamel.
Conclusion: These findings suggest that veneer thickness influences laser debonding efficiency, with thinner veneers being removed more rapidly.

Keywords*:* Veneer; Debonding, Laser; Er,Cr:YSGG; Transluscent veneers

INTRODUCTION

Ceramic materials have been refined in recent years to combine both the strength and the esthetics required for modern restorations.[1] One of the most popular choices is lithium disilicate glass-matrix ceramic, which is used for veneers, inlays, onlays and crowns because it offers biocompatibility, high flexural strength, natural translucency and reliable adhesive bonding.[2] When these ceramics are cemented with resin luting agents, they gain excellent fracture resistance, consistent shade matching and long-term durability. Resin cement itself is valued for its saliva resistance, strong adhesion, ability to reinforce the ceramic, range of shade options and overall enhancement of restoration appearance. The trade-off, however, is that resin-bonded all-ceramic restorations are extremely difficult to remove by conventional mechanical methods, making complete debonding nearly impossible without damaging the restoration or the tooth.[1]

Specialized crown-removal tools can dislodge many types of fixed prostheses, but they are ineffective against resin-bonded ceramics. Clinicians typically resort to grinding away the cemented ceramic with rotary burs, a process that is time-consuming, uncomfortable for the patient, and carries a risk of harming underlying enamel. Moreover, once a ceramic restoration has been aggressively ground, its integrity is compromised and reuse becomes problematic.[3]

To address these drawbacks, laser-assisted debonding techniques have been introduced as more conservative, patient-friendly alternatives.[4]

Laser debonding has already been applied successfully to porcelain veneers[5] and orthodontic brackets.[6] Various laser systems—including CO2, Nd:YAG, diode, ytterbium-fiber and Er:YAG—have been tested for this purpose.[7] Among these, erbium-based lasers such as Er,Cr:YSGG (wavelength 2,780 nm) and Er:YAG (2,940 nm) are of particular interest because their emission wavelengths coincide with the primary absorption peaks of water, hydrated tissues and water-containing resin cements.[8] Er:YAG has higher absorption in these media, leading to very shallow penetration, rapid ablation and lower energy requirements. By contrast, Er,Cr:YSGG demonstrates about one-third the absorption of Er:YAG, a difference attributed to the lower water content in enamel compared with dentin.[9]

The efficiency of laser-assisted veneer removal depends on multiple factors: the ceramic's composition and crystalline phase (e.g., feldspathic versus lithium disilicate), its thickness, the resin cement's type and shade, and the laser settings (power, pulse duration, frequency and exposure time). Studies have shown that energy transmission through ceramics varies by both material and thickness—for example, Er:YAG transmission rates of roughly 60 percent through feldspathic ceramics versus about 40 percent through lithium disilicate of comparable thickness.[10]

During laser debonding, most of the incident energy passes via the translucent ceramic and is absorbed by the cement layer.[1] The resin then undergoes a combination of photomechanical and photothermal ablation: water molecules absorb laser energy, vaporize explosively and generate pressure that mechanically disrupts the cured resin. Simultaneously, heat causes rapid melting of the organic matrix, further contributing to debonding forces. Once sufficient cement removal has occurred, the restoration detaches without mechanical cutting.[11]

This study was designed to evaluate how an Er,Cr:YSGG laser performs when debonding ceramics of different translucencies and to characterize the resulting modes of failure. The ultimate goal is to refine laser parameters and clinical protocols that ensure safe, efficient and enamel-preserving removal of ceramic restorations.

MATERIALS AND METHODS

- **Sample Collection and Grouping**

A total of forty sound maxillary first premolars were extracted from orthodontic patients aged between 15 and 20 years. Teeth presenting with cracks, caries, developmental enamel defects, abrasions, discoloration, or previous restorations were excluded to minimize potential confounding variables. From the eligible specimens, thirty premolars exhibiting comparable occluso-cervical and mesiodistal dimensions were selected for the present in vitro study. Following initial cleaning, the teeth were stored in a 0.1% thymol solution for 48 hours to inhibit microbial growth. Residual debris was subsequently removed using an ultrasonic scaler, and the specimens were maintained in distilled water at room temperature for the duration of the study. The absence of enamel cracks was confirmed using blue-light transillumination to further ensure sample uniformity. The selected teeth were then randomly allocated into two groups (n = 15 each): Group 1 received high-translucency (HT) IPS e.max Press veneers, and Group 2 received low-translucency (LT) IPS e.max Press veneers.

- **Specimen Mounting**

Each tooth was embedded individually in a custom-fabricated mold by pouring cold-cure, color-coded acrylic resin into plastic cubes measuring 3 × 3 × 1.5 cm. Prior to resin placement, a thin layer of petroleum jelly was applied to the inner surfaces of the molds to act as a separating medium. Teeth were positioned so that only the crown, up to the cementoenamel junction (CEJ), remained exposed above the resin. A dental surveyor was employed to ensure that the buccal surfaces were oriented parallel to the base of the mold, and the resin blocks were subsequently polished to complete specimen preparation.

- **Tooth Preparation Protocol**

Tooth preparations were standardized using a high-speed handpiece mounted to the horizontal arm of a dental surveyor, thereby maintaining a consistent bur angulation parallel to the tooth's long axis. The specimens were secured in custom-made acrylic resin blocks affixed to the surveyor's mobile platform. Initially, 0.5 mm-deep orientation grooves were made on the labial surfaces using a depth-limiting bur under constant water irrigation. The preparation margins were delineated with a permanent, water-insoluble marker. A round-ended, tapered diamond fissure bur was then used to reduce enamel between the grooves while maintaining the defined depth. In accordance with Ztürk et al. (2013), enamel reduction continued until the marker delineating the middle third of the facial surface was completely removed. The final preparation dimensions measured approximately 5 mm in length and 4 mm in width. All prepared surfaces were polished using 600-grit silicon carbide paper to achieve a uniform, smooth bonding surface.

- **Ceramic Fabrication**

Fifteen ceramic discs were fabricated for each group using IPS e.max Press lithium disilicate ingots (Ivoclar Vivadent, Liechtenstein) in shade A1. The HT and LT variants were used to correspond with the respective experimental groups. According to the manufacturer's guidelines, each disc was standardized to a diameter of 5 mm and a thickness of 0.5 mm to ensure uniformity across samples.

- **Tooth Surface Treatment**

Prior to bonding, all specimens were polished with pumice using a low-speed handpiece and a plastic prophylaxis cup. A dental surveyor was used to maintain a consistent tooth orientation throughout the bonding process. Each tooth surface was etched with 32% phosphoric acid gel (Scotchbond, 3M ESPE, Minnesota, USA) for 15 seconds, thoroughly rinsed with water, and air-dried. Subsequently, Single Bond Universal Adhesive (3M ESPE, Minnesota, USA) was applied with a microbrush for 20 seconds, followed by gentle air-drying for 5 seconds.

- **Ceramic Surface Treatment**

The internal surfaces of the ceramic discs were etched with 9% buffered hydrofluoric acid (Ultradent, Utah, USA) for 20 seconds, then thoroughly rinsed and air-dried. RelyX Ceramic Primer (3M ESPE), containing a silane coupling agent, was applied to the etched surfaces and allowed to react for one minute before air-drying.

- **Cementation Procedure**

Each ceramic disc was coated with RelyX Veneer resin cement (shade A1, 3M ESPE) and positioned on the prepared tooth surface using the dental surveyor. A consistent load of 200 g was applied using a straight rod fixed to the surveyor arm to standardize the cementation pressure. A tack cure of 2 seconds was performed using a small-diameter Elipar light-curing tip (3M ESPE), avoiding polymerization of excess resin. Marginal excess was removed with a pointed explorer, followed by a final light-curing phase of 30 seconds around the entire disc periphery (Figure 1). After cementation, all specimens were stored in distilled water at 37 °C for 24 hours to simulate intraoral conditions.

Figure 1. The cemented sample on the tooth

- Laser-Assisted Debonding Protocol

An Erbium, Chromium:Yttrium-Scandium-Gallium-Garnet (Er,Cr:YSGG) laser system (Waterlase iPlus; Biolase, CA, USA) equipped with a Turbo handpiece and an MX7 sapphire tip was employed for the debonding procedure. The laser was operated in free-running pulse mode at a frequency of 20 Hz, with an output power of 4.5 W and a pulse duration of 60 µs (H-mode). The air and water parameters were set to 60% and 80%, respectively.

During irradiation, the laser tip was maintained at a fixed distance of 2 mm from the ceramic surface in a non-contact orientation. To ensure consistent and perpendicular laser scanning across the surface of the ceramic discs, the handpiece was mounted on a dental surveyor (Figure 2). The duration required for complete veneer removal was recorded using a stopwatch.

Following laser-assisted debonding, the mean, standard deviation, and range of removal times were calculated. The debonded tooth and disc surfaces were subsequently examined under scanning electron microscopy (SEM) by a blinded evaluator at the Department of Physics, College of Science, University of Basrah. Failure modes were categorized as either cohesive (within the resin cement) or adhesive (at the tooth–ceramic interface)

Figure 2. The laser tip with the sample

Statistical analyses were performed using SPSS version 25. The Shapiro–Wilk test was used to check data distribution, and a student t-test compared the two groups numerically and analyzed the statistical data. A change was deemed statistically significant at a p-value of less than 0.05 ($p < 0.05$).

RESULTS

In both groups, the ceramic veneers on the teeth were swiftly and completely removed using the Er,Cr: YSGG laser.

Table 1 shows a normality test done by Shapiro-Wilk statistical analysis which was a non-significant indicating that the data of the tested groups were normally distributed

Table 1. Normality test for both groups

Material Type	Shapiro-Wilk Statistic (P-Value)	Independent Sample T-Test (P-Value)
E.Max Press High Translucency Debonding Time	0.945 (0.192)	1.046 (0.305)
E.Max Press Low Translucency Debonding Time	0.919 (0.185)	

The descriptive statistics are shown in Table 2 which reveals a slightly longer time was required for removing the E.Max Press Low Translucency (5.960 ± 0.723) than E.Max Press High Translucency (5.653 ± 0.875).

Table 2. Descriptive statistics of both groups

Material Type	N	Mean ± SD	Minimum	Maximum
E.Max Press High Translucency Debonding Time	15	5.653 ± 0.875	4.7	7.1
E.Max Press Low Translucency Debonding Time	15	5.960 ± 0.723	4.7	7

The t test showed a non-significant effect ($P < 0.05$) of both variables (high and low translucent) on time required to debond the veneers.

Although the low transluscent Emax required somewhat more time removal (5.960 ± 0.723) when compared with high transluscent sEmax (5.653 ± 0.875) but there was no significant difference between both groups as shown in table 3 and figure 3.

Table 3. Student t-test result

Material Type	N	Mean ± SD	P Value
E.Max Press High Translucency Debonding Time	15	5.653 ± 0.875	0.2529*
E.Max Press Low Translucency Debonding Time	15	0.723 5.960	

*Non-Significant

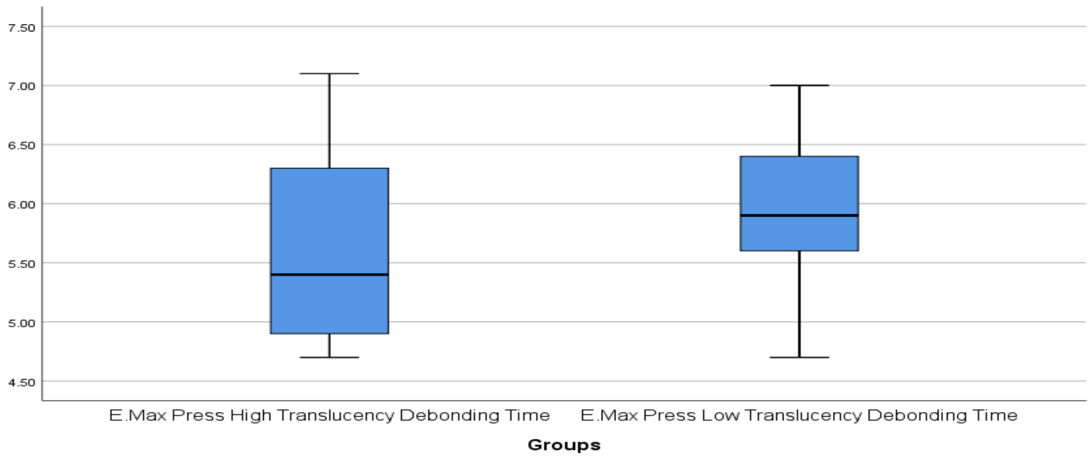

Figure 3. Bar chart demonstration of the groups' mean values and SDs.

- **Analysis of Sem**

None of the teeth or crowns appeared damaged on visual inspection or under an optical microscope using a ×40 magnification lens after irradiation.
The examination of the SEM did not show any damages or major structural changes suggesting photoablation or thermal ablation of the abutment teeth influence by irradiation. Failures were primarily cohesive within the cement. No enamel or ceramic failure was observed, regardless of veneer thickness.

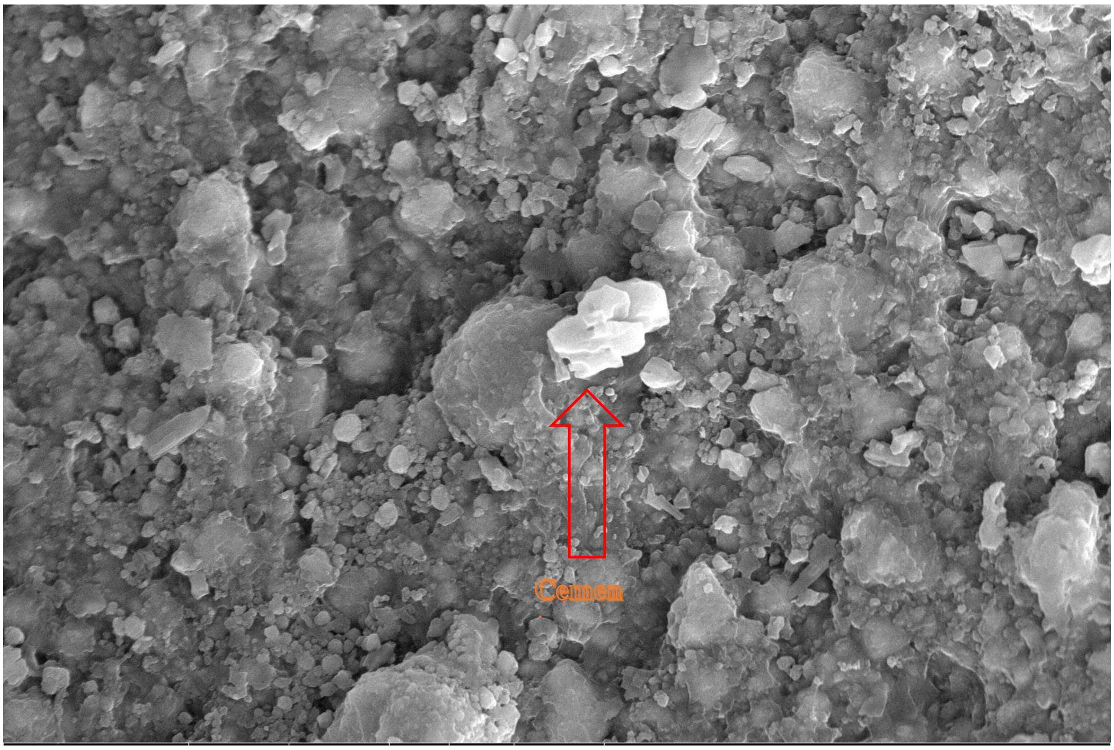

Figure 4. SEM image of the lithium disilicate (HT) glass-ceramic ingot intaglio surface (25,000×).

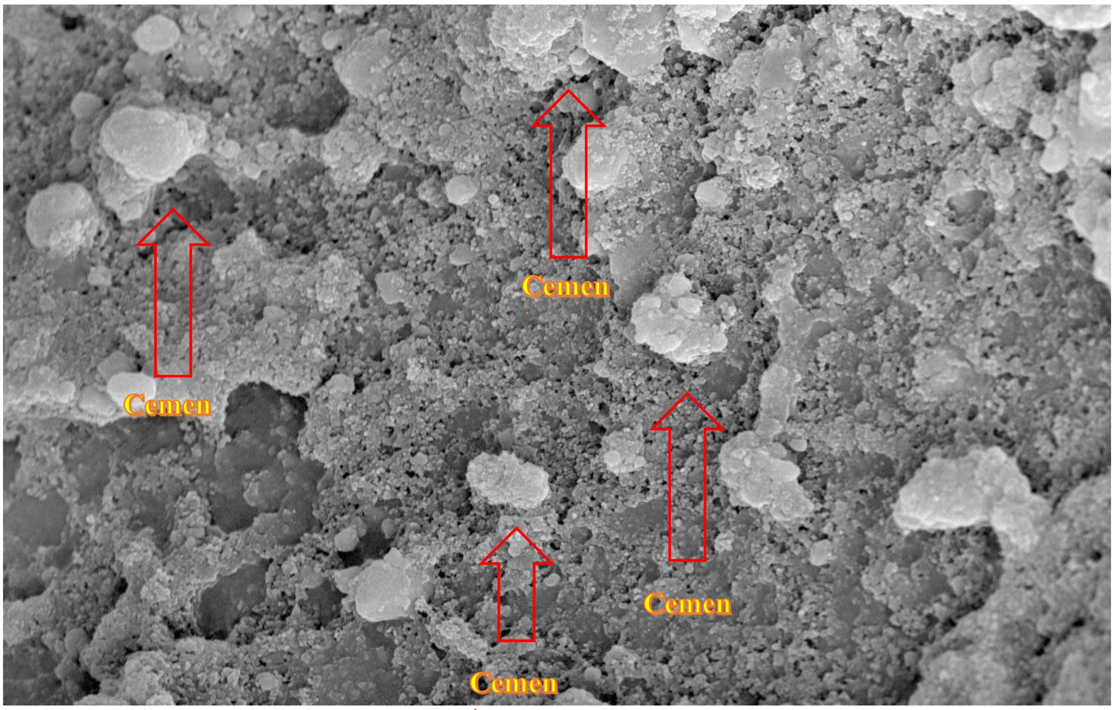

Figure 5. SEM image of the lithium disilicate (LT) glass-ceramic ingot intaglio surface (25,000×).

DISCUSSION

The removal of cemented laminate veneers is often required in various clinical scenarios—such as correcting veneers that are aesthetically unacceptable or exhibit marginal discrepancies leading to gingival and periodontal issues.[13] Likewise, if a newly fabricated veneer is improperly seated during cementation but remains intact, it must be debonded and then recemented. Traditionally, veneer removal in the dental office has relied on grinding techniques that demand considerable shear force, generate heat, increase patient discomfort, and risk damaging the underlying tooth structure.[14]

Using lasers offers a more conservative approach. Laser energy passes through the ceramic veneer, is absorbed by the underlying resin cement, and degrades it via one of three mechanisms: thermal softening, photoablation, or thermal ablation.[1] In thermal softening, the resin cement is heated until it loses rigidity, allowing the veneer to slide off. In photoablation, high-power laser pulses elevate the energy levels of resin molecules beyond their dissociation thresholds, causing direct decomposition.[15] At still higher temperatures—where adhesive resin vaporizes—thermal ablation can eject the veneer from the tooth surface, sometimes preceding softening.[16] Compared with conventional grinding, laser debonding is gentler, less painful, and preserves the restoration for potential reuse.[3]

We chose an Er,Cr:YSGG laser (wavelength 2,940 nm) for this study because its strong affinity for water enables efficient interaction with resin cements.[17] Stereomicroscopic evaluation revealed that 0.5 mm veneers retained less cement on their intaglio surfaces than 1.0 mm veneers, likely reflecting greater laser energy transmission through thinner ceramics. These findings agree with Sari et al., who reported higher energy transmission through 0.5 mm lithium disilicate than through 1 mm.[18]

Although low-translucency e.max veneers required slightly more time to debond than high-translucency ones, the difference was not statistically significant, in line with the results of Alikhasi et al.,[10] indicating that thickness does not appreciably affect removal time.

To assess failure mode, an external examiner—blinded to group assignments—used scanning electron microscopy at the University of Basrah. No enamel fractures were observed; failures predominantly occurred within the cement layer, leaving over 70 percent of the enamel surfaces coated with softened cement, similar to Karagoz et al.'s observations.[18] When cohesive failure occurred, resin remained on the inner veneer surface, while the tooth surfaces displayed scattered cement remnants. Because failure at the veneer–cement interface spares the enamel, the risk of tooth damage is minimized. Indeed, all specimens were debonded without significant destruction of healthy tooth structure or evidence of laser-induced ablation, echoing Morford et al.'s findings in 2011.[3]

This in vitro study was limited by the use of a single laser type and parameter set, one resin cement formulation, the absence of aging protocols, and exclusion of full-contour crowns. Further research is therefore necessary before clinical application, particularly to optimize post-laser bond strength between ceramics and tooth structure.

CONCLUSIONS

Within the parameters of this study, the Er,Cr:YSGG laser effectively and safely removed ceramic veneers of both high and low translucency. Although debonding low-translucency veneers took slightly longer, the difference was not statistically significant. SEM examination showed that most failures were cohesive at the cement–veneer interface, preserving the enamel and leaving the veneers intact and clean for potential clinical reuse.

DECLARATIONS

Ethics approval and consent to participate

Not applicable.

Conflict **interests**

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

This research received no external funding.

REFERENCES

1. Tak O, Sari T, Arslan Malkoç M, Altintas S, Usumez A, Gutknecht N. The effect of transmitted Er:YAG laser energy through a dental ceramic on different types of resin cements. Lasers Surg Med. 2015;47(7):602-607. doi:10.1002/lsm.22394
2. Zarone F, Di Mauro MI, Ausiello P, Ruggiero G, Sorrentino R. Current status on lithium disilicate and zirconia: a narrative review. BMC Oral Health. 2019;19(1):134. doi:10.1186/s12903-019-0829-5
3. Morford CK, Buu NCH, Rechmann BMT, Finzen FC, Sharma AB, Rechmann P. Er:YAG laser debonding of porcelain veneers. Lasers Surg Med. 2011;43(10):965-974. doi:10.1002/lsm.21144
4. Grzech-Leśniak K, Bencharit S, Skrjanc L, Kanduti D, Matys J, Deeb JG. Utilization of Er:YAG laser in retrieving and reusing of lithium disilicate and zirconia monolithic crowns in natural teeth: an in vitro study. Appl Sci. 2020;10(12):4357. doi:10.3390/app10124357
5. Gurney ML, Sharples SD, Phillips WB, Lee DJ. Using an Er,Cr:YSGG laser to remove lithium disilicate restorations: A pilot study. J Prosthet Dent.

2016;115(1):90-94.
doi:10.1016/j.prosdent.2015.08.003
6. Feldon PJ, Murray PE, Burch JG, Meister M, Freedman MA. Diode laser debonding of ceramic brackets. Am J Orthod Dentofacial Orthop. 2010;138(4):458-462.
doi:10.1016/j.ajodo.2008.11.028
7. Sari T, Tuncel I, Usumez A, Gutknecht N. Transmission of Er:YAG laser through different dental ceramics. Photomed Laser Surg. 2014;32(1):37-41. doi:10.1089/pho.2013.3611
8. Rechmann P, Buu NCH, Rechmann BMT, Finzen FC. Laser all-ceramic crown removal and pulpal temperature—a laboratory proof-of-principle study. Lasers Med Sci. 2015;30(8):2087-2093. doi:10.1007/s10103-015-1738-1
9. Mirhashemi A, Chiniforush N, Jadidi H, Sharifi N. Comparative study of the effect of Er:YAG and Er:Cr:YSGG lasers on porcelain: etching for the bonding of orthodontic brackets. Lasers Med Sci. 2018;33(9):1997-2005. doi:10.1007/s10103-018-2573-y
10. Alikhasi M, Monzavi A, Ebrahimi H, Pirmoradian M, Shamshiri A, Ghazanfari R. Debonding time and dental pulp temperature with the Er,Cr:YSGG laser for debonding feldspathic and lithium disilicate veneers. J Lasers Med Sci. 2019;10(3):211-214. doi:10.15171/jlms.2019.34
11. Zanini NA, Rabelo TF, Zamataro CB, Caramel-Juvino A, Ana PA, Zezell DM. Morphological, optical, and elemental analysis of dental enamel after debonding laminate veneer with Er,Cr:YSGG laser: a pilot study. Microsc Res Tech. 2021;84(3):489-98. doi: 10.1002/jemt.23605.
12. Tuzzolo Neto H, do Nascimento WF, Erly L, et al. Laminated veneers with stratified feldspathic ceramics. Case Rep Dent. 2018;2018:5368939. doi:10.1155/2018/5368939
13. Albalkhi M, Swed E, Hamadah O. Efficiency of Er:YAG laser in debonding of porcelain laminate veneers by contact and non-contact laser application modes (in vitro study). J Esthet Restor Dent. 2018;30(3):223-228. doi:10.1111/jerd.12361
14. Van As GA. Using the erbium laser to remove porcelain veneers in 60 seconds. J Cosmet Dent. 2013;28(4):20-34.
15. Han X, Liu X, Bai D, Meng Y, Huang L. Nd:YAG laser-aided ceramic brackets debonding: effects on shear bond strength and enamel surface. Appl Surf Sci. 2008;255(2):613-615.
doi:10.1016/j.apsusc.2008.06.082
16. Mundethu AR, Gutknecht N, Franzen R. Rapid debonding of polycrystalline ceramic orthodontic brackets with an Er:YAG laser: an in vitro study. Lasers Med Sci. 2014;29(5):1551-1556. doi:10.1007/s10103-013-1274-9
17. Coluzzi DJ, Parker SP, eds. Lasers in Dentistry–Current Concepts. 2017:20-22.
18. Karagöz Yıldırak M, Ok Tokaç S, Özkan Y, Gözneli R. Effects of different Er:YAG laser parameters on debonding forces of lithium disilicate veneers: A pilot study. Marmara Dent J. 2019;1:8-13.