



LASER-ASSISTED REMOVAL OF ALL-CERAMIC CROWNS AND VENEERS: A NARRATIVE REVIEW

Prosthodontics

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ABSTRACT

All-ceramic crowns and veneers are now routinely used for their appearance and biological compatibility, yet no restoration lasts indefinitely. Caries, pulpal disease, cement failure, fracture, or the need to reach an underlying tooth or implant can all make removal necessary, and clinicians increasingly want to retrieve these restorations intact rather than destroy them. Rotary sectioning remains the standard method because it is predictable, but it sacrifices the restoration and adds chairside time, heat, and vibration. Atraumatic mechanical techniques can sometimes preserve a crown or veneer, though outcomes depend heavily on cement type and retention form and are not consistently reproducible. Erbium lasers offer a more conservative option. Er:YAG, at 2940 nm, is absorbed strongly by water and by the water-containing components of resin and cement, so energy delivered through the ceramic can weaken the luting layer while sparing the ceramic and tooth from mechanical damage. Laboratory work has retrieved lithium disilicate and zirconia crowns this way without detectable harm to the dentin, and early clinical reports support its feasibility. Er,Cr:YSGG, emitting near 2780 nm, works through a similar mechanism but tends to need longer exposure in comparable crown-removal models. Cement composition, water content, ceramic thickness and type, and laser settings all shape how well debonding works. Taken together, the evidence favors Er:YAG as the better-studied option for conservative crown and veneer retrieval, provided cooling, non-contact delivery, and case-appropriate parameters are used. Larger clinical trials are still needed before standardized protocols can be recommended.

KEYWORDS

All-Ceramic Crown, Ceramic Veneer, Crown Removal, Debonding, Er:YAG laser, Er,Cr:YSGG Laser, Zirconia, Lithium Disilicate

INTRODUCTION

All-ceramic crowns and veneers are now central to fixed prosthodontics because of their optical quality, biocompatibility, and, in contemporary ceramic systems, adequate strength. Even so, no indirect restoration is meant to last forever. Secondary caries, pulpal or periapical disease, marginal breakdown, fracture, prosthetic failure, a wish to replace a restoration for esthetic reasons, or the need to reach an implant or tooth underneath can all prompt removal. The task becomes harder when the goal is to retrieve the restoration intact, since sectioning it with a bur destroys a crown or veneer that may otherwise still be usable.

Mechanical removal with rotary instruments, crown removers, or sectioning followed by controlled prying is the conventional approach. It works reliably, but it sacrifices the restoration and can generate heat, vibration, and inadvertent damage to the tooth, along with considerable chairside time. Atraumatic techniques have also been described, including devices designed for crown removal and a method in which impression material is bonded to the ceramic and withdrawn to dislodge it; these approaches depend heavily on the individual case and are not universally predictable [1].

Laser-assisted debonding was developed to weaken the bond between a restoration and its luting cement while limiting mechanical stress on the tooth and ceramic. Erbium lasers are particularly suited to this because their wavelengths are absorbed strongly by water, and several reviews have traced the growing evidence supporting their use as a conservative alternative to sectioning [2]. This review brings together the conventional and atraumatic removal methods, explains how laser debonding works physically, weighs the evidence for the two erbium systems used in crowns and veneers, and outlines a practical approach for clinicians considering this technique.

MATERIAL AND METHODS

This is a narrative rather than a systematic review. Relevant literature was identified through PubMed/MEDLINE and Google Scholar, with additional papers located by checking the reference lists of key articles on ceramic crown and veneer removal. Search terms included combinations of "all-ceramic crown removal," "ceramic crown debonding," "laser-assisted crown removal," "Er:YAG," "Er,Cr:YSGG," "zirconia," "lithium disilicate," "ceramic veneer debonding," and "laser dental restoration retrieval." Priority was given to studies reporting debonding time, restoration integrity after removal, changes in tooth or pulpal temperature, ceramic thickness, cement type, and clinical outcomes. Because the aim was a clinically

useful synthesis rather than a formal systematic appraisal, no PRISMA-based selection protocol was followed.

RESULTS AND DISCUSSION

Conventional and Atraumatic Removal

Mechanical removal is still the most accessible option in everyday practice. Crown removers apply tensile or impact force at the cement interface, while rotary removal involves sectioning the restoration with a diamond or carbide bur and then prying the pieces apart. Its main drawback is that it destroys the restoration outright, which is acceptable when the crown or veneer is already defective but wasteful when an intact restoration could have been reused.

Ceramic restorations add a further complication because their shade and translucency often make it hard to see exactly where the cement layer ends and the restoration or tooth begins. Zirconia is especially resistant to conventional cutting, and pushing a bur too hard against it risks generating excess heat and vibration, with some chance of cutting into sound tooth structure by accident.

Atraumatic techniques try to avoid this by relying on controlled dislodging forces instead of cutting. Ardu and Perroud, for example, described gripping a ceramic crown with adhesive and polyether impression material and withdrawing it without sectioning [1]. Methods like this work well when retention is modest, but they cannot reliably debond a restoration that is strongly resin-bonded. Ultrasonic instruments have also been tried as a gentler alternative; evidence from ceramic bracket removal suggests they can lower bond strength, though sometimes at the cost of surface defects or voids, and this evidence does not transfer cleanly to full-coverage crowns [3].

The Physics of Laser-Assisted Debonding

Laser debonding works on a different principle than sectioning. Rather than cutting through the ceramic, the laser delivers energy through or around the restoration so that the cement itself absorbs it and loses structural integrity. Er:YAG emits at 2940 nm and Er,Cr:YSGG at roughly 2780 nm; both sit near strong water-absorption bands, which makes them well matched to hydrated tissues and to the water content of resin and cement.

When resin-based cement absorbs this energy, the water and residual monomer within it heat rapidly and vaporize, producing localized pressure changes that break down the cement matrix. As cohesion and adhesion drop, the restoration can usually be lifted free with only gentle mechanical assistance, which is why the process is better

described as laser-assisted debonding rather than laser cutting [4].

How well this works depends on how much energy actually reaches the cement, which in turn depends on the ceramic's composition, thickness, translucency, and shade. Morford et al. found that porcelain veneers transmitted a measurable fraction of Er:YAG energy, with transmission varying by ceramic type and thickness. All 24 veneers in their study were successfully removed, in an average of 113 ± 76 seconds, with no detectable damage to the underlying tooth [5].

Evidence for Er:YAG

Of the two erbium systems, Er:YAG has the stronger evidence base for full-coverage restorations. Rechmann and colleagues characterized the optical and material properties of several all-ceramic systems and then went on to remove lithium disilicate and zirconia crowns from natural teeth. Mean removal times were 190 ± 92 seconds for lithium disilicate, 226 ± 105 seconds for feather-edge zirconia, and 312 ± 102 seconds for regular-margin zirconia, with no fractured crowns or dentinal damage and visible deterioration of the cement during irradiation [6].

Implant-supported restorations are a natural fit for this technique, since retrieval without damaging the crown, abutment, or implant is often desirable. Elkharashi et al. removed monolithic zirconia crowns cemented to zirconia implant abutments in roughly five minutes on average, and the crowns could be recemented and removed again without visible structural damage on microscopic examination [7].

More recent work has focused on how much the cement and restoration themselves change the outcome. Chen et al. found that cement type, water content, and zirconia thickness all significantly affected Er:YAG debonding; glass-ionomer cements generally debonded faster than resin cements, thicker zirconia reduced efficiency, and adding water to resin cement lowered residual bond strength without consistently cutting irradiation time [8]. In short, no single laser setting works for every ceramic-cement combination.

Evidence for Er,Cr:YSGG

Er,Cr:YSGG has also proven capable of debonding ceramic restorations. In a permanent-molar model comparing the two erbium wavelengths directly, Er,Cr:YSGG required an average of 3 minutes 13.9 seconds to remove prefabricated zirconia crowns versus 1 minute 32.7 seconds for Er:YAG, with modest temperature increases of $2.2 \pm 0.99^\circ\text{C}$ and $1.41 \pm 1.36^\circ\text{C}$ respectively [9].

A separate study of primary and permanent molars found that Er,Cr:YSGG could remove prefabricated zirconia crowns cemented with resin-modified glass-ionomer, though removal took longer in permanent teeth; temperature rises stayed modest throughout [10]. Together these findings support Er,Cr:YSGG as a workable alternative, even though the body of evidence behind it remains smaller than for Er:YAG.

Veneer Removal

Veneers pose a different optical challenge because they are thin and the cement sits close to the enamel. Morford and colleagues found that Er:YAG irradiation weakened the cement-veneer bond while leaving the underlying tooth structure intact, though outcomes varied by ceramic type: several leucite-reinforced veneers fractured, while lithium-disilicate veneers generally survived [5].

Subsequent studies of veneer debonding report similar reductions in bond strength after erbium-laser irradiation, with ceramic thickness, adhesive type, and irradiation time all playing a role. The practical takeaway is the same as for crowns: use the laser to weaken the bond, then remove the veneer with as little mechanical force as possible. Since most of this evidence comes from laboratory studies, clinicians should treat each case individually rather than applying a fixed protocol.

Thermal Considerations

Heat generation is the main safety concern with laser debonding. Studies have generally used a pulpal temperature rise of around 5.5°C as the threshold beyond which pulpal injury becomes a concern, though the real risk also depends on how long the exposure lasts and how much dentin remains [4]. With adequate air-water cooling and controlled irradiation, Er:YAG studies have generally stayed within a safe temperature range.

Laser parameters should be tailored to the ceramic's thickness, the cement in use, the restoration's design, and whether natural tooth structure is present underneath. Continuous cooling, non-contact delivery where the manufacturer recommends it, intermittent rather than continuous irradiation when needed, and close attention to heat build-up are all sensible precautions. Implant-supported restorations remove pulpal risk from the equation but still require care to protect the peri-implant tissue, cement interface, and prosthetic components.

Comparing the Available Laser Systems

Table 1 (T-1) sets out the wavelength, mechanism, supporting evidence, and overall clinical standing of the laser systems discussed here, including diode, CO_2 , and Nd:YAG lasers for context.

Table 1: Comparative Characteristics and Clinical Relevance of Laser Systems Used For Removal of All-Ceramic Restorations.

Laser	Wave-length	Primary interaction	Evidence for ceramic retrieval	Overall role
Er:YAG	2940 nm	Strong water absorption; cement ablation/degradation	Strongest evidence for crowns and veneers; successful retrieval from natural teeth and implants	Preferred / best-supported
Er,Cr:YSGG	2780 nm	Strong water absorption; cement weakening	Effective for crown and veneer debonding; usually slower than Er:YAG in comparative models	Effective alternative
Diode	$\approx 655\text{--}980$ nm	Predominantly photothermal interaction	Evidence mainly from bracket/adhesive debonding; little direct evidence for full ceramic crowns	Not first-line for ceramic crown retrieval
CO_2	10,600 nm	Strong absorption by water; superficial thermal interaction	Limited evidence for controlled ceramic retrieval; greater thermal risk	Not routinely preferred
Nd:YAG	1064 nm	Lower absorption by water; deeper tissue penetration	Limited evidence for conservative ceramic crown debonding	Not routinely preferred

What Determines Clinical Success

Several factors decide whether a restoration comes off cleanly. Cement composition matters because the laser has to pass through the ceramic before it can act on the cement, and resin cements do not necessarily behave like glass-ionomer or resin-modified glass-ionomer cements. Restoration thickness and translucency govern how much energy actually gets through, while ceramic composition affects how much light is absorbed rather than transmitted. Irradiation parameters, such as pulse energy, repetition rate, pulse duration, spot size, working distance, and water/air settings, shape both how efficiently debonding occurs and how much heat is generated. Restoration geometry and the volume of cement present also affect how long retrieval takes (Chen et al.; 2026, Ghazanfari et al.; 2019).

Zirconia is consistently harder to retrieve than lithium disilicate or other more translucent glass ceramics, since its crystalline structure limits how much light passes through, especially as thickness increases. A setting that works for a thin lithium-disilicate veneer should not be assumed to work for a thick monolithic zirconia crown.

A Practical Approach

When an intact restoration seems worth saving, the clinician should first work out why it needs to come off, what it is made of, how thick it is, what cement was used if known, how accessible it is, and the condition of the tooth or abutment underneath. Conventional sectioning is still the right call when the restoration is already compromised, when speed matters more than preservation, or when laser equipment or training is not available. Mechanical or atraumatic retrieval can be tried when retention is favorable and the risk of damage looks low.

When conservative retrieval is the goal and a suitable erbium laser is on hand, Er:YAG currently has the best evidence to support it. The restoration should be irradiated according to the device's validated settings and whatever material-specific data exists, with cooling and eye protection in place throughout. The laser's job is to weaken the cement, not to cut the ceramic, so gentle removal force should follow sufficient irradiation rather than replace it. If the restoration does not release, further irradiation in controlled increments is preferable to forcing it mechanically. A reasonable sequence in practice is to identify the material and cement, decide whether preservation is worthwhile, choose an evidence-based erbium-laser protocol, cool continuously, irradiate the accessible surfaces systematically, check for gentle mobility, repeat controlled cycles if needed, and inspect both the restoration and the underlying tooth or abutment once it is out.

Limitations of the Current Evidence

Most of what is known still comes from laboratory studies. Sample sizes tend to be small, ceramic systems and cements vary widely between studies, and laser parameters are rarely standardized across devices, all of which make it hard to generalize. Clinical evidence lags well behind the in-vitro literature. Successful debonding in a laboratory setting also does not automatically mean the retrieved restoration is fit for reuse; residual cement, marginal fit, surface changes, and bond strength after recementation all need separate evaluation. Long-term clinical comparisons between laser retrieval and conventional sectioning are still lacking.

Zirconia formulations add another layer of complexity, since 3Y-, 4Y-, and 5Y-zirconia differ in their optical behavior, and repeated laser exposure may warrant further study using techniques such as Raman spectroscopy or X-ray diffraction. What the evidence supports at this stage is laser-assisted retrieval as a promising, conservative option, not yet a universal substitute for conventional crown removal.

CONCLUSION

The removal of all-ceramic crowns and veneers has moved away from destructive sectioning toward methods that try to save the restoration where possible. Rotary sectioning is still dependable, but it sacrifices the crown or veneer and carries some risk to the tooth. Atraumatic mechanical methods can work in selected cases, though not consistently enough to rely on.

Erbium lasers, and Er:YAG at 2940 nm in particular, currently offer the best-supported route to conservative debonding. Their effect depends on interacting with the water in the luting cement, which breaks down the bond without placing much mechanical stress on the ceramic or the tooth. Er,Cr:YSGG works through a similar mechanism and has shown real efficacy, though it tends to take longer than Er:YAG in head-to-head comparisons. Ceramic thickness and composition, cement type and water content, and the specific laser parameters chosen all influence how well the technique performs. Er:YAG should be regarded as the more thoroughly validated option for now, not as a wholesale replacement for conventional removal. Training, cooling, laser safety, and case-specific parameter selection remain essential wherever this technique is used.

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Conflict of Interest

The authors declare no conflict of interest.

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