Intraoral Repair of Dental Restorations with Resin Composite

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Abstract

Dental restorations suffer deterioration and degradation over time due to undesirable conditions; accordingly, their clinical life is reduced. The complete removal of defective dental restoration can lead to progressive cavity enlargement with unnecessary sound tooth tissue removal and weakening of the remaining dental tissue, which can lead to complicated treatment procedures, loss of vitality of the tooth, and result in an economic disadvantage. The repair approach, which provides the advantage of preserving a sound tooth structure by keeping tissue loss to a minimum level, has become an alternative to the replacement process. Today, there is not a clear consensus on selecting the appropriate treatment method from between the repair or replacement procedures. This review aims to provide information about the procedures to be applied when the repair approach is to be carried out, surface treatment methods and some of the results of studies on this subject which were carried out within the last 5 years.

Keywords: Composite resin, dental restoration repair, ceramics, CAD/CAM, surface treatment

INTRODUCTION

One of the most important principles of modern dentistry is minimally invasive interventions. Dentists should be cautious during the removal process in order to prevent unnecessary loss of sound tooth tissue. Although their durability has been increased with improvements developed in recent years, dental restorations suffer deterioration and degradation due to undesirable conditions in the oral environment over time. Localized secondary caries, localized defects, and defective restorations are amongst the most commonly encountered clinical observations in dental practice.

For defective restorations, there are 4 options which can be carried out which were clearly defined in 2004 by Setcos et al. In the presence of minor defects such as superficial staining which do not cause clinical disadvantages, only monitoring without treatment can be chosen. Refurbishment is the process done without damage to the tooth surface such as; recontouring the surface, removal of discoloration, removal of overhangs, sealing of small gaps, and pores without adding new restorative material (except bonding or glaze). Repair is the treatment of localized defects that are clinically unsatisfactory by partially removing the defective part and adding new restorative material. Replacement is the process including the complete removal and rebuilding of defective restoration. While removing the restorative material, the portions that might appear to be clinically acceptable can also be removed. This application also can lead to a loss of dental tissues.

Renovation of existing restorations is one of the most common clinical applications in dental practice. Studies have shown that almost half of the restorations performed in dental practice are replacements of restorations rather than new restorations. The complete removal of defective dental restoration approach can lead to progressive cavity enlargement with unnecessary sound tooth tissue removal. This can cause an acceleration in the restoration cycle accompanied by complicating the treatment process and even loss of tooth vitality.

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Further disadvantages of replacements of restorations are that they are an expensive and time-consuming method.  

Repair of the restoration approach, which provides the advantages of preserving the sound tooth structure by keeping material loss to a minimum level, and reducing microbial adhesion to the damaged areas, is a viable alternative to the replacement process.  

Advances in adhesive technology, an integral part of the minimally invasive treatment approach, enable intraoral repair of defective indirect and direct restorations using composite resins so as to extend the longevity of the restoration.  

Advantages of repair instead of replacement of a restoration can be summarized as follows;  

- Preservation of dental remnant and reduction of tooth tissue loss  
- Reduction of the risk of pulp damage  
- No anaesthesia is needed unless the area to be repaired is large  
- Reduction of the risk of iatrogenic damage  
- Shortened treatment time  
- Reduction of the cost of treatment  
- Extension of the life cycle of restoration  
- Protection against mercury vapours which may harm patients and dentists during the removal of amalgam restoration.  

The results of the meta-analysis of Kanzow et al. published in 2018 showed that although the repair process was taught in most schools, repair of partial defective restorations was preferred by only about two thirds of dentists. In Turkey, it was reported that the demographic differences of Turkish practitioners and the differences of the cases might affect the decision for repair or replacement. It was stated in that study that younger dentists preferred repair procedures more, but this difference with the older ones was not significant. It is obvious that the repair approach, which causes less tooth tissue loss, should be preferred more in suitable indications. Additionally, to the best of our knowledge, there is no clear consensus on the best surface treatment method that should be used in the repair treatment protocol. Therefore, this review aims to provide information about the procedures to be applied when the repair approach is to be carried out and to present the surface treatment methods and results of many studies on this subject which were carried out within the previous 5 years.  

Surface treatment methods: The prerequisites for repair protocols are applying the ideal surface treatment method for the existing restoration, and selecting an appropriate adhesive and restorative material. Removing the superficial layer to expose a clean and high-energy surface and increasing the bonding area by creating irregularities are the two main purposes of surface treating the pre-existing adhesive restorations. Surface treatment methods in the repair protocol investigated in the literature are; surface grinding with burs, laser irradiation, surface etching with phosphoric acid and hydrofluoric acid and air abrasion with alumina particles as mechanical procedures, silane applications, and the use of adhesives as chemical procedures and additionally tribochemical silica coating as both a mechanical and chemical procedure. The purpose of these procedures is to increase the surface energy of the existing restorative material to be repaired and provide better wettability by the adhesive agents. There have been many investigations about the materials and techniques in the literature but there is no clear consensus on a universal technique that should be used in repair protocols since there is a great variability in composition among different brands of resin composites.  

Air abrasion/sandblasting with Al\(_2\)O\(_3\): Sandblasting is a surface roughening method based on direct sandblasting of the surface by an intraoral device that cleans the surface, increases the surface area used for bonding, and provides micromechanical retention by applying aluminium oxide particles to the restoration surface with a certain pressure. Resin composite, amalgam, ceramic, or metal materials are abraded from a distance of approximately 10 mm for about 10 seconds by 30 to 50 µm aluminium oxide particles.  

Tribochemical silica-coating: Silica-coating or tribochemical surface conditioning provides micromechanical retention with aluminium oxide particles coated with a silicone-dioxide layer. The tribochemical silica-coating process strengthens the adhesion to the surface of silica-free material. This reinforcement is accomplished by bonding the silane coupling agent to the silica-coated layer formed on the substrate material. The basic principle of the tribochemical silica-coating procedure is that mechanical energy causes chemical and physicochemical changes in the substance throughout the application. Thus, the tribochemical coating can be used to increase both mechanical and chemical bonding. The CoJET (3M ESPE, Seefald, Germany) device is used in dentistry for this purpose.  

Bur abrasion: This method is based on the simple roughening of the restoration surface with diamond burs that are commercially available with different grit sizes. After the surface is abraded using diamond burs, macro mechanical retention is achieved through holes and undercuts. It is claimed to be advantageous since it is an easy procedure to be applied and does not require additional equipment or chemical substances allowing it to be cost-effective. In one study, the effect of surface roughness and repair bond strength of three different grit sizes (medium, fine, extra-fine) were evaluated and all types of burs with different grit sizes increased the repair bond strength when compared to an untreated control group. Additionally, it was found that the difference among the grit-sizes affected the repair bond strength. Medium-grit-sized diamond bur showed the lowest repair bond strength while fine grit size achieved the highest repair bond strength. 

Tinaztepe et al. compared the shear bond strength values of three pre-treatment groups; diamond bur grinding, silica coating, and no treatment, for the repair of CAD/CAM resin nanocomposites with composite repair materials. After each surface pre-treatment group, they applied 4 different conditioning methods. The conditioning methods were as follows; Adper scotchbond multipurpose adhesive (3M ESPE, St. Paul, MN, USA), Scotchbond universal (3M ESPE), Ultradent silane (Ultradent, USA) + Adper scotchbond multipurpose adhesive (3M ESPE, St. Paul, MN, USA) and no conditioning. At the end of the study, they concluded that surface treatment followed by diamond bur grinding followed by silane and adhesive application is superior to the silica coating, and no treatment groups.  

Surface etching: Surface etching procedures are usually carried out with phosphoric or hydrofluoric acid in restorative dentistry. Etching with 30-40% phosphoric acid is used for both enamel and dentin tissue. Thus, the smear layer is completely removed; micro-porosity is obtained on the surface, and the bonding capacity increases. Although phosphoric acid is effective in enamel and dentin, it has no direct effect on the surface characteristics of composite resins, ceramics, and metals.
Unlike phosphoric acid, hydrofluoric acid dissolves glass particles and exposes the crystalline matrix in ceramic causing increased surface roughness. Enhanced wettability and surface energy are also provided by this process leading to increased bond strength. In cases of resin composite, the effect of hydrofluoric acid is highly dependent on the filler particle composition. Phosphoric acid with 37% concentration is not as adequately effective in removing silica as hydrofluoric acid. 4-10% concentration is recommended to obtain better bond strength for hydrofluoric acid.

**Laser irradiation:** The application of laser irradiation on enamel surface leads to an irregular and rough shape with the effect of micro-explosions. The surface roughness that is realized is different from acid roughening. After the traditional method, a structure with boundaries of prisms is formed, while after laser irradiation different structural shapes with different sizes and depths are formed. Er:Cr:YSGG (erbium, chromium: yttrium, scandium, garnet), Er:YAG (erbium: yttrium, aluminum, garnet), Neodymium: yttrium, aluminum, garnet (Nd:YAG) and CO₂ (carbon dioxide) lasers are the types of lasers generally used for this procedure. It can be concluded from the studies in the literature that the type of laser used and the substrate material to be repaired are the two most important factors determining the efficiency of this surface treatment method.

**Silane coupling agent application:** Silane coupling agents are important mediators for combining two dissimilar materials. Silane is a primer with two functional groups, the silanol and the organofunctional groups. The silanol group attaches to the methacrylate of the adhesive resin, while the organofunctional group attaches to the methacrylate of the adhesive system.

Adhesive agents: Adhesive systems have become more important with the repair approach. The content and application method of the adhesive system used for repair affects the success of the repair. The adhesive systems can be divided into two: namely “etch & rinse” and “self-etch adhesive” systems according to their interaction with the dental substrate. Etch & rinse systems, which contain separate etching and rinsing, are classified as 3-step or 2-step depending on the combination of primer and adhesive resin separately or in a single bottle respectively. Unlike etch & rinse systems, self-etch systems do not require separate etching and rinsing steps thanks to the monomers they contain. Thus, less application time and technical sensitivity as well as lower sensitivity in post-operative make these systems more user-friendly.

Universal systems can be used for bonding to both dental tissues and restoration materials thanks to the special monomers they contain. The most widely used is 10-Methacryloyloxydecyl dihydrogen phosphate (MDP) functional monomer, which apart from mechanical bonding, provides chemical bonding to restoration materials such as zirconia, while providing mechanical bonding as well as forming insoluble calcium salts in dental tissues. The compatibility of universal adhesives with resin-based systems has the advantage that they can be used in the cementation of indirect restorations. It is also stated that it can be used as a primer in zirconia, precious-nonprecious metal alloys, composite resins, and various silica-based ceramics. In this way, universal adhesives make it possible to bond to these surfaces without the need for separate agents. In addition to being able to be used for adhesion of indirect restorations, universal adhesives can also be used to repair these restorations, and surface roughening is recommended by using burs or air-abrasion before adhesive application to increase bond strength. Some manufacturers have added silanes to universal adhesives to simplify the bonding protocol of glass-matrix ceramic restorations. Since bonding is adversely affected due to changes in the content added to the silane, a separate silane application before universal adhesive is recommended for optimal adhesion.

The literature was searched electronically via the PubMed database using the keywords “repair, bond strength, composite resin, surface treatment” as MeSH terms. Original research articles published in English between 2015 to February 2020 were deemed eligible for inclusion. The titles and abstracts of all articles available as full text were carefully reviewed to eliminate those articles that were not within the scope of this review. If the focus of the article could not be determined exactly from the title and abstract, the full text of the article was examined. The surface treatment methods, materials and conclusions of the studies selected in accordance with the specified criteria for resin composites and ceramics, and CAD/CAM materials are indicated in Table 1 and Table 2 respectively.

**CONCLUSION**

For composite repair, air abrasion and diamond burs can both be effectively used for surface roughening, however, the advantages such as ease of availability, lower cost, and reduced risk of damage to the patient make surface roughening with diamond burs preferable. After roughening, the debris on the surface should be removed with phosphoric acid and thus the surface energy should be increased. Micro-hybrid composite resins seem beneficial to be used as the repair material.

In the repair of ceramic restorations, after surface roughening with burs, it is recommended to use hydrofluoric acid if the ceramic material contains silica, and to apply tribochemical silica-coating to the surface if the ceramic does not contain silica. In the next step, by applying silane, both surface wettability and adaptation of the adhesive resin to the surface can be increased. The content of the composite resin as a repair material does not make a significant difference.

In the repair procedure, the application of an adhesive resin step seems to have a positive effect on the bond strength. Universal adhesives in adhesive systems stand out with their special functional monomers which can provide chemical bonding to some materials, for their ease of use and also due to the property that they can be applied as a thinner layer than other systems.

**MAIN POINTS**

- Repair of restorative materials, which are currently the preferred procedures in terms of minimally invasive approaches, should be performed with surface roughening procedures.
- In cases of composite repair, surface treatment with air abrasion or diamond burs can be effective. However, advantages such as ease of availability, lower cost, and reduced risk of damage to the patient make surface roughening with diamond burs preferable.
- In the repair of ceramic materials, the silica content of the material is important for the surface treatment to be preferred.
- Applications of adhesive resin systems have a beneficial effect on the repair of aesthetic restorative materials.
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<tr>
<td>Kaneko et al.</td>
<td>SRC, MRC</td>
<td>SRC, MRC</td>
<td>Al₂O₃, TE</td>
<td>+</td>
<td>-</td>
<td>Higher tensile bond strength values were observed in SRC samples and greater percentage of adhesive failures in MRC samples. Application of bonding system plays a secondary role in tensile bond strength. All surface treatment methods showed similar and optimal repair bond strengths.</td>
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<tr>
<td>Gupta et al.</td>
<td>SRC, MRC</td>
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<td>Consani et al.</td>
<td>SRC, MRC</td>
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<td>Wendler et al.</td>
<td>SRC, MRC</td>
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<td>SRC, MRC</td>
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<td>Al₂O₃, TE</td>
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<td>Arami et al.</td>
<td>SRC, MRC</td>
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<td>Souza et al.</td>
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<td>de Jesus Tavares et al.</td>
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<td>Kiomarsi et al.</td>
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<td>Altinci et al.</td>
<td>SRC, MRC</td>
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<td>Kouros et al.</td>
<td>SRC, MRC</td>
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<td>Ayar et al.</td>
<td>SRC, MRC</td>
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<td>Sismanoglu &amp; al.</td>
<td>Nanofill RC</td>
<td>Self-adhering flowable RC</td>
<td>H₃PO₄, Al₂O₃, Tribochemical silica coating</td>
<td>UA</td>
<td>-</td>
<td>Amalgam restorations may be repaired using RC, but the shear bond strength was lower than that obtained with RC. Amalgam repair with RC was suggested to be done with silica coating and application of a silane-containing adhesive.</td>
</tr>
<tr>
<td>de Medeiros &amp; al.</td>
<td>Bulkfill RC, conventional RC</td>
<td>Micro-hybrid RC</td>
<td>H₃PO₄, Bar abrasion</td>
<td>TE, UA</td>
<td>+</td>
<td>Similar micro-tensile bond strength values among different adhesion protocols were obtained. Comparable bond strength values are presented between repairing restorations with bulk fill composites and conventional composites.</td>
</tr>
<tr>
<td>Kanzow &amp; al.</td>
<td>Conventional RC, Amalgam</td>
<td>Conventional RC</td>
<td>H₃PO₄, Bur abrasion, Al₂O₃, Tribochemical silica coating</td>
<td>TE</td>
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<td>Eren &amp; al.</td>
<td>Nanohybrid RC</td>
<td>Nanohybrid RC, Self-adhering flowable RC</td>
<td>H₃PO₄, laser irradiation, Bur abrasion, Al₂O₃, Tribochemical silica coating</td>
<td>SE</td>
<td>+</td>
<td>Bur abrasion, silica coating and air abrasion with Al₂O₃ showed reliable shear bond strengths, while laser abrasion was not recommended.</td>
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Table 2. Surface treatment methods used and conclusions of the studies on ceramic and CAD/CAM materials

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<td>Neis &amp; al.</td>
<td>Feldspathic ceramic, leucite-reinforced glass-ceramic, lithium disilicate-reinforced glass-ceramic</td>
<td>Nanofilled RC</td>
<td>H₃PO₄, HF, Bur abrasion, Trbochemical silica coating</td>
<td>TE</td>
<td>+</td>
<td>Effective surface treatment method varies depending on the type of ceramic. Suitable matches were: Feldspathic and leucite-reinforced ceramics-bur abrasion, lithium disilicate-reinforced ceramic-HF etching, leucite-reinforced ceramic-tribochemical silica-coating.</td>
</tr>
<tr>
<td>Wiegand &amp; al.</td>
<td>Polymer-based CAD/CAM material, MRC</td>
<td>Bur abrasion, A1O₂, Trbochemical silica coating</td>
<td>TE, UA</td>
<td>+</td>
<td>Surface pre-treatment especially tribochemical silica coating was recommended for CAD/CAM polymers. Repair bond strength of CAD/CAM polymers was found to be weaker than RC.</td>
<td></td>
</tr>
<tr>
<td>Sadeghi &amp; al.</td>
<td>Feldspatic Porcelain</td>
<td>Micro-hybrid RC</td>
<td>HF, Laser irradiation</td>
<td>SE</td>
<td>+</td>
<td>Pre-treatment with HF and laser was found to provide more effective shear bond strength than laser only.</td>
</tr>
<tr>
<td>Yoo &amp; al.</td>
<td>Feldspatic porcelain, Ni-Cr metal alloy</td>
<td>Micro-hybrid RC</td>
<td>HF, Bur abrasion, Al₂O₃, Trbochemical silica coating</td>
<td>SE, TE</td>
<td>+</td>
<td>Al₂O₃ blasting application was suggested for repairing a fracture with an exposed area of porcelain. Tribochemical silica coating was recommended if the fracture extended to the metal surface.</td>
</tr>
<tr>
<td>Duzyol &amp; al.</td>
<td>Lithium disilicate CAD/CAM, feldspar ceramic</td>
<td>Nano-hybrid RC</td>
<td>HF, Bur abrasion, Al₂O₃, Trbochemical silica coating</td>
<td>SE, TE</td>
<td>+</td>
<td>Lithium disilicate CAD/CAM materials require an etching procedure for repair. Surfacing treatments did not increase repair microtensile bond strength of feldspar ceramic CAD/CAM material while they reduced the bond strength of the nanoceramic resin group.</td>
</tr>
<tr>
<td>Subaşı &amp; Alp.</td>
<td>Aged-non-aged nanoceramic CAD/CAM restorations</td>
<td>Nano-hybrid RC</td>
<td>Al₂O₃, Tribochemical silica coating</td>
<td>UA</td>
<td>+</td>
<td>For aged nanoceramic CAD/CAM restorations, Al₂O₃ blasting is recommended as a surface treatment method.</td>
</tr>
</tbody>
</table>
Conclusion
Repair Material
Nanofill RC
Adhesive
Hybrid ceramic CAD/CAM
Nanoceramic resin CAD/CAM, Hybrid ceramic
Polymer infiltrated ceramic, nanoceramic CAD/CAM, Tribochemical silica coating
Surface Treatments
Silane UA, TE
Adhesive UA, TE
In this aging procedure reduced the repair shear bond strength of hybrid ceramic and polycrystalline alumina ceramic. Conditioning with silica-based paper followed by the application of a universal adhesive system followed by air abrasion for nano ceramic CAD/CAM and arc ejection silanization recommended for hybrid ceramic glass ceramic CAD/CAM.

Table 2. Continued

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<tr>
<td>Arpa et al.</td>
<td>Micro-hybrid RC</td>
<td>Tribochemical silica coating</td>
<td>UA, TE</td>
<td>Grounding with silicon carbide paper followed by the application of a universal adhesive system followed by air abrasion with Al₂O₃ provided satisfactory repair bond strengths for each CAD/CAM ceramic tested.</td>
</tr>
<tr>
<td>Yaman BC.</td>
<td>Micro-hybrid RC</td>
<td>Tribochemical silica coating</td>
<td>UA, TE</td>
<td>Air abrasion with Al₂O₃ or tribochemical silica coating followed by UA application is recommended.</td>
</tr>
<tr>
<td>Rodrigues SA Jr, Ferracane JL, Della Bona A.</td>
<td>Nanofilled RC</td>
<td>HF, Tribochemical silica coating</td>
<td>UA</td>
<td>HF: Bur abrasion, Al₂O₃, Tribochemical silica coating</td>
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<td>Silva PNFD, Martinelli-Lobo CM, Bottino MA, Melo RM, Valandro LF.</td>
<td>Nanofilled RC</td>
<td>HF, Tribochemical silica coating</td>
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<td>Verissimo et al.</td>
<td>Nanofilled RC</td>
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<td>Blum IR, Özcan M.</td>
<td>Resin composite based, silorane-based adhesive, PO, NH2, aluminium oxide, M1, methacrylate-based resin composite, SIC, silorane-based resin composite, Si-etch, TE, total-etch, UK, universal adhesive, SBA, silorane-based adhesive, Ni, nickel, Cr, chromium.</td>
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| REFERENCES


ETHICS
Peer-review: Externally peer-reviewed.

Authorship Contributions

DISCLOSURES
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