INTRA-ORAL REPAIR OF CERAMIC CHIPPING USING RESIN COMPOSITE: DESCRIPTION OF A STEP-BY-STEP TECHNIQUE

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ABSTRACT

https://doi.org/10.25241/stomaeduj.2021.8(2).art.6

Aim This article aims to present and discuss an intra-oral repair technique for repairable ceramic fractures in tooth- or implant-supported fixed dental prostheses.
Summary In the intra-oral repair technique, after insulation with rubber-dam and proper cleaning, a bevel was prepared at the margins of the fractured area with a fine-grain diamond bur. Conditioning with 9.6% hydrofluoric acid was carried out for 120 s in the bevel and in the fractured area. On the clean and dry surface, the silane coupling agent was applied and allowed to react for one minute. Afterwards, the resin adhesive was rubbed on the surface, allowing the restoration of the area to repair with small increments of resin composite. The intra-oral repair was finished and polished with discs and rubber tips, and the occlusion was adjusted.
Key learning points 1. To execute a minimally invasive approach. 2. To repair the damaged ceramic area of a prosthesis restored in a single session. 3. To learn the meticulous order of surface conditioning, finishing and polishing protocols.

KEYWORDS

Adhesion; Ceramics; Chipping; Intra-Oral Repair; Resin Composite.

1. INTRODUCTION

Despite advances in digital laboratory strategies to manufacture tooth- and implant-supported fixed dental prostheses (FDP), obtaining personalized esthetic results, especially in anterior areas, still depends on traditional ceramic stratification techniques. In these techniques, feldspar porcelain is applied on the framework, layer by layer, using powders with different colors and opacities [1]. An excellent esthetic result is obtained in multi-layered prostheses; however, an interface is generated between the framework and the veneering ceramic, representing the most fragile link of this type of restorations [2]. Thus, chipping and fractures of the veneering ceramic are frequently observed in such FDPs [3]. This is due to the lower strength of porcelain compared to the material used in the framework (metal or zirconia); the presence of residual stress resulting from the incompatibility of the thermal expansion coefficients (CET) between the materials, and the tension resulting from the cooling that occurs after ceramic sintering [3,4].

Associated with this, laboratory factors, such as the irregular thickness of the veneering ceramic, inadequate infrastructure design, and the presence of defects and micro-porosities incorporated after stratification, further increase the risk of failure. Insufficient dental preparation, inadequate occlusal adjustment, lack of ceramic polishing after occlusal adjustment, stresses during chewing, trauma, or the presence of parafunctions also contribute to the formation of cracks and their propagation until fracture [5,6].
Clinical follow-up studies report that fractures of the veneering ceramic and the presence of dental caries are the most frequent failures in metal-ceramic FDPs [7]. The fracture of the veneering ceramic is also observed in prostheses with zirconia frameworks, with failure rates ranging between 6 to 15%, after 3 years [8]. These prostheses have a higher percentage of failures than traditional metal-ceramic FDPs, which present chipping or fracture rate of about 4% over a 10-year period of clinical follow-up [9].

Peer-Reviewed Article
Citation: Özcan M, Garbelotto LGD, Volpato CAM. Intra-oral repair of ceramic chipping using resin composite: a step-by-step technique. *Stoma Edu J.* 2021;8(2):126-131.
Received: May 16, 2021 **Revised:** June 08, 2021; **Accepted:** June 22, 2021; **Published:** June 24, 2021
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Regarding failures, different behaviors are also observed in implant-supported FDPs. In these prostheses, the masticatory load is about 8 to 10 times greater than in the teeth, due to the lack of proprioceptive receptors in the periodontal ligament [10]. The implant/prosthetic component has an elasticity module much higher than the natural tooth [11], which results in a higher concentration of stresses and an increase in failures. Fractures and chipping of the veneering ceramic were observed in about 12.4% of implant-supported FDPs, after 5.7 years [12].
Regardless of the prosthesis present in the oral cavity, fractures and chipping result in great discomfort for the patient, who seeks care to solve this problem and esthetic compromise, especially when the fracture occurs in the anterior area. The replacement of these restorations must be carefully evaluated by the clinician, since it involves additional costs, as well as increase in working time [5]. If the prosthesis has good marginal adaptation and adequate esthetic quality, the fractured area can be repaired without the need of removal, as long as the failure has not compromised the structural, functional and esthetic integrity of the prosthesis [13].

2. INTRA-ORAL REPAIR USING RESIN COMPOSITE

The technique of resin composite intra-oral repair is a minimally invasive approach that aims to restore the damaged area of a prosthesis, avoiding its removal and subsequent replacement [6]. If the clinician chooses to replace the prosthesis, she/he must consider that removing the prosthesis with burs can lead to greater wear of the dental tissue, in addition to being a more expensive and complex procedure. On the other hand, intra-oral repair is a quick and economical procedure, which can be done in a single clinical session, without the need for additional clinical steps or laboratory costs [14]. In this technique, the fractured area is restored with resin composite materials.
For the intra-oral repair to be successful, it is essential to confirm the clinical and radiographic quality of the prosthesis before the intervention along with assessing the type and size of the failure. A direct repair with resin composite can only be made if the prosthesis has good marginal adaptation and adequate esthetics [14]. The patient must be informed about the advantages and disadvantages of the intra-oral repair technique before the procedure.
The fracture that occurs in the veneering ceramic may or may not expose the framework. Thus, different materials may be present after the fracture, guiding the adhesive protocol that should be used during the repair technique (Table 1). Regarding the size, the failures can be small, moderate or large [15]. Minor failures, such as discreet chipping of the veneering ceramic, can be solved by finishing with discs and polishing with rubber tips. Intra-oral repairs made with resin composite resin can solve small and medium failures that present esthetic and functional implications. On the other hand, major failures, which involve areas of proximal and occlusal contacts, are usually resolved with indirect repairs made in the laboratory or by replacing the prosthesis [15].
The durability of intra-oral repairs made with resin composite depends of the factors such as the location of the failure, adhesive potential of the substrate, previous treatment of the surface to be repaired, quality of the adhesive protocol, and direction and magnitude of the forces applied in the resin composite repair [6]. In order to improve the adhesive potential of different ceramic substrates, surface treatments such as conditioning with hydrofluoric acid (HF), air-abrasion with aluminum oxide particles or tribo-chemical treatment followed by the application of a silane coupling agent can be used [16,17].

Table 1. Surface conditioning protocols for different substrates present in intra-oral fractured areas.

Substrate present after fracture	Adhesive protocol
Tooth (enamel or dentin)	Etch with 37% phosphoric acid (30 seconds for enamel and 15 seconds for dentin), rinse for the same time and dry with oil-free air, taking care not to dehydrate the dentin. Apply a coat of primer on the dentin with a disposable brush, followed by applying the adhesive resin to the enamel and dentin.
Metal	Air-abrasion using alumina particles coated with silica or silica only (particle size range: 30 to 50 microns, blasting pressure: 2.5 bar), for approximately five seconds in circling motion, and rotating the nozzle at a distance of approximately 10 mm. Apply a coat of primer and allow the solvent to volatilize for 1 minute. Then, apply adhesive resin agent and photo-polymerize for 20 seconds before starting the intraoral repair.
Feldspathic porcelain and glass-ceramics (leucite and lithium disilicate)	Clean the area with fluoride-free prophylaxy paste or pumice, followed by etching with hydro-fluoric acid 5 to 9.6% for 2 min (feldspathic porcelain), 1 min (leucite) or 20 s (lithium disilicate). Rinse for the same duration and dry with oil-free air. Apply one coat of the silane coupling agent and allow the solvent to volatilize for 1 minute. After, apply adhesive resin agent and photo-polymerize for 20 seconds before starting the intraoral repair.
Oxide ceramics (zirconia)	Air-abrasion using alumina particles coated with silica or silica only (particle size range: 30 to 50 microns, blasting pressure: 2.5 bar), for approximately five seconds in circling motion, and rotating the nozzle at a distance of approximately 10 mm. Apply a coat of primer and allow the solvent to volatilize for 1 minute. Then, apply adhesive resin agent and photo-polymerize for 20 seconds before starting the intraoral repair present after fracture.

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3. DESCRIPTION OF THE TECHNIQUE

The intra-oral repair technique is indicated for dental- and implant-supported fixed prostheses that have small to moderate failures. In addition, these prostheses should have good clinical and radiographic adaptation, in addition to an acceptable esthetic appearance [12,14]. The steps to make an intra-oral repair in resin composite are described below:

1. After identifying the need to make an intra-oral repair (Fig. 1), match the color of the resin composite that will be used during the clinical protocol (Fig. 2). A shade guide or a small increment of photo-polymerized resin composite over the area can be used for shade selection.
2. Insulation of the working site with rubber-dam to protect the soft tissue and adjacent teeth from the damaging effects of hydrofluoric acid (HF), and to keep the area dry during adhesive procedures, avoiding contamination with saliva.
3. Make a prophylaxis of the area to be repaired with brushes and prophylactic paste without fluoride to remove the contaminants present on the ceramic surface (Fig. 3).
4. Prepare a bevel in the remaining ceramic with a fine-grain diamond bur (Fig. 4). Use abundant irrigation to avoid heating of the ceramic, preventing the propagation of cracks. The bevel will allow a smoother transition between the ceramic and the resin composite, in addition to increasing the area available for adhesion of the material (Fig. 5).
5. The remaining ceramic surface that will not be repaired, must be protected by glycerine gel or a polyfluoroethylene tape. Air-abrasion of the area can also be made before acid conditioning, for 10 seconds, in order to obtain a more effective cleaning (Fig. 6).

If adhesion is made on feldspathic porcelain, 9.6% hydrofluoric acid should be applied to the bevel and fractured area for two minutes (Fig. 7). If the metal or ceramic infrastructure is exposed, it must be properly treated before conditioning the porcelain. In exposed metal frameworks, air-abrasion the surface with alumina particles coated with silica or silica only (particle size range: 30 to 50 microns, blasting pressure: 2.5 bar), for approximately five seconds in a circling motion, and rotating the nozzle at a distance of approximately 10 mm.

In zirconia infrastructures, air-abrasion or tribo-chemical treat-ment with silica deposition must also be made before the application of the silane coupling agent. The lithium disilicate infrastructures respond well to conditioning with hydrofluoric acid for 20 seconds, allowing the action of the silane agent and bonding with the adhesive resin.

6. After conditioning, wash the area with abundant water for three minutes. Neutralizing agents can be applied on the area for one minute to neutralize the action of the acid. The area is washed and dried again.
7. Apply silane coupling agent on the dried area with a clean disposable brush (Fig. 8). The silane is maintained for one minute and the solvent is removed with oil-free air.
8. Rub the adhesive resin over the area with a clean disposable brush for 20 seconds (Fig. 9). The adhesive resin excess is removed by aspiration and photo-polymerized for 20 s.
9. Afterwards, the intra-oral repair is performed with the resin composite previously selected, through small increments. Place each increment in the area with a spatula, placing them in position (Fig. 10). Each increment is photo-polymerized for 20 seconds (Fig. 11).

If the metal infrastructure is exposed, mask the metal with opaque resin before making the repair and photo-polymerize for 40 seconds from each direction.

10. The repair is finished with discs and polished with rubber tips and polishing paste (Figs. 12 and 13). Afterwards, check the patient's occlusion so that the repaired area is not overloaded during the function (Fig. 14).

Figure 1. Chipping of the veneering ceramic in ceramic implant-supported crown.

Figure 2. Color matching of resin composite with shade guide (VITA Classical, VITA Zahnfabrik, Germany).

Figure 3. Rubber-dam and cleaning of the area with prophylaxy paste.

Figure 4. Preparation of the bevel with a fine-grain diamond bur (KG Sorensen, FF Series, Brazil).

Figure 5. Completed bevel..

Figure 6. Air-abrasion with aluminum oxide particles for effective cleaning of the area. Before air-abrasion, the remaining ceramic was protected with glycerin gel and the adjacent teeth with protective tape.

Figure 7. Conditioning the fractured area and bevel with 9.6% hydrofluoric acid gel (Pulpdent, USA) for two minutes.

Figure 8. Application of the silane coupling agent (RelyX, 3M ESPE, USA) over the conditioned area with a clean disposable brush.

Figure 9. The adhesive resin bonding (Adper Scothbond Multi-Purpose, 3M ESPE, USA) is rubbed on the area with a clean disposable brush, and the excess adhesive is removed with disposable suction.

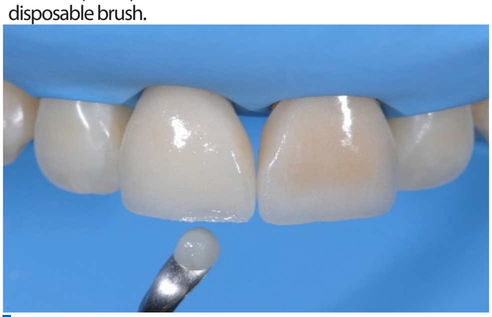

Figure 10. A small increment of resin composite (Filtek Z-350 XT, 3M ESPE, USA) is placed in the area.

Figure 11. Each increment is photo-polymerized for 20 seconds.

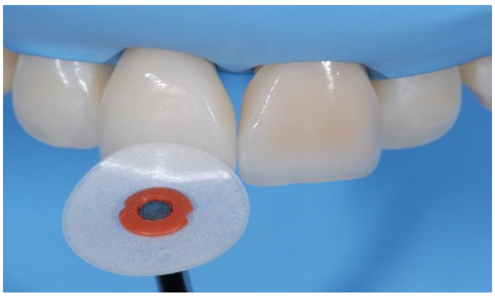

Figure 12. The intra-oral repair is finished with discs.

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Figure 13. The intra-oral repair is polished with rubber tips.

Figure 14. Final view of intra-orally repaired ceramic using resin composite.

4 . DISCUSSION

If intra-oral repair on a prosthesis is indicated upon fracture or chipping, the esthetic and functional problems caused by these failures can be more quickly resolved, without the need for removal and subsequent replacement of the prosthesis [12,14,15]. This procedure reduces the cost and time of treatment, and also provides immediate comfort to the patient, who has his problem solved in a single clinical session [14]. However, the success and longevity of resin composite intra-oral repair depends on compliance with the adhesive protocol, which will be defined according to the type of ceramic exposed after the failure [13,17,18].
In this technique, adhesion is essential to maintain the resin composite repair strongly attached to the damaged surface, without the need to create additional mechanical retentions on the ceramic surface, which would certainly result in increased failure and possible crack propagation.
The surfaces of ceramic materials currently available on the market exhibit different adhesive behavior based on their composition and crystalline structure [16-18]. Feldspathic porcelains and vitreous ceramics such as leucite and lithium disilicate are acid-sensitive ceramics, responding well to classic adhesive techniques that employ hydrofluoric acid and the application of the silane coupling agent. The more glass phase is present in the microstructure of these ceramics, the greater the surface roughness produced by acid conditioning, improving the bond to the resin adhesive [16]. The use of silane coupling agent allows the union of silicon dioxide (SiO_2) present in the ceramic surface with the resin adhesive [13]. These agents are inorganic-organic hybrid bifunctional molecules, capable of creating a siloxane network with the hydroxyl (OH) of the silica present on the ceramic surface, and copolymerizing with the adhesive agent, which will bond with the restorative material. However, the use of hydrofluoric acid must be performed carefully, as it can result in damage to soft tissues, like burns, due to their corrosive potential [14,15]. The severity of the burn is dependent upon the concentration of the acid and the duration of the exposure [19]. In this way, proper control of conditioning time, adequate absolute isolation, as well as a good suction system, should be used when employing the intra-oral repair technique.
In contrast, zirconia is an acid-resistant ceramic, which does not respond well to acid conditioning as it does not have silica in its microstructure. Additionally, zirconia is an inert substrate with low surface energy and wettability [17]. To obtain a strong and reliable adhesion to zirconia surfaces, it is essential to employ methods based on the use of air-borne particle abrasion with alumina particles or physicochemical methods use silica-coated alumina particles (tribochemical silica coating) followed by silanization. After the application of silane, the zirconia surface can be chemically activated by using functional-monomer containing adhesive promoters (such as 10-methacryloyloxydecyldihydrogenphosphate - MDP) [17,18].
Other precautions that must be taken during the intra-oral repair technique refer to the execution of a bevel on the margins of the fractured area; a refined finishing and polishing, and a careful occlusal adjustment [14]. A larger area of ceramic is exposed after making the bevel, with more silica particles, increasing the surface available for adhesion. In addition, especially in failures that occur in esthetic areas, a smoother transition between the two different materials (resin composite and ceramic) can be achieved. The finishing and polishing of the repair guarantees greater patient comfort, as well as reducing the possibility of future pigmentation, which would imply its replacement [14,15]. The occlusal adjustment after the intra-oral repair is decisive for its success, since often premature contacts and occlusal interference are responsible for the failure and, if they are not solved, the intra-oral repair will certainly fail.

5. CONCLUSIONS

- The intra-oral repair is a minimally invasive technique that increases the survival of prostheses that have suffered chipping of the veneering porcelain.
- Resin composite is the material of choice for this technique as it can be used for direct failure repair.
- The damaged ceramic area of a prosthesis can be restored in a single session, with an adequate aesthetic and functional solution.

- The prosthesis can be kept functional in the mouth, without the need for replacement and costly replacements.
- The meticulous execution of an adequate adhesive protocol will guarantee the success and longevity of the repair made.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGMENTS

None

AUTHOR'S CONTRIBUTION

MÖ: concept, design of the study and critical review, revising the article critically for important intellectual content, final approval of the version to be submitted.
LG: acquisition of data, drafting the article.
CV: acquisition of data, drafting the article, final approval of the version to be submitted.

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Questions

1. Intra-oral repairs with resin composite are indicated for:

❑a. Small to moderate failures in the veneering ceramic of bilayer prostheses;
❑b. Large failures in occlusal areas;
❑c. Large failures in proximal areas;
❑d. Failures that compromised the integrity of bilayer prostheses.

2. For the success of the intra-oral repair technique, it is important to consider:

❑a. The prosthesis must be removed to facilitate the adhesive protocol;
❑b. A chamfer should be performed on the margins of the fractured area;
❑c. The ceramic around the fractured area must be removed until the infrastructure is completely exposed;
❑d. A bevel should be made on the margins of the fractured area.

3. To make the intra-oral repair technique, it is important to use:

❑a. Relative insulation made with cotton rolls;
❑b. Clean and disposable brushes for applying silane agent silane and resin adhesive;
❑c. Coarse grain bur to prepare the fractured area;
❑d. Retraction cords for isolation.

4. The most suitable treatments for the exposed surface after the ceramic fracture are:

❑a. Conditioning with 9.6% hydrofluoric acid for metal surfaces;
❑b. Conditioning with 9.6% hydrofluoric acid for zirconia surfaces;
❑c. Conditioning with 9.6% hydrofluoric acid for feldspathic porcelain surfaces;
❑d. Tribo-chemical treatment for feldspathic porcelain surfaces.