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CASE REPORT

Replacement of Two Failed Indirect Restorations with Direct-Bonded Restorations Using a Minimally Invasive Strategy

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ABSTRACT

Deciding on what treatment (repair or replacement) to provide for a failed indirect restoration can be challenging. Notably, the strength of the residual tooth structure could be improved after replacing the failed indirect restoration using a minimally invasive strategy. **Objective:** To describe the use of a minimally invasive strategy for the successful clinical replacement of two failed indirect metal restorations with direct composite restorations and the attainment of bonded restoration. **Case Report:** Case 1. A 52-year-old male patient came to the dental hospital complaining of discomfort when drinking cold beverages and food impaction on the proximal area of the upper left first molar. Case 2. A 45-year-old female patient complained about her debonded metal onlay and secondary caries in the upper right second molar. Both of these indirect restoration failures were treated with direct resin composite restoration. Both patients were highly satisfied with the results. **Conclusion:** This report presents the benefits of adopting a minimally invasive strategy approach for replacing failed indirect restorations (inlays and onlays) with direct-bonded composite restorations. Minimally invasive direct restorations are designed to maximize the preservation of tooth structure, thereby ensuring a long-term bonded restoration and leaving future options open when a failure occurs.

Key words: replacement, failure, minimally invasive, fractured tooth, debonding

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INTRODUCTION

Minimally invasive dentistry has become more frequent in daily clinical practice as a consequence of shifting trends in caries management, adhesive systems, and restorative materials.[1] Clinical success when using a minimally invasive operative caries management strategy requires a thorough understanding of how to remove the infected dentin while leaving the affected dentin as a dental substrate for treatment, how to handle the adhesive materials used to restore the cavity, and what techniques to use for minimal caries excavation.[2]

The rationale for deciding whether to repair or replace an old restoration has been categorized into three aspects: 1) aesthetic, including staining, color matching, and translucency, which can be seen visually; 2) functional, including marginal adaptation, occlusal contour, approximal anatomical form, secondary caries, or significant gaps that need radiographic examination; and 3) biological, including tooth vitality, tooth integrity, periodontal response, and oral health.[3] The chance of finding hidden defects or caries increases in failed restorations and could prevent their repair;[4] however, replacing a failed restoration using minimally invasive strategy might be beneficial in these cases.

A minimally invasive strategy in restoration has well-documented benefits, including less loss of tooth structure compared to maximum intervention. This is because minimally invasive approaches can preserve both the affected and normal dentin, reduce insults to the dentin-pulp complex, and minimize the risk of iatrogenic damage to adjacent hard and soft tissues. A minimally invasive strategy improves the strength of the residual tooth structure by using optimal adhesive restorative materials designed to restore function and aesthetics with durable, long-lasting restorations that are easy for the patient to maintain.[5]

The aim of this case report was to describe two clinically successful replacements of two failed indirect metal restorations with direct composite restoration and the attainment of bonded restorations using a minimally invasive strategy.

CASE REPORT

Case 1: Use of a direct-bonded resin composite to replace a failed inlay that was causing tooth fracture
A 52-year-old male patient came to the Cariology and Operative Dentistry Department at Tokyo Medical and Dental University Hospital complaining of discomfort while drinking cold beverages and food impaction on the proximal area of the upper left first molar. A fracture on the distopalatal side of the tooth was found beyond the metal inlay restoration placed fifteen years previously. The patient was able to maintain good oral hygiene. Patient consent was obtained prior to the treatment, and dental impressions, dental radiography, and clinical photography were carried out.

An intra-oral examination showed that the tooth had a fracture on half of the distal wall extending to the palatal area (Figure 1A). Bitewing radiography confirmed both the tooth fracture and a deep caries lesion. However, it also revealed that the pulp and periapical tissue were in normal condition, although the interdental region indicated vertical alveolar bone loss (Figure 1B).

Prior to the restoration treatment, a silicon index was produced after applying blue resin to the fracture area, with the aim of restoring the normal anatomy of the upper left first molar (Figure 2). A rubber dam was then placed to make a proper isolation.

Soon after removal of the inlay metal restoration, the infected dentin was removed using a hand excavator under the guidance of caries dye (Caries Detector, Kuraray Noritake Dental Inc., Japan). The application of caries dye was repeated until no more red color was observed on the dentin, indicating that only the affected dentin remained (Figure 3).

The next step was to use an appropriate adhesive system. A two-step self-etch adhesive (Clearfil SE Bond 2, Kuraray Noritake Dental Inc., Tokyo, Japan) was used, along with an additional selective etch procedure (K-Etchant Syringe, Kuraray Noritake Dental Inc., Tokyo, Japan) (Figure 4).

Choosing the proper restorative material was addressed in this case based on the application of a minimally invasive strategy. Resin composites in a flowable (Clearfil Majesty ES Flow, shade A2, Kuraray Noritake

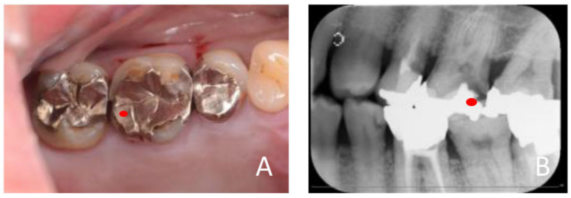

Figure 1. A. Pre-operative clinical photograph; B. Pre-operative bitewing radiograph of the upper left first molar (Red dot marks the failure area)

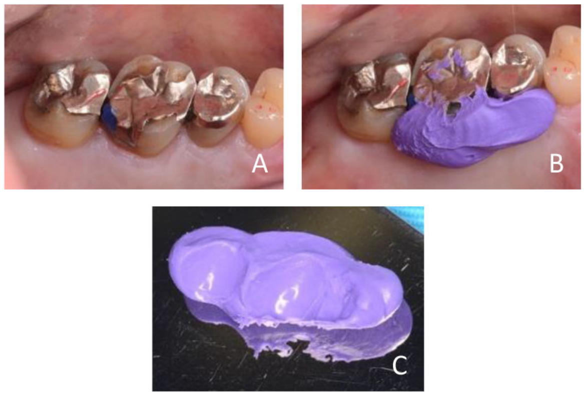

Figure 2. A. The application of blue resin; B. Placement of silicon material; C. A silicon index was produced

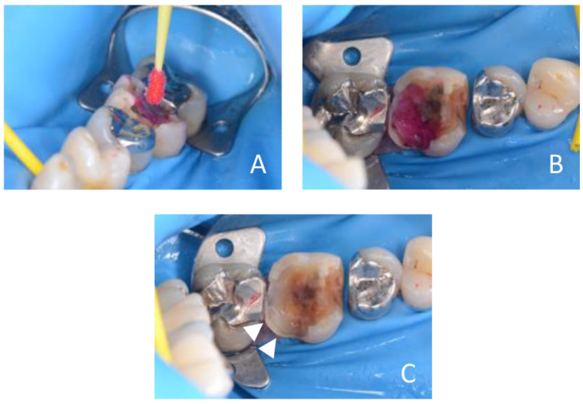

Figure 3. A. Caries dye was applied to the cavity; B. Red stain indicates infected dentin; C. Only the affected dentin was left; the white arrows showed sufficient caries-free enamel and dentin (peripheral seal zone)

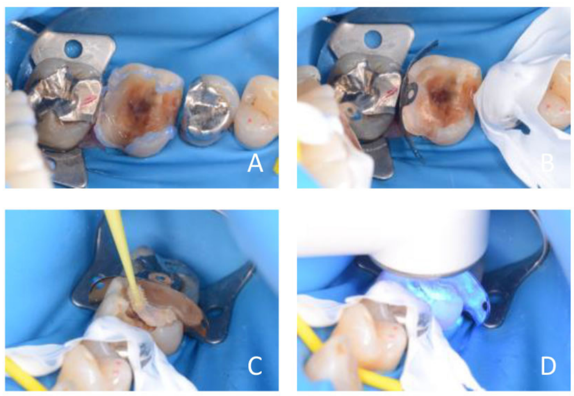

Figure 4. A. Selective etch on enamel; B. Placement of a metal matrix on the distal side and Teflon tape on the mesial side; C. Primer application to the entire cavity; D. Bond application, then light-curing for 10 s.

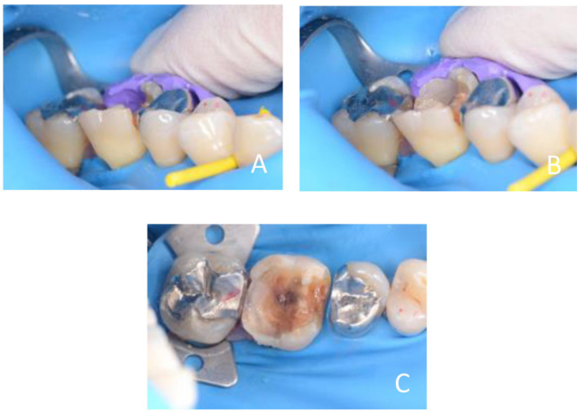

Figure 5. A. Placement of a silicon index to support the distopalatal wall restoration; B. Distopalatal wall restoration process; C. Results of rebuilding the distopalatal wall

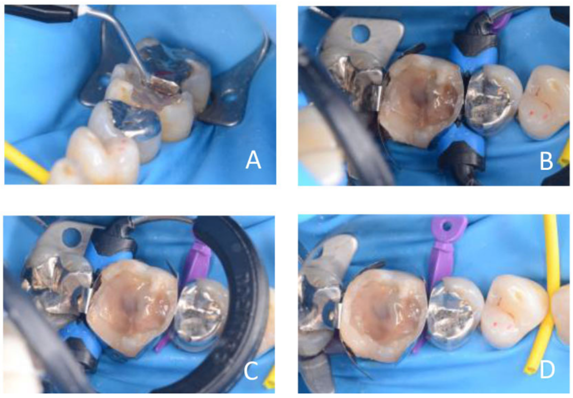

Figure 6. A. Application of flowable composite into the dentin cavity floor; B. Placement of sectional matrix on the mesial to support mesial wall restoration; C. Placement of sectional matrix on the distal to support distal wall restoration; D. Result of rebuilding the mesial and distal walls

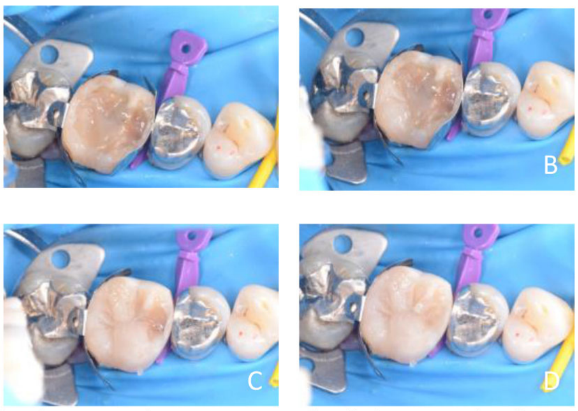

Figure 7. A. Application of resin composites to create a dentin layer on the distopalatal side of the cavity floor; B. Application of enamel layers to create a distopalatal cusp, and application of tint between the layers of enamel; C. The procedure was repeated to create mesio-palatal, distobuccal, and mesio-buccal cusps; D. Final results after restoration of all cusps and grooves

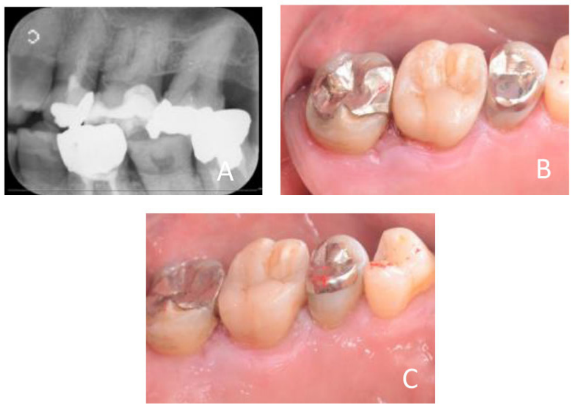

Figure 8. A. Bitewing radiograph (post-operative); B. Final restoration (occlusal view); C. Final restoration photograph (palatal view)

Dental Inc., Tokyo, Japan) and a packable (Clearfil AP-X, shade A2 and A4, Kuraray Noritake Dental Inc., Tokyo, Japan) form, together with a silicon index support, were used to restore the cavity (Figure 5). A sectional matrix was used during restoration of the mesial and distal walls (Figure 6).

A dentin layer was created by applying packable shade A4 composite to the dentin cavity floor on the distopalatal side. This was followed by building up enamel layers using the packable shade A2 composite applied to the dentin layer to restore the distobuccal cusp, with tint (color: ochre) applied between the layers of enamel. The same restoration procedure was repeated for the rest of the cusps, followed by finishing and polishing (Figure 7). The post-operative radiograph and clinical photographs are shown in Figure 8.

Case 2: Replacement of a debonded onlay with a direct-bonded resin composite

A 45-year-old female patient came to the Cariology and Operative Dentistry Department at Tokyo Medical and Dental University Hospital complaining about her debonded metal onlay and an accompanying secondary caries on the upper right second molar. Her metal onlay restoration had been placed 20 years previously.

An intra-oral examination showed the tooth had a cavity with onlay preparation (Figure 9A). A bitewing radiograph revealed a dentin caries lesion, with normal pulp and periapical tissue. However, the interdental region indicated vertical alveolar bone loss (Figure 9B).

The procedures used to replace the indirect onlay restoration with a direct-bonded resin composite restoration were the same as those described for case 1. During the restoration procedure, a rubber dam was used to isolate the teeth (Figure 10A). The final restoration is shown in Figures 10B and C. All the materials, their compositions, and the application methods used in both cases are presented in Table 1.

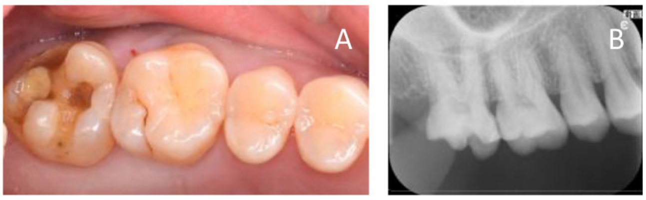

Figure 9. A. Pre-operative clinical photograph; B. Pre-operative dental radiograph of the upper right second molar

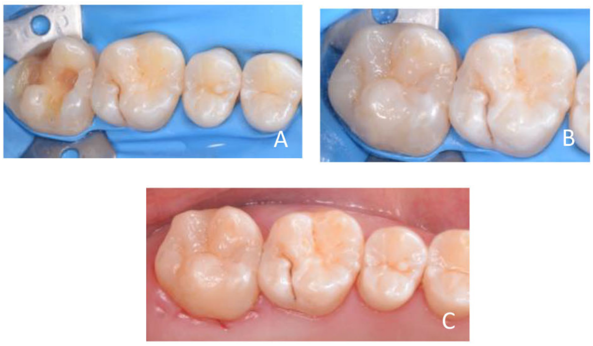

Figure 10. A. Rubber dam placement; B and C. Final restoration

Table 1. List of all materials, compositions, and the amplification methods that were used for the case management

No	Materials	Composition	Application Methods
		Materials, Composition, and Application Methods	
1	Caries Detector (Kuraray Noritake Dental Inc., Tokyo, Japan)	Propane-1,2-diol (propylene glycol) dyes	Place one drop of caries detector on a micro-brush, apply to the cavity, leave for 10 s, rinse with water, remove the infected dentin, which will be stained red. Repeat detection to ensure removal of infected dentin.
2	K-Etchant Syringe (Kuraray Noritake Dental Inc., Tokyo, Japan)	35% phosphoric acid, water, colloidal silica, pigment	Selective etch: Apply the etch on the enamel only and leave for 15 s, rinse with water, dry with mild air.
3	Clearfil SE Bond 2 (Kuraray Noritake Dental Inc., Tokyo, Japan)	Primer: 10-MDP, 2-HEMA, hydrophilic aliphatic dimethacrylate, dl-CQ, water pH = 2.5 Bond: 10-MDP, 2-HEMA, Bis-GMA, hydrophobic aliphatic dimethacrylate, dl-CQ, initiators, accelerators, silanated colloidal silica	Apply primer to entire cavity and leave for 20 s; dry with mild air. Apply bond to entire cavity, create a uniform bond film using a gentle air stream; light-cure for 10 s.
4	Clearfil AP-X (Shade: A2 and A4) (Kuraray Noritake Dental Inc., Tokyo, Japan)	Bis-GMA, TEGDMA, barium glass filler, silanated silica filler, silanated colloidal silica, CQ	Place resin composite into the cavity; light-cure for 20 s.
5	Clearfil Majesty ES Flow (Shade: A2) (Kuraray Noritake Dental Inc., Tokyo, Japan)	Barium glass filler, silica filler, TEGDMA, hydrophobic-aromatic dimethacrylate, dl-CQ, PI	Place the flowable resin composite into the cavity; light-cure for 20 s.
6	Estelite Color (Color: ochre) (Tokuyama Dental, Japan)	Silica-zirconia filler 58%w, silica-titania filler, TEGDMA, UDMA	Using a fine tipped instrument or fine tipped brush, apply the Estelite color sparingly (maximum thickness 0.5 mm) over the fossa; light-cure for 30 s.

10-MDP: 10-methacryloyloxydecyl dihydrogen phosphate; HEMA: 2-hydroxyethyl methacrylate; CQ: camphorquinone; BIS-GMA: 2,2-bis[4-(2-hydroxy-3-methacryloyloxypropoxy)phenyl]propane; TEGDMA: triethylene glycol dimethacrylate; PI: photo initiator; UDMA: 1,6-bis(methacrylethyloxycarbonylamino)trimethyl hexane.

DISCUSSION

Approximately 76.8% of inlays will last for 20 years, and more than 90% of onlays will last for 10 years.[6] However, the remainder are likely to undergo an earlier failure for many reasons. The failure of an indirect restoration is usually associated with extensive restoration that creates unsupported enamel cusps.[7] In the present case reports, the fractures were caused by large inlay restorations. The fractured cusps originated in the crown of the tooth and extended to the dentin, and the fracture terminated in the cervical region. According to the FDI World Dental Federation report in 2002/2008 and improved by Hickel et al. in 2010, the reasons for restoration replacement could be the loss of tooth integrity (enamel cracks and cusp/tooth fractures), debonding of the restoration, and poor marginal adaptation. The other key issues to consider in restoration replacement are patient discomfort associated with food impaction and sharp edges caused by the fracture of the restoration or the remaining tooth structure.[3]

A concomitant increase in cavity size is created by the clinician when restorations are removed, and this results in further weakening of the residual tooth structure. Prior to a restoration replacement, the causes of the lesion formation should be identified and biologically respectful interventions designed, focusing on preservation of the natural tooth structure to achieve longevity of the bonded restoration to the tooth.[5] Therefore, the current treatment plan was to replace indirect restorations with direct resin composite bonded restoration using a minimally invasive strategy. The use of only traditional visual and tactile techniques is no longer appropriate due to the inconsistency in determining the need for caries removal. In 1980, Takao Fusayama and his Tokyo Medical and Dental University team identified two layers in caries lesions. The first layer is the outer carious dentin/infected dentin, which is highly infected, acidic, and demineralized. The second layer is the inner carious dentin/affected dentin, which is only partially demineralized and slightly infected, but the collagen fibrils retain their natural structure around intact dentinal tubules. The difficulty in distinguishing between these two caries layers led Fusayama to search for a caries dye solution.[8,9] He found that a 0.5% basic fuchsin-propylene glycol solution would specifically and distinctly stain the superficial layer of carious dentin without any staining of the deep layer.[9] An expert working group subsequently agreed, by consensus, that removal of carious dentin was effectively indicated by the color after staining using a dye consisting of 1% acid red-propylene glycol.[10] Therefore, in this case report, a caries dye (Caries Detector, Kuraray Noritake Dental Inc., Japan) was used as a guide for removing the infected dentin with a hand excavator as a strategy for minimally invasive caries removal.

In the case of a caries depth of 3 to 4 mm on the occlusal surface (intermediate dentin), the caries removal end-points with light pink staining can be predictably achieved inside the peripheral seal zone by further excavation of the red outer carious dentin. The concept of a peripheral seal zone is that the enamel, the dentin–enamel junction, and the superficial dentin constitute a caries-free area for a highly bonded adhesive restoration. Caries removal end-points for the peripheral seal zone can be determined with a combination of caries-detecting dye and other caries diagnostic tools (e.g., fiber-optic light transmission). The final goal of achieving ideal caries removal end-points and peripheral seal zones is to create an adhesive bond that will be preserved for as long as possible.[8]

An excellent understanding of the adhesive systems is required for successful implementation of the minimally invasive strategy. The clinician must enhance the physico-chemical interaction of the dental substrate left at the cavity surface with the adhesive material to achieve successful long-term performance. Some two-step self-etch adhesives have a long track record, proven by randomized clinical trials, regarding their bonding effectiveness beyond ten years, and some, such as Clearfil SE Bond 2 (Kuraray Noritake, Noritake Dental Inc., Tokyo, Japan), have been on the market for more than 20 years.[11] Therefore, a two-step self-etch adhesive that contains the 10-methacryloyloxydecyl dihydrogen phosphate (MDP) monomer in both primer and bond was used for both cases described in the present report. One previous study performed to understand the adhesion mechanism of self-etch adhesives to the tooth structure through acidic monomers, such as MDP, reported that MDP yields a more chemically stable calcium salt than other monomers (e.g., 4-MET and phenyl-P) and bonds electrostatically to hydroxyapatite to improve the durability of the adhesive-dentin interface.[12,13]

In the present cases, optimal bonding was obtained between the adhesive system and the tooth substrates by applying a selective etch combined with a two-step self-etch adhesive system, as recommended by Van Meerbeek et al. in 2020.[11] The enamel was selectively etched with 35% phosphoric acid for 15 s and subsequently air dried until the etched enamel appeared frosted white. This was taken as a clinical sign that sufficient enamel etching was achieved. The aim of this procedure is to create wide etched pits between the enamel prisms that, upon resin infiltration, result in macro-resin tags. At the enamel-prism cores, individual hydroxyapatite crystals become thinned by (superficial) demineralization, creating narrow but deeply etched pits into which the resin is drawn by capillary action to form micro-resin tags. Upon polymerization, the resin is micro-mechanically interlocked, thereby producing the most durable bond to the tooth structure. For this reason, the enamel should always be preserved as much as possible when preparing the teeth.[11] Improvement in enamel bonding durability and formation of the acid–base resistant zone on the enamel are also promoted when using selective enamel etching with self-etch adhesive systems.[14]

Subsequent scrubbing techniques for managing two-step self-etch adhesive systems may improve the bond strength and sealing performance of direct-bonded composite restorations through the effective contact of the monomers with the tooth substrate, while also increasing the action to dissolve the smear layer and underlying dentin.[15] For these reasons, scrubbing techniques were used in both of the present case reports during application of the primer to the enamel and dentin. The other strategy adopted to create a bonded restoration was a double application of the hydrophobic layer of the adhesive system. The second layer served as a stress breaker/shock absorber to minimize polymerization shrinkage stress, thereby improving the bond durability.[16] The placement of the interproximal matrix either before or after the adhesive system application created disadvantages in the adhesive placement, as the adhesive materials could reach locations that could jeopardize comprehensive adhesive polymerization. Therefore, to improve the restoration longevity, all cervical margins of the bonded resin composite restorations should be carefully prepared to remove the adhesive-rich layer and to improve marginal adaptation, regardless of the clinical restorative protocol adopted.[17]

Excellent aesthetic results and improved bond strength were attained by building each cusp individually from the dentin cavity floor to the enamel on the occlusal level. Successive cusp building is one of the conventional incremental techniques used to reduce the amount of polymerization shrinkage.[18] By adopting a step-by-step procedure for tooth restoration using a minimally invasive strategy with proper adhesive materials, a direct-bonded composite restoration was achieved and may prove to have long-term durability.

CONCLUSION

This report has presented the benefits of adopting a minimally invasive approach for replacing failed indirect restorations (inlays and onlays) with direct-bonded composite restorations. The minimally invasive direct restorations are designed to maximize the preservation of tooth structure, thereby ensuring a long-term bonded restoration and leaving future options open when a failure occurs.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest related to this case report.

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