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# Effect of Air Abrasion on Delayed Dentin Sealing Post-operative Sensitivity for Indirect Resin Composite Restorations

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**Abstract**

**BACKGROUND:** There are several treatment options available to reduce the post-operative sensitivity (POS) of indirect resin composite restorations.

**AIM:** This study was to evaluate the effect of air abrasion on delayed dentin sealing POS for indirect resin composite restorations.

**MATERIALS AND METHODS:** Twenty-eight patients between the ages of 18 and 30 were enrolled and randomly assigned to one of two treatment groups, with 14 teeth (n = 14) in each group. Following the collection of baseline pre-operative data, the diagnosis of caries was made based on the clinical examination and radiographic examination, and all cavities were prepared. Group one (G1) prepared cavities were exposed to airborne particles before the selective etch technique was used without the use of cementation, and the selective etch technique was used. In the second group (G2), air abrasion during cementation. The visual analog scale was used to evaluate POS at baseline, 1 day after cavity preparation (T1), 1 week after indirect composite restoration cementation (T2), 3 months (T3), and 12 months (T4).

**STATISTICAL ANALYSIS USED:** The one-sample Kolmogorov–Smirnov test was used to assess the normality of distribution parameters first, and then, for non-parametric distributions, the Kruskal–Wallis test was used to assess the interaction between different variables. The Mann–Whitney U-test was then used to compare the two groups.

**RESULTS:** Despite air abrasion's effect, there was no statistically significant change in scores between the G1 and G2 groups. POS was highest at T1, then T2, T3, and T4. Statistically, these differences were significant ($p = 0.001$). No statistically significant differences ($p > 0.05$) were found between T2, T3, and T4 with or without air abrasion.

**CONCLUSION:** The delayed dentin sealing POS is unaffected by air abrasion during indirect resin restorations' cementation.

## Introduction

Indirect resin composite restorations have less polymerization shrinkage, better esthetic, physical, and mechanical properties [1], [2]. Indirect restorations can also be used to fix deep preparations where the gingival edges are in the dentin [3]. One of the most annoying problems that both patients and dentists must deal with is post-cementation hypersensitivity, which happens after indirect restorations are bonded in place. Short, sharp pain is a defining feature of dental hypersensitivity when thermal and chemical stimuli are present. Brannstrom's hydrodynamic theory is the main mechanism underlying dentinal hypersensitivity [4]. According to this theory, a stimulus like friction or cold applied to open dentinal tubules causes a fluid flow that may result in pain. Following the installation of a freshly cemented indirect restoration, post-cementation hypersensitivity happens. According to Rosenstiel and Rashid's survey, post-cementation hypersensitivity occurs about 10% of the time [5]. Post-operative hypersensitivity is influenced by a variety of factors. Pulpal harm can result from desiccation and overheating. Pulpal damage beneath restorations can also be brought on by the infiltration of bacteria that are left behind or that enter the dentin as a result of microleakage. Post-cementation hypersensitivity is affected by the degree of tooth reduction. According to studies, 5% of cavities with dentinal thickness remaining >1 mm and 60% of teeth prepared to within 0.5 mm of the pulp experienced severe pulpal reactions [6]. Various techniques can now be used to bond dentin. Etch-and-rinse adhesives traditionally condition with 30–40% phosphoric acid gel [7]. Air abrasion is an old technique that's recently gained popularity. This technique is similar to sandblasting, which has many common applications [8]. There are several different types of abrasive particles available for intraoral air abrasion, each with a different abrasiveness. The most common type of particle used to roughen and "cut" tooth structure is aluminium oxide (alumina). Other, less abrasive particles have been used to remove biofilm or stain from a tooth's surface before bonding [9]. The wettability of the adhesive systems is improved as a result of the air abrasion, which also produces a surface that is rough and irregular. Studies on the shear bond strength of enamel or dentin after air abrasion are contradictory. Some studies turned out well. With a total etch system, the bond between enamel and dentin became stronger after air abrasion with alumina at 25 microns and 120 psi [10]. The bond between the enamel and the self-etch system was made stronger by air abrasion with 27.5-micron alumina at 60 psi [11]. On the other hand, other studies have shown that air abrasion with 50-micron alumina decreased enamel adhesion but had no effect on dentin when using the etch-and-rinse system [12]. When phosphoric etching was used instead of air abrasion with alumina at 120 psi, the photos from a scanning electron microscope showed that the tooth structure was weaker after air abrasion, which could weaken the bond strength. There was less of a bond to enamel and dentin [13]. Furthermore, some studies found that alumina air abrasion did not change the strength of the bond between the resin composite and either enamel or dentin. Other studies have shown that air abrasion at 60 Psi with 50-micron alumina had no effect on the bond to dentin when using a self-etch system [14]. In the same way, it was said that air abrasion with 27- and 50-micron alumina at 120 psi did not affect the bond to enamel and dentin with an etch-and-rinse system. In addition, abrasion from the air is not always completely painless. Some people's teeth may become sensitive as a result of the air and the abrasives that are used [15]. However, other studies found that particles that are less abrasive and can occlude dentin tubules can effectively decrease sensitivity [16]. Since there is not enough information about the protocol and clinical effectiveness of the air abrasion procedure to reduce post-operative sensitivity (POS), more research is needed. This study looked at how air abrasion affects delayed dentin sealing POS for indirect resin composite restorations. The null hypothesis that was tested was that there is a difference in delayed dentin sealing POS between using air abrasion on prepared teeth during cementation of indirect resin composite restorations versus not using air abrasion.

## Materials and Methods

### Patients and study design

This study included 28 patients between the ages of 18 and 30. Patients were recruited from the Department of Operative Dentistry, Faculty of Dentistry, Suez Canal University's main clinic. The study was conducted after receiving approval from the faculty research ethics committee (approval number #250/2019). The study was conducted in accordance with the standard protocol items: Recommendations for interventional trials (SPIRIT) statement as a randomized, controlled clinical trial [17]. The SPIRIT 2013 statement provides recommendations for the minimum content of clinical trial protocols based on evidence. SPIRIT is widely accepted as an international standard for trial protocol development. Each participant was informed of the purpose of the study, agreed to take part, and signed a consent form. This study excluded patients with a history of hypersensitive teeth, xerostomia, pregnancy or breastfeeding, smoking habits, antibiotic therapy 1 month before sampling, systemic disease, or severe medical complications. Each patient in this study has an extensively taken class II radiograph that reaches more than half of the dentin of the lower permanent first molar, indicating that indirect restorations are indicated. Excluded were molars with spontaneous pain, periapical lesions, endodontic treatment, teeth affected by periodontal disease, and shallow or enamel caries. According to the type of surface treatment during cementation, teeth were divided into two groups. Group one (G1) dentin was exposed to airborne particles, and selective etching was performed. In the second group (G2), selective etching was employed during cementation without the use of air abrasion. To determine which patients would receive air abrasion and which would not, a random coin toss was used to assign patients (the king goes for Group 1 and the writer goes for Group 2). We ensured allocation secrecy using opaque, sequentially numbered envelopes with opaque seals. POS was evaluated using the visual analog scale (VAS) at baseline, 1 day after cavity preparation (T1), 1 week after indirect composite restoration cementation (T2), 3 months (T3), and 12 months (T4).

### Sample size calculation

The sample size: The Epicalc program version 1.02 is used to calculate a total of 18 in each group, assuming a power of 80% and an alpha of 0.05. The sample size is determined by the percentage decrease in mild hypersensitivity at 6 months, 12 months, and 24 months, which was 28%, 12%, and 12%, respectively, [18]. A total sample size of 28 samples would be used. Each group would be represented by 14 samples.

### Interventions

After a full examination and diagnosis of the patients with a diagnostic mirror and explorer, the case of an extensively cavitated lesion reaching more than half of the dentin thickness on periapical digital radiographic examination was added to the study. After the baseline information was collected, the participants were randomly assigned to one of two treatments, each of which involved 14 teeth (n = 14) (Table 1). It was not possible to blind the operator because the main operator had to do the intervention and control. However, the test for hypersensitivity was done by the colleague's assistant, who was blinded by the protocol for abrasion. A statistician also looked at the treatment results without knowing anything about them.

**Table 1: Variables of the study and levels of investigation**

| Variable | Symbol | Refers to |
|---|---|---|
| Surface treatment (G) | G1 | Surface treatment with air abrasion |
| | G2 | Surface treatment with no air abrasion |
| Testing time (T) | T1 | 1 day after cavity preparation |
| | T2 | 1 week post-cementation |
| | T3 | 3 months |
| | T4 | 12 months |

G1: Group one, G2: Second group.

### *The cavity preparation protocol*

The operation field was isolated with a rubber dam after the patient was anaesthetized. Under ×2.5 magnification, a rotary high-speed bur 330 was used to enter the lesion and extend laterally through the cavity. A spoon excavator was used to remove the softened dentin. The SIRO inspect (Dentsply Sirona) device was used to ensure that all caries in the cavity had been removed. It uses violet light to illuminate the tooth, causing both caries bacteria products and healthy dentin to fluoresce. Red-fluorescing decayed areas can thus be identified quickly and safely. Healthy tooth structure is distinguished in this regard by fluorescing green. The remaining walls of the prepared cavity had to be 1.5 mm thick for standardization, with the occlusal intercuspal distance measured with dental calipers ranging from 2.5 to 3 mm. The gingival floor of the cavity's proximal part is prepared to be continuous with the pulpal floor of the occlusal part, which is prepared to provide a depth range of 3–4 mm. Using blue-coded diamond-tapered round-end burs with diameter 16 and length 10, the angulation of the cavity walls was adjusted to be 6° diverging from the axial inclination (MIDWEST Dentsply). The prepared proximal box was one-third the distance between the buccal and lingual surfaces of the teeth, with the occlusal isthmus being 2–3 mm wide. Teeth were excluded from the study if they had pulp exposure or a prepared cavity that did not meet standardization requirements.

### *Final impression taking*

A two-step technique was used with addition polyvinyl siloxane as an impression material: Putty was used as a preliminary impression (Zhermack Elite HD + Germany) using a stainless steel dentulous full arch tray of the appropriate size based on the arch size, and then wash (Zhermack Elite HD+ Monophase Germany) was used to record fine details. Squash bite wax registration was used for bite registration (Cavex Holland BV). The impression was disinfected with Camcare health UK impression disinfectant spray, packed in a sealed pouch, and sent to the laboratory for the fabrication of the removable die, and the final composite restoration was made with 3M Filtek Z250 resin composite.

### *Temporization*

Following the placement of a small piece of cotton that served as a temporary filling material in the cavity, the cavity was then temporarily filled with Coltosol® F (Coltene, France), which is a temporary filling material that does not contain eugenol.

### *A try-in of the restoration*

The temporary restoration was removed during the try-in visit, and the restoration was tried in by inserting it inside the cavity to check the fitting, full seating, marginal integrity, occlusal pre-maturities, proximal contacts, and occlusal anatomy of the restoration. Any flaws that were discovered were corrected, and the try-in procedure was repeated until the restoration was satisfactory.

### *Final restoration cementation protocol*

The restoration's fitting surface was etched for 60 s with 37% phosphoric acid (Scotchbond TM Universal Etchant 3M), rinsed for 30 s, and air dried for 5 s. Curing time for air-thinned single-bond universal adhesive (3M ESPE, St Paul, and MN USA) was 10 s. In the case of delayed dentin sealing with air-abrasion surface treatment G1, the prepared cavity was exposed to airborne particles containing 29-micron aluminium oxide powder (Velopex International, UK). For 10 s, airborne particle abrasion was performed at a constant distance (1 cm) and angle (90°) from the treated surface. The "AquaCareTM Twin" air abrasion unit was used to abrade airborne particles under continuous water at 72.5 psi pressure (Velopex International, UK) [19], [20], the selective etch technique was used, in which 37% phosphoric acid was applied to the enamel for 15 s, rinsed for another 15 s, and dried for 5 s, and a single bond universal adhesive layer was applied to the dentin with rubbing action for 20 s, air thinned for 5 s, and cured for 20 s. In the case of delayed dentin sealing without air-abrasion surface treatment G2, the selective etch technique was applied to the prepared cavity as mentioned before without an air-abrasion surface treatment. RelyX Unicem clicker from 3M ESPE was used in accordance with instructions for cementing the restoration.

### ***Hypersensitivity assessment***

Sensitivity was measured using the VAS. It is a horizontal line with a descriptor on the far-left end indicating no pain and one on the far right end indicating the worst possible pain. Color-coded illustrations of facial expressions were added below the 10-cm line of the VAS [21]. One day after cavity preparation, the temporary restoration was removed, and the baseline was measured with a sterile metal triple-way syringe at a standard distance of 1 cm from the prepared cavity and an air pressure of 0.5 N/mm$^2$. The duration of the air blast, according to the patient's response, ranged from 1 to 5 s. The VAS scale was used to assess the participants' level of pain. Post-cementation hypersensitivity was assessed 1 week, 3 months, and 12 months after the indirect composite restoration was cemented using air from a triple-way syringe directed toward the margins of the restoration at the standard distance of 1 cm from the cavity margins, and the patient scored the pain level on the VAS scale.

#### *Statistical analysis*

Data wete collected, checked, edited, and organized in tables and figures using Microsoft Excel 2016. The data were checked for normality of distribution parameters using one-sample Kolmogorov–Smirnov; for non-parametric distributions, the Kruskal–Wallis test was used to test the interaction between different variables. After that, the Mann–Whitney test was used to compare the two groups.

## Results

#### *Effects of air abrasion*

There was no statistically significant difference in the scores between surface treatment with air abrasion (G1) (0.07) and surface treatment with no air abrasion (G2) (0.12) (p = 0.541).

#### *Effects of time*

POS had the highest significant mean value of VAS at T1, followed by T2, T3, and T4. Those differences were statistically highly significant (p = 0.001), while there were no statistically significant differences between T2, T3, and T4 (p > 0.05) either for surface treatment with or without air abrasion.

#### *Effect of air abrasion in each interval*

There was no statistically significant difference; between surface treatments with air abrasion (G1) and no air abrasion (G2) at each time interval at T2, T3, and T4 (Table 2).

**Table 2: Descriptive statistics for visual analog scale (VAS) for different methods of surface treatment and follow-up intervals before and after aging**

| Time | Surface treatment with air abrasion (G1) | | | | Surface treatment with no air abrasion (G2) | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean | SD | Median | Range | Mean | SD | Median | Range |
| T1$^{a}$ | 6.07 | 0.83 | 6 | 5–7 | 5.93 | 0.83 | 6 | 5–7 |
| T2$^{b, c, d}$ | 0.21 | 0.43 | 0 | 0–1 | 0.36 | 0.50 | 0 | 0–1 |
| T3$^{b, c, d}$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| T4$^{b, c, d}$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Kruskal–Wallis | 47.9 | | | | 46.4 | | | |
| p-value | <0.001** HS | | | | <0.001** HS | | | |

Kruskal–Wallis, different superscript letters indicate a statistically significant difference within the same column, while same letters indicate not statistically significant. **HS, (p>0.01), NS: not significant (p>0.05).

## Discussion

For the time being, the main concern for direct posterior composites is the invention of conservative and minimally invasive restorative techniques, but indirect composite restorations for posterior teeth are not [22], [23]. Indirect composites are recommended for heavily decayed teeth that need large restorations because their fabrication process reproduces anatomic form and proximal contact and limits polymerization shrinkage to the thin layer of luting cement used for cementation [24]. Indirect resin composite restorations absorb compressive forces and reduce masticatory force transfer by 57% compared to porcelain. Indirect resin composites could withstand occlusal loading [25]. Due to their similar composition to luting cement, resin composites have a lower tendency for marginal chipping and better marginal adaptation than ceramics, so they were chosen as the indirect laboratory-fabricated material for this study [26].

In terms of hypersensitivity to indirect and direct composite restorations, the results were better for direct composite restorations than for indirect inlays [27]. After 5–11 years, there is not much difference between the two methods, but the direct composite showed less hypersensitivity [28]. This study was done to find a solution to the problems listed above. The goal was to reduce the risk of post-operative hypersensitivity of indirect resin composite restorations.

Hannig and Femerling discovered that combining air abrasion and adhesive systems resulted in gap-free adaptation between composites and dentin in the majority of cases when evaluating different composite resins [29]. Airborne-particle air abrasion has been shown to increase the shear bond strength of composite to enamel and dentin [10]. Air abrasion and acid etching increase the tensile bond strength of composite materials to enamel [30]. However, without acid etching, air abrasion alone does not increase bond strength [31]. To solve the problem of POS following composite restorations, a combination of air abrasion and selective acid etching was used.

Early clinical studies found that up to 30% of patients who had posterior resin composite restorations experienced POS, mostly due to the etch-and-rinse adhesive system [32]. Etch-and-rinse systems remove the smear layer by etching enamel and dentin and rinsing with water. The demineralized dentin collapses during air-drying, preventing resin from diffusing into collagen fiber spaces and sealing dentin tubules [33]. Denuded collagen fibrils and voids in the hybridized area cause dentin fluid to move under occlusal stress, extreme temperatures, and sweet stimuli. Self-etch adhesive systems incorporate the smear layer into the hybridized area, reducing POS. Dentin tubules are more likely to seal when resin infiltration and conditioning occur simultaneously [34]. Only the one-step and two-step self-etch bonding agents sealed dentin better than etch and rinse [35]. The selective etch technique with a self-etch adhesive "single-bond universal" system was used in the present study to eliminate adhesive strategy variability and simplify bonding procedures. Indirect composites do not need silane coupling agent like ceramics, but the single bond universal in this study already has it. Silane coupling agents, adhesion promoters with two reactive functional groups, can react with various inorganic and organic materials to bond dissimilar materials. In this study, the silane-containing adhesive was advantageous.

When investigating post-operative hypersensitivity, the cavity preparation design, particularly the depth of the preparation, is critical. The variation in cavity depth can have an impact on the hypersensitivity assessment. The number of dentinal tubules per unit area and radius of the tubules increase from the dentinoenamel junction to the pulp, resulting in a 20-fold increase in water content or wetness of the dentin in patent tubules from superficial to deep dentin. As a result, when the deeper dentin is exposed to the oral environment, it has larger dentinal tubules that are closer together than the original surface dentin structure of the tooth. This results in rapid fluid flow and sensitivity through tubular orifices. Clinically, however, the opposite appears to be true with small, newly exposed dentin lesions [36]. As a result, the cavity depth provided in this study comprises more than half of the dentin depth. Although the best standard cavity preparations were used, the study was conducted *in vitro*, which is simpler. Since *in vivo* studies on indirect restorations have never done, so the present study had to standardize cavity dimensions, which was difficult. Because this technique is simple, relatively clean, and quick, cavity preparation for both groups was done using a traditional high speed rotary instrument in this study [37]. Air abrasion preparations have been observed to lack precise and easily identifiable outlines [38]. Thus, the present study attempted to combine the benefits of both high-speed cutting and air abrasion.

It is preferable to use non-eugenol materials as temporary filling because eugenol-based materials may inhibit polymerization of the resin cement. As a result, in this study, Coltosol F Eugenol-free temporary filling was used with the assistance of very small cotton in the cavity's base for ease of removal [39].

According to Baiping *et al*. study, enamel surfaces that have been air-abraded with 50-micron particles are more favorable to the application of composite resin than enamel surfaces that have been air-abraded with 27-micron aluminium oxide particles. However, despite the effects of abrasive particle size, numerous studies found no difference in microleakage or bond strength [40]. In this study, 29-micron aluminium oxide powder was used.

By introducing an evaluation period factor into the study design, one could assess the durability and effectiveness of the investigated materials over time. Most studies that tested a strategy to reduce POS lacked an adequate evaluation period to determine its efficacy. A low-shrinkage composite was tested to reduce POS after 7 days [41]. Another study compared self-etch adhesive to etch and rinse adhesive in reducing POS for up to 2 weeks. Another study examined POS in self-etch adhesive and nano-filled composites for 1 month [42]. A 24-month study examined the effects of immediate dentin sealing on post-cementation hypersensitivity prevention [18]. Like previous studies, the present study assessed POS 1 day after cavity preparation (baseline) and up to 12 months.

There was no discernible difference between the groups 1 week, 3 months, and a year after cementation whether or not the surfaces had been treated with air abrasion. This could be because the dentin was previously sealed with a self-etch adhesive ("single bond universal") and a self-adhesive resin cement ("Relyx unicem clicker"), the margins of the indirect composite restorations fit correctly in both sealing protocols, and there were no open margins to allow leakage. When comparing the follow-up intervals, the results obtained at baseline are highly significant. This could be attributed to the delayed dentin sealing's lack of patent tubules sealing.

## Conclusion

Under the limitations of the present study, air abrasion during cementation of indirect resin restorations does not affect POS.

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