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

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Abstract

BACKGROUND: Various treatment modalities are available to decrease the post-operative sensitivity of indirect resin composite restorations.

AIM: The aim of the study was to compare the effectiveness of immediate dentin sealing using universal adhesive and air abrasion versus immediate dentin sealing without air abrasion on post-operative sensitivity in teeth prepared for indirect resin composite restorations.

MATERIALS AND METHODS: Twenty-eight patients between 18 and 30 years of age were recruited and randomized to two treatment protocols with fourteen teeth (n = 14) included in each protocol. After baseline pre-operative data collection, the diagnosis of caries was made depending on the clinical examination and radiographic examination. After cavity preparation was done, all cavities in each protocol were managed with immediate dentin sealing, and the single-bond universal adhesive was applied over all the dentinal surfaces according to the manufacturer's instructions. Protocol One (P_1) air abrasion was used for immediate dentin sealing before cementation. In the second protocol (P_2), the dentin was sealed without the use of air abrasion. Post-operative sensitivity (POS) was evaluated using the visual analog scale at baseline, 1 day after the cavity preparation (T_1), 1-week post-cementation of the indirect composite restoration (T_2), after 3 months (T_3), and after 12 months (T_4).

STATISTICAL ANALYSIS USED: The normality of distribution parameters was evaluated by one-sample Kolmogorov–Smirnov first, and then, for nonparametric distribution, the Kruskal–Wallis Test was used to test the interaction between different variables, followed by the Mann–Whitney U test to compare the two groups.

RESULTS: Despite air abrasion's effect, there was no statistically significant change in scores between the P_1 and P_2 groups. Post-operative sensitivity was highest at T_1, then T_2, T_3, and T_4. Statistically, these differences were significant ($p = 0.001$). No statistically significant differences ($p > 0.05$) were found between T_2, T_3, and T_4 with or without air abrasion.

CONCLUSION: Air abrasion during cementation of indirect resin restorations does not affect post-operative sensitivity after immediate dentin sealing. Air abrasion applied to immediate dentin sealing can be used safely without affecting post-operative sensitivity.

Introduction

Indirect resin composite restorations offer decreased polymerization shrinkage, improved aesthetic, physical, and mechanical properties through post-curing with light or heat, ideal occlusal morphology, interproximal contacts, and wear compatibility with opposing teeth [1], [2]. Deep preparations with gingival margins located in dentin can also be restored using indirect restorations [3]. To complete indirect restorations, a provisional phase is required. A delayed dentin sealing procedure is traditionally carried out for indirect restorations. This involves the dentin being sealed during the cementation appointment, which takes place after the provisional phase. Because of the contamination of the tooth surface by bacteria, impression material, and even provisional cement, this method is unfortunately unable to provide optimal conditions for bonding procedures [4], [5].

Inlays, onlays, and laminate veneers are used as minimally invasive restorations. However, no matter how much tooth substance is removed, dentin tubule exposure is unavoidable [6]. Because provisional cementation materials provide insufficient sealing, exposed dentin is subjected to bacterial microleakage as well as chemical and mechanical stimuli transmitted during impression-taking, rinsing, drying, function, and removal of provisional materials [7]. In addition, post-cementation hypersensitivity occurs after the placement of a newly cemented restoration. Post-cementation hypersensitivity is a symptom characterized by a brief, sharp pain when thermal and chemical stimuli are applied to vital teeth following a newly cemented indirect restoration [8]. Post-cementation hypersensitivity affects about 10% of patients [9]. To overcome the previous issues and prevent potential pulp damage, the immediate application of a dentin-bonding agent after tooth preparation and before impression-taking was introduced in the early 1990 s by Pashley *et al*. [10] This method, which is also referred to as prehybridization, dual bonding technique, and resin coating technique, was established with the term "immediate dentin sealing." [11] In conventional procedures, sealing of the dentin tubules takes place at the bonding stage of the final restoration, delaying dentin sealing [12]. Thus, during temporization, exposed dentin leaves a potential pathway for bacterial infiltration. Conversely, in the immediate dentin sealing technique, dentin adhesives are applied before the provisional phase, which presents benefits regarding bacterial microleakage, dentin hypersensitivity, gap formation, and bond strength [13].

For optimal bonding, a contaminant-free substrate is required. As a result, selecting the most appropriate conditioning method is critical. Magne *et al*. used airborne particle abrasion with aluminum oxide, whereas Dillenburg *et al*. found that additional phosphoric acid etching improved the condition of sealed dentin [13], [14]. Because the final strength of the tooth-restoration complex is highly dependent on adhesive procedures, further advancements in dentin bonding are desirable [15]. A rougher dental surface, as a physical phenomenon, may increase the adhesion of a restoration by creating a more extended tooth-adhesive interface [16]. Tooth surface sandblasting is regarded as a simple method of increasing surface roughness [17], [18]. Black described intraoral sandblasting with alumina particles for the first time in 1945 [19]. It was initially reported that the bond strength to the tooth surface improved, a finding that has since been confirmed by new research, and some authors have adopted its use in clinical procedures even after preparing the cavity with rotating instruments [18], [20], [21], [22], [23]. As a result, tooth sandblasting was introduced as a method of cavity preparation in restorative dentistry and was termed "air abrasion." [24].

There is currently insufficient literature on the protocol and clinical effectiveness of the immediate dentin sealing procedure to reduce hypersensitivity; thus, additional research is required [25]. The effect of immediate dentin sealing with and without air abrasion on post-operative sensitivity for indirect composite restoration was investigated in this study. The null hypothesis was tested to see if there was a difference in post-cementation hypersensitivity between immediate dentin sealing with air abrasion and immediate dentin sealing without air abrasion in teeth prepared for indirect resin composite restorations.

Materials and Methods

Patients and study design

This study included 28 patients, ranging in age from 18 to 30 years. Patients were recruited from the main clinic of the Department of Operative Dentistry, Faculty of Dentistry, Suez Canal University. The study was carried out after the faculty Research Ethics Committee approved it (approval number #250/2019). The study was carried out as a randomized, controlled clinical trial in accordance with the Standard Protocol Items: Recommendations for Interventional Trials (SPIRIT) Statement [26]. The SPIRIT 2013 Statement provides evidence-based recommendations for clinical trial protocol minimum content. SPIRIT has received widespread acceptance as an international standard for trial protocols. Each patient was informed about the study's purpose, agreed to participate, and signed a consent form. Patients with a history of hypersensitive teeth, xerostomia, pregnancy, or breastfeeding, smoking habits, who received antibiotic therapy for 1 month before sampling, or systemic disease or severe medical complications were excluded from this study. On visual and radiographic examination, each patient in this study has a lower permanent first molar that is extensively Class II (reaching >1/2 of the dentin), indicating that indirect restorations are indicated. Excluded were molars with spontaneous pain, periapical lesions, endodontic treatment, periodontally affected, and shallow or enamel caries. After cavity preparation was done in all 28 molars, all cavities in each protocol were managed with immediate dentin sealing, and the single-bond universal adhesive was applied over all the dentinal surfaces according to the manufacturer's instructions. Protocol One (P_1) air abrasion was used for immediate dentin sealing before cementation. In the second protocol (P_2), the dentin was sealed without the use of air abrasion. To determine which patients would receive air abrasion and which would not, patients were randomly assigned using coin tossing (the king goes for Group 1 and the writer goes for Group 2). We ensured allocation concealment using sequentially numbered opaque sealed envelopes. Sensitivity testing was performed on each patient 1 day after cavity preparation, 1 week after cementation, 3 months, and 12 months.

Sample size calculation

The sample size was calculated using the Epicalc program version 1.02, with an assumed power of 80% and alpha of 0.05. It was discovered that a sample size of 18 was sufficient to detect the effect size. The sample size is determined by the percentage decrease in mild hypersensitivity at 6 months, 12 months, and 24 months, which were (16%), (8%), and (8%), respectively [27]. A total sample size of 28 samples would be used. Each group would be represented by 14 samples.

Interventions

After the patients were subjected to a full examination and diagnosis using a diagnostic mirror and explorer pre-operative radiographic examination, the case of an extensively cavitated lesion (reaching >1/2 of the dentin thickness on periapical digital radiographic examination) was enrolled in the study. Following the collection of baseline records, participants were randomly assigned to one of two treatment procedures, each consisting of fourteen teeth (n = 14) (Table 1). Blinding the operator was not possible because the main operator was responsible for applying the intervention and control. However, the hypersensitivity test was done by the assistant colleague, who was blinded by the sealing protocol. In addition, the treatment results were assessed blindly by a statistician.

Table 1: Variables of the study and levels of investigation

Variable	Symbol	Refers to
Surface treatment (A)	P_1	Surface treatment
	P_2	No surface treatment
Testing time (T)	T_1	1 day after cavity preparation
	T_2	1 week post-cementation
	T_3	3 months
	T_4	12 months

The cavity preparation protocol

After anaesthetizing the patient, the operation field was isolated with a rubber dam. Under magnification using loupes ×2.5, entrance to the lesion and lateral extension through the cavity were done using a rotary high-speed bur 330. The softened dentin was removed using a spoon excavator. To make sure that all caries in the cavity had been removed, the SIRO inspect (Dentsply Sirona) device was used. It illuminates the tooth with violet light, which stimulates both the products of caries bacteria as well as healthy dentin to fluoresce. In this way, red-fluorescing cancerous areas can be recognized both quickly and safely. Healthy tooth structure differs in this respect by fluorescing green. For standardization, the thickness of the remaining walls of the prepared cavity had to be 1.5 mm, with the occlusal inter-cuspal distance ranging from 2.5 to 3 mm, measured by dental calipers. The gingival floor of the proximal part of the cavity is prepared to be continuous with the pulpal floor of the occlusal part, which has the same depth and is prepared to provide a depth range of 3–4 mm. The angulation of the cavity walls was adjusted to be 6° diverging from the axial inclination using blue-coded diamond-tapered round-end burs with diameter 16 and length 10 (MIDWEST Dentsply). The proximal box prepared corresponded to one-third the distance between the buccal and lingual surfaces of the teeth, with the width of the occlusal isthmus being 2–3 mm. In cases where a pulp exposure or prepared cavity did not meet standardization criteria, teeth were excluded from the study.

The immediate dentin sealing protocol

All cavities were managed with immediate dentin sealing; after proper air drying for 5 s, the single-bond universal adhesive (3M ESPE, St Paul, MN USA) was applied over all the dentinal surfaces according to the manufacturer's instructions. A single coat of the adhesive was applied and rubbed for 20 s, then blown with a gentle air blow for 5 s to evaporate the solvent, and then light cured for 10 s using LED curing light (Elipar S10, 3M ESPE) at a light intensity of 1200 mw/cm^2. To prevent the formation of an oxygen inhibition layer, a layer of glycerin was applied and cured for another 10 s before being removed with copious irrigation [28], [29]. A proper evaluation of the cavity was done regarding the sharp margins, absence of undercuts, and absence of contact between the cavity and the adjacent teeth. The impression was then taken with addition polyvinylsiloxane as an impression material, and the bite registration was done with squash bite wax registration. Finally, a small piece of cotton is placed in the cavity, followed by an eugenol-free temporary filling.

Final restoration cementation protocol

The temporary restoration was removed with a spoon excavator, the cavity was checked for residual temporary filling, and the restoration was inserted to check fit, insertion, and proximal contacts. The restoration was then etched with 37% phosphoric acid for 60 s (Scotchbond TM Universal Etchant 3M), rinsed for 30 s, and air dried for 5 s. Air-thinned single-bond universal adhesive was cured for 10 s.

In the immediate dentin sealing with surface air abrasion group, the resin coat was abraded with 29-micron aluminum oxide powder (Velopex International, UK). Airborne-particle abrasion was performed for 10 s at a consistent distance (1 cm) and angle (90°) from the treated surface. Airborne particle abrasion was done under continuous water at 5 bar pressure using the "AquaCare™ Twin" air abrasion unit (Velopex International, UK) [14], [30]. 15 s of 37% phosphoric acid were applied, rinsed, and dried [14], [31]. Single-bond universal adhesive was rubbed on for 20 s, air-thinned for 5 s, and cured for 20 s. In the immediate dentin sealing group with no surface air abrasion, 37% phosphoric acid was used to etch the enamel margin and sealed dentin for 15 s, then rinsed and air dried for 5 s. Single-bond universal adhesive was rubbed on for 20 s, air-thinned for 5 s, and cured for 20 s. For restoration cementation, 3M ESPE's RelyX Unicem clicker was used per instructions.

Hypersensitivity assessment

The visual analog scale (VAS) was used to assess sensitivity (VAS). It is a horizontal line with a descriptor at the far-left end indicating no pain and a descriptor at the far-right end indicating the worst possible pain. Below the 10-cm line of the VAS, color-coded illustrations of facial expressions were added [32]. The temporary restoration was removed 24 h after cavity preparation, and the baseline was assessed using 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. According to the patient's response, the duration of the air blast ranged from 1 s to 5 s. The VAS scale was used to rate the pain level of the participants. One week after cementation, 3 months, and 12 months after the indirect composite restoration, post-cementation hypersensitivity was assessed using air from the triple-way syringe directed towards 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

Using Microsoft Excel 2016, data were collected, checked, edited, and organized in tables and figures. Data were checked for normality of distribution parameters, which was evaluated by one-sample Kolmogorov–Smirnov first; then, for nonparametric distribution, the Kruskal–Wallis Test was used to test the interaction between different variables. The Mann–Whitney test was then used to compare the two groups.

Results

Effects of surface treatment

There was no statistically significant difference in the scores between the application of air abrasion (P_1) and no application of air abrasion groups (P_2) ($p = 1.0$).

Effects of time

Post-operative sensitivity had the highest significant mean value of VAS at T_1, followed by T_2, T_3, and T_4. Those differences were statistically highly significant ($p = 0.001$). While there were no statistically significant differences between T_2, T_3, and T_4 ($p > 0.05$) either for the surface treatment or no surface treatment groups.

Effect of surface treatment in each interval

There was no statistically significant difference; between surface treatments (P_1) and no surface treatments (P_2) at each time interval at T_2, T_3 and T_4 (Table 2).

Discussion

It is generally agreed on that post-cementation hypersensitivity, which is accompanied by newly cemented indirect restorations, is one of the most irritating complications that patients and dentists alike must deal with. Post-cementation hypersensitivity is a condition in which the vital abutment tooth hurts sharply and briefly when it is exposed to heat or chemicals [8]. About 10% of people become hypersensitive after cementing. Most of the time, this kind of hypersensitivity goes away on its own. However, it can also last for a long time, which is why many dentists are interested in it [9]. Other main causes of post-cementation hypersensitivity are overheating during cavity preparation, the amount of tooth reduction and how close it is to the pulp, microleakage, and bacterial infiltration, all of which have a direct effect on the sensitivity [27]. Researchers should find ways to reduce it as much as possible.

Researchers were able to find ways to stop dentin hypersensitivity by figuring out how it happened. Dentin desensitizers such as GLUMA Desensitizer, antimicrobial solutions before cementation, and dentin bonding agents that help block the dentinal tubules are all ways to try to reduce dentinal sensitivity and treat dentinal hypersensitivity [33]. But in reality, dentinal hypersensitivity does not just happen after cementation. It also happens right after the local anesthetic wears off during the temporization period. This is because the temporary filling cannot completely seal the exposed dentin, which lets bacteria get in and causes dentinal hypersensitivity. The “hybrid layer” is made when monomers mix together in hard tissues [34]. Once the infiltrating resin is polymerized, a “structural” bond forms that is like the interphase that forms at the dentin-enamel junction [35]. During dentin-resin hybridization, the most important things to think about are how the dentin can contaminate the resin and how easy it is for the hybrid layer to break down before it hardens. Based on these factors and the way indirect bonded restorations work, the dentin should be sealed right after the tooth is prepared. Immediate dentin sealing is a new approach that has been developed. It is considered a new technique that is added to the steps of indirect restorations just after cavity preparation and before impression taking. This is done to properly seal the dentinal surfaces, which, in turn, reduces bacterial infiltration and post-operative hypersensitivity during the temporization stage as well as during the post-cementation period [13].

Sealing the freshly cut dentin surface can be done by different techniques; immediate dentin sealing using 3-step etch and rinse adhesives and 2-step self-etch adhesives have been proposed and tested, showing significant aid in immediate bond strength [36], [37], [38]. Early clinical studies found that up to 30% of patients with posterior resin composite restorations experienced post-operative sensitivity, mostly due to etch-and-rinse adhesive systems [39]. Etch-and-rinse systems remove the smear layer by etching enamel and dentin and rinsing. The demineralized dentin collapses during air-drying, limiting resin diffusion into collagen fiber spaces and leaving dentin tubules incompletely resin sealed [40]. Thus, dentin fluid moves under occlusal stress, extreme temperatures, and sweet stimuli due to hybridized area voids and denuded collagen fibrils. This sensitizes dentinal tubule nerve endings, causing post-operative sensitivity. Self-etch adhesive systems incorporate the smear layer into the hybridized area, reducing post-operative sensitivity. Dentin tubules are more likely to seal when resin infiltration and conditioning occur simultaneously [41]. A three-step etch-and rinse bonding agent used for immediate dentine sealing had 5 times the mean Micro Tensile Bond Strength of the delayed dentine sealing group [13]. While total-etch and self-etch dentin bonding agents had high bond strengths after immediate dentin sealing [3]. A potential improvement in the immediate dentin sealing technique was suggested by adding a layer of low-viscosity flowable resin composite to the adhesive layer during the immediate dentin sealing [42], [43]. Biomimetic material such as bioactive glass is a therapeutic ion releasing approach that can create a bioactive smear layer which, in turn, can interact with body fluids encouraging mineral deposition through the formation of hydroxy apatite. A novel bioactive glass powder material “Sylc®” is used in airborne abrasion system has shown promising result in enhancing adhesion and selective removal of resin material from tooth structure. This strategy is not yet applicable in everyday clinical practice since there is no enough evidence in literature to support the idea [44]. The current study used a self-etch adhesive “single bond universal” system to eliminate variability in the adhesive strategy and simplify bonding procedures. Since filled dentin bonding agents had a more uniform film thickness than unfilled ones, they were more likely to be used [45]. Using a filled adhesive also reduces the risk of re-exposing the dentin during preparation cleaning before final cementation, since studies on simplified adhesives in immediate dentin sealing showed that surface treatments like airborne particle abrasion can remove the adhesive layer. One advantage of using the single bond universal in this study is the presence of a silane coupling agent, though indirect composites do not require a separate step of silane application like ceramics. To increase the union of dissimilar materials, silane coupling agents, which are adhesion promoters with two different reactive functional groups that can react with various inorganic and organic materials, are used. The silanes’ hydrolysable functional groups react with the surface hydroxyl groups of inorganic substrates to form a siloxane bond (Si-O-Si), whereas the organic non-hydrolysable functional group with a carbon-carbon double bond can polymerize with resin composite monomers containing double bonds. As a result, the use of the silane-containing adhesive was advantageous in the current study [46]. Surface treatment and conditioning of the resin layer in immediate dentin sealing with 37% phosphoric acid, soft-air abrasion, airborne particle abrasion with aluminum oxide, and fluoride-free pumice paste systems are recommended for the purpose of increasing bond strength [47], [48]. Airborne particle abrasion with aluminum oxide particles has demonstrated successful results in bonding to cured or aged composites. It has also demonstrated some success in treating the immediate dentin sealing layer while cementation is in progress [30], [49]. The presence of residual free radicals, Van der Waals-type interactions, and micromechanical retention may all contribute to the adhesion of the sealed dentin to the resin cement [13]. When compared with the use of a polishing brush, the accessibility of airborne particle abrasion to reach and condition the resin coat layer in all parts of the cavity is significantly superior. In addition, controlling parameters such as pressure and distance is significantly easier, which contributes to the airborne particle abrasion technique’s increased clinical reliability [50]. As of right now, there is an insufficient amount of literature available on a protocol and the clinical effectiveness of various methods of surface treatment and conditioning of the resin layer in immediate dentin sealing to minimize hypersensitivity. Because of this, this study was carried out to add to the evidence that is required for this topic. Therefore, the conditioning method that was utilized in this investigation was airborne particle abrasion with 29-micron aluminum oxide powder, which was then followed by 37% phosphoric acid for the group. Another group was treated with 37% phosphoric acid but did not undergo air abrasion in the conditioning process. Several studies assessed post-operative sensitivity using fixed-category scales. The Numeric Rating Scale (NRS) rates pain with three numbers (0–3). Participants were instructed to choose a number between 0 and 3 to indicate pain intensity [51]. The Verbal Descriptor Scale (VDS) includes adjectives for no pain, mild pain, moderate pain, severe pain, extreme pain, and worst pain. “No pain” scored 0 and “worst pain” scored 10, with more intense adjectives scoring higher [52]. Their weakness is that they imply using words that may not express what the patient is experiencing or have the same meaning for each participant. Its crude measurements are a major drawback [53]. However, the VAS method used to evaluate post-operative sensitivity in the current study gives participants a wider range of responses and more uniform instructions by avoiding descriptors such as mild, moderate, and severe, which can be interpreted differently by different people [54]. It is also more accurate and effective than fixed-category statistical tests [55]. In the current study, facial expression illustrations were added below the 10-centimeter line of the VAS to help low-educated patients understand it [32]. The results of a comparison between the two

Table 2: Descriptive statistics for visual analogue scale for different methods of surface treatment and follow-up intervals before and after aging

Follow-up intervals	Surface treatment (P_1)				No surface treatment (P_2)			
	Mean	SD	Median	Range	Mean	SD	Median	Range
T_1^{a}	0.57	0.51	1	0–1	0.57	0.51	1	0–1
$T_2^{b,c,d}$	0.07	0.27	0	0–1	0.07	0.27	0	0–1
$T_3^{c,b,d}$	0	0	0	0	0	0	0	0
$T_4^{d,b,c}$	0	0	0	0	0	0	0	0
Kruskal–Wallis	23.3				23.3			
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).

protocols with and without surface conditioning by air abrasion at 1 week, 3 months, and 12 months after cementation revealed that there was no significant difference between the two. This could be because the dentin was already sealed using the self-etch adhesive “single bond universal” and the self-adhesive resin cement “Relyx unicem clicker,” the margins of the indirect composite restorations were properly fitted for both sealing protocols, and there were no open margins that could have caused marginal leakage. In this investigation, the self-adhesive resin cement was supposed to interact with the dentin substrate in a way that required only a small amount of additional surface preparation to make the application process more straightforward and without the utilization of dentin etching. In the current investigation, the application of selective etching to enamel was found to be helpful in the establishment of an effective and long-lasting bonding that promoted the sealing of cemented restoration by the self-adhesive. This was accomplished by increasing the surface area of the enamel. This is consistent with Solon-De-Mello *et al*.’s discussions from 2019, in which they stated that self-adhesive resin cement performed better bonding effectiveness when tested with selectively acid-etched enamel before luting due to the large, microscopic irregularities produced by the separate strong acid in comparison to those produced by the cement itself, and that the use of phosphoric acid pre-treatment should be limited [56].

Conclusion

Under the limitations of the current study, the following could be concluded:

1. The immediate dentin sealing protocol using a universal adhesive could decrease the hypersensitivity problem associated with indirect resin composite restorations
2. Air abrasion during cementation of indirect resin restorations does not affect post-operative sensitivity after immediate dentin sealing.

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