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HYPER-SENSITIVITY ASSESSMENT AFTER IMMEDIATE VERSUS DELAYED DENTINE SEALING IN INDIRECT COMPOSITE RESTORATIONS: RANDOMIZED CONTROLLED CLINICAL TRIAL

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ABSTRACT

Aim: to evaluate the efficacy of immediate dentin sealing using universal adhesive in comparison to delayed dentin sealing in the reduction of the hypersensitivity in teeth prepared for indirect tooth composite restorations using Visual Analog Scale (VAS).

Materials and methods: Fifty-four patients between 18 and 30 years of age were recruited and randomized to the treatment protocols. After baseline preoperative data collection, diagnosis of caries was done depending on the basis of clinical examination that was done tentatively and radiographic examination was done as well. After cavity preparation was done, for the cavities to be managed with immediate dentine sealing, the single bond universal adhesive was applied over all the dentinal surfaces according to the manufacturer's instructions. For the cavities to be managed with delayed dentine sealing, no adhesive was applied on the dentinal surfaces and the impression was taken directly after cavity preparation using two-step technique. Hyper-Sensitivity was evaluated both intra-operatively (at baseline one day after the cavity preparation: by applying air from the triple way syringe directly over the prepared cavity and one week during temporization) and post operatively using (VAS). After try in and cementation of the indirect composite restoration post-cementation evaluation was done. (VAS) results were tabulated and statistically analyzed.

Results: Delayed dentin sealing group (4.75) had a significantly higher median value of (VAS) than immediate dentin sealing group (0.32) ($P<0.001$). There was a significant difference between the scores at different follow-up intervals ($P<0.001$). The highest median value of (VAS) was found at baseline (3.37) followed by that found one week during temporization (2.91) while the lowest median value was found one week after cementation (0.16). Pairwise comparisons showed median value found one week after cementation (0.16) to be significantly lower than those found at baseline (3.37) and one week during temporization (2.91) ($P<0.001$).

Conclusions: Inter-operative and post-cementation hypersensitivity problem after indirect resin composite restorations could be solved by using the immediate dentin sealing protocol using a self-etch adhesive.

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INTRODUCTION

Dentinal hypersensitivity is characterized by short sharp pain when introducing thermal and chemical stimuli[10]. The principle mechanism explaining dentinal hypersensitivity is the hydrodynamic theory by Brannstrom [2]. This theory states that a stimulus such as cold or friction on open dentinal tubules create a fluid flow in the dentinal tubules that can cause pain. Post-cementation hypersensitivity occurs after a newly cemented indirect restoration is placed. Rosenstial and Rashid survey stated that the incidence of post-cementation hypersensitivity is about 10% [26]. Many factors are associated with post-operative hypersensitivity. Desiccation and overheating can cause pulpal damage [2]. Also, infiltration of bacteria that were left behind or reached the dentin due to microleakage can cause pulpal damage beneath restorations. The amount of tooth reduction affects post-cementation hypersensitivity. Studies resulted that 60% of teeth prepared to within 0.5mm of the pulp had a severe pulpal reaction, while 5% of cavities with remaining dentinal thickness more than 1mm had a severe reaction [4]. In addition, interfering with the sensitivity of mechanoreceptor or dentinal tubules occlusion are both strategies for treatment of dentinal hypersensitivity. Immediate dentin sealing (IDS) is considered a new approach in which the dentin is sealed immediately after tooth preparation and prior to impression taking. IDS improves comfort during provisional restoration stage, limited anesthesia during insertion of the definitive restoration and reduced post-operative sensitivity [23] and seals the dentin with which patients experience improved comfort during provisional restoration stage and during insertion of definitive restoration. [11]. The choice of the bonding system to be used in IDS procedure is also critical with regard to dentin sensitivity. The self-etch systems are less technique sensitive and have higher qualitative and quantitative capacity of penetration than conventional system pointing out a tendency towards minimizing post-operative sensitivity [27]. There is inadequate literature available at present on the protocol and clinical effectiveness of IDS procedure to minimize hypersensitivity [21] hence, further studies are necessary. Rationale: An effective protocol should be done to decrease dentinal hypersensitivity by sealing the freshly cut dentin after tooth preparation in order to be more resistant to bacterial leakage and sensitivity during impression taking and the provisional restoration phase. Single bond universal adhesive provides a strong bond to seal the dentin if used in the self-etch or total-etch mode and protects the dentin from open tubules and potential sensitivity, or as a method for reducing sensitivity for patients who are already symptomatic. Accordingly, immediate dentin sealing (IDS) after tooth preparation using this bonding agent could reduce or eliminate the occurrence of post-cementation hypersensitivity. Benefits to patients/population are to preserve pulp vitality, preserve healthy dental tissue like dentin, avoid patient discomfort, time and cost saving and effective methods to provide painless technique. The null hypothesis tested is that there is no difference in post-cementation hypersensitivity between immediate dentin sealing by single bond universal adhesive and delayed dentin sealing in teeth prepared for indirect tooth colored restoration.

MATERIALS AND METHODS

All the Materials' specifications, composition and manufacturers are represented in table (1).

This randomized controlled clinical trial was conducted following the Standard Protocol Items: Recommendations for Interventional Trials (SPIRIT) Statement. The SPIRIT 2013 Statement provides evidence-based recommendations for the minimum content of a clinical trial protocol. SPIRIT is widely endorsed as an international standard for trial protocols. This study was approved by the Ethics in Human Research Committee of the faculty of Dentistry, Cairo University (no.1869). Fifty-four patients between 18 and 30 years of age were included in this study. Patients were recruited from

TABLE (1): Materials' specifications, composition and manufacturers

Material	Specifications	Composition	Manufacturer
Single bond universal	One Step, Self-Etch Adhesive system	MDP Phosphate Monomer Dimethacrylate resins HEMA Vitrebond Copolymer Filler Ethanol Water Initiators Silane	(3M ESPE, St Paul, MN USA)
Filtek™ Z250 XT	3M™ Filtek™ Z250 Universal Restorative is an esthetic, light-cured, composite specifically designed for use in both anterior and posterior direct or indirect restorations	Bis-GMA UDMA Bis-EMA TEGDMA Zirconia, silica (5–20 nm, 78.5 wt%)	(3M ESPE, St Paul, MN USA)
Rely X Unicem Clicker™ Dispenser	Self-Adhesive Universal Dual Cure Resin Cement	**Base paste (white)** Methacrylate monomers containing phosphoric acid groups Methacrylate monomers Silanated fillers Initiator components Stabilizers **Catalyst paste (yellow)** Methacrylate monomers Alkaline (basic) fillers Silanated fillers Initiator components Stabilizers Pigments	(3M ESPE, St Paul, MN USA)

the outpatient clinic of the Conservative department, Faculty of Dentistry, Cairo University. Each patient was informed of the nature of the study, consented to participate and signed a consent form. Inclusion and exclusion criteria used for enrolment of patients and investigated teeth were as follows:

Inclusion criteria of participants:

1. Lower first molars with extensive carious lesions indicated for indirect restorations
2. Both genders of age 18 -30 years
3. Not received antibiotic therapy since 1 month before sampling
4. Good oral hygiene

Exclusion criteria of participants:

1. Pregnancy
2. Systemic disease or severe medical complications
3. Heavy smokers
4. Xerostomia patients
5. Patients having dental hypersensitivity

Inclusion criteria of teeth:

1. Extensively class II cavitated lesions in permanent first molars on visual and radiographic examination (reaching >1/2 of the dentin)
2. Absence of spontaneous pain; negative sensitivity; and absence of periapical lesions (radiographic examination).

Exclusion criteria of teeth:

1. Endodontically treated teeth
2. Periodontally affected teeth

Based on the previous study by Hu,J.,and Zhu,Q 2010[11] the success rate among controls is 28%. If the true success rate for the experimental group is 68%. Using power 80% and 5% significance level we needed to study 23 patients in each group. This number to be increased to a sample size of 27 to compensate for losses during follow up (20% more than the calculated). Sample size calculation was achieved using PS: power and sample Size calculation software Version 3.1.2 (Vanderbilt University, Nashville, Tennessee, USA). Patients were recruited from outpatient Clinic of Conservative Dentistry Department, Faculty of Dentistry, Cairo University; after explaining the benefits/risks from the application of the intervention and control, the eligible patients were recruited to fulfil the eligibility criteria according to participant timeline and teeth inclusion and exclusion criteria. The patients were subjected to full examination and diagnosis using a diagnostic mirror and explorer aided by the light from the dental unit and signed a written consent. Pre-operative radiographic examination was routinely taken to evaluate cavity proximity to the pulp and any sign of periapical radiolucency that could preclude the patient enrolment. After diagnosing the case as an extensively cavitated lesions (reaching >1/2 of the dentin thickness on periapical digital radiographic examination) the patient was enrolled in the study. Randomization was done for patients using coin tossing to identify which patient was to be assigned for the immediate dentin sealing and the patient to be assigned for delayed dentin sealing. Blinding of the operator was not possible, because main operator was responsible for applying the intervention and control. However, the hypersensitivity test was done by the assistant colleague who was blinded from the followed sealing protocol. In addition, the treatment results were assessed blindly by a statistician. The enrolled patient was anaesthetized using a local anesthetic Mepecaine-L local anesthesia and the field of operation was isolated with the application of a rubber dam. Entrance to the lesion and lateral extension through the cavity was then done using a high speed hand piece using (conventional bur # 330) under magnification using loupes 2.5x. In cavities with large amount of carious dentin, the softened dentin was removed using a spoon excavator. SIROinspect (Dentsply Sirona) device was used to make sure that all caries in the cavity has been removed. During excavation procedure the device probe illuminates the tooth with violet light (approx. 405 nm). This stimulates both products of caries bacteria as well as healthy dentine to fluoresce. In this way, red fluorescing carious areas can be recognized both quickly and safely. Healthy tooth structure differs in this respect by fluorescing green. In case of a pulp exposure, teeth were excluded from the study. The angulation of the cavity walls was adjusted to be 6 degrees diverge of the axial inclination using blue coded diamond tapered with round end bur. During the preparation of in the included molars, the following parameters checklist was followed for standardization:

1- Thickness of remaining walls (in order to maintain them) had to be ≥ 1.5 mm measured by dental caliper
2- The occlusal inter-cuspal distance ranged from 2.5 -3 mm measured by the dental caliper
3- The pulpal floor was prepared to provide depth range of 3- 4mm.

4- Width of occlusal isthmus had to be 2-3 mm.

5- Buccal and lingual walls of the proximal part of the cavity were prepared using the same diamond bur used for the occlusal part of the cavity to provide the same angle of divergence (6 degrees) as that of the occlusal walls.

6- The proximal box corresponded to one-third the distance between the buccal and lingual surfaces of the teeth

7- The gingival floor of the proximal part of the cavity had to be continuous with the pulpal floor of the occlusal part having the same depth.

8- Interproximal overjet had to be ≤ 2 mm.

9- The internal line angles were rounded, the cavo-surface angles were 90°

If the previously mentioned checklist wasn't achieved in the prepared molar, this molar had to be excluded since large differences in the preparation parameters of the included molars might affect the outcome assessment. For the cavities to be managed with immediate dentine sealing, after proper air dryness for 5 seconds and with the aid of a micro-brush, the single bond universal adhesive 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 seconds then blown with a gentle air blow for 5 seconds to evaporate the solvent and then light cured for 10 seconds using LED curing light at a light intensity of 1200 mw/cm2. Before the impression was taken, proper evaluation of the cavity was done regarding the sharp margins, absence of undercuts, absence of contact between the cavity and the adjacent teeth. For the cavities to be managed with delayed dentine sealing, after proper dryness of the cavities, no adhesive was applied on the dentinal surfaces and the impression was taken directly after cavity preparation. Using addition polyvinylsiloxane as an impression material, two-step technique was employed as a preliminary impression using stainless steel dentulous full arch tray of the suitable size according to the arch size, and then wash was taken to record fine details. Bite registration was taken using squash bite wax registration. The impression was disinfected using 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 fabricated using 3M Filtek Z250 resin composite. Temporization was done by placement of a small piece of cotton in the cavity followed by temporary filling material Coltosol® F. Sensitivity was evaluated both intra-operatively and post operatively using Visual Analog Scale (VAS). It is a horizontal line graded from 1 to 10 with a descriptor at its far left end indicating no pain, and at its far right end indicating the worst possible pain. Illustration of facial expressions with color codes was added below the 10-centimeter line Visual Analog Scale [3]. All participants in both groups were evaluated for hypersensitivity at baseline one day after the cavity preparation and one week during the temporization period. After 24 hours from cavity preparation, the temporary restoration was removed by excavator and the base line record was evaluated using sterile metal triple way syringe at standard distance of one cm from the prepared cavity and air pressure of 0.5N/mm2. The 1cm distance was standardized using a measured-1cm plastic stick that was fixed to the triple way syringe. The duration of air blast ranged from 1-5 seconds according to patient's response. As soon as the patient reported pain, the stimulus was stopped, and pain intensity was recorded. The participants were instructed to rate the pain level using VAS scale as follows: If the pain was the worst possible, the participant would mark at the far right end of the line and, in the absence of pain, he/she would mark at the far left end. For pain levels between the two extremes, participants made a mark at a point along the line that best represented their pain. The distance in millimeters from the far left end of the line to the marked point of intersection was measured and recorded.

After one week of temporization, the patient was recalled for sensitivity assessment by applying the same protocol as mentioned in the base line assessment. At the try in visit, the temporary restoration was removed and try-in of the restoration was done by inserting the restoration inside the cavity to check the fitting, full seating, marginal integrity, occlusal prematurities, contacts and occlusal anatomy of the restoration. Any found defect was corrected and the try in procedure was repeated till the restoration was satisfactory. No L.A. anesthesia was necessary in the final visit for proper sensitivity assessment. After the final indirect restoration was delivered from the laboratory, removal of the temporary restoration was done using a spoon excavator (Dentsply Sirona), the cavity was checked for any residual temporary filling material, the restoration was inserted to check fit, insertion and proximal contacts. After that the fitting surface of the restoration was treated as follows to be ready for cementation: Etching with 37%phosphoric acid for 60 seconds, Etchant was rinsed for 30 seconds and air dried for 5 seconds, then Single bond universal adhesive layer was applied, air thinned for 5 seconds and cured for 10 seconds. For the immediate dentin sealing group, Etching of enamel margin and the sealed dentin for 15 seconds using 37% phosphoric acid for refreshing of the dentin coating, etchant was rinsed for 15 seconds and air dried for 5 seconds then, single bond universal adhesive layer was applied with rubbing action for 20 seconds, air thinned for 5 seconds and cured for 10 seconds .While for delayed dentin sealing group, the selective etch technique was used in which the above protocol was applied except etchant application on unsealed dentin. The RelyX Unicem clicker 3M ESPE was used for the restoration cementation according to the manufacturer instructions, tac cured for 5 seconds, then, a dental floss was passed inter-proximally to remove excess cement and excess cement flashes around the margins were removed using sharp molar scaler. Final light curing was done for 20 seconds from all aspects. After final occlusal adjustments, restoration was finished and polished intra-orally, post-cementation digital periapical radiograph was taken to check interproximal contacts and gingival overhangs. Post-cementation hypersensitivity assessment was done one week after cementation of the indirect composite restoration using the air from the triple way syringe which was directed towards the margins of the restoration at standard distance of one cm from the cavity margins and air pressure of 0.5N/mm2and asking the patient to score the pain on the VAS scale as done in the previous assessments. The results were converted into a table to facilitate the description of results and the data were entered and stored on a personal computer. Double data entry was saved on an external hard disc to prevent loss of data. Ordinal data of visual analogue scale (VAS) were represented as median and range values. Intergroup comparisons were done using Mann Whitney U test, while intragroup comparisons were done using Friedman test of repeated measures followed by multiple pairwise comparisons utilizing Wilcoxon signed ranks test with p-value adjustment using Bonferroni correction. The significance level was set at $P \leq 0.05$ within all tests. Statistical analysis was performed with IBM® (IBM Corporation, NY, USA) SPSS (SPSS, Inc., an IBM Company)® Statistics Version 25 for Windows.

RESULTS

Effect of dentine sealing methods:

Delayed dentin sealing group (S2) (4.75) had a significantly higher median value of (VAS) than immediate dentin sealing group (S1) (0.32) ($P<0.001$). In the immediate dentin sealing group, all the members were free of pain, while for in the delayed dentin sealing group (24) (33.3%) felt pain. Odds ratio of pain was (0.0003), 95%CI (0.0002-0.0563) which was statistically significant ($p <0.001$). Relative risk was (0.001), 95%CI (0.0006-0.1576) which was statistically significant ($p =0.001$).

TABLE (2): Descriptive statistics for visual analogue scale (VAS) for different methods of dentine sealing and Follow-up intervals before and after aging

Dentine sealing methods	Follow-up intervals	Mean	Std. Deviation	Median	Range
Immediate (S1)	Baseline	0.64	0.49	0.64	1.00
	One week during temporization	0.32	0.48	0.32	1.00
	One week after cementation	0.00	0.00	0.00	0.00
Delayed (S2)	Baseline	0.32	0.47	5.43	1.00
	One week during temporization	5.38	0.71	5.43	2.00
	One week after cementation	5.38	0.71	0.33	2.00

Effect of time

There was a significant difference between the scores at different follow-up intervals (P<0.001). The highest median value of (VAS) was found at baseline (3.37) followed by that found one week during temporization (2.91) while the lowest median value was found one week after cementation (0.16). Pairwise comparisons showed median value found one week after cementation (0.16) to be significantly lower than those found at baseline (3.37) and one week during temporization (2.91) (P<0.001).

Effect of dentine sealing methods within each follow-up interval

- Baseline: Delayed dentin sealing group (5.43) had a significantly higher median value of (VAS) than immediate dentin sealing group (0.64) (P<0.001). All members of immediate dentin sealing group didn't feel pain, while all members of delayed dentin sealing group felt pain. Odds ratio of pain was (0.0004), 95%CI (0.0001-0.0210) which was statistically significant (p <0.001). Relative risk was (0.0196) 95%CI (0.0013-0.3056) which was statistically significant (p =0.049).
- One week during temporization: Delayed dentin sealing group (5.43) had a significantly higher median value of (VAS) than immediate dentin sealing group (0.32) (P<0.001). All members of immediate dentin sealing group didn't feel pain, while all members of delayed dentin sealing group felt pain. Odds ratio of pain was (0.0004), 95%CI (0.0001-0.0210) which was statistically significant (p <0.001). Relative risk was (0.0196) 95%CI (0.0013-0.3056) which was statistically significant (p =0.049).
- One week after cementation: Delayed dentin sealing group (0.33) had a significantly higher median value of (VAS) than immediate dentin sealing group (0) (P=0.002). All members of both groups didn't feel pain, while all members of (S2) group felt pain. Odds ratio of pain was (0.961), 95%CI (0.0183-50.35) which was not statistically significant (p =0.984). Relative risk was (0.961) 95%CI (0.0198-46.63) which was statistically insignificant (p =0.984).

Effect of time within each dentine sealing method used

- Immediate dentine sealing (S1): There was a significant difference between the scores at different follow-up intervals (P<0.001). The highest median value of (VAS) was found at baseline (0.64) followed by that found one week during temporization (0.32) while the lowest median value was found one week after cementation (0). Pairwise comparison

showed median value at baseline (0.64) to be significantly higher than that found after one week of cementation (0) (P<0.001)

- Delayed dentine sealing (S2): There was a significant difference between the scores at different follow-up intervals (P<0.001). The highest median value of (VAS) was found at baseline and one week during temporization (5.43) while the lowest median value was found one week after cementation (0.33). Pairwise comparisons showed median value found one week after cementation (0.33) to be significantly lower than those found at baseline and one week during temporization (5.43) (P<0.001).

DISCUSSION

Post cementation hypersensitivity accompanied by newly cemented indirect restorations is considered one of the most irritating complications that face dentists as well as patients. Post cementation hypersensitivity is a symptom characterized by sharp, short pain when the vital abutment tooth is subjected to thermal and chemical stimuli [14]. When Rosenstial and Rashid conducted a survey they found that post cementation hypersensitivity incidence is about 10%. Usually this kind of hypersensitivity is self-healing but it can also last for a long time which makes it a point of interest for many dentists. [26] The overheating during cavity preparation, the amount of tooth reduction in and its proximity to the pulp, micro leakage and bacterial infiltration are considered other main causes of post cementation hypersensitivity [11] and have direct effect on the sensitivity [4], thus researchers should find out solutions to reduce it to the minimum. Knowing the mechanism of dentin hypersensitivity that was previously explained by Brannstrom [2] helped researchers to find several ways to decrease this incidence. There are many attempts trying to reduce dentinal and cure dentinal hypersensitivity through the application of dentin desensitizers like GLUMA Desensitizer (Heraeus Kulzer) [12], the use of antimicrobial solutions before cementation or the application of dentin bonding agents that help in blocking the dentinal tubules. But in fact, the dentinal hypersensitivity doesn't only occur post cementation, it occurs just after the effect of local anesthesia diminishes during the temporization period due to the inability of the temporary filling to completely seal the exposed dentin which allows for the bacterial infiltration thus, dentin hypersensitivity. The inter-penetration of monomers into the hard tissues allows for the formation of what is called the hybrid layer [16]. A ''structural'' bond similar to the interphase formed at the dentino-enamel junction (DEJ) is formed once the infiltrating resin is polymerized[15]. The most important problems needed to be taken into consideration during dentin–resin hybridization, are the problems related to dentin contamination and susceptibility of the hybrid layer to collapse until it is polymerized. And when these factors were viewed relative to the frame of indirect bonded restorations, they led to the conclusion that dentin should be sealed immediately after tooth preparation. And accordingly, a new approach has been developed called "Immediate dentin sealing" which is considered a new technique which is added to the steps of indirect restorations just after the cavity preparation and before impression taking trying to properly seal the dentinal surfaces, thus decreasing the bacterial infiltration and decrease post-operative hypersensitivity during the temporization stage and as well the post cementation period[7]. One of the advantages of immediate dentine sealing is the ability of the adhesive to bond to freshly cut dentin which is present only at the time of tooth preparation (before impression taking). This is due to dentin contamination owing to the temporization usually reduces the potential to dentin bonding. Studies done by Paul and Magne[17,24] revealed significant reductions in bond strength due to dentin contamination with various provisional cements and materials. There is inadequate literature available at present on a protocol and clinical effectiveness of IDS procedure to minimize hypersensitivity hence, this study was conducted for

increasing the evidence needed for this issue. For the time being, the invention of conservative and minimally invasive restorative techniques for direct posterior composite is the main concern, but actually this is not the scenario in indirect composite restorations for posterior teeth. [19] Indirect composites are usually highly recommended when teeth are extensively decayed and require large restorations since their process of fabrication allows a good anatomic form and proximal contact reproduction in addition to reducing the main direct composite disadvantage which is the polymerization shrinkage and limiting it to the thin layer of luting cement used for cementation. [18] The findings of this clinical study didn't support the null hypothesis that there would be no difference in post-cementation hypersensitivity between immediate dentin sealing using single bond universal bonding agent and delayed dentin sealing in teeth prepared for indirect composite restoration. However, the findings of this study showed that the immediate dentin sealing showed lower VAS values than the delayed dentin sealing and this can be explained by the sealing effect of the patent dentinal tubules, done by the single bond universal adhesive after cavity preparation and caries removal, on the passage of the dentinal fluids which are the main cause of the dentin hypersensitivity. Elaboration of the sequence of events in which the dentinal fluids take in order to cause such sensitivity is of much importance, whereas, the passage of the dentinal fluids which occupy the space between the odontoblastic process and the tubule wall (the peri-odontoblastic space) [20] ,as well as the ions and other molecules, is restrained by the odontoblastic cell layer that creates a barrier along the extracellular pathways. These fluids are solely under the odontoblastic control and this may also involve external stimuli that encompass tissue-damaging (eg, caries, cavity preparation, abrasion) [1]. This can be explained as most studies that discussed the dentinal fluid flow and consistency are based on cavity preparations that may disrupt the tight junctions between odontoblasts and fluids from the pulp, blood vessels, or both may diffuse into the dentin thus, the fluid will exist as a reaction to trauma, which might disagree with the origin of dental fluid. It is usually accepted that dentin sensitivity to extrinsic irritants is facilitated by alterations in hydraulic conductance (osmotic pressure) [20]. Dentin exposed to external stimuli results in a fluid shift across the dentin to create a neurovascular response (pain sensation). And in agreement with the results obtained by Fiocchi, Moretti et al. 2007 [9], da Rosa, Lund et al. 2013 [6] and since human teeth are more sensitive to outward than inward flow, the evaporative stimulus used in the current study when testing the dentin hypersensitivity in the group of the delayed dentin sealing showed more VAS pain values as it directly stimulated the fluid movements that affect the odontoblastic cells, therefore the nervous plexus. In addition, the human dental pulp fibroblasts express thermosensitive transient receptor potential (TRP) channels which was demonstrated by El Karim, Linden et al. 2011[8]. These channels are a group of nonselective calcium-permeable cationic channels that act as polymodal sensors of environmental stimuli (eg, thermal and chemical) in which TRPM8 and TRPA1 are cold-sensing TRP channels that were definitely affected by the air applied by the triple way syringe. The mechanism of dentinal fluid sealing might also have an impact on the study results. Using a self-adhesive "single bond universal" while applying the immediate dentin sealing is thought to be of much value as using such adhesives doesn't require etching of the dentin which, if was done, might have caused changes in the VAS values of the IDS, as the etchant is considered one of the greatest stimulants to the dentin that might increase the ability to postoperative hypersensitivity. There was a significant difference between the two sealing protocols upon follow-up intervals in each group (baseline, one week during temporization and one-week post cementation). The results obtained at baseline and one week during temporization are highly significant when comparing

immediate dentin sealing to delayed dentin sealing but insignificant when comparing the follow up intervals of the same protocol where IDS showed lower values than DDS but had the same values at baseline and one week during temporization.

This might be attributed to the absence of patent tubules sealing in the DDS as mentioned before in addition, to the weak sealing effect of the temporary filling compared to that of the adhesive and the final restoration itself. When comparing both protocols at when week post cementation both protocols showed no significant difference. This might be explained by the already sealed dentin using the self-etch adhesive "single bond universal" and the self-adhesive resin cement "Relyx unicem clicker", the properly fit margins of the indirect composite restorations in both sealing protocols and the absence of any open margins that might cause marginal leakage. The purpose of the self-adhesive resin cement in this study was to interact with the dentin substrate with minimal additional surface preparation in order to simplify the application and without the use of dentin etching.

The use of selective etching to enamel in the current study aided the establishment of an efficient and durable bonding that promoted the sealing of cemented restoration by the self-adhesive. This comes in agreement to Solon-De-Mello et al in 2019 [29] who discussed that self-adhesive resin cement when tested with selectively acid-etched enamel prior to luting presented better bonding effectiveness than the result obtained when tested without pre-treatment due to the large microscopic irregularities produced by the separate strong acid compared to that produced by the cement itself and that the indication of the use of phosphoric acid pretreatment should be limited to enamel only and not to dentin as they found that without the pretreatment it has been shown to produce fairly strong bonds to dentin. Kumar V et al. 2015 [13] when they tested the effect of Immediate Dentin Sealing in Prevention of Post-Cementation Hypersensitivity in full-coverage restorations and also compared the effect in the age ranges of 21-30 and 31-40 years, they found that there was statistically significant difference in the reduction of sensitivity with the use of a dentin bonding agent at 1 week and 1 month but not at 6 months and there was no significant difference between the age groups when they used a split mouth technique for each range of age.

This supports the results of the current study which stated that at baseline, one week during temporization and one-week post-cementation the delayed dentin sealing group had a significantly higher median value of (VAS) than immediate dentin sealing group. But in the current study, the post-cementation hypersensitivity wasn't measured at six months at which they found that there is no significant difference and they referred this to Pameijer CH et al 1994 [22] who concluded, that post-cementation hypersensitivity appeared to be a negligible problem, and it was only attributed to the time span between preparation and cementation, which exceeded in most instances four weeks. And this is in concurrence with the study carried out by Hu and Zhu 2011 [11]whereas there was no significant difference between the immediate and delayed dentin sealing at the end of 6, 12, and 24 months. In the current study, most of the recorded hypersensitivity was from moderate to severe which was contradictory to Kumar V et al. 2015[13] and Hu and Zhu 2011 [11] in which all the reported sensitivity were only mild or moderate form which is similar to the findings of Saad et al 2010 [28] who also found that negligible number of patients experienced severe sensitivity and this can be owing to the proper provisionalization. But this might have another explanation is that Saad et al 2010 was testing postoperative sensitivity for fixed partial dentures which wasn't the situation in the current study since the amount of exposed dentin is considered an non negligible factor. Marginal microleakage can also be one of the causes of post-cementation hypersensitivity due to the contamination with the temporary filling material as stated by Watanabe

EZ et al 1997 [31] and thus the immediate dentin sealing technique consists of the application of an adhesive system immediately after finishing the tooth preparation but before the impression and this provides protection to the dentin-pulp complex immediately after cavity preparation by the application of a resin agent, preventing and decreasing the sensitivity and bacterial infiltration during the provisional stage which explain the results of the current study.

Though, on the contrary, Spohr et al. 2015[30] when tested the efficacy of immediate dentin sealing techniques on marginal micro leakage of composite resin inlays they found that there were no significant differences in the dye penetration between the groups in either the enamel or the dentin even for the dentin which was protected by Protect liner F and they also stated that the IDS with Clearfil SE Bond, either associated or not associated with Protect Liner F, was not capable of producing complete sealing of the enamel and dentin margins, but they referred these results to the reason that the one-step self-etching primer that they used has a moderate capacity of dentin demineralization due to the presence of the hydrophilic monomer HEMA thus, allows some permeability which makes changes at the dentin–adhesive interface, and consequently, hydrolytic degradation of this interface this causing the marginal microleakage. [5]

CONCLUSIONS

Under the limitations of the current study the following conclusions could be derived

1- Inter-operative and post-cementation hypersensitivity problem after indirect resin composite restorations could be solved by using the immediate dentin sealing protocol using a self-etch adhesive.

2- Visual Analog Scale (VAS) as hypersensitivity assessment method is still considered reliable, simple and fast method that could be applied intra-, inter- and post-operatively.

3- The indirect composite restorations are considered as a very good solution to restore the extensively wide cavities regarding the technique simplicity and cost.

4- For in vivo studies to be of value, standardization of the conditions of work regarding the operator, the material used, the applied protocol and assessment method is very crucial.

RECOMMENDATIONS

1. Further investigations are required for assessing the postoperative and post-cementation hypersensitivity in short and long-term.

2. More in-vivo studies are needed about the hypersensitivity in indirect composite restorations regarding micro leakage and bacterial infiltration which only give indication for postoperative hypersensitivity.

3. The immediate dentin sealing concept should stimulate the researchers and clinicians for introducing of new protocols for the rationalization and standardization of adhesive techniques in order to provide maximum tooth structure preservation, improved patient comfort, and long term survival of indirect bonded restorations.

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