REVIEW

Posterior Composite Restorations and Post-operative Sensitivity

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INTRODUCTION

Modern patients are well informed and often demand posterior 'aesthetic' restorations. To the patient the type or brand name of the product which is used is irrelevant, as long as the results are aesthetic, affordable, and can be placed quickly and with minimal personal discomfort and post-operative problems[1,2]. One of the most affordable aesthetic options is a directly-placed, composite restoration. The overall success of such restorations not only depends on the clinical situation, but also on the expertise of the dentist and the time he/she is willing to spend for the fee he/she will be paid[3]. Placing a successful posterior composite restoration is a technique-sensitive, time-consuming art and any shortcuts used during the placement of such a restoration is sure to lead to post-operative problems[4]. It is well known that post-operative sensitivity is one of the major problems regarding this type of restoration[3,5-8]. This article will address various factors that could contribute or lead to post-operative sensitivity.

Possible causes of Post-operative sensitivity

Dental pain or discomfort can originate from periodontal origin, pulpal pathology or dentinal involvement. Most sensory interdental nerves are either myelinated A-δ nerves or smaller, unmyelinated C-Fibers. The sensation resulting from activation of the C-fibers is a diffuse, burning or throbbing pain mostly associated with pulpal pathology. The A-δ nerves have low sensitization thresholds, and easily react to hydrodynamic pressure phenomena, and with activation the result is a sharp, intense pain[9,10]. Brännstrom, (1986) explained the sensitivity of exposed dentine according to the "Hydrodynamic theory of pain"[11].

Dentinal "Hypersensitivity"

This topic was covered in an article by Brandt & De Wet (2002). Dentine will only be sensitive 'post-operatively' should the dentine be left exposed due to the restorative process and/or accompanying Oral Hygiene treatment[12].

Pulpal Pathology

An inflammatory response is the natural defense mechanism of any tooth with caries that is reaching into the dentine. Early caries does not cause any pain, but any traumatic procedure, such as cavity preparation and/or the placement of a restoration, may trigger an enhanced inflammatory response with associated pain. Spontaneous pain then occurs once the anaesthetic has worn off, or soon after. The possibility of such pain occurring will depend on the severity of the caries, as well as possible trauma caused during the restorative process. Any additional bacterial activity due to post-operative micro-leakage will also exaggerate the existing inflammation, thereby causing pain[8].

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Liners

This is a controversial, but important, topic. Do we really need any form of liner under a composite restoration when a good seal can be achieved using a bonding system? Why cover the dentine, which is an excellent bonding surface, with a liner with questionable value? Current thinking is steering away from the use of liners but more research needs to be done[13-15]. It has to be kept in mind that a near 'perfect' seal in the clinical situation is very difficult to achieve, while in the situation of a "not so perfect seal", the liner might still have a real value. Liners, when used, need to support (and keep on supporting) the overlaying composite restoration. Any decomposition will result in a defective base, causing a possible pumping/percolating action during mastication - resulting in sensitivity[7,8]. The use of Calcium Hydroxide liners to stimulate secondary dentine formation for pulp protection is being re-considered. Some researchers say secondary dentine will form in any case - as a response to the restorative process, while others question the need for secondary dentine when a good seal can be provided[11,16-20]. Regardless, many still advocate the use of Calcium Hydroxide in near exposures until such time as other methods and materials could be clinically proven[21-23].

Cavity Preparation Techniques

a) Trauma: This is an important factor often overlooked as a possible cause of post-operative pain. With dentine being living tissue we should expect some response, no matter how "atraumatic" the operator removed the caries and prepared the cavity.

b) Heat: This can be generated during cavity preparation due to excessive pressure, and is often caused by blunt burs. Cavity preparation without using proper water spray could also result in excessive heat build-up or dehydration of the pulp. According to Zach and Cohen, (1965) a 5.6°C pulpal temperature rise could cause severe pulpal necrosis[24]. Sharp burs with adequate water spray should always be used during preparation, as well as an intermittent drilling action. Operators should be especially careful when using slow handpieces for caries removal – burs must be sharp, while the pressure applied and duration of contact must be kept to a minimum.

c) Pulpal dehydration: This can occur due to the displacement of pulpal fluid. Dehydration is limited by the resulting smear layer, but prolonged exposure, especially after etching, could lead to pulpal trauma through dehydration[6].

d) Pulpal exposure: If complicated with bacterial contamination, it can definitely cause sensitivity. Caries on the

pulpal floor area should be removed last to prevent/limit bacterial contamination in case of an accidental pulpal exposure (first remove caries along the cavity walls).

Cavity Margins

An important factor in preventing possible micro-leakage (and thus sensitivity) is the part of the tooth in which the cavity margins are located. The bonding procedure is only reliable in dentine and enamel but questionable in cementum. According to Ferrari et al. (1997) a hybrid layer can be established in cementum, but it is not clear if long term stability can be maintained[25]. Root cementum is often poorly mineralized due to Tomes' granular layer and the hyaline layer and therefore etching of the cementum produces only limited micro-retentions for the bonding agent to adhere to[26]. Ideally the restoration margins should be kept in enamel or dentine. Restorations with margins in cementum are highly questionable.

Bevels

It is generally accepted that in adhesive preparations, some type of bevel must be prepared on the cavo-surface margins. Bevels provide more surface area for bonding and help reduce marginal fracture and leakage[3,27-31]

Composite Restorative Techniques And Materials

During the preparation of an adhesive resin restoration, various factors must be taken into account:

a) Isolation: The placement of rubber dam is important in areas where the prevention of contamination cannot be guaranteed. Should the clinician not be able to place a proper functioning rubber dam, at least optimal contamination control should be provided using haemostatics with cord (class V lesions) and accompanying cotton rolls and suction[26, 32-37].

b) Etching: Etching removes the smear layer, smear plugs and also de-mineralizes the surface dentine. Although a contentious issue, some believe that etching with 37% phosphoric acid for 10- 30 seconds does no permanent damage to the pulp, even if some etchant comes into direct contact with pulpal tissue[13]. Subsequent research does however question the long-term outcome of pulpal contact with acid and/or bonding agent and clinicians are currently advised to await long-term clinical studies before exposing the pulp to such materials[21, 38-42]. Etching per se. is probably not a cause of post-operative sensitivity. What may be a factor is that the positive pulpal pressure might cause an outward fluid flow through the dentinal tubuli once the smear plugs are removed. This could lead to pulpal dehydration or contamination of the bonding surface[43]. Vasoconstriction of pulpal blood supply by some anaesthetizing agents limit this flow but prolonged "open" tubuli might still result in dehydration of the pulp.

The etching time is also a factor to be considered. Etch the dentine for 10 seconds using 35-37% Phosphoric acid. This will ensure that the dentine is decalcified to a depth of only 1-5 μm. Deeper decalcification might result in incomplete resin penetration during hybridization and subsequently lead to various post-operative problems such as sensitivity, nano-leakage and ultimately premature failure of the bond to tooth structure[44-46].

Rinse the tooth structure well in order to completely remove all acid and silica which is used in the gel-type etchants. Particular care should be taken not to leave behind etchant in the floor area of distal 'boxes'. After washing off all the etchant, the tooth structure should not be dried as was recommended a few years ago. Exposed dentine has to be kept moist at all times to prevent possible dehydration of the pulp as well as collapse of the exposed collagen network[47,48].

c) Priming And Bonding: The main aim is to establish a proper dentine hybrid layer. This layer will provide a solid bonding surface and also seal all exposed dentinal tubuli. If all tubuli are sealed, no fluid movement can take place, no sensitivity can be provoked and no bacteria or bacterial products can penetrate the pulp [49,50]. The correct procedure for primer application is to apply it according to the manufacturers' instructions. The primer has to displace water in the demineralized dentine and in the absence of water, support the collagen[51-53]. If the clinician does not correctly apply adequate primer on the dentine surface, and also does not wait for at least 15-20 seconds for the primer to perform its role, complete adhesive resin penetration and fully hybridized dentine will not be achieved.

The correct application technique of the adhesive resin affects film thickness as well as the quality of the oxygen inhibition layer (the shiny non-polymerized layer that should be visible). Both are important in proper bonding to the composite restoration[6,54]. Incomplete resin penetration into the decalcified dentine will result in water leakage into the hybrid layer (nanoleakage) with resulting hydrolysis and degradation of the hybrid layer[55]. Each bonding system contains different resins and has different viscosities and properties. Using the correct application technique suitable to that specific bonding agent (according to the manufacturer's instructions) is of vital importance. The operator should never assume that, "if you can use one, you can use them all".

Self-etching Systems

Low post-operative sensitivity following the use of self-etching systems has been reported by various authors[56,57]. Although sufficiently high shear bond strength values have been obtained *in vitro*, some authors remain concerned about the long-term stability of these bonds[58-60]. Further areas of concern that were raised was the possibility of inadequate etching of enamel with weak acids, possible hydrolysis and expansion of the hydrophilic acid monomers due to water absorption, which may all compromise the adhesion to tooth structure[44,61,62]. However, some Self-etching systems have proven to be more than adequate for use in the clinical situation, with high bond-strength to both enamel and dentine, low micro-leakage and long-term favourable clinical results[63-67].

Contamination Of The 'Bonding Surface'

The proteins in saliva, blood and gingival fluid impair the wettability of etched enamel as well as dentine and tend to decrease bond-strength[68-70] .It seems as

if a surface contaminated with blood is a more serious problem than a surface contaminated with saliva[71,72]. Many studies, providing contradictory results, have been done on the contamination influence of temporary cements, in particular on the bond to dentine[73-75]. Eugenol has been reported to inhibit the polymerization of composite restorative materials. One study has shown that etching of enamel and dentine with 37% phosphoric acid effectively neutralizes the effect of eugenol but it remains questionable if this observation is applicable to all bonding agents[76].

d) Composite Application Techniques

Goldman, (1983) found a 1.7-5.7% volumetric shrinkage when he compared the polymerization shrinkage of various resin-based restorative materials[77]. Some modern highly filled (packable) composites tend to shrink even less (3.3-0.3%) with some modern formulations such as Siloranes shrinking less than 1%[78,79] . Shrinkage causes internal stress in the restoration itself, at the bonding interface as well as in the tooth structure. Correct techniques have to be applied to manage these stresses and minimize its negative effects. Negative effects include tooth cracks or deformation, de-bonding at the tooth/hybrid layer interface or cracks at the hybrid layer/composite interface. Internal stress lead to subsequent stress fractures[2,80,81].

Packing And Layering Technique

Students at most Dental Schools are taught to use incremental packing of composites and to limit the thickness of each layer to 2 mm. This ensures complete curing of each layer per 30-40 seconds curing and also better management of shrinkage stress. Modern thinking is that the use of 2mm horizontal increments alone is not adequate to limit shrinkage-related stress damage. The so-called configuration factor (C-factor) was formulated as a means to determine the stress effects according to cavity geometry. The C-factor is described as the total number of bonded surfaces divided by the number of free surfaces[82,83]. The higher the C-factor, the more the chance of the restoration failing due to the effect of shrinkage-related stress on the bonded surfaces. The five potential 'surfaces' involved are the 'cavity walls', i.e. buccal, lingual, occlusal, mesial and distal. A class one cavity will have a C-factor of 5/1, with a class two cavity a C-factor of 3/2. Therefore, by packing horizontal layers (3-5 bonded surfaces), the operator is in fact causing a higher C-factor than when packing that same layer vertically or diagonally (thereby connecting fewer "bonded surfaces" per layer packed). The clinical application is that when packing the increments, the dentist has to guard against connecting any two cavity walls per layer of material packed, (especially B-L) thereby limiting the effect of the C-factor.

e) Light-curing (Polymerization)

Light-curing of composite materials is a current and controversial topic. Positive and negative results with slow/ramp using traditional lights have been obtained[82,84].Conflicting results have also been obtained using rapid Laser, Diode or Plasma light curing[85-90]. Notwithstanding the technique used, complete curing of the restoration is essential, because the patient will bite/chew on the restoration within a few minutes after placement. It is well known that even with "complete" 40 second curing, using a traditional curing light, curing is not 100% and according to Braem et. al., (1987) the cured composite is especially vulnerable within the first 10-15 minutes after curing. Modern high-energy curing lights have increased conversion rates and although polishing and finishing should ideally be postponed until the next day, clinically acceptable finishing and polishing can be performed immediately following placement and curing[91-93]. Research into the effects of different curing lights and techniques are ongoing, with the ultimate goal of achieving a complete, rapid cure, but at the same time minimizing the shrinkage stress which occurs in the polymerizing composite. It has to be remembered that two different composites, exhibiting the same amount of shrinkage, might produce different shrinkage stresses when the same curing technique is used. The higher the total polymerization stress, (not necessarily the shrinkage) the greater the chances of microleakage and/or cracks occurring[82,94,95].

Traumatic Occlusion

Posterior teeth are subject to constant occlusal forces and changing temperatures, constantly stressing the material as well as the bonding interface. Should the restoration interfere with the occlusion in any way, this will aggravate the problem and traumatize the periodontal ligament. Any of these situations could lead to immediate and/or subsequent sensitivity. It is vital to ensure that, once the restoration has been completed, the occlusion will be normal in all planes with no part of the restoration interfering.[96,97].

Polishing And Sealing

The advantages of proper polishing of all restorations are well known. Polishing does not have much effect on post-operative sensitivity unless the technique used generates excess heat from either too long contact, or too high pressure applied to polishing cups. Even short application at moderate pressure can cause heat build-up with resultant pulpal trauma. Sealing of restorative surfaces is a relative new innovation with a few companies marketing products specifically for this purpose[98,99]. The reasoning for the use of these products is as follows: Since a "perfect" seal is difficult to achieve, it is safe to say that most restorations will have micro-gaps (at least in some areas) at the cavo-surface margin once initial polymerization has been completed[3]. A low viscosity, unfilled resin is applied to the surface of the restoration, left for 10-15 seconds, air thinned to force it into possible gaps or irregularities and subsequently light-cured. Although research provides conflicting reports on the success of such seals, they might provide additional protection from micro-leakage, post-operative pain and subsequent secondary caries[100,101]. Examples of such products are: Fortifya and PermaSeal[b]

CONCLUSION

There are many possible causes of post-operative sensitivity. Any open tubules, voids, internal stresses, cracks or marginal leakage might cause trouble in due course. Microleakage and sometimes nanoleakage will start destroying the restoration from the moment the patient leaves the dental office. Post-operative pain serves as a warning that something is wrong. If nothing is done to investigate the cause, pulpal death

may be approaching slowly and silently. Posterior composite restorations (compared to anterior region composite restorations) pose some special problems ie. larger volumes of restorative material, larger cavities with resultant tooth weakening, high occlusal forces, inter-proximal contact that has to be maintained and difficulty in achieving and maintaining moisture control.

It is a challenge to operate in the 'difficult-to-work-in' posterior region using 'difficult to-work-with' and 'technique sensitive' materials. Post-operative sensitivity can occur easily, and great care should be taken in order to properly complete all the steps in the placing of resin restorations. It is advised that practitioners who do not feel comfortable with the difficult composite technique at this stage, should rather do a good amalgam restoration, thereby ensuring a far more predictable outcome and a longer life for the tooth/teeth in question.

With excellent high quality resin restorative and bonding materials available, and by using the correct placement techniques, nobody should doubt the potential long-term clinical success of a posterior composite restoration. A composite which had been placed correctly, can be expected not to cause any post-operative sensitivity.

Footnote:

a- Bisco, Lombard, Illinois, USA
b- Ultradent Products, Salt Lake City, Utah, USA

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