POSTERIOR COMPOSITE RESINS

A CURRENT ASSESSMENT

HISTORY

The use of posterior composite resins has been increasing for some time due to patients' expectations for esthetics and the lingering concern over mercury toxicity despite decades of formal proceedings on the safety of dental amalgams that produced no sound scientific evidence of chronic toxicity in humans.

Figure 1

The quest for composite resins with sufficient strength and durability for posterior placement actually began nearly four decades ago, shortly after this class of materials was introduced to the dental profession as an extraordinarily successful alternative to silicate cements and direct filling resins.[1,2] Earlier materials showed relatively high rates of wear and secondary caries after a couple of years. [3,4] Figure 1 shows a cast of an earlier composite resin in tooth number 19 after two years. The occlusal wear along the margins is apparent and measured approximately 400 microns.

For the most part, these problems have been overcome due to evolutionary advances in composite resin technology that included improved adhesion to dentin resulting in less microleakage and secondary caries development, a reduction in the size of inorganic filler particles resulting in less wear, and visible light curing resulting in improved adaptation due to an unlimited working time as well as increased physical properties due to the elimination of voids incorporated during the mixing process.

ADVANTAGES

The advantages posterior composite resin restorations offer over dental amalgam are many:

Esthetics

Most modern day composites are made available in numerous shades and several variations in opacity making possible excellent optical matches to tooth structure. The figures below (series courtesy Dr. Jeff Blank) show a commonly used composite layering technique that can result in a high level of esthetics when restoring posterior teeth.

Figure 1. Cavity preparation

Figure 2. Flowable composite liner placed

Figure 3. Body layer placed up to DEJ

Figure 4. Enamel layer placed – finished restoration

Conservative Cavity Preparations

A major benefit to using composite resins is the ability to prepare very conservative cavity preparations. When coupled with the strong bonds that can be formed with enamel and dentin, the result is less weakening of tooth structure. There is usually no need for undercuts or extending cavity preparations into self cleansing areas. Line angles are rounded and occlusal bevels are often not necessary. Figures 5 and 6 show an array of conservative cavities prepared to receive composite resin restorations.

Figure 5

Figure 6

Increased Wear Resistance

At a recent meeting of the International Association of Dental Research, data were presented on a packable posterior composite resin, SureFil® High Density Posterior Restorative, DENTSPLY/Caulk, Milford, DE, showing mean marginal wear of only 142 microns after ten years.[5] Considering this is less than wear measurements recorded for posterior enamel cusps,[6,7] it is apparent that contemporary composite resins matrerials can withstand the challenges posed in the posterior region of the mouth.

Reparability

It has been shown that composite resin can bond to previously cured material, even after the oxygen inhibition layer is removed, if the cured surface is first etched with phosphoric acid and then coated with a chemically compatible bonding agent.[8]

Lower Coefficient of Thermal Conductivity

Teeth often become more sensitive to temperature fluctuations following operative procedures, and restorative materials capable of rapidly conducting heat can only add to the problem. Dental amalgam is more than 30 times more conductive than dentin and gold is approximately 500 times more conductive;[9] therefore insulating bases are required when these materials are used in deeper restorations. While the minimal thickness of an insulating material has not been specified, anything less than 0.5 mm would be considered of little help.[10] Filled resin materials are not good conductors of heat and in fact offer greater insulation than dental enamel,[11] a desirable property that obviates the need for insulating bases.

Lower Incidence of Cusp Fractures?

Numerous statements and implications have been made that composite resin restorations in posterior teeth are less likely to be associated with fracturing of remaining cusps because they can be bonded so well to tooth structure. The argument makes sense from the standpoint of material science, however, it is not well supported with evidence. One study that observed 10,869 posterior teeth with amalgam or composite resin restorations in 1,902 patients found no significant difference in the prevalence of cusp fractures between the two restorative materials.[12] There was a higher prevalence of cusp fractures in teeth with more than one surface restored and in older individuals but these were independent of the specific restorative material used.

Figure 7. Fractured DB cusp #3 (Courtesy Dr. Jeff Blank)

DISADVANTAGES

Despite the many advantages offered by composite resins and the vast improvements that have been made in the properties of these materials over the past three plus decades, issues remain with their use in the posterior region of the mouth, particularly for larger restorations. In 1998 the American Dental Association (ADA) issued a position statement on posterior resin-based composites that in general supported their use, but not in teeth with heavy occlusal stress, in sites that cannot be isolated or in patients who are allergic or sensitive to resin-based composite materials.[13] While a more recent position statement has not been published, the ADA did host a panel discussion on posterior composite resins, the proceedings of which appeared in the summer, 2006 issue of the ADA Professional Products Review.[14] The panelists noted that while the reports on the performance of posterior composites have generally been favorable, concern remains regarding use of the material in large restorations and the durability of the bond to tooth structure since bonds have been shown in the laboratory to deteriorate over time. It was further suggested in the panel discussion that posterior composite resins not be placed in situations where good isolation is not possible, in patients with a high caries rate and/or poor oral hygiene or in patients who clench or brux their teeth.

Some disadvantages associated with the placement of composite resin restorations in the posterior region of the mouth are as follows:

Technique Sensitivity

It has long been recognized that placing posterior composites resins is a more demanding clinical procedure compared to dental amalgam and may require twice the time for completion, particularly in multi-surface restorations.[15] Adequate light curing is essential for maximal physical properties, and incremental placement is necessary due to polymerization shrinkage stress and depth of cure limitations. Obtaining proper anatomic form and marginal adaptation is more difficult with composite resins due to their plastic consistency compared to the carving characteristics associated with dental amalgam. Isolation becomes more critical when using composite resins than with dental amalgams or glass ionomer cements since moisture contamination during the polymerization process can result in reduced physical properties.

Obtaining proximal contact is also more difficult since even the heaviest bodied composite resin formulations have difficulty holding an extended matrix band in position, and specialized matrix systems are normally required (Figure 8).

Figure 8. Sectional matrix in place (Courtesy Dr. Mark Latta)

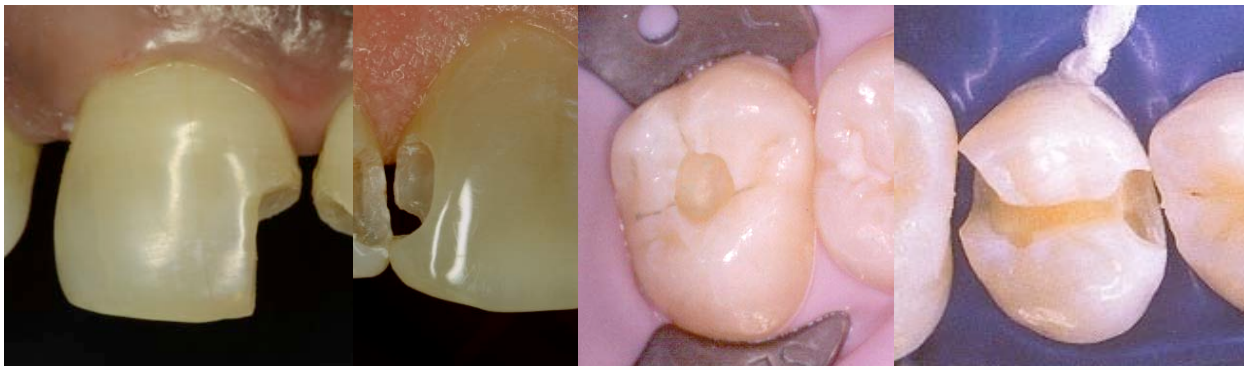
Perhaps the greatest source of technique sensitivity in using composite resins is the need to bond to enamel and dentin. Modern day adhesives can bond adequately to both hard tissues even though they vary considerably in the number of steps involved, the type of solvent used and, in the case of self-etch adhesives, the pH value which can greatly influence the aggressiveness of the etching pattern. Most of the documented clinical trials on adhesives have been in non-carious cervical erosion lesions since their non-retentive nature presents a formidable clinical challenge to the strength and durability of an adhesive bond. These trials have shown good results with both etch-and-rinse and self-etch adhesives, but the most consistent results seem to be associated with the three-step etch-and-rinse systems and the two-step self-adhesive sytems.[16]

Non-antimicrobial

Unlike dental amalgam, composite resins are unable to arrest the growth of microorganisms, which could result in a more rapid progression of recurrent or secondary caries.[15,20]

Polymerization Shrinkage Stress

The resin matrix of composite resin materials is composed of monomer molecules that upon polymerization convert to a polymer network wherein molecules are packed closer than in their free state leading to bulk contraction.[17] If the resulting stress is greater than the bond strength to tooth structure, debonding could occur leading to marginal gap formation and irritation of the pulp due to microbial colonization.[18] The extent of shrinkage and the resulting stress will depend upon the dynamics of the polymerization reaction and the level of inorganic filler loading. At the clinical level, the degree of stress placed on restorative margins is most influenced by the bulk of material being cured and the configuration of the cavity into which the material is placed. The potential for a given cavity configuration to cause stress at the margins of a restoration is known as the "C" factor and is calculated very simply by dividing the number of bonded internal cavity surfaces by the number of non-bonded surfaces. Below are shown the C factors for the various cavity classes (Courtesy Dr. Jeff Blank).



Class IV C=0.5 Class III C=1.0 Class I C=5.0 Class II C=2.0

Little clinical evidence exists to support a relationship between negative outcomes and polymerization shrinkage stress; however, direct effects relative to bond stability can be shown in the laboratory. It is therefore prudent to at least bear in mind that shrinkage stress is likely an undesirable property for a restorative material and practical steps that could minimize shrinkage stress should be considered. Such steps include vertical rather than horizontal layering of composite resins and avoiding the placement of bulk amounts of the material prior to light curing.

POSTERIOR RESIN COMPOSITE FAILURE AND CAUSES

Since composite resins were first considered as a potential replacement for dental amalgam, questions have been raised as to their suitability for such a critical role in dentistry. There are many reports comparing the success rates of the two materials, and by and large composite resins have shown acceptable performance even if not quite to the level of dental amalgam. Matching the efficiency of dental amalgam as a public health measure is indeed beyond the reach of most restorative materials. Table 1 shows the results of one comprehensive study that followed over 1700 posterior restorations for a seven year period. Half of the patients received composite resin restorations while the other half received amalgam.

TABLE 1

MEAN ANNUAL SURVIVAL RATES OF COMPOSITES AND AMALGAMS AFTER SEVEN YEARS (%)		
CHARACTERISTIC	**AMALGAM**	**COMPOSITE**
TOOTH TYPE		
Premolar	**94.5**	**85.7**
Molar	**94.4**	**85.5**
RESTORED SURFACES		
1	**98.8**	**93.6**
2	**90.5**	**80.6**
3	**88.5**	**66.2**
4 or more	**81.8**	**50.0**
SIZE		
Small	**98.9**	**93.6**
Medium	**93.3**	**84.9**
Large	**89.5**	**74.3**
ALL	**94.4**	**85.5**

Adapted from Bernardo M et al[19]

As evident from the table, amalgam restorations did demonstrate fewer failures than composite resins over the seven year period, particularly in restorations with three or more surfaces where composite resins experienced a 50% failure rate in the largest restorations. This study also reported that the main reason for restoration failures in both groups was secondary caries. However, the proportion of failures due to secondary caries was higher in the composite resin group (88%) compared with the

amalgam group (66%). It has been reported that the most frequent sites for secondary caries are the gingival margins of all classes of restorations.[20] This is not terribly surprising given the difficult access many of these areas present as well as the challenges posed by bonding to dentin and cementum as compared with enamel.

While the main cause for failure of posterior composite resin restorations appears to be secondary caries in the area of the gingival margin, the specific reasons for caries development are far less clear. Certainly a low level of oral hygiene is considered by many as causative, yet the evidence is scant. It is known that the replacement rate for posterior composite resins is higher in adolescents compared with adults, perhaps owing to poorer oral hygiene and higher sugar intake in the younger cohort. The technique sensitivity of composite resin placement and associated bonding procedures have been thought to contribute to a reduced survival rate compared with amalgam, but evidence here is also lacking. One study had Class II restorations placed in teeth destined for extraction, following which the restorations were observed on radiographs and under scanning electron microscopy.[21] It was reported that only 27% of gingival margins were free of defects, a finding that would support the technique sensitivity involved with placing composite resins in posterior teeth and perhaps also the higher risk these areas face with respect to secondary caries. Surprisingly, the study also found that *none* of the following variables had an effect on the quality of gingival margins:

- Experience level of the operator
- Horizontal versus vertical layering of restorations
- Type of adhesive; one-step etch-and-rinse, two-step etch-and-rinse or two-step self-etch

While this study highlighted the gingival margin as an area that should receive focused attention, it did not suggest that experience, layering technique or adhesive selection would help remedy the observed defects. Another study that evaluated the longevity of posterior resin composite restorations cast a shadow of doubt over the insistence on the part of some that rubber dam isolation is essential for a successful restoration since it did not result in significantly higher survival rates than isolation by cotton rolls.[22]

LINERS

Some comments regarding the use of liners- and flowable composites in particular- beneath posterior composite resin restorations are in order since a recent survey[23] indicated that 90% of dentists have used a flowable composite in the past twelve months, and that 82% of flowable users apply them as liners. The use of flowable composite liners has been claimed to increase marginal adaptation in the gingival marginal area of Class II restorations thereby reducing microleakage. It has also been claimed to mollify polymerization shrinkage stress on the part of the composite resin due the more more elastic nature of flowable composite resins. Recent work has shown that the use of a flowable liner showed fewer voids at the interface of the restoration and tooth structure in the cervical area of Class II restorations when compared with bonding agent and resin composite alone.[24] The study also showed that thicker (2mm) flowable pre-cured liners showed more marginal leakage when compared with thinner (0.5-1mm) liners. This finding would obviously refute the notion that flowable liners could counteract the effects of polymerization shrinkage stress from the composite resin. Finally, this study showed that a lining technique originally presented by Jackson and Morgan[25] involving placement of a packable composite over a thin uncured flowable liner resulted in the best marginal sealing of all groups tested.

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