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Guidance on posterior resin composites: Academy of Operative Dentistry - European Section

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ABSTRACT

There have been many developments in operative dentistry in recent years, including a progressive shift to the use of resin composites, rather than dental amalgam, in the restoration of posterior teeth. This shift allows the adoption of minimal intervention approaches, thereby helping to conserve and preserve remaining tooth tissues and structures. This paper presents the position of the Academy of Operative Dentistry European Section (AODES) in relation to posterior resin composites. The AODES considers adhesively bonded resin composites of suitable composition and properties to be the ''material of choice'' for use in direct minimal intervention approaches to the restoration of posterior teeth. In so doing, the AODES emphasises the importance of the practice of evidence-based minimal intervention dentistry, including the use of refurbishment and repair techniques to extend the longevity of restorations. Guidance, based on best available evidence, has been made in relation to certain aspects of resin composite placement techniques in posterior teeth.

Introduction

Operative dentistry remains the mainstay of dental practice. It accounts for a large element of the oral healthcare provided by dental practitioners on a daily basis. Much of this care comprises the prevention and diagnosis of caries, the restoration of diseased and damaged teeth, and the monitoring and care of teeth previously restored. The replacement of defective restorations continues to be a very common procedure.

Traditionally, in most countries of the world, dental amalgam has been the material most commonly used for the restoration of posterior teeth affected by caries. The

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popularity of dental amalgam stems from practitioners' familiarity with its handling, ease of placement, predictable performance in clinical service and low cost.[1] However, dental amalgam suffers the major limitation, amongst others, that cavities destined to be restored with this material invariably have to be modified, at the expense of sound tooth tissue, to provide necessary resistance form and mechanical retention. Without reliance on modern approaches to prevention, the traditional, widespread use of dental amalgam has, in many countries, created a phenomenon known, in particular in the UK, as the ''heavy metal generation'' – the cohort of ageing patients who received many extensive restorations of amalgam in the 1970s and 80s, during the so-called ''drill and fill'' era.[2] Such patients present a significant and growing challenge clinically, with ever-increasing costs associated with the maintenance of their restored teeth by means of replacement restorations, and more advanced forms of care, including endodontic treatments and crownwork, as indicated clinically.

In contrast to the use of dental amalgam, the use of adhesively bonded resin composite materials, which are increasingly found to perform as well as dental amalgam in clinical service, allows the adoption of minimal intervention approaches to the restoration of posterior teeth.[3] This, together with the capacity to repair posterior resin composites in ways which are not possible with dental amalgams, helps conserve and preserve tooth tissues, let alone provide more biomechanically-favourable restored tooth units.[4,5] The main disadvantages associated with the use of resin composites in the restoration of posterior teeth include contraction on polymerisation and relatively long placement times, which may extend to nearly twice the time taken to complete an equivalent procedure using dental amalgam. However, the use of careful application techniques may largely eliminate the potentially damaging effects of polymerisation contraction, and when considering placement times, it is to be remembered that completed posterior resin composites are typically finished to a much higher standard than a newly placed restoration of dental amalgam.[6]

Recently, the United Nations Environmental Programme has put in place arrangements – the Minamata Treaty – for a phase-down in the use of dental amalgam as part of an overall objective to reduce environmental mercury levels.[7] The implementation of the arrangements set out in the Minamata Treaty will necessitate new thinking and approaches in the practice and teaching of operative dentistry, which is anticipated to accelerate the rate of shift to the use of resin composites in restoration of posterior teeth.[8,9] Indeed, the Minamata Treaty may be considered to signal the beginning of the end for dental amalgam. A similar decision was published by the European Commission in July 2012.[10]

Posterior resin composites: the evidence

Lingering scepticism in relation to the suitability of resin composites for the restoration of posterior teeth is not supported by the growing body of relevant evidence. In a comprehensive review of clinical outcome studies, Manhart et al. reported a mean annual failure rate of 2.2% for direct posterior resin composites, in comparison to an annual failure rate of 3% for restorations of dental amalgam.[11] The Nijmegen group has for several years followed a large cohort of patients in whom posterior resin composites have been placed in a primary care setting.[3,12] They have published 10- and 12-year outcome data demonstrating comparable longevity for restorations of dental amalgam and resin composites, including large restorations of both materials. In low caries risk patients the performance of posterior resin composite restorations was superior to that of dental amalgam. Large composite restorations showed annual failure rates of 1%. In high caries risk patients there was a tendency for more failures of the posterior resin composites, significantly for smaller restorations, and annual failure increased to more than 3%. Similar findings were obtained in two clinical trials comparing restorations of dental amalgam and resin composites placed in the management of primary caries in children.[13,14] Analysis of insurance data from the northwest USA revealed that within a group of more than 300,000 patients with restorations placed during 1993–1999, the probability of survival of an amalgam restoration was 94% over five years if the patient was followed up by the same dentist. The corresponding figure for posterior resin composites was 93%. When patients changed dentist, the probability of survival of both amalgam and resin composite over the five-year period dropped to 60%.[15] A Brazilian group has published data, based on long observation times (up to 22 years), demonstrating annual failure rates of 1–3% with the use of resin composites in the restoration of posterior teeth.[16,17] A recently-published prospective study of posterior resin composite restorations placed by several practitioners in a large group of children and young adults in Denmark found an annual failure rate of 2% over the eight years follow-up period.[18] A study of similar design demonstrated a 2.9% annual failure for resin composite restorations, compared to 1.6% for restorations of dental amalgam after 4.6 years observation.[19] These data suggest, contrary to thinking typically based on the findings of cross-sectional surveys,[20] that the overall success of posterior resin composite restorations may be found to match, and in specific situations exceeds that of restorations of dental amalgam, even in patients with a relatively high caries risk.[3,12] A more recent investigation of replacement rates for restorations placed with US Navy and Marine Corps Personnel revealed no increased risk of restoration replacement when comparing posterior resin composite restorations to those of amalgam.[21]

In the management of specific conditions, including cracked tooth syndrome, often found in patients with extensive restorations of dental amalgam, and tooth wear, the use of resin composites has been found to offer many advantages, in particular when the use of a resin composite strengthens the remaining tooth structure and avoids the need to resort to more invasive and costly procedures such as the provision of a crown.[22,23] Furthermore, surveys of the teaching in dental schools over the past 20 years have demonstrated a progressive shift in countries across the world to the use of posterior resin composites in an ever-expanding range of situations.[24–38] In most European and, it is understood, many other countries around the world, dental students now gain greater experience in the placement of resin composites than amalgam in the restoration of posterior teeth.

Given the available evidence, the Academy of Operative Dentistry European Section (AODES) considers adhesively bonded resin composites of suitable composition and properties to be the ''material of choice'' for use in direct minimal intervention approaches to the restoration of posterior teeth. The AODES acknowledges that resin composites do suffer certain limitations and there are certain indications for the use of alternative tooth coloured materials. The AODES is, however, of the opinion that such alternate materials should be used only in situations in which the use of a resin composite is contraindicated or is inferior. The AODES therefore considers the placement of resin composites to be appropriate in the following clinical scenarios in posterior teeth:

- treatment of primary lesions of caries.
- replacement of existing defective direct restorations.
- replacement of most inlays.
- repair of existing restorations, both direct and indirect.
- restoration of endodontically treated teeth which do not require the protection afforded by an extracoronal restoration.
- restoration of fractured and cracked teeth.
- restoration of teeth affected by tooth wear or erosion.

It is also noted that when managing early lesions of caries, resin-based technology such as resin infiltration techniques show much promise. Future developments are awaited in this important preventive approach to minimal invasive management of caries.[39,40]

However, certain scenarios cause specific challenges. As discussed below these include: subgingival margins and altered/abnormal enamel and dentine (e.g. amelogenesis imperfecta). As well as this, consideration may be given to alternate approaches when managing extensive cavities including those where multiple cusps require replacement. In this situation, practitioners may feel an indirect approach may offer a reasonable alternate choice. However placement of an indirect restoration may involve further loss of tooth tissue. A recent randomised controlled trial of direct and indirect composite cuspal restorations showed comparable outcomes for both techniques over a five-year follow-up period.[41]

Techniques

The AODES does not wish to be prescriptive in relation to the choice of techniques for the placement of resin composites in posterior teeth. It is recognised that an ever-increasing range of techniques, materials and instruments exist to facilitate the placement of posterior resin composites. In the best interests of patients, however, and with the aim of increasing the predictability of posterior resin composite restorations, the AODES considers it appropriate to outline evidence relevant to various aspects of the application of resin composites in the restoration of posterior teeth. In all situations resin composites must be used in strict accordance with the directions of the relevant manufacturer. The operative technique should include the use of magnification aids and be meticulous in its detail.

Contraindications

There are relatively few contraindications to the placement of posterior resin composites. These contraindications are shared with other restorative materials, notably an oral environment in which restorations will be prone to early failure. Good moisture control is essential during the placement of posterior resin composites to avoid, in particular, failure of adhesive bonding. The use of an effective rubber dam is ideal.

Special circumstances

In the presence of altered and abnormal enamel and dentine, as may occur in rare conditions such as amelogenesis and dentinogenesis imperfecta, but more commonly in situations where, for example, remaining dentine is affected by caries or is sclerotic, successful adhesive bonding may be difficult to achieve. In such situations the patient must be advised of the complication and its possible consequences, and consideration should be given to the placement of a 'trial' restoration to ascertain the likelihood of postoperative complications and early failure. In difficult cases e.g. with very deep/large lesions consideration may have to be given to an alternative, possibly indirect approach, which will inevitably be more invasive than the use of an adhesively bonded resin composite.

Where the cavity margin extends deep below the gingival margin, two problems typically need to be addressed. First, the cavity should be assessed to ascertain if steps can be taken to make the margin supragingival, or at least accessible for rubber dam isolation by means of typically some form of crown lengthening procedure. Should this not be possible then special soft tissue management measures must be taken to facilitate moisture isolation. Secondly where the cavity margin extends beyond the cement-enamel junction (CEJ) special attention must be paid to the adhesive bonding procedure and the placement of at least the first increment of resin composite. It is sometimes suggested that a very deep proximal box should be restored with a resin-modified glass-ionomer cement to the level of the gingival margin, prior to restoring the remaining cavity with resin composite. However, such 'sandwich restorations' may be found to be susceptible to fracture and other modes of failure.[42]

Cavity design

As one of the principal advantages of the use of a resin composite is the opportunity to adopt a minimal intervention approach to the restoration of a tooth, such opportunity must always be taken and used to realise the maximum benefit possible.

Following access to, and the appropriate management of the caries, there should be no need to enlarge the preparation. When designing cavities it would be sensible to identify the occlusal contacts with articulating paper first. Ideally these occlusal contacts should remain on enamel where possible. Assuming the application of appropriate indications for operative intervention, the preparation should never need to be deepened, in the belief that such action will enhance the mechanical properties of the completed restoration. All forms

of unnecessary cavity preparation iatrogenically weaken the remaining tooth tissues and structure.

In contrast to the techniques used in the placement of resin composite restorations in anterior teeth, which involve bevelling of the cavosurface margin, the completion of preparations to accept a posterior resin composite should not include bevelling of the margins.[43] Notwithstanding the evidence to discredit cavosurface margin bevelling when completing a cavity for a posterior resin composite, such bevelling causes confusion and the unnecessary loss, or at least damage to sound tooth tissue, as and when it becomes necessary to refurbish, repair or replace the restoration.

The situation in relation to the placement of bevels on the cavosurface margins of proximal boxes to be restored with a resin composite is less clear. There is some evidence to suggest that such bevelling can enhance the marginal adaptation of the completed restoration.[44,45] However, concern exists in relation to such bevelling resulting in loss of already-thin enamel from the gingival margin,[46,47] and the creation of thin flashes of excess resin composite in proximal areas difficult to access at the time of finishing the restoration. On balance, it is suggested that the cavosurface margins of proximal boxes to be restored with resin composite should be carefully smoothed and finished, but not bevelled.

Management of operatively exposed dentine

The decision to bond a posterior resin composite directly to operatively exposed dentine, or to first place a liner or base, causes concerns for many practitioners.[24,48] The decision to place a liner or base prior to placing a posterior resin composite appears to follow the traditional techniques used in the placement of a dental amalgam of more than minimum depth. As resin composites do not conduct heat in the same way as a metallic restoration, it is advantageous to maximise the surface area of dentine available for bonding, and the presence of a liner or bases may compromise the biomechanical behaviour of the restored tooth unit,[42] it would appear logical to avoid the use of a liner or base. Furthermore, there is evidence of no difference in outcome in terms of post-operative sensitivity when a resin composite is ''bonded'' or ''based''.[49] There is also biological evidence that etching exposed dentine, followed by bonding can drive dentine repair and new dentine formation, thereby helping to protect the pulp.[50,51] In areas very close to the pulp (<0.5 mm), the placement of an indirect pulp cap may be indicated. A recent review on direct and indirect pulp capping concludes that exposure of the vital pulp should be avoided at all times.[52] Should a pulpal exposure occur, emerging evidence suggests that MTA is superior to calcium hydroxide.[53] Newer products such as Biodentine have potential use in this situation.

In selecting a dentine adhesive system for bonding, consideration needs to be given to the suitability of the various systems available to the practitioner. A systematic review based on the retention rates for cervical restorations concluded that two-step self-etching systems, preferably with mild etching, and three-step etch and rinse systems may presently be considered as 'gold standard' materials for bonding.[54,55] This guidance is considered to be appropriate for posterior resin composite restorations. As in the use of resin composite systems the directions of manufacturers must be followed carefully at all times, in particular, to limit the risk for postoperative sensitivity. Self-etch adhesives cause more marginal staining, therefore in visible anterior areas with higher aesthetic demands additional enamel etching with phosphoric acid is recommended (so called 'selective enamel etching') when using self-etch systems.[56]

Selection of resin composite and placement techniques

The selection of resin composite is critical to clinical success. Fine (micro)- and certain nano-particle hybrid resin composites are, in general, appropriate for use in posterior load-bearing situations. As a general rule, the resin composite selected should contain at least 60% filler by volume. Careful technique is required during the placement of resin composite to limit the adverse effects of polymerisation contraction. Various incremental layering techniques have been recommended to reduce these effects. These techniques tend to concurrently enhance the depth and sufficiency of cure of the resin composite.[5] Reduced polymerisation contraction resin composites are now available. There is early evidence to support their use, but longer term performance data is awaited.[57,58]

Light curing

An ever-increasing range of light curing technologies exist for the photopolymerisation of resin composites. Currently available technologies include quartz tungsten halogen (QTH) light curing units (LCUs) and light emitting diode (LED) LCUs. LED LCUs provide comparable outcomes to QTH LCUs. LED LCUs have the advantage of being more energy efficient and portable than QTH LCUs. QTH LCUs have a broader spectrum in wavelength and could therefore activate all used photo initiators but are more susceptible to reductions in the quality and intensity of light output than LED LCUs, resulting in reduced curing potential and, in turn, compromised completed restorations. The power output of all LCUs should be checked regularly with a suitable radiometer. Care has to be taken with duo- and multi- wavelength LED units, as the distribution of the wavelength is not homogenous. Extended curing times (>10 s), with the light guide being held as close as possible to the resin composite being cured, are recommended on the basis that many problems are associated with insufficient curing.

Proximal contours and contacts

The creation of both a suitable proximal contact area and contour is necessary to avoid food impaction. A variety of matrix systems and devices exist to aid in the restoration of proximal contours and contact areas.

Transparent matrix bands and light-transmitting wedges were introduced at a time when it was thought that resin composites contracted towards the source of the incident curing light. Such thinking is, however, flawed, as it is has been appreciated for several years that resin composite does not contract towards the incident LCU source.[59] More

importantly, it is recognised that transparent matrix bands are excessively thick and can result in open proximal contacts.[60] In addition, light-transmitting wedges are too stiff to allow efficient adaptation of a matrix band to the gingival margin, thereby increasing the likelihood of proximal overhang formation.[61] As such, the use of transparent matrices and light-transmitting wedges is now contraindicated.

In contrast, metal matrix systems are thinner than their transparent counterparts and, as such, their use reduces the risk of deficient proximal contacts. The use of a flexible (wooden or plastic) wedge with a metal matrix system is capable of producing good gingival adaptation, limiting the risk of proximal overhang formation. Newer sectional, metallic matrix systems are widely considered to be the most effective matrices for use in the placement of posterior resin composites. Such systems may include separating rings to create an interproximal gap greater than the thickness of the matrix, thereby helping to create a tight proximal contact. The matrices in these systems are curved/precontoured, helping to create a favourable proximal contour.[61–63] Moreover, a properly contoured proximal surface makes the completed restoration, in particular, the marginal ridge less liable to chip and fracture in clinical service.[64] There is however some evidence of increased ''flash'' formation when sectional systems are used.[65] Overall, existing evidence indicates that precontoured, sectional, metal matrix systems, used together with flexible (wooden or plastic) wedges are best suited for use in the placement of posterior resin composites. The proximal margins of posterior resin composites placed using this approach to matricing need to be carefully assessed and, where indicated clinically, finished.

Finishing

Similar instrumentation and techniques should be utilised as used for anterior resin composites. However efforts should be made to render the completed posterior restoration a rounded, anatomically correct morphology and as smooth a surface as possible. Care should be taken, wherever possible, to contour and finish from restoration to tooth surface and to avoid overheating of the resin.

Refurbishment and repair

The vexed issue of managing defective restorations poses many challenges,[66–70] with evidence suggesting that dentists spend more time managing defective restorations than in the placement of initial restorations.[71] An important realisation is that many composite restorations with limited forms of deterioration can be successfully refurbished and caries at the margins of a restoration are new rather than recurrent lesions and do not always necessitate restoration replacement.[72] Oftentimes, it is possible to remove the caries and any associated defective section of restoration and, following appropriate caries management, effect a repair.[66–70]

While there is a concern that high-quality evidence does not yet exist to support restoration repair,[73,74] there is evidence to demonstrate the success of restoration repair when practised appropriately.[75–77] The view must be taken that the replacement of a restoration is contraindicated when the majority of the restoration concerned is intact and caries free. A repair offers an effective minimal intervention approach in such situations.[78]

Conclusion

The Academy of Operative Dentistry European Section (AODES) considers adhesively bonded resin composites of suitable composition and properties to be the ''material of choice'' for use in direct minimal intervention approaches to the restoration of posterior teeth. In so doing, the AODES emphasises the importance of the practice of evidence-based minimal intervention dentistry, including the use of refurbishment and repair techniques to extend the longevity of restorations. Recommendations, based on best available evidence, have been made in relation to certain aspects of posterior resin composite placement techniques. The application of modern, evidence-based approaches may be found to result in the safe provision of effective and predictable posterior resin composites.

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