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A History of Posterior Composite Restorations As Viewed Through the Pages of *Dental Update*

Abstract: Patients today are increasingly seeking tooth-coloured restorations for their posterior dentition, and with the anticipated decline in the use of amalgam as a result of the Minamata Agreement, this trend will increase. However, these are relatively recent considerations, given that the first dedicated resin composite material intended for use in posterior teeth appeared in 1986. Although macro-filled resin composite materials were available prior to 1986, they exhibited poor wear resistance. This article reviews the history of so-called 'posterior composite' restorations as gleaned from the pages of *Dental Update*, including how some of the early techniques described were subsequently proved to be erroneous, and how knowledge from research and clinical experience corrected these, so that clinicians may now place predictable, reliable, aesthetic 'posterior composite' restorations.

CPD/Clinical Relevance: Lessons from the history of posterior composites may provide the foundation for their successful use in contemporary clinical practice.

Dent Update 2023; 50: 401–410

The use of resin composite as a restorative material for loadbearing situations in posterior teeth (termed 'posterior composite' throughout this article) has increased in recent years.[1] However, in terms of dental history, posterior composite is relatively young, at least compared with dental amalgam, which has been the 'gold standard' for over 125 years,[2] and gold castings, which have been used for a similar length of time. However, patient attitudes to a dental material that was not tooth-coloured appeared to change in the final decade of the last century,[3] as patient demand for aesthetic restorations in their posterior, as well as anterior teeth increased, patient anxiety with regard to a mercury-containing material being used in their teeth increasing,[4] and, the increasing impetus away from dental amalgam for environmental reasons, which was hastened by the Minamata Agreement in 2013,[5] in which 147 countries agreed to reduce (or phase out) their use of mercury. Dentistry, by way of dental amalgam, was part of that. The continuing reduction in the use of dental amalgam also results from professional demand for adhesive materials that promote the principles of minimally invasive dentistry.

As with any new material or technique, publications may have provided misleading information that purported to be sound advice at the time of the introduction, but which were later found wanting, even if much of the advice was correct. It is therefore the aim of this article to trace the history of posterior composite restorations by reviewing articles that were published in *Dental Update,* and other texts on the subject, in some instances amending the advice that was given in light of subsequence research and experience.

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A brief history of resin composite materials

Among the earliest publications on composite materials (now correctly termed *resin composite*) were two by Barnes and Kidd in 1980.[6] In a comprehensive and well-illustrated (particularly by SEM images) article, the authors did not specifically mention their use in loadbearing situations in posterior teeth, but provided the background for resin composite systems. Namely that they comprised a filler that may be powdered quartz, glass beads and/or ceramic particles, depending upon the manufacturer, colour provided by tinted powders and the resin, the so-called Bowen's resin, bisphenol A-glycidyl methacrylate (bis-GMA). This resin was too viscous for clinical use, so was diluted with resins of lower viscosities (and higher polymerization contraction), which contributed to the overall shrinkage of the material.

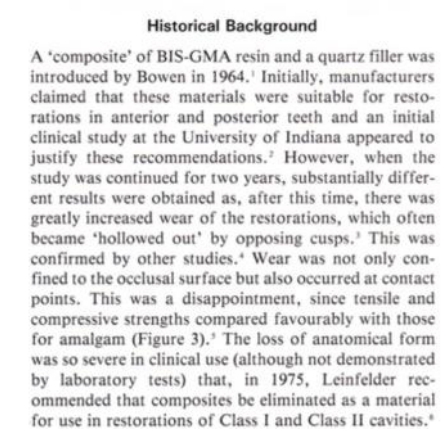
Manufacturers supplied unfilled resin (optimistically called the 'bonding agent') as a viscous fluid to be applied to the tooth before placing the restorative material. What might be surprising to readers who have only experienced the curing of resin composite materials by a light-curing unit, is that these early materials, introduced in the late 1960s, were generally paste/paste systems that polymerized when mixed, examples being Adaptic (Johnson & Johnson, Windsor, NJ, USA), advertised as an 'invisible filling material', and Concise (3M, St Paul, MN, USA). One paste contained peroxide, the other an amine: the material polymerized by reaction of these. These were 'macro-filled' composites, with large filler particles of up to 100 microns. This article also mentions light-cured materials, which were a novelty at that time.[6] The authors also suggested the need to acid-etch enamel margins, stating that gaps will occur if this is not carried out, and, while Buonocore,[7] in 1955, is widely credited with the first description of etched enamel used for acrylic restorations, without recourse to pins or undercuts, readers were advised that it was not actually until 1972 that Ward *et al*[8] described a similar technique using resin composite. Lastly, Barnes and Kidd[6] described the 'hazards' of placing resin composite materials in unlined cavities, resulting in pulp death, because of bacterial leakage, and resin penetrating the dentinal tubules.

In a second lengthy and well-illustrated article, Barnes and Kidd[9] described the clinical techniques for placement of resin composite restorations. While these included standard Class II and IV restorations, a wide variety of indications were covered, including composite veneers, changing tooth shape (peg-shaped laterals and diastema closures), splinting mobile teeth, constructing temporary bridges using a denture tooth as pontic, bonding of orthodontic appliances, and, probably the only technique that is not considered appropriate at the present time, pinned composite cores to support crowns on worn anterior teeth. This article, which is considered by the present authors to be truly ahead of its time, provides the first mention of the use of resin composite in posterior teeth and the subsequent loss of anatomical form after 3 years (Figure 1). In this regard, Barnes and Kidd[9] finished their article by stating 'the price of silver amalgam continues to rise and concerns have been raised about the availability and toxicity of mercury. There is therefore a need to develop a tooth-coloured restorative material as an alternative to amalgam alloy'.

Figure 1. Composite restorations in posterior teeth after 3 years, noting 'loss of anatomic form'. (Reproduced with permission from Barnes and Kidd[9]).

Posterior composites

Although there is anecdotal evidence that macro-filled resin composite materials were used by some operators in posterior teeth, the first resin composite material designed specifically for use in posterior teeth was released in 1986, namely, a light-cured, highly filled, hybrid type urethane-based posterior composite (Occlusin, ICI Dental, Macclesfield, UK). The same year saw the first publication in *Dental Update*[10] specifically relating to posterior composite: it carried the statement 'it is likely that patient demand for good aesthetics will lead to the increased use of these materials'. It provided a potted history of posterior composite (Figure 2) and the problem of the poor wear resistance of the early (macro-filled) materials that were available. This was a complication that had been identified by a number of researchers, but was brought into focus in a paper[11] that described wear on Class II restorations, not only on the occlusal surface, but also on proximal surfaces, and led to Leinfelder and colleagues[12] recommending that composites be 'eliminated' as a material for use in Class I and II cavities. However, that earlier publication indicated how 'new composites for use in stress bearing situations' overcame these difficulties by:



Historical Background

A 'composite' of BIS-GMA resin and a quartz filler was introduced by Bowen in 1964.[1] Initially, manufacturers claimed that these materials were suitable for restorations in anterior and posterior teeth and an initial clinical study at the University of Indiana appeared to justify these recommendations.[2] However, when the study was continued for two years, substantially different results were obtained as, after this time, there was greatly increased wear of the restorations, which often became 'hollowed out' by opposing cusps.[3] This was confirmed by other studies.[4] Wear was not only confined to the occlusal surface but also occurred at contact points. This was a disappointment, since tensile and compressive strengths compared favourably with those for amalgam (Figure 3).[5] The loss of anatomical form was so severe in clinical use (although not demonstrated by laboratory tests) that, in 1975, Leinfelder recommended that composites be eliminated as a material for use in restorations of Class I and Class II cavities.[6]

Figure 2. The situation, copied from Burke,[10] with regard to posterior composites in 1975.

- Manufacturers decreasing the exposed resin at the surface by increasing the filler content;
- Formulating new resins that showed improved corrosion resistance; and
- Improving the bonding of the filler particles to the resin matrix using a silane.

By the early 1990s, resin composite materials were found to have more than adequate resistance to occlusal wear.[13] Indeed, results of a 5-year multi-centre study on the survival of 649 Occlusin restorations in 1991 indicated a 12%

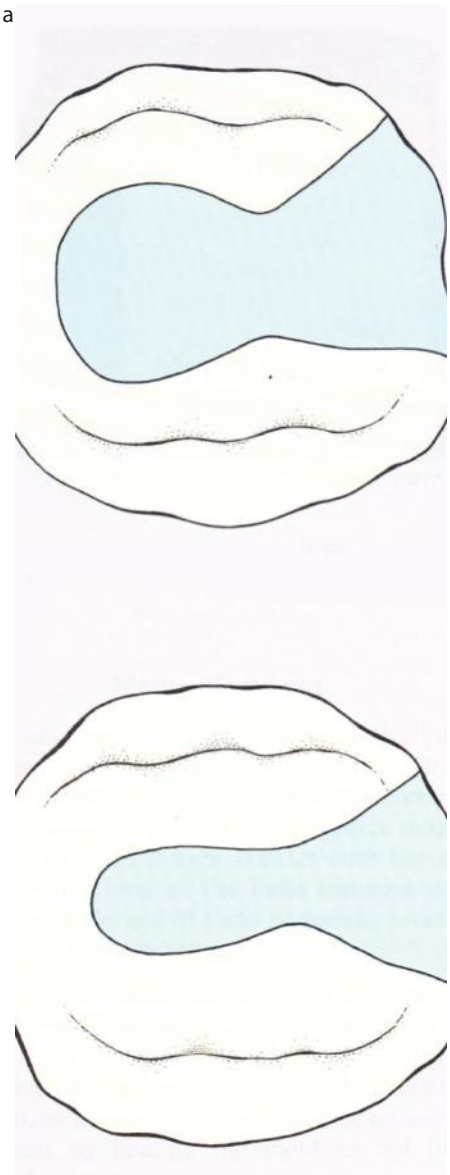


Figure 3. (a) Suggested Class II cavity design for composite (bottom) as opposed to that for amalgam (top), demonstrating reduced removal of tooth substance (reproduced from Burke[10]). Today, however, for posterior composite restorations, which are adhesive to tooth substance, there is no need for any occlusal key, unless caries is present occlusally. **(b)** Suggested Class II cavity design for composite, with no resistance to occlusal displacement, indicating tooth substance saved by avoiding undercuts and using rounded line angles. (Reproduced from Burke.[10])

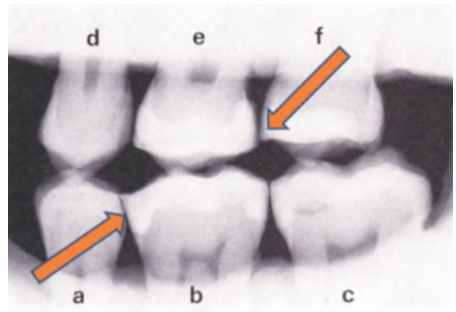


Figure 4. Radiograph demonstrating 'flat' interproximal contour and point contact too far occlusally as a result of an unburnished metal matrix being used in a Siqveland matrix.

failure rate over 5 years.[14] However, the authors of the study added that 'the results obtained could not apply to other posterior composites as the properties of the material under investigation are unique and were considered to be a major factor in the behaviour of the restorations'. They concluded that 'the findings provided substantial evidence that the material satisfies established clinical requirements for posterior composite restoratives over five years, despite the generalized occlusal wear of many of the numerous extensive, complex Class II restorations in molars having been found to be appreciably greater than that in the amalgam restorations investigated'. Posterior composites had arrived!

Early technique tips

Regarding cavity design, the 1986 publication[10] did not go so far as to suggest the minimal cavity design that has been considered appropriate for the initial Class II carious lesion today (and described later), but suggested a less aggressive Class II design (with no undercuts) than the conventional 'GV Black' cavity design for amalgam (Figure 3).

While these suggestions have stood the test of time, another suggestion in the 1986 publication stated 'since composite materials exhibit a mild irritant effect on the pulp, it is necessary to cover exposed dentinal tubules with a protective base'. Calcium hydroxide-containing materials, such as Dycal (LD Caulk) and Life (Kerr Mfg Co, Orange, CA, USA), were suggested as the lining of choice. Contemporary thinking is now very much against the placement of an intermediate liner under resin composite restorations,[15] with clinicians instead being encouraged to trust the bonding agent to seal the tooth tissue under the restoration. Linings also reduce the surface area available for bonding to dentine and to caries-affected dentine, to which contemporary adhesives form satisfactory bond strengths (*vide infra*).

Regarding contact points, a statement, now deemed to be erroneous, suggested that the Siqveland matrix, favoured for amalgam restorations, may be used for posterior composites. On the other hand, the author added, correctly, that, 'as composites may not be condensed or packed like amalgam, this type of matrix may not be pushed out to form a tight contact'. In that regard, a radiograph of extracted teeth simulating posterior teeth in a bitewing radiograph was included in the paper to demonstrate the opacity of various composite materials (Figure 4). However, this inadvertently showed the flat interproximal contour (arrowed) which may result from using a metal matrix in a Siqveland matrix holder. Celluloid matrices were also suggested. However, it is the present authors' opinion that these are unsuitable for placing posterior composite restorations as they present difficulty in being placed through a tight contact point, being thicker. They therefore cannot be burnished out to the contact. A circumferential matrix (Caulk Automatrix, Dentsply, UK) was suggested, as it was considered to be more easily burnished than the Siqveland system. This is still available, although the present authors consider that the SuperMat system (Kerr Mfg Co) is optimal for wide interproximal boxes and cusp replacements.

Pre-wedging (the technique by which a wedge is placed interproximally to achieve separation of the teeth prior to placement of the restoration) was suggested as necessary. The 1986 publication[10] stated that 'positive contact is achieved, compensating for the thickness of the matrix. This may be so, but the present authors consider that this is not often a factor with modern matrix systems, such as the sectional matrix (*vide infra*).

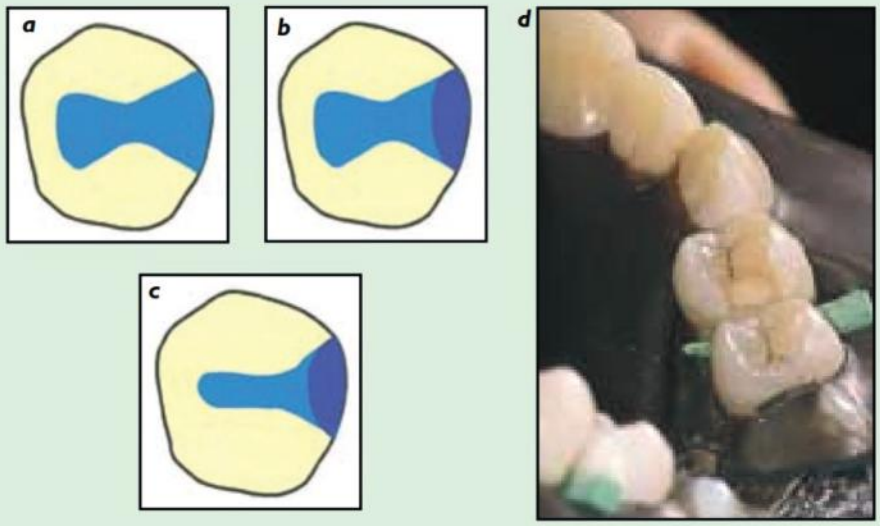


Figure 2. *Cavity designs.* ***(a)*** *'Traditional' GV Black design Class II cavity.* ***(b)*** *A minimal cavity preparation may be used for adhesive restorations, its size being governed only by the need to visualize caries and by the size of the instruments for packing the composite.* ***(c)*** *Tooth substance saved by use of an adhesive cavity design (shaded pale blue).* ***(d)*** *A minimal cavity in an upper premolar.*

Figure 5. Reproduced from Burke and Shortall.[22]

During placement of the restoration, this early paper suggested that good isolation is needed, and the use of rubber dam is mandatory. However, recent research has indicated that it might not be essential, provided that good isolation by other means is obtained, and an experienced dental nurse is available[16].

This early publication[10] also suggested that the cavity margins are etched prior to placing the 'bonding resin'. This was not a dentine adhesive as we now know them, but a coating of unfilled resin. There was a warning – 'if more than a minimal layer or unfilled resin is present at the restoration margins, this will wear excessively and lead to a deficient restoration'.

In summary, many of the recommendations stated in the original *Dental Update* article on posterior composites still hold true today, but others are subsequently considered erroneous by the advent of new matrix systems and new dentine adhesives.

However, the article[10] listed the advantages of posterior composites over amalgam, and it may be considered worthwhile to restate those, as all hold true in 2023:

- Superior aesthetics;
- Adhesive technique reduces the need for preparation of cavity retention and resistance form;
- Conservation of tooth substance;
- Suitable for large and small cavities;
- Protects residual tooth tissue;
- Using light-activated materials, a long working time is available;
- It is a proven, safe material with possible side effects of mercury (to patients and dental staff) being avoided;
- No possibility of galvanic action;
- Lower thermal conductivity;
- Shorter setting time, and polishable at the same appointment as placement;
- May be added to, or repaired easily;
- There is improved fracture resistance of teeth restored with posterior composite restorations.

This article concluded by stating 'in comparison to amalgam, our experience with composites in posterior teeth is small and it will be many years before we recommend these materials as a true amalgam alternative'.

The year 1988 saw the publication of an article describing the restoration of the minimal carious lesion using composite resin.[17] This described an alternative to 'prophylactic odontotomy', which was named the 'preventive resin restoration' (PRR) by Simonsen,[18] who later published[19] good success rates with the technique. It could be considered that this heralded thinking about minimally invasive restorative techniques, along with Mertz-Fairhurst's ground-breaking 'sealing caries' 10-year study.[20]

Meanwhile, by 2001, the results of a UK questionnaire-based study[21] with 654 respondents indicated that 35% of respondents used composite 'sometimes', 15% 'often' and 1% 'always' for restoration of extensive loadbearing restorations in molar teeth. Given that posterior composites were becoming more widely used, if by no means in the majority of cases, *Dental Update* articles played their part in suggesting methods whereby clinicians could enhance the quality of their posterior composite restorations, and use techniques which were readily reproducible, and, in turn, improve their success rates.

2001: more technique tips

In 2001, the placing of posterior composite restorations was, to many clinicians, something of a novelty. A publication in this year[22] mentioned that early evaluations of posterior composites demonstrated poor performance,[11] but by then, it was possible for two of the present authors to reference the results of a 10-year prospective clinical trial of posterior composites in Liverpool that demonstrated good performance.[23] Posterior composites were said to be suitable for small carious lesions, restorations for which appearance was important, moderate-sized Class I/II restorations: stated contraindications were patients with high caries risk, and/or poor oral hygiene, when isolation was not possible, large restorations, patients with bruxing habits and patients who were allergic to any of the constituents of composite materials. It was also suggested that patients needed to be made aware that posterior composite restorations were more time consuming to place than amalgam, and therefore more expensive. On the other hand, it was argued that the restoration types could not readily be compared because less tooth preparation was needed for composite because 'adhesive techniques are being used and there is no need for retentive features such as occlusal keys'. The figure in the article[22] that demonstrated this is reproduced here as Figure 5: this also shows a minimal, saucer-shaped Class II cavity (with an unnecessary lining in place!)

Restorative dentistry had also arrived in the era of matrix systems that were designed for posterior composites, such as

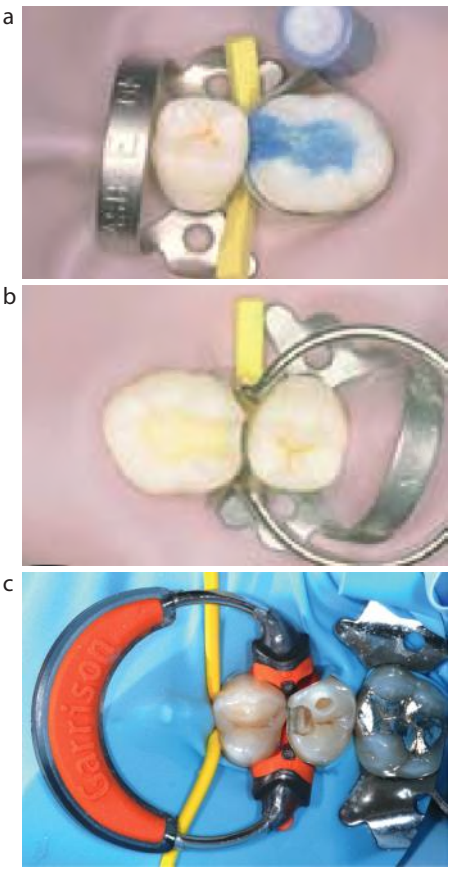


Figure 6. (a,b) Reproduced from Burke and Shortall,[22] illustrating matrix systems that were suggested as appropriate in 2001, and which are still recommended by the present authors. Hawe SuperMat is now Kerr SuperMat. **(c)** How a sectional matrix system (Garrison ComposiTight, Spring Lake, MI, USA) looks today.

Figure 7. Optitip in action.

Kerr SuperMat (previously Hawe Supermat) (Figure 6a, b) and sectional matrices, the latter having undergone many design improvements since 2001 (Figure 6c).

Regarding cavity design, it was suggested that 'extension for prevention' was not necessary across the fissures of an occlusal surface, and that cavities need not be extended through the buccolingual contacts. However, this publication reinforced the concept that, since interproximal caries occurs at contact areas, failure to extend the cavity beyond the contact area in a cervical direction could lead to leaving untreated residual caries, and/or secondary caries beneath the restoration. In addition, failure to extend through the contact in an apical direction would create difficulty in placing the matrix. This is reinforced in a publication over 10 years later.

The authors also advised (correctly) that occlusal analysis should form part of the assessment. In that regard, recent research[24] has advised that, for posterior composite restorations, the occlusal cavity margin should not be under occlusal load, indeed that any occlusal load should either be on enamel or on the restoration, and NOT be at the cavity/restoration interface. Also regarding cavity design, thin bevels were not advised at occlusal margins, given that they increase the surface area of the restorations and may predispose to fracture of the thin marginal composite. Another clinical suggestion that has stood the test of time.

The achievement of a tight interproximal contact has always been a challenge when placing posterior composites. In the 2001 publication,[22] the authors suggested Supermat (Kerr Mfg Co) and sectional matrices. The present authors, 23 years later, have the same recommendations. Additionally, they recommended Optitip (Kerr) (Figure 7), which was used to press the matrix against an adjacent tooth. The present authors recommend contact-forming instruments, such as Perform (Optident) and TriMax (AdDent Inc, Danbury, CT, USA). All of this is important when the consequences of a poor contact are apparent, namely, periodontal disease (Figure 8a) and caries (Figure 8b).

Figure 8. (a) Periodontal disease as a sequel to a deficient contact point. **(b)** Caries as a sequel to a deficient contact point and cavity insufficiently prepared in an apical direction.

The 2001 publication[22] was among the first to discuss the problems of polymerization contraction stresses, and how to counteract those. It suggested 'ramped curing', 'use of macrofillers' and the use of a flowable composite base. While the first two suggestions were later found to be of dubious value, the latter was later shown by research to be of value when a conventional resin composite was used,[25] but later work recommended the use of low shrinkage stress resins (*vide infra*). Finally, this publication[22] suggested that 'the practitioner takes hands-on courses for those wishing to add direct-placement tooth-coloured restorations to treatments available at their practices'. The same may apply at the present time, particularly to older clinicians who may have less experience in placing posterior composites, having not had the benefit of undergraduate training in such techniques, in contrast to new graduates in the UK today who are likely to have benefited from training in posterior composite techniques during their undergraduate careers.[26] Alas, the scarcity of postgraduate posterior composite training courses remains to this day.

In 2001, readers were introduced to the concepts of the configuration factor (C-Factor) (Figure 8), originally described by Feilzer *et al*,[27] which described the ratio of bonded to unbonded surfaces, the latter being where any shrinkage could occur. The occlusal restoration is therefore one of potentially high stress, while the cusp replacement (bottom centre in the diagram) is low stress. Incremental placement is therefore essential for conventional resin composites in occlusal cavities and Class II cavities (Figures 8 and 9).

Results of a 2004 publication[28] indicated that 'amalgam use was declining, particularly in the USA, Australia and Scandinavia, with lesser decreases in the UK, but that there were few governmental restrictions on the use of amalgam'. (In

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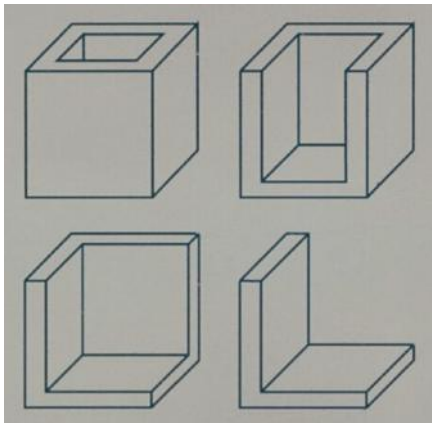

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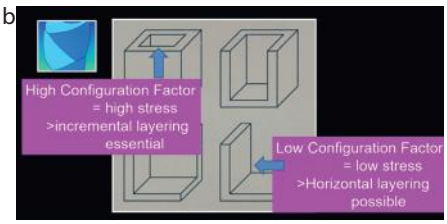

Figure 9. (a) The configuration factor. Schematic representation of a Class I cavity (top left), Class II (top tight), Class IV or cusp replacement (bottom left) and total cusp loss (bottom right). (Reproduced from Burke and Shortall.[22]) **(b)** For a Class I, high C-factor cavity being restored with a resin composite material, high stress means that incremental layering is necessary: not so with an extensive cusp replacement restoration, unless the resin composite thickness exceeds the manufacturer's cure depth.

that regard, it may be of interest to note that a dental school in the Netherlands (Nijmegen) ceased the teaching of dental amalgam in the year 2000). This publication also suggested that 'the advent of low-shrinkage resins, or self-etch composites, perhaps based upon recently introduced resin composite luting materials, may herald a new era of less technique sensitive resin composite materials and the final demise of the amalgam era'. Such predictions were hopeful, and, in retrospect misplaced – the low shrinkage resin composite (Filtek Silorane, 3M ESPE, Seefeld Germany) has come and gone (*vide infra*) and there are two relatively new self-adhesive resin composites described in the literature, with only one on the market in the UK, and the other one having published 2-year survival data,[29] but not yet on sale.

2009: low shrinkage composite

Today, it is recognized that two principal problems with posterior composite restorations are post-operative sensitivity and deficient contact points, and it is the present authors' view that the former problem has largely been solved by the use of matrix systems that were originally described *circa* 40 years ago, namely sectional matrix systems, and the SuperMat circumferential matrix system. However, the problem of post-operative sensitivity has remained, and a recent publication[30] has suggested means of preventing that. One factor has been the contraction of resin composite materials on polymerization and the associated shrinkage stress, which is a function of the contraction of the material and its modulus of elasticity, with a more rigid material having a higher shrinkage stress. A resin composite material with minimal polymerization contraction would also have low shrinkage stress.[31] One such material was Filtek Silorane (3M). As therefore might be anticipated, results of a 5-year clinical evaluation[32] in UK dental practices indicated no post-operative sensitivity and a good survival rate. Unfortunately, one of the resins used in the production of the material ceased to be available, and Filtek Silorane was withdrawn from the market *circa* 7 years ago. However, using a resin developed at the University of Colorado (addition fragmentation resin, AFM) and Urethane dimethacrylate (UDMA), 3M successfully produced another low shrinkage stress resin composite material, first named Filtek Bulk Fill Restorative, then renamed Filtek One after some shade changes.

In that regard, the first bulk-fill resin composite material was introduced, as SDR (Dentsply, Weybridge, UK): it was designed to be placed in bulk, in depths of up to 4.0 mm and was shown to have low levels of polymerization contraction stress.[33] This was classified as a bulk-fill base material because its wear resistance was insufficient for exposure on loadbearing restoration surfaces. There is, however, today, a group of bulk-fill materials with satisfactory wear resistance, the bulk-fill restorative materials, from various manufacturers: these have depths of cure of *circa* 5 mm owing to the presence, among other factors, of translucent fillers. These include Tetric Evo Ceram Bulk Fill Restorative (Ivoclar Vivadent, Schaan, Liechtenstein), Beautifil Bulk Fill Restorative (Shofu, Kyoto, Japan) and Admira Fusion Extra (VOCO GmbH, Cuxhaven, Germany). SonicFill (Kerr, Orange, CA, USA) is another bulk-fill material, differing from those above by being supplied with a handpiece that imparts sonic energy to the uncured material to make it less viscous when activated.

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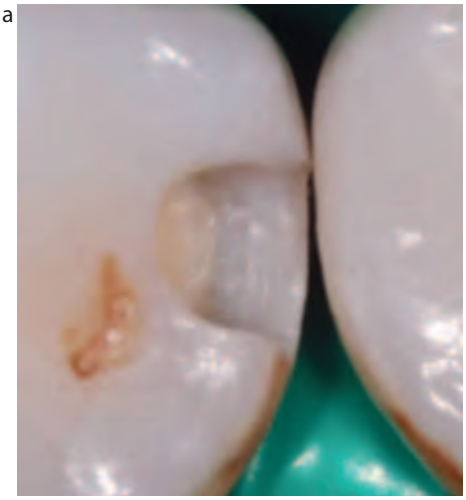

b

Figure 10. (a) Proximal box preparation extended just below contact point cervically. **(b)** A large posterior composite restoration, 15 years post-operatively.

2009 onwards: more technique tips

2009 saw the publication of the first of Mackenzie and colleagues from the University of Birmingham's 'Practical guides'.[34] This provided an extended list of applications for posterior composites, including large initial caries lesions, conservative restorations in the aesthetic zone, treatment of cracked teeth, and, adding that the range of indications will grow, as clinicians' confidence and skill in placing such restorations increases. This article reinforced the minimal box preparation for the initial Class II lesion, with vertical box margins being left in contact (Figure 10). The GV Black era of extension for prevention was truly history.

This 2009 publication[34] also reinforced the use of sectional matrices and Supermat,

Figure 11. Pre- and post-operative illustrations. In terms of aesthetics (among other advantages), posterior composite outperforms any other direct placement material.

providing a wealth of illustrations of a variety of techniques, which readers might do well to access from the *Dental Update* website. Three years later, a further practical guide[35] introduced readers to the use of an occlusal template, taken prior to cavity preparation if the occlusal surface of the affected tooth is relatively intact. This is taken in a clear polyvinyl siloxane material (Memosil 2, Hereaus Kulzer, Germany) and is later applied to the uncured resin composite material, which is then cured through the transparent template. This article also provided a practical guide to the use of a bulk-fill base material (SDR, Dentsply, UK).

An intermediate dentine adhesive is still needed

Early publications on composite restorations mentioned the use of a 'bonding agent'. These initially were unfilled resin, which filled the gap between the restoration and the tooth. Bonding agents, since then, have undergone many iterations to become the materials of today, with their sophisticated chemistry. Two recent publications[36,37] reviewed the laboratory and clinical performance of the latest dentine adhesives, the Universal adhesives and concluded that their performance merited serious consideration as today's dentine adhesives of choice.

Lessons from the past

- Flat metal matrices in a Siqveland holder present difficulty in achieving an anatomical interproximal contour, as with transparent matrices.
- Circumferential matrices, such as Supermat, have been recommended for over 20 years, particularly for the wide interproximal box and cusp replacements. Contact forming devices are of value. Sectional matrices are valuable for the small/medium interproximal box. However, the operator should burnish all matrices out at the correct level to ensure a tight, an anatomically correct contact point.
- Bases/liners are not needed – trust the bonding agent.
- Minimal cavity non-retentive designs, which save valuable tooth substance, are possible when using adhesive resin composite techniques.
- Among other factors, a low shrinkage stress material is helpful in reducing the potential for post-operative sensitivity.
- An understanding of the configuration factor is essential to the correct placement of the resin composite material, in layers if necessary.
- For any clinician new to posterior composites – good advice is to attend a hands-on course, particularly one majoring on matrix techniques.
- Extension for prevention is no longer appropriate.
- Occlusal analysis should form part of the assessment prior to commencing a cavity preparation for posterior composite.
- Unlike early resin composite materials, wear of restorations using today's materials is not a problem.
- Using a material from a manufacturer with experience and research in the field of dental materials makes sense. The cost of one premature failure obviates any savings accrued by purchasing a cheap material.
- Rubber dam provides optimal isolation, but successful outcomes have been obtained without it in some, ideal, clinical situations.
- Repair/refurbishment of defective restorations is now considered good practice as compared with replacement.
- Composite onlays are now a valuable clinical technique.
- Restoration of endodontically treated teeth, with cuspal coverage, once the domain of indirect techniques, can be carried using direct placement restorations.
- Resin composite restorations have been shown to be of value in the treatment of wear in anterior and posterior teeth.[38]
- Fibre-reinforced composite resin-bonded bridges are a valuable clinical technique for suitable cases.

Discussion

This article has used a series of articles, spanning more than 30 years to give a history of posterior composites and the lessons contained therein. Many advances have occurred. In the more recent publications, especially in the recent articles by Mackenzie and colleagues,[34,35,39] it was stressed that success with 'posterior composites' was dependent also upon the operator's knowledge of, and familiarity with, the various technique sensitivities that have been described. It has also been considered that use of materials with research to back up their formulation is to be advised, given that the evidence base for 'own label' materials is at best dubious, and, at worst nil.[40–43]

The survival rates of posterior composite restorations have been evaluated in a recent review,[44] with the results indicating, both from cohort studies and meta-analyses that fulfilled the inclusion criteria (among these being that the studies were based in primary care), that resin composite restorations have acceptable survival rates when placed in loadbearing situations in posterior teeth, with annual failure rates within the range 2–3% being recorded. As time since the Minimata Agreement passes, and patients' expectations of aesthetically pleasing restorations in their posterior dentition increases, the ability to successfully place posterior composite restorations will become increasingly important to successful clinical practice. The fact remains that these restorations take longer to place than the amalgam restorations of yore, but the latest bulk-fill restorations have been shown[45] to be less time consuming to place (when used with a Universal adhesive in self-adhesive mode) than conventional resin composite materials. This may point to posterior composites being more competitive economically than in the past. Self-adhesive resin composite materials, if and when they become commonplace, will further bring posterior composites into line with what patients might have expected to pay for an amalgam restoration in the past. Add to this the many advantages accruing from their posterior composite, principally the less invasive cavity preparation and much superior aesthetics, something that patients are increasingly requesting (Figures 10 and 11).

The teaching and practice of posterior composite restorations has continued to grow, improve and evolve, and techniques using resin composites may be expected to replace amalgam and posterior indirect restorations as the treatment of choice for all clinical situations – from minimally invasive restoration of early cavitated carious lesions to the complex restoration of badly damaged or endodontically treated teeth, and the restoration of extensively worn dentitions. In this respect, composite may be considered to be the future of posterior restorations. Some difficulties remain, these having been listed by the present authors 4 years ago, but some solutions have arrived:

- Time factors – now not so much of a problem with the introduction of bulk-fill materials.
- Remuneration system/financial considerations – state-funded systems may not be considered to provide adequate remuneration for the time costs of placing posterior composite restorations. This remains a problem with the UDA system in England.
- Poor/inconsistent teaching – may confuse clinicians – the authors hope that this article will help to clear up confusion.
- Poorly equipped practices – a clinician who decides to place posterior composites for a majority of patients needs to be equipped with the correct materials and matrix systems.
- Poor reputation – some practitioners may still suspect that the wear resistance of composite materials is inadequate, when such difficulties were overcome in the 1990s, as has been demonstrated in the present article.
- Limited access to postgraduate courses.

However, it is apparent that problems related to the materials for posterior composite have been overcome.

Finally, the future? Bulk-fill resin composites have been considered by the present authors, because of their easier and faster placement, to be the posterior composite/amalgam replacement materials of choice for the short to medium term, until truly self-adhesive materials (be they resin-based or glass ionomer-based) or alternative novel systems become commonly available and are demonstrated to be clinically successful in loadbearing situations in posterior teeth.

Conclusion

Our audit of composite resin publications in *Dental Update* spans 40 years, a practising lifetime, with the journal's articles serving to appropriately update its readers along the way. In that regard, lessons from the history of posterior composites may provide information for satisfactory placement today.

Compliance with Ethical Standards

Conflict of Interest: The authors declare that they have no conflict of interest.

Informed Consent: Informed consent was obtained from all individual participants included in the article.

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