

Teaching posterior resin composites in UK and Ireland dental schools: do current teaching programmes match the expectation of clinical practice arrangements?

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Key points

Provides understanding of changes in dental education in terms of how dental students are trained in the modern management of dental caries.

Considers the established evidence base for posterior resin composite restorations.

Considers the implications of the Minamata Treaty and how UK dental practice will be shaped by this.

Objectives Against a backdrop of evidence of divergence between dental school teaching and clinical practice in relation to the restoration of posterior teeth, the aim of this study was to investigate the current teaching of posterior resin composites in UK and Ireland dental schools. **Methods** An online survey was distributed to the 18 dental schools in the United Kingdom and Ireland with dental degree programmes in 2015. This questionnaire sought information in relation to the current teaching of posterior resin composites. **Results** A 100% response rate was achieved (n = 18 schools). All schools taught the placement of posterior resin composites in occlusal cavities of premolar and molar teeth. One school did not include teaching of two-surface occlusoproximal resin composites in molars and two schools did not include the teaching of three-surface occlusoproximal resin composites in premolar or molar teeth. Students place twice as many posterior resin composites, on average, than restorations of amalgam: posterior resin composites account for 66% of restorations placed (range: 30–80%), while amalgam accounts for 33% (range: 20–70%). Within five years, it is anticipated that this ratio will increase to 78% resin composite: 22% amalgam, with one school indicating they will no longer teach clinical amalgam restoration placement, while an additional seven schools indicate that amalgam will account for 10% or less of posterior restorations placed by students. There is limited exposure to more novel techniques such as bulk-fill materials (seven schools include didactic teaching, but only three include clinical experience of such materials). The Minamata Treaty is not expected to have any short- to medium-term impacts: more than half of the respondents (n = 9 schools) felt that amalgam would not be phased out until sometime between 2020 and 2025. **Conclusions** This study has highlighted that the current cohort of dental students, who are the emerging dental workforce, have much more substantial experience in the placement of posterior resin composites than ever before.

Introduction

For many years, debate has persisted as to the most appropriate material for the direct restoration of posterior teeth.¹ Historically, the

proponents of amalgam have argued that this material is strong and durable, capable of withstanding occlusal loading during mastication, and could be placed with confidence in 'challenging situations' (for example, subgingival margins and/or poor moisture control). Such views were reflected in position statements, such as those published in the mid-1990s, which recommended that the use of amalgam alternatives, such as resin composite, should be restricted to small occlusal or occlusoproximal cavities, preferably in premolars with limited occlusal function.² Amalgam has a long-standing record of service in dentistry for over 100 years.

However, alternate arguments have developed in relation to the suitability of

amalgam for direct restoration of posterior teeth. Amalgam requires needless sacrifice of otherwise healthy tooth tissue to achieve sufficient resistance form and retention of the restoration.^{3,4} In contrast, the selection of resin composite materials avoids the destruction of such healthy tissues: simple excision of the lesion of caries and occasional limited smoothing of the remaining tooth tissue are all that is required before application of the resin composite material.⁵ Around the turn of the millennium, there was an emerging and growing evidence base to demonstrate that, where placed appropriately, posterior resin composites could match the longevity of posterior amalgams, thereby avoiding the already-noted needless destruction of tooth

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tissue. The Bogacki study (of dental insurance claims from northwestern USA) demonstrated that the longevity of posterior resin composites matched closely that of amalgam, over the period of the study, and was in excess of 90% for both materials.⁶ Interestingly, within this study, the success of both materials fell to the mid-60s when the patient changed dentist. In the early 2000s, Manhart and colleagues in Munich demonstrated that the annual failure rate of posterior resin composites was less than that of amalgam – meaning that posterior composites could be used with growing confidence in posterior teeth.⁷ In the mid-2000s, the first longer-term primary care data emerged from the Nijmegen group: Opdam and colleagues demonstrated, using 5- and 10-year data, that where placed appropriately, the longevity of posterior resin composite restorations could match and exceed that of posterior amalgams.⁸

The potential to offer patients superior, minimally invasive treatment, which limited the destruction of teeth and slippage of the restored tooth along the ‘downward restorative death spiral’, was apparent.

What of dental teaching? Dental school programmes are often criticised as ‘lagging behind’ developments in clinical practice.⁹ Surveys of dental school teaching programmes show that students who qualified in the late-1990s had limited experience of posterior resin composite placement with as few as one-in-ten students gaining any clinical experience of this treatment.^{10,11} Coupled with the increasing evidence base detailed above, along with greater appreciation for minimally invasive dental techniques by dental school teachers, the amount of posterior resin composites placed by students increased such that the ratio was 30% resin composite: 70% amalgam by 2005.¹²⁻¹⁵ In 2007,

arising from a national meeting of the British Association of the Teachers of Conservative Dentistry, Lynch and colleagues reported an endorsed position statement that within student teaching programmes, resin composite should be the ‘material of choice’ for restoration of posterior teeth.¹⁶ Further surveys of teaching in 2009/10 demonstrated that the amounts of posterior composites placed by students had increased further such that the ratio was now 55% resin composite: 45% amalgam in UK and Ireland dental schools.¹⁷ Such advances were supported by further longer-term clinical data such as the 12-year primary care-based results of Opdam and colleagues in Nijmegen.¹⁸ Data from Pallesen and colleagues showed that of 4,355 posterior resin composites placed in teenagers in Denmark and followed for eight years, that the annual failure rate was 2% – which is regarded as very acceptable for most restorative materials.¹⁹

Table 1 Contraindications taught for placement of posterior composite restorations

Contraindications	Occlusal cavities		Occlusoproximal cavities	
	Premolars	Molars	Premolars	Molars
Inability to place rubber dam	5	7	9	10
Parafunctional activity	1	1	1	4
Pathological wear	0	0	0	0
Poor oral hygiene	6	6	8	9
Replacement of a large amalgam restoration	1	1	2	4
History of adverse reaction to composite materials	17	17	17	17
Atypical diet	0	0	0	0
Large pulp	0	0	0	0
Proximity to the pulp	0	0	0	0
Denture abutment	0	0	0	1
Subgingival margins			15	17
Temporomandibular dysfunction	0	0	0	0
No valid aesthetic requirement	0	0	1	2
Endodontically-treated tooth	0	0	1	1
Opposing composite restoration	0	0	0	0
High caries rate	5	5	7	7
Poor patient cooperation	6	7	7	8
History of postoperative pain with posterior composite restorations	2	2	3	3
Poor enamel quality	5	5	6	6
Buccolingual width of occlusal portion is <1/3 of the intercuspal width	0	0	0	0
Buccolingual width of occlusal portion is 1/2 of the intercuspal width	0	0	0	0
Buccolingual width of occlusal portion is >2/3 of the intercuspal width	0	0	1	2
Buccolingual width of proximal box >1/2 intercuspal width	0	0	1	1

Notwithstanding this, evidence suggests the uptake and placement of posterior resin composites among UK dental practitioners, especially those engaged in NHS funded dentistry, remains relatively low.²⁰ This illustrates a significant divergence between research-led, evidence-based dental school teaching and existing practice arrangements which appear to remain wedded to outdated funding schemes. Data from the teaching surveys, when compared to those of existing patterns in UK dental practice would suggest that the potential for tension exists when newly qualified graduates (currently trained on mainly posterior resin composites) emerge into the dental workforce and are employed by established colleagues (many of whom continue to extensively place amalgams).²¹ With this in mind, the aim of this study is to report current teaching of posterior resin composites within UK and Ireland dental schools.

Method

Following receipt of positive ethical review an email invitation was distributed to the 18 established dental schools in the UK and Ireland with dental school training programmes leading to registration as dentists. The email was sent to the individual identified as being responsible for the delivery of operative/restorative dentistry teaching programmes within each school. The invitation sought information relating to the teaching of posterior resin composites, which was to be returned via internet-based questionnaire software (Bristol Online Surveys, Bristol, UK).

The questionnaire sought information in relation to current practices in preclinical and clinical teaching of posterior composites, including the nature and extent of teaching, clinical experience on the part of students, and techniques taught. Both 'open' and 'closed' design questions were included. Non-respondents were followed up by email. Descriptive results are reported.

Results

All 18 UK and Ireland dental schools with dental school training programmes leading to registration as dentists responded to the survey, yielding a response rate of 100%. It is understood that the survey was completed by a senior member of staff with responsibility for directing teaching in preclinical and clinical operative dentistry.

Preclinical teaching

All 18 schools reported that they taught placement of posterior resin composites in occlusal cavities of premolar and molar teeth, as well as in two-surface occlusoproximal cavities of premolar teeth. One school did not include teaching of posterior resin composites in 2-surface occlusoproximal cavities of molars, while two schools did not include teaching of 3-surface cavities of premolar or molar teeth. One of these three schools indicated that they did not intend to include such teaching within their curriculum over the next five years; the other schools gave no indication either way.

On average, respondent schools indicated that posterior resin composite placement techniques accounted for 36% of their preclinical programme in operative dentistry (range: 10–75%). Similarly, amalgam placement techniques accounted for 25% of teaching within the preclinical operative dentistry programme (range: 10–45%). In five years' time (that is, by 2020), respondent schools estimated that the approximate proportions would be:

- Posterior resin composite: average: 48% (range: 10–80%)
- Amalgam: average: 16% (range: 0–40%).

The majority of schools (n = 11, 61%) indicated that students in the preclinical programme were taught posterior resin composite placement techniques before those for amalgam, while the remaining seven (39%) were taught the amalgam placement techniques first. In five years' time, 15 schools (83%) anticipated they would teach posterior resin composite placement techniques first, while the remaining three schools (17%) anticipated continuing to teach amalgam placement techniques first.

Schools were asked to report their staff: student teaching ratio within their preclinical programme. The mode was 1:10, with range being 1:6–1:22.

Clinical teaching

Seventeen schools provided information on the current and anticipated proportions of posterior resin composites and amalgam restorations placed clinically by students. Based on the reported information, it would appear that currently students place twice as many posterior resin composites, on average, than those of amalgam:

- Posterior resin composites: mean = 66% (range: 30–80%)
- Amalgam: mean = 33% (range: 20–70%).

In five years, schools estimated that the proportion of posterior resin composites: amalgam would increase to:

- Posterior resin composites: mean = 78% (range: 40–100%)
- Amalgam: mean = 22% (range: 0–60%).

One school indicated they will no longer provide clinical teaching of amalgam restorations in five years' time, while an additional seven schools indicated that amalgam will account for 10% or less of posterior restorations placed by students over the same period.

Clinical placement techniques

Cavity design

Schools were asked to comment on the principles of cavity design taught for posterior resin composites which were different to those for amalgam:

- 16 schools (89%) taught there was no need for additional mechanical retention
- 14 schools (88%) taught 'slot type' cavities
- 12 schools (75%) taught there was no need for 'extension for prevention'
- 11 schools (65%) taught rounded internal line angles
- Four schools (25%) taught beveling of the occlusal and proximal box cavosurface margins.

Contraindications taught to the placement of posterior composites

Contraindications taught to the placement of posterior composites are summarised in Table 1.

Rubber dam use and moisture control

Eight schools (44%) taught that rubber dam was essential/mandatory (n = 8; 44%) for posterior resin composite placement, while seven schools (39%) taught that rubber dam was mostly required (approximately 75% of cases). Two schools (11%) taught that rubber dam use was not at all essential/mandatory for placement of posterior resin composites. Alternate techniques taught included cotton wool rolls (n = 15; 83%), or a dry guard (n = 11; 61%). Three schools felt there was no alternative to rubber dam use (17%).

Protection of operatively exposed dentine

Different clinical techniques taught for protection of operative exposed dentine are reported in Table 2. In addition to the information reported, one school noted they taught MTA or biodentine placement for pulp capping treatments.

Recreating proximal contours

In relation to teaching the restoration of proximal contours, the reported teaching of matrix bands was as follows:

- Circumferential metal matrix band: 16 schools
- Sectional metal matrix band: 11 schools
- Circumferential clear band: five schools.

The reported teaching of wedging systems were as follows:

- Wooden wedges: 17 schools
- Plastic/flexible wedges: seven schools
- Light transmitting/clear wedges: five schools.

Materials selection

All schools (n = 18) taught the use of hybrid or nano-hybrid resin composites for placement in posterior teeth. One school taught the placement of flowable resin composites in occlusal cavities only.

Seven schools included didactic teaching of bulk-fill materials and three schools included clinical teaching of bulk-fill placement. In terms of material choice, three schools taught SDR (Dentsply), one school taught Sonicfill (Kerr) and one school taught Tetric EvoCeram Bulk Fill (Ivoclar Vivadent). Some of the more interesting comments from respondent schools in relation to bulk-fill materials are included in Box 1.

Light curing units

The use of light curing units (LCUs) was reported as follows:

- Light-emitting Diode LED (only): 12 schools
- Quartz Tungsten Halogen QTH (only): three schools
- Both LED and QTH: three schools.

Fees

Fourteen schools provided information on fees paid by patients. In one UK school, patients are charged the NHS patient fee for a 'Band 2' treatment when placing amalgam or resin composites. Two schools reported patient charges ranging from €30–60 for posterior resin composites or amalgams placed by students.

Indirect resin composites

Fourteen schools (78%) report that they include teaching of indirect resin composites. In ten of these schools, this teaching included both didactic and clinical teaching. In four

Box 1 Comments received from respondents on their perceptions of novel 'bulk fill' materials

- 'Would prefer to have students understand the basics with increments – we discuss the theory behind bulk fills but do not want to confuse the issue at such an early stage'
- 'Only in senior years. Wish to avoid adoption of a time saving technique inappropriately. We prefer teaching incremental build up so that undergraduates take care to cure smaller increments, otherwise they may use bulk-fill techniques with inappropriate materials (especially early in their career when they are not familiar with different materials)'
- 'Not enough evidence (yet)'
- 'Require more clinical studies'
- 'Very useful in certain situations. Important adjunct'
- 'Taught but not yet commonly used in clinics. Awaiting longer-term clinical trials of performance. Limitations in relation excessive flow (self-leveling?)'
- 'They are to be introduced to the clinic/teaching shortly'
- 'The aesthetic of the bulk fill is not as good. No long term data on performance'
- 'This may be the norm in the future – more evidence required'
- 'This approach is favoured by 1-2 individuals, however, clinical evidence is lacking and laboratory data is unconvincing'
- 'The students receive theoretical teaching on bulk fill/low shrink composites but we currently do not use them in the clinical skills room'
- 'We consider this a technique that has risks regarding complete polymerisation at depth, and that students should practise incremental build up until they are suitably experienced'
- 'We have been advocating this for about two years now and feel the students are more reliably restoring teeth due to the time saving and difficulty they find handling composite in deeper boxes'

schools, there was didactic teaching only, with no clinical experience.

Awareness of Minamata

Schools were asked to indicate, given the signing of the Minamata Treaty, over what period of time they believed amalgam should be phased down. Responses were received from 17 schools:

- Less than three years: no schools
- Three to five years: four schools
- Six to seven years: four schools
- Eight to ten years: three schools
- More than ten years: six schools.

One school commented: 'The phasing out of [amalgam] use is purely a political matter. We still need to teach some background to amalgam style preparations for a considerable period after ceasing to use it, with our population and funding system.'

Discussion

The findings from this study are of interest not only to those involved in the teaching of operative dentistry, but also to policy makers, funders of oral healthcare, including the NHS, and those with a wider interest in the ongoing professional development of dental practitioners such as providers of dental education, dental foundation trainers and postgraduate dental

deans. It is clear that modern dental students have been trained with increased exposure, and competence, in the restoration of posterior teeth with resin composite. Leaders and established members of the profession may not be considered to be acting in the best interests of patients, or younger members of the profession, if they dissuade and discourage new graduates from employing their skills in placing posterior resin composites, using preventatively-orientated, minimally invasive approaches. In contrast to more than 20 years ago when posterior resin composites had a dubious track record and a limited supportive research base, the evidence in support of posterior resin composite use is abundant and significant.^{18,19} The authors wish to emphasise their often-stated position that their objection to the use of amalgam is not related to the material itself, or any speculative or dubious claims relating to mercury toxicity. Rather than being 'anti-amalgam', the authors are 'pro-preventatively-orientated, minimally invasive dentistry' and feel that this can only be realistically achieved when posterior teeth are restored with resin composite, rather than amalgam, which is ill-suited to placement in minimally invasive preparations. The time to stop the needless mutilation of posterior teeth, through the sacrifice of otherwise-healthy tooth substance to create amalgam-required resistance form and mechanical cavity features such as undercuts, reverse curves and

extension-for-prevention has long passed. Respondents to this survey indicate that within five years there will be one school no longer teaching clinical placement of amalgam, while an additional seven schools indicate that amalgam will account for 10% or less of posterior restorations placed by students. The implications and changes for the profession will be profound.

As well as a developing and significant research base, recent international policy changes also mean that the future use of amalgam will come under further pressure and scrutiny. The recently enacted Minamata Treaty (2013) – named after the location of an environmental disaster in Japan due to the release of methylmercury in industrial wastewater from 1932 to 1968 causing widespread neurological disorders and birth defects – puts pressure on governments to eradicate sources of environmental mercury.^{22,23} As part of this, a ‘phase-down’ in the use of dental amalgam was agreed. While there has been resistance to the ‘phase-down’, let alone ‘phase-out’ of amalgam in certain sectors of UK dentistry, the trend towards the discontinuation of amalgam use is inevitable and has already been successfully achieved in countries such as Norway.²³ Furthermore, the EU has indicated that it wishes to phase out amalgam by 2030, and has banned the use of amalgam in pregnant and breastfeeding women and in children under the age of 15 years from July 2018.²⁴ NHS dental practices have developed around the use and availability of amalgam. A recent survey of more established practitioners has demonstrated that financial and bureaucratic considerations such as the organisation and funding of NHS dentistry are problematic for facilitating such a discontinuation in the use of amalgam.²⁰ This survey (of 270 predominantly NHS practitioners in Wales), has estimated that restorations could take 1.6 times longer to place, if resin composites were used instead of amalgam and that relevant NHS fees would need to increase by 55–60% to account for this change in restorative material. Leadership at a national level is indicated, to facilitate established practitioners employing the principles of evidence-based, preventatively-orientated, minimally invasive dentistry. The shift from traditional mechanistic, interventive dentistry to preventatively orientated, minimally invasive dentistry should, however, realise cost savings with the associated shift to oral healthcare maintenance rather than the often repeated treatment of dental disease.

Table 2 Teaching of the management of operatively exposed dentine

Cavity Depth	No liner/ base ('total-etch')	Calcium hydroxide + Glass ionomer cement	Glass-ionomer cement only
Shallow cavities (outer third of dentine)	18	0	0
Moderate cavities (middle third of dentine)	12	0	6
Deep cavities (inner third of dentine)	3	10	9

*Schools were allowed to select more than one option per scenario.

In terms of techniques taught, some concerns are highlighted with the intention of improving the quality of teaching and treatment provided:

Protection of operatively exposed dentine

The choice of techniques for ‘lining and basing’ posterior resin composite restorations has long proved a vexed matter.²⁵ Within this survey, while the management of ‘shallow’ cavities is relatively consistent among schools, diversity of opinion is seen in other scenarios, most notably in relation to very deep cavities. The evidence for placing a base at all for a resin composite is dubious – the choice of techniques themselves appears to be extrapolated from approaches to amalgam placement (that is, ‘if we need a base for an amalgam, then we need a base for resin composite’).²⁶ Such logic is flawed, primarily as resin composites do not transmit heat in the same way as amalgam. Indeed, the need for a base under a resin composite has recently been questioned, except in situations where a pulp capping agent has been applied and protection of this is required.²⁷ Findings from a recent *ex vivo* study demonstrate that application of phosphoric acid, to the base of a cavity without pulpal exposure, (that is, as part of a direct dentin bonding technique rather than using an intermediary base) can stimulate regeneration of dentine.²⁸ Clinical studies have demonstrated no difference in terms of post-operative sensitivity between posterior resin composites placed with and without a base.²⁹

Restoration of proximal contour – matrices and wedges

As seen within this study, a small, but significant number of schools (n = 5) continue to teach the use of clear matrix bands and light transmitting wedges. These techniques, being fraught with difficulties and adverse outcomes, have been discredited since the work of Mullejans in 2003.³⁰ Clear matrix bands are thick and stiff,

making them more likely to be associated with open, and poorly contoured proximal contacts. Light-transmitting wedges were one time considered helpful to ensure adequate illumination of the base of the proximal box. However these wedges are very stiff, and do not ensure adequate adaptation of the matrix band along the curved profile of the proximal box – rather they tend to touch the gingival margin of the box at only one point, resulting in overhang formation in the other marginal areas not sealed by the wedge.³⁰ Furthermore, it is now known that composites do not ‘shrink’ towards the light, therefore, there is no need to try to direct the incident light from the light-curing unit through the light-transmitting wedges from the facial or lingual embrasure side of the proximal box.³¹ Application of the light from the occlusal surface of a tooth to which a well-adapted thin metal proximal band has been applied, if practised carefully will not cause any adverse outcome. Conversely, it was heartening to see that 11 schools teach the use of sectional matrix systems – this is to be welcomed as such techniques are associated with the formation of tight contacts in the correct anatomic locations and appropriately (that is, convexly) contoured proximal surfaces.^{32,33}

It was also of interest to note that there was, as yet, relatively limited teaching of newer techniques such as resin composites. Only three schools reported that students gained clinical experience in resin composites in such material. Bulk-fill materials are supported by a growing and supportive evidence base and will, in all probability, address the concerns of many established practitioners in terms of time taken for completion of a restoration as well as confidence that the material has been polymerised adequately.³⁴ It is noted within the comments in Box 1 that some schools, from an educational viewpoint, would still wish their students to practise the traditional application of increments. This is a reasonable approach, particularly if the graduating students are

employed in clinics that do not have access to bulk-fill material. That said, it would be reasonable for more senior, competent students to gain experience in the placement of bulk-fill materials.

Concluding remarks

A revolution in the restoration of posterior teeth with appropriate, research-led, minimally invasive operative dentistry techniques, via the placement of posterior resin composites, has occurred in UK and Ireland dental schools over the past 20 years. The graduating classes of the late-2010s are more skilled and adept at placing posterior resin composite than their predecessors. The clinical approaches of such graduates, in terms of their minimising the needless destruction of healthy tooth tissue, should be welcomed and nurtured by established members of the profession.

Leaders of the profession and governmental policy-makers need to rethink established models of UK oral healthcare practices to ensure that patients are best served by receiving minimally invasive, preventatively orientated treatments, which given their established and significant evidence-base, can no longer be ignored. It is time to transform oral healthcare strategies from the interventive management of disease to the maintenance of oral health.

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