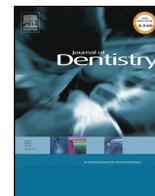




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Use of lining materials under posterior resin composite restorations in the UK

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ABSTRACT

Objectives: To investigate opinions on, and current use of lining materials prior to the placement of posterior resin composite restorations by general dental practitioners (GDPs) in the UK. A further objective was to investigate aspects of posterior resin composite restoration placement techniques employed by UK GDPs.

Methods: A questionnaire was devised to gain the information sought. It was sent to 500 UK dentists, chosen at random from the register of the General Dental Council.

Results: Three hundred and fifty four replies were received, which gave a response rate of 71%. Eighty two percent of respondents reported placing lining materials in deep cavities to be restored with resin composite. Regarding moderately deep cavities, half of the respondents indicated a preference to place a lining material, whilst 44% were not sure if a lining was required. The remaining 6% did not respond to the question. Of the respondents, 39% reported that they did not place lining materials in shallow cavities. Regarding techniques for posterior resin composite placement, two-step etch and rinse systems were the most common adhesive bonding systems used (60%). The majority of respondents (80%) reported not using rubber dam when restoring posterior teeth with resin composite.

Conclusions: There was considerable confusion about the need to place a lining prior to resin composite restorations placement in moderate depth and shallow cavities, whilst most favoured the placement of a lining in deep posterior cavities. The majority of GDPs may not routinely use rubber dam for the placement of posterior resin composite restorations.

Clinical significance: Decision making and operative techniques for cavity linings under posterior composite restorations in moderately deep and deep cavities is contentious among dentists, resulting in a need to generate more convincing, practice-relevant data on the use of lining materials to inform the dental profession.

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1. Introduction

Posterior composite restorative materials and adhesive bonding technologies have evolved over many decades [1]. The materials and adhesive techniques currently available are greatly improved in comparison to early formulations. Concerns over the longevity of posterior resin composites have reduced as clinical studies suggest that this now matches that of restorations of dental amalgam [2,3]. Contemporary literature would suggest an increasing trend towards the use of resin composites in the restoration of posterior teeth, and there is evidence that dental schools, both in the UK and elsewhere around the world, now

teaching resin composites as the material of choice for the restoration of posterior teeth [4]. However, variation has been reported in the teaching of the use of linings¹ prior to the placement of posterior resin composites [5]. For decades, the restorative management of caries involved the placement of a lining on the floor and, when present, axial walls of the cavity [6]. The placement of a lining was proposed for several reasons: to reduce the number of viable bacteria remaining close to the pulp, to induce development of reactionary/repairative dentine, to possibly remineralize remaining demineralized hard tissues, to isolate the pulp against thermal and electric conduction, to protect pulpal cells against chemical irritants such as methacrylates from adhesives [6,7] and to prevent the effects of restoration leakage on the pulp. However, the development of new restorative materials

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¹ The term lining in the present paper includes liners and bases.

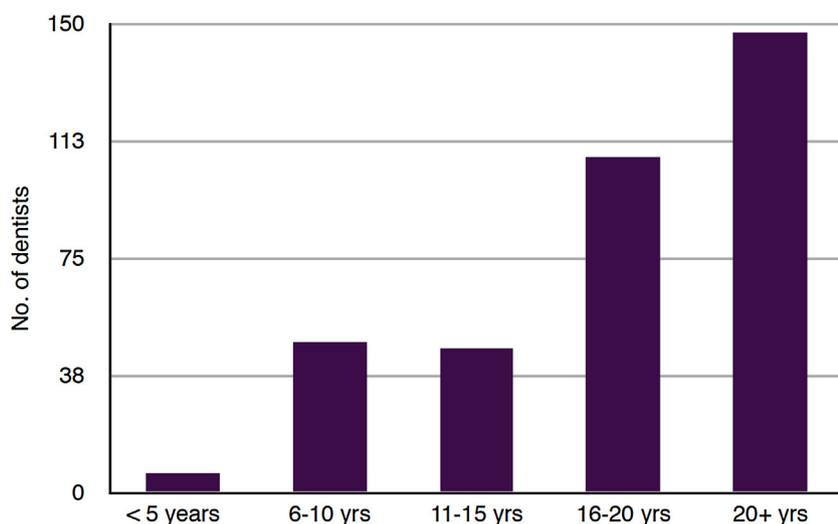


Fig. 1. Respondents' years since qualification.

and the emerging concept of minimum intervention dentistry, including changes in the perceived need to remove all caries, i.e., removing only infected dentine, leaving affected dentine [8–10], have raised doubts regarding the need for a cavity lining to maintain pulpal vitality [11–14].

To date, little information, other than anecdotal, subjective comments, exists regarding general dental practitioners' use of dental lining materials prior to the placement of posterior resin composite restorations. No such information exists for the UK. It was therefore considered important to investigate this important aspect of everyday restorative dentistry.

The aim of this study was to investigate opinions on, and current use of lining materials prior to the placement of posterior resin composite restorations by GDPs in the UK. A further aim was to investigate aspects of posterior resin composite restoration placement techniques employed by UK GDPs.

2. Materials and methods

A questionnaire was developed and piloted amongst six GDPs at two dental practices in Northern England to assess content validity. Following constructive feedback resulting in the modification of the questionnaire a focus group comprising a further four GDPs was conducted to establish the face validity of the questionnaire. Feedback from the focus group included identifying ambiguous items and suggesting additional items. Items were reworded to eliminate ambiguous phrasing resulting in the final version of the questionnaire.

The final questionnaire was organised in seven sections, seeking information on (i) the respondents, (ii) the provision of posterior resin composites, (iii) factors affecting the use of lining materials prior to the placement of posterior resin composite restorations, (iv) factors influencing the choice of lining materials (v) attitudes towards lining materials, (vi) techniques used in the placement of posterior resin composites, and (vii) problems encountered with or without the use of liners under such restorations.

The questionnaire consisted of open and closed structured questions and a free response section.² The questionnaire was sent to 500 dental practitioners selected at random from the UK Dental Register. The questionnaires were sent to the selected

practitioners, together with a covering letter and a self-addressed stamped return envelope, for anonymous completion. A specially devised coding system was used to keep the responses to the questionnaire anonymous.

Up to four copies of the questionnaires were sent over a 9-month period to all GDPs who failed to respond. The data collected from the returned questionnaires was entered anonymously onto an electronic database (Excel, Microsoft Inc.®) to facilitate collation and analyses of the responses. The findings were considered as percentages of the responses returned by the participating practitioners and were analysed statistically, where appropriate.

3. Results

A total of 354 completed questionnaires were received, giving a response rate of 71%. The findings were divided according to the seven sections of the questionnaire.

3.1. General information

Two hundred and sixteen responses (61%) were received from female practitioners and 138 (39%) from male practitioners. One hundred and sixty seven (47%) practitioners reported to work in predominantly mixed NHS and private practice, respondents working in exclusively NHS or Private practices were found to be 100 (28%) and 86 (24%) respectively. Fig. 1 summarizes respondents' years since qualification.

3.2. Provision of posterior resin composite restorations

The majority of the respondents [n=325 (92%)] reported placing posterior resin composite restorations – Twenty nine (8%) did not provide such treatment. Reasons for this included: not practicing restorative dentistry, and budgetary and time constraints in the provision of National Health Service (NHS) dentistry. Data returned by practitioners not practicing restorative dentistry were excluded from further data analyses.

3.3. Factors affecting the use of lining materials

The findings on factors that influenced GDPs when choosing a lining material for use in a cavity in a posterior tooth to be restored with resin composite are set out in Fig. 2. Depth of the cavity had the greatest influence [n=270 of 325 (83%) of respondents]. The

² The questionnaire is available, on request, from the corresponding author.

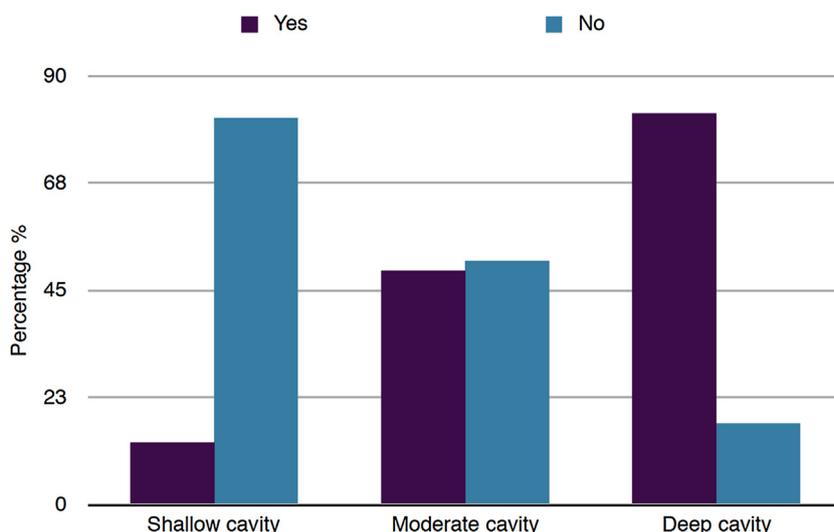


Fig. 2. Factors influencing dentists' choice in using a lining material under posterior resin composite restorations.

number of years since graduation was not found to significantly influence the use of lining materials (Chi-square test: $p = 0.04$). For example, recently qualified dentists were almost equally likely to place a lining in deep cavities (i.e., cavities which extended into the inner third of the dentine) as colleagues who have been qualified for more than 20 years [$n = 244$ (75%) and $n = 250$ (77%) respectively].

Of the respondents, 266 (82%) reported leaving shallow cavities unlined (i.e. cavities which extended $< 1/3$ into dentine), whereas 43 respondents (13%) reported placing a lining, presumably a liner in shallow cavities. In contrast, 270 (83%) of respondents reported placing a lining in deep cavities compared to 56 (17%) who left such cavities unlined. With regard to moderately deep cavities (i.e., cavities which extended between $1/3$ and $2/3$ into dentine), 158 (49%) of respondents reported placing a lining compared to 165 (51%) who did not (Fig. 2). Seventy four respondents (23%) reported being unsure whether a lining was required in a moderately deep cavity.

3.4. Factors influencing the selection of lining material

The respondents were asked what influenced their selection of material for use as a lining prior to the placement of a posterior resin composite restoration. Availability in the workplace, radiopacity and delivery system were reported to be important.

Published research, cost, manufacturer and advertising were less influential. A wide range of materials was selected for the purpose of a lining prior to the placement of posterior resin composite restorations. The material most commonly selected was conventional glass- ionomer cement [$n = 144$ (44%)], followed, in descending order, by flowable resin composite [$n = 127$ (39%)], calcium hydroxide liner [$n = 125$ (38%)], and resin modified glass-ionomer cement [$n = 103$ (32%)]. Other materials included 'Smart Dentine Replacement' [$n = 10$ (3%)], zinc oxide eugenol [$n = 7$ (2%)], compomers [$n = 6$ (2%)], and 'Biodentine' [$n = 5$ (2%)] as shown in Fig. 3. Thirty seven (11%) of respondents reported applying no lining prior to the placement of posterior resin composite restorations, irrespective of depth of cavity.

3.5. General statements

The participants were asked a series of questions to ascertain their confidence in linings as part of the process of restoring a posterior tooth with resin composite. One hundred and twenty eight (39%) of the respondents reported that they were confident that a lining was not required in shallow cavities, while 229 (70%) reported that they are confident that a lining was required in deep cavities. Interestingly, 62 (19%) of the respondents who reported placing a lining in deep cavities indicated that that they are unsure about the need to do so. Of the respondents who placed a lining in

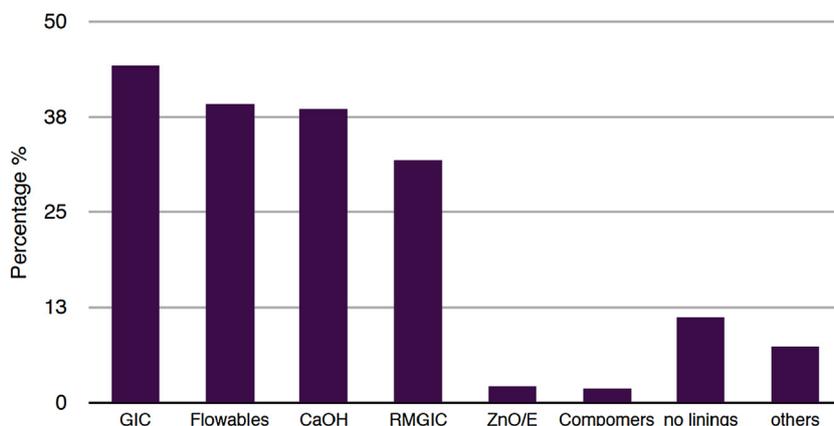


Fig. 3. Lining materials used under posterior resin composite restorations.

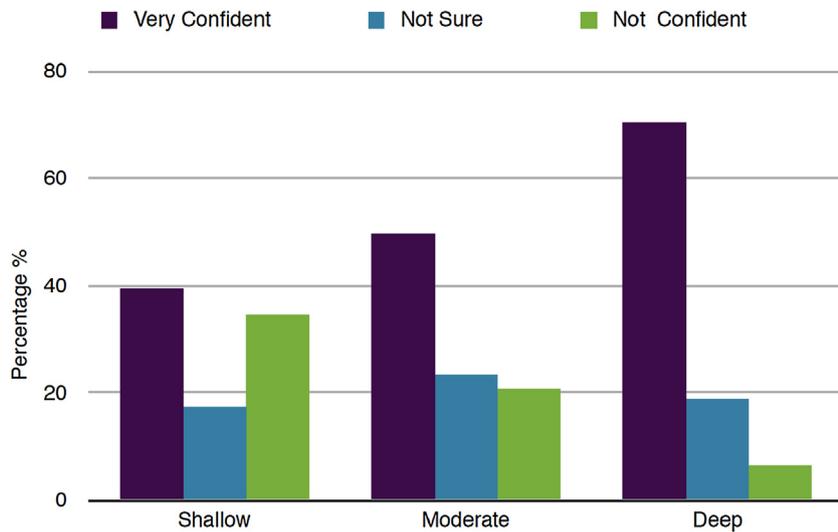


Fig. 4. Confidence in the indication for using a lining material under posterior resin composite restorations.

moderately deep cavities (n=160), 49% were very confident and 20% (n=65) lacked confidence about this practice. A summary of these findings is shown in Fig. 4.

3.6. Placement techniques for posterior resin composites

3.6.1. Adhesive bonding systems

Whilst 196 (60%) of respondents reported using a two-step etch and rinse system and a further 55 (17%) reported using a three-step system, 49 (15%) respondents used a one-step self-etch adhesive technique when restoring posterior teeth with resin composite. A smaller proportion of respondents [n=33 ((10%)] reported using two-step, self-etch adhesives, whereas 13 (4%) of respondents reported using other methods. A summary of these findings is illustrated in Fig. 5.

3.6.2. Use of rubber dam

Two hundred and sixty three (81%) of respondents reported using some form of moisture control on a routine basis, but only 63 (19%) indicated that they routinely used rubber dam when placing posterior resin composite restorations. Reported reasons for not using rubber dam included: poor experience with rubber dam, use of rubber dam not being cost effective, lack of clinical experience with rubber dam, time constraints in the provision of NHS care, and

that moisture control was achievable by other (simpler more user friendly) means. Other reasons for not using rubber dam included: “inertia”, “hassle”, “gets in the way-hate using it”, “don’t use for ‘special care’ patients”, “patient’s don’t like it”, “problems with the use of rubber dam when restoring Class II cavities”, and “use it for lower teeth, but not for upper teeth”.

3.7. Problems with linings

Whilst Two hundred and thirty eight (73%) of the respondents reported an absence of postoperative problems with linings under posterior resin composite restorations, 76 (23%) reported to commonly encounter problems. Of the problems encountered, postoperative sensitivity [n=65 (20%)], caries development [n=27 (8%)] and loss of retention [n=23 (7%)] were reported as most common.

4. Discussion

A questionnaire study requires a good response rate to be effective. Tan and Burke [15] suggested that an acceptable response rate for postal surveys was 64%. This study achieved a 71% response, reduced to 65% when the response from practitioners who did not place posterior resin composite restorations were

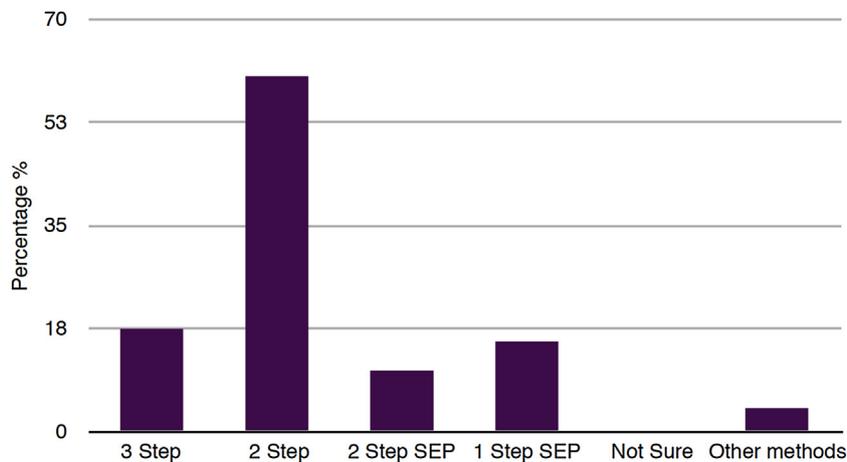


Fig. 5. Adhesive bonding systems used for posterior resin composite restorations.

excluded. There is always a risk of sample bias in questionnaire studies, with only those interested in the subject responding. In the present study, there was a significantly higher response rate from female dentists than would have been expected from dental workforce demographics. The majority of the respondents worked in mixed NHS/private practices and indicated that they placed both load bearing and other posterior resin composite restorations on a routine basis.

A consensus report by opinion in the teaching of operative dentistry in the UK and Ireland concluded that resin composite is the material of choice when restoring posterior teeth [16]. This was attributed to improved physical and handling characteristics of resin composites, better understanding of relevant techniques, favourable survival rates for posterior resin composites and the opportunity to practice preventatively orientated, minimum intervention operative dentistry. By way of example of relevant survival data, Opdam et al. [17] reported the survival rates for posterior resin composites of 91.7% at five years and 82.2% at 10 years. These rates were considered to be comparable to those for more interventive amalgam restorations, which the same authors reported to have survival rates of 89.6% and 79.2% at five years and 10 years respectively [16], indicating that, direct posterior resin composites provide a viable alternative to restorations of dental amalgam. Subsequently, it was reported that in dental schools in the UK and Ireland, dental students gain more experience in the placement of direct resin posterior composite restorations than in the placement of amalgams [16].

Practitioners have many decisions to make in the provision of restorative care to their patients, one of which whether to place a lining and, if so, what material to use. It has been reported that, rightly or wrongly, the placement of a lining under posterior resin composites remains popular amongst general dental practitioners, possibly because dentists fear that adhesive restorations placed without a liner or base might compromise pulp vitality, or suffer postoperative sensitivity [18,19]. The variation in the placement of linings and the materials selected for use in cavities of different depth appears to reflect the variation in the teaching of the use of liners and bases under posterior resin composites [5]. Whilst glass-ionomer cements are suggested for linings in moderately deep and deep cavities by some dental schools in the UK and Ireland to avoid, in particular, postoperative sensitivity, research is inconclusive on this matter [16,20]. A study by Opdam et al. [21] looking at longevity and reasons for failure of class II posterior composite restorations placed with or without a lining of glass-ionomer cement lining has found that posterior composite restorations placed with a resin-modified glass-ionomer lining clinically showed more frequent fractures than PCR's placed with a total-etch technique.

More recently, a long-term clinical study by van de Sande et al. [22] evaluated the effect of glass-ionomer-cement liners in the survival of posterior composite restorations, compared to restorations without liners. The authors concluded that the use of the liner did not affect the survival of resin composite restorations [22]. The authors further concluded that there is no evidence to support the approach whereby attempts are made to restore posterior teeth using a dentine replacement material to replace dentine overlaid by composite or ceramic to replace lost enamel [22]. Indeed, the authors state that it is possible that such an approach may make the restoration more liable to suffer failure by fracture [22].

It was disappointing to note that 7 respondents (2%) mentioned the use of zinc oxide eugenol cement for a lining under posterior resin composite restorations, obviously not taking into account the adverse effects that eugenol may have on composite resin systems [23].

Whilst the findings of this study indicated a general consensus amongst the respondents in the placement of a lining in deep

cavities and leaving shallow cavities unlined, it was apparent that there was wide variation in the use of linings in moderately deep cavities. Thus, it is concluded that the management of operatively exposed dentine in moderately deep cavities may be found to remain a vexed issue amongst practitioners, with no substantial evidence favouring the placement or non-placement of a lining [22]. As highlighted by Lynch et al. [24] best practice in the protection of operatively exposed dentine may be determined by the following considerations: (1) the use of liners and bases is traditionally associated with amalgam, mainly because these materials are necessary to provide thermal insulation between amalgam and underlying vital dentine. Resin composites are insulators and do not therefore require a lining for insulation purposes; (2) predictable adhesion of resin composite restorations to remaining tooth tissues can be achieved using modern dentine bonding systems. A lining limits the available surface area for bonding and reduces the thickness of resin composite >1.5 mm, limiting the physical and biomechanical properties of the completed restoration. Furthermore, the application of a dentine bonding agent will seal the restoration and the underlying dentine protecting the pulp from stimuli and bacterial ingress. It would appear, therefore, that there is no longer an indication to place a lining under a posterior resin composite. Lynch et al. [24] acknowledge one exception – where materials are applied to facilitate remineralisation of affected dentine and possibly pulpal healing, if a calcium hydroxide cement were to be selected for this purpose in situations very close to the dental pulp. It would be sensible to cover a liner of calcium hydroxide with a base of a resin modified glass-ionomer cement to protect it during, in particular, subsequent etching of the cavity and to facilitate any planned re-entry procedure.

The indication from this study that many practitioners do not consider refereed journals an important influence on their decision making processes, for at least linings and lining materials under posterior resin composites is discouraging, if not worrying. A wish to be practicing evidence-based approaches should be the norm, albeit in the case of linings and the use of lining materials that there is a dearth of relevant evidence from high quality long-term clinical studies [25]. In addressing this gap in the existing evidence-base, the priority should be best practice in the restoration of moderately deep cavities to be restored with resin composites – the area of most uncertainty amongst practitioners. Once this research, possibly best conducted in the practice environment to increase its relevance, had been concluded, the further challenge would be the dissemination of the findings amongst practitioners, given their apparent indifference to refereed journals.

Regarding the techniques used by dentists to place posterior composite restorations, there was considerable variation in the use of different types of adhesive bonding systems. Three-fifth of respondents were found to use a two-step etch and rinse technique ('fifth-generation' adhesives) and nearly two-fifth a three-step etch and rinse technique ('fourth-generation' adhesives) when restoring deep cavities. Interestingly, despite ease and speed of application, only 15% of respondents reported using a one-step self-etch technique ('sixth-', 'seventh-' or 'eighth-generation' adhesives) when restoring deep cavities with resin composite. A systematic review by Peumans et al. [26] reported that there does not appear to be any clinically significant difference in the performance of 'fourth-', 'fifth-' or subsequent generation adhesives. That said, self-etch adhesives 'lightly' dissolve the smear layer before infiltration, while etch-and-rinse systems remove it. In all probability, effective clinical technique with meticulous attention to detail may be found to be more important than which of the current bonding systems is selected for use [24].

In terms of moisture control, it was encouraging to note that 80% of respondents routinely used some form of moisture control. However, only 20% reported that they typically used rubber dam when placing posterior resin composites. This is better than the 12% recorded in a study by Gilmour et al. [27] and is comparable to the finding reported by Brunton et al. [28] where 18% of dentists were found to be using rubber dam for direct posterior resin composite restorations. Gilbert et al. [29] found that 63% of GDPs did not use rubber dam for any restorative procedure, whereas Lynch and McConnell [30] reported that 53% of GDPs never used a rubber dam for posterior resin composites.

A survey of the teaching of moisture control in relation to posterior resin composites in dental schools in the UK and Ireland found that all schools taught rubber dam placement. Thirteen out of the 15 schools also taught the use of cotton wool rolls and 11 taught the use of dry guards as alternative forms of moisture control [5].

Good moisture control is critical to the success of all adhesive procedures. It is widely accepted that best moisture control is achieved under rubber dam [6]. Whilst the majority of respondents did not report encountering repeated problems following the placement of posterior resin composites, 20% reported to commonly encounter postoperative sensitivity, despite many of them placing a glass-ionomer cement or other lining to combat post-operative sensitivity. The key to understanding this conundrum may be the creation of microgaps between dentine and lining, in particular in the presence of moisture contamination [31]. Calcium hydroxide cements do not adhere to the cavity floor. When overlying RMGIC or resin composite contracts on polymerisation the liner of calcium hydroxide may be disrupted resulting in the formation of microgaps [31]. Similarly, if RMGIC is used as a liner on its own, microgap formation may occur, as the bond strength of RMGIC to dentine is typically less than that of RMGIC to an overlying adhesively bonded resin composite. Peliz et al. [31] postulated that microgap formation results in the movement of dentine tubular fluid, causing post-operative sensitivity. If the seal of the restoration is subsequently lost, bacterial ingress into microgaps may result in pulpal inflammation.

More recent research corroborates the hypothesis that placing a cavity liner in a posterior tooth does not reduce the incidence of post-operative sensitivity in moderately deep and deep cavities restored with resin composite [32,33].

Post-operative sensitivity may, at least in part, be attributed also to other non-material related factors, ranging from suboptimal operative technique; for example, excessive drying of dentine, to operator error in the handling of technique sensitive adhesives and resin composites.

5. Conclusions

The findings of the present study indicate that dental practitioners, while typically confident to restore a shallow cavity in a posterior tooth with resin composite without the placement of a lining, may be found to be uncertain and confused as to the best approach to manage operatively exposed dentine in moderately deep posterior resin composite cavities, and inclined to place a lining if such cavities if they are deep.

As practitioners would appear to be disabused by refereed journals and unconvinced by the existing evidence-base indicating that a lining under a posterior resin composite may be indicated only in situations where it is intended to have therapeutic pulpal effects in deep cavities, it is concluded that there is a need to generate more convincing, practice-relevant data on indications for linings, and to disseminate this data in ways which may influence decision making and operative technique behaviours amongst practitioners.

Conflicts of interest

None.

Financial support

None.

References

- [1] N. Minguéz, J. Ellacuría, J.I. Soler, R. Triana, G. Ibaseta, Advances in the history of composite resins, *J. Hist. Dent.* 51 (2003) 103–105.
- [2] R. Hickel, J. Manhart, Longevity of restorations in posterior teeth and reasons for failure, *J. Adhes. Dent.* 3 (2006) 45–64.
- [3] H.Y. Marghalani, A.S. Al-jabab, Compressive creep and recovery of light-cured packable composite resins, *Dent. Mater.* 20 (2004) 600–610.
- [4] C.D. Lynch, R.J. McConnell, N.H.F. Wilson, Challenges to teaching posterior composites in the United Kingdom and Ireland, *Br. Dent. J.* 201 (2006) 747–750.
- [5] C.D. Lynch, R.J. McConnell, N.H.F. Wilson, Teaching of posterior composite resin restorations in undergraduate dental schools in Ireland and the United Kingdom, *Eur. J. Dent. Educ.* 10 (2006) 38–43.
- [6] R. Weiner, Liners and bases in general dentistry, *Aust. Dent. J.* 56 (Suppl. 1) (2011) 11–22.
- [7] T.J. Hilton, Cavity sealers, liners, and bases: current philosophies and indications for use, *Oper. Dent.* 21 (1996) 134–146.
- [8] F. Schwendicke, G. Göstemeyer, C. Gluud, Cavity lining after excavating caries lesions: meta-analysis and trial sequential analysis of randomized clinical trials, *J. Dent.* 43 (2015) 1291–1297.
- [9] F. Schwendicke, C.E. Dörfer, S. Paris, Incomplete caries removal: a systematic review and meta-analysis, *J. Dent. Res.* 92 (2013) 306–314.
- [10] D. Ricketts, T. Lamont, N.P. Innes, E. Kidd, J.E. Clarkson, Operative caries management in adults and children, *Cochrane Database Syst. Rev.* 3 (2013) Cd003808.
- [11] C.F. Cox, S. Suzuki, Re-evaluating pulp protection: calcium hydroxide liners vs. cohesive hybridization, *J. Am. Dent. Assoc.* 125 (1994) 823–831.
- [12] C.F. Cox, A.A. Hafez, N. Akimoto, M. Otsuki, J.C. Mills, Biological basis for clinical success: pulp protection and the tooth-restoration interface, *Pract. Periodontics Aesthet. Dent.* 11 (1999) 819–826.
- [13] D.J. Corralo, M. Maltz, Clinical and ultrastructural effects of different liners/restorative materials on deep carious dentine: a randomized clinical trial, *Caries Res.* 47 (2013) 243–250.
- [14] F. Schwendicke, F. Meyer-Lückel, C. Dorfer, S. Paris, Failure of incompletely excavated teeth—a systematic review, *J. Dent.* 41 (2013) 569–580.
- [15] R.T. Tan, F.J.T. Burke, Response rates to questionnaires mailed to dentists: a review of 77 publications, *Int. Dent. J.* 47 (1997) 349–354.
- [16] C.D. Lynch, K.B. Frazier, R.J. McConnell, I.R. Blum, N.H.F. Wilson, State of the art techniques in operative dentistry: contemporary teaching of posterior composites in UK and Irish dental schools, *Br. Dent. J.* 209 (2010) 129–136.
- [17] N.J. Opdam, E.M. Bronkhorst, J.M. Roeters, B.A. Loomans, A retrospective clinical study on longevity of posterior composite and amalgam restorations, *Dent. Mater.* 23 (2007) 2–8.
- [18] M. Unemer, Y. Matsuya, A. Akashi, Y. Goto, A. Akamine, Composite resin restoration and postoperative sensitivity: clinical follow-up in an undergraduate program, *J. Dent.* 29 (2001) 7–13.
- [19] F. Schwendicke, F. Meyer-Lückel, C. Dorfer, Attitudes and behaviour regarding deep dentine caries removal: a survey among German dentists, *Caries Res.* 47 (2013) 566–573.
- [20] E.S. Akpata, W. Sadiq, Post-operative sensitivity in glass ionomer versus adhesive resin-lined posterior composites, *Am. J. Dent.* 14 (2001) 34–38.
- [21] N.J. Opdam, E.M. Bronkhorst, J.M. Roeters, B.A. Loomans, Longevity and reasons for failure of sandwich and total-etch posterior composite resin restorations, *J. Adhes. Dent.* 9 (2007) 469–475.
- [22] F.H. van de Sande, P.A. Rodolpho, G.R. Basso, R. Patias, Q.F. da Rosa, F.F. Demarco, N.J. Opdam, M.S. Cenci, 18-year survival of posterior composite resin restorations with and without glass ionomer cement as base, *Dent. Mater.* 31 (2015) 669–675.
- [23] S. Fujisawa, Y. Kadoma, Effect of phenolic compounds on the polymerization of methyl methacrylate, *Dent. Mater.* 8 (1992) 324–326.
- [24] C.D. Lynch, R.J. McConnell, N.H.F. Wilson, Posterior composites: the future for restoring posterior teeth, *Prim. Dent. J.* 3 (2014) 49–53.
- [25] B.L. Chadwick, E.T. Treasure, P.M.H. Dummer, Challenges with studies investigating the longevity of dental restorations—a critique of a systematic review, *J. Dent.* 29 (2001) 155–161.
- [26] M. Peumans, P. Kanumilli, J. De Munck, K. Van Landuyt, P. Lambrechts, B. Van Meerbeek, Clinical effectiveness of contemporary adhesives: a systematic review of current clinical trials, *Dent. Mater.* 21 (2005) 864–881.
- [27] A.S. Gilmour, P. Evans, L.D. Addy, Attitudes of general dental practitioners in the UK to the use of composite materials in posterior teeth, *Br. Dent. J.* 202 (E32) (2007) 1–7.
- [28] P.A. Brunton, M.O. Sharif, S. Creator, F.J. Burke, N.H. Wilson, Contemporary dental practice in the UK in 2008: aspects of direct restorations endodontics and bleaching, *Br. Dent. J.* 212 (2012) 115–119.

- [29] G.H. Gilbert, M.S. Litaker, D.J. Pihlstrom, C.W. Amundson, V.V. Gordon, Rubber dam use during routine operative dentistry procedures: findings from The Dental PBRN, *Oper. Dent.* 35 (2010) 491–499.
- [30] C.D. Lynch, R.J. McConnell, Attitudes and use of rubber dam by Irish general dental practitioners, *Int. Endod. J.* 40 (2007) 427–432.
- [31] M.L.L. Peliz, S. Duarte, W. Dinnelli, Scanning electron microscope analysis of internal adaptation of materials used for pulp protection under composite resin restorations, *J. Esthet. Restor. Dent.* 17 (2005) 118–128.
- [32] M.F. Burrow, D. Banomyong, C. Harnirattisai, H.H. Messer, Effect of glass-ionomer cement lining on postoperative sensitivity in occlusal cavities restored with resin composite—a randomized clinical trial, *Oper. Dent.* 34 (2009) 648–655.
- [33] B. Strober, A. Veitz-Keenan, J.A. Barna, A.G. Matthews, D. Vena, R.G. Craig, F.A. Curro, V.P. Thompson, Effectiveness of a resin-modified glass ionomer liner in reducing hypersensitivity in posterior restorations: a study from the practitioners engaged in applied research and learning network, *J. Am. Dent. Assoc.* 144 (2013) 886–897.