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The teaching of posterior composites: A survey of dental schools in Oceania

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ABSTRACT

Objective: To investigate current teaching and operative techniques of posterior composite restorations in dental schools in Oceania (Australia, New Zealand, Fiji and Papua New Guinea).
Methods: A 24-item validated questionnaire including closed and open questions was mailed to the Heads of Department of Operative/Restorative Dentistry in 16 dental schools. Responses were compiled in Excel and analyzed.
Results: The response rate of this study was of 94% (n = 15). All respondent schools taught the use of posterior composites for occlusal and occluso-proximal cavities in premolars and molars. The mean percentage of pre-clinical teaching devoted to composites was greater than for amalgam (39% vs 29%). This proportion was anticipated to be 3:1 for posterior composite/amalgam in five years' time. Most posterior restorations placed by students are composites (average 64%, ranging from 10 to 100%), with amalgam representing 19.5% of the restorations placed (ranging from 0%–50%). Slot-type cavities were the preparation techniques most commonly taught (80%) and most schools (67%) teach the mandatory use of rubber dam for moisture control. The most common contraindication to composite placement (67% of the schools) was a history of adverse reaction to composites. The phase down of teaching and use of amalgam in Oceania is expected to occur within 8–10 years.
Conclusions: Despite minimally invasive approaches becoming increasingly common worldwide, the use of amalgam is still taught in Oceania. Future studies should assess whether the clinical teaching of posterior composites is in keeping with material development and trends in mainstream dental practice.

1. Introduction

The materials used most commonly in the direct restorations of posterior teeth are dental amalgam and resin-based composites (composites). Since the 1800s dental amalgam has been a popular choice of material for restoring carious posterior teeth [1,2]. Dental amalgams are wear resistant with good compressive strength, being less technique sensitive than composites [3]. Dental amalgam has, however, several perceived negative attributes, including its metallic appearance, concerns regarding its safety and risk of leakage and recurrent caries given that it is not normally bonded to remaining tooth tissues [4]. Other disadvantages include a relatively high risk of tooth fracture, linked to poor tooth reinforcement, and the need for unnecessary removal of sound tooth structure to provide mechanical retention [5]. Currently, the use of amalgam is being phased down due to environmental concerns over mercury pollution by the United Nations Environmental Programme (UNEP) [6–8]. By 2030, the European Parliament will assess the feasibility of completely phasing out the use of amalgam in the provision of oral healthcare [8–10].

Resin composites, which have been available since the late 1960s [11] are considered suitable materials for restoring occlusal and occluso-proximal cavities in posterior teeth, given the now substantial body of evidence to support the use of composite systems and associated adhesive technologies in such situations [3,12]. Modern bonding technologies and techniques have reduced polymerisation shrinkage, microleakage and the occurrence of secondary caries adjacent to composite restorations [13]. Alongside a growing evidence base to support its use in the restoration of posterior teeth, the popularity of composites is attributed to an increased demand for aesthetic restorations from patients [14]. Resin composites are a suitable replacement for natural tooth tissue, as the adhesive properties of the material mean that otherwise healthy tooth tissue is not needlessly sacrificed to create

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mechanical undercuts. This means that further weakening of the remaining dental structure is avoided [12]. It is important to note that non-invasive and preventive approaches such as local application of fluoride, resin infiltration, oral hygiene and dietary advice should be adopted when there is no need for surgical intervention [15–17]. However, their success depends on good patient compliance and are often ineffective in advanced stages of the carious process.

The successful placement of posterior composite restorations poses a number of challenges that must be addressed in the teaching of such restorations. Core skills and competences are acquired by dental practitioners in their undergraduate studies, which commonly shape their approach to the management and treatment of patients [18]. Dental schools should ensure that their students gain appropriate theoretical and clinical exposure relevant to contemporary and anticipated developments in clinical practice. With the existing high level of use of posterior composites, and in anticipation of composites becoming the preferred material for the restoration of posterior teeth, the teaching of posterior composites should be firmly imbedded in dental undergraduate curricula.

The first worldwide investigation on the teaching of posterior composites was completed in 1989. The authors concluded that many schools should review their approach to the teaching of posterior composites, and consider expanding such teaching [19]. A study in Japan in 2009 revealed that at that time, only two out of 25 schools did not teach Class I and II composite restorations [20]. Other studies in Europe and North America at the time showed that as few as 1-in-10 graduates had any clinical experience of placing posterior resin composites while in dental school [21,22]. Later studies highlighted that most schools anticipated that the proportion of teaching time devoted to posterior composite restorations had, and would to continue to, increase within the subsequent five years [20,23–25]. A study by Lynch et al. (2011) on the teaching of posterior composites in North American dental schools found that the amount of teaching on this topic had increased in recent years [25]. The same trend was observed in an earlier study in UK and Irish dental schools [26]. In a study in the early 2000s, the majority of general dental practitioners in the UK placed direct composite resin restorations in occlusal and occluso-proximal cavities of molar teeth [27]. However, practice trends indicated that a majority of GDPs in the UK continue to place amalgam in preference to composite [28,29]. Although most dental schools teach the use of composite in selected posterior cavities, there is still considerable variation in the principles taught, and in the clinical experience gained by undergraduate students [21,25,26].

Past studies have investigated the teaching of posterior composite restorations in dental schools in North America, Europe and some parts of Asia (for a review, see [30]); however, little is known about the teaching of posterior composite restorations in dental schools in Oceania. This study aimed to investigate the current trends in the teaching of materials and techniques for posterior composite placement in dental schools in New Zealand, Australia, Papua New Guinea and Fiji.

2. Materials and methods

Ethical approval for this project was granted by the University of Otago Human Ethics Committee (Category B, ethics number D18/043). An already trialled and validated questionnaire (following [14]) comprising 24 questions and sub-questions, was sent by postal mail to the Head of Operative/Restorative Dentistry in 16 Dental Schools in Oceania (Table 1). Two follow-up reminders were sent after two weeks and one month.

Information was sought in relation to preclinical and clinical teaching of posterior resin composites, including:

- The nature and extent of preclinical teaching, including the amount of time devoted to teaching different techniques;
- The nature and extent of clinical teaching, including clinical techniques for placement, and contraindications to placement of posterior resin composites;
- Respondents were also invited to comment on the anticipated developments in posterior resin composite teaching in the future, and the timeframe they believed the teaching and use of amalgam should be phased out.

Respondents were given free text space to add any additional comments in regards to the teaching of posterior composites. The data was collected and entered into an Excel spreadsheet and results were calculated and analysed.

Table 1
Dental schools in Oceania surveyed.

Countries	Dental Schools
New Zealand	Auckland University of Technology
	University of Otago
Australia	University of Melbourne
	Griffith University
	University of Western Australia
	Curtin University Australia
	University of Newcastle
	Central Queensland University
	University of Adelaide
	Charles Sturt University
	University of Sydney
	La Trobe University
	University of Queensland
	James Cook University
Fiji	Fiji National University
Papua New Guinea	University of Papua New Guinea

3. Results

From the 16 Dental schools invited to participate in this study, completed questionnaires were received from 15, giving a response rate of 94%. All 15 schools taught the placement of occlusal, two- and three-surface occluso-proximal composite restorations in premolar and molar teeth as part of their undergraduate programmes.

The average proportion of preclinical time assigned to the teaching of posterior composite restorations was found to be higher than the time devoted to amalgam teaching (posterior composite = 39% of preclinical course, range = 13–85%; posterior amalgam = 29%, range 5–70%). Over the next five years, it was anticipated that the amount of preclinical time assigned to the teaching of amalgam will decrease while that devoted to posterior composites will increase. The amount of time devoted to teaching these techniques was anticipated to be 3:1 posterior composite/amalgam (53.9% vs. 17.2%). The average teacher/student ratio in the preclinical programme of the schools surveyed was 1:9 (range 1:4 to1:15).

3.1. Teaching of amalgam and composite

Eight schools (53%) taught dental amalgam before posterior composites, while seven schools (47%) taught posterior composites first. In five years' time, it was anticipated that the majority of schools will be teaching posterior composites [n = 10; (67%)] prior to the teaching of amalgam (Fig. 1).

An average of 64% of posterior restorations placed by dental students in Oceania were reported to be composite restorations (ranging from 10%–100%), while 19.5% were amalgams (ranging from 0%–50%). It was anticipated that in five years' time this average will be 80.0% for composite restorations (range 50–100%), with approximately only one in eight (12.5%) of posterior restorations being amalgam (range 0–40%).

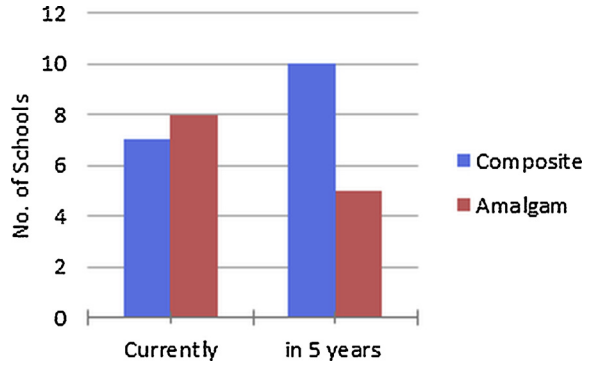

Fig. 1. Posterior restoration techniques taught first in dental schools in Oceania.

3.2. Preparation techniques

Most of the respondents [n = 12; (80%)] taught slot-type cavities for occluso-proximal composites, possibly including grooves. The teaching of rounded internal features was common [n = 11; (73%)]. Bevelled occlusal margins were less common [n = 5; (33%)] (Fig. 2). Several respondents further commented that the requirement of additional mechanical retention is case-dependent. Some comments included that: "*cavity design is mostly governed by caries*" and that "*pins may be essential for both amalgam and composite cavity preparation in extensive caries*". Other comments included that: "*no dovetail preparation was required for composites*" and "*minimum depth required for amalgam is 2 mm while it is 1.5 mm for composites*". Only one school taught dental students different protocols for managing residual caries before placing dental amalgam or posterior composites in the form of lectures.

3.3. Contraindications of posterior composite placement

The factors that contraindicated the placement of posterior composites are shown in Fig. 3. Although there seemed to be no consensus, the most common contraindication was a history of adverse reaction to composite materials for both occlusal [n = 10; (67%)] and occluso-proximal [n = 11; (73%)] restorations both in premolar and molar teeth, followed by subgingival margins.

3.4. Moisture control

Composite restorations are technique-sensitive, with good moisture isolation being an important key to a successful clinical outcome. Most schools [n = 10; (67%)] taught the mandatory use of rubber dam for isolation prior to the placement of all posterior composites, whilst 33% of the schools (n = 5) taught that rubber dam should be used wherever possible. In terms of alternative forms of moisture control, the use of cotton wool rolls was taught by almost all of the schools [n = 14; (93%)]. This was followed by the use of dry guards [n = 11; (73%)] and gauze/throat-packs [n = 4; (27%)]. Only one school (6.7%) did not teach other alternative forms of moisture control, having rubber dams as a mandatory practice.

3.5. Protection of operatively exposed dentine

In deep cavities where the preparation is extended to the inner third of dentine, closer to the pulp and at a higher risk of pulpitis, the combined use of calcium hydroxide and glass- ionomer cement prior to composite placement was taught by most schools [n = 10; (67%)] (Fig. 4). The use of glass ionomer cement alone as a base was mostly used in moderate [n = 13; (87%)] and shallow cavities [n = 9; (60%)]; respectively. Nine respondents (60%) taught the use of the 'total-etch' method in shallow and moderate cavities.

3.6. Matrix and wedge technique

The use of a circumferential metal matrix to build up proximal areas of occluso-proximal posterior composite restorations was the technique most commonly taught among dental schools in Oceania [n = 13; (87%,)], followed by using a sectional metal matrix [n = 12; (80%)]. On the other hand, the use of a clear circumferential matrix band [n = 2; (13%)] was the least common matrix technique taught.

To achieve good contact area between teeth after matrix band placement, the most common wedge techniques taught were wooden [n = 13; (87%)] and plastic/flexible wedge [n = 12; (75%)].

3.7. Composite materials and bonding systems

Nanofilled hybrid and flowable resins [n = 7; (47%)] were the most common types of composite resin used in dental schools in Oceania for the restoration of occlusal cavities, followed by nanofilled resins [n = 6; (40%)] (Fig. 5). For occluso-proximal restorations, hybrid [n = 7; (47%)], followed by nanofilled hybrid [n = 6; (40%)], were the most common types of composite used. One of the participants mentioned that: "*students use nanofilled and microhybrid materials in clinics, but hybrid and bulk fill materials in simulation clinics*". Common brands of

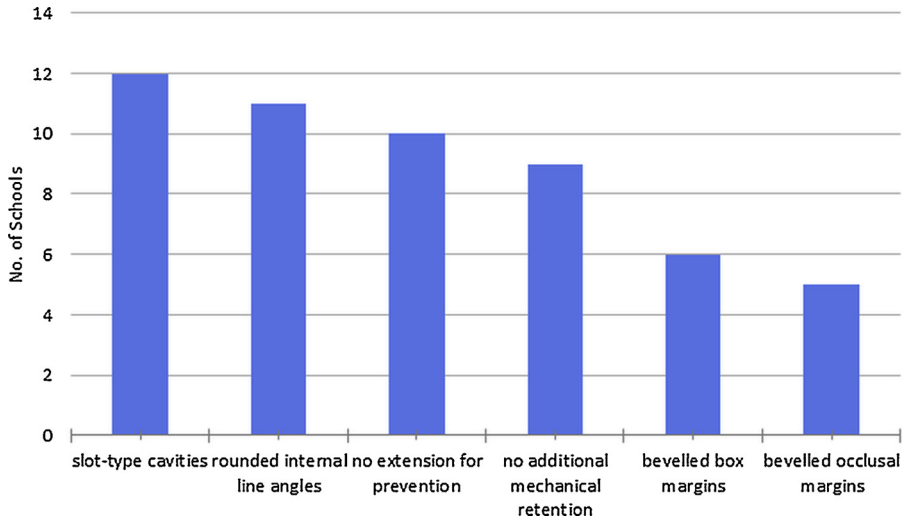

Fig. 2. Posterior composite cavity preparation techniques taught in dental schools in Oceania.

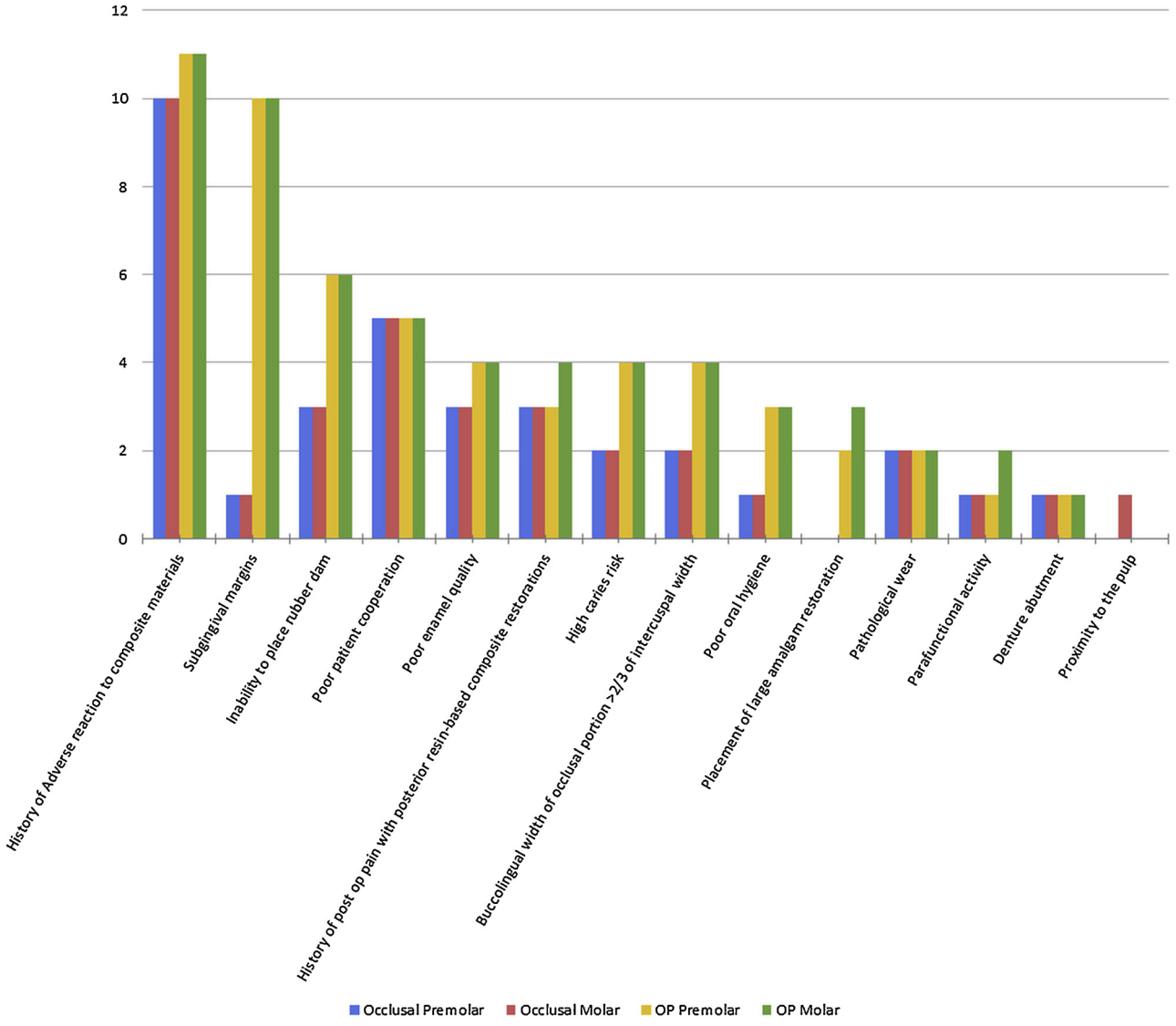

Fig. 3. Most common contraindications for the placement of posterior composite restorations.

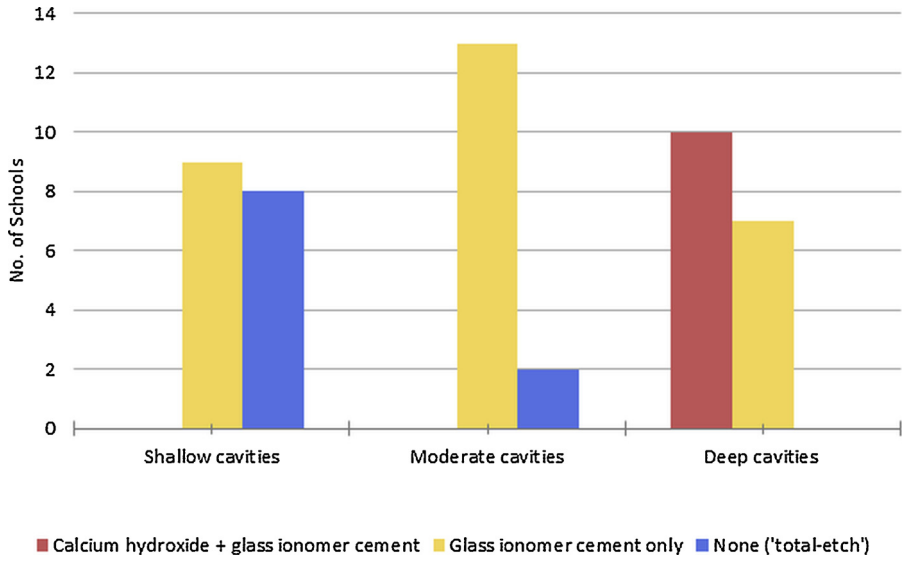

Fig. 4. Liners/bases used by students prior to placement of posterior composites in dental schools in Oceania.

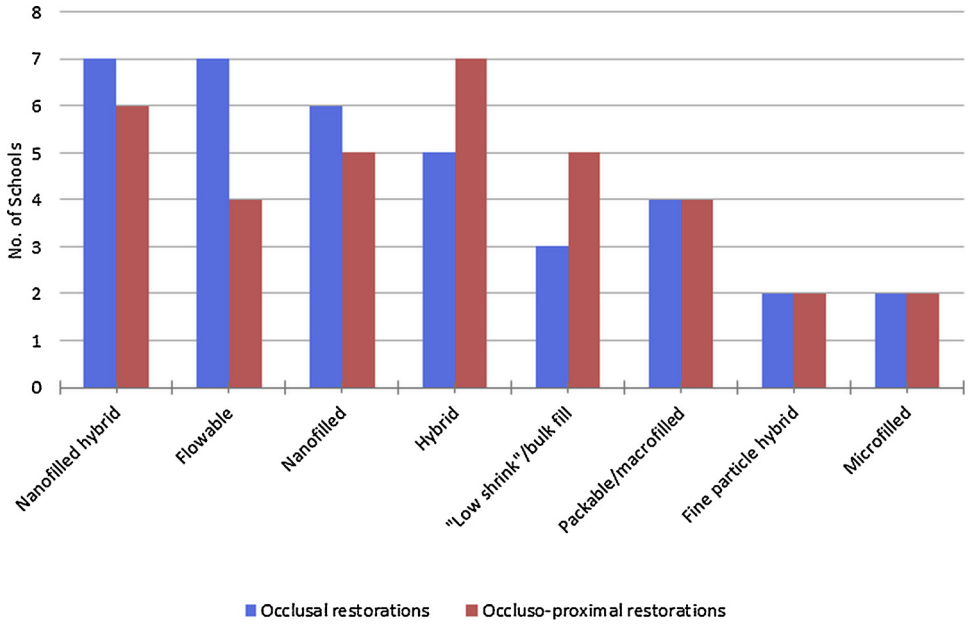

Fig. 5. Types of composite resins used for posterior restorations among dental schools in Oceania.

composites used for posterior restorations included Filtek Supreme XTE [n = 5; (33%)] and Gradia [n = 5; (33%)].

Respondents were also asked to describe scenarios in which students were taught to use flowable resin composites when placing direct posterior composite restorations. Most participants indicated that flowable composites were commonly placed in shallow cavities. This would be the case when doing a preventive resin restoration (PRR), as well as areas where access is difficult such as the line angle between tooth and matrix, in buccal pits, proximal boxes or when there are voids or undercuts. Another possibility would be beneath heavily filled resin composites in larger preparations or as stress-breakers in shallow occlusal restorations. Three schools specifically reported not teaching the use of flowable composites in posterior restorations.

Most schools surveyed did not teach the "bulk fill" technique [n = 9; (60%)]. Four out of the six schools that taught this technique commented that the teaching was limited to theoretical and simulation clinics, and not used at clinical level given the lack of evidence on the long term clinical performance of restorations placed using this method. The remaining two schools that taught the technique indicated they did so when indicated clinically. The respondent schools that did not teach this technique mainly reasoned that, while promising, published evidence does not support the use of "bulk fill" techniques.

Various brands of materials were used in the schools that taught "bulk fill"/low shrink posterior composites. These included 3 M Filtek One Bulk, Tetric Evo Cram, and Aural/SDI. The brands commonly used for bonding agents included 3 M ESPE Scotchbond Universal, Optibond, "All in One" Kerr, Solo, Siloplus, Optibond Plus, G-bond, and Clearfill SE.

3.8. Curing light

Almost all the schools surveyed [n = 14; (93%)] taught the students the routine use of LED curing light for posterior composite restorations. The use of traditional quartz-halogen light was taught in few schools [n = 2; (13%)].

3.9. Finishing

The different types of finishing techniques taught are listed in Fig. 6. For occlusal posterior composites, the technique taught most commonly was finishing diamonds [(n = 13; (87%)] with the majority of the schools teaching immediate finishing [n = 12; (80%)] and water cooling [n = 10; (67%)]. For occluso-proximal restorations, finishing diamonds were most commonly used for immediate finishing [n = 13; (87%)]. Finishing strips were commonly used in the finishing of occluso-proximal restorations [n = 12; (80%)].

3.10. Fees

Concerning fees, six out of 15 schools (40%) did not charge patients for posterior restorations placed by students. In one of the schools, fees were charged for restorations placed by final year students. Four out of 15 schools (27%) charged patients for posterior restorations placed by students. Price range varied from NZD $0 to $130 for an amalgam in occlusal and occluso-proximal cavities. For posterior composite restorations, the price range varied from NZD $0 to $146 in occlusal and occluso-proximal cavities.

3.11. Indirect posterior composite restorations

The majority of schools [n = 9; (60%)] did not teach indirect composite restorations to undergraduate students. Only 33% of the schools (n = 5) included the teaching of indirect composite restorations as part of their curriculum, but only in a didactic form with no clinical placement.

3.12. Phase down of amalgam

The respondent schools indicated that amalgam restorations would no longer be taught within 8–10 years or in more than 10 years (27%; n = 4 in both cases). Only two schools (13%) indicated that the teaching of amalgam would be phased down in less than three years (Fig. 7). Concerning the use of amalgam, respondent schools indicated that it should be discontinued within 8–10 years, or in more than 10 years [n = 5; (33%) in both cases)]. One school indicated that the use of dental amalgam should be discontinued within less than three years [n = 1; (7%)].

Respondents were also asked to give any further comments on the teaching of posterior composites. One school mentioned that: *"a major challenge in the teaching and use of posterior composites is the availability of composite in service clinics as well as the dental accessories to assist the quality of restorations, such as rubber dam*". Three schools mentioned that

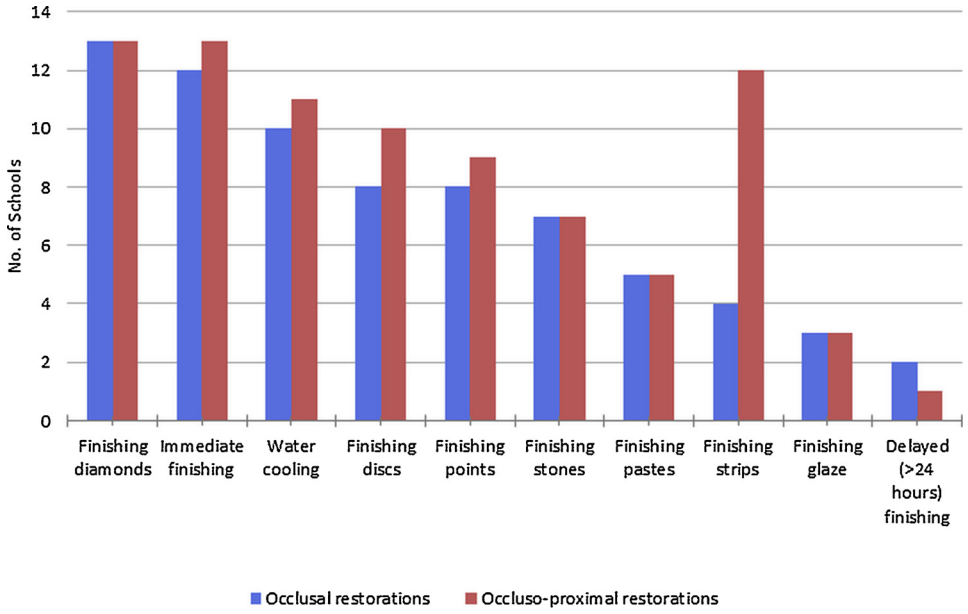

Fig. 6. Types of finishing techniques used for posterior composite restorations in dental schools in Oceania.

amalgam is still part of the teaching and practice, and another participant stated that: "*amalgam remains as the strongest dental material than others such as composites*". All three schools agreed that the phase down in amalgam is definitely happening albeit slowly, and that the preference and choice of materials from amalgam to composite is likely to change over time.

4. Discussion

This study aimed to investigate the teaching of posterior composites in dental schools in New Zealand, Australia, Fiji and Papua New Guinea. All 15 respondent schools taught posterior composites in their undergraduate curriculum, covering the placement of posterior composites in premolar and molar teeth, encompassing occlusal, 2- and 3-surfaces occluso-proximal cavities.

In most schools in Oceania, the teaching of dental amalgam placement tends to precede the teaching posterior composites. It was anticipated that the proportion of preclinical teaching of posterior composites will increase over the next five years with the concomitant decrease in the teaching of amalgam. In contrast, the majority of the dental schools in the United Kingdom and Japan taught the placement of posterior composites before teaching amalgam placement [20,24]. Despite minimally invasive approaches such as local application of fluoride, resin infiltration, oral hygiene and dietary advice becoming increasingly common worldwide [16,17], the teaching of amalgam placement is still common in Oceania.

The average proportion of composite posterior restorations placed by dental students in Oceania was much higher than for amalgam (64% vs 19.5%). There was some variation among schools, with some not having amalgam restorations placed by students at all, and others where half of the restorations placed were amalgam and the other half were composite. Most respondents indicated that this proportion will increase in five years' time in favour of composites. Previous studies have reported average proportions of 45% for composites and 0% for amalgam in posterior restorations placed by students in Japan [20]; 55% for composites and 44% for amalgam in United Kingdom and Ireland [26]; 49% for composites and 48% for amalgam in the United States and Canada [25]; and 44% for posterior composites and 26% for

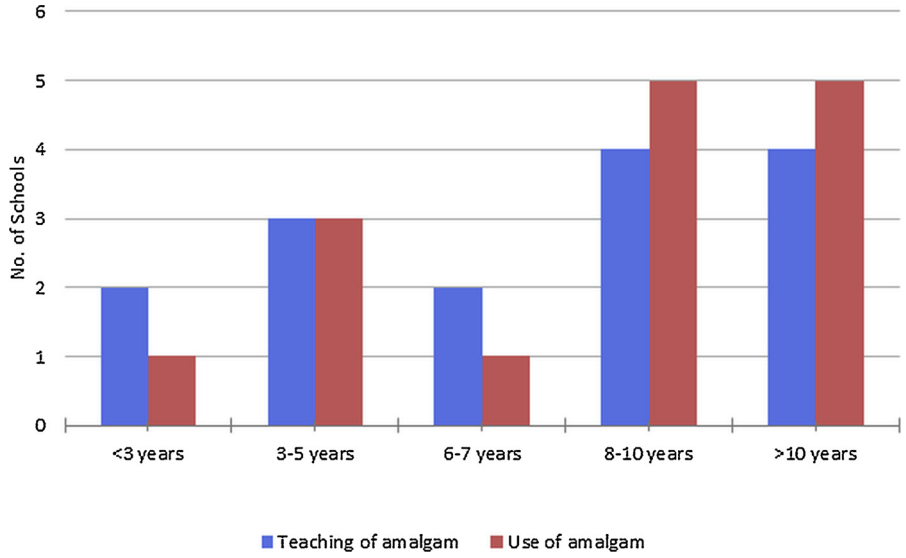

Fig. 7. Timeframe for amalgam use and teaching phase down among Oceania dental schools.

posterior amalgam in Spain [23]. In Japan, most students are not given instructions on amalgam restorations and the teaching of posterior composites is a well-established component of the dental school curricula [20]. In the present study, the higher proportion of composite teaching in Oceania could be related with timing as some of those previous studies were carried out around 10 years ago.

In relation to materials and techniques used in posterior composite placement, 33% of schools in Oceania taught bevelling on the occlusal cavosurface margins, while 40% taught bevelling of the proximal box margins. Comparatively, these technique were taught by 17% and 48% of schools in Japan [20], and by 60% of Spanish schools [23]. Some authors suggest that bevelling of the occlusal cavosurface margins, in contrast to intra-enamel bevelling, can result in the formation of thin extensions of composite on the occlusal surface of the restored tooth [20]. Such extensions, under functional load, have a high risk of fracture [31], giving a positive enamel to tooth step, which increases the risk of cavosurface margin staining and loss of the marginal integrity of the restoration [20]. Laboratory studies have reported that bevelled restorations exhibit higher fracture strength values than the non-bevelled restorations [32], but such possible advantage must be weighed against the negative effects of bevelling other than intra-enamel bevelling. Bevelling of proximal box margins, which makes it extremely difficult to achieve good marginal adaptation and may compromise rather than enhance marginal integrity gingivally, is an inappropriate transfer of techniques for anterior composites to the posterior composites [33]. The use of dentine pins, as suggested by one dental school, is not considered to have a place in the placement posterior composites [34].

A history of allergic reaction to resin-based materials was the main contraindication to the placement of posterior composites according to most dental schools in Oceania. The same reason was also the most common contraindication reported in previous studies [20,25,26]. Despite this, there seems to be little clinical evidence in regards to allergy to composites [21]. Other common contraindications in this study included subgingival margins and inability to place rubber dams. Rubber dam plays a crucial role in avoiding moisture contamination prior to successful bonding, as composites are hydrophobic and have technique-sensitive placement requirements [35]. In cases where rubber dam cannot be placed, alternative forms of moisture control such as cotton wool and dry guards were common among dental schools in Oceania. For only one school the placement of rubber dam was mandatory. Our results are similar to studies in Japan, Spain, UK and Ireland where rubber dams were preferred in most cases, but alternative forms of moisture control were also taught [20,23,26]. In North American dental schools, 63% of them taught the mandatory use of rubber dam for posterior resin-based composite placement, with 16% of the schools not teaching any alternative form of moisture control [25]. Previous studies have shown satisfactory clinical performance of posterior composite restorations placed with and without rubber dam (isolation with cotton rolls and aspiration) after 10 years, with no significant difference in survival between groups [36,37].

It is known that polymerisation shrinkage may affect the marginal seal, increasing risk of microleakage and recurrent caries [38]. An indirect restoration is preferred where cusp deflection is likely, following bulk polymerisation [39]. Although 60% of dental schools in Oceania provide instructions regarding indirect composite restorations, this is done only in didactic form. Clinical teaching of indirect composite restorations was present in 20% of dental schools in Spain [23], 52% in Japan [20] and 18% of schools in UK and Ireland [26]. In the US and Canada, the placement of indirect resin composites is more common than multi-surface resin-based composite restorations in posterior teeth [25]. Composites might become more common as a material of choice in wide occlusal restorations due to the improvement in material properties and reduced risk of fracture on the remaining natural tooth structure [3].

Regarding the management of operatively-exposed dentine, 67% of dental schools in Oceania taught the use of calcium hydroxide with a layer of glass-ionomer cement before composite placement in deep cavity preparations extended to the inner third of dentine. Only 13% of the schools taught the “total-etch” technique for moderate cavities; and the majority of schools (87%) taught the placement of a layer of glass-ionomer cement for moderate cavities. There is scarce evidence available on the advantages of a cement base under resin-based composites, except in deep cavities [40,41]. The placement of a base layer of glass-ionomer cement tends to reduce the available surface area for bonding and the mechanical performance of the final restoration [3]. Indeed, the need for a lining or 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 [42,43]. Recent research suggested the efficacy of the “total-etch” approach for managing dentine in both shallow and moderate cavities, in which resin-based composite is bonded after dentine etching with phosphoric acid [44]. The authors suggested that the application of phosphoric acid to dentine can also promote new dentine formation and thus generating a protective effect to the pulp [44].

In relation to matrix and wedge techniques, the majority of dental schools in Oceania (87%) taught the placement of circumferential metal matrix with wooden wedges for posterior composite placement. Metal matrices are thought to provide better pre-contour with superior adaptability to the tooth surface, thereby holding the proximal contour better than transparent matrices [45]. Few schools in Oceania use clear sectional matrix bands and light transmitting/clear wedges. According to Müllejans et al., (2003) [45], clear wedges are stiff and lack the ability to adapt the matrix band to the floor of the proximal box, resulting in increased proximal overhangs, inappropriate contour and open proximal contacts. The thickness and stiffness of clear matrix bands, together with the use of clear wedges, can generate significant overhang with poor proximal contour when compared to metal matrices [45].

Globally, resin-based composites have become the material of choice for restorative purposes in dentistry [16]. Resin composites require less invasive and less destructive preparation and placement methods, with minimal removal of healthy tooth tissue [46]. In recent years, resin composites have been modified to mimic the properties of sound enamel and dentine [16]. Dental amalgam has been used for almost 200 years, despite the controversy due to its mercury content [47]. However, there is little evidence of mercury release effects from dental amalgam on general chronic disease incidence, mortality or reproductive hazards [47]. Amalgam still has its place in teaching and dental practice in Oceania. Respondents of this study suggested the phase down of amalgam will perhaps happen in the next 8 to 10 years, or longer than that. This includes both the teaching and the reduced use of amalgam as a restorative material. One of the disadvantages of a complete cessation of amalgam use would be limited options for patients who may suffer allergies to other restorative materials [48]. In a study conducted by Lynch et al. in Europe, most dental students did not regard amalgam as being threatening to an individual patient’s health [2]. This study also mentioned that the environmental impact of mercury from dental amalgam would be insignificant compared to industrial pollution and fossil fuel combustion, for example [2]. Studies on restorative material use in Oceania are sparse. A cross-sectional study of private dental practices in Australia showed that amalgam rates remained high for replacement restorations and restorations involving more than one surface [49]. However, another survey conducted in 2003 showed that 59% of respondents reported a decreased use of amalgam over the previous five years [50].

In a recent systematic review, the success rates of posterior composites from 1995 to 2005 and 2006–2016 were considered highly satisfactory (89.41% and 86.87%, respectively). The success rate also improved from 2006 to 2016 (minimum 64% to maximum 96.9%) compared to 1995–2015 (minimum 50% and maximum 83%) [51]. Despite the placement of composites in multi-surface and more complex

cavities having a higher risk of failure, the clinical performance of posterior composites has been satisfactory and improved over the last two decades [51]. Composite restorations are also amenable to repair, which may greatly increase longevity in clinical service.

The choice of materials for posterior composite restorations is ultimately at the discretion of the clinician. Although the decision on when to prepare a cavity is also subject to the clinician's judgement, operative intervention is normally indicated when a carious lesion has reached the EDJ and has progressed towards dentine [15]. These decisions tend to be based on what they have been taught, modulated by clinical experience and judgement. The teaching of posterior composites in dental schools in Oceania and worldwide needs to be in line with the current evidence and trends in clinical practice. However, there seems to be no consensus in regards to operative techniques and the teaching of this concept [14,24]. Dental curricula should be dynamic and able to change over time to adapt to the evolving world of dentistry, whilst responding to the best evidence and objective evaluation available [52]. The mapping of trends in the teaching of operative dentistry helps developing and informing clinical teachers, drives postgraduate dental education and stimulates research in restorative dentistry.

Acknowledgements

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References

[1] J.M. Campbell, Dentistry Then and Now, Bell and Bain, Glasgow, 1981.
[2] C.D. Lynch, S.E. Guillem, B. Nagrani, A.S. Gilmour, D. Ericson, Attitudes of some European dental undergraduate students to the placement of direct restorative materials in posterior teeth, J. Oral Rehabil. 37 (12) (2010) 916–926.
[3] N. Opdam, E. Bronkhorst, B. Loomans, M.-C. Huysmans, 12-year survival of composite vs. amalgam restorations, J. Dent. Res. 89 (10) (2010) 1063–1067.
[4] Z. Fedorowicz, M. Nasser, N. Wilson, Adhesively bonded versus non-bonded amalgam restorations for dental caries, Cochrane Database Syst. Rev. 4 (2009).
[5] W.S. Eakle, M. Staninec, A.M. Lacy, Effect of bonded amalgam on the fracture resistance of teeth, J. Prosthet. Dent. 68 (2) (1992) 257–260.
[6] A.M. Kielbassa, G. Glockner, M. Wolgin, K. Glockner, Systematic review on highly viscous glass-ionomer cement/resin coating restorations (Part I): Do they merge Minamata Convention and minimum intervention dentistry? Quintessence Int. (Berl) 47 (10) (2016).
[7] A.M. Kielbassa, G. Glockner, M. Wolgin, K. Glockner, Systematic review on highly viscous glass-ionomer cement/resin coating restorations (Part II): Do they merge Minamata Convention and minimum intervention dentistry? Quintessence Int. 48 (1) (2017).
[8] T.K. Mackey, J.T. Contreras, B.A. Liang, The Minamata Convention on Mercury: Attempting to address the global controversy of dental amalgam use and mercury waste disposal, Sci. Total Environ. 472 (2014) 125–129.
[9] C. Lynch, N. Wilson, Managing the phase-down of amalgam: part I. Educational and training issues, Br. Dent. J. 215 (3) (2013) 109.
[10] C.D. Lynch, N. Wilson, Managing the phase-down of amalgam: part II. Implications for practising arrangements and lessons from Norway, Br. Dent. J. 215 (4) (2013) 159.
[11] S.C. Bayne, Beginnings of the dental composite revolution, J. Am. Dent. Assoc. 144 (2013) 42S–46S.
[12] J.L. Ferracane, Resin composite—state of the art, Dent. Mater. 27 (1) (2011) 29–38.
[13] A.V. Ritter, Posterior resin-based composite restorations: clinical recommendations for optimal success, J. Esthet. Restor. Dent. 13 (2) (2001) 88–99.
[14] C. Lynch, R. McConnell, N. Wilson, Teaching of posterior composite resin restorations in undergraduate dental schools in Ireland and the United Kingdom, Eur. J. Dent. Educ. 10 (1) (2006) 38–43.
[15] O. Fejerskov, E. Kidd, Dental Caries: the Disease and Its Clinical Management, John Wiley & Sons, 2009.
[16] J.E. Frencken, M.C. Peters, D.J. Manton, S.C. Leal, V.V. Gordan, E. Eden, Minimal intervention dentistry for managing dental caries–a review: report of a FDI task group, Int. Dent. J. 62 (5) (2012) 223–243.
[17] A.M. Kielbassa, J. Mueller, C.R. Gernhardt, Closing the gap between oral hygiene and minimally invasive dentistry: a review on the resin infiltration technique of incipient (proximal) enamel lesions, Quintessence Int. 40 (8) (2009).
[18] N. Wilson, S. Dunne, I. Gainsford, Current materials and techniques for direct restorations in posterior teeth: part 2: resin composite systems, Int. Dent. J. 47 (4) (1997) 185–193.
[19] N. Wilson, J. Setcos, The teaching of posterior composites: a worldwide survey, J. Dent. 17 (1989) S29–S33.
[20] M. Hayashi, L. Seow, C.D. Lynch, N. Wilson, Teaching of posterior composites in dental schools in Japan, J. Oral Rehabil. 36 (4) (2009) 292–298.
[21] N. Wilson, I. Mjör, The teaching of Class I and Class II direct composite restorations in European dental schools, J. Dent. 28 (1) (2000) 15–21.
[22] I.A. Mjör, N.H. Wilson, Teaching Class I and Class II direct composite restorations: results of a survey of dental schools, J. Am. Dent. Assoc. 129 (10) (1998) 1415–1421.
[23] R. Castillo-de Oyagüe, C. Lynch, R. McConnell, N. Wilson, Teaching the placement of posterior resin-based composite restorations in Spanish dental schools, Medicina oral, Patología oral y Cirugía bucal 17 (4) (2012) e661.
[24] C. Lynch, A. Shortall, D. Stewardson, P. Tomson, F. Burke, Teaching posterior composite resin restorations in the United Kingdom and Ireland: consensus views of teachers, Br. Dent. J. 203 (4) (2007) 183.
[25] C.D. Lynch, K.B. Frazier, R.J. McConnell, I.R. Blum, N.H. Wilson, Minimally invasive management of dental caries: contemporary teaching of posterior resin-based composite placement in US and Canadian dental schools, J. Am. Dent. Assoc. 142 (6) (2011) 612–620.
[26] C.D. Lynch, K.B. Frazier, R. McConnell, I. Blum, N. Wilson, State-of-the-art techniques in operative dentistry: contemporary teaching of posterior composites in UK and Irish dental schools, Br. Dent. J. 209 (3) (2010) 129.
[27] F. Burke, S. McHugh, A. Hall, R. Randall, E. Widstrom, H. Forss, Amalgam and composite use in UK general dental practice in 2001, Br. Dent. J. 194 (11) (2003) 613.
[28] A.S. Gilmour, M. Latif, L.D. Addy, C.D. Lynch, Placement of posterior composite restorations in United Kingdom dental practices: techniques, problems, and attitudes, Int. Dent. J. 59 (3) (2009) 148–154.
[29] C. Lynch, D. Farnell, H. Stanton, I. Chestnutt, P. Brunton, N. Wilson, No more amalgams: use of amalgam and amalgam alternative materials in primary dental care, Br. Dent. J. 225 (2) (2018) 171.
[30] N.H. Wilson, C.D. Lynch, The teaching of posterior resin composites: planning for the future based on 25 years of research, J. Dent. 42 (5) (2014) 503–516.
[31] J. Roeters, A. Shortall, N. Opdam, Can a single composite resin serve all purposes? Br. Dent. J. 199 (2) (2005) 73.
[32] F. Coelho-De-Souza, G. Camacho, F. Demarco, J. Powers, Fracture resistance and gap formation of MOD restorations: influence of restorative technique, bevel preparation and water storage, Oper. Dent. 33 (1) (2008) 37–43.
[33] C.D. Lynch, N.J. Opdam, R. Hickel, P.A. Brunton, S. Gurgan, A. Kakaboura, A.C. Shearer, G. Vanherle, N.H. Wilson, Guidance on posterior resin composites: academy of operative dentistry-European section, J. Dent. 42 (4) (2014) 377–383.
[34] S.J. Bonsor, Are dentine pins obsolete? Dent. Update 40 (4) (2013) 253–258.
[35] S. Mala, C.D. Lynch, F. Burke, P.M.H. Dummer, Attitudes of final year dental students to the use of rubber dam, Int. Endod. J. 42 (7) (2009) 632–638.
[36] A. Raskin, J. Setcos, J. Vreven, N. Wilson, Influence of the isolation method on the 10-year clinical behaviour of posterior resin composite restorations, Clin. Oral Investig. 4 (3) (2000) 148–152.
[37] A. Brunthaler, F. König, T. Lucas, W. Sperr, A. Schedle, Longevity of direct resin composite restorations in posterior teeth: a review, Clin. Oral Investig. 7 (2) (2003) 63–70.
[38] W.V. Duncalf, N.H. Wilson, A comparison of the marginal and internal adaptation of amalgam and resin composite restorations in small to moderate-sized Class II preparations of conventional design, Quintessence Int. 31 (5) (2000).
[39] V.V. Gordan, I.A. Mjör, A.V. Ritter, Teaching of posterior resin-based composite restorations in Brazilian dental schools, Quintessence Int. 31 (10) (2000).
[40] C.D. Lynch, I.R. Blum, Successful posterior composites, Quintessence (2008).
[41] S. Dunne, I. Gainsford, N. Wilson, Current materials and techniques for direct restorations in posterior teeth: part 1: silver amalgam, Int. Dent. J. 47 (3) (1997) 123–136.
[42] I.R. Blum, N. Younis, N.H. Wilson, Use of lining materials under posterior resin composite restorations in the UK, J. Dent. 57 (2017) 66–72.
[43] I.R. Blum, N.H. Wilson, An end to linings under posterior composites? J. Am. Dent. Assoc. 149 (3) (2018) 209–213.
[44] L. Sadaghiani, A. Gilmour, C. Lynch, A. Sloan, Effects of adhesive restorative agents on solubilising dentine matrix proteins, J. Dent. Res. 89 (2010).
[45] R. Mullejans, M. Badawi, W. Raab, H. Lang, An in vitro comparison of metal and transparent matrices used for bonded class II resin composite restorations, Oper. Dent. 28 (2) (2003) 122–126.
[46] M. Dallı, H. Çolak, M. Mustafa Hamidi, Minimal intervention concept: a new paradigm for operative dentistry, J. Investig. Clin. Dent. 3 (3) (2012) 167–175.
[47] M.N. Bates, Mercury amalgam dental fillings: an epidemiologic assessment, Int. J. Hyg. Environ. Health 209 (4) (2006) 309–316.
[48] G. Alexander, M. Hopcraft, M. Tyas, R. Wong, Dentists' restorative decision-making and implications for an 'amalgamless' profession. Part 1: a review, Aust. Dent. J. 59 (4) (2014) 408–419.
[49] D. Brennan, A. Spencer, Restorative service patterns in Australia: amalgam, composite resin and glass ionomer restorations, Int. Dent. J. 53 (6) (2003) 455–463.
[50] F. Burke, S. McHugh, R. Randall, I. Meyers, J. Pitt, A. Hall, Direct restorative materials use in Australia in 2002, Aust. Dent. J. 49 (4) (2004) 185–191.
[51] N. Alvanforoush, J. Palamara, R. Wong, M. Burrow, Comparison between published clinical success of direct resin composite restorations in vital posterior teeth in 1995–2005 and 2006–2016 periods, Aust. Dent. J. 62 (2) (2017) 132–145.
[52] J. Kaidonis, V. Skinner, D. Lekkas, T. Winning, G. Townsend, Reorientating dental curricula to reflect a minimally invasive dentistry approach for patient-centred management, Aust. Dent. J. 58 (2013) 70–75.