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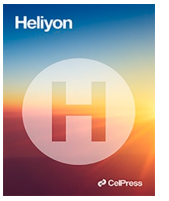

Research article

Teaching posterior composite restorations: A survey of dental schools in Palestine

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A R T I C L E I N F O

Keywords:
Posterior composites
Teaching
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A B S T R A C T

Aim: This study aimed to assess different aspects of teaching posterior composite restorations in two dental schools in Palestine.

Materials and methods: A questionnaire was emailed to the heads of the operative and conservative dentistry departments to collect detailed information on the teaching practices related to posterior composite restorations. The questionnaire comprised 22 questions structured to collect information on the time dedicated to teaching the topic, competency assessments, future plans for allocating time for each restoration type, relevant indications and contraindications, specific materials and techniques utilized in the application, and fees charged for posterior restorations. The gathered responses were collated in Excel and analyzed.

Results: Both dental schools allocated similar teaching times to posterior composites and amalgam in their preclinical operative dentistry courses. However, there was a greater emphasis on composites in the clinical course than in the preclinical course at both institutions. Despite these differences, both institutions expressed a shared intention to allocate more time to teaching posterior composites while reducing the emphasis on teaching amalgam procedures. Consistency was observed across competency testing, cavity design preferences, and contraindications, with both schools favoring slot-type cavities. Furthermore, uniformity was noted in the management of operatively exposed dentin and matrix techniques, although variations existed in moisture isolation. Notably, both schools taught circumferential and sectional metal matrices but did not teach clear sectional matrices or use of bulk-fill composites. Additionally, the adhesive and light-curing practices remained consistent across both institutions.

Conclusion: The findings of this study indicate that the teaching of posterior composite restorations is consistent across both Palestinian dental schools. Their curricula are aligned with contemporary international practices, demonstrating a strong commitment to modern operative dentistry and adherence to global standards. These findings offer valuable insights for educators and researchers and emphasize the need for ongoing adaptations to maintain high clinical standards.

1. Introduction

Operative dentistry has evolved significantly in recent decades, with resin composite becoming a key material, particularly for posterior restorations [1,2]. Historically, dental amalgam has been the preferred material because of its durability and ease of use. However, the introduction of the Minamata Convention on Mercury—a global treaty aimed at protecting human health and the

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environment from the harmful effects of mercury—has discouraged use of amalgam, accelerating the global adoption of resin composites for posterior restorations [3–5].

This shift has been driven by the growing interest in minimally invasive dentistry, which emphasizes the preservation of tooth structure. Modern resin composites combined with advanced adhesive techniques support this approach by enabling restorations that closely mimic the natural appearance and function of teeth and align with the principles of conservative dental care [6,7]. Additionally, the aesthetic appeal of resin composites and patient preferences for more "natural-looking" restorations have supported their widespread adoption [8–12]. Innovations, such as bulk-fill composites, improved bonding agents, and advanced light-curing units, have enhanced the efficiency and durability of posterior restorations [13].

Despite these advancements, the longevity and success of posterior composite restorations is heavily dependent on the practitioner's knowledge, proficiency, and skills [14–18]. Research indicates that the correct application of restorative techniques and the knowledge of the operator are paramount for achieving favorable outcomes, regardless of the material used [19,20]. Operator decision making regarding restorations is critical because it can affect the longevity of the restoration [21]. Factors such as cavity preparation, material selection, and insertion techniques are directly correlated with the incidence of recurrent caries and restoration fractures, which are the primary reasons for failure [22].

Studies have shown that the placement of posterior composite restorations by general practitioners may often fall below optimal standards, with evidence suggesting that general practitioners frequently encounter issues with posterior composite restorations, usually due to inadequate bonding, improper curing, and suboptimal handling of materials [23–28]. These issues are compounded by significant variability in restorative decision-making practices among graduates worldwide, reflecting differences in training and experience [25–27].

As dental materials and techniques continue to evolve, it has become increasingly essential to improve dental education to keep pace. Recognizing this need, dental schools worldwide have updated their curricula to include comprehensive didactic and practical training in composite restoration techniques to ensure that students gain proficiency in modern materials and methods [29,30]. However, such integration presents several challenges. The rapid pace of advancement in dental materials and techniques necessitates continuous curriculum updates, which can be resource intensive for institutions [29]. Furthermore, providing sufficient hands-on training is particularly demanding when addressing the diverse competency levels of students [31,32]. A tailored approach is essential, with tiered education and personalized feedback to address the needs of beginners, intermediates, and advanced learners.

Numerous survey studies have assessed how posterior composite restorations are taught in dental schools globally, revealing a variety of approaches [30,33–39]. Some institutions have adopted an amalgam-free curriculum whereas others are phasing out amalgam, but many continue to include amalgam placement in their programs [30]. Despite these insights, a notable gap exists in the literature regarding the teaching of posterior composite restorations in Palestinian dental schools.

This study aimed to evaluate the current teaching methods for posterior composite restorations in the two main dental schools in Palestine. By comparing these methods with international standards, this study seeks to identify areas for improvement. The findings provide valuable insights that can inform curriculum development, enhance student preparedness for contemporary clinical challenges, and ensure that Palestinian dental education aligns with global standards. This focused examination will help bridge the gap in the literature regarding the teaching of posterior composite restorations in Palestinian dental schools and contribute to better clinical outcomes.

2. Material and Methods

This study was conducted between August and September 2023. A questionnaire was created using Google Forms and emailed to the heads of the Department of Conservative Dentistry at the only two dental schools in Palestine, requesting their input or directing them to the faculty members responsible for teaching or coordinating operative dentistry at their respective institutions.

The questionnaire, which was adapted from a previous investigation [39], comprised 22 questions structured to collect thorough information on the teaching of posterior composite restorations (Appendix 1). The first 12 questions focused on the time dedicated to teaching the topic, competency assessments, and future plans for allocating time for teaching each type of restoration. Question 13 asked about relevant indications and contraindications, while questions 14–21 explored the specific materials and techniques used in the application. Question 22 asked about the fees charged for posterior restorations.

A cover letter accompanied the survey and explained the study objectives of ensuring voluntary and anonymous participation and confidentiality. Before engaging in the survey, the participants were informed that by clicking "Submit," they consented to participate in the study.

The participants' responses were collected and entered into an Excel spreadsheet, and the collected data were analyzed.

3. Results

In both dental schools, approximately half of the teaching time dedicated to posterior restorations in the preclinical operative dentistry courses was devoted to posterior composites, with the remaining half allocated to amalgam. In clinical operative dentistry courses, both schools allocated 75 % of their teaching time for posterior restorations to placing posterior composite restorations and 25 % to amalgam. Both institutions expressed their intent to increase the teaching time for posterior composite procedures in preclinical courses to 75 % in the future. Concurrently, they plan to reduce the time allocated to teaching the amalgam in preclinical courses to 25 % of their total teaching time. In preclinical courses at both institutions, amalgam restoration techniques were introduced before posterior composite techniques. Additionally, competency tests for both amalgam and posterior composite resin restorations were

consistently conducted in the preclinical and clinical courses at both schools (Table 1).

Regarding preferences in cavity design, both schools refrained from providing instructions on occlusal mechanical retention features and occlusal and gingival cavosurface margin bevels. They focused on the 'slot-type' preparation design (Fig. 1). Both schools identified "poor oral hygiene with a high risk of caries," "subgingival margins," "a history of an adverse reaction to composite resin," and "moisture control problems" as contraindications for the placement of posterior composite restorations. One school identified "parafunctional activity (bruxism)" as a contraindication, while the other highlighted "inability to place a rubber dam."

Regarding moisture control, one school instructed students to use rubber dams whenever feasible, allowing for alternative methods when rubber dams were impractical. In contrast, the other school mandated rubber dam application and did not accept alternative moisture control approaches. Neither school taught the use of liners for shallow and moderately deep cavities during posterior composite restorations. Both schools instructed on the application of liners for deep cavities, typically utilizing calcium hydroxide covered with a glass ionomer cement (GIC) protective base (Fig. 2).

Both schools taught circumferential and sectional metal matrices, but neither provided instructions on clear sectional matrices. Bulk-fill composites were not part of the practical training for posterior restoration purposes at either institution, although they did include the topic in their theory courses. Both schools primarily taught students to use two-step etch-and-rinse adhesives to bond posterior resin composites. Additionally, both institutions opted for light-emitting diode (LED) curing lights for posterior composite placement, and neither provided instructions on using conventional quartz-halogen lights (QTH). None of the participating schools charged fees for placing posterior composite restorations and treatment was provided free of charge.

4. Discussion

While the current study highlights both schools' emphasis on dedicating equal time to teaching composite and amalgam posterior restorations during the preclinical phase of dental education, the existing literature presents diverse patterns in allocating instructional time for teaching posterior composite and amalgam restorations during this phase [30,34–37,39]. In a recent study, nine dental schools in Canada were surveyed to assess the current trends in the teaching of posterior composite restorations. The findings revealed that 78 % of the responding schools allocated 25%–50 % of their preclinical restorative teaching time to posterior composite placement. The remaining 22 % of schools dedicated more than 50 % of their teaching time to this subject [36]. In contrast, U.S. dental schools place a strong emphasis on posterior resin composites. In a survey of 34 schools, 38 % reported assigning 75 % or more of their preclinical teaching time to the technique. Additionally, another 38 % devoted 50%–75 % of their preclinical courses to teaching posterior resin composites, while 24 % allocated 25%–50 % of their teaching to the same [39]. Similarly, other surveys have consistently indicated prioritizing posterior composites over amalgams in preclinical/phantom head courses, with more time dedicated to teaching posterior composite restorations [30,34,35,37].

Both schools emphasized composite restorations over amalgam during the clinical phase, aligning with the prevailing trend in dental schools worldwide [35,37–39]. Despite significant advancements in adhesive technologies and the properties of resin composite materials, the global phase-out in dental amalgam use as mandated by the Minamata Convention [34], and the concurrent shift towards preventive and minimally invasive dentistry [7], both dental schools in Palestine continue to incorporate instruction on posterior amalgam restorations into their preclinical and clinical curricula. The persistence of teaching amalgam restorations in the dental school curriculum seems to be driven by factors such as local dental practice realities, professional norms, and patient demands and needs. Similar patterns have been observed in various regions, including the UK, Ireland, Malaysia, Canada, Switzerland, Germany, Austria, and Oceania, where dental students receive training in dental amalgam restorations [34–38]. Both Palestinian dental schools anticipate a reduction in teaching dental amalgam over the next five years, aligning with the broader international shift towards reducing emphasis on amalgams and enhancing the focus on posterior composites in undergraduate dental education [30,34,35,37,38].

The investigation revealed a common preference among the surveyed schools to prioritize teaching dental amalgam placement before posterior composite placement in preclinical courses. This trend aligns with the predominant approach observed in most Canadian (89 %), Malaysian (69 %), and American (62 %) dental schools [36,38,39]. In contrast, a survey of 15 dental schools in Oceania (New Zealand, Australia, Fiji, and Papua New Guinea) revealed that only 53 % preferred to teach amalgam before posterior composites at the preclinical level. This preference indicates a more conservative approach in Oceania than in other regions where the emphasis on resin composites is more pronounced [35]. Teaching amalgam placement is beneficial, as it helps students develop fundamental skills in handling dental materials and understanding the principles of tooth preparation. However, the variability in educational approaches across dental education programs is worth noting [30]. Some programs have introduced composite restorations earlier in the curriculum, which is often attributed to the increasing emphasis on minimally invasive and aesthetic dentistry. Notably, this alternative strategy is prevalent in most Japanese dental schools, where instruction on posterior composite placement precedes that of amalgam [33]. Similar variations were observed in the UK and Ireland, where a survey of 18 dental schools found that 61 % had introduced

Table 1
Distribution of teaching time for posterior restorations.

Teaching aspect	Posterior composite	Posterior composite	Posterior composite
Institution	Preclinical course	Clinical course	Planned preclinical time
School 1	50 %	75 %	75 %
School 2	50 %	75 %	75 %

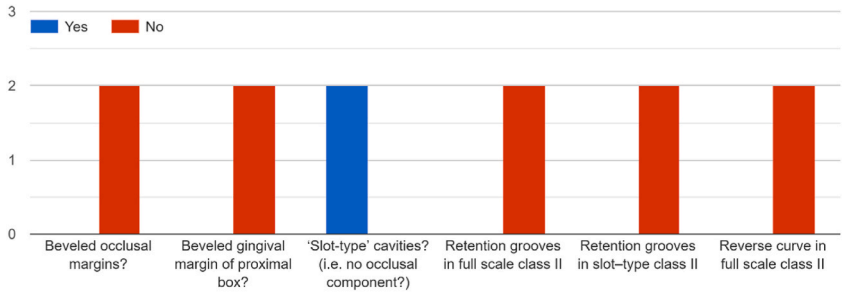

Fig. 1. Posterior composite cavity preparation techniques taught in dental schools.

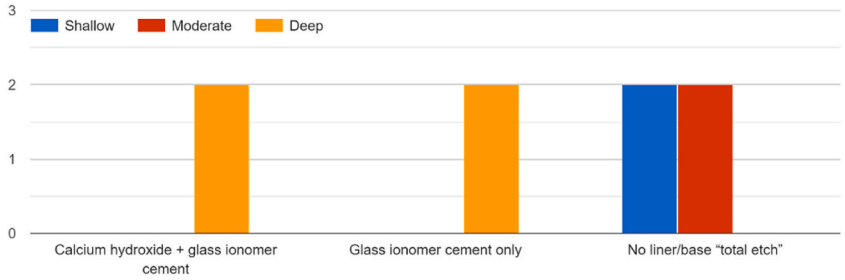

Fig. 2. The use of liners and bases in the management of operatively exposed dentine.

training in posterior resin composite placement techniques before those for amalgam [34]. Conversely, a survey of 33 dental schools in Austria, Germany, and Switzerland revealed that 64 % followed the practice of teaching posterior composites before posterior amalgams in preclinical/phantom head courses [37].

Both dental schools incorporated competency tests for composite and amalgam restorations into their teaching programs. These assessments are crucial for evaluating the efficacy of education and determining whether students have achieved the desired learning outcomes in both preclinical and clinical courses. In the United States, 91 % of surveyed schools mandate competency evaluations for both resin composite and amalgam during preclinical teaching [39]. Similarly, 67 % of institutions in Canada require equal competency assessments for both techniques [36]. Such assessments align with educational objectives and ensure that students acquire proficiency in composite and amalgam restorations.

Effective moisture control is essential for the placement of posterior resin composites to ensure successful adhesive bonding and restoration longevity. Although rubber dams are highly recommended for this purpose, alternative moisture-control techniques (cotton wool rolls, dry guards, and high- or low-volume suction) may be utilized [40,41]. This study investigated moisture control techniques taught in dental schools, revealing differences between the two schools: one prioritized rubber dam usage but accepted alternatives when impractical, whereas the other mandated rubber dams without alternatives. The literature underscores the various approaches for teaching rubber dam usage in dental schools across regions, highlighting differences in mandates and preferences [30]. For instance, in Austria, Germany, and Switzerland, 97 % of the surveyed dental schools considered rubber dam isolation essential for posterior composite applications, with alternative moisture control methods taught when rubber dam placement was not feasible. Only one school (3 %) instructed its students that it was mandatory and that they should not use alternative moisture control methods [37]. In the UK and Ireland, 44 % of studies reported that rubber dams were essential or mandatory for posterior resin composite placement. Seven schools (39 %) taught that rubber dams were required in approximately 75 % of cases. Two schools (11 %) reported that rubber dam use was neither essential nor mandatory for placing posterior resin composites [34]. Dental schools in Malaysia and Oceania lean towards a more uniform approach, with 85 % and 67 % mandating rubber dam use, respectively [35,38]. In contrast, Japanese dental schools vary in preferences, with 24 % mandating rubber dam in all cases, 38 % in 'most' cases, and 17 % using it 'sometimes' [33]. In the United States, 94 % of the schools affirmed the necessity of rubber dam application for posterior resin composites. In comparison, 6 % allowed for alternative moisture control methods [39].

In general, there are inconsistencies in the teaching of operatively exposed dentin across dental schools, with diverse approaches observed in different regions. This discrepancy underscores the absence of a consensus within the research community regarding proper dentin management following cavity preparation. None of the schools in the current study mandated the use of liners to place posterior composites in shallow cavities. This aligns with the approach observed in prior studies in Germany, Switzerland, Austria, Malaysia, the UK, Ireland, and the United States, where most surveyed schools also did not advocate for liner or base application in such cases [34,37–39]. Conversely, in the Oceania region, there were notable differences, with eight schools (53 %) endorsing the "total etch" technique. In comparison, nine schools (60 %) advocated the use of GIC alone as a base for shallow cavities [35].

Neither school employed liners to restore moderate cavities that extended into the middle third of the dentin. Regional variations in the management of moderately deep cavities have been reported. While some schools do not mandate linear usage, others recommend

the use of GIC or a combination of materials. Notably, in Switzerland, Germany, and Austria, none of the responding schools mandate the use of liners when placing posterior composites in moderately deep cavities [37]. In Malaysia, a survey of 13 schools revealed that 77 % typically leaned towards not using a liner or base for moderately deep cavities. Nevertheless, 38 % of the schools instructed the use of GIC as a liner [38]. In the United States, 50 % of dental schools have taught the placement of GIC in moderately deep cavities [39]. In the UK and Ireland, 67 % of the surveyed schools reported that they did not instruct their students to place a liner or base before applying composite restoration in moderately deep cavities. In comparison, 33 % of the participants reported instruction in a GIC base [34]. Conversely, in Oceania, only two schools advocated no liners or bases in moderate cavities, whereas the prevalent practice (87 %) involved using GIC alone as a base [35]. In Japan, the findings indicated that 93 % of the respondent schools did not advocate using liners or bases in moderately deep cavities. Furthermore, one school recommended using calcium hydroxide and GIC, whereas another advocated using GIC alone [33].

In the present study, both schools instructed students to use calcium hydroxide liners and GIC bases when dealing with deep cavities extending into the inner third of the dentin. This finding is in agreement with the results of other studies. In Switzerland, Austria, and Germany, 58 % of schools reported teaching the obligatory placement of a liner when dealing with deep cavities [37]. In Malaysia, most respondents (85 %) instructed students to use calcium hydroxide and GIC beneath posterior composite restorations in deep cavities [38]. Similarly, in the United States, 79 % of the surveyed schools recommended a calcium hydroxide liner and GIC base for treating deep cavities, with only 6 % advocating a no-liner/base approach [39]. In Oceania, 67 % of the surveyed schools prescribed a calcium hydroxide liner and GIC base, while 47 % emphasized the use of only GIC for deep-cavity treatment [35]. In the UK and Ireland, diverse opinions have been reported regarding deep cavities, with ten schools (56 %) providing instructions for placing calcium hydroxide in combination with a GIC base. In comparison, nine schools (50 %) only taught a GIC liner/base. However, three schools (17 %) opted for no liners or bases beneath the composite restorations, even in deep cavities [34]. In Japan, there has been a prevailing shift towards minimizing the use of liners and bases, even when dealing with deep cavities. Among the surveyed schools, 62 % advised against using liners for deep cavities, whereas 24 % recommended using a combination of calcium hydroxide and GIC before placing composites in such cavities. Additionally, 14 % of respondents advocated using only GICs in this context [33].

While beveling was once thought to enhance marginal bonding and integration with surrounding tooth structures, contemporary literature suggests otherwise [2,29,42–44]. Beveling on the occlusal cavosurface angle is now discouraged to prevent the fracture of thin restoration margins under occlusal loads, reducing the risk of cavosurface margin staining and maintaining marginal integrity [43–48]. Despite the evidence discouraging this practice, it persists in dental school curricula worldwide, highlighting the persistence of traditional teaching methods in certain regions. For example, in Japan [33], 52 % of responding schools include instruction on beveled occlusal margins, whereas in Austria, Germany, and Switzerland [37], the figure is 42 %. However, teaching this approach is less common in Canada (11 %) [36], Oceania (33 %) [35], the United States (17 %) [39], and the UK and Ireland (25 %) [34]. Despite the evolving guidelines and evidence-based recommendations, these disparities underscore the persistence of traditional teaching methods in certain regions.

The decision to employ proximal gingival bevels must be carefully made, considering the risk of iatrogenic damage to adjacent teeth and challenges in achieving optimal marginal adaptation and integrity [29]. Beveling may result in the removal of thin gingival margin enamel and the creation of thin excess resin composite flashes in hard-to-reach proximal areas during restoration finishing [2, 43,45]. The findings of the current study indicate a consensus among dental schools in Palestine regarding beveling of the proximal gingival margin. Conversely, varying proportions of schools in countries such as Canada, Japan, Malaysia, the United States, the United Kingdom, Ireland, Oceania, Austria, Germany, and Switzerland incorporate teaching about beveling [33–38].

Clinicians and researchers have endorsed vertical slot or "Minibox" preparations for restoring proximal lesions in posterior teeth as a minimally invasive and relatively successful technique [8,49,50]. The "slot-type" preparation design involves removing carious lesions through the marginal ridge while excluding the occlusal pits and fissures if caries removal in these areas is not required. This approach saves time, conserves tooth structure, offers better aesthetics, does not alter occlusal relationships, preserves natural proximal contact, and enjoys greater patient acceptability than traditional approaches [8]. Both respondent schools in the study and many others worldwide integrate instruction on "slot-type" preparations into their curricula [34–36,38,39]. By contrast, the adoption of this technique is less prevalent in certain regions. In Japan, only 38 % of dental schools include this technique in their teachings [33]. Similarly, in Switzerland, Austria, and Germany, "slot-type" preparations were incorporated into the curricula of 67 % of responding schools [37]. These variations underscore the diverse approaches to teaching and integrating minimally invasive techniques into dental education across different regions.

The teaching of sectional and circumferential matrix-band systems for posterior composite restorations is emphasized in both dental schools, highlighting their distinct advantages. Sectional matrices are valued for their precision in achieving tight interproximal contacts, whereas circumferential matrices are essential for restoring multiple surfaces or when significant contouring is required. Comprehensive training in both systems equips dental students with the skills necessary to adapt their restorative techniques to various clinical scenarios, thereby ensuring the delivery of high-quality posterior composite restorations. Despite some limitations of circumferential metal matrices in restoring proximal contour [51,52], they are incorporated into the curriculum of most surveyed dental schools. Malaysia, Canada, and Japan incorporate the use of circumferential metal matrices into their curriculum for achieving proper contact in class II composite restorations [33,36,38]. Additionally, a study revealed that 87 % of dental schools in Oceania incorporate the teaching of circumferential metal matrices for posterior composite placement [35]. However, the proportion of schools teaching this technique varies, with lower adoption rates (58 %) observed in regions such as Austria, Germany, and Switzerland [37]. Interestingly, some dental institutions in the USA have used sectional metal matrices more extensively than circumferential matrices [39]. Although not used by the respondent schools in the present study, clear sectional matrices are taught in certain dental schools worldwide [35,37,38]. However, concerns regarding proximal overhang formation and flat proximal contours are associated with

their use [53].

Bulk-fill restorative materials offer advantages such as time efficiency and the potential for sufficient polymerization. However, the existing literature emphasizes the need for well-structured randomized clinical trials to establish definitive evidence supporting their efficacy [54–56]. Consequently, dental school curricula often provide limited exposure to this technique with minimal emphasis on its clinical application [30]. The present study's findings revealed that both dental schools reported limited coverage of bulk-fill composites, focusing solely on theoretical aspects without practical application. This trend is consistent with observations from other regions, indicating a widespread lack of emphasis on bulk-fill materials in dental education. For instance, in Malaysia, none of the 13 dental schools surveyed integrated the teaching of bulk-fill composites into their undergraduate programs [38]. A similar approach was observed in Oceania, where 60 % of the surveyed schools did not instruct on the bulk-fill technique. The same study reported that 27 % of the respondent schools provide theoretical and preclinical training on this technique but do not implement it at the clinical level [35]. In Canada, 56 % of the surveyed schools did not teach bulk-fill composite materials for posterior restorations, while 44 % reported including use of bulk-fill composites in their restorative curriculum [36]. In the United States, 59 % of the surveyed schools do not teach bulk-fill resin composite materials for posterior restorations. In comparison, 41 % of schools include this type of resin composite in their teaching [39]. In the UK and Ireland, 39 % of the respondent schools provided didactic teaching of bulk-fill materials, and 17 % of the schools included clinical teaching of bulk-fill placement [34]. In contrast, dental schools in Austria, Germany, and Switzerland demonstrated higher instruction rates on using "low shrinkage" or bulk-fill composites, with over half (58 %) of the schools in these regions providing such training [37].

In the present study, both dental schools opted for LED curing lights over the 'traditional' QTH curing lights when placing posterior composites. This choice likely arose from the superior efficiency of LED lights in light production and the added benefits of being cordless, portable, silent, and lighter than alternative options [57]. LED curing lights are widely used in dental education across various regions. Observations from different studies have revealed the prevalent use of LED curing lights over QTH lights in dental schools worldwide. Most schools (92 %) in Malaysia use LED curing lights for posterior composite placement, whereas only one school (8 %) uses traditional QTH curing lights [38]. In Oceania, almost all the surveyed schools (93 %) instructed students to use LED curing lights. In contrast, a few schools (13 %) included training in traditional QTH curing lights [35]. In Austria, Germany, and Switzerland, almost all dental institutions (94 %) provided their students with LED curing lights, whereas only two schools (6 %) used traditional QTH curing lights [37]. In Japan, all 29 surveyed schools offered instructions on LED curing units, and five (17 %) offered guidance on using QTH curing lights [33]. In the UK and Ireland, the majority of schools (66 %) taught the use of LED curing lights, three schools (17 %) exclusively used QTH, and another three (17 %) employed both LED and QTH light-curing units [34]. In Canada, 78 % of the responding schools reported that LED curing lights were used to cure posterior composite restorations. QTH lights were used in only two schools (22 %) [36]. In the United States, almost all responding schools (97 %) reported the use of LED curing, whereas QTH lights were used by only four schools (12 %) [39].

Both surveyed dental schools predominantly favored the use of two-step etch-and-rinse adhesives for posterior resin composite restorations. These adhesives have a long history of successful clinical application and represent a fundamental technique in restorative dentistry. Teaching about these adhesives provides dental students with essential knowledge of traditional adhesive methods, including enamel and dentin preparation, acid etching, and the creation of an optimal bonding environment. The emphasis on traditional adhesive techniques is important, as it forms the basis for a comprehensive understanding of dental science and technological advancements. Mastering these foundational techniques will enable students to effectively adopt advanced adhesive methods in their future practices. However, there is notable variability in the adhesive agents taught in dental schools worldwide, suggesting that there is no consensus on the optimal adhesive system, with some regions favoring different approaches. In Austria, Germany, and Switzerland, etch-and-rinse adhesives are predominantly preferred over self-etch adhesives (88 % vs. 36 %) [37]. Conversely, in Canada, there is a split between the three-step and two-step etch-and-rinse adhesive systems (56 % vs. 44 %) [36]. American dental schools exhibit even greater diversity in teaching various adhesive systems, including three-step etch-and-rinse (56 %), self-etching with selective etching (50 %), two-step self-etch (29 %), and one-step self-etch adhesives (24 %), for posterior resin composite bonding [39].

While neither of the surveyed dental schools charged patients for posterior restorations placed by their students, significant variations in fee practices were observed across different regions, with fees imposed in Malaysia, Japan, Oceania, the UK, and Ireland. In Malaysia, 8 of 13 schools (61 %) imposed fees on patients for posterior restorations [38]. Similarly, patients in Japan are also subject to fees for restorations [33]. In Oceania, 40 % of surveyed schools did not impose charges for posterior restorations, whereas 27 % required patient contributions to the cost of such procedures [35]. Dental schools in the UK and Ireland also provide information on patient fees for similar procedures [34]. Adopting a fee-free model not only enriches the educational experience of dental students by enabling them to work with a broader and more diverse patient population but also contributes to the community's oral health and promotes dental care access for individuals facing financial constraints.

This study offers significant insights into the teaching practices related to posterior composite restorations in Palestinian dental schools. Identifying both the strengths and areas for improvement is a valuable tool for enhancing the quality of dental education and subsequently improving patient care standards within the region. Moreover, it facilitates comparative analysis on a global scale, enabling educators worldwide to identify best practices and exchange knowledge. A structured analysis of teaching methods enables educators to recognize emerging trends and adapt curricula accordingly to meet evolving standards and patient preferences. This adaptive approach enhances the quality and relevance of dental education programs, ensuring that students are adequately prepared to deliver high-quality services in clinical settings.

Researchers and educators should consider the inherent limitations in the interpretation and application of the findings of this study. This study relied predominantly on quantitative data obtained from closed-ended questions. Although this approach offers

valuable insights, particularly in terms of identifying trends and patterns, it may restrict the depth of the responses, particularly regarding complex topics. Qualitative research methods can offer additional perspectives such as faculty viewpoints, challenges encountered, and unexpected outcomes, thereby providing a more comprehensive understanding of dental education practices.

5. Conclusion

This study revealed that the teaching of posterior composite restorations in the two dental schools in Palestine is consistent and aligns with contemporary practices observed internationally. The curricula of these institutions demonstrate a strong commitment to equipping students with the necessary skills and knowledge of modern operative dentistry. Given that these are the only dental schools in the country, the findings provide a comprehensive overview of current educational practices in Palestine. These insights can serve as valuable references for educators and researchers seeking to further refine and enhance dental education. Continued evaluation and adaptation of teaching practices are essential to maintain the high standards required for proficient clinical practice in this evolving field.

Scientific field of dental science

Restorative Dentistry, Operative Dentistry, Dental Materials.

Ethics approval and consent to participate

The study obtained ethical approval from the Institutional Review Board (IRB) at the Arab American University in Palestine (Approval Code: 2022/A/8/N).

Data availability statement

The data supporting this study's findings are available from the corresponding author, NZA, upon reasonable request.

Funding and conflict of interest

This research received no external funding.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e39154.

References

[1] L. Pizzolotto, R.R. Moraes, Resin composites in posterior teeth: clinical performance and direct restorative techniques, Dent. J. 10 (2022), https://doi.org/10.3390/dj10120222.
[2] C.D. Lynch, N.J. Opdam, R. Hickel, P.A. Brunton, S. Gurgan, A. Kakaboura, A.C. Shearer, G. Vanherle, N.H.F. Wilson, Guidance on posterior resin composites: academy of operative dentistry - European section, J. Dent. 42 (2014) 377–383, https://doi.org/10.1016/j.jdent.2014.01.009.
[3] 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, https://doi.org/10.1016/j.scitotenv.2013.10.115.
[4] S.E. Kopperud, F. Staxrud, I. Espelid, A.B. Tveit, The post-amalgam era: Norwegian dentists' experiences with composite resins and repair of defective amalgam restorations, Int. J. Environ. Res. Public Health 13 (2016), https://doi.org/10.3390/ijerph13040441.
[5] J. Nicholson, Progress in eradicating amalgam from restorative dentistry, Balk, J. Dent. Med. 27 (2023) 63–72, https://doi.org/10.5937/bjdm2302063n.
[6] M. Laske, N.J.M. Opdam, E.M. Bronkhorst, J.C.C. Braspenning, W.J.M. Van Der Sanden, M.C.D.N.J.M. Huysmans, J.J. Bruers, Minimally invasive intervention for primary caries lesions: are dentists implementing this concept? Caries Res. 53 (2019) 204–216, https://doi.org/10.1159/000490626.
[7] Y. Alyahya, A narrative review of minimally invasive techniques in restorative dentistry, Saudi Dent. J. (2023) 1–5, https://doi.org/10.1016/j.sdentj.2023.11.005.
[8] M. Dallı, H. Çolak, M. Mustafa Hamidi, Minimal intervention concept: a new paradigm for operative dentistry, J. Investig. Clin. Dent. 3 (2012) 167–175, https://doi.org/10.1111/j.2041-1626.2012.00117.x.
[9] A. Kusumawardani, S. Sukmasari, N. Ab Halim, R.B. Raja Nhari, S.B. Abdul Habi, Patient satisfaction towards composite and amalgam restorations in IIUM dental polyclinic, Sci. Dent. J. 4 (2020) 93, https://doi.org/10.4103/sdj.sdj_37_20.
[10] W. Asiri, Dental restoration selection by students at southern Saudi Arabian universities, Bioinformation 18 (2022) 986–990, https://doi.org/10.6026/97320630018986.
[11] A.A. Al-Asmar, K.M. Al-Khatib, T.Z. Al-Amad, F.A. Sawair, Has the implementation of the Minamata convention had an impact on the practice of operative dentistry in Jordan? J. Int. Med. Res. 47 (2019) 361–369, https://doi.org/10.1177/0300060518802523.

[12] Ö. Erçin, B. Berkmen, E. Durukan, N. Arhun, Awareness about dental amalgam among Turkish dentists and patients: a questionnaire and search engine based cross-sectional study, Int. Dent. J. 71 (2021) 113–121, https://doi.org/10.1111/idj.12610.

[13] B.S. Bohaty, Q. Ye, A. Misra, F. Sene, P. Spencer, Posterior composite restoration update: focus on factors influencing form and function, Clin. Cosmet. Investig. Dent. 5 (2013) 33–42, 10.2147CCIDE.S42044.

[14] F.F. Demarco, M.B. Correa, M.S. Cenci, R.R. Moraes, N.J.M. Opdam, Longevity of posterior composite restorations : not only a matter of materials, Dent. Mater. 28 (2012) 87–101, https://doi.org/10.1016/j.dental.2011.09.003.

[15] G.G. Nascimento, M.B. Correa, N. Opdam, F.F. Demarco, Do clinical experience time and postgraduate training influence the choice of materials for posterior restorations? Results of a survey with brazilian general dentists, Braz. Dent. J. 24 (2013) 642–646, https://doi.org/10.1590/0103-6440201302361.

[16] M.N. Coppola, Y.A. Ozcan, R. Bogacki, Evaluation of performance of dental providers on posterior restorations: does experience matter? A data envelopment analysis (dea) approach, J. Med. Syst. 27 (2003) 445–456, https://doi.org/10.1023/A:1025659822427.

[17] M. Laske, N.J.M. Opdam, E.M. Bronkhorst, J.C.C. Braspenning, M.C.D.N.J.M. Huysmans, Risk factors for dental restoration survival: a practice-based study, J. Dent. Res. 98 (2019) 414–422, https://doi.org/10.1177/0022034519827566.

[18] N.J.M. Opdam, B.A.C. Loomans, F.J.M. Roeters, E.M. Bronkhorst, Five-year clinical performance of posterior resin composite restorations placed by dental students, J. Dent. 32 (2004) 379–383, https://doi.org/10.1016/j.jdent.2004.02.005.

[19] M. Elgezawi, R. Haridy, M.A. Abdalla, K. Heck, M. Draenert, D. Kaisarly, Current strategies to control recurrent and residual caries with resin composite restorations: operator- and material-related factors, J. Clin. Med. 11 (2022), https://doi.org/10.3390/jcm11216591.

[20] F.F. Demarco, M.S. Cenci, A.F. Montagner, V.P. de Lima, M.B. Correa, R.R. Moraes, N.J.M. Opdam, Longevity of composite restorations is definitely not only about materials, Dent. Mater. 39 (2023) 1–12, https://doi.org/10.1016/j.dental.2022.11.009.

[21] C.M. Maciel, K. Baroudi, L.D.S. Barroso, L.D.C. Costa, T.C.V. Souto, R.P. Vitti, Longevity of resin composite and amalgam posterior restorations: a systematic review, Eur. J. Prosthodont. Restor. Dent. 30 (2022) 267–275, https://doi.org/10.1922/EJPRD_2371MACIEL09.

[22] F.F. Demarco, K. Collares, M.B. Correa, R.R. de Cenci, Maximiliano Sergio Moraes, N.J. Opdam, y composite restorations last forever? Why are they failing? Braz. Oral Res. 31 (2017) 92–99, https://doi.org/10.1590/1807-3107BOR-2017.vol31.0056.

[23] N.Z. Arandi, Current trends in placing posterior composite restorations: perspectives from Palestinian general dentists: a questionnaire study, J. Int. Soc. Prev. Community Dent. 14 (2024) 112–120, https://doi.org/10.4103/jispcd.JISPCD.

[24] R. Alsheikh, K.S. Almulhim, M. Abdulkader, R. Haridy, A.S. Bugshan, R. Aldamanhouri, M. Elgezawi, Toward a clinically reliable class II resin composite restoration: a cross-sectional study into the current clinical practice among dentists in Saudi arabia, Int. J. Dent. 2022 (2022) 1–8, https://doi.org/10.1155/2022/2691376.

[25] S. Ali, K. Iqbal, M. Asmat, I. Farooq, A.M. Khan, M.K. Alam, Dental resin composite restoration practices amongst general dental practitioners of Karachi, Pakistan, World J. Dent. 10 (2019) 129–134, https://doi.org/10.5005/jp-journals-10015-1618.

[26] A.A.A.A. Aziz, A.A. Ahmad, A. Jaafar, N. Mohammad, A.H.A. Al-Kadhim, Posterior restoration selection among general dental practices in Malaysia: a preliminary study, IIUM Med. J. Malaysia 18 (2019) 53–58, https://doi.org/10.31436/imjm.v18i2.97.

[27] M.M. Awad, M. Alradan, N. Alshalan, A. Alqahtani, F. Alhalabi, M.A. Salem, A. Rabah, A. Alrahlah, Placement of posterior composite restorations: a cross-sectional study of dental practitioners in al-kharj, Saudi Arabia, Int. J. Environ. Res. Public Health 18 (2021) 1–14, https://doi.org/10.3390/ijerph182312408.

[28] A.S.M. 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 (2009) 148–154, https://doi.org/10.1922/IDJ.

[29] N.H.F. Wilson, C.D. Lynch, The teaching of posterior resin composites: planning for the future based on 25 years of research, J. Dent. 42 (2014) 503–516, https://doi.org/10.1016/j.jdent.2014.02.014.

[30] P. Kanzow, C. Lechte, A. Wiegand, N.H.F. Wilson, C.D. Lynch, I.R. Blum, Teaching of posterior composites for the restoration of permanent teeth in undergraduate dental training programmes: systematic review and meta-analysis, J. Dent. 135 (2023) 104589, https://doi.org/10.1016/j.jdent.2023.104589.

[31] E. Kehily, A. Gallagher, F. Allen, A. Roberts, Developing procedural metrics for training in class II posterior composite resin restorations: outcomes from an international Delphi panel, J. Dent. 135 (2023) 104584, https://doi.org/10.1016/j.jdent.2023.104584.

[32] D.C.M. dos Santos, J.F. Besegato, J.F. Zaniboni, S. de Paula Ramos, S. de Almeida Cardoso, M.G. Hoeppner, Clinical performance of resin composite restorations placed by dental students: a retrospective, cross-sectional, and observational study, Brazilian J. Oral Sci. 21 (2022) 1–10, https://doi.org/10.20396/BJOS.V21I00.8665991.

[33] M. Hayashi, T. Yamada, C.D. Lynch, N.H.F. Wilson, Teaching of posterior composites in dental schools in Japan – 30 years and beyond, J. Dent. 76 (2018) 19–23, https://doi.org/10.1016/j.jdent.2018.02.002.

[34] C.D. Lynch, I.R. Blum, R.J. McConnell, K.B. Frazier, P.A. Brunton, N.H.F. Wilson, Teaching posterior resin composites in UK and Ireland dental schools: do current teaching programmes match the expectation of clinical practice arrangements? Br. Dent. J. 224 (2018) 967–972, https://doi.org/10.1038/sj.bdj.2018.446.

[35] C. Loch, Y. Liaw, A.P. Metussin, C.D. Lynch, N. Wilson, I.R. Blum, P.A. Brunton, The teaching of posterior composites: a survey of dental schools in Oceania, J. Dent. 84 (2019) 36–43, https://doi.org/10.1016/j.jdent.2019.01.005.

[36] L. Alreshaid, W. El-Badrawy, H.P. Lawrence, M.J. Santos, A. Prakki, Composite versus amalgam restorations placed in Canadian dental schools, Oper. Dent. 46 (2021) 621–630, https://doi.org/10.2341/20-212-C.

[37] P. Kanzow, A.F. Büttcher, N.H.F. Wilson, C.D. Lynch, I.R. Blum, Contemporary teaching of posterior composites at dental schools in Austria, Germany, and Switzerland, J. Dent. (2020) 103321, https://doi.org/10.1016/j.jdent.2020.103321.

[38] P. Sidhu, O.S. Sultan, S.Y. Math, N.A. Malik, N.H.F. Wilson, C.D. Lynch, I.R. Blum, U. Daood, Current and future trends in the teaching of direct posterior resin composites in Malaysian dental schools: a cross-sectional study, J. Dent. 110 (2021) 1–6, https://doi.org/10.1016/j.jdent.2021.103683.

[39] L. Alreshaid, W. El-Badrawy, G. Kulkarni, M.J. Santos, A. Prakki, Resin composite versus amalgam restorations placed in United States dental schools, oper, Inside Dent. 48 (2023) 21–32, https://doi.org/10.2341/22-007-C.

[40] C. Miao, X. Yang, M.C.M. Wong, J. Zou, X. Zhou, C. Li, Y. Wang, Rubber dam isolation for restorative treatment in dental patients, Cochrane Database Syst. Rev. 2021 (2021) 1–42, https://doi.org/10.1002/14651858.CD009858.pub3.

[41] I.C. Olegário, B.L.P. Moro, T.K. Tedesco, R.D. Freitas, A.L. Pássaro, J.R. Garbim, R. Oliveira, F.M. Mendes, A.C. Serra, A.C.L. Silva, C. de Picoli Acosta, C.M. Laux, C.S. Saihara, H.C.M. Maia, I.C. Olegário, I.R. de Almeida, J.D.Y. Vargas, J.C.P. Imparato, J.G. Freitas, K.H. De Natal, K.R. Ekstrand, L.R.A. Pontes, M. Bifulco, M. M. Braga, M.P. Araújo, M.A. do Vale, R.M. Samuel, R. Baronti, S. Cesar, T.L. Lenzi, T.F. Novaes, T. Gimenez, C. Signori, M.S. Cenci, D.P. Raggio, Use of rubber dam versus cotton roll isolation on composite resin restorations' survival in primary molars: 2-year results from a non-inferiority clinical trial, BMC Oral Health 22 (2022) 1–13, https://doi.org/10.1186/s12903-022-02449-y.

[42] L. Lang, J. Burgess, B. Lang, R. Wang, Wear of composite resin restorations in beveled and nonbeveled preparations, J. Dent. Res. 74 (1995) 165. https://scholar.google.com/scholar_lookup?title=WearofcompositeresinrestorationsinbeveledandnonbeveledpreparationsLA.Lang&publication_year=1995. (Accessed 31 October 2023).

[43] C.D. Lynch, A.C. Shortall, D. Stewardson, P.L. Tomson, F.J.T. Burke, Teaching posterior composite resin restorations in the United Kingdom and Ireland: consensus views of teachers, Br. Dent. J. 203 (2007) 183–187, https://doi.org/10.1038/bdj.2007.726.

[44] B. Isenberg, K. Leinfelder, Efficacy of beveling posterior composite resin preparations, J. Esthet. Dent. 2 (1990) 70–73.

[45] S. Soliman, R. Preidl, S. Karl, N. Hofmann, G. Krastl, B. Klaiber, Influence of cavity margin design and restorative material on marginal quality and seal of extended class II resin composite restorations in vitro, J. Adhes. Dent. 18 (2016) 7–16, https://doi.org/10.3290/j.jad.a35520.

[46] H. Heymann, E.J. Swift, A.V. Ritter, C.M. Sturdevant, Sturdevant's Art and Science of Operative Dentistry, Elsevier/Mosby, 2013.

[47] C.R.G. Torres, Modern Operative Dentistry: Principles for Clinical Practice, Springer, 2020. https://www.google.co.id/books/edition/Modern_Operative_Dentistry/X0XEDwAAQBAJ?hl=id&gbpv=1&dq=dental+ergonomic&pg=PA74&printsec=frontcover.

[48] C.D. Lynch, K.B. Frazier, R.J. Mcconnell, I.R. Blum, 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, https://doi.org/10.1038/sj.bdj.2010.674.

[49] C. Murdoch-Kinch, M. McLean, Minimally invasive dentistry, J. Am. Dent. Assoc. 134 (2003) 87–95.
[50] P. Hörsted-Bindslev, B. Heyde-Petersen, P. Simonsen, V. Baelum, Tunnel or saucer-shaped restorations: a survival analysis, Clin. Oral Investig. 9 (2005) 25–30, https://doi.org/10.1007/s00784-005-0011-6.
[51] E. Wirsching, B.A.C. Loomans, B. Klaiber, C.E. Dörfer, Influence of matrix systems on proximal contact tightness of 2- and 3-surface posterior composite restorations in vivo, J. Dent. 39 (2011) 386–390, https://doi.org/10.1016/j.jdent.2011.03.001.
[52] D. Kampouropoulos, C. Paximada, M. Loukidis, A. Kakaboura, The influence of matrix type on the proximal contact in class II resin composite restorations, Oper. Dent. 35 (2010) 454–462, https://doi.org/10.2341/09-272-L.
[53] R. Müllejans, M.F. Badawi, W. Raab, H. Lang, An in vitro comparison of metal and transparent matrices used for bonded class II resin composite restorations, Oper. Dent. (2003) 122–126.
[54] A. Sengupta, O. Naka, S.B. Mehta, S. Banerji, The clinical performance of bulk-fill versus the incremental layered application of direct resin composite restorations: a systematic review, Evid. Based. Dent. 24 (2023) 1–11, https://doi.org/10.1038/s41432-023-00905-4.
[55] S.R.M. Veloso, C.A.A. Lemos, S.L.D. de Moraes, B.C. do Egito Vasconcelos, E.P. Pellizzer, G.Q. de Melo Monteiro, Clinical performance of bulk-fill and conventional resin composite restorations in posterior teeth: a systematic review and meta-analysis, Clin. Oral Investig. 23 (2019) 221–233, https://doi.org/10.1007/s00784-018-2429-7.
[56] H.I. Arbildo-Vega, B. Lapinska, S. Panda, C. Lamas-Lara, A.S. Khan, M. Lukomska-Szymanska, Clinical effectiveness of bulk-fill and conventional resin composite restorations: systematic review and meta-analysis, Polymers 12 (2020) 1–51, https://doi.org/10.3390/polym12081786.
[57] F.A. Rueggeberg, State-of-the-art: dental photocuring - a review, Dent. Mater. 27 (2011) 39–52, https://doi.org/10.1016/j.dental.2010.10.021.