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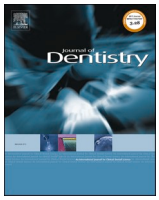
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Teaching repair versus replacement of direct composite resin restorations: A cross-sectional study across dental schools in Malaysia

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ABSTRACT

Objective: To investigate the teaching of repair versus the replacement of defective direct composite resin restorations in undergraduate curricula in Malaysian dental schools.
Methods: A 24-item validated questionnaire, including closed and open questions regarding the teaching of repair versus the replacement of direct composite resin restorations (DCRs) was emailed to faculty members in all 13 dental schools in Malaysia. Responses were compiled in Excel and analysed. The questionnaire asked about the inclusion of DCR repair in the curriculum, the underlying reasons for its inclusion, the methods employed for teaching, the indications for repair, the operative techniques and materials used, the acceptability of repairs to patients, the anticipated longevity of repairs, and recall arrangements.
Results: All 13 dental schools completed and returned the questionnaire, reporting that composite repairs were taught as an alternative to the replacement of defective DCRs. All schools imparted theoretical and practical knowledge of repair within a clinical context. Twelve dental schools (92 %) agreed that the primary objective of teaching repair is the preservation of tooth structure. The principal reasons for repair were marginal defects (84 %), followed by marginal discoloration and partial loss of restoration (61 %). All 13 schools reported a high level of patient acceptance, which they regarded as a strong indicator. Eleven dental schools (84 %) reported recall arrangements to review repairs of DCRs.
Conclusion: All undergraduate dental students in Malaysia are taught the use of repairs as an alternative to the replacement of defective DCRs. The advantages of this approach are considered in Malaysian dental schools to include, minimum intervention and preservation of tooth structure, with opportunity for time and cost savings. Further research should include the development of consensus criteria for the repair rather than replacement of defective DCRs and long-term clinical trials to further investigate the benefits of repair over the replacement of defective DCRs.
Clinical significance: With all undergraduate dental students being taught the use of DCR repairs, the percentage of defective DCRs in Malaysia managed by means of a repair may be anticipated to increase in years to come. The cumulative effects of this increase may contribute to the conservation of teeth, with opportunity for cost savings.

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Introduction

Restorations, cavity liners, sealants for pits and fissures, cores, inlays, and onlays are just a few of the many dental applications of composite resins [1]. Composite resins have gained favor among both patients and dentists given, amongst other things, their aesthetic qualities and ability to be bonded to tooth tissues [2]. If directions for use are followed, direct composite restorations (DCRs) do not require substantial tooth preparation and may be found to exhibit good performance. Low rates of secondary caries, and low levels of polymerization shrinkage and tooth/restoration interface leakage have resulted from advancements in composite systems, bonding technologies and placement procedures [3]. Given these benefits, composite resins are the preferred material for ever-increasing numbers of clinicians for both anterior and posterior restorations [1].

Dental restorations are susceptible to failure. Composite failure, necessitating replacement, may be caused by biological, mechanical, or aesthetic causes. Many composites in clinical service develop defects, rather than suffer frank failure, and it may be difficult for clinicians to decide whether to replace or repair such restorations. If restorations have irretrievably failed, they must be replaced [4]. Repairing defective composites rather than removing them entirely has become more commonplace in recent years [5–8,9]. Retaining the structurally sound elements of a restoration has numerous benefits including, the possibility of avoiding the need for local anesthesia, needless removal of remaining tooth structure, minimizing the risk of damage to the pulp, saving the patient and dental team time and money, and favorable immediate to long term clinical outcomes [5,6,9].

The choice to replace or repair a defective composite restoration is a matter for the clinician's discretion. The multifactorial judgement involved is typically influenced by what the clinicians have been taught, and their relevant knowledge and skills, combined with their practical experience and preferences. The repair of composites is generally restricted to the management of relatively small defects- a typical defect in a direct restoration involving <20 % of the cavosurface margin and adjoining surface of the restoration. Effective repairs may be found to have the same longevity as replacement restorations, with more of the remaining tooth structure having been preserved, thereby slowing the downward restorative cycle [10,11]. Currently, there is a trend towards more conservative, less interventive techniques in dental treatment. As a result, several dental schools worldwide are increasingly including instruction on the repair of dental restorations, as part of their undergraduate curriculum, in preclinical and clinical years [4,12,13].

Newly cured composite resin materials have an oxygen inhibited layer. This layer helps create a chemical bond between increments of composite, resulting in a homogenous restoration, assuming careful handling and placement of increments [14]. A potential problem in the placement of DCR repairs is bonding new composite to the composite of the remaining restoration which, amongst other things may have suffered some water sorption. This leads to the possibility of less-than-optimal increment interface bond strength [11]. Therefore, the surfaces of a defective DCR prepared to receive repair require surface treatment which may include finishing with diamond burs or air abrasion with or without acid etching/cleaning and the application of silane/MDP [15]. Appropriate mechanical and chemical treatments are important to optimize the bond between existing and new composite in the placement of DCR repairs.

Although repairs are being taught and practiced widely there is no internationally recognized consensus on criteria and techniques for the repair of DCRs, let alone restorations of other materials. Previous studies conducted in various countries and regions of the world, including the UK and Ireland [12,16,17], Germany and Scandinavia [4,18,19], the United States of America and Canada [11,20], Oceania [21], Japan [22], Brazil [23], and in the Middle Eastern and North African countries [24], have not yielded the required criteria and guidance on the most effective operative techniques. This paper reports the findings of a survey on the teaching and operative techniques used in 2024 for the repair rather than replacement of direct composite restorations in dental schools in Malaysia.

Materials and methods

Prior to initiation, the Institutional Review Board of the International Medical University granted ethical approval for this study (IMU 589/2023). An online Google form was created from a questionnaire developed by Lynch et al. in 2006 [10]. The form was sent to the heads of the departments of restorative dentistry in the 13 dental schools in Malaysia. The questionnaire sought data on the inclusion of DCR repair instruction in the undergraduate curriculum and plans for the teaching of DCR repairs over the next five years; the rationale for teaching methods (didactic versus practical), the criteria for determining the need for repair, patient acceptance, operative techniques and materials used, estimated life expectancy of repaired restorations, and the monitoring of repaired DCRs.

The heads of departments of restorative dentistry were given six weeks to complete and return the form. The responses were sent to the principal investigator *(MI)*. The data collected was entered on an Excel spreadsheet (2019 version, Microsoft Redmond Campus, Redmond, Washington, United States). Mean percentages were calculated for all variables analyzed. The data was subjected to statistical analysis using the Statistical Package for the Social Sciences (SPSS v 26.0, IBM). The chi-square test was employed to assess the disparity in the occurrence of variable categories among distinct groups. A significance level of $p < 0.05$ was employed in all statistical tests to ascertain statistical significance. By maintaining a 5 % level of significance for the α error and a 20 % level for the β error, the study achieved a power of 80 %.

Results

The response was 100 %. All 13 respondents (100 %) had performed repairs on DCRs and considered the treatment to be effective and successful. All dental schools in Malaysia (100 %, $n = 13$) provided instruction on the repair of DCRs as a viable alternative to the replacement of defective DCRs in their undergraduate teaching. Clinical evidence and experience were identified as the primary reasons for teaching composite repair (100 %, $n = 13$). The second reason was case reports (38 %, $n = 5$). Tooth preservation techniques, advances in dentin bonding agents and surface treatment protocols were other reasons identified for teaching composite repair.

Defects in restorations which warranted consideration for management by repair included, marginal defects (84 %, $n = 11$), marginal discoloration and partial loss of the restoration (61 %, $n = 8$), superficial colour correction and discoloration of the restoration cervically (53 %, $n = 7$), discoloration of the labial or occlusal surface(s) of the restoration, (46 %, $n = 6$), wear (46 %, $n = 6$) and discoloration involving more than one surface (38 %, $n = 5$) (Table 1).

Most schools (*69 %, $n = 9$*) provided instruction on the theoretical and practical components of composite repair at a clinical level only. Teaching at both the preclinical and clinical levels was given by 15 % of schools (15 %, $n = 2$). However, teaching at the preclinical level was not common (15 %, $n = 2$) (Table 2). The primary reasons for teaching the repair of DCRs were tooth substance preservation (92 %, $n = 12$), reducing potential harmful effects on the pulp (53 %, $n = 7$), a reduction in treatment time (30 %, $n = 4$) and reduced cost to the patient (30 %, $n = 4$) (Fig. 1).

Most fractures observed in anterior restorations, specifically incisal fractures, were considered appropriate for repair (76 %, $n = 10$), as were proximal fractures (69 %, $n = 9$), and proximal-incisal fractures (46 %, $n = 6$). In posterior restorations, occlusal fractures (69 %, $n = 9$) and marginal ridge fractures (61 %, $n = 8$) were the most common types of fractures managed by repair, followed by isthmus and box fractures (30 %, $n = 4$ and 23 %, $n = 3$ respectively) (Table 3). All schools indicated

Table 1
Indications for the repair rather than the replacement of direct composite restorations.

Restoration related failure	Number of schools
Marginal defects	11
Marginal discoloration	8
Superficial colour correction	7
Restoration discoloration labial/buccal	6
Restoration discoloration occlusal	6
Restoration discoloration cervical	7
Restoration discoloration proximal	5
Discoloration involving more than one surface	4
Partial loss of restoration	8
Abrasion/attrition/erosion	6
Bulk fracture of an anterior restoration (incisal)	11
Bulk fracture of an anterior restoration (proximal)	9
Bulk fracture of an anterior restoration (proximal-incisal)	6
Bulk fracture of a posterior restoration (occlusal)	9
Bulk fracture of a posterior restoration (isthmus fracture)	4
Bulk fracture of a posterior restoration (box fracture)	3
Bulk fracture of a posterior restoration (marginal ridge fracture)	8

Table 2
Teaching techniques for undergraduate students for composite repair as an alternative to the replacement of failing composites according to nature and level of teaching.

Response rate	Teaching at Theoretical Level	Response rate	Teaching at Practical Level
6 (46.1 %)	Preclinical and Clinical Levels	2 (15.3 %)	Preclinical and Clinical Levels
4 (30.7 %)	Clinical Level	9 (69.2 %)	Clinical Level
1 (7.6 %)	Preclinical Level	2 (15.3 %)	Preclinical Level
2 (15.3 %)	Not at Theoretical Level	-	-

that patients were willing to accept composite repairs as an alternative to replacement.

Repair of DCRs was considered a definitive measure by most schools (84 %, $n = 11$). Respondents stated that the anticipated longevity of repairs was influenced by many different factors, which vary on a case-to-case basis. Views on the anticipated longevity of DCR repairs were diverse. Five respondents (38.4 %) indicated five-years; two (15.3 %) indicate 10-years, while other respondents indicated a range varying from three months to 10 years (Fig. 2). Regarding the success of repairs to DCRs conducted by students, 10 schools (76 %) reported a success rate of 50 %, whereas three schools (23 %) reported a success rate of 100 %, with success being considered with repairable defects.

All schools (100 %, $n = 13$) taught the use of one or more isolation techniques for performing composite repair procedures. All the schools (100 %, $n = 13$) taught the use of rubber dams, with four (30.7 %) teaching also Optra Dam (Ivoclar, Schaan, Liechtenstein) and five schools (38.4 %) including the use of cotton wool rolls in the teaching. No school taught the use of dry shields.

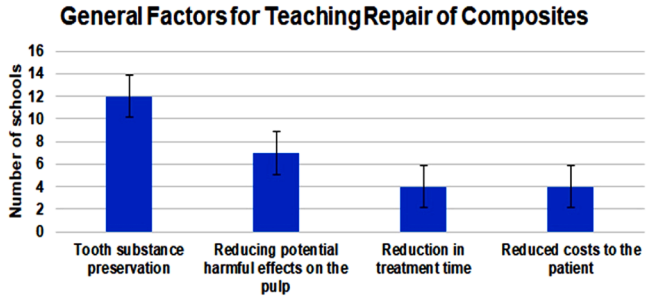


Fig. 1. General factors for teaching repair of composites in thirteen dental schools in Malaysia.

Table 3
Restoration related failures observed in anterior and posterior tooth observed and reported by dental schools in Malaysia.

Restoration related failure	Number of schools	
Percentage		
Incisal	11	84.6
Proximal	9	69.2
Proximal-incisal	6	46.1
Occlusal	9	69.2
Isthmus fracture	4	30.7
Box fracture	3	23.07
Marginal ridge fracture	8	61.5

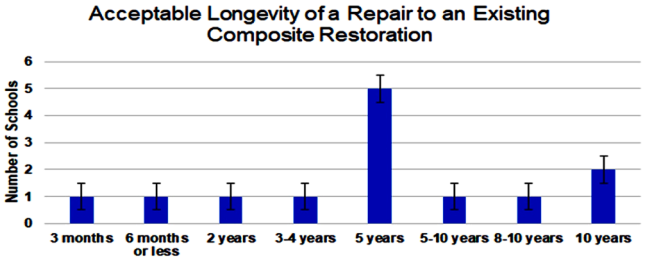


Fig. 2. Acceptable longevity of a repair to an existing composite restoration reported by thirteen dental schools in Malaysia.

Phosphoric acid for acid etching (76 %, $n = 11$), adhesive bonding agents (69 %, $n = 9$), nanohybrid - (61 %, $n = 8$), and flowable composites (53 %, $n = 7$) were the materials most widely taught for the repair of DCRs.

For contouring and polishing, the schools taught the use of finishing discs (76 %, $n = 10$), diamond finishing instruments (69 %, $n = 9$), polishing points (69 %, $n = 9$), and tungsten carbide finishing instruments (53 %, $n = 7$). Four schools (30.7 %) taught the use of silane coupling agents while three schools taught the use of aluminium oxide (Al_2O_3) and CoJet air abrasion to improve bond strength (23 %). No schools taught the use of glazing resin in composite repair procedures (Table 4). Regarding monitoring, a large proportion of the schools (76 %, $n = 10$) indicated having recall arrangements. Three schools (23 %) had no such arrangements.

Discussion

The purpose of the present study was to investigate the teaching of the repair of defective DCRs as an alternative to restoration replacement

Table 4
Instruments, surface treatment and materials included in teaching of repair of composite restorations in dental schools in Malaysia.

Instrument, surface treatment and materials included in teaching of repair	Number of schools	Percentage
Diamond finishing instrument	9	69.2
Tungsten Carbide finishing instrument	7	53.8
Finishing discs	10	76.9
Composite polishing points	9	69.2
Composite polishing paste	5	38.4
Acid etching with phosphoric acid	10	76.9
Adhesive bonding system	9	69.2
Flowable composites	7	53.8
Micro-hybrid composites	5	38.4
Nano-hybrid composites	8	61.5
Nano-filled composites	5	38.4
Al_2O_3 Air Abrasion	3	23.07
CoJet Air Abrasion (silica station)	3	23.07
Silane Coupling Agent	4	30.7
Glazing resin	0	0
No mechanical surface treatment	0	0

in the dental schools of Malaysia in 2024. Whilst acknowledging the limitations of studies of the type reported, with a power of 80 %, the use of a tried and tested research protocol, specifically the use of a questionnaire which had been refined following its use in numerous related studies [22,23,24], and a 100 % response, the findings of the study are considered to provide a highly credible overview of the teaching of the repair of defective DCRs in the dental schools of Malaysia in 2024.

The principal rationale cited for teaching the repair of defective DCRs in the dental schools of Malaysia was clinical experience, a finding that aligns with the outcomes of related investigations involving dental schools across Africa [24], Oceania [20], Japan [22], Brazil [23], the United States, and Canada [13,19], UK and Ireland [12], Germany [17], Austria and Switzerland [25], and Scandinavia [18]. Ideally, the teaching of clinical procedures and techniques should be evidence-based; however, as with many aspects of both traditional and contemporary operative dentistry, there have been no investigations, notably randomized controlled clinical trials, to verify the efficacy, let alone the effectiveness of the repair rather than the replacement of defective DCRs. Furthermore, it is considered unlikely that such trials will be conducted, given that they would need to be long term (at least 5 years) to demonstrate meaningful findings, during which time relevant materials, approaches and instrumentation; for example, adhesive bonding systems and restoration finishing instrumentation, let alone composite restoratives, will have been superseded, limiting the practical relevance of findings. This emphasizes the importance of research into clinical teaching and instruction, as reported in the present paper, to investigate and share what is state-of-the-art teaching in Conservative Dentistry in different dental schools within and between different countries and regions of the world. Through such research, there is at least consensus, expert opinion on aspects of the content of programs of instruction culminating in the award of qualifications which qualify individuals to be licensed or become registered for the practice of dentistry.

The conservation of remaining tooth tissues was identified as the most important aspect of the rationale for teaching the repair rather than the replacement of defective DCRs. The advantages of this minimum intervention approach have been acknowledged, including the limited need to remove remaining tooth structure to ensure appropriate resistance and retention form, as may be required to complement adhesive bonding [26]. Limiting the removal of tooth structure in the management of a defective restoration helps reduce the risk of adverse pulpal effects, limits the increase in the length of the cavosurface margin-the exposed element of the tooth-restoration interface, and the weakening effect on the biomechanical properties of the restored tooth unit, notwithstanding making the procedure quicker, simpler and cheaper and less traumatic to the patient, especially if the application of a local anesthetic can be avoided. As such, the repair of defective restorations, where indicated clinically, is in the best interests of the patient. Indeed, it is suggested that repair rather than replacement should be the default option in the management of specifically limited defects in DCRs.

In common with previous research, our findings support the view that marginal defects are the most common indication for the repair rather than the replacement of defective DCRs. As most marginal defects affect <20 % of the cavosurface margin of a restoration [27], the use of repair procedures to manage such defects may avoid the unnecessary replacement, and in the process increase in the length and surface area of >80 % of the tooth-restoration interface. The longer the cavosurface margin and the greater the surface are of the tooth-restoration interface, the greater the risk of subsequent failures and the associated sequelae [28]. Hence, state-of-the-art management of marginal defects, making best possible use of repair procedures is considered to have, amongst other things, a significant impact on restoration longevity – a restoration found to require a repair not being a failed restoration, the subsequent need for endodontic and extra coronal restoration interventions and, in turn, tooth retention [29].

It has been shown that mechanical surface treatments, which enhance mechanical interlocking, play a vital role in improving the bonding of new composites to existing composite, as occurs in DCR repair procedures [16,17], specifically in cases in which chemical bonding may be limited [30]. Only 23 % ***(n = 3)*** of dental schools in Malaysia taught the use of aluminium oxide air abrasion - a technique that improves composite bond strength [28], as a mechanical surface treatment. This observation aligns with the data obtained from schools in Oceania and Germany, as opposed to schools in the United States and Canada and the United Kingdom and Ireland. Aluminum oxide air abrasion has been found to be commonly used in schools in Scandinavia [31].

None of the dental schools in Malaysia reported the use of hydrofluoric acid for etching prior to the placement of a repair -a finding in common with dental schools in Africa [23]. In contrast, the surveys conducted in Oceania [20,24], the United States, and Canada reported some use of hydrofluoric acid for etching [13]. While some studies have reported positive outcomes with this approach, other studies have indicated that it is ineffective and should not be applied as a matter of routine [32]. As reported by Loomans [33], in applying repair procedures to DCRs different composite substrates will be encountered, and, as such, the surface changing effects of etching, specifically with hydrofluoric acid, will be variable [20,24]. All forms of etching, however, will facilitate whatever chemical bond between new and existing composite materials.

As taught in most schools in the present study, in the placement of a DCR repair an adhesive bonding agent should be applied, amongst other reasons, to optimize bonding with exposed tooth structures [34]. To enhance the seal between tooth structures and the composite selected to affect the repair, as well as the interfaces between new- and existing composites, the use of a flowable composite material [35] has the potential to complement and enhance the effects of the chosen adhesive bonding technology [36]. The selection of materials and techniques for DCR repair, as in all minimum intervention Conservative Dentistry procedures, requires knowledge of contemporary composite systems and bonding technologies, strict adherence to directions for use, and meticulous attention to detail.

All participants in the study indicated that they taught the use of finishing discs and polishing points to optimize the marginal adaptation and surface finish of repairs of DCRs. The data obtained shows similarities to the data obtained from dental schools in the United States and Canada but some dissimilarities with the corresponding data obtained in Oceania. The cause of these, and other dissimilarities observed in both this and related studies, is uncertain given that the teachers in all the schools investigated are understood to have access to global dental literature, specifically contemporary literature on the finishing of composite restorations [37] and the same products, specifically those of multinational producers and suppliers. In the interests of harmonizing the teaching of future generations of practitioners, many of whom may practice in different countries, let alone regions of the world during typically their early years in practice, teachers in dental schools around the world should critically review the approaches, materials and devices taught and used in their clinical instruction if studies, such as the present study, indicate that they are at variance with colleagues within or between countries and geographic regions, specifically in the absence of evidence to support their teaching. Wherever possible, teaching and instruction in the clinical practice of dentistry should be based on the best available evidence.

Most of the participants in the present study ($n = 11$, 84.6 %), as in the related studies in Oceania, North America, UK and Ireland, Germany, and Scandinavia [20,17] considered repairs to DCRs as a definitive measure, albeit that they had varying views on the anticipated longevity of repaired DCRs. Also, in common with the findings of related studies, in the present study patients exhibit a high level of receptivity towards the repair rather than the replacement of restorations, given the benefits of repair procedures over procedures for total restoration replacement. Given that restorations placed by inexperienced operators

have a greater likelihood of requiring repair [16], more reason that existing and future generations of dentists and, in countries with extended dental teams, dental therapists, or their equivalent, are competent in restoration repair procedures at the time of graduation. A challenge going forward may be amending the ways in which initial restoration placements are completed to facilitate repair in clinical service – the typically time from placement to development of some form of repairable defect in a restoration such a DCR being, in all probability, a matter of a few years.

Most schools in Malaysia (84 %), in contrast to most schools included in related studies, had recall arrangements to monitor the clinical performance of repairs to DCRs. Such arrangements are to be commended, specifically if they yield much-needed data on the effectiveness of repairs to DCRs. It is suggested that it would be good practice for dental schools to monitor clinical outcomes, both for audit and research purposes. With the increasing use of electronic patient record systems, such highly desirable arrangements should be part of the programmed into the global shift to digitized clinical records. Through the suggested audit and research, it would be possible to refine and further develop, amongst many other procedures, the repair of DCRs. Furthermore, if there were national and, wherever possible, international collaborative working on such audit and research, great strides could be taken in the global advancement and harmonization of teaching and clinical instruction in dental schools across the world.

Conclusion

All undergraduate dental students in Malaysia are taught the use of repairs as an alternative to the replacement of defective DCRs. The advantages of this approach are considered in Malaysian dental schools to include, minimum intervention and preservation of tooth structure, with opportunity for time and cost savings. Further research should include the development of consensus criteria for the repair rather than replacement of defective DCRs and long-term clinical trials to further investigate the benefits of repair over the replacement of defective DCRs

Consent

All authors have provided consent for publication.

CRediT authorship contribution statement

Umer Daood: Conceptualization, Formal analysis, Methodology, Supervision, Writing – original draft. **Preena Sidhu:** Conceptualization, Formal analysis, Investigation, Methodology, Supervision, Writing – original draft. **Omer Sheriff Sultan:** Investigation, Methodology. **Normaliza Ab Malik:** Conceptualization, Investigation, Methodology, Writing – original draft. **Liang Lin Seow:** Conceptualization, Methodology, Writing – original draft. **Nairn H F Wilson:** Conceptualization, Supervision, Writing – review & editing. **Christopher D. Lynch:** Conceptualization, Methodology, Writing – review & editing. **Sahar Fatima:** Formal analysis, Investigation, Writing – original draft. **Igor R. Blum:** Conceptualization, Formal analysis, Investigation, Methodology, Supervision, Writing – original draft.

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.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jdent.2025.105765.

Data availability

All data, code, and materials used in the analysis is available to any researcher for purposes of reproducing or extending the analysis. The datasets generated and/or analyzed during the current study are not publicly available due to confidentiality but are available from the corresponding author on reasonable request.

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