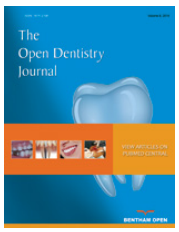

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RESEARCH ARTICLE

Toward Optimum Light Curing of Resin Composite Restorations: A survey on Current Awareness and Practice among General Dentists in Saudi Arabia

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Abstract:

Introduction:

This study aimed to assess the current awareness and practices of resin composite light curing of general dental practitioners (GDPs) in Saudi Arabia and to set several evidence-based recommendations to improve the quality of the outcome of concern.

Methods:

An online questionnaire was created. Two hundred and fifty email invitations were sent to GDPs appointed in general governmental hospitals in five main cities in Saudi Arabia to join the survey voluntarily and anonymously. The survey consisted of 24 questions classified into the following domains: 1-Demographic criteria 2- frequency and technical aspects of resin composites application 3- criteria of the currently used light curing units and curing light. Descriptive statistics and *chi*-square test were used to analyse the obtained responses.

Results:

One hundred and fifty-six responses were received. A significant number of GDPs are significantly satisfied with the quality of their light curing, not aware of the thermal hazards of light curing, and do not check power output of their LCUs (light curing units) ($P<0.05$). An insignificant number of respondents use eye shields for eye protection during light curing.

Conclusion:

There was no uniform light curing protocol followed by respondent GDPs. GDPs in Saudi Arabia should improve their knowledge and clinical skills of light-curing resin composite.

Keywords: Resin composite, Light curing, Awareness of general dentists, General Dental Practitioners (GDPs), Curing protocol, Eye protection.

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1. INTRODUCTION

Since their introduction in the sixties, resin composites have become a basic restorative option in the every-day practice of restorative dentistry. The American Dental Association has estimated that more than 67 million resin composite restorations of new posterior resin composite restorations have been placed in one year in USA constituting about 60% of all placed posterior restorations [1]. A basic aspect of a resin composite restoration that affects its quality and long-term reliability is the degree of conversion (DC), which reflects the percentage of terminal aliphatic carbon-carbon double bonds (C=C) converting into primary (C-C) covalent bonds between methacrylate monomers [2, 3]. The specifications of the light curing unit and the clinical technique employed during light curing have a deciding influence on the DC of resin composites [2 - 4].

The polymerization kinetics are complex and influence the

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mechanical, biological, and physical properties of light cure resin composite. The photo-initiated free radicle polymerization reaction of light cure resin composite is markedly influenced by the curing light energy density. Curing light energy density determines the properties of light cure resin composite [5]. The degree of conversion, flexural strength and modulus of elasticity are influenced by variations in energy density and curing light exposure duration [5].

Different resin composites respond differently to curing light awing to the chemical make-up and relative volumetric compositional content of each of the organic matrix and filler phases, filler particle size and distribution in addition to the type of the photo-initiator and the used shade of the material [6]. Bulk-fill composites were introduced to allow insertion of up to 4-5 mm thick increment of resin composite. Manufacturers of this category of resin composites indicate the necessity of using light curing units that provide at least a power output of 1000 mW/cm.2. Furthermore, three directional light curing has been recommended to cure bulk-fill composites [7, 8].

The distance between the light curing tip and the surface of the resin composite, light curing duration, and direction are among the determinants of curing light energy density and hence the quality of the final resin composite. A crucial aspect of effective light curing is the periodic inspection of the level of the power of the curing light and the need to change the light bulb of the curing unit [9 - 15].

Different light-curing devices provide varying light-curing capacities and require specific guidelines for use [16]. Various shades of the same resin composite can light cure with different sensitivities to light [17]. Consequently, studying the awareness of GDPs of the criteria and recommendations during light curing is mandatory for optimum quality resin composites. The literature shows general recommended practices to attain adequate light curing of resin composites [16]. Familiarity with the evidence-based criteria of optimum light curing is an essential aspect of concern.

Therefore, this cross-sectional survey study was designed to investigate the awareness of GDPs in Saudi Arabia towards the criteria of optimum resin composite light curing and their routine practices of concern. Moreover, several evidence-based recommendations to improve their clinical quality practice of concern will be presented.

2. MATERIALS AND METHODS

This is a questionnaire-based survey research that was online developed and electronically announced *via* email addresses of GDPs (general dental practitioners) in Saudi Arabia.

This research has received an exemption from the IRB review from the IRB committee of Princess Nourah bint Abdulrahman University, Riyadh, Saudi Arabia. The estimated population was 250 general dentists from five main cities in different Saudi provinces. Only GDPs after completing their internship program and currently appointed in general nonuniversity public hospitals in Riyadh, Jeddah, Dammam, Tabouk and Abha were included in the study. Three main general hospitals from each city were included in the study after sequencing general hospitals in each city according to the number of dental clinics available in each. The 15 hospitals included in the study were selected after contacts with Saudi Health authorities to identify the three largest general governmental hospitals with the largest number of appointed DGP in each of five different Saudi Provinces. The targeted population size of 250 resulted in a calculated sample size of 152 dentists. The targeted population was similarly used in previous surveys to use a sample that represents GDPs of around the Kingdom of Saudi Arabia of different Saudi dental schools' graduation [18]. The number of non-respondents was assumed to be like previous similar studies [18]. Calculations were performed at the 95% confidence level using a free online sample size calculator: https://www.calculator.net/sample-size.

Email invitations were sent to all the 250 general dentists after collecting their email addresses by direct contact with respective hospital administrators of concern and obtaining due hospital administrative approvals after explaining the objective of the study and providing copies of the attained letter of exemption of IRB ethical approval. Google's free online survey platform was used to create and conduct the current study.

The questions used in the current study were structured using previous similar studies [3] with due modifications and additions consistent with the current study objectives and the need to improve the quality of outcomes [19]. The previous similar survey of S.E. Kopperud *et al.* [14], was a guide in designing the questions and the used statistical analysis in the current cross-sectional survey. However, since most of the questions of our survey have multiple answers rather than two answers, descriptive statistics and *chi*-square testing for relevant associations were performed without multiple logistic regression analysis. The dependent variable of the current study is 'GDPs using eye protection during resin composite light curing and awareness of potential hazards of light curing on pulp tissue [14]. The independent variable is listed in Table **1**.

The validity and reliability of the questions were tested by content validation [20]. Ten experts were invited to validate each question of the survey using the following scale: the question is not relevant, the question is somewhat relevant, the question is quite relevant, or the question is highly relevant. All of them ranked all questions as highly relevant. Demographic data, including gender, age, duration, and location of the appointment, were among the items analysed.

The survey consisted of 24 questions classified into the following domains: 1- Demographic criteria in the form of four questions including the age, gender, years, and city of employment. 2- Frequency and technical aspects of resin composites application comprised of nine questions 3- Criteria of the currently used light curing units and curing light formed up of 11 questions. The questionnaire was designed without having the option of skipping any of the questions. Participants had to answer all survey questions [21].

Following many previous similar cross-sectional studies, descriptive statistical analysis, and *chi* square testing at a level of significance ($p \leq 0.05$) were employed to analyse the received responses [14, 22 - 24].

Table 1. Questions, respective responses, and frequency.

Domain	Questions	Modalities	Respondent	Response in %	*P*-value
Demographic	1- Age	23-30	85	54.5	*
		31-39	42	26.9	0.099
		40-49	17	10.9	0.076
		Above 50	12	7.6	0.038
	2- Gender	Male	88	56.4	*
		Female	68	43.5	0.132
	3- Years of employment	Less than 5 years	103	66	*
		6-10 years	37	23.7	0.085
		More than 10 years	16	10.2	0.0231
	4- Where you have been practicing in Saudi Arabia?	Riyadh	42	26.9	*
		Dammam	38	24.3	0.146
		Jeddah	35	22.4	0.122
		Abha	22	14.1	0.113
		Tabouk	19	12.1	0.104
Frequency and technical aspects of resin composites application	5- How many light cure resin composite restorations on average do you insert per week?	0 – 10	73	46.8	*
		11 – 20	56	35.9	0.136
		21 – 30	17	10.9	0.081
		> 30	10	6.4	0.043
	6- What is the thickness of resin composite increment that you insert?	2 mm	138	88.5	*
		3 - 4 mm	17	10.9	0.0162
		4 - 5 mm	1	0.6	<0.01
	7- What is the duration of light curing that you use regularly per each increment?	20 sec	90	57.7	*
		20 sec	7	4.5	<0.01
		30 sec	20	12.8	0.065
		40 sec	39	25	0.134
	8- What is the direction of light that you provide during curing of resin composite?	Perpendicular at the center	133	85.3	*
		Angulated from one side	23	14.7	0.0643
	9- What is the technique of light curing that you usually use?	Full intensity	130	83.3	*
		Pulse cure	10	6.4	0.025
		Soft start	16	10.3	0.0432
	10- Do you use bulk-fill composite?	Yes	48	30.8	*
		No	108	69.2	0.134
	11- Do you implement three directional curing with resin composites in class II cavities?	Yes	33	21.2	*
		No	24	15.4	0.163
		Sometimes	99	63.5	0.113
	12- Do you use a flowable composite layer following the bonding step?	Yes	100	64.1	*
		No	56	35.9	0.142
	13- Do you routinely use eye protection in the form of an eye shield for you and your patient during light curing?	Yes	97	62.2	*
		No	59	37.8	0.147

(Table 1) contd.....

Domain	Questions	Modalities		Respondent	Response in %	*P*-value
Criteria of the currently used light curing unit and curing light	14- What is the power output of the light curing unit that you use in your practice? (mW/cm^2)	300 – 500		16	10.3	*
		600 – 800		22	14.1	0. 138
		> 800		19	12.2	0.148
		Don't know		99	63.5	0.047
	15- What is the average time for you to change the curing light bulb of your curing unit?	Once in 6 months		12	7.7	*
		Once in year		30	19.2	0.068
		Once in 2 years		8	5.1	0.137
		When it goes off		106	67.9	0.033
	16- Do you regularly check the power of the light output of your curing unit using a testing device (radiometer)?	Yes		27	17.3	*
		No		129	82.7	0.068
	17- What is the maximum distance between light curing tip and the curing resin composite surface that you think can provide an adequate degree of conversion?	< 1 mm		96	61.5	*
		3 mm		44	28.2	0.873
		6 mm		13	8.3	0.322
		9 mm		3	1.9	0.021
	18- Do you think that optimum curing of resin bonding agents is mandatory for efficient bonding to tooth structure?	Yes		147	94.2	*
		No		9	5.8	<0.01
	19- Are you aware of the total-energy concept that determines the quality of the light cure composite?	Yes		55	35.3	*
		No		101	64.7	0.123
	20- Are you aware of cure depth, shade, and microfiller content of composites?	Yes		94	60.3	*
		No		62	39.7	0.131
	21- Are you aware of the potential thermal hazards of light curing on the pulp?	Yes		86	55.1	*
		No		70	44.9	0.148
	22- Are you satisfied with the quality of curing achieved regularly by your curing light?	Yes		138	88.5	*
		No		18	11.5	0.0451
	23- What is the nature of curing light that you are using in your practice? (Please indicate whether satisfied or not with selected curing light)	LED curing lights	Satisfied	94	(60.2%)	
			Not satisfied	10	(6.4%)	
			Total	104	66.6%	*
		Argon ion lasers	Satisfied	11	(7%)	
			Not satisfied	0	(0%)	
			Total	11	7%	0.0476
		Plasma arc	Satisfied	3	(2.2%)	
			Not satisfied	0	(0%)	
			Total	3	2.2%	<0.01
		Quartz-tungsten-halogen	Satisfied	30	(19.2%)	
			Not satisfied	8	(5.1%)	
			Total	38	24.3%	0.0753
	24- What is the power output of the light curing unit that you use in your practice?	300 – 500	Satisfied	13	(8.3%)	
			Not satisfied	3	(1.9%)	
			Total	16	10.2%	*
		600 – 800	Satisfied	19	(12.1%)	
			Not satisfied	3	(1.9%)	
			Total	22	14%	0.301
		> 800	Satisfied	19	(12.1%)	
			Not satisfied	0	(0%)	
			Total	19	12.1%	0.331
		Don't know	Satisfied	87	(55.8%)	
			Not satisfied	12	(7.7%)	
			Total	99	63.5%	0.018

Note:*P*-values by *chi* square testing are listed in association with the first response (*) in each study question.
P-values and association are only for the totals. individual satisfactions were not subject of chi square testing P-values determination

3. RESULTS

Out of the 250 invitations, 156 responses were received over a period from February 2020 to September 20, 2020. The 94 non-respondents constituted 37.6%. The 24 questions, their possible answers, and the corresponding results and respective

non-respondents for each question in the form of frequency and percentage are presented in Table **1**.

Riyadh followed by Dammam provided the greatest responses while Abha provided the least responses. Sixty-eight female responses and 88 male responses were received. About 54.5% of the respondents were 23-30 years old and 66% of participant GDPs have less than 5 years of experience. The greatest fraction of responses were received by general dentists with less than 5 employment years while dentists with more than 10 years of employment constituted the least participation.

The mean score of knowledge and awareness is 3.06 out of 5, 103 (66.02%) of the participant were practicing dentistry for 1-5 years, 37 (23.72%) for 6-10 years and 16 (10.26%) for more than 10 years. The reported satisfaction of curing achieved by light curing unit (LCU) is high with 138 (88.5%) satisfied, however, *chi*-square test showed a statistically significant difference in participants' satisfaction with their employed light curing ($P<0.05$). There is no statistical significance between responding GDPs who are aware of the potential thermal hazard of curing light on the pulp and those who are not aware of that ($P> 0.05$).

Gender of respondents, duration and location of employment had no significant influence on the response ($P> 0.05$). Out of the 88 male respondents, 58 use LED light curing, 79 do not regularly check the power output of LCUs, 40 are not aware of the potential hazards of light curing on the pulp, and 51 use eye shields during light curing. Thirty-six Female respondents use LED LCUs out of 68 respondents, 50 do not regularly check the power output of LCUs, 30 are not aware of the potential hazards of light curing on the pulp, and 46 use eye protection shields during light curing. Ninety-nine respondents (63.5%) do not know the power output of their LCUs.

4. DISCUSSION

Adequate curing of resin composite restorations is a basic prerequisite for the clinical effectiveness and durability of the restoration. An optimum degree of conversion is mandatory for achieving the most favourable physical, mechanical and optical properties of the resin composites [19]. Furthermore, residual unpolymerized monomers in resin bonding agents and resin composite restorations can induce adverse biological effects on the pulp tissue and reduce tooth-restoration bonding effectiveness. Adequate DC improves the biodegradation resistance of resin composite restoration and bonding agent, with favourable interfacial adaptation and effectiveness of bonding to the tooth structure and hence long-term clinical reliability and patient satisfaction [20]. Inadequate DC is associated with compromised physicochemical properties and biocompatibility of resin composites, inferior clinical performance, and increased risk of future caries recurrence [25].

The literature has extensive *in vitro* and *in vivo* reports, systematic reviews and meta-analysis demonstrating the criteria of optimum light-curing resin composite [16].

The questions of this survey were designed after reviewing previous similar surveys and interviews [26]. Moreover, previous systematic and narrative reviews were used to structure the domains, questions and provided answers [14]. Conforming with previous similar surveys, our questionnaire did not have the option of skipping any of the included questions [14]. Therefore, there were no individual questions for non-respondents [21].

Although dichotomization, where only two possible answers are provided, is a popular format in designing questions of surveys [27], most of the questions of the current survey have more than two optional answers. The main answers to questions 23 and 24 were eventually dichotomized into satisfied or not satisfied but only the totals of main answers were used in *chi*-square testing since the overall satisfaction of light curing was assessed in question 22. For simplicity, questions were categorized into domains.

Following previous similar studies and for providing simple, concise yet precise information, multiple analyses were not used in the current study [3, 14, 18]. However, using multiple analyses might have added to the value of the outcome.

The lack of agreement among the survey respondents regarding their clinical protocol of light curing and the unawareness of a considerable number of participants of the power output of their LCUs is in line with a similar survey carried out in Norwegian [14].

A recent study investigated the clinical practice of dentists towards light curing resin units in Riyadh city, the capital of the kingdom of Saudi Arabia with different study designs and objectives. Our current study has targeted border demographic participants including five main cities in five different Saudi provinces. Our study aimed to invite GDPs of varying educational backgrounds having graduated from different Saudi dental schools [28, 29].

4.1. Demographic Analysis

Our email invitations to targeted GDPs announced that the present student research is regulated and supervised by the college of dentistry, Princess Nourah Bint Abdulrahman University in Riyadh. This might have encouraged more dentists from Riyadh to join the survey explaining the greatest contribution from Riyadh. Moreover, it might have motivated more female GDPs to participate since it is known that Princess Nourah University is for female students only. This might explain the relatively high female participation in the current study in comparison to similar previous studies [30]. Our results indicated that demographic factors of gender, age, duration, and city of appointment, had no individual significance on awareness of using protective eye shields during light curing or potential hazards of light curing on the dental pulp. This might reflect similarities in the curriculum, quality of basic dental education and training programs during their internship phase and thereafter received by DGP around the Kingdom of Saudi Arabia [31].

The design of the current study included the three largest general governmental hospitals in the main cities of five different Saudi provinces covering all geographic locations in Saudi Arabia. GDPs in smaller governmental hospitals and

health services centres were not included in the study and might have affected the attained outcome because of the difference in facilities and availability of experienced senior consultants and specialists. Future studies should consider this limitation by using broader locations and a larger population.

4.2. Composite Structure and Thickness of Inserted Increments

Most respondents, 88.5%, insert resin composite in prepared cavities in the form of subsequent increments of 2mm thickness each, whereas the remaining 11.5% insert resin composite in increments greater than 2 mm. This contradicts our perceived data that 69.2% of respondents use conventional incremental resin composite while 30.2% use bulk-fill composites. These findings suggest that a fraction of the respondent GDPs insert bulk-fill composites incrementally, while at the same time, they do not preclude that conventional incremental composite is inserted by all respondents as 2 mm thick maximum each increment. Evidence-based recommendations indicate that incremental insertion is the gold standard of resin composite [11, 13, 32]. Cavity configurations and presence of intervening tooth structure relative to curing light direction, and incremental *versus* bulk curing all influencing factors are crucial factors when optimum light curing, and shrinkage behaviour of resin composites are considered [33, 34].

Lighter shades, and more translucent composites allow deeper penetration of curing light than darker, and opaquer ones. Furthermore, increasing the microfillers content of resin composite impedes curing light penetration [10, 13].

About 60.3% of our participants are aware of the influences of resin composite shade and microfillers content on curing light penetration. This raises strong concerns that a considerable fraction of GDPs should improve their knowledge and awareness of concern.

Our 69.2% of respondents who don't use bulk-fill composites draw attention since bulk-fill composites reduce the time and effort of application and have been reported as satisfactorily performing composites [7, 35 - 37]. The unavailability of bulk-fill composites at respective workplaces and lack of adequate knowledge and awareness of participating dentists are probable explanations. Optimum curing of bulk-fill composites requires a curing light output of at least 1000 mW/cm.2 with three-directional approach [37, 38]. Our 21% of respondents who use three-directional light curing with bulk-fill composites constitute only a minority of respondents giving clues that awareness of GDPs should be improved.

4.3. Polymerization Technique, Duration, Direction

The use of full-intensity light curing technique by 83.3% of respondents, *versus* 10.3% and 6.4% who use Soft-start, and pulse cure techniques, respectively, might be related to the simplicity and ease of application, lack of adequate knowledge, and shortage of facilities.

Strong evidence exists that slow conversion reduces interfacial shrinkage stresses. Soft-start and pulse curing methods were introduced to induce light curing over time leading to better adaptation and reduced interfacial shrinkage stresses [4, 13, 39, 40].

Our findings that only 25% light cure resin composite increment for 40s while 12.8% and 4.5% cure each resin composite increment for 30s and 10s, respectively.

Cumulating evidence shows that 40s light curing is mandatory to achieve optimum light curing for LED curing units [41 - 43]. For optimum DC, the manufacturer's recommendations of light curing should be followed. Light curing time generally depends on resin matrix chemical composition, composite material shade, translucency, inorganic filler content [44], and thickness of inserted composite [45]. According to the total energy concept, increasing light curing time and/ or intensity is needed for darker and opaquer composites with greater microfillers content [5, 13, 46]. According to our results, only 35.3% are aware of the total-energy concept despite the solid evidence that it determines the quality of the light-cured composite [5, 47]. Accordingly, GDPs should promote knowledge and awareness of regard.

The attenuation of curing light energy with increasing distance of the curing light tip from the surface of the resin composite layer is another considerable factor [11]. About 61.5% of the perceived responses conform with established evidence that this distance should be < 1mm to achieve optimum DC. On the other hand, the rest of the responding GDPs of 28.2% and 10.3% who replied that 3 mm and a distance >6mm, respectively can result in adequate curing, need to urgently upgrade their knowledge, and improve their practice of concern. The literature shows that at a distance of greater than 5mm, like in deeply inserted resin composite increments in deep cavities or in cores build ups, the exposure time should be increased or a dual cure resin composite [48, 49] might be preferrable in order to assure adequate DC [11, 13, 43, 50, 51].

The 15% of our attained responses who angulate the curing light beam from one side during resin composite curing raise concerns since evidence-based practices recommend perpendicular curing light beam. It has been reported that angulated light curing tips are associated with lower DC especially with lower energy output LCUs. To achieve maximum light intensity, it is recommended to maintain a perpendicular curing light beam to the surface of the composite. For unavoidable angulation of curing light beam other than 90°, curing time needs to be extended [25, 52].

4.4. Eyes Protection during Light Curing

The feedback of respondents indicating that 62.2% of them use eye shields for themselves and their patients while 37.8% do not use eye protection warrants consideration. The literature shows wide information regarding the potential hazards and possible adverse effects of curing light on the retina of the human eye. The use of protecting eye shields during light curing has been advocated [53]. In a previous study, one-third of dentists did not use any personal eye protection during light-curing resin composite restorations, while 1.7% of participants stated that they do not utilize any sort of eye protection against blue light and 7.7% turn their heads away from the light, with eventual light curing tip to drift away adversely affecting DC. In the same previous study, a protective shielding mounted to the curing light was utilized by only 19.7% of dentists [4, 54].

The total wavelength received from the light curing unit (LCU) can produce ocular damage. Former reports show that blue light poses a risk of retinal degeneration which is directly proportional to the duration of exposure to curing light [53, 55].

Evidence-based recommendations and precautions for eye protection during light curing include the maximum daily retinal exposure limit without the use of eye protection that should not exceed 61 seconds if a low-power LCU is used and 28 seconds when using a high-power LCU is used with a minimum distance of 30 cm between the eyes and the light source [54, 56].

Several aspects are crucial when it comes to the type of eye protection to lessen or even block the hazardous wavelength of the curing light: the Composition, colour, thickness, and physical size and field cover. When employing monowave LED, the red-colored eye protection was shown to be less effective than the orange-colored eye protection. Eye protection during light curing should be provided to dentists, dental assistants, and patients [54, 55].

4.5. Nature and Intensity of Curing Light

Our results that the majority of respondents, 64.6% use LED LCUs, 24.3% use QTH LCUs, 7% use argon laser, and 2.2% use plasma arc fit to accumulating reports showing that most the dentists worldwide use LED as they can cure resin composites satisfactorily [16]. A previous study found LED units to have higher curing light intensity than that of QTH. Moreover, it was reported that QTHs have a greater frequency of repair than LEDs. Due to the higher radiant emittance of plasma arch light and argon ion laser, less light curing time is needed. However, greater polymerization shrinkage stresses and marginal discrepancies were demonstrated with these modes of light curing [13, 57, 58].

These findings are in line with a previous similar survey conducted in Norway in 2015 [14]. Periodic monitoring of the curing light power output is essential and to timely change the LCU bulb is critical to assure effective light curing. QTH LCUs have a bulb lifetime of 50-100 hours (approximately 6 months of clinical use), whilst LED LCUs should last for thousands of hours if operated and cared for according to manufacturer's guidelines [13, 19]. Surprisingly, 63.5% of our respondent GDPs do not know the power output of their LCU. Moreover, 67.9% of the participant do not change the light curing bulb unless it goes off and 83% of participants do not regularly check the power of the light output of their LCUs using radiometers testing devices. Periodically monitoring the power output of LCUs on a daily basis of practice has been highly recommended to assure efficient composite light curing [59]. Consequently, it appears demanding that GDPs should broaden their knowledge and correct their practice by regularly checking the power output of their LCUs.

4.6. Potential Thermal Hazards on the Pulp

The potential risk for heat-induced pulpal injury upon light-curing resin composites is evident particularly at deeper cavity locations near the pulp. Long-exposure light curing should be avoided as it might lead to thermal damage to the pulp [60, 61]. Although 55.1%of respondents reported that they are aware of the potential thermal hazards of extended light curing on the pulp, 44.9% are not aware of this risk warranting thoughtful considerations. Firm evidence demonstrates that the nature, intensity of output and duration of light curing, the distance of light curing tip, and thickness of remaining dentin bridge are all contributing factors in determining the total amount of thermal damaging effect on the pulp [62, 63]. Modern LCUs use higher light intensity output than older-generation LCUs. Therefore, there is an urgent need for GDPs to improve their awareness of the potential hazards of curing light on dental pulp [63].

Resin composite restorations form the core of everyday restorative dentistry practice in Saudi Arabia, for best quality restorative dentistry community services, the authors of the current study recommend periodically organizing continuing educational programs and workshops for optimum clinical practice for light curing of resin composite. The greatest number of participants in the current survey have less than 5 years of clinical experience. This might explain the lack of consistency in the employed light curing criteria and inadequate awareness of optimum light curing criteria based on evidence-based practice. Our results indicate that GDPs in Saudi Arabia needs to improve awareness of light curing criteria relative to the nature of used resin composite to assure adequate DC by using optimum criteria of curing light yet minimizing the potentials of thermal hazards of curing light on dental pulp [64].

GDPs in Saudi Arabia need to improve its routine practice of light-curing resin composites. This can be achieved by joining continuous education and training programs to upgrade their clinical skills of concern [65, 66], and joining workshops under the supervision of experienced consultants and faculty members [31].

The current study has some unavoidable limitations. The study being cross-sectional in nature, is performed at one single phase of time. The responses were collected from GDPs of variable years of clinical experience after the internship program in only five main cities in Saudi Arabia with only three main general hospitals in each city included in the study. Furthermore, only governmental hospitals which provide dental services completely free of charge and consequently have greater patient flow seeking free treatment with patient treatment time and facilities limitations were included in the study. This might have added facility limiting factors and patients' socioeconomical influencing factors. A broader study perspective and a more reliable outcome could have been obtained if a greater population was targeted by including GDPs at private and university hospitals. Since it was inconvenient to get email addresses of GDPs appointed in private sectors and many governmental hospitals, the study has a relatively small population size. The unavoidable bias of following expert opinion and not responding with self-behaviour were previously discussed in similar surveys [14]. On the other hand, the current study has included GDPs from all provinces of Saudi Arabia which can constitute a truly representative sample of all GDPs in Saudi Arabia. The survey has been performed during the period from February 2021 to

September 2021 while Covid 19 pandemic was still affecting dental practice after a considerable phase of lockdown that has influenced dental practice in Saudi Arabia and around the world. This might have relatively limit the targeted population in the study design and reduced the number of participants [67, 68]. The answers might have been influenced by the practice regulations, precautions, and priorities. At the time of writing this manuscript, dental practice in Saudi Arabia has moved to the after-pandemic 'new normal' phase.

CONCLUSION

According to the results of this investigation and putting into consideration all its limitations, the following conclusions could be drawn:

1- There is no uniform agreement between GDPs in Saudi Arabia in their clinical practice of light-curing resin composites regardless of gender, age, duration, or location of the practice.

2- A considerable fraction of the GDPs in Saudi Arabia should improve their awareness of potential hazards of curing light on pulp tissue, take necessary safety measures of eye protection, and reconsider their clinical protocol of light curing of resin composite and handling of their LCUs.

LIST OF ABBREVIATIONS

GDPs	=	General Dental Practitioners
LCU	=	Light Curing Unit
DC	=	Degree Of Conversion

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This research has received an exemption of the IRB review from the IRB committee of Princess Nourah bint Abdulrahman University, Riyadh, Saudi Arabia. The IRB Log Number 19-0114 on August 27, 2019.

HUMAN AND ANIMAL RIGHTS

No animals were used in this study. All the procedures performed in the studies involving human participants were in accordance with the ethical standards of institutional and/or research committee and with the 1975 Declaration of Helsinki, as revised in 2013.

CONSENT FOR PUBLICATION

Informed consent was obtained from all the participants.

AVAILABILITY OF DATA AND MATERIALS

All datasets used and/or analysed during the current study are available from the corresponding author [M.A] upon reasonable request.

A preliminary previous version was available as a preprint.

STANDARDS OF REPORTING

COREQ guidelines were followed in the study.

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CONFLICT OF INTEREST

The authors declare no conflict of interest financial or otherwise.

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