KNOWLEDGE OF DENTISTS FROM ARACAJU/SE REGARDING LIGHT-ACTIVATION OF BULK FILL COMPOSITES AND DEPTH OF POLYMERIZATION ACHIEVED IN PRIVATE AND PUBLIC HEALTH SERVICES

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ABSTRACT

This study evaluated the protocols of light-curing used by dentists in the city of Aracaju/SE (Brazil) and the depth of polymerization of a bulk fill composite achieved with theirs light-curing devices. Thirty-three dentists were randomly included in the study, while 15 were in health public service. The profile and knowledge of these clinicians regarding composite light-curing in posterior teeth and bulk fill composites were assessed. The external diameter of light-curing unit tips was measured with a digital caliper, and the brand and model of these devices was recorded. The clinicians performed class II MOD restorations in stone models with a bulk fill composite using their light-curing units, without any additional instruction, and the details about the light-curing protocol used was recorded. The depth of polymerization was measured by inserting a composite into a metallic matrix with 8 mm of depth, followed by the removal of unpolymerized material with a metallic spatula. Descriptive analyses of data were performed, and depth of polymerization achieved by units located in public and private services was compared by T-test and Fisher Exact test (α = 0.05). It was observed a low level of knowledge of dentists regarding bulk fill composites and light-curing, resulting in large variability of light-curing protocols. The depths of polymerization observed in public and private services were 3.1 and 3.3mm, respectively, without statistical differences between them. Only 10% of light-curing protocols yielded depth of polymerization of 4 mm. In conclusion, the light-curing units and techniques of light-curing used remains an important challenge to obtain proper polymerization of bulk fill composites.

KEYWORDS

Dental curing lights. Composite resins. Permanent dental restoration.

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INTRODUCTION

Resin composites have been widely used to replace amalgam as a direct restoration material for posterior teeth because of their versatility and good optical and mechanical properties.[1,2] In addition to the aesthetic advantage, it can be bonded to dental tissues, which allows its use even in wide cavities for which amalgam is contraindicated, due to the increased risk of fracture.[3] Another important advantage of composites is their polymerization, which begins at photoinitiation of the material and gives clinical dentists control over working time. The light emitted by the light-curing unit at the proper wavelength, compatible with the photoinitiation system of the composite, excites photoinitiators and generates free radicals that activate the polymerization reaction, usually a chain reaction.[4] Although working time may be controlled, the reaction is dependent on light curing this initiation system, and light emission at an incorrect wavelength or at a low irradiance may compromise the correct composite polymerization and the clinical longevity of the restoration.[5,6]

The placement of composite in the cavity at small increments (up to 2 mm thick) has been recommended to increase polymerization of the resin composite body, as the light emitted by the light-curing unit in this case has to penetrate a thinner layer to reach the deeper areas of the material.[7] In addition to ensuring better polymerization, incremental placement also helps reducing the stresses generated by polymerization shrinkage of the resin composite.[8,9] Resinous materials polymerize by chain reaction as monomers come together, and this may result in clinical problems, such as enamel cracks, dental structure deformation or rupture of the bonding interface.[10] However, although the incremental placement technique helps polymerization and reduces shrinkage stresses, it increases the time necessary to build up the restoration and, consequently, the cost of the restorative procedure. To reduce clinical time for this procedure, composites known as bulk-fill, recently introduced in the market, may be placed at increments of up to 5 mm, which often makes it possible to restore a tooth with a single increment. To make it possible, bulk-fill composites have fewer (*flow* composites) or smaller fillers, as well as organic and inorganic portions that have more similar refraction index, which allows better light transmission. They also have more efficient photoinitiating systems and/or changes in the organic matrix, mainly by incorporating new monomers or additives that reduce shrinkage stresses.[11,12]

Despite the limitations of composites and the sensitivity of the operating technique, particularly when the incremental technique is used, prospective and retrospective clinical trials found an excellent clinical performance of composite restorations in posterior teeth, with a annual failure rate of less than 2%.[13,14] Their excellent clinical performance is also confirmed when bulk-fill composites are evaluated [15]. In many of these studies, however, restorative technique and materials are standardized, and calibrated professionals perform restorative procedures using equipments and techniques that follow exact specifications to ensure high-quality restorations. In contrast, the same performance may not be repeated in daily clinical practice, under different oral healthcare dispensation conditions.[16] One of the explanations for this lower results may be associated with the quality of light-curing units, which often have a irradiance that is lower than the irradiance recommended for the correct photoactivation of restorative composites.[17-19] This problem may be worse when bulk-fill composites are used, because photoactivation using the recommended technique and irradiance is essential to achieve good polymerization of all the increment layer, which may be up to 5-mm thick.

This study evaluated how much dentists in the city of Aracaju, Brazil, know about bulk-fill resin composites and light-curing units, as well as what light-curing protocols they use to polymerize bulk-fill composite restorations placed in a single increment in complex class II cavities. The light-curing units available in private and public dental services were also described, and depth of polymerization obtained with their units was compared.

MATERIAL AND METHODS

Thirty-three professional from Sergipe, Brazil, were selected to participate in this study. Fifteen of them were reached while attending in basic healthcare units of Dental Specialties Centers associated with the public healthcare system, and the others were reached in private offices and clinics. All participants signed an informed consent term and agreed to participate in the study.

The profile of the professionals included in this study was defined using a questionnaire about time since graduation, area of specialization and complementary training in Restorative Dentistry. Those who had complementary training in Restorative Dentistry were also asked whether they had classes about resin composites in posterior teeth and light-curing units. The questions about light-curing units evaluated their satisfaction with the units they used, the criteria used to select them before buying and the minimum power output that they should have. The brand and model of the light-curing unit used by the professionals in their practice were recorded, and the external diameter of the tip of the unit was measured using a digital caliper. To check their knowledge about bulk-fill resin composites, they were asked if they had already used this type of material, if they knew what it was, if they used it or were in any way insecure about using it. Those who said that they would use bulk-fill composites were asked if they would change any light-curing strategy when using them.

To check the photoactivation technique used by the dentist for a bulk-fill composite, a complex mesial-occlusal-distal (MOD) class II cavity was prepared in the mandibular right first molar of a dental arcade. The cavity had an isthmus width of ¼ of the intercuspal distance, occlusal box depth of 3 mm and proximal boxes depth of 6 mm. Two biconvex sectional contoured metal matrix bands were placed on the proximal surfaces of tooth #46 and stabilized with wooden wedges to protect adjacent teeth during preparation. Partial models of the prepared molar and adjacent teeth were fabricated using polyvinyl siloxane impressions. Those models were then used to fabricate thirty-three working models (Fig 1).

A working model was given to each of the study participants, together with an Aura Bulk-Fill (SDI, Victoria, Australia) composite kit. No instructions for the resin composite photoactivation method were given. Participants were allowed to check the composite manufacturer instructions, but no participants showed any interest in using it. The number of times the light-curing unit was activated and the position of the light-curing unit tip in each activation were recorded. In addition, the participants received a metal matrix with a 4-mm internal diameter and 8-mm depth, filled with the same bulk-fill composite used before. The dentists were asked to photoactivate the composite and to polymerize as much material as possible. The number of unit activation times, changes of the position of the unit tip, and total light-emitting time were recorded.

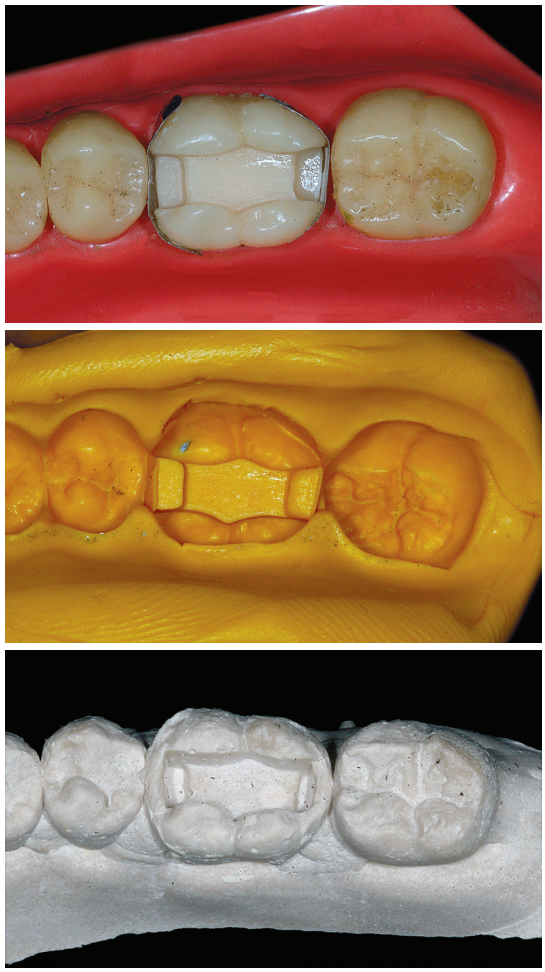

Figure 1:
Fabrication of working model to evaluate photoactivation technique used by dentists: (**A**) preparation of complex class II cavity in first molar of dental arcade; (**B**) polyvinyl siloxane impression; and (**C**) working model with cavity in molar.

The bulk-fill composite material that the dentist had placed and photoactivated in the metal matrix was removed, and the soft portion, that is, the portion not fully photopolymerized, was scraped off using a metal spatula. The remaining polymerized composite height was measured using a digital caliper, and the depth of polymerization was defined as half that height. This method followed the 4049/2009 specifications of the *International Organization for Standardization* (ISO).[22] The percentage of samples with a 4-mm polymerization depth, the maximum depth indicated by the composite manufacturer, and 80% of this value were calculated.

The data about participant profiles and light-curing units were analyzed descriptively. The photoactivation protocols used to polymerize both the composite in the working model and in the metal matrix were also analyzed descriptively. Data about composite depth of cure in the public services and in the private offices were compared using a t test. The Fisher's exact test was used to analyze the effect of type of service — public or private — on the percentage of samples with a 4-mm depth and on the 80% value. The significance level was set at 95% for all the analysis.

RESULTS

Table 1 summarizes the data about the profile of the dentists included in the study. Mean time from graduation was 15 years, and 87.9% had some type of specialized training, half of whom had finished their course over 9.5 years ago. Participants with a graduate specialty in Restorative Dentistry made up 15.2% of the sample, whereas 42.4% had taken some other type of advanced training course in this specialty. The graduate specialty courses in Restorative Dentistry had been completed, meanly, 5.5 years before. 78.6% of the participants had classes about resin composites in posterior teeth, and 57.1%, about photoactivation.

Table 2 shows the answers that the dentists gave to the questions about light-curing units. Most of the dentists in the study (87.9%) were satisfied with their light-curing units, and 6.1% were not; the others did not know how to answer this question. The output (57.6%) and the unit brand (54.5%) were the main factors to determine their choice of a light-curing unit. Ease of use was chosen by 30.3% of the dentists, whereas 21.2% said that they considered price as an important factor when buying a unit. When asked about minimum unit irradiance, 69.7% did not know how to answer, and 12.1% said that they did not know the answer.

Table 1:

Profile of dentists included in the study.

Graduated for (years)*	**15 (8/23)**
Did you take any graduate specialty course?	**29/33 (87.9%)**
Prosthetics	8/33 (24.2%)
Endodontics.	6/33 (18.2%)
Restorative Dentistry	5/33 (15.2%)
Orthodontics	5/33 (15.2%)
Dental Implants	3/33 (9.1%)
Other	3/33 (9.1%)
How long ago did you conclude graduate specialty course?	9.5 (6.3/15.5)
Did you take any other training in Restorative Dentistry?	**14/33 (42.4%)**
How long ago?*	5.5 (2/8)
Did you have classes on the use of composites in posterior teeth?	11/14 (78.6%)
Did you have classes on light-curing units?	8/14 (57.1%)

* Median (1st and 3rd quartiles)

Table 2:

Answers of participant dentists about light-curing units.

Are you satisfied with your light-curing unit performance?	
Yes	29/33 (87.9%)
No	2/33 (6.1%)
No answer	2/33 (6.1%)
How do you select a light-curing unit to buy?	
Unit power output	19/33 (57.6%)
Unit brand	18/33 (54.5%)
Ease of use	10/33 (30.3%)
Unit price	7/33 (21.2%)
Other criteria	4/33 (12.1%)
What minimum output (irradiance) should a light-curing unit offer?	
400 mW/cm^2	1/33 (3.0%)
450 mW/cm^2	2/33 (6.1%)
1200 mW/cm^2	3/33 (9.1%)
Não sabe	4/33 (12.1%)
Não respondeu	23/33 (69.7%)

The answers that the dentists gave to the questions about their knowledge about bulk-fill composites are shown in Table 3. Only 18.3% of the dentists in the study had already used bulk-fill composites, and only 54.5% knew what these materials were. Despite that, 66.1% said that they would use these composites in their clinical practice, and only one dentist (3.0%) admitted being afraid of using this type of material. Only 21.2% said that they would change the photoactivation protocol for these materials.

Table 4 shows the protocols used by the dentists for the photoactivation of the bulk-fill material to restore a MDO class II cavity made in a working model. There was a great variation of protocols, from one to more than eight light-curing activation times. Total photoactivation time also ranged from 20 seconds to more than three minutes.

Table 3:

Answers of participant dentists about bulk-fill composites.

Have you ever used bulk-fill composites?	
Yes	6/33 (18.2%)
No	26/33 (78.8%)
No answer	1/33 (3.0%)
Do you know what bulk fill means?	
Yes	18/33 (54.5%)
No	14/33 (42.4%)
No answer	1/33 (3.0%)
Do you or would you use bulk-resin composites in you clinical practice?	
Yes	22/33 (66.1%)
No	7/33 (21.2%)
No answer	2/33 (6.1%)
Do you or would you feel insecure about using this type of composites?	
Yes	1/33 (3.0%)
No	29/33 (87.9%)
No answer	3/33 (9.1%)
If you decided to use them, would you change any photoactivation strategy that you currently use in your clinical practice? If yes, why?	
Yes	7/33 (21.2%)
I would follow the manufacturer's instructions	*3/7 (42.9%)*
Because of the larger increment volume	*3/7 (42.9%)*
Because it requires a shorter photoactivation time	*1/7 (14.3%)*
No	22/33 (66.7%)
Maybe, depending on other factors	2/33 (6.1%)
No answer	6/33 (6.1%)

Table 5 describes the light-curing units used by the dentists according to place where they were reached. It also shows the photoactivation time used to polymerize bulk-fill composite placed in a metal matrix and the depth of cure achieved. Tip diameter ranged from 6.6 mm to 12.5 mm, and photoactivation time, from 20 s to 100 s. The evaluation of more than three units of the same brand and model revealed that there was a weak correlation between photoactivation time and depth

Table 4:

Photoactivation protocols used by dentists for restoration of a complex class II cavity in a working model using a bulk-fill composite.

Number of light-curing unit activation times	
Only one	4/33 (12.1%)
Two	8/33 (24.2%)
Three	7/33 (21.2%)
Four	4/33 (12.1%)
Five	5/33 (15.2%)
Six or more	5/33 (15.2%)
Total photoactivation time	
Up to 20 seconds	2/33 (6.1%)
>20 seconds to 40 seconds	6/33 (18.2%)
>40 seconds to 60 seconds	7/33 (21.2%)
>60 seconds to 120 seconds	9/33 (27.3%)
>120 seconds to 180 seconds	7/33 (21.2%)
>180 seconds	2/33 (6.1%)

of cure. The Pearson test revealed that the correlation between depth of cure and photoactivation time of the light-curing units was negligible (R = 0.235) for private offices and weak (R = 0.414) for public services. Table 6 shows the comparisons of the effectiveness of the polymerization of bulk-fill composite placed in a metal matrix between the places where the study was conducted. There were no statistically significant differences (p = 0.594) between mean depth of cure achieved in the private offices (3.33 mm) and in the public services (3.10 mm). Only two samples (13.3%) in public services achieved a depth of cure of 4 mm, whereas this result was down to 5.6% in the private offices. Only six samples in the public services and seven in the private offices reached the 80% of depth of cure reported by manufacturers.

Table 5:

Light-curing units and models used to photoactivate composite during the study in public services and private offices, and results of depth of cure for each unit.

Brand	Model	Tip diameter	Number	Time to use	Depth of cure*
Microdont	Blue Star+	8.0 mm	Public: 6	20-80 seconds	2.1-4.0 mm R = 0.658
Schuster	Emitter A	8.0 mm	Public: 2	20-100 seconds	2.5-2.6 mm
	Emitter A Fit	8-12.5 mm	Private: 4	20-100 seconds	3.0-4.0 mm R = 0.469
	Emitter B	8.0 mm	Private 1	20 seconds	3.6 mm
	Emitter D	8-12.5 mm	Private: 2	40 seconds	3.0-3.8 mm
	Emitter G	8.0 mm	Private: 1	40 seconds	3.9 mm
	Vibramart	9.4 mm	Public: 1	20 seconds	2.2 mm
3M	Ortholux XI	8.0 mm	Private: 1	20 seconds	3.2 mm
Altlux	Alt	7.5 mm	Private: 1	40 seconds	3.2 mm
Dabi-Atlante	Fibralux	6.6 mm	Private: 1	80 seconds	2.3 mm
	DB-682	8.6 mm	Private: 1	20 seconds	2.2 mm
Demetron	Optil Iwc	12.2 mm	Private: 1	20 seconds	2.9 mm
Ecel	EC450	11 mm	Public: 4	20-90 seconds	3.1-4.0 mm R = 0.433
Gnatus	LD Max	8.6 mm	Private: 1	40 seconds	1.8 mm
Kavo	Poly Wireless	8.1 mm	Private: 1	20 seconds	2.8 mm
LVXII	Pistola	8.4 mm	Public: 1	80 seconds	3.6 mm
MMOptics	LEC470II	8.2 mm	Public: 1	20 seconds	2.1 mm
SDI	Radii-Cal	11.4 mm	Private: 2	40-60 seconds	3.8-3.9 mm
Woodpecker	LED.B	6.8 mm	Private: 1	80 seconds	3.8 mm

* For models with more than four measurements, the Pearson correlation test was performed to verify the relation between the measurements of polymerization depth as a function of time. R = correlation coefficient.

Table 6:

Comparison of place and bulk-fill composite polymerization in a metal matrix.

Measurements	Study place		P value
	Public service (n=15)	Private office (n=18)	
Depth of cure[1]	3.10 (0.76)	3.33 (0.65)	0.594[2]
% polymerization up to 4 mm*	13.3% (2/15)	5.6% (1/18)	0.579[3]
% polymerization up to ≥ 3.6 mm**	40% (6/15)	38.9% (7/18)	1.000[3]

[1]. Mean (standard deviation); [2]. T Test; [3]. Fisher's Exact Test. * Maximum thickness of the increment recommended by the manufacturer of the composite resin. ** 80% of the maximum thickness of the increment recommended by the manufacturer of the composite resin.

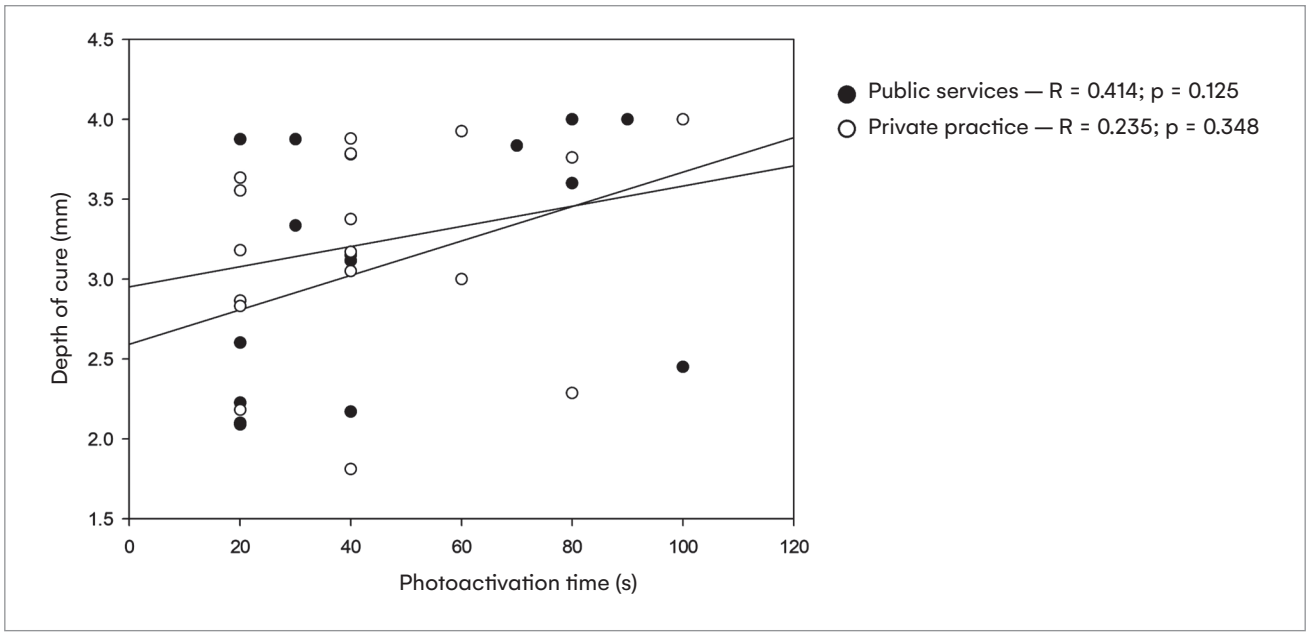

Figure 2:

Pearson's correlation coefficient between data for photoactivation time and depth of cure.

DISCUSSION

The use of resin composites in posterior teeth has increased considerably in the last decades and, consequently, has reduced amalgam use, particularly because of the evolution of the mechanical properties of composites, which resulted in better clinical restoration longevity.[23] However, although some clinical studies found annual failure rates below 2%,[13-15] the replacement of restorations classified as unsatisfactory still accounts for a large number of procedures in clinical practice. A recent review of the literature found that procedures to replace composite restorations are up to twice more frequent than those for new restorations.[23] An analysis of survival using a large database in the United Kingdom revealed that re-interventions were necessary in 11%, 20% and 50% of the restorations after one, three and 10 years of clinical performance.[24] This discrepancy found between the high rate of success of posterior tooth restorations in controlled clinical trials and the results observed in clinical practice may be associated with other factors, such as the restorative technique, including operative errors that may compromise the quality of material polymerization.

Technical sensitivity may be reduced by developing restorative materials that facilitate the procedure by reducing the number of steps, such as the use of self-etching adhesive systems or of single-increment composites, depending on cavity depth. Therefore, some brands of bulk-fill composites introduced in the market may be placed in the cavity in increments of up to 5 mm thick, which are then light cured. This type of restorative technique requires less clinical time to finish the restoration than the incremental technique, in which increments less than 2 mm thick are necessary to ensure proper composite polymerization.[7] To be used in single-increments, bulk-fill composites underwent changes in their composition to reduce shrinkage and increase material translucency [25,26]. Changes in light transmission were achieved with increases in material translucency by means of changes in index matching and organic matrix,[27] or reductions of filler content (less viscous composites), for example.[28]

In addition to material characteristics, the use of an efficient light-curing unit and the correct photoactivation technique are essential to achieve an adequate depth of cure.[29] Several manufacturers have reduced the diameter of the active tip of the unit to "concentrate" greater irradiance at light output and thus increase the irradiance of light-curing units.[30] However, such reduction results in greater light emission heterogeneity and reduces the area of composite polymerization; because of that, the unit has to be activated several times to effectively polymerize bulk-fill composite placed in a wide cavity.[29] This study measured only the external diameter of the unit tip and found that most units under evaluation had a tip of about 8 mm in diameter. As the internal diameter of the unit tip (light output) is even smaller, most of the units used required that the tip should be placed at three positions at least - center of the occlusal surface and on the proximal surfaces - to polymerize the complex class II cavity used in this study. However, about 36% of the dentists used less than three activations, and most did not change the position of the unit. This may

be explained by the fact that the dentist knew little about composites used in posterior teeth, bulk-fill composites and light curing. Only 18% of the participants in the study had already used bulk-fill composites, and only 21% considered changing the light-curing technique for this type of material.

Good polymerization also requires that the light-curing unit have an adequate level of irradiance. Despite the importance of this factor, more than 80% of the dentists did not know how to determine the correct irradiance for effective polymerization, although more than 50% of them said that they considered this characteristic when buying their unit. It is difficult to determine ideal irradiance, particularly because methacrylate polymerization does not follow the reciprocity law – the proportion of polymerization and total light dose – and other factors may affect this process.[31] Besides irradiance, the homogeneity of the emitted light spectrum and the photoactivation time also have great relevance in achieving an adequate depth of cure.[32,33] In this study, mean depth of cure was 3.1 mm and 3.3 mm for public services and private offices, without any difference between places. This is deeper than the 2 mm depth necessary for the incremental technique, but lower than the 4-5 mm recommended for the bulk-fill technique. The manufacturer of the composite used in this study recommends its use in increments of up to 4 mm, but only 10% of the photoactivation procedures reached this depth, and only 40% reached 3.6 mm or more. Photoactivation time was weakly correlated with depth of cure, which indicates that the quality of light-curing units (irradiance and emission homogeneity) may be a major factor in the low effectiveness of polymerization found in this study.

The results of this study revealed that the adoption of bulk-fill composites in clinical practice, both in public services and private offices, should be combined with the use of the best light-curing units. Moreover, dental care professionals have to be educated to improve their knowledge about these materials and about photopolymerization. One of the limitations of this study was that it did not describe irradiance and emission spectrum of the light sources, factors that might explain the deficiency of the light-curing units used in a large number of dental offices.

CONCLUSION

This study found that this sample of dentists working in public services and private offices in Aracajú, Brazil, had little information about light-curing units and bulk-fill composites and, therefore, used different light-curing protocols and obtained mean depths of cure below the minimum recommended for bulk-fill composites.

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