Journal of Dentistry 58 (2017) 67–73

Contents lists available at ScienceDirect

Journal of Dentistry

journal homepage: www.intl.elsevierhealth.com/journals/jden

Light curing procedures – performance, knowledge level and safety awareness among dentists

S.E. Kopperud, H.V. Rukke, H.M. Kopperud, E.M. Bruzell*

Nordic Institute of Dental Materials (NIOM), Norway

ARTICLE INFO

Article history:
Received 1 December 2016
Received in revised form 19 January 2017
Accepted 4 February 2017

Keywords:
Dental curing lights
Maximum permissible exposure time
Visible light
Dental restoration
Resin composite

ABSTRACT

Objectives: This study aimed to investigate dentists' exposure to curing light and to obtain information about the dentists' knowledge on practical use and technical features of their curing lights as well as their safety awareness.
Methods: A pre-coded questionnaire was sent electronically to all dentists (n = 1313) in the Public Dental Service (PDS) in Norway in 2015.
Results: The Response rate was 55.8%. The dentists spent on average 57.5% of their working days placing restorations, ranging from 1 to 30 (mean 7.7, SD 3.6) restorations per day. The average length of light curing one normal layer of composite was 27 s. The longest individual mean curing time per day was about 100 times higher than that of the lowest. The mean curing time for lamps of the lower reported irradiances was similar to the time representing exceedance of international guidelines for limit values for blue light to the eyes. Almost one-third of the dentists used inadequate eye protection against blue light. The odds of using adequate eye protection were significantly higher among young dentists ($p < 0.01$). The majority of the respondents (78.3%) were unaware of the irradiance value of their curing lights, thus rendering the curing time uncertain. More dentists in this group did not perform regular maintenance of their curing lights compared with all respondents (17.1% vs. 3.3%, $p < 0.01$).
Conclusions: This study revealed considerable variations among Norwegian dentists in the Public Dental Service with respect to performance of light curing of restorations, safety awareness and technical knowledge of the curing light.
Clinical significance: The questionnaire study identifies specific knowledge gaps among Norwegian dentists with regard to curing lights and use of personal protection. Today's dependence on technology in dentistry necessitates that the operator possesses knowledge of essential technical specifications and safe use of devices and instruments routinely used in dental treatment.

1. Introduction

In many parts of the world, dental amalgam is being phased out and replaced by adhesive materials in restorative treatment of dental caries [1–6]. Most adhesive materials found on the market today contain photoinitiators that require absorption of optical radiation in the wavelength range ~350–500 nm to set. Light emitting diode (LED)-based curing lights are the most used light sources. The emission peak for these dental LED lights is in the blue/blue-green range (430–490 nm), and some curing lights emit a second peak around 400 nm, i.e. in the transition between ultraviolet (UV) and visible radiation. Both UV- and visible radiation may induce biological hazards. The light emission, radiant flux [7], being transmitted from the output area of the curing device has the quantity irradiance [7]. The unit of irradiance is watts (W) per square metre (m^2), frequently expressed as milliwatts per square centimetre (mW/cm^2). The quantity radiant exposure [7], popularly expressed as "light dose" or "energy output", is the product of irradiance and exposure (curing) time with the unit (milli-)joules per m^2 (cm^2), ((m)J/cm^2). A typical radiant exposure range required to sufficiently cure a layer of composite polymer is reported to be about 8–50 J/cm^2 [8–10]. The radiant exposure required is dependent on material characteristics. Recommended irradiance by educational institutions and manufacturers of curing lights and restorative materials may vary from about 300 mW/cm^2 to more than 2000 mW/cm^2, with corresponding recommended curing times in the range 100 s to <5 s. Theoretically, these values can give light doses outside the

* Corresponding author at: Nordic Institute of Dental Materials (NIOM), Sognsveien 70a, NO–0855 Oslo, Norway.
E-mail addresses: s.e.kopperud@niom.no (S.E. Kopperud), ebr@niom.no (E.M. Bruzell).

http://dx.doi.org/10.1016/j.jdent.2017.02.002

required range for adequate curing. Thus, decision on the duration of curing time requires knowledge of the irradiance level.

Blue light, such as that emitted from curing lights, can cause eye damage [11,12]. The risk is dependent on lamp emission and radiative geometry, exposure time, the degree to which light is reflected as well as the use of adequate eye protection [13]. Limit values for exposure of blue light to the eyes are provided by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) [11]. When these guidelines are applied to the reflected light from today's curing lights, the limit value denoted "maximum permissible exposure time" (t_{max}) [11] can theoretically be exceeded after 5 min of exposure during a workday [13]. In modern dental practice, safety concerns are crucial to avoid work injury. Nevertheless, in a survey among Norwegian dentists in 2009, one-third of all dentists reported that they refrained from using any personal eye protection when light curing restorations [14].

With respect to patient safety and radiation protection principles, dentists should optimise the curing procedure. Too long exposure may cause thermal damage to the pulp and other tissues exposed to the light [15]. For example if, unintentionally, higher irradiance than usual is applied while keeping the curing time constant, thermal injury may be induced in the patient's oral tissues. Contrary, applying too low irradiance or too short curing time can cause inadequate curing of restorations [16] leading to possible early restoration failures and/or monomer leakage [17]. Low irradiance may be caused by scratches, spots or remains of restorative material on the light output area [18]. Further, although LEDs are generally regarded as stable and long-lasting compared to halogen lamps, the irradiance of LEDs may decrease over time due to e.g. technical failure or battery drain [19]. Thus, all curing lights require regular maintenance and monitoring to control that the irradiance is relatively stable.

The current investigation was part of a larger survey which aimed to evaluate dentists' treatment choices in operative dentistry [20]. One aim of the present study was to assess Norwegian dentists' exposure to curing light and whether any curing procedures lead to exposure times exceeding radiation limit values. Another aim was to obtain information about the dentists' knowledge about practical use and technical features of their curing lights, routines for maintenance and use of personal eye protection when light curing restorations.

2. Material and methods

2.1. Questionnaire

A pre-coded questionnaire (Supplementary material) was sent electronically to all dentists (n = 1313) employed in the Public Dental Service (PDS) in Norway in February 2015, using the Internet-based software Questback (Oslo, Norway). The questionnaire software was configured to automatically send reminders to all participants who did not reply within 2, 10 and 14 weeks. Information was collected on the respondents' age, gender, clinic size, rural or urban work site, and to which extent the respondents were using restorative materials on a daily basis. The participants were asked questions related to light curing of dental restorations, such as average time of light curing a normal layer (defined here as ≤2 mm) of resin composite and the average number of restorations placed during a working day. Furthermore, questions were asked about the survey participants' use of eye protection when light curing, their knowledge of age and irradiance of their light curing unit, routines for maintenance of the device and which curing time recommendations they followed.

2.2. Ethical considerations

Participation was voluntary, and no remuneration was given to the respondents. Anonymity of the participants was ensured by Questback. The study was registered with The Norwegian Data Protection Authority (ID: 70269).

2.3. Estimations

Curing times data were divided into four ranges (8–19 s (n = 30); 20–29 s (n = 275); 30–39 s (n = 87); 40–60 s (n = 153)). Radiant

Table 1
Associations between selected variables and the odds of the dentist using adequate eye protection when light curing restorations. The results are calculated using logistic regression analyses. Unadjusted results were obtained by performing separate regression analyses for each selected variable. Adjusted results were obtained by including all the selected variables in one regression analysis. Thus, in the adjusted analysis the result for each variable is adjusted for all the other variables listed in Table 1.

		UNADJUSTED			ADJUSTED		
	% (n)	OR	95 % CI	P–value	OR	95 % CI	P–value
Dentist's age (years)							
52–75	24.4 (174)						
39–51	25.0 (178)	1.63	1.05–2.53	0.03	1.41	0.86–2.29	0.17
32–38	24.1 (172)	2.47	1.55–3.94	<0.01	2.07	1.24–3.47	0.01
25–31	26.1 (189)	2.72	1.71–4.31	<0.01	2.26	1.34–3.83	<0.01
Dentist's gender							
Male	30.4 (217)						
Female	69.6 (496)	1.81	1.29–2.55	0.00	1.42	0.96–2.12	0.08
Size of dental clinic							
1–3 dentists	45.8 (326)						
>3 dentists	54.2 (387)	1.36	0.98–1.88	0.06	1.17	0.78–1.76	0.44
Work site							
Rural	36.3 (259)						
Urban	63.7 (454)	1.44	1.03–2.01	0.03	1.42	0.94–2.16	0.09
Age of curing light (years)							
Do not know	23.6 (168)						
New (1–5 yrs)	55.5 (377)	0.64	0.42–0.97	0.03	0.83	0.53–1.31	0.42
Old (>5 yrs)	16.3 (168)	0.65	0.38–1.11	0.11	0.85	0.48–1.49	0.56
Irradiance of curing light (mW/cm^2)							
Do not know	78.3 (549)						
1000–1499	12.4 (87)	0.77	0.48–1.25	0.29	0.88	0.53–1.48	0.64
1500–1999	4.9 (34)	0.92	0.43–1.98	0.84	1.06	0.47–2.39	0.88
≥2000	4.4 (31)	0.81	0.37–0.59	0.59	1.02	0.43–2.42	0.96