A new approach for curing light activated oral biomaterials

Dental composite depth of cure with halogen and blue light emitting diode technology R W Mills, K D Jandt, S H Ashworth Br Dent J 1999; 186: 388-391

Objectives
To test the hypothesis that a blue light emitting diode (LED) light curing unit (LCU) can produce an equal dental composite depth of cure to a halogen LCU adjusted to give an irradiance of 300 $mWcm^{-2}$ and to characterise the LCU's light outputs.

Materials and methods
Depth of cure for three popular composites was determined using a penetrometer. The Student's *t* test was used to analyse the depth of cure results. A power meter and a spectrometer measured the light output.

Results
The spectral distribution of the LCUs differed strongly. The irradiance for the LED and halogen LCUs were 290 $mWcm^{-2}$ and 455 $mWcm^{-2}$, when calculated from the scientific power meter measurements. The LED LCU cured all three dental composites to a significantly greater ($P < 0.05$) depth than the halogen LCU.

Conclusions
An LED LCU with an irradiance 64% of a halogen LCU achieved a significantly greater depth of cure. The LCU's spectral distribution of emitted light should be considered in addition to irradiance as a performance indicator. LED LCUs may have a potential for use in dental practice because their performance does not significantly reduce with time as do conventional halogen LCUs.

In brief

- A new technological approach for curing light activated oral biomaterials is presented. The new light curing unit (LCU) is based on blue light emitting diodes (LED).
- The main potential benefits of LED LCU technology are: long lifetime of LED LCU (several thousand hours), no filters or cooling fan required, virtually no decrease of light output over lifetime with resulting consistent and high quality of material curing.
- Simple depth of cure experiments of dental composites cured with LED technology show promising results.

Comment

It is generally accepted that the properties and clinical performance of visible-light activated resin-based materials is related to their extent of cure. Research has shown that the extent of cure of dental composites is most affected by factors under the control of the clinician, such as composite thickness, duration of light exposure and light source intensity.[1] A minimal level of irradiance of blue light necessary to produce acceptable cure has been identified,[2] and there are many ways to achieve and exceed this minimal level. Conventional halogen bulbs, argon lasers and xenon arc lights are currently used in clinical practice. This study describes another approach employing a collection of blue light emitting diodes. The new curing light claims the following benefits over existing halogen bulb systems: significantly longer bulb life, consistent light output over time, filterless operation, and minimal heat buildup.

In this paper, a light curing unit composed of 25 blue LEDs was compared with a conventional halogen light curing unit in terms of its ability to cure three different dental composites. The irradiance of both curing units was measured accurately with a power meter, and their spectral outputs were evaluated with an imaging spectrograph. Depth of cure was evaluated using a penetrometer.

This study showed that the light emitting diode system produced slightly greater depth of cure for each composite despite having only 70% of the irradiance of the halogen source. An important distinction made in this work is that the output of these light sources differ and that this has a large effect on curing efficiency. The authors explain that the LED system is more efficient for curing composites because it has higher irradiance at the wavelengths over which the camphoroquinone initiator molecule absorbs in the visible spectrum. Previous work has shown that depth of cure and degree of conversion in composites is dependent upon total light exposure, as represented by the product of light intensity and irradiation time.[3] However, as the current study clearly shows, this is only true for a given light source because it does not account for differences in spectral output.

As the authors correctly point out, there are many other factors that must be addressed to determine the clinical efficacy of this new light curing method. A few of note are the extent of cure as measured by IR spectroscopy, mechanical properties, wear, cost, and durabilty. However, the listed advantages coupled with the data presented in this study provide strong justification to continue the development of blue light emitting diode curing units for dentistry.

1 Rueggeberg F A. A predictive model for the polymerization of photo-activated resin composites. *Int J Prosthodont* 1994; 7: 159-166.
2 Shortall A, Harrington E. Guidelines for the selection, use, and maintenance of visible light activation units. *Br Dent J* 1996; **181**: 383-387.
3 Nomoto R, Uchida K, Hirasawa T. Effect of light intensity on polymerization of light-cured composite resins. *Dent Mater J* 1994; **13**: 198-205.

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What reference doses should we use?

Reference doses for dental radiography I D Napier Br Dent J 1999; 186: 392-396

Objective
To establish reference doses for use within dental radiography.

Design
Retrospective analysis, single centre.

Setting
UK General Dental Practice, 1995–1998.

Method
A statistical analysis was performed on the results from NRPB evaluations of dental x-ray equipment within general practice. The third quartile patient entrance dose was determined from 6,344 assessments of intra-oral x-ray equipment. The third quartile dose-width product was determined from 387 assessments of panoramic x-ray equipment.

Results
The third quartile patient entrance dose for an adult mandibular molar intra-oral radiograph is 3.9 mGy. The third quartile dose-width product for a standard adult panoramic radiograph is 66.7 mGy mm.

Conclusion
NRPB recommends the adoption of reference doses of 4 mGy for an adult mandibular molar intra-oral radiograph and 65 mGy mm for a standard adult panoramic radiograph. These reference values can be used as a guide to accepted clinical practice. Where radiography is carried out using doses above these reference values, a thorough review of radiographic practice should be made to either improve techniques, or justify keeping the current techniques. However, attainment of doses at or below the reference values cannot be construed as achievement of optimum performance; further dose reductions below the reference value are still practicable.

In brief

- A wide variation is observed in patient doses from dental radiography. This indicates a significant potential for dose reduction.
- The concept of a reference dose is a useful aid to help identify where action is most urgently needed.
- Reference doses of 4 mGy (patient entrance dose) for an adult mandibular molar intra-oral radiograph and 65 mGy mm (dose-width product) for a standard adult panoramic radiograph are recommended.

Comment

Many dental practitioners would find it helpful to know that their radiation protection measures are effective and to see how typical radiation doses delivered in their surgeries compare with national patterns. Napier presents the results of an analysis of the patient entrance doses for two commonly taken dental projections, and enables the practitioner to make this comparison. His extensive data has been gathered from the x-ray equipment postal pack surveys offered by the NRPB's Dental X-Ray Protection Service.

Dental radiographs account for around 25% of all radiological investigations undertaken in the UK, making them one of the most common radiographic examinations.[1] Although dental radiographs contribute only a small amount to the collective radiation dose of the UK population, when such high numbers of radiographs are involved there is always scope for dose reduction.

There are two approaches to dose reduction; by reducing the numbers of radiographs taken and by reducing dosages from individual radiographs. The Royal College of Radiologists, taking the former approach, published guidelines for doctors on prescribing radiographic investigations,[2] which set out to reduce the number of unnecessary and unproductive examinations. Recently similar guidelines on selection criteria in dental radiography have been published by the Faculty of General Dental Practitioners,[3] suggesting timing and indications for dental radiographs in a variety of clinical situations. Both publications categorise recommendations by the level of evidence that exists thus making these, as far as possible, evidence-based.

Dose reduction represents the alternative approach. Both legislation and published guidelines have addressed this issue.[1,4,5] Despite the existence of these, this paper usefully highlights the fact that there is still wide variation in the doses received by patients undergoing similar dental radiographic examinations. Dose measurement is a complex area. Skin entrance doses measured here are a simple measure of the radiation reaching the patient but give an indication of the radiobiological harm. Napier is justified in suggesting that some doses — which may be as much as 13 times higher than the average — should be brought into line with those to which most patients are exposed. This is not only a problem in dentistry — the NRPB have identified a similar problem in general x-ray departments. Here they have recommended the introduction of 'reference doses' for common examinations,[6] suggesting dose reduction targets at or below this level.

Napier extends the concept of 'reference doses' to dental radiography, and, as elsewhere, sets this at the third quartile. Thus 75% of practitioners already deliver less that the reference dose. It is primarily the 25% who expose patients to doses in excess of this (and he shows that some are far in excess of this) that are recommended to implement urgent dose control. A further target, the 'achievable dose', is set at the mean national dose.

The aim of a reference dose is to set thresholds above which immediate action is needed to reduce the dose. Practitioners producing exposures below the reference dose should now be looking at how they may continue to work toward doses as low as reasonably practicable.

1. National Radiological Protection Board/Royal College of Radiologists. *Guidelines on radiology standards for primary dental care.* Doc. NRPB Vol 5, No 3, 1994 .
2. Royal College of Radiologists. *Making the best use of a department of clinical radiology. Guidelines for doctors.* 4th ed, 1998.
3. Faculty of General Dental Practitioners (UK). *Selection criteria for dental radiography*. 1998.
4. *The Ionising Radiations Regulations 1985.*
5. *The Ionising Radiation (Protection of persons undergoing medical examination or treatment) Regulations 1988.*
6. *'Guidelines on patient dose to promote the optimisation of protection for diagnostic medical exposures.'* Report of an Advisory Group on Ionising Radiation. Doc. NRPB Vol 10, No 1, 1999.

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Is tooth decay in 5-year-olds related to fluoridation and social deprivation?

The relationship between water fluoridation and socioeconomic deprivation on tooth decay in 5-year-old children
C M Jones and H Worthington Br Dent J 1999; 186: 397-400

Aim
To examine the relationship between water fluoridation, socioeconomic deprivation and tooth decay in 5-year-olds.

Setting
10,004 children: 1,051 in naturally fluoridated Hartlepool in 1991/92, 3,816 in fluoridated Newcastle & North Tyneside and 5,137 in non-fluoridated Salford & Trafford in 1993/94.

Outcome measures
Correlations between mean electoral ward dmft and ward Townsend Scores from the 1991 census.

Results
Regardless of the level of water fluoridation significant correlations were found between deprivation and tooth decay. Multiple linear regression models for dmft showed a statistically significant interaction between ward Townsend score, and both types of water fluoridation, confirming the more deprived the area the greater the reduction in tooth decay. At a Townsend score of zero (the English average) there was a predicted 43% reduction in decay in 5-year-olds in fluoridated areas.

Conclusions
Tooth decay is strongly associated with social deprivation. The findings confirm that the implementation of water fluoridation has halved tooth decay in 5-year-old children and that the dental caries divide between rich and poor is reduced.

In brief

- Dental caries in 5-year-old children is strongly associated with poverty.
- Water fluoridation produced a 43% reduction in dmft in England in 1993/94.
- Water fluoridation reduces dental caries more effectively in areas of social deprivation and so reduces dental health inequalities.

Comment

This elegant ecological statistical study demonstrates yet again, if further evidence were needed, the effectiveness of water fluoridation. It also confirms, at electoral ward level, the link between dental decay and social deprivation, and the greater reduction in dental decay produced by fluoridation in socially deprived communities. Similar evidence led the Acheson Report to recommend fluoridation as one of the most effective interventions to reduce inequalities in health.[1]

The authors correlate previous survey results with the Townsend score of wards, which is a more appropriate indication of social deprivation than the Jarman scores used in earlier studies. It is encouraging to those far seeing individuals in BASCD who promoted standardised comparable surveys, and those who carry out and co-ordinate these surveys[2] to see the results used to contribute to the scientific evidence base for dental public health policy making.

Five-year-old children in non-fluoridated areas have nearly twice as much tooth decay as those who benefit from water fluoridation. The authors state that water fluoridation is a well accepted public health measure, but one has to ask, by whom? As they point out, few of the British population currently benefit from fluoridation, and no new fluoridation schemes have been introduced since the *Water (Fluoridation) Act* of 1985. The opponents of fluoridation have managed, with a diligence and commitment that all members of the dental team would do well to emulate, to exert an influence out of all proportion to their numbers. The Consumers' Union of the USA published a report on the fluoridation controversy over 20 years ago and concluded that 'the survival of this fake controversy represents, in the Consumers' Union's opinion, one of the major triumphs of quackery over science in our generation'.[3]

The publication of this paper is very timely as we await the *Healthier Nation White Paper* from a government committed to reducing inequalities in health. Will they propose an amendment to the legislation, which the Minister for Public Health has described as a mess, and which a judicial review has found to be ineffective? Will they find yet another reason to delay the implementation of the one dental public health strategy which has been demonstrated to reduce inequalities in dental health?

1 *Independent Inquiry Into Inequalities In Health Report.* Sir Donald Acheson (Chair). DoH, 1998.
2 Pitts N B, Evans D J, Nugent Z J. The dental caries experience of 5-year-old children in the United Kingdom. Surveys co-ordinated by the British Association for the Study of Community Dentistry in 1997/8. *Community Dent Health* 1990; **16**: 50-56.
3 Consumers Union of the United States. *Consumer reports: A two-part report on fluoridation. Part I: The cancer scare, Part II: The misleading claims.* New York, Consumers Union, 1978.

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