J Clin Periodontol 2004; 31: 77–78
Printed in Denmark. All rights reserved

Journal of Clinical Periodontology

Short Communication

Does cavitation occur around powered toothbrushes?

S. C. Lea[1], G. J. Price[2], and A. D. Walmsley[1]

[1]School of Dentistry, The University of Birmingham, St Chad's Queensway, Birmingham, UK and [2]Department of Chemistry, University of Bath, Bath, UK

Lea SC, Price GJ, Walmsley AD: Does cavitation occur around powered toothbrushes? J Clin Periodontol 2004; 31: 77–78. © Blackwell Munksgaard, 2004.

Abstract

Aims/objectives: The aim of this investigation was to determine if cavitational activity occurred around powered toothbrushes using a chemical dosimeter system based on terephthalic acid (TA).

Material and Methods: Five powered toothbrushes were used in this investigation: Braun Plaque Remover D8, Braun Oral-B 3D, Philips Jordan Sensiflex HX2520, Sonicare PS-1 and Sonicare Elite HX 7351/02. Each brush head was inserted into a conical flask containing 50 cm^3 of aqueous TA solution. Brushes were operated for 10 and 20 min and a cuvette of the solution was placed in a fluorescence spectrometer (Perkin Elmer 3000). The fluorescence emitted at wavelength 425 nm, which is proportional to $^{\bullet}OH$ radical concentration, was monitored.

Results: Any cavitational activity that may have been produced by the powered toothbrushes was below the limit of detection of the system ($< 10^{-8}$ M) for the timescales investigated.

Conclusions: This work has demonstrated that cavitational activity does not occur around powered toothbrushes. Operating the toothbrushes for periods up to 20 min resulted in no cavitational activity being detected.

Key words: cavitation; powered toothbrushes; terephthalate dosimeter

Accepted for publication 22 September 2003

Powered toothbrushes operate at frequencies between 62.5 and 262.5 Hz (Lea et al. 2003a). The primary cleaning action of these instruments is attributed to the vibratory motion of the bristles. It has been stated that the high-frequency bristle oscillations generate cavitational activity, which aids the removal of plaque from tooth surfaces (Engel et al. 1993, O'Beirne et al. 1996).

During cavitational bubble collapse, hydroxyl ($^{\bullet}OH$) radicals are formed due to the high energies generated (Price et al. 1997). The terephthalate dosimeter is a system that measures $^{\bullet}OH$ radical yield (Price et al. 1997). The system uses an aqueous solution of terephthalic acid (TA), which on reaction with $^{\bullet}OH$ radicals forms 2-hydroxyterephthalate and is readily detectable using fluorescence spectroscopy (Price et al. 1997).

The terephthalate dosimeter has recently been shown to be an effective tool for assessing the cavitation produced around dental ultrasonic scalers (Lea et al. 2003b). The aim of this investigation was to determine if cavitation occurred around powered toothbrushes using the terephthalate dosimeter.

Material and Methods

Five commercially available powered toothbrushes were used in this investigation (Fig. 1) including Braun Plaque Remover D8 and Braun Oral-B 3D Excel (Braun Oral-B, South Boston, MA, USA), Philips Jordan Sensiflex HX2520 (Philips Jordan, Veldhoven, The Netherlands), Sonicare PS-1 (Philips Oral Healthcare Inc., Snoqualmie, WA, USA) and Sonicare Elite HX 7351/02 (Philips Oral Healthcare Inc., Snoqualmie, WA, USA).

A solution of TA was prepared (Price et al. 1997). A toothbrush was inserted into a conical flask containing 50 cm^3 of aqueous TA solution, such that the head of the brush was completely submerged. The toothbrush was operated for 10 min and then removed. From the conical flask, 3.5 cm^3 of solution was pipetted into a cuvette, which was placed in a fluorescence spectrometer (Perkin Elmer 3000; Perkin Elmer, Beaconsfield, UK) at an excitation wavelength of 325 nm and monitoring the fluorescence emission at 425 nm.

The solution was then replaced in the conical flask. The toothbrush was reinserted into the solution and the procedure was repeated for a further 10 min (20 min total). From the conical flask, 3.5 cm^3 of solution was again pipetted into the cuvette and placed in the fluorescence spectrometer to monitor the fluorescence emission at 425 nm. The process was repeated for each of the toothbrushes.

The fluorescence detected is proportional to the concentration of $^{\bullet}OH$ radicals produced as a result of cavitation. Prior to each measurement, the spectrometer was zeroed using a cuvette of unsonicated TA solution. As a positive control, a TFI-3 ultrasonic scaler insert (Dentsply Preventive Care,

Fig. 1. Powered toothbrushes investigated in this study including Sonicare Elite HX 7351/02, Sonicare PS-1, Philips Jordan Sensiflex HX2520, Braun Plaque Remover D8 and Braun Oral-B 3D excel.

York, PA, USA) was operated at a high generator power setting, with its tip in a cuvette of TA solution, for 1 min.

Results

Any cavitation that might have been produced by the powered toothbrushes was below the limit of detection of the experimental system ($<10^{-8}$ M) for both 10 and 20 min of operation.

Cavitational activity was shown to occur around the TFI-3 scaler tip, which produced a mean $^{\bullet}$OH radical concentration of 0.47×10^{-6} mol/l.

Discussion and Conclusion

Powered toothbrushes have vibration frequencies of up to 262.5 Hz (Lea et al. 2003a). Although the destructive properties of cavitation are normally observed at ultrasonic frequencies, some researchers claim that cavitational activity occurs around sonic toothbrushes (Engel et al. 1993, O'Beirne et al. 1996). Other research has maintained a more skeptical view about the contribution of cavitation to the cleaning process (Khambay & Walmsley 1995, Walmsley 1997).

It has been suggested that the high-frequency bristle motion of sonic toothbrushes in a fluid environment generates an alternating pressure field producing what is referred to less specifically as ''dynamic fluid activity'' and ''acoustic effect'' (Blanco et al. 1997). Such phrases are used by toothbrush manufacturers in their advertising literature (Sonicare Elite Website 2003, Oral B Website 2003).

Using the terephthalate dosimeter, this work has demonstrated that chemical reactions resulting from cavitational activity do not occur to any significant extent around the commercially available powered toothbrushes investigated here. To ensure that the system was working correctly, measurements were performed on a TFI-3 ultrasonic scaler insert, around which cavitational activity was readily detected. Operating the toothbrushes for periods up to 20 min resulted in no radical activity being detected.

Acknowledgment

This project was funded by EPSRC Grant No. GR/R82050/01.

References

Blanco, V. L., Cobb, C. M., Williams, K. B. & Manch-Citron, J. N. (1997) In vitro effect of the Sensonic toothbrush on *Treponema denticola*. *Journal of Clinical Periodontology* **24,** 318–323.

Engel, D., Nessly, M., Morton, T. & Martin, R. (1993) Safety testing of a new electronic toothbrush. *Journal of Periodontology* **64,** 941–946.

Khambay, B. S. & Walmsley, A. D. (1995) An in vitro evaluation of electric toothbrushes. *Quintessence International* **26,** 841–848.

Lea, S. C., Landini, G. & Walmsley, A. D. A novel method for the evaluation of powered toothbrush oscillation characteristics. *American Journal of Dentistry* (in press).

Lea, S. C., Price, G. J. & Walmsley, A. D. (2003b) A study to determine whether cavitation occurs around dental ultrasonic scaling instruments. *Ultrasonics Sonochemistry* (in press).

O'Beirne, G., Johnson, R. H., Persson, G. R. & Spektor, M. D. (1996) Efficacy of a sonic toothbrush on inflammation and probing depth in adult periodontitis. *Journal of Periodontology* **67,** 900–908.

Oral B Website accessed (16/07/03) via http://www.oralb.com/pdfs/B8_d15.pdf [Research performed by Guerrero, D. M. et al. (1999) Effect of a powered toothbrush on in vitro bacterial plaque. *Journal of Dental Research* **78,** 414.]

Price, G. J., Duck, F. A., Digby, M., Holland, W. & Berryman, T. (1997) Measurement of radical production as a result of cavitation in medical ultrasound fields. *Ultrasonics Sonochemistry* **4,** 165–171.

Sonicare Website accessed (16/07/2003) via http://sonicare.com/elite/clinical.asp.

Walmsley, A. D. (1997) The electric toothbrush: a review. *British Dental Journal* **182,** 209–218.

Address:
S. C. Lea
School of Dentistry
The University of Birmingham
St Chad's Queensway
Birmingham B4 6NN
UK
Fax: +44 121 625 8815
E-mail: s.lea@bham.ac.uk