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Effects of enamel and dentine thickness on laser doppler blood-flow signals recorded from the underlying pulp cavity in human teeth *in vitro*

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ARTICLE INFO

Article history:
Accepted 11 August 2013

Keywords:
Laser Doppler flow metre
Pulpal blood flow
Pulpal perfusion

ABSTRACT

Objective: To determine the effect of enamel and dentine thickness on laser Doppler blood-flow (LDF) signals recorded from dental pulp.
Design: Observations were made on 18 human premolars that had been extracted from young patients during orthodontic treatment. The apical 2/3 of the root was cut off and the remaining pulp removed. Blood flow signals were recorded from the buccal surface of the crown with a laser Doppler flow metre while dilute blood was pumped at 10 ml/min. through a cannula inserted into the pulp cavity. Recordings were made from the enamel surface and at 0.5 mm steps through the enamel and dentine.
Results: The blood flow signal increased significantly as the cavity depth increased and at 2.0 mm, the median flux signal was more than ten times greater than that obtained on the enamel surface. The backscattered light intensity did not change with cavity depth.
Conclusion: When recording pulpal blood flow from a human tooth with a laser Doppler flow metre, a substantially better signal-to-noise ratio should be obtained by placing the probe on dentine in the floor of a cavity than on the enamel surface.

1. Introduction

Laser Doppler flow-metres (LDF) have been used in many studies to record pulpal blood-flow from human teeth.[1] This method has the advantage over alternative techniques of recording pulpal blood-flow that recordings can be made non-invasively from intact teeth[2]; but the records obtained from intact teeth are not derived exclusively from the pulp and include contributions from tissues outside the tooth, such as the gingiva and periodontal ligament. The contribution of these non-pulpal tissues can be reduced by covering the adjacent gingiva with rubber dam[3] or periodontal paste[4]; but even with opaque rubber dam, only approximately 43% of the LDF signal recorded from the crown of an intact anterior tooth is due to blood-flow in the pulp.[3] Without dam, the corresponding figure is 10%.

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0003–9969/$ – see front matter
http://dx.doi.org/10.1016/j.archoralbio.2013.08.007

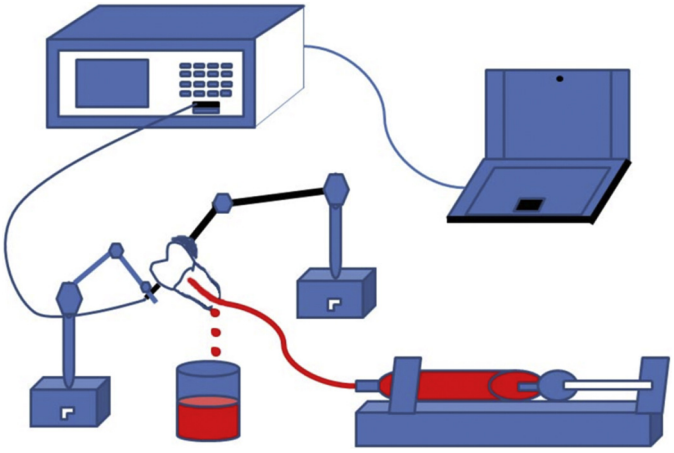

Fig. 1 – Diagram of the experimental set-up showing a tooth supported on a metal rod with a nylon cannula inserted into its pulp cavity. Diluted blood was pumped through the cannula and recordings of the flux of red cells made with a laser Doppler flow metre. The flow metre probe was clamped in contact with the buccal surface of the tooth. The flow metre output was recorded with a computer.

Furthermore, in order to detect blood-flow in the pulp of an intact tooth with a probe on the surface of the enamel, laser Doppler flow metres often have to be used near the limit of their resolution and the signal-to-noise ratio is poor.[3,5] The fact that it is possible to detect blood flow through such a large amount of tissue appears to be due to the optical properties of the dentine.[2,6]

In the present experiments, we have investigated the possible advantages of making the recordings from exposed dentine instead of the enamel surface, when the amount of tissue intervening between the laser probe and the pulp will be less and the LDF signal should be stronger, as appears to be the case in experimental animals.[2]

2. Materials and methods

Observations were made on eighteen extracted human premolars from 18 patients aged 12–20 years. The teeth were extracted as a part of orthodontic treatment. They were collected from the Department of Oral Surgery, Faculty of Dentistry, Chiang Mai University or from private clinics. The study was approved by the Human Experimentation Committee of the Faculty of Dentistry of Chiang Mai University, and complied with the principles of the Declaration of Helsinki. After extraction, the teeth were cleaned and stored in normal saline solution at 5 °C.

All specimens were prepared in the same way. The apical two thirds of each root was cut off with a slow-speed diamond disc. The remaining pulp was removed with a barbed broach through the opening in the root canal. The crown was fixed with self-curing acrylic resin to a stainless steel rod which was supported on a magnetic base (Fig. 1). The pulp chamber was filled with normal saline solution and a nylon cannula (ext. diam. 0.75 mm, int. diam. 0.51 mm) was inserted into the root canal and advanced as far as it would go into the coronal pulp cavity. This was connected to a motorized syringe and perfused at a flow rate of 10 ml/min with dilute, heparinised, human blood. The dilute blood flowed back over the outside of the cannula and dropped from the opening in the root canal, from which it was collected and recycled. The blood was withdraw from one of the authors and diluted to a final concentration of 1.0% v/v with heparinised normal saline.

Blood-flow recordings were made with a Laser Doppler flow-metre (Moor type MBF3D/42, Moor Instruments, Axminster, U.K.; wavelength, 780–820 nm). The probe (ext. diam. 1.5 mm, with two, 0.2 mm diam. optical fibres 0.5 mm apart at the tip) was held in a clamp and was placed initially with its tip in contact with the enamel surface about 2 mm from the cement-enamel junction, and with its long axis at right angles to the enamel surface over the central long axis of the crown. LDF signals were recorded from this position on the enamel surface and then from the floor of a cavity prepared at the same site as enamel and dentine were removed in steps of 0.5 mm until the pulp chamber was reached. The cavity was prepared with a slow speed, cylindrical, diamond bur under watered coolant. At each stage, before recordings were made, the cavity was cleaned and rinsed with normal saline solution and mopped dry with a cotton pellet.

Three sets of measurements were made at each level through the tooth, both with the pump switched on and off. For each set, the mean of the three values of the flux signal representing blood flow (in arbitrary perfusion units, PU), and the corresponding figure for the DC value representing the backscattered light intensity (in arbitrary units, AU) were determined. To correct for the effect of noise in the recording system and the flux signal not being zero when there was no flow,[2] each mean flux value obtained with the pump switched on was corrected by subtracting the corresponding figure obtained with the pump switched off. Data were collected using the Moorsoft® program.

At the end of the experiment, all specimens were sectioned longitudinally with a diamond disc and the thickness of enamel and dentine adjacent to the recording site was measured using callipers with a Vernier scale.