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The effect of direct and alternating electrical currents on the vessel walls of the tooth pulp — TEM studies

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Devices which operate on the basis of electrical charges are increasingly being used in stomatology, such as in cariology for the detection of invisible caries lesions or for the measurement of canal lengths during patient treatment. The majority of these devices now emit a current of alternating frequency. The aim of the work was to explain how the electrical devices of labile frequency commonly used in stomatology influence the vessels of the tooth pulp. Teeth extracted for orthodontic reasons were investigated with the use of a transmission electron microscope. The teeth were treated with current emitted by a specially constructed device. The control group comprised 4 teeth. No changes were found in the electron microscopic studies in the slides of the teeth treated with low charges of current. However, in the specimen treated with current charges of 9600 μC or more flattened endotheliocytes were found together with exudation in the vessel lumen. Cases are referred to in which the duration of the work was 2 or 3 times longer than normal and in which a current of constant intensity was emitted uninterruptedly.

Key words: vessels, tooth pulp, TEM, alternating electrical current, erythrocytes

INTRODUCTION

The expanding possibilities for the use of low intensity electrical currents have given rise to need for a statement as to whether or not these currents damage the tissues of the teeth. Possible injuries to the cells may affect first of all the odontoblasts and the blood vessels. The formation of lesions depends on the current intensity and on the duration of its passage (thus on the electrical charge). Devices whose action is based on electrical charges are now increasingly being used in stomatology. In cariology Electronic Caries Monitors (ECM), in which the mean charge values are 50 μC, are employed for the detection of invisible caries lesions [4, 8]. Charges of 300 μC are used for the measurement of canal lengths with very helpful electronic apex locators. [6]. Another commonly used device is the pulp sensitivity tester. The results of the action of direct and alternating electrical currents on dental pulp with the use of a light microscope were presented in an earlier paper [1]. The aim of the work was to investigate how these electrical devices, commonly used in stomatology, influence the vessels of the tooth pulp.

MATERIAL AND METHODS

Teeth extracted (with the use of local anaesthesia) for orthodontic reasons in patients of 10–31 years old were investigated. For the studies 33 teeth

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were used: 9 molars and 8 premolars and 7 premolars and 5 molars for the alternating and direct current respectively. The anode of the apparatus was placed at the crown and the cathode was placed at the apex of the roots. A conductive medium (physiological saline) was applied at the surfaces of the electrodes to ensure proper contact. The remaining 4 teeth formed the control group. Currents of the following values were applied immediately after extraction of the teeth: 2000 μC, 5000 μC, 9600 μC, 54000 μC or 120000 μC. The teeth were cut and their pulps fixed in 2% glutardialdehyde in cacodylate buffer and then in 1% osmium tetroxide. After this they were dehydrated and embedded in epoxy resin (EPON 812 with DDSA and MNA) for electron microscopic studies. Semithin sections were made with the use of a Tesla BS 480 ultramicrotome and stained with buffered 1% toluidine blue. Ultrathin sections were cut in MTI ultramicrotome and contrasted with uranyl acetate and lead citrate. They were investigated and photographed in a JEOL electron microscope.

RESULTS AND DISCUSSION

No changes were found in the electron microscopic studies in the vessels in sections of the control group and in the teeth treated with the direct current (Fig. 1).

Low charges of alternating current also did not damage the walls of vessels. However, in the specimens treated with current charges of 9600 μC or more flattened endotheliocytes as well as exudation in the vessel lumen were found (Fig. 2). Apparatus for the diagnosis of caries lesions, electronic apex locators and devices for electroanaesthesia are therefore safe for the patients, while the values of current used for ionophoresis of fluoride or calcium ions are too high.

According to Jacobsen and Heyeraas [3] electrical tooth stimulation caused an increase in interstitial fluid pressure and pulp blood flow in 2 groups of ferrets tested: the control group and animals that had undergone sympathectomy 5 days before the experiments. The electrical stimulation did not change either variable in the axotomised animals. The authors concluded that the sensory nerves were responsible for the increased interstitial fluid pressure and pulp blood flow during stimulation.

Dentine permeability depends not only on histological factors (which are static in character), but also on the physiological processes in the endodontium which determine the values of the pressure in the tooth cavity and on the dynamic of the passage of dentinal fluid. The hydrostatic pressure of the dental cavity was 10–30 mm Hg. Passage of dental fluid could be delayed after the application of the anaesthesia with contractile agents [2, 5] to the lesion or to the pulp (but in these experiments this was not a significant issue).

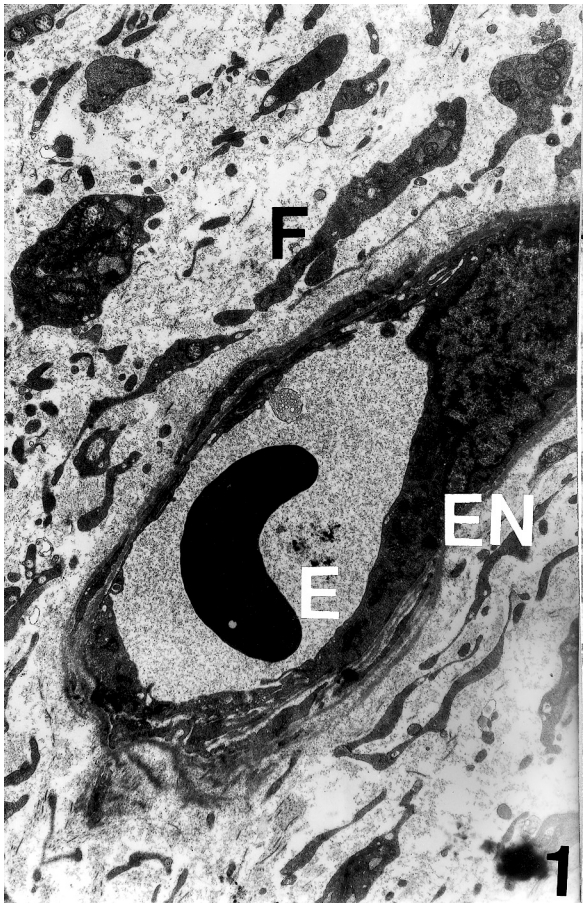

Figure 1. Ultrastructure of the capillary of control dental pulp E — erythrocyte; EN — endotheliocyte; F — fibrocytes (fragments). Magnification 3000 ×.

Sawa et al. [7] noticed that the significant morphological difference between the vessels of healthy and inflamed dental pulp was the width of the vascular lumen. In the healthy dental pulp the vascular lumina were mostly occluded whereas in the inflamed pulp they were expanded. Later in the discussion the authors conclude that this may be caused by the increased outflow of the tissue fluids. The same phenomenon applies to the subodontoblastic layer.

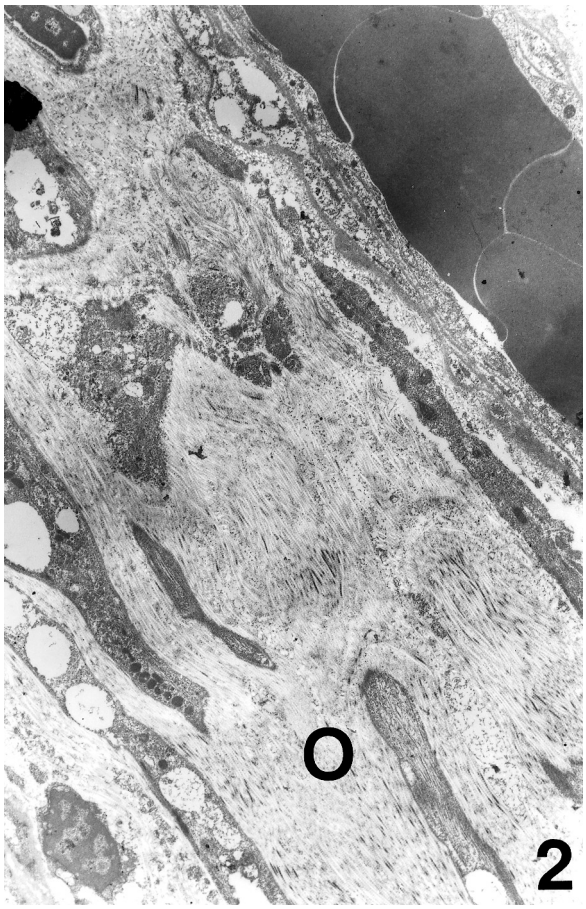

Figure 2. Alternating current of 9600 μC. Ultrastructural picture of erythrocytes filling the dental pulp capillary; O — oedema in the perivascular connective tissue. Magnification 3000 ×.

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