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Bioelectrochemistry
Bioelectrochemistry 72 (2008) 41 – 46
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# Magnetic fields of 10mT and 120mT change cell shape and structure of F-actins of periodontal ligament cells

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Received 7 July 2007; received in revised form 28 October 2007; accepted 16 November 2007
Available online 24 November 2007

## Abstract

Dental magnetic attachments, usually applied locally to oral cavities, produce stray fields (flux leakage) spreading in adjacent tissues. It has been found that human periodontal ligament (PDL) cells change their geometry and the structure of their cytoskeleton F-actins when the cell cultures are exposed to $B$-field strengths of $B$ = 10mT and 120mT, respectively, which are similar to those generated by dental magnetic attachments. Analytically, after long-time exposures to $B$-fields for 12h, 36h and 60h, respectively, cytoskeleton F-actins are labeled with a fluorescent dye and observed under a laser scanning confocal microscope. The geometrical cell parameters of cell length and cell width and the fluorescence emission of labeled F-actins, respectively, were determined and subjected to an automatic image analysis using a special software. The results on cell shrinkage and filament reorganizations were statistically analyzed by the program ANOVA ($P < 0.05$). It was found that only long-time (hours) exposure to high fields in the order of 0.1T may produce tissue irritations during long-time medical treatments using open- and closed-field dental magnetic attachments.


*Keywords:* Magnetic dental attachment; Static magnetic $B$-fields; Periodontal ligament cell; Cytoskeleton; Confocal fluorescence microscopy

## 1. Introduction

There is appreciable continuous public concern on potential health hazards from technical electromagnetic field (EMF) radiations experienced in daily life of our civilization. The targets of concern are the high voltage power transmission lines, industrial machines, household appliances, communication equipments and medical electromagnetic instruments, including NMR devices, in the diagnosis and during treatment of diseases [1–4].

Specifically, magnetic fields are also used in clinical prosthodontics. Several types of dental magnetic attachments have been applied to aid the retention of prosthesis with claimed "favorable effects" [5]. Dental magnetic attachments utilize the static magnetic field generated by strong permanent magnets to aid the retention and stability of dentures. Early magnetic attachments are of the open-field type and have relatively small retentive forces. The most frequently used magnetic attachments are of the closed-field type, which are composed of $Nd_2Fe_{14}B$ magnets with "yokes and keepers" of soft magnetic alloy.

In 1979, Wertheimer and Leeper reported that children resided near transmission lines had 2 to 3 times higher risk of cancer occurrences [6]. Their report revived appreciable attentions on potential biological effects of even small magnetic fields and small exposure time. There are many reports and claims on beneficial effects as well as negative EMF effects on all kinds of biological materials [7–10]. Many of the claims of biological effects of magnetic $B$-fields are hardly biophysically rationalizable and are thus controversially discussed [11–25].

In the context of medical $B$-field treatments, both the open-field and the closed-field dental magnetic attachments produce stray fields, called flux leakages, spreading to the adjacent tissues, for instance, when locally used in the oral cavity [5,26].

Presently there are few reports about the biological effects of $B$-fields generated by magnetic attachments on human tissues

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doi:10.1016/j.bioelechem.2007.11.009

and, in vitro, on cell cultures. We previously reported that *B*-fields, similar in intensity to those generated by dental magnetic attachments, lead to changes in the cell morphology and proliferation of human periodontal ligament (PDL) cells [27]. These *B*-fields obviously affect the cytoskeleton filaments, which are known as key components in maintaining the overall shape of cells [11,28,29].

The present study reports that *B*-fields and long exposure time cause cell shrinkage and structural reorganizations of the cytoskeleton F-actins in human PDL cells. The applied fields are comparable to those generated by dental magnetic attachments.

## 2. Materials and methods

### *2.1. Cell culture*

Human PDL cells were isolated from the ligament tissues of a periodontally healthy, non-carious human tooth extracted for orthodontic reason from one donor (14-year-old male) with informed consent. The cells were maintained and expanded in Dulbecco's Modified Eagle's Medium (DMEM, Gibco, Grand Island, NY, USA) supplemented with 10% fetal bovine serum (FBS, Hyclone Laboratories, Logan, UT, USA) and antibiotics (100U $ml^{-1}$ penicillin, 100μg $ml^{-1}$ streptomycin). PDL cells were used in these experiments at passage 5 to 6.

### *2.2. Magnetic exposure*

A cellular *B*-field exposure system utilizing arrays of Nd2Fe14B permanent magnets has been developed by the authors. It consists of 5 components: array of permanent magnets, pedestal, loading platform, vernier scale and magnetic shield (Fig. 1).

Cell culture dishes were placed on the loading platform above the magnetic array and cells cultured on the dishes were exposed the *B*-fields. The distance between the loading platform and the array was adjustable. Because the *B*-fields around magnets decrease with distance from the surfaces of the magnets [30], the *B*-field strength is adjusted via altering the height of the loading platform. Based on previous results, obtained with two commonly used commercial magnetic attachments (Magfit EX600W and Magnedisc 800, Aichi steel Co. Ltd, Japan) [26], the specifications of $B$ = 10mT and $B$ = 120mT were selected, to simulate the conditions of the closed-field and the open-field magnetic attachments, respectively.

Human PDL cells were plated on 60mm culture dishes at a concentration of $2 \times 10^5$ cells/dish and cultured in a $CO_2$ incubator (Model MCO-15AC, Sanyo electric Co. Ltd, Japan) at 37°C in a humidified 5% $CO_2$ atmosphere. After 3days of cultivation, PDL cells were exposed to $B$ = 10mT and to $B$ = 120mT, respectively, each for 12h, 36h and 60h, respectively, 12h per day; the exposure system is located in the $CO_2$ incubator. The mode of 12h exposure per day is to simulate the clinical situation of magnetic attachment denture, which is worn by patients only during day time. Control cells were cultured outside of the exposure system in the $CO_2$ incubator at 37°C in a humidified 5% $CO_2$ atmosphere and were exposed to geomagnetic fields in the range of $0.03 \leq B/\text{mT} \leq 0.07$, as measured with a digital Teslameter (Model 7010, F.W.Bell, USA).

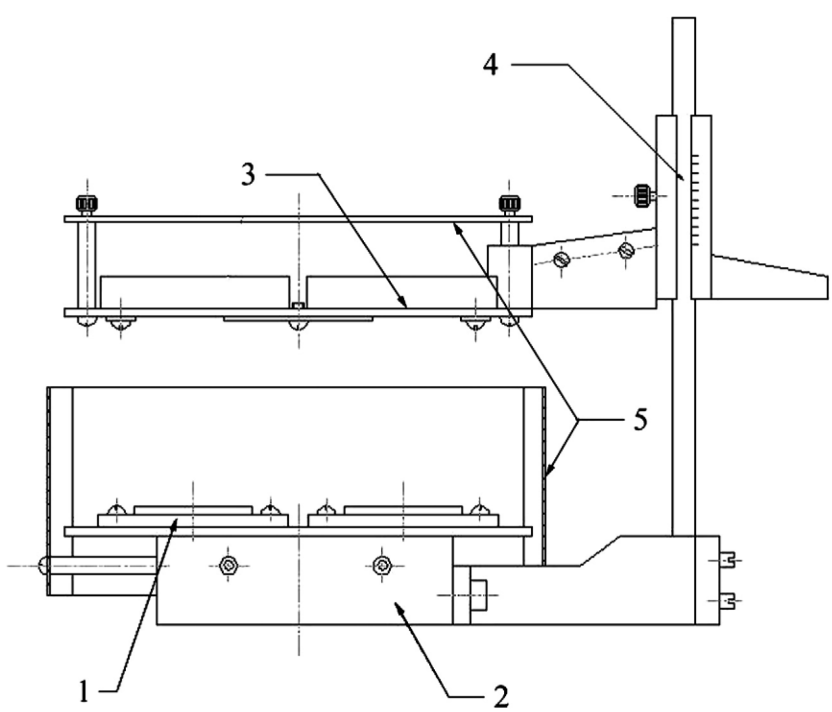


Fig. 1. Sketch map of the structure of the B-field exposure system. 1: array of the permanent magnets, 2: pedestal, 3: loading platform, 4: vernier scale, 5: magnetic shield.