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Electromagnetic interference of endodontic equipments with cardiovascular implantable electronic device

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ABSTRACT

Objectives: Assess the electromagnetic interference (EMI) of endodontic equipment with cardiovascular implantable electronic devices (CIEDs) and related factors.
Methods: The laser device, electronic apex locators (EAL), optical microscope, endodontic rotary motors, gutta-percha heat carrier (GH), gutta-percha gun and ultrasonic device were tested next to CIEDs (Medtronic and Biotronik) with varied sensitivity settings and distances. CIEDs were immersed in a saline solution to simulate the electrical resistence of the human body. The endodontic equipment was tested in both horizontal and vertical positions in relation to the components of the CIED. The tests were performed on a dental chair in order to assess the cumulative effect of electromagnetic fields.
Results: It was found no EMI with the Biotronik pacemaker. EALs caused EMI with Medtronic PM at a 2 cm distance, with the NSK® EAL also affecting the Medtronic defibrillator. GH caused EMI at 2 cm and 5 cm from the Medtronic defibrillator. EMI occurred when devices were horizontally positioned to the CIED. In the majority of the cases, EMI occurred when the pacemaker was set to maximum sensitivity. There was cumulative effect of electromagnetic fields between GH and dental chair.
Conclusions: EALs and GH caused EMI which ranged according to type and sensitivity setting of the CIEDs and the distance. However, no endodontic equipment caused permanent damage to the CIED. The use of GH caused a cumulative effect of electromagnetic fields. It suggests that during the treatment of patients with CIEDs, only the necessary equipments should be kept turned on.
Clinical relevance: Patients with CIEDs may be subject to EMI from electronic equipment used in dental offices, as they remain turned on throughout the treatment. This is the first article assessing the cumulative effect of electromagnetic fields.

1. Introduction

Pacemakers (PMs) and implantable cardioverter defibrillators (ICDs) are cardiovascular implantable electronic devices (CIEDs). CIEDs consist of two main parts: a generator and an electrode. The generator is hermetically sealed by a titanium casing that houses an electronic system that produces the electronic pulses stimulating the heart in order to regulate its pace. The lead detects the heart's pulse and transmits this to the generator and vice-versa [1].

The function of these cardiac devices can be disrupted by the electromagnetic waves emitted by electronic devices, an effect referred to as electromagnetic interference (EMI) [2]. The today's CIEDs are generally well shielded against this interference, since they are in a hermetically sealed casing, and have filters, rejection circuits, and bipolar modes [3]. However, despite these features, apparatuses such as magnetic resonance imaging and ionizing radiation devices should be avoided in a medical setting [4].

In dentistry, there is a long list of electronic equipment capable of interfering with a CIED's functioning. Some studies have shown no EMI from an amalgamator, [5] piezoelectric ultrasonic device

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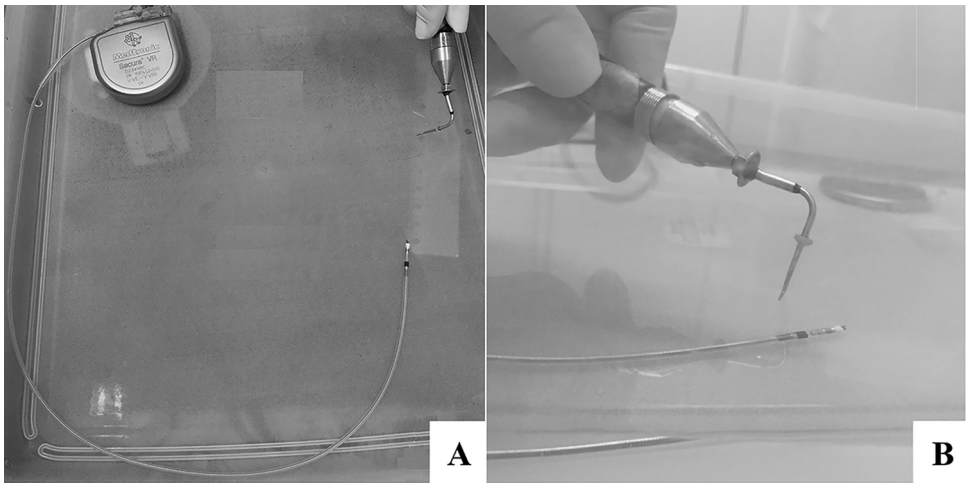

Fig. 1. Approximation of the gutta-percha heat carrier handpiece to the Medtronic ICD. Horizontal (A) and vertical (B) position.

[6], dental chair [7] or handpiece [5], whereas diathermy units [8] and ultrasonic cleaners [5,7] were found to cause such interference. Results regarding other equipments, such as electric scalpel [5,7] and light-curing unit [5,7,9], remain controversial, possibly owing to the different brands of dental equipments tested and variations in the type and sensitivity setting of CIEDs.

In endodontics, the literature is controversial regarding the effect of electric pulp test [5,7–10] and apex locators [11–15], whereas some equipment such as rotary motors [9,15], gutta-percha heat carrier [9,6] and gutta-percha gun [9] remain understudied and others had never been investigated, such as laser devices and optical microscope. Moreover, the occurrence of EMI depends on the characteristics of the CIED, such as brand, type of stimulation and polarity[1,17].

Lakshmanadoss et al [18] reported that EMI emitted from multiple sources in the same environment simultaneously can have greater than expected combined effects. However, as far as we are concerned, there is no study assessing this issue, even though there is a wide range of equipment in the dental office which are often turned on at the same time.

Therefore, the aim of this *in vitro* study was to carry out an assessment of the EMI from endodontic equipment with CIEDs, including related factors (e.g., cumulative effect of different electromagnetic fields), and to evaluate whether the proximity of an endodontic equipment towards the CIED increases the occurrence of such interference.

2. Materials and methods

This *in vitro* study was based on the simulation and stimulation model of Luker [8] and Miller et al [7], but with modifications [6,12]. It consists of a plastic container containing 1.5 L of saline solution whose electrical resistance was adjusted to 400–800 ohms, thus simulating that of the human body. The CIEDs (Table 1) were immersed in the solution and the resistance was maintained by adding sodium chloride or distilled water. The electrodes (Biotronik® Setrox S 53) of the dual chamber devices were placed at a distance of 20 cm (atrial electrode) and 30 cm (ventricular electrode) from the generator, to simulate the position of the CIED in the body. The electrode of the single chamber device was placed at a distance of 20 cm from the generator.

A cardiologist, specialist on the monitoring and controlling of the heart rate stimulation, monitored the CIEDs and analyzed the results on a telemetry device (Biotronik® ICS 3000, Medtronic CareLink® 2090), with the telemetry's head being placed below the container positioned under the generator. The telemetry device also measured the electrical resistance of the solution.

The container with saline solution and the devices were placed on a dental chair (B-Safe®, Dabi Altlante). A total of 12 different brands of dental equipment used in endodontic treatment were tested (Table 2). Of these, the X-SmartPlus®, Easy® and VDW® rotary motors were tested at continuous rotary and reciprocating motions; the ultrasonic device was used at its maximum power. Only one operator performed all the tests.

Table 1
Characteristics of CIEDs tested.

CIED			Electrode type	Stimulation type	Sensitivity (mV[a])	
Type	Brand	Model			Maximum	Minimum
Pacemaker	Medtronic (Minnesota, USA)	Adapta ADR	Unipolar	Atrio-ventricular	0.5–1	1–2.5
			Bipolar	Atrio-ventricular	0.18–1	1–2.5
	Biotronik (Berlin, Germany)	Entovis	Unipolar	Ventricular	Auto	2.5
				Atrial	Auto	1
			Bipolar	Ventricular	Auto	2.5
				Atrial	Auto	1
Defibrillator	Medtronic (Minnesota, USA)	Secura VR	Bipolar	Atrial	0.15	1.2

[a] mV: millivolts.