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Measurement of Magnetic Field in Dentistry

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ABSTRACT

The principal objective was to measure the magnetic fields occurring in dental surgeries at simultaneous subtraction of direct ground component of the magnetic field. A specifically designed instrument with the Hall probe was used for the measurement. It consisted of two amplifiers and a low frequency filter. Its task was to measure mean square values of the field (RMS) dependent on the position in space. Qualitative and quantitative analyses of the investigated variables enabled making conclusions about the magnetic fields in dental surgeries. A number of studies have shown that many dental instruments produce radiation with magnetic field higher than 40 G, at a significant decrease in power of the magnetic field with increasing distance from the source. It has also been reported that instruments of older generations produce stronger magnetic fields than do the new ones.

Introduction

The effects of magnetic radiation on humans and other biological entities have been the subject of many studies for more than two thousand years. During the history of human civilisation many discoveries have been connected with magnets and magnetic field that have contributed to our knowledge about the Earth and its magnetism, to explanations of many natural phenomena, to development of navigation and other scientific disciplines, even to studies of electromagnetic field in bio-medicine, dentistry in particular[1–6]. These studies have provided evidence for both desirable and undesirable effects of magnet and magnetic field. A visionary and investigative approach of many teams of exquisite scien-

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tists served the efforts to single out and make use of all positive effects of magnetism on man and his environment and to minimise and reduce or completely remove all negative effects[7–12]. The data about measurements, values and use of magnet in dentistry are still scarce and show many dilemmas yet to be resolved, to which, we hope, this paper will contribute. For lack of evidence in reference literature it is not yet possible to make a comparative study of the obtained results.

Material and Methods

The research instrument used to measure the power of magnetic field was of our own design. It measures the magnetic field by the Hall sensor that is powered with 5 to 10 V and is integrated in one chip together with pre-amplifier. The Hall sensor is placed in a specifically designed aluminium holder so that it could be brought close to inconveniently positioned objects of measurement. The sensor output is differential (Q1–Q2) and proportionate to measurement values of magnetic induction B. As the values of alternate fields in a laboratory setting are small (the level of micro-Tesla, μT), the differential output voltage (Q1–Q2) should be increased for about 100 times. This is achieved by the amplifier A1 with reverse resistance of R2 = 100 R1. Since the amplifier has direct offset error it needs to be compensated at resistance points R' and R'' by selecting the voltage between V+ and V– using appropriate potentiometer Rz. As the smallest direct magnetic field of the Earth, of about 10 μT induction is constantly present in the space it is important that this and all other possible direct fields be excluded from measurements of alternate fields. It is achieved by A2 amplifier that functions as a filter. Filtering of direct signals is carried out by Ro-Co circle at inverted amplifier input. If direct field is to be measured the Co capacitor is bridged over by S switch.

At the A2 amplifier output the signal, although increased, is still alternate and inappropriate for measurement within the instrument, either analogue or digital. Therefore integration of signal in A3 amplifier is needed through R4 resistance and Rx–Cx parallel reverse resistance in A3 amplifier. In order for the signal to be stabilised it has to be additionally processed through D diode in C1 capacitor. The instrument is supplied by 220 V power source through a converter with ±10 V output power.

Our study samples consisted of instruments currently available at dental surgeries:

A halogen type lamp is a relatively strong source or electromagnetic radiation produced by the transformers that provide power to the bulb. The transformers convert the voltage up to the level of 115 Volts, which produces strong radiating field. The lamp itself is a significant source of radiation due to strong pulsating currents produced in emission space.

The main part of the amalgam mixer is a synchronous motor with adjustable number of rotations, which, as a rule, is a powerful source of radiation, although in modern mixers the problem has already been solved. Rotation speed, approximating the radiation frequency, ranges between 3000 and 4000 rotations per minute.

The sources of magnetic field produced by micro-motors are the electromagnets that start them. Although electromagnets are the source of relatively small magnetic field acting at small distances, during operation they act upon dental surgeons with their maximum field. Hence it was considered necessary for the electromagnets to be separately tested.

Dental chair produces the largest source of radiation at the point of its connection to electrical power system, which may also be the site for silencers, transformers and older versions of fuses. It is important to note that the most modern types of dental chairs do not emit electromagnetic radiation that might be defined in other dental chairs by highly sensitive gauss-meter.

First, the instrument for the measurement of magnetic field was calibrated in the way that the ground magnetic field and magnetic field of disturbances caused by different conductors were annulled. Then the spot was defined with the greatest magnetic field power. The obtained value was designated as the initial point of measurement of magnetic field produced by the investigated instrument. After that the measuring instrument was moved away from the initial point by 5 cm, and the measurements were repeated for as long as the null value of magnetic field power for the investigated instrument was obtained.

Results and Conclusions

By specifically designed instrument and the described methods of measurement the values indicating relations between the power of magnetic field and the distance between the investigated objects were obtained (micro-motors, dental chairs, halogen lamps, dental lamps and amalgam mixers).

Relations between the power of magnetic field expressed in gauss and the distance from the source of radiation was investigated in four types of micro-motors (MIKR 1, 2, 3 and 4), and in four types of dental chairs (MAS 1, 2, 3 and 4).

The obtained data were analysed by simple statistical regression method and for that purpose the data were transformed from the exponential model into the linear one that is appropriate for regression analysis that enables the calculation of magnetic field values at any point in the space. Deviations are relatively small for which reason the regression model describes the obtained data in a satisfactory manner. By adding the de-

TABLE 1
ARRANGEMENT OF INSTRUMENTS ON THE BASIS OF RADIATION AMOUNT AND ITS SPREAD

No.	Code	A. Coeff.	B. Coeff.
1	LMP2	5.748320	1.493910
2	MAS3	4.952120	0.906100
3	MAS2	4.810890	0.864800
4	SLP2	2.473500	0.648500
5	MIKR1	2.413400	0.646000
6	MAS1	2.278830	0.575800
7	LMP4	1.399410	0.370600
8	LMP1	1.259650	0.371700
9	MZG1	1.250660	0.252200
10	LMP3	1.216900	0.390800
11	MIKR3	1.106720	0.457900
12	SLP1	1.105500	0.283300
13	MIKR4	0.746700	0.452700
14	MIKR2	0.698500	0.199700
15	MAS4	0.655600	0.267500
16	LMP5	0.616700	0.292800

TABLE 2
AVERAGE REGRESSION EQUATIONS OF THE TESTED GROUPS OF INSTRUMENTS

	A. coeff	B. coeff	Variance	Standard deviation
Dental machines	3.174360	0.653550	0.043304	0.204690
Dental lamps	2.139930	0.468425	0.021913	0.113775
Micro motors	1.323323	0.439075	0.023530	0.147975
Polymerisiing lamps	2.048196	0.583962	0.006815	0.071090
Silamat	1.250660	0.252200	0.002110	0.045930

terminant coefficient to the description it becomes obvious that the regression equation explains 95% and more of the obtained data.

The tested instruments were arranged on the basis of magnetic field power and its spreading in the environment.

Table 1 shows the rank of the tested instruments on the basis of initial amount of radiation and its spread. The average value (arithmetic mean) of regression equation may thus be calculated and it serves to define the average amount of radiation that the dental surgeon and the patient in dental surgery are exposed to.

Radiation square root value (GAUSS) = 1.987294–0.479442 (distance in cm); $y = 1.987294–0.479442x$.

The method of average regression equation for individual groups of instruments of the same function in dental surgery indicate the arithmetic mean of the power of magnetic field by which the tested instruments act on human subjects.

The average regression equations for the groups of instruments are presented in Table 2. Each equation was obtained by average arithmetic mean for the equation of instruments tested in our study.

Table 3 shows the values of average radiation of dental instruments in a dental surgery at a given distance from the source.

TABLE 3
AVERAGE VALUES OF RADIATION IN DENTAL SURGERY (X = DISTANCE OF A PERSON FROM RADIATION SOURCE; Y = AMOUNT OF RADIATION EXPRESSED IN GRAYS AT THAT DISTANCE)

X	Y
0	3.949336
5	0.837642
10	0.221995
15	0.017010
20	0.000000

The following conclusions are made on the basis of our study results and their statistical analysis:

- The power of magnetic field decreases with increasing distance from the source.
- Magnetic field spreads through space in ISOTROPIC manner.
- The investigated instruments produce negligible effects on dental staff and their patients.
- The instruments producing stronger magnetic field are located far enough from persons on whom they act, so that the activity of this specific magnetic field decreases with distance and is reduced to the values we are exposed to in our daily surroundings.
- The instruments that the dental staff is in direct contact with are relatively mild sources of magnetic field and they

do not differ from objects we are surrounded by on a regular daily basis.

- The newly designed and produced instruments act on their environment by smaller magnetic fields.
- The greatest frequency obtained at the smallest distance was 100 kH.
- The sensitivity of measurement instrument was 0.0001 μT
- The majority of instruments produce magnetic field radiation higher than 40 G.

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MJERENJE MAGNETSKOG POLJA U STOMATOLOGIJI

SAŽETAK

Svrha je rada bila izmjeriti magnetska polja u stomatološkim ordinacijama uz istodobno oduzimanje istosmjerne komponente magnetskog polja zemlje. U mjerenju je korišten aparat s Hallovom probom posebno konstruiran za tu namjenu, koji se sastoji od dva pojačala i niskofrekventnog filtera. Zadaća je uređaja da izmjeri srednje kvadrate vrijednosti polja /RMS/ u zavisnosti od položaja u prostoru. Kvalitativne i kvantitativne analize istraživanih varijabli omogućuju stvaranje zaključaka o magnetskim poljima u stomatološkim ordinacijama. Istraživanja su pokazala da neke aparature zrače magnetskim poljem većim od 40 G uz izrazito smanjivanje jakosti magnetskog polja udaljavanjem od izvora. Zapaženo je također da aparature starije proizvodnje stvaraju jače magnetsko polje od novijih aparatura.