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THE BIOLOGICAL EFFECTS OF IMPLANTED MAGNETIC FIELDS PART II. MAMMALIAN TISSUES

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Introduction

There have been few reports in the literature on the effects of magnetic fields generated by implanted magnets on mammalian tissues and cells. Such reports (Toto et. al., 1962) are unanimous in their conclusions that implanted magnetic fields are biologically harmless. The tissues examined were limited to those immediately surrounding the magnetic implants (dermal, osseous, fibrous). The magnetic fields generated by magnets for intra-oral use in dentistry would be expected to extend to other tissues including the brain and glands around the mouth.

General biomagnetic studies performed on mammals have shown a variety of effects, often damaging, on different mammalian tissues. These studies differed from magnetic implant studies in that the study animal was itself placed within a magnetic field much larger than the earth's magnetic field of 0.05 milliteslas*. The harmful effects demonstrated by such studies included the following:

1. Retarded wound healing. Gross and Smith (1964) found that a strong magnetic field (3,000 milliteslas) markedly delayed fibroblast proliferation and wound healing in mice.
2. Damage to internal organs and the endocrine system. Barnothy and Sumegi (1969) found that strong magnetic fields of 4,200 milliteslas could damage the zona fasciculata of adrenal glands, the bone marrow, the liver and the spleen of mice after four days of continuous exposure.
3. Damage to brain tissue. Kholodov et. al. (1969) showed that static magnetic fields of 300 milliteslas could increase the number of astrocytes in the sensomotor area of the cerebral cortex of a rabbit after a one hour exposure.
4. Transformation of mammalian cells. Malinin et. al. (1976) found that strong magnetic fields of 5,000 milliteslas for four to eight hours would induce morphological and physiological transformations of target cells.

These unusual tissue effects are as yet unexplained and indicate the need for a more thorough investigation of the tissues and cells which would lie within the active magnetic field radius of any magnetic material used in or about the mouth. The recent development of new super permanent magnetic alloys of cobalt and rare earth elements with properties applicable to prosthetic dentistry and orthodontics (Cerny 1978, 1979), prompted the need for further investigations into the biological effects of implanted magnets.

The purpose of this study was to determine what effects the magnetic fields from implanted cobalt-samarium (Co_5Sm) magnets have on the following tissues:

1. Dermal 2. Osseous 3. Brain 4. Glandular 5. Muscular

* Millitesla — unit of magnetic field strength

Materials and methods

The 36 adult S.D. (Sprague-Dawley) albino rats used for analysing mammalian blood cells (Cerny, 1979) were also used for this study. All materials were the same and the method differed only after sacrifice of the rats.

Immediately after sacrifice, the rats were weighed and the implants were located and surgically removed together with the surrounding tissues for histological analysis. Some macroscopic observations were recorded on photographic slides. The tissue specimens were placed in 10% buffered formalin solution for fixation. Histological slides were prepared for analysis, all sections were stained with haematoxylin and eosin and brain tissue specimens were also stained with Hortega's and Mallory's P.T.A.H. for astrocyte analysis, to check on the possibility of cerebral gliosis.

Results

During the term of these experiments, the rats were cared for and observed on a daily basis by the author. At no time was there any noticeable difference in the behaviour patterns or physical well-being amongst or within the different groups of rats. Some rats from the groups engaged in supervised breeding. Breeding from their progeny was also carried out. The breeding programme resulted in two generations of healthy rats with no detectable abnormalities. Out of the initial 36 rats, 20% of the control rats died whereas 23% of the magnet group rats died. The causes of death varied from malignant lesions to cannibalism. There was no pattern which suggested that the magnetic fields were responsible.

Upon sacrifice, there was no significant difference in the average weight of the rats between the control and magnets groups. Of the 81 implants inserted at the beginning of the experiment 11 (13%) were not recovered. These were presumed to have migrated out of the tissues shortly after implantation. Macroscopic observations of the tissues around the implants showed no abnormalities or differences of note between the magnet and control groups. The implants were usually encapsulated in a thin fibrous capsule which was often transparent. The degree of encapsulation depended upon the implant site and not the magnetic quality. Subcutaneous implants had thin fibrous capsules whereas intra-peritoneal implants were contained in larger fibrous fatty capsules.

There was a noticeable decrease in the magnetic energy of the implant magnets which had been in tissues for six months or more. The gold foil did not prevent contact between the implants and the tissue fluids and marked corrosion of the cobalt samarium alloy occurred whether magnetized or non-magnetized. There were eight non-coated magnet implants of cobalt-samarium which showed little tissue irritation when recovered after three and a half months of implantation. Experimental details have been tabulated in Table 1.

The independant pathologists who examined the tissue specimens and slides could find no harmful effects attributable to the magnetism in any of the tissues examined. However, microscopic analysis is not considered to be a conclusive means of showing that no tissue damage had occurred. Electron microscopic analysis of the fine cellular structures is necessary to confirm the microscopic conclusions.

Discussion

The results of this study show that magnetic fields from implanted cobalt-samarium magnets of the order of 95 milliteslas or less, had no observable harmful effects on

Table 1. Summary of the types and number of implants inserted and recovered, survival, weight at sacrifice and sites of tissue samples for histological analysis from the rats used in this experiment.

GROUP		RAT NUMBER	NUMBER OF IMPLANTS	DIED	WEIGHT AT SACRIFICE	NUMBER OF IMPLANTS RECOVERED	TISSUE SAMPLES OBTAINED: Skin Bone Brain	Peritoneal	Gonad	Sub-Mandib Gland	Others
A		1	3	√							
		2	3		405	2	√	√			
	M	3	3		510	3	√	√	√		
MAGNETIC		4	3		447	3	√		√√		
Co_5Sm		5	3		370	3	√	√√			
	F	6	3		375	1	√				
		7	3		285	3	√	√√			Abdominal Muscle
		8	3		270	3	√	√√			
NON MAGNETIC		9	3		440	2	√		√		
CONTROL	M	10	3		492	3	√	√	√		
Co_5Sm	F	11	3		330	3	√	√√			Fat
		12	3		295	3	√	√√			
ALLOY	M	13	3	√							
		14	3		482	3	√	√	√		
	F	15	3		311	3	√	√√			
		16	3		297	3	√	√√			Abdominal Muscle
B		17	3	√							
	M	18	3	√							
MAGNETIC		19	3		450	2	√	√			
Co_5Sm		20	3	√							
	F	21	3		348	2	√	√			
		22	3		305	NIL					
C		23	4*		392	4*				√√	Abdominal Muscle
		24	2		296	2				√√	
	M	25	2		432						
MAGNETIC		26	2		430	2				√√	
Co_5Sm		27	2		370	2				√√	
		28	2		452	2				√√	
		29	2	√							
		30	2	√							
	F	31	2		296	2				√√	
		32	2		230	2				√√	
		33	2		292	2				√√	
		34	4*		282	4*				√√	Abdominal Muscle
CONTROLS	M	35	2	√							
	F	36	2		291	2				√√	

the surrounding tissues or on the development and well-being of the rats. This supports other published works of a similar nature and suggests that if implanted magnetic fields are going to be biologically harmful, the field strengths must be of a higher intensity than those already used. The magnets used in this experiment were measured for their field intensity by the C.S.I.R.O.*

measurements laboratory in Sydney. The average magnetic field strength was 95 milliteslas at 1 mm distance from the magnet, at 2 mm the field strength was 40 milliteslas.

For general applications in dentistry, magnets of a similar size would be used either in or bonded to teeth and the distance between the magnetic fields and the nearest tissues is expected to be in excess of 1 mm. The magnetic fields extending to the brain, submandibular and parotid glands, and other tissues examined in this study would be weaker than those which have shown no apparent harmful effects. Further studies with larger and more powerful magnets are in progress to substantiate the findings of this study.

Conclusions

The implantation into mammalian tissues of powerful cobalt-samarium (Co_5Sm) magnets with a maximum flux density of 95 milliteslas produced no apparent harmful biological effects which could be attributed to the magnetic fields.

The cobalt-samarium magnets showed marked corrosion and magnetic energy decay due to contact with the tissue fluids. This indicates the need for encapsulation of the cobalt-samarium magnet alloy in a thin and biologically inert material which will isolate the cobalt-samarium from the tissue fluids and which will not interfere with its magnetic energy.

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* Commonwealth Scientific and Industrial Research Organization