Static Magnets and Wound Healing
- A Scientific Review-

By

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Abstract

To date there is only one double blind study in the scientific literature that has looked at the effects of static magnets in wound healing. Significant positive effects were described in this study. A case study is also published that reports favourable results. Electrical current has been demonstrated in many published trials to promote wound healing. This may be due to promotion of the so-called injury current that is generated rapidly at a wound site after injury. It is postulated that a similar beneficial effect may be achieved by static magnetic.
A recent systematic review has reported a significant trend towards static magnets being effective analgesics (Eccles, 2002) across a broad range of different types of pain. It is uncertain whether this effect is mediated by a change in circulation and/or an effect on ionic exchange and neuronal pain signalling. Generally however, these results taken together with all the evidence cited in this review indicate that static magnets have a significant and favourable interaction with human physiology.

There is much anecdotal evidence that static magnets can promote ulcer healing. The potential saving to the NHS in wound care expense and district nurse time if this proves to be the case in controlled trials, is enormous, not to mention the relief to the patients themselves. A double blind placebo controlled trial is currently underway to examine the effect of static magnets in ulcer healing; the results of which are expected before the end of 2003.

Literature

A search was performed of scientific journals from 1966 to September 2002 of the following databases: MEDLINE 1966 – 09/2002, EMBASE 1989 – 09/2002, LIFE SCIENCES 1990 – 09/2002, APPLIED & COMPLEMENTARY MEDICINE 1985 – 09/2002, SPORTS DISCUSSIONS 1830 – 09/2002. Search terms used were: *magnets, magnotherapy, ulcers, wounds, wound healing, healing, oedema, blood flow and circulation*. In addition Internet searches were performed in G*oogle* using the same terms. Original articles were obtained, and all references were scanned for further relevant articles.

Introduction

In the field of medicine as a whole there has been a recent surge in interest by patients and physicians alike in the use of magnetic fields in the treatment of pain. Attraction of the lay healer, the over promotion and unscientific approach to study and aggressive claims have led to scepticism. New controlled studies have begun to change this stance. In a recent scientific review (Eccles, 2002) of 12 double-blind placebo-controlled studies 7 out of the 8 well-controlled studies demonstrate a positive effect of static magnets in pain relief.

Although well-controlled studies have been performed on the stimulation of bone growth by electric and magnetic fields, effects of magnetic fields on soft tissues remain unclear; they represent the next frontier in electromagnetic biology and medicine. Electrical and magnetic field have been associated with a number of demonstrable effects that are advantageous to wound healing such as increased collagen deposition, increased fibroblast migration, increased migration of macrophages and leucocytes leading to decreased bacterial counts, reduced sympathetically-mediated vasoconstriction, increased cellular oxygen delivery and increased wound epithelialization (Man et al, 1999).

All electrical currents generate magnetic fields and all magnetic fields cause a change in electrical potential. *Therefore, an interaction of magnetic fields with ion fluxes across the cell membrane is very likely.*

Atoms are spinning magnets and therefore must interact with each other. It is logical to assume that magnetic fields can influence the charged state of biological systems (Adey, 1986). Living systems maintain magnetic profiles in the range of 10^{-7} Gauss to 10^{-12} Gauss. Faradays law states that a magnetic field will exert a force on a moving ionic current. Ionic currents across cell membranes are fundamental to maintenance of cellular integrity and cell communication. Ionic effects e.g. changes in ion binding have been described with magnetic fields as low as 0.1 to 1 microtesla (Muehsam & Pilla, 2000).

Healthy cells seem to have greater electrical charge than unhealthy cells (Owen, 1986). Cellular health and efficient function is to a large degree dependent on the maintenance of correct ionic gradients across the cell membrane. These ionic gradients are maintained by continuous inputs of energy. Most of the chemical energy of our body is used up to re-establish ion gradients, gradients that keep metabolic processes going, including signaling mechanisms. Important examples include Na/K transporters, which can either be antiporters, coupling the counter movement of Na and K ions across membranes, or symporters, moving Na^+ and K^+ synchronously and unidirectional to the same side of the membrane.

There is certainly evidence that electrical fields are a necessary component of amphibian limb regeneration (Borgens et al, 1977, 1979, 1979; Vanable et al, 1983). That electrical fluxes are important in healing in mammals is evident form studies on bone deformation. Compression of bone generates a negative electrical potential. Furthermore, the cells are responsive to alteration in externally applied DC electrical fields (Basset & Becker, 1962).

As long ago as 1792, Galvani observed that injured tissues generated small electrical currents. Becker measured these injury currents in bone and others have measured them in injured soft tissue (Wolcott et al, 1969).
Electrical stimulation has been used to facilitate wound healing for more than 30 years (Carey & Lepley, 1962). Two aspects of electric currents have potential to influence healing tissue 1) The ability of certain types of electric currents to attract oppositely charged particles and thus possibly enhancing the migration of cells like macrophages and fibroblasts. These effects are strongest when direct current is used (Wolcott et al, 1969). A current of injury is well described (Becker & Selden, 1985) that involves the flow of charged particles from uninjured to an injured site. Wounds failing to heal have been reported to display reduced levels of current of injury (Burr et al, 1938). As a wound heals the current of injury reduces as well. It is thought that externally-applied electrical currents are able to promote wound healing by augmenting the injury currents.2) Activation of cutaneous nerves may create a centrally-mediated increase in circulation (Kaada, 1982).

The greatest difficulty in evaluating efficacy of electrical current or electromagnetic stimulation for acceleration of wound healing is the variety of the parameters of the applied stimulation i.e. frequency, amplitude, signal shape, field gradients, duration of exposure etc. It is difficult to ascertain which parameters of the EM signal are responsible for the observed bio-effect. Of course with static magnetic fields there are less of these variables to consider.

The prevalence of active leg ulceration in the UK is 0.15-0.18% which represents 450 patients per health district of 250,000 population. There are estimated to be 100,000 ulcer patients in the UK. Seventy to 90% are venous in origin, 5-20% arterial, 10-15% combined and 5-10% due to other causes such as diabetes, vasculitis, neoplasm, infection, trauma etc. There is an increased prevalence with age so that the average of 1.5 to 1.8 per 1000 population rises to 3 per 1000 at age 61-70 and 20 per 1000 at age 80 and above. Nearly 1% of the population are affected by leg ulcers at some point in their lives. Over two thirds of leg ulcer sufferers have recurrence and a third have 4 or more episodes. Fifty percent of ulcers are open for 9-12 months, 20% are open for 2 years and 8% are open for more than 5 years. Sixty to 90% are managed in the community and this represents 8-22% of district nurse workload.
From an expenditure point of view it has been estimated that in the late 1980's £100-120 million a year was being spent on ulcer care although other estimates put the figure much higher than this at £600 million per year. These estimates amount to between £1100 and £5000 being spent on each patient per year. For comparison, in the USA the annual cost of wound care has been estimated to be $3 billion annually (National Institutes of Health release, Oct 2000).
Clearly, chronic ulceration is a problem and a major financial burden on the NHS.

The purpose of this review is to look at the existing evidence that a non-invasive approach using magnetic fields, and in particular static magnetic fields, can expedite wound healing. There is much anecdotal evidence to suggest that this is the case. There is an enormous potential saving to the NHS of a simple and yet effective adjunct treatment such as this to existing wound care.

The Main Trials

On review of the literature there was only one double blind study that has examined the effects of static magnets in wound healing and one published case history. These are outlined in detail below.

The main study was a double blind placebo controlled trial performed by Man et al in 1999 on 20 patients (aged 18 to 75) who underwent suction lipectomy surgery of various regions (abdomen, saddlebags, love handles and thighs) by the same surgeon and whose postoperative wound progress was investigated with and without static magnets.
Ten patients were assigned a placebo sham magnet to apply over their wound dressing and 10 were assigned to the test group with a live static magnet. Magnets varied in size from 5 x 15cm to 20 x 30cm and were square to rectangular in shape. Ceramic unidirectional magnets were used of field strength 150 to 450 gauss. The negative pole of the magnet was placed against the skin. In the control group sham patches were used which contained the same ceramic magnets with no power. The magnet or sham patches were applied immediately post-operatively and left on for 14 days. Wound pain, oedema and discolouration were assessed on days 1,2,3,4 and 7 and again after 14 days. All observations were made by the same-blinded observer. The patients, surgeon and observer were all blinded as to which devices were magnets and which were placebos. Discolouration was graded 0 – 10, oedema was also graded 0 – 10 and pain was assessed by way of a visual analogue scale. The following conclusions were made:

> **There was a statistically significant ($p<0.05$) reduction in pain between days 1 to 7 in the magnet group.** Pain scores were also less in the magnet group at day 14 but this difference was not statistically significant.
>
> There was a **37 to 65% reduction in pain levels** in the magnet group with a **reduction in the number of analgesics consumed compared to the control group.**
>
> **There was a statistically significant reduction in oedema ($p< 0.05$) by 40 to 53% in the magnet group compared with the control group on days 1 to 4.** There was also a reduction in oedema in the magnet group compared to the control group on days 4 to 14, but this difference did not reach statistical significance.
>
> **In the magnet group, a statistically significant ($p< 0.05$) decrease in discolouration occurred when compared with the control group on post-operative days 1,2 and 3.** The magnitude of reduction in discolouration was also clinically significant, ranging from 43% on post-operative day 1 to 28% on post-operative day 3. By post-operative days 4 to 14 there was no longer any significant difference in discolouration between the two groups.
>
> No side effects were observed in either group.
>
> The authors made the important comment that **in procedures in which significant bruising occurs, one would normally expect manifestations**

A Case Study

A case study was published in 1998 by Szor & Topp. This report was of a 51 year old paraplegic woman who had an abdominal wound secondary to multiple surgeries. The wound had persistently failed to heal over one year despite traditional wound management treatments (antibiotic ointments, foam dressings, anti-fungal powders and hydrocolloid dressings). Prior to magnet therapy, the wound had reached 2 x 2 cm in size. Her surgeon suggested resecting the whole scar, but this option was not acceptable to the patient. There were no obvious factors impairing wound healing. For example, she was not malnourished or hypoxic, there was no excessive pressure on the wound, no shear or friction and no diabetes or uraemia. The patient agreed to a trial of magnet therapy. A magnet of 650 gauss strength, 1.5 inches in diameter was applied and she continued with the same wound care as before i.e. antibiotic ointment and twice-daily change of dressings.

At the first visit at 11 days, remarkable progress was noted.

One week later the red colour of the scar had gone and the texture of the wound was much smoother.

At 4 weeks the wound had completely healed.

The wound has remained completely healed one year on.

There is a vast amount of anecdotal evidence that suggests that static magnets are effective in healing wounds and ulcers and relieving pain. The focus of the above short report has been to highlight the published scientific evidence to support these claims.

A double blind placebo controlled trial is about to commence in two UK centres to investigate the efficacy of static magnets in promoting the healing of leg ulcers.

Mechanism of action of magnets in wound healing

The most important principle of wound management is to provide a natural physiological environment for optimal healing.

Electrical interactions are regulators of many basic physiological processes ranging from conformation of molecules within the cell membrane bilayer to the macroscopic mechanical properties of tissues (Markov, 1995). In vitro studies suggest that biological activity of the cell e.g. cell division or cell differentiation can be modulated by electrical currents and electromagnetic fields and alteration of cell activity by weak electromagnetic fields has been reported by several researchers (Cleary, 1994; Markov, 1994; Bassett, 1989). DuBois-Reymond in 1860 was the first to detect a current flowing through wounded mammalian skin. Cunliffe-Barnes discovered that the potential difference between injured and intact skin decreases during the healing process and disappears when the wounds are healed (1945).
Living tissues possess direct current electro potentials that regulate, at least in part, the healing process. Following tissue damage, a current of injury is generated that is thought to trigger biological repair. Exogenous electrical stimulation has been shown to enhance healing of wounds in humans and animals (Weiss et al, 1990). As early as 1940, Burr et al described an electric correlate of wound healing and measured surface electro potentials over healing incision sites in patients after abdominal surgery. Electrical potentials were initially positive and then became negative after the fourth day of healing and remained negative till healing was complete. A similar effect had been described in guinea pigs by the same authors previously. The proliferative phase of healing was related to negative electrical potential. Similar electrical potential have been described in mechanically stressed bone (Fukada & Yasuda, 1957). Becker proposed that a localized shift in current flow triggers biological repair. He showed that the healing phase of limb regeneration in the salamander was associated with negative polarity at the stump and that the healing could be enhanced by artificially augmenting the negative polarity.
A sort of skin battery has been described in the epidermis of animals and humans, the presence of which is thought to subserve wound healing, the average potential being –23mV (Foulds & Barker, 1983). Potential differences across the epidermis in the intact skin can drive DC currents into the epithelial wounds of approximately 1 microamp per millimetre of wound perimeter. Maximum values of current leaving the wound are greatest just after the wounding and this decreases as the wound heals (Jaffe et al, 1984). It would seem that this ionic current between normal and insulted tissue is essential for the restoration of the latter to a normal functioning state. Lateral voltage gradients can be measured in the vicinity of the wound (Jaffe et al, 1984). The battery can maintain transcutaneous potential differences of up to 80mV, inside positive. This epidermal battery in animals has been shown to be inhibited by the drug amiloride suggesting that sodium ion channels are crucial to its generation (Jaffe et al, 1984).
One of the most important processes in wound healing is re-epithelialization. Studies in guinea pigs have shown that cells migrating across a wound come from a strip of intact skin approximately 0.5mm wide around the wound (Winter, 1964) and it is in this area that substantial voltage gradients occur. Cells appear to move and orientate according to voltage gradient (Hinkle et al, 1981). Cell migration is one of the earliest signs of epithelial repair of epidermal wounds both in mammals and amphibians (Christophers, 1972). Wounds are initially closed by a rapid migration of cells of the

inner epidermal layer. The outer layer moves more slowly. It is plausible that epithelial cell migration is speeded or directed by external electromagnetic fields (Jaffe et al, 1984). In chronic wounds cell proliferation is usually suppressed. Alvarez et al (1983) demonstrated a significant increased rate of wound epithelialization, increased collagen synthesis and healing rates 5 to 7 days after 24 hours continuous treatment of pig wounds with 20-300 microampere currents.

Wounds exposed to the negative electrode have been shown to have increased tensile strength. Bigelow et al (1979) showed that skin wounds in dogs have greater tensile strengths after stimulating them electrically. There is evidence that collagen fibres orientate parallel to surfaces exposed to external current, whereas control, non-exposed collagen fibres orientate in a perpendicular fashion (Rowley et al, 1974). Similar reports were made by other researchers working with human tissues. Assimacopoulos (1968), described dense connective tissue rich in hyalinized collagen fibres orientated parallel to the wound surface after exposure to electrical currents. On the basis of earlier experiments in rabbits, Assimacopoulos (1969) electrically stimulated chronic leg ulcers secondary to venous insufficiency in 3 patients in which conservative management had failed. Application of low intensity (50 to 100 microamp) direct current through the negative electrode resulted in *complete healing of all 3 ulcers within 6 weeks*. Enhanced leg ulcer healing has been described especially when polarity was changed during treatment. At 8 weeks with such treatment 40% of ulcers had healed completely with a mean decrease in ulcer volume of 82% for all treated ulcers (Wolcott et al, 1969). Other researchers have described similar results on wound healing with this type of electrical treatment (Weiss et al, 1990). Carley & Wainapel (1985) demonstrated in a controlled study a 1.5 to 2.5 increased healing rate of ulcers as well as subjective reduction of pain in 30 patients with ischaemic ulcers treated with electrotherapy. In fact there appear to be consistent reports of healing of chronic ulcers with pulsed electrical stimulation (Karba et al, 1991; Kaada, 1983; Barron et al, 1985) in a period of 4.5 to 10 weeks. This effect seemed to be independent of the nature of the ulcer (traumatic, pressure or vascular resistant to other therapies). Both low and high intensity direct currents have been shown to enhance ulcer healing (Kloth & Fedar, 1988). Accumulation of charges may be a key factor for cell regeneration in non-excitable cells, which for some reason fail or are pathologically slow to regenerate (Markov, 1995). There may be a local effect of electrical stimulation to increase ATP and protein synthesis and a CNS-mediated vasodilation reflex (Markov'1995).
Electric current has also been reported to have an anti-bacterial effect (Rowley et al, 1974; Barranco et al, 1974). This effect may be mediated by attraction of macrophages to the wound site. Stimulation of fibroblasts has also been demonstrated. Fibroblasts orientate their long axis perpendicular to field lines. Increased collagen synthesis has also been demonstrated (Weiss et al, 1990). Electrical currents increase the receptor number for growth factors in human dermal fibroblasts in culture (Falanga et al, 1987).

Taken together the evidence shows clearly that electrical stimulation accelerates the healing of intractable ulcers and furthermore skin wounds resurfaced faster with better tensile properties.
<u>There are numerous experimental studies that support the view that wound healing is, at least in part, mediated by electrical signals.</u>

Whilst all of the above information concerns the action of electrical currents to promote wound healing one must remember that all electrical currents generate magnetic fields and all magnetic fields cause a change in electrical potential. *A potential overlap in the mechanism of action of electrical currents and static magnetic fields to promote healing is perhaps suggested by their similar action in promoting bone healing.* That electrical fluxes are important in bone healing is evident form studies on bone deformation. Compression of bone generates a negative electrical potential. Furthermore, the cells are responsive to alteration in externally applied DC electrical fields (Basset & Becker, 1962). Very low electrical currents applied to fractures accelerate their healing. The ability of low voltage electric currents to stimulate bone formation is established (Becker, 1978; Zengo & Basett, 1976). Pulsed electromagnetic fields (PEMFs) have been shown to increase collagen synthesis in cultured fibroblasts (Farndale & Murray, 1985). PEMFs create both a magnetic field and an induced electrical field. Bruce et al (1985) studied the effects of static magnetic fields on fracture healing in the rabbit radius. They applied 220 to 260 gauss magnetic fields to the fracture sites. The contra lateral radii were also fractured and acted as controls. Significantly greater forces ($p<0.01$) were required to break bone exposed to the magnetic field. Calluses were not larger but stronger. It has been suggested that static magnetic fields hasten the maturation of tissues and therefore increase the strength of a healing callus. Connective tissue cells placed in a static magnetic field increase proliferative and functional capacity by 20% (Bassett & Herrmann, 1968).

Magnetic fields may enhance the injury current and therefore augment cellular orientation with increased rate of tissue differentiation.

Magnetic fields cause a change in electrical potential. ***Therefore, an interaction of magnetic fields with ion fluxes across the cell membrane is very likely.*** Faradays Law states that magnetic fields will exert a force on electrically charged particles (i.e. a moving current of ions). The Hall effect describes how charged ions will tend to be separated and moved when a magnetic field is placed at 90 degrees to an electrical current.

It has been postulated that magnetic fields exert their effects by an action on the ion pumps in the cell membrane; particularly those involved in pumping calcium, sodium and potassium ions such as sodium-potasium-ATPase and calcium-ATPase (Itegin, 1995; Burkhart & Burkhart, 2000;Aceto et al, 1982;Gualtierotti, 1964). The interaction with calcium ions may be important in their proposed circulatory enhancement effects (Horowitz, 2000). Changes in tissue calcium concentration have been described after static magnetic field exposure (Itegin et al, 1995).
It has also been postulated that magnets encourage the supply of negative charges to cells thereby restoring cellular resting membrane potentials (Weinberger et al, 1996).

Low amplitude electro magnetic fields alter the threshold for electrical stimulation in nervous tissue (Scherlag & Yamanashi, 2000). There is evidence of pain signal inhibition by this mechanism (Mclean et al, 1995 and Cavopol et al, 1995). Significant reductions in nerve conduction times have been reported in the ulnar nerves of subjects wearing magnetic necklaces 24 hours a day for 3 weeks (Hong et al, 1982).

Static magnets have been postulated to alter sodium/potassium concentrations leading to an increase in resting membrane potentials. The potential consequence of this would be reduced membrane depolarisation and inhibition in transmission of pain impulses and producing analgesia (Borsa & Liggett, 1998;Lednev, 1991 and Olney et al, 1990). Magnets may create a field that alters how pain signals are transmitted (Hawkins, 1998**). Since static magnets appear to be able to alter membrane ion fluxes they also have the potential to interact with and perhaps enhance the injury currents crucial to effective wound healing.**

Static as well as electromagnetic fields boost ATP production in the test tube (Rosch, 1998). This effect may be mediated by magnets affecting the pH difference across the mitochondrial membrane. This pH difference results from positively charged hydrogen ions being pumped out of the mitochondrial membrane to maintain an electrical potential across the membrane of 220 mV; an effect crucial to driving energy production.

An increase in the synaptic cleft has also been described i.e. the gap between nerve endings and their target tissue, raising the possibility of a biomechanical as well as a bioelectric action of magnetic fields (Itegin et al, 1995).

Magnets and circulation

Chronic wounds have a reduced supply of oxygen and nutrients due to poor blood flow. Healing requires an environment that will optimise supply of nutrients and oxygen. Increased blood perfusion and skin temperature have been observed in human arms exposed to pulsed magnetic fields (Mayrovitz & Larsen, 1992). Many of the studies that demonstrate a beneficial effect of electrical currents on wound healing report an improved circulation as well as pain relief as a consequence of treatment. There are several studies that suggest a similar effect may be elicited by static magnetic fields.

In a microphotoelectric pletysmographic study of rabbit ear circulation in anaesthetised rabbits, static magnets of 0.25-tesla strength were observed to cause an 20% increase of circulation in the face of a 10-15% decrease in circulation in control rabbits (thought to be due to either anaesthetic and/or stress) (Gmitrov et al, 2002). Increased rat skin fold circulation has been measured for 5 minutes after exposure to an 8-tesla static magnet. This was followed by a gradual return to control levels (Ichioka et al 1998).

Static magnet fields of 0.2-0.35 tesla (1,500 gauss) applied to the carotid artery sinus baroreceptor region was found to produce significant macro-circulatory effects in reducing blood pressure and modified micro-circulation (Gmitrov, 2002). There was a time delay of 40 minutes before the effect was observed. In other animal studies it has been suggested that the pain relief due to static magnets may be accounted for by an increase in circulation and there was evidence that this circulatory increase may be elicited by enhanced cholinergic vasodilator neurotransmission or by an anticholinesterase action to prevent breakdown of the vasodilator acetylcholine (Takeshige & Sato, 1996). Serum cholinesterase in rats is inhibited by static magnetic fields (Gorczynika & Wegszynowicz, 1989).

Migration of erythrocytes (red blood cells) has been described along a magnetic field (Saygih et al, 1992). Others have reported a blood viscosity lowering effect of magnets (Cisarik, 1986).
In contrast mini magnets (0.005-0.3 tesla) had no significant effect on buccal mucosal blood flow (Saygih et al, 1992). The aim of this study was to establish whether or not magnets had any untoward effects on blood flow or blood cells. The authors concluded that there were no harmful effects on either blood flow or on blood cells. No detectable effect of static magnets of 500 gauss on human skin blood perfusion, as assessed by laser Doppler flowmetry or laser Doppler imaging was detected over a period of 36 minutes exposure (Mayrovitz et al, 2001). After application of static magnets of 700 gauss to the human quadriceps muscle, no thermal effect was noted in the skin or intramuscularly up to 60 minutes after application. In contrast, Kanai's double blind study (1998) showed that back pain sufferers had colder areas, as assessed by thermal imaging, in painful areas that these warmed after application of static magnets. The increase in temperature paralleled pain relief. These findings would suggest that static magnets can increase blood flow.
Blood oxygen changes have been described in both directions in magnetic fields (Kutrumbus & Barnes, 2000).

There is certainly evidence that static magnets can increase blood flow. It is not certain whether this is their primary action or whether this effect is secondary to ionic changes that favor an increase in blood flow. If indeed static magnets do lead to an increase in circulation then clearly this may be a possible explanation of their analgesic and wound healing properties.

Summary and Conclusions

To date there is only one double blind study in the scientific literature that has looked at the effects of static magnets in wound healing. This was the study of Man et al (1999) on post surgical wounds. Significant positive effects were described in this study on wound healing. On critical review of this study on the basis of methodological quality it scored a 3 out of 5 on the Jadad scale (Jadad, 1996). The study therefore merits attention. A case study is also published that reports favourable results.

The introduction highlights many studies demonstrating the efficacy of electrical current in promoting wound healing. It seems likely that this is due to promotion of the so called injury current that is generated rapidly at a wound site and which is a crucial part of the wound healing mechanism. Perhaps the best recognised and acknowledged effect of electric current is in the promotion of fracture healing. A bone growth stimulator, which works by electromagnetism, has an 80% success rate in promoting the union of non-healing fractures and has FDA approval (Bassett et al, 1982). All electrical currents generate magnetic fields and all magnetic fields cause a change in electrical potential. *Therefore, an interaction of magnetic fields with ion fluxes across the cell membrane is very likely.* The study of Bruce et al (1985) of the effects of static magnetic fields on fracture healing in the rabbit radius that demonstrated significantly greater bone strength at the fracture site perhaps suggests that static magnetic fields could promote bone healing in a similar fashion. Furthermore as stated earlier it has been shown that connective tissue cells placed in a static magnetic field increase proliferative and functional capacity by 20% (Bassett & Herrmann, 1968).

A recent systematic review has reported a significant trend towards static magnets being effective analgesics (Eccles, 2002). Overall 9 of the 12 studies reported a significant analgesic effect due to static magnets. Of the 10 better quality studies with 3 points (Table 2 & 3) or more on the quality assessment, 7 were positive and 3 were negative. Seven out of 8 of the better quality studies demonstrated a positive effect of static magnets in achieving analgesia across a broad range of different types of pain (neuropathic, inflammatory, musculoskeletal, fibromyalgic, rheumatic and post-surgical). It is uncertain whether this effect is mediated by a change in circulation and/or an effect on ionic exchange and pain signalling. Generally however, these results together with the evidence cited above clearly point towards static magnets having a significant interaction with human physiology.

There is much anecdotal evidence that static magnets can promote ulcer healing. The potential saving to the NHS in wound care expense and district nurse time if this proves to be the case in controlled trials, is enormous, not to mention the relief to the patients themselves. A double blind placebo controlled trial is currently underway to examine the effect of static magnets in ulcer healing; the results of which are expected before the end of 2003.

APPENDICES

APPENDIX 1

Anecdotal Evidence

The following testimonials were obtained from the Company Magnopulse after approaching them for feedback that they had obtained from patients using their products, and in particular their Legcare product, a strap containing 3 magnets of 1850 gauss (measured at the strap surface) and designed specifically for treatment of lower leg problems such as ulcers and pain.

District Nurse Reports

Nurse G.P - Bristol

7 patients have worn Legcare (static magnet).

General comments: Definite results on ulcers with massive reductions in swelling of arthritic joints. Questionnaire analysis received from 6 patients – 3 claimed it did not work and took it off. 3 had complete healing of ulcers in 3 months. One patient scheduled for leg amputation was able to avoid this.

Notes on rate of healing

Patient 1	Ulcer 7 x 4cm reduced to 5 x 3cm in 2 months
Patient 2	Ulcer 2.75 x 5.25cm reduced to 1.5 x 3.75cm after 1 month
Patient 3	Had ulcer for 3 years. Ulcer of 6.2 x 2.5cm reduced 25% by one week. Pain relief was noted. Ulcer reduced to 4 x 1.5cm at 2 months.

Staff Nurse LW, Stockwood Medical Centre, nr Bristol

General comments: Ulcers stable for 3.5 to 5 years have been seen to improve dramatically.

One patient who had a leg ulcer for years, resistant to other treatment tried, was noted to have great changes in 6 weeks. This patient had one large and one small ulcer. After 6 weeks the small ulcer had healed and the large ulcer was pink instead of grey. With the Legcare magnet off for 4 days the ulcer was noted to start to turn grey again.

“Every nurse should know about this,” says LW

Amelia NSH Clinic Case Study

Patient GM, aged 87

Badly swollen leg with a 4cm ulcer. This reduced to 1cm in 6 weeks. The limb oedema was also noted to reduce. The device was removed on a doctor's advice and the leg swelled up again.

Nurse SH

Individual testimonials

Mrs McC

Had ulcer for 3 years. This has been different since her leg wrap. There has been no more pain and the ulcer has improved.

Mrs D, aged 75 years

Had a bad ulcer that cleared up in a matter of 2 weeks.

Mrs SK

Had ulcer, swelling and varicose veins. The ulcer healed completely in 2 months. She had been having NHS treatment for the ulcer for the previous 6 months. The varicose veins were also noted to be not so prominent.

Mrs C

Has had osteoporosis for 15 years. She has tried everything. The pain was particularly bad in the right leg to the extent she was shouting with pain on walking. The situation was made worse by her having a partial paralysis of the left leg. There was also swelling of the right leg. Within 3 days of wearing the magnet the pain was gone.

Miss MC, aged 65, Londonderry

Has had 3 operations on her legs for thread veins. She had a swelling with dark veins in the leg that was under investigation by a specialist. Within a few days of wearing the magnet, the lump had gone, the veins were red rather than black. She had also been diagnosed with fibromyalgia and had no relief from pain until now. She reports the pain to have gone after wearing a magnetic wristband.

Ms MG

Has a worn disc in her spine. She spent 4 months of last year bed-ridden. She declined surgical intervention, feeling the risks of success were too low to be acceptable. With static magnet treatment her pain is now gone. She is able to sleep at night and whilst she was previously immobilised, she is now able to walk everywhere.

Ms FL, aged 57, Dombarton

Leg pain. The Legcare magnet helped straight away, and she was able to get her first night's sleep in many months. She is now able to move bales of hay, a feat that would not have been possible before the Legcare. She noted that the leg was immediately warmer. She now only wears the Legcare at night.

CS

Has had bad pain due to peripheral neuropathy ????? for several years. Started wearing the Legcare magnet constantly on one leg. After one day of wearing it the pain was reduced. The foot was much more responsive after 3 days and after 2 weeks there was dramatically less pain in both feet.

Mr A, aged 50, Bradford

Works in DIY and stands for 8-9 hours a day. His leg pains are relieved by wearing Legcare magnets in the evening.

Mr A senior

Due to arthritis in the legs associated with aching and swelling he had a history of not being able to walk well for 2 years. Within 2 weeks of wearing the Legcare he was able to walk without difficulty.

Mr W

Has osteo-arthritis of the knee. He had a knee operation many years ago but nothing had relieved his pain in recent times. After wearing the Legcare he had relief straight away.

Ms JP, aged 70

Has aching legs with venous insufficiency. She has found the Legcare to be of tremendous help.

Mrs A, aged 50

Has aching varicose veins. She has had remarkable improvement in the aching in 3 days after wearing the Legcare.

Ms ID, aged 83 (Nurse GW)

Had a leg ulcer for 3 years. This resolved in 8 weeks after wearing the Legcare magnet. (Nurse Observations)

Mrs J, aged 79, Granby House Clinic

The nurses observed reduced pain in her arthritic knee and also reduced swelling after wearing the Legcare magnet. (Nurse Observations)

Mr J, aged 68, Granby House Clinic

Found the Legcare bulky but very effective in reducing his leg pain due to arterial disease. (Nurse Observations)

Mrs WP, aged 65

Has chronic venous ulcers (15-20 years) in both legs and also ulcerated toes. She also suffers from rheumatoid arthritis. After 3 months if wearing the Magnopulse leg wrap there has been no decrease in size of the ulcers but she has had no pain since. (Nurse Observations)

Mr RP, age?, Knowle Leg Ulcer Clinic

After 2 months wearing the Legcare his ulcer reduced in size from 7 x 4cm to 5 x 3cm. He also states that his pain is improved. (Nurse Observations)

Mr GM, aged 87, Amelia NSH Clinic

His leg ulcer has reduced by 1cm in size since wearing the Legcare. The nurses comment that there is 5-6cm less swelling in the affected leg and that the tissue hardness has significantly reduced.

Mr AB, aged 87

Mixed aetiology leg ulcer for 3 years. He has been using the Legcare for 3 months. Within one week his ulcer had improved 25% but more significantly his pain resolved. At 3 months he still had no pain and his ulcer, originally 6.5 x 2.5cm had reduced in size to 4 x 1.5cm. (Nurse Observations)

Ms WK, aged 87, Knowle Leg Ulcer Clinic

She had a leg ulcer 5.25 x 2.75cm in size. After 3 months of wearing the Legcare her ulcer had completely healed. (Nurses' Measurements and Observations)

APPENDIX 2

Magnetic devices: some considerations

Strength, source, polarity and size of magnets and duration of exposure should be taken into consideration (Owen, 1986; Barnothy, 1964). The optimum magnetic field strength is unknown and this is complicated by the fact that different cells or cellular components seem to have different thresholds of response to magnetic fields (Pilla, 2000). Nakagawa (1995), from his experience and work with magnets in Japan, concluded that magnets need to exceed 500 gauss strength to be effective on the human body. Magnetic power is expressed in modern units of tesla (T) but the older unit of gauss is still used. 1 telsa is equivalent to 10,000 gauss. The earth's magnetic field is 0.5 Gauss (1/10,000 tesla). Most commercial static magnets have powers of less than 1,000 gauss (0.1 tesla). Moreover, gauss readings are often found to be much lower than manufacturers' claims (less than 20% of the claimed power in some cases) (Blechman et al, 2001). Also, the surface of a magnet usually has non-uniform gauss readings.

One of the limitations of magnet therapy in the past has been the use of relatively low magnetic power for weight ratios of ferrite-based magnets. The advent of neodymium/boron/iron magnets in the 1980s allowed for high magnetic field to weight ratios making therapeutic devices significantly more practical and portable. They also have the advantage of retaining their magnetism for decades.

Field flux density is often greater at the edges compared with the centre of the magnet (Blechman et al, 2001). The field strength is proportional to the square of the distance from the magnetic source. The strength falls off rapidly from the body surface. This makes it difficult to assess penetrability. A non-uniform field results in tissues after application to the skin surface (Pilla, 2000). Devices that utilise a directional plate to focus the magnetic effect in one direction are therefore potentially useful. The degree of sub-dermal decay varies with different magnetic alloys (Blechman et al, 2001)

The optimum treatment duration is also not established and positive results have been obtained from 45 minutes to 24 hours (Grigat et al, 2000).

Some feel that the polarity of the magnet that faces the skin may have a differential effect (Owen, 1986). Most of the double blind studies cited in this review have employed the south pole of the magnet adjacent to the skin. There is still debate over whether application of north or south poles determines the nature of the effect. According to Vallbona (1999) both bipolar (alternating north and south poles in concentric pattern or a grid) and unipolar (one pole at the surface applied to the skin) magnets are effective in pain relief. Some have hypothesised that multi-polar magnets may generate deeper field gradient penetration than either unipolar or bipolar magnets (Weintraub, 2000).

Magnetic fields are not impeded by bone and other structures.

Static magnet safety

The evidence that certain electric and magnetic fields augment DNA synthesis has been met with concern over cancer risk. This concern is largely directed at pulsed electromagnetic fields, and in particular continuous exposure to high voltages e.g. overhead power lines, electric blankets etc (Trock, 2000). No adverse effects on human health have been observed with static magnets up to 2 Tesla or 20,000 Gauss (WHO, 1987). (Vallbona et al, 1997;Jonas, 2000). Magnet therapy practitioners usually recommend that once the magnet has done its job it should be removed, allowing the body to heal itself naturally. Magnetic fields can alter rate of chemical reactions and in some circumstances can enhance conventional drug treatments necessitating a dose reduction in the latter. There is however a paucity of research in this area. Consultation with a Medical practitioner is recommended if regular medication is being taken. Magnetic fields of 2 and 7 Tesla produced no teratogenic effects in pregnant mice (Wagner et al, 2000). However, some studies have reported effects on young animals. It therefore seems prudent to avoid magnets in pregnancy and young children less than 3 months (Coghill, 2000). It is also recommended that magnets should be avoided in pacemaker wearers and those who have metal implants or who wear insulin syringe drivers.

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