LOW ENERGY HIGH FREQUENCY PULSED ELECTROMAGNETIC THERAPY FOR ACUTE WHIPLASH INJURIES1

A DOUBLE BLIND RANDOMIZED CONTROLLED STUDY

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From Mater Misericordiae Hospital, Dublin 7, Ireland

ABSTRACT. The standard treatment of acute whiplash injuries (soft collar and analgesics) is frequently unsuccessful. Pulsed electromagnetic therapy PEMT (pulsed 27 MHz) has been shown to have pro- recovery, and analgesic effects. This study examines the effect of PEMT on the acute whiplash syndrome. One half of the 40 patients entering the study received active PEMT collars; the other half had sham (placebo). All patients were given instructions to wear the collar for eight hours a day at home and advised to mobilise their necks. At 2 and 4 weeks the actively treated group had significantly improved (p<0.05) in terms of pain (visual analogue scale). By chance movement scores for the PEMT group were significantly better at entry to the study than the control groups (p<0.05). At 12 weeks they had become significantly better (p<0.05). PEMT as described is safe for domiciliary use and this study suggests that PEMT has a beneficial effect in the management of the acute whiplash injury.

Key words: short wave diathermy, neck pain, neck sprain, whiplash, electromagnetic field.

Since the Second World War there has been a dramatic increase in the number of motor car accidents resulting frequently in neck injuries and an associated whiplash syndrome (1). The syndrome's perception for many people is that of a latent injury and is often frightening, by which many people involved in vehicular accidents fraudulently gain compensation after a trivial injury. The literature does not support such a view, as will be later elucidated. While the persistence of neck pain suggests we are not efficiently treating the cervical component of the whiplash injury, there have been surprisingly few therapeutic studies comparing treatments for the patients with acute whiplash syndrome. The standard treatment for acute whiplash injuries has been immobilisation in a soft cervical collar combined with adequate analgesics (2, 3). Early active mobilisation has only recently been shown to be more effective than the standard treatment (4). Because of the cost involved in providing such an immediate service, this has only become available in certain centres (5). McKinney's recent report (6) shows no difference in early management outcome (loss of pain and range of motion as the important outcome parameters) between outpatient physiotherapy and a structured verbal and written mobilisation instruction programme geared to facilitating self-mobilisation.

Over the last thirty years increased attention has focused on the use of electrical stimulation to stimulate tissue healing especially in cases where conventional therapy is ineffective. This has resulted from the seminal observations of Becker (7), Bassett et al. (8) and Fukuda & Yasuda (9) that bioelectrical fields are associated with limb regeneration and bone dynamics. These studies suggested that imposed fields could selectively trigger desirable biomechanical events if the appropriate field parameters were used. Pulsed electromagnetic therapy (PEMT) has been shown to accelerate fracture healing in refractory cases (10, 11) and used to treat failed joint arthrodesis (12) and avascular necrosis (13). Low frequency (40-70 Hertz) medium power PEMT has been used in these trials. Higher frequency PEMT devices have been reported to accelerate wound healing (14) dental alveolar healing (15) and nerve regeneration (16, 17). Symptomatically treated and accelerated healing have also been reported in studies of patients with ankle ligament injuries.

1 An abbreviated form of this study has been presented at the British Society for Rheumatology meeting in Birmingham, July 1988, at the American College for Rheumatology meeting in Cincinnati, June 1989, and at the Bioelectromagnetic Society meeting in Tucson, June 1989.
(19) and rotator cuff tendinitis (19). We have recently reported that low energy high frequency PEMT improves pain and increases range of motion in patients with persistent neck pain (20). Low power PEMT would deliver approximately 1.5 milli-Watt/cm² while medium power would deliver approximately 0.5 Watt/cm² at the skin surface. Nagelshmidt in 1940 proposed in relation to the therapeutic effectiveness of short wave diathermy "there must be some other effect, not as yet realised to account for the phenomena which could not be reasonably attributed to heat alone (31)". In this study we chose low power pulsed short wave (approximately 27 MHz) because of its safety over prolonged periods (22) allowing a safe eight hour/day minimum treatment duration, with minimal inconvenience for the patient treated in their own home. To assess the impact of treatment in acute whiplash injuries using low energy high frequency PEMT we conducted a double-blinded randomized controlled trial in a group of patients presenting with acute whiplash injuries resulting from rear end motor vehicle accidents.

PATIENTS AND METHODS
The Accident and Emergency (A & E) Department of Mater Misericordiae Hospital, Dublin serves a population of 500,000 providing a 24-hour emergency service in rotation with two other major hospitals. Between September and December 1987 all patients over 18 years who presented with acute "whiplash" injuries (injuries of the cervical spine resulting from rear end collisions), were considered potential candidates for a randomized trial of PEMT. The study was approved by the Hospital Ethical Committee. Initial assessment of potential study subjects was by history taking, physical examination and radiographs of the cervical spine (A/P and Lateral). Patients who presented to the A & E Department more than 72 hours after the injury or who had any active inflammatory process, neoplasm, or metabolic bone disease involving the cervical spine were not included in the trial. In addition anyone who had sustained a cervical fracture, a bony injury with loss of consciousness or who had impaired reflexes indicative of a cervical root lesion was excluded. The trial purpose and design was explained to suitable subjects and their consent to participate was sought. A total of 46 patients were enrolled in the trial. The patient data is presented in Table I. Eight patients in each group showed either reduction in disc height, osteophytes, facet joint spurring or foraminal narrowing on the normal cervical lordotic view. There was no significant difference between the treatment and control groups with respect to age, sex distribution or previous whiplash injury.

| Type of PEMT unit
| The "treatment" units were designed as active PEMT units and dummy (placebo) units, twenty of each type. An active PEMT unit consisted of a soft collar into which a flexible miniaturized short wave diathermy generator, weighing approximately 100 grams was incorporated. The generator produces a pulsed magnetic field in the treatment area with a mean power of 1.5 milli-Watt/cm² at the patient’s surface. The nominal frequency of the unit was 27 MHz, with a pulse burst width of 60 microseconds and a repetition frequency of 450 per second. Each unit was controlled by an On/Off switch. An indicator light confirmed that the system was operational. The power source for the unit was two nine volt batteries which were replaced at four weeks. The facsimile unit was also a soft collar into which a generator of equal weight was incorporated but did not produce PEMT waves. The facsimile unit also had an On/Off switch and an indicator light which were properly operated. The units were supplied, each bearing an identity number, by H. and K. Electronics. The status of each unit (i.e. whether active or facsimile) was known only to the agent for the manufacturer. There is no perceptible sensation associated with the use of low energy high frequency PEMT as described nor does the collar with the unit enclosed make any perceptible noise.

Study design
As patients were enrolled in the study they were randomly assigned a collar, the status of which was unknown to either the patient or the principal investigators (D.F.N. and K.M.). Patients were advised to wear their collar eight hours per day for the duration of the study (12 weeks). Patients were also prescribed the same anti-inflammatory analgesics (meatamidophenol) and asked to record their daily consumption of this medication, reducing them if they no longer needed them. Patients were advised to mobilize at their usual daily level parking daily the movement of each of the six cervical movements five times each within their pain-free range. Patients were referred for physiotherapy treatment if they were unhappy with their progress at four weeks. The treatment was given twice weekly for six weeks and was continued individually at the patient's request. The typical management included hot pack, pulsed short wave diathermy (SWD), ultrasound and active reductive movements.

Assessment
Patients were assessed at entry to the trial and at 2, 4, and 12 weeks. At each assessment the endpoint of interest was level of pain, range of neck movement and subjective assessment of progress. Pain was assessed by means of a visual analogue scale (VAS) (10 cm horizontal line with "no pain" and "worst possible pain" marked at each end of the line), and by analgesic consumption. Cervical range of movements (ROM) were graded as: full, two thirds normal, one third normal or absent. Thus a patient could score a maximum of six, if they had a full range of passive movement in all six directions tested: flexion, extension, lateral flexion to the right and left and rotation to the right and left. At each review patients were asked to make a global assessment of their progress over the previous three weeks. There were nine options from which to choose: worst possible, much worse, moderately worse, mildly worse, no change, mildly better, moderately better, much better and completely well. If all four patients were dissatisfied with the progress they had made over the initial four weeks they were referred for mobilizing physiotherapy. The number code designating active and facsimile units was broken only upon completion of the 12 week assessment of all patients.

Statistical methods
Demographic and clinical features of Group A and Group B were compared using the Wilcoxon ranked sum test. Chi squared test and Fisher's exact probability test was appropriate. Changes in pain and movement scores within each group were assessed using the Wilcoxon signed rank sum test. Statistical significance implies p ≤ 0.05 unless otherwise stated.

RESULTS
Patients were assessed at the initial visit in the A & E department at a median of 24 hours (range 2-60) after their whiplash injury had been sustained. The level of compliance among trial participants was remarkably high. All patients who entered the study attended for assessment at the designated times and completed the study. In addition, each patient wore the collar for the recommended period of time and kept a log of his/her analgesic consumption.

There was no difference in pain score at entry to the trial between the groups. The median pain scores of both groups are presented in Table II and graphically in Fig. 1. At two weeks and four weeks, the treatment group had significantly less pain than the control group. Of interest was the fact that both in active and placebo groups the VAS median pain was initially higher for females than for males, 7.75 compared to 6.5 (active) and 8.0 compared to 6.5 (placebo). While this trend was maintained at 4 weeks (i.e. female scores higher than male scores) in both active and placebo groups, by 12 weeks it was only true for the placebo group. At no time was the difference noted statistically significant, however the number of females in each group was small (Table I). At 4 weeks 9 patients in the treatment group and 12 patients in the control group were referred for mobilizing physiotherapy. At 12 weeks the median pain scores were 1.5 and 2.75 respectively which difference was not statistically significant. Within group statistical analysis

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Table I. Demographic and clinical data

<table>
<thead>
<tr>
<th>Group A</th>
<th>Group B</th>
<th>Significant level</th>
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<tr>
<td>(N=20)</td>
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<td>Gender M/F</td>
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<td>Previous whiplash</td>
<td>4 (20%)</td>
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<td>Physical therapy at 4/52</td>
<td>4 (9%)</td>
<td>12 (46%)</td>
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<td>Possible litigation</td>
<td>14 (70%)</td>
<td>13 (65%)</td>
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</table>

* Fisher's exact test.

Table II. VAS Pain, movement and analgesic consumption

<table>
<thead>
<tr>
<th>Time</th>
<th>Group A (Active)</th>
<th>Group B (Control)</th>
<th>Significance level between group comparisons</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>6.75</td>
<td>6.25</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>2/52</td>
<td>6.00</td>
<td>6.00</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>4/52</td>
<td>2.5</td>
<td>5.00</td>
<td>p&lt;0.05</td>
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<tr>
<td>12/52</td>
<td>1.5</td>
<td>2.25</td>
<td>p&lt;0.05</td>
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</table>

B. Movement scores median

<table>
<thead>
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<th>Time</th>
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<th>Group B (Control)</th>
<th>Significant level between group comparisons</th>
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<tr>
<td>4/52</td>
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<td>4.00</td>
<td>p&lt;0.05</td>
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C. Number of analgesics median

<table>
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<th>Time</th>
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<th>Group B (Control)</th>
<th>Significant level between group comparisons</th>
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<tbody>
<tr>
<td>0</td>
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<td>6.0</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>2/52</td>
<td>3.5</td>
<td>6.00</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>4/52</td>
<td>4.0</td>
<td>5.00</td>
<td>p&lt;0.01</td>
</tr>
<tr>
<td>12/52</td>
<td>0.0</td>
<td>1.5</td>
<td>p&lt;0.05</td>
</tr>
</tbody>
</table>

* Within group comparison.
PATIENTS AND METHODS

The Accident and Emergency (A & E) Department of Mater Misericordiae Hospital, Dublin serves a population of 500,000 providing a 24-hour emergency service in rotation with two other major hospitals. Between September and December 1987 all patients over 18 years who presented with acute "whiplash" injuries (injuries of the cervical spine resulting from rear end collisions), were considered potential candidates for a randomized trial of PEMT. The study was approved by the hospital Ethical Committee. Initial assessment of potential study subjects was by history taking, physical examination and radiographs of the cervical spine (AP and Lateral). Persons who presented to the A & E Department more than 72 hours after the injury or who had any active inflammatory, infective, neoplastic, or metabolic bone disease involving the cervical spine were not included in the trial. In addition anyone who had sustained a cervical fracture, a bony injury with loss of consciousness or who had impaired reflexes indicative of a cervical root lesion was excluded. The trial purpose and design was explained to suitable patients and their consent to participate was sought. A total of 40 patients were enrolled in the trial. The patient data is presented in Table I. Eight patients in each group showed either reduction in disc height, osteophytes, facet joint proliferation, or either flattening or curving of the normal cervical lordotic curve. There was no significant difference between the treatment and control groups with respect to age, sex distribution or previous whiplash injury.

Type of PEMT unit

The "treatment" units were designed as active PEMT units and dummy (placebo) units, twenty of each type. An active PEMT unit consisted of a soft collar into which a flexible miniaturized short wave diathermy generator, weighing approximately 100 grams was incorporated. The generator produces a pulsed magnetic field in the treatment area with a mean power of 1.5 milliwatts/cm² at the patient's surface. The nominal frequency of the unit was 27 MHz, with a pulse burst width of 60 microseconds and a repetition frequency of 400 per second. Each unit was controlled by an On/Off switch. An indicator light confirmed that the system was operational. The power source for the unit was two nine volt batteries which were replaced at four weeks. The facsimile unit was also a soft collar into which a generator of equal weight was incorporated but did not produce PEMT waves. The facsimile unit also had an On/Off switch and an indicator light which was very operated. The units were supplied, each bearing an identity number, by H and K Electronics. The status of each unit (i.e. whether active or facsimile) was known only to the agent for the manufacturer. There is no perceptible sensation associated with the use of low energy high frequency PEMT as described nor does the collar with the unit enclosed make any perceptible noise.

Study design

As patients were enrolled in the study they were randomly assigned a collar, the status of which was unknown to either the patient or the principal investigators (D.F. N. and K.M.). Patients were advised to wear the collar up to eight hours per day for the duration of the study (12 weeks). Patients were also prescribed the same anti-inflammatory analgesics (mefenamic acid) and asked to record their daily consumption of this medication, reducing them if they no longer required them. Patients were advised to mobilize and perform a daily hour's daily exercise. They were advised to constantly move their head during each of the six cervical movements five times each within their pain-free range. Patients were referred for physiotherapy treatment if they were unhappy with their progress at four weeks. The treatment was given twice weekly for six weeks and was tailored individually. Typical management included hot pack, pulsed short wave diathermy (SWD), ultrasound and active resistive movements.

Assessment

Patients were assessed at entry to the trial and at 2, 4, and 12 weeks. At each assessment the residents of interest were level of pain, range of neck movement and subjective assessment of progress. Pain was assessed by means of a visual analogue pain score (VAP) (10 cm horizontal line with "no pain" and "worst possible pain" marked at either end of the line), and by analogical consumption. Cervical range of movements (ROM) were graded as 1, 2 and 3, normal, one third normal or absent. Thus, a patient could score a maximum of six, if they had a full range of passive movement in all six directions tested: flexion, extension, lateral flexion to the right and left and rotation to the right and left. At each review patients were asked to make a global assessment of their progress over the previous three weeks. There were nine options from which to choose: worst possible, much worse, moderately worse, mildly worse, no change, mildly better, moderately better, much better and completely well. If at four weeks patients were dissatisfied with the progress they had made over the initial four weeks they were referred for mobilizing physiotherapy. The number code designating active and facsimile units was broken only upon completion of the 12-week assessment of all patients.

Statistical methods

Demographic and clinical features of Group A and Group B were compared using the Wilcoxon ranked sum test. Chi square test and Fisher's exact probability test were appropriately used. Changes in pain and movement scores within each group were assessed using the Wilcoxon signed rank sum test. Statistical significance implies p < 0.05 unless otherwise stated.

RESULTS

Patients were assessed at the initial visit in the A & E department at a median of 24 hours (range 2-60) after their whiplash injury had been sustained. The level of compliance among trial participants was remarkably high. All patients who entered the study attended for assessment at the designated times and completed the study. In addition, each patient wore the collar for the recommended period of time and kept a log of his/her analogical consumption.

There was no difference in pain score at entry to the trial between the groups. The median pain scores of both groups are presented in Table II and graphically in Fig. 1. At two weeks and four weeks, the treatment group had significantly less pain than the control group. Of interest was the fact that both active and placebo groups of the VAS median pain was initially higher for females than for males, 7.75 compared to 6.5 (active) and 8.0 compared to 6.5 (passive). While this trend was maintained at 4 weeks (i.e. female scores higher than male scores) in both active and placebo groups, by 12 weeks it was only true for the placebo group. At no time was the difference noted statistically significant, however the number of fe- males in each group was small (Table I). At 4 weeks 9 patients in the treatment group and 12 patients in the control group were referred for mobilizing physio- therapy. At the 12 weeks median pain scores were 1.5 and 2.75 respectively which difference was not sta- tistically significant. Within group statistical analysis

Table I. Demographic and clinical data

<table>
<thead>
<tr>
<th>Group</th>
<th>Group B</th>
<th>Signific</th>
</tr>
</thead>
<tbody>
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<td>(Soft collar)</td>
<td>level</td>
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<td>(N=20)</td>
<td>(N=20)</td>
<td></td>
</tr>
<tr>
<td>Age (yrs)</td>
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<td>31</td>
</tr>
<tr>
<td>Range</td>
<td>22-60</td>
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<tr>
<td>Gender MF</td>
<td>2:1</td>
<td>3:1</td>
</tr>
<tr>
<td>Previous whiplash</td>
<td>4 (20%)</td>
<td>1 (5%)</td>
</tr>
<tr>
<td>Physiotherapy</td>
<td>4 (20%)</td>
<td>2 (10%)</td>
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<tr>
<td>Possible litigation</td>
<td>14 (70%)</td>
<td>13 (65%)</td>
</tr>
</tbody>
</table>

* Fisher's exact test.

Table II. IVS Pain, movement and analogical consumption

<table>
<thead>
<tr>
<th>Time</th>
<th>Group A (Active)</th>
<th>Group B (Control)</th>
<th>Significance level between group comparisons</th>
</tr>
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<tr>
<td>0</td>
<td>6.75</td>
<td>6.25</td>
<td>NS</td>
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<tr>
<td>2/2</td>
<td>6.00</td>
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<td>NS</td>
</tr>
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<td>4/2</td>
<td>2.5</td>
<td>5.00</td>
<td>p &lt; 0.05</td>
</tr>
<tr>
<td>12/2</td>
<td>1.5</td>
<td>2.25</td>
<td>NS</td>
</tr>
</tbody>
</table>

### Within group comparison.

Their statistical analysis
showed a significant improvement in pain by two weeks and thereafter at four and twelve weeks in the actively treated group and only by twelve weeks in the control group.

Range of movement (ROM) scores, which improved as pain scores fell, are presented graphically in Fig. 2. While by chance alone the ROM scores of the treatment group were significantly worse than the ROM scores of the control group at entry to the trial (p<0.05), they were significantly better at the end of the trial (p<0.05). To examine this finding further, we looked at the outcome for individuals within each group. In the treatment group 19/20 (95%) showed an improved ROM at 12 weeks while in 1 person the ROM was unchanged. In the control group, however, 10/20 (50%) had a better ROM, in 6/20 (30%) the ROM was unchanged and 4 patients (20%) had a reduced ROM at 12 weeks compared with entry ROM. Comparing median ROM scores within (rather than between) each group there was no significant improvement from entry to 12 weeks in the control group. The treatment group showed a highly significant (p<0.001) improvement, however (Wilcoxon signed rank test).

Patients in the control group were taking a median of six tablets on their first visit and five tablets a day by four weeks as compared to five tablets initially falling to three and a half in the actively treated group. The actively treated groups reduction was statistically significant when compared to the control groups at the two and four weeks assessment. By twelve weeks the groups were again comparable in terms of analgesic consumption (Table II). The patient's global assessment of their treatment reflected the changes in pain and range of movement. At four weeks 17/20 (85%) in the actively treated group felt either "moderately better" or "much better" while only 7/20 (35%) in the control group placed themselves in these categories, which was highly statistically significant (p<0.001). At 12 weeks the proportions improved (in the "moderately better" or "much better" categories) were 85% in the actively treated group and 60% in Group B (Table III), respectively.

Discussion

Hypertension hyperflexion injuries of the neck were first described with the popularisation of train travel and consequently train accidents in the latter half of the 19th century (23). Crowe in 1928 introduced the term "whiplash" to describe a syndrome resulting from rear-end motor vehicle accidents, in which a result of sudden acceleration and deceleration of the neck with forced hyperextension likely to be the more damaging movement, damage is done to the underlying structures (24). In common usage the term has come to mean the syndrome of neck pain and other features resultant from vehicle impacts in any direction rear, front or side. As the whiplash injury is perceived by many to be no more than a relatively trivial soft tissue injury frequently associated with compensation claims the term itself is considered by many to be emotive and unhelpful. Nonetheless, it has merited in that it emphasizes the fact that while we understand the mechanism we are unsure of the pathology involved. Animal studies (25, 26) and studies using brave volunteers (27) have established that the forces generated even in low velocity impacts are considerable, e.g. in a 10 mph rear-end collision the force at the cervical region would be 9 g (27). Holb has documented that muscle ligament and nerve injuries can occur in his animal whiplash model (28).

There are great variations in the prevalence of persistent neck pain arising from rear-end motor accidents ranging from 75% (29) to 25% (30) of symptomatic patients at six months in different studies. Persistent neck ache is one of the most frequently disabling features of the whiplash syndrome (2) causing sick leave in up to 39% of patients (31), permanent medical disability in up to 9.6% of patients (29) and interference with daily living in 59% of patients (32). Because of the frequent concomitant claim for compensation the authenticity of symptoms has been queried by many authors (33, 34).

If a motive (financial gain) rather than an organic lesion was the ultimate basis for the persistence of neck pain after whiplash injuries, then settlement of such compensation claims should allow the neck pain to resolve with litigation settlement. Gorton (35) found that 46% of whiplash patients recovered 1-26 months after compensation case settlement still had symptoms (12% were still severely incapacitated by their injuries). Another report gives a 45% figure for neck symptoms two years after settlement (1) while Holb found 43% had some neck pain five years after settlement (2). It is easy to imagine how the added worry of impending litigation may have a tendency to amplify and perpetrate symptoms. Analysing the re-
showed a significant improvement in pain by two weeks and thereafter at four and twelve weeks in the actively treated group and only by twelve weeks in the control group.

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**DISCUSSION**

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ults of these studies performed post litigation settle-
ment suggest that a sizeable proportion of patients continue to experience neck pain thereafter.

In the case of neck pain in many different cul-
tures and in cases where there was no litigation in-
volved corroborate the case for an underlying organic
basis for the symptoms (23). The prolonged duration of
symptoms in comparison to the expected normal
recovery period for a soft tissue injury (1) suggests
that the injury causing persistent symptoms is not the
traditionally accepted whiplash injury, a grade I or II
ligamentous injury. Magnetic resonance imaging
(MRI) can demonstrate soft tissue cervical structures
in great detail (36). An MRI study to establish whether
tissues are damaged and the extent of such injuries
would help our understanding of the whiplash injury.

A previous study showed that low energy high fre-
quency PEMT can benefit patients with persistent
neck pain (26). The ease of use and lack of side-effects
allowed a safe home treatment, while the low energies
allowed a safe eight hour per day treatment. No side-
effects were reported in that study or in the present
study using the same form of PEMT other than pins
and needles on taking off the collar in the early stages.

This resolved in all cases. This study’s design was
based on the previous study which showed that this
form of PEMT reduces pain within three weeks in
patients with persistent neck pain.

The most immediate improvement seen in the pres-
ent study was in terms of pain reduction in the PEMT
-treated group with a significant reduction in pain
VAS seen at 2 weeks and reflected in a significant
reduction in analgesic consumption and an improve-
ment in the subjective assessment of progress at the
monthly follow-up visit. The changes in range of neck
movement were more gradual. While by chance alone
the treatment group had a statistically significant
stiffer neck at the initial observation by three months
the treatment group had a more mobile neck. It would
appear that pain relief occurs more quickly in patients
with whiplash treated by PEMT than does an im-
provement in ROM. The subjective assessment of
progress mirrored the improvements in the other pa-
tameters with a clear benefit in outcome greater than
placebo perceived by the actively treated group at
four weeks.

At four weeks patients who were not happy with
their progress were referred for a physiotherapy regi-
nament. In the case of whiplash group and 60% of the placebo
treated group took this option. These figures suggest that most of the patients
still perceived themselves to be having some trouble
at four weeks. It is noteworthy that the majority of
patients (70% in Group A and 65% in Group B) were
considering seeking further medical advice, which
were asked about this at twelve weeks. More patients in
the actively treated group felt themselves improved com-
pared to the placebo group (85% vs. 60%) at 12
weeks. Their improvement reflects the natural history
of recovery as well as the effects of the various treat-
ments employed, analgesics, home-exercises, physio-
therapy and PEMT collar/soft collar. The gradual im-
provement in ROM of the actively treated group sug-
gests that the beneficial effects of PEMT in achieving
this depend on pain reduction or else that a longer
duration of PEMT exposure is needed to achieve
different clinical effects.

In the present study low energy pulsed 27 MHz was
used. 27 MHz is the frequency commonly used in
SWD machines which are well accepted forms of
physical therapy (37), whose beneficial effects are
generally accepted to be related to deep heating of the
tissues, though this has been disputed (21, 38). Opti-
nal treatment time for SWD is between five and thirty
minutes (39). Longer treatments can result in
significant complications in addition to burning and
localized irritation (40, 41).

In the context of successfully treating whiplash pa-
ents the beneficial effects of conventional high en-
ergy SWD studied that might be important are pain
relief (42), a reduction in muscle spasm (43), an eleva-
tion of pain threshold (44), a reduction in spindle
excitability (45) and joint stiffness (46). Notwith-
sanding the widespread use of SWD there are a pa-
ucity of controlled studies examining the benefits of
SWD in the treatment of the various specific muscu-
lar-knot conditions including whiplash. The seminal
observation of Nagelschmidt (21) that there were
athermal beneficial effects of SWD suggest that a
longer treatment time might maximize such effects.
Recent observations have demonstrated athermal ef-
fects of PEMT in inflammatory conditions (14, 15, 18, 19), in modulating enzyme functions (4, 7, 46,
49), and in producing effects as cellular orientation
(50). These effects corroborate the initial report and testify to the biological athermal effects of PEMT.
Wilson (18) has demonstrated that pulsed SWD (at
an energy level approximately six times greater than
the present study) produces a significant improve-
ment in ankle ligament injuries. PEMT was shown to
be significantly more effective than continuous SWD in a subsequent study of ankle liga-
ment injuries (51) while Wagstaff (52) found a similar
result in treating low back pain. The energies used by
Wilson & Wagstaff in their pulsed SWD studies are
comparable to the present study and have achieved
both analgesic and anti-inflammatory effects. Their
superior results achieved by pulsing SWD thus using
lower amounts of energy than used in conventional
SWD suggests that the total energy transfer does not
determine the degree of beneficial effects seen and
that parameters as the pattern and pulse repetition
frequency may be just as important as the amplitude
of the PEMT associated field, provided one is above a
critical threshold level. How such PEMT parameters
modulate overall effectiveness has yet to be deter-
mined. These studies show that low energy pulsed
SWD is clinically effective and sometimes more effec-
tive than continuous SWD even with short (30 min-
imum) treatments. Pulsing electromagnetic fields
have some different biological effects than using con-
secutive therapy (53, 54).

The precise interactions of pulsed SWD (PEMT) in
the form used in this study at a tissue level are not yet
known. The very low energies involved imply a co-
operative signalling mechanism at the cell membrane
surface (55) resulting in the generation of inflammatory
alteration in specific proteins (56). Such a phenomenon
is significant change in enzyme function presumably
related to a change in conformational shape of the
enzyme) has been reported to occur for three impor-
tant enzymes membrane bound adenylyl-cyclase [49]
cyclic adenosine monophosphate independent protein
kinase [47] and ornithine decarboxylase (49) after
exposure to specific PEMT waveforms.

Among PEMT parameters that are important in
determining the cell response are carrier frequency,
rise time, pulse repetition frequency and amplitude
(50). Specific forms of PEMT show narrow therapeu-
tic "window effects" in different tissues (57). The
present study shows that lower energy pulsed SWD
used over a longer time period has clinical effective-
ness. In broad outline the beneficial effects seen in
this study in reducing pain and improving mobility
are likely to be due to similar pro-healing and anti-
Inflammatory effects previously reported (14, 15, 18, 19).
The facilitative effect on nerve injury healing is also
possibly important (16, 17).

The management of acute whiplash injuries is a
problem because of the ineffective standard treat-
ment (2) and rehabilitative problems. Reduced pain
was shown to be significantly more effective than
continuous SWD in a subsequent study of ankle liga-

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We acknowledge the support of the Mater College for their funding of this project.

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19: 781-5.
ults of these studies performed post litigation settlement suggest that a sizeable proportion of patients continue to experience neck pain thereafter.

There is much variation in many different cultures and in cases where there was no litigation involved corroborate the case for an underlying organic basis for the symptoms (23). The prolonged duration of symptoms in comparison to the expected normal recovery period for a soft tissue injury (1) suggests that the injury causing persistent symptoms is not the traditionally accepted whiplash injury, a grade I or II ligamentous injury. Magnetic resonance imaging (MRI) can demonstrate soft tissue cervical structures in great detail (36). An MRI study to establish which tissues are damaged and the extent of such injuries would help our understanding of the whiplash injury.

A previous study showed that low energy high frequency PEMT can benefit patients with persistent neck pain (20). The case of use and lack of side-effects allowed a safe home treatment, while the low energies allowed a safe eight hour per day treatment. No side-effects were reported in that study or in the present study using the same form of PEMT other than pain and needles on taking off the collar in the early stages. This resolved in all cases. This study's design was based on the previous study which showed that this form of PEMT reduces pain within three weeks in patients with persistent neck pain.

The most immediate improvement seen in the present study was in terms of pain reduction in the PEMT treated group with a significant reduction in painVAS seen at 2 weeks and reflected in a significant reduction in analgesic consumption and an improvement in the subjective assessment of progress at the monthly follow-up visit. The changes in range of neck movement were more gradual. While by chance alone the treatment group had a statistically significant higher neck at the initial observation by three months the treatment group had a more mobile neck. It would appear that pain relief occurs more quickly in patients with whiplash treated by PEMT than does an improvement in ROM. The subjective assessment of progress mirrored the improvements in the other parameters with a clear benefit in outcome greater than placebo perceived by the actively treated group at four weeks.

At four weeks patients who were not happy with their progress were referred for a physiotherapy regimen. At that time 60% of the PEMT group and 60% of the placebo treated group took this option. These figures suggest that most of the patients

ment injuries (51) while Wagstaff (52) found a similar result in treating low back pain. The energies used by Wilson & Wagstaff in their pulsing SWD studies are manageable to the present study and have achieved both analgesia and anti-inflammatory effects. Their superior results achieved by pulsing SWD thus using lower amounts of energy than used in conventional SWD suggests that the total energy transfer does not determine the degree of beneficial effects seen and that parameters as the pattern and pulse repetition frequency may be just as important as the amplitude of the PEMT associated field, provided one is above a critical threshold level. How such PEMT parameters modulate overall effectiveness has yet to be determined. These studies show that low energy pulsed SWD is clinically effective and sometimes more effective than continuous SWD even with short (30 min) maximum treatments. Pulsing electromagnetic fields have some different biological effects than using continuous therapy (53, 54).

The precise interactions of pulsed SWD (PEMT) in the form used in this study at a tissue level are not yet known. The very low energies involved imply a co-operative signalling mechanism at the cell membrane surface (55) resulting in electroconformation alteration in specific proteins (56). Such a phenomenon is a significant change in enzyme function presumably related to a change in conformational shape of the enzyme) has been reported to occur for three important enzymes membrane bound adenylyl cyclase (48) cyclic adenosine monophosphate independent protein kinase (47) and ornithine decarboxylase (49) after exposure to specific PEMT waveforms.

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