

The Effects of Home Interferential Therapy on Post-Operative Pain, Edema, and Range of Motion of the Knee

Gregg J. Jarit, MD, Karen J. Mohr, PT, SCS, Robert Waller BS, and Ronald E. Glousman, MD

Kerlan-Jobe Orthopaedic Clinic, Los Angeles, California, U.S.A.

Objective: We studied the effects of home interferential current therapy (IFC) on postoperative pain, range of motion, and edema in subjects undergoing anterior cruciate ligament (ACL) reconstruction, meniscectomy, or knee chondroplasty.

Design: Randomized, double-blind, placebo-controlled prospective study.

Setting: A tertiary care outpatient orthopaedic clinic/ambulatory surgery center.

Subjects or Participants: Eighty-seven subjects were separated into three groups based on their type of knee surgery and within each group randomized into a treatment or placebo group.

Interventions: All subjects received home IFC units. Subjects randomized to treatment group received a working IFC unit. Placebo subjects received units that were previously set to deliver no current.

Main Outcome Measurements: Post-operative edema at 24, 48, and 72 hours, and weeks 1-8; range of motion at 1, 3,

6, and 9 weeks; pain immediately after surgery, at 24, 48, and 72 hours, and weeks 1-7; and amount of pain medication taken at days 1-10 were compared between treatment and placebo groups.

Results: All IFC subjects reported significantly less pain and had significantly greater range of motion at all post-operative time points. ACL and meniscectomy IFC subjects experienced significantly less edema at all time points, while chondroplasty subjects experienced significantly less edema until 4 weeks postoperatively.

Conclusions: These findings indicate that home IFC may help reduce pain, pain medication taken, and swelling while increasing range of motion in patients undergoing knee surgery. This could result in quicker return to activities of daily living and athletic activities.

Key Words: Interferential current—Electrotherapy—knee—Rehabilitation—Postoperative
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INTRODUCTION

The use of electrical stimulation has been reported as early as A. D. 46 when torpedo fish, which can generate 100 to 150 Volts,¹ were shown to relieve pain.² The fish was placed directly on the subject's head to treat headaches, under the foot to treat arthritis, and ingested for the treatment of asthma. In the late 19th century, methods were developed to safely use electricity to treat patients.¹ In 1965, Melzack and Wall developed the gate theory for pain modulation,³ which helped to establish that external neuronal stimulation could be used to relieve pain.¹ Today, the goals of electrical stimulation include strength augmentation, pain control, wound healing, reduction of edema, fracture healing, and iontophoresis.⁴ Several different electrical stimulation modalities are used to accomplish these goals.

Interferential current therapy (IFC) was developed in the 1950s by Nemeč, an Austrian physicist,⁵ and is based on the crossing of two different medium-frequency sine

waves usually between 4000 and 4100 Hz. The two currents create waves which interfere constructively (resulting in increased amplitude) and destructively (resulting in no wave) to produce a beat frequency.⁶ This effect is called amplitude modulation.⁷ The beat frequency can be changed by adjusting each medium frequency wave. Medium frequency currents encounter low skin resistance and can therefore penetrate into the deeper tissues. These currents have less effect on cutaneous nerves and superficial muscle-nerve complexes than low-frequency currents.^{6,8} Therefore, the use of two waves at approximately 4000 Hz minimizes skin impedance and allows for deep penetration into the tissues. The resultant beat frequency between 0-150 Hz has supposed beneficial effects via decreasing inflammation in and around the joint, which include decreased pain, decreased edema, and increased range of motion.

Few clinical studies have been used to evaluate the benefit of IFC to subjects. One investigation found subjects treated with IFC for low back pain displayed a lower level of disability and less pain.⁹ Another study found no effect of IFC on subjects with soft tissue shoulder disorders.¹⁰ There has yet to be a published study specifically evaluating the use of IFC for post-operative knee patients. The purpose of this study was to compare range of motion, pain, and edema in post-operative knee

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Address correspondence to Dr. Ronald E. Glousman, Kerlan-Jobe Orthopaedic Clinic, 6801 Park Terrace, Los Angeles, CA 90045, U.S.A.

subjects receiving home IFC to subjects using a placebo unit.

MATERIALS AND METHODS

87 subjects were recruited for this prospective study, and were separated into groups based on the surgery performed. All surgeries were performed in 1997 between January 1 and November 29 by physicians affiliated with the Kerlan-Jobe Orthopaedic Clinic (6801 Park Terrace, Los Angeles, CA 90045). The three surgical groups included ACL reconstruction (28 subjects: 18 men, 10 women), meniscectomy (34:26,8), and knee chondroplasty (25:17,8). All subjects were over 18 years of age and had no previous history of back injuries causing referred pain or impairment of the extremities, surgical history on the uninvolved leg, or previous injury to the uninvolved leg within the past six months. No specific medical exclusion criteria were utilized (such as collagen or circulatory disorders). However, for a subject to participate, they needed to be cleared by the surgeon. Each surgeon required that the subject be in good general overall health, with no apparent limiting factors.

Within each of the three groups, each subject was randomly assigned to receive either home interferential therapy or placebo. The ACL group consisted of 14 IFC and 14 placebo, the meniscectomy group consisted of 17 IFC and 17 placebo, and the chondroplasty group consisted of 15 IFC and 10 placebo. All subjects received a standard physical therapy protocol for knee rehabilitation. Subjects were allowed to choose their physical therapist, however all subjects were given the same guidelines for the therapist to follow and received the same frequency of treatment. The physical therapists were unaware of which group the subjects belonged to. Ice was the only additional modality used by all subjects.

All subjects were given a Stimtech IF4 interferential therapy unit (Stimtech, Inc. 5 Northern Blvd, Amherst, NH. 03031) for home use. The units had usage meters to monitor compliance. The placebo subjects received a unit that was previously set to deliver no therapy. A company representative gave all subjects specific instructions on the use of the unit after their surgery. The subjects were instructed where to place each electrode, and then supplied with specific instructions and a diagram to take home. The channel 1 electrodes were placed superior to the medial aspect of the patellar base and anteroinferior to the fibular head. The channel 2 electrodes were placed superior to the lateral aspect of the patellar base and inferior to the medial condyle of the tibia. The electrodes were applied in the operating room before a dressing or splint was applied. The units were then turned on as soon as possible in the recovery room. The intensity was set per protocol.

As recommended by the manufacturer of the device, subjects were instructed to use the units three times daily, for 28 minutes each session for 7 to 9 weeks and were instructed in the exact frequency settings to use. The IFC subjects had two 14-minute phases. The first was at a beat frequency of 5-10 Hz, and the second was at 80-150

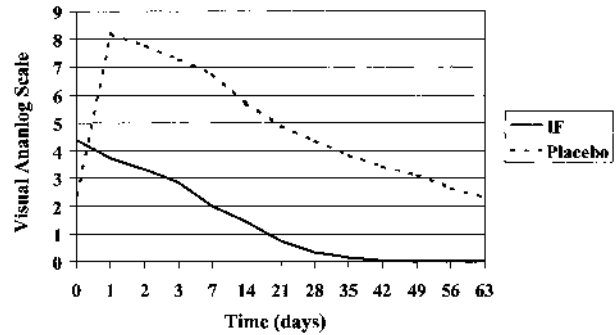


FIG. 1. ACL Reconstruction: Pain.

Hz. They were instructed to set the amplitude as high as possible up to 30 milliamps without pain or muscle contraction. The placebo subjects were told that the unit was preset to the appropriate pulse frequency. They were instructed to turn the unit to setting number 4 and leave it on for 30 minutes three times per day. At this setting the unit appeared as if it was turned on, but no current was being delivered. They were instructed not to be alarmed if no sensation was felt from the electrodes during therapy. The difference in time of electrode application for each group can be accounted for by the time needed for the IFC group to switch frequencies after 14 minutes. Subjects enrolled in the study had no connection with each other and were unlikely to communicate concerning the nature of the treatments.

Each subject was instructed on how to measure the circumference of their affected and uninvolved extremities. The subject performed these measurements 24, 48, and 72 hours after surgery and then once per week until home IFC was terminated. These measurements were performed and recorded at the subject's home in the morning before the use of any pain medications. The subject also recorded all medications taken at the end of each day, including amounts, in a chart provided to them. Range of motion measurements and verification of the knee circumference were done by the physician during post-operative follow-ups at 1, 3, 6, and 9 weeks. The physician also checked the home IFC unit to determine subject compliance.

Edema, measured as a change in circumference from the preoperative value, at 24, 48, and 72 hours, and

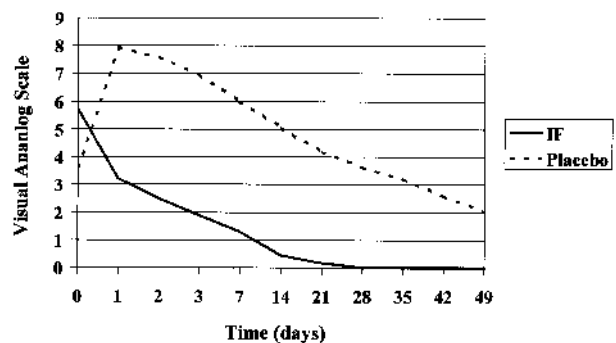


FIG. 2. Chondroplasty: Pain.

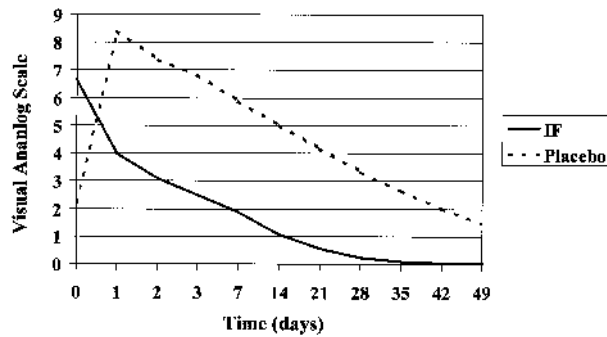


FIG. 3. Menisectomy: Pain.

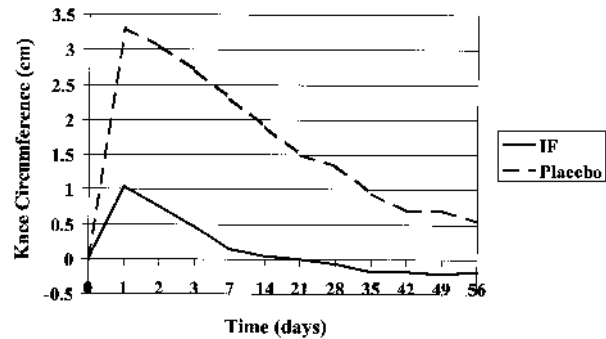


FIG. 5. Chondroplasty: Edema.

weeks 1 to 8; range of motion at 1, 3, 6, and 9 weeks; pain in the recovery room immediately after surgery, at 24, 48, and 72 hours, and weeks 1 to 7, measured using the visual analog scale; and amount of pain medication—measured in 500 mg units of hydrocodone bitartrate/acetaminophen 5/500 (Vicodin)(Knoll Laboratories, 3000 Continental Drive North, Mount Olive, NJ 07828-1234)—taken at days 1 to 10 were compared between treatment and placebo groups using two-tailed t-tests. The criterion for statistical significance was a p value < .05.

RESULTS

There were no significant preoperative differences between placebo and interferential subjects for range of motion or edema. Subjects with home interferential therapy units showed improvement for all three surgical procedures at most of the time points for all parameters.

Pain

All IFC subjects experienced significantly less pain at all time points after time 0. At time 0, the ACL IFC subjects reported significantly more pain (184%) than placebo subjects (Fig. 1). IFC subjects subsequently reported 220% less pain at 24 hours, with the difference increasing until week 6. After week 7, the IFC subjects reported no pain, while the placebo subjects reported 3.11, 2.65, and 2.31 pain levels for weeks 7-9 on the visual analog scale. At 24 hours the chondroplasty IFC subjects reported an average of 248% less pain (Fig. 2).

By week 4 they were reporting no pain, while the placebo subjects reported an average of 3.65, 3.21, 2.59, and 2.05 on the pain scale from weeks 4 to 7, respectively. Menisectomy IFC subjects at time 0 reported 297% less pain than placebo subjects (Fig. 3). By 24 hours, placebo subjects reported an average of 211% more pain.

Pain Medications

ACL IFC subjects took less pain medication at all time points, with a significant difference at days 1 to 2, and 6 to 10. Chondroplasty IFC subjects took less pain medication at all points, however only days 6 and 7 had significant differences. Menisectomy IFC subjects took more pain medication on day 1 and placebo subjects took more on days 2 to 10, with the difference being significant on days 4 to 9.

Edema

For ACL subjects, the IFC subjects' knee circumference was an average of 2.07 cm less than the placebo subjects at 24 hours (Fig. 4). That difference, which was significant at all time points, steadily decreased over time to 1.22 cm at 9 weeks. Chondroplasty IFC subjects experienced less swelling at all time points, with a significant difference displayed at all points until 5 weeks (Fig. 5). At 24 hours the IFC subjects had an average of 2.26 cm less knee circumference than placebo subjects. By week four the average difference was 1.42 cm. Menisectomy IFC subjects had significantly less swelling at all time points (Fig. 6). At 24 hours the IFC subjects' knee circumference averaged 2.36 centimeters less than

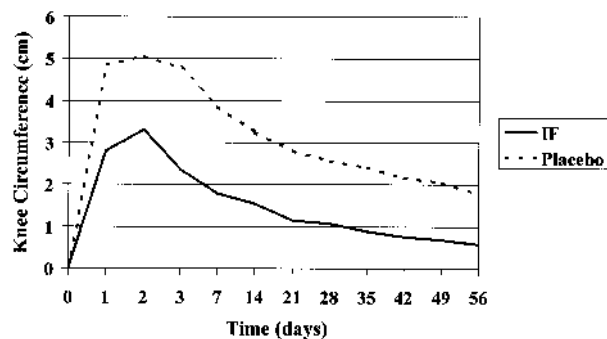


FIG. 4. ACL Reconstruction: Edema.

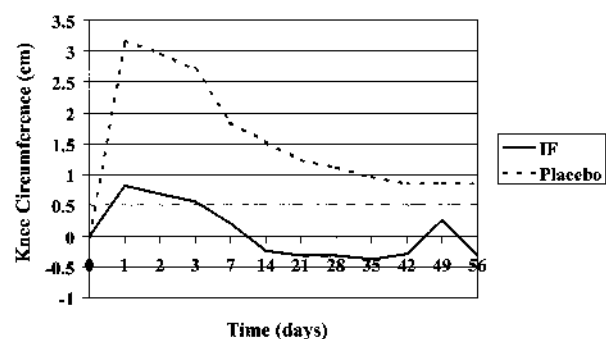


FIG. 6. Menisectomy: Edema.

the placebo subjects. That difference decreased over time to an average of 1.14 cm at weeks 6 to 8.

Range of Motion

All IFC subjects experienced significantly greater range of motion at all time points. ACL IFC subjects averaged 20.25 degrees greater ROM after one week (Fig. 7). At 9 weeks, the IFC subjects averaged 18.85 more degrees. At week 1 the chondroplasty IFC subjects averaged 24 degrees greater ROM (Fig. 8). This difference decreased until 9 weeks, when the IFC subjects averaged 9 degrees greater ROM. Meniscectomy IFC subjects achieved an average of 18.82 degrees greater range of motion than placebo subjects at one week (Fig. 9). By nine weeks the difference had decreased to 7.65 degrees.

DISCUSSION

IFC is an electrotherapy modality that is thought to decrease pain, increase range of motion, and decrease edema. The data shows that IFC has a positive effect on post-operative recovery from knee surgery. We would expect the biggest effect to be in the early post-operative period. However, the results show that IFC continued to provide a valuable role later in the course.

All IFC subjects experienced significantly less pain than placebo subjects at all post-operative time points. The fact that the IFC subjects experienced less pain is expected, considering that the primary effect of IFC is decreased pain. However, it is surprising that the difference was still significant for meniscectomy and ACL subjects at 9 weeks. By this time we would expect the differences between the groups to decrease and the subjects to be in little or no pain. Chondroplasty subjects may have more pain even at nine weeks because they are weight bearing directly on the impaired articular cartilage.

Our study is consistent with previous results reported by Werners et al. that showed a progressive decrease in low back pain with use of IFC.⁹ However, in that study the IFC group was compared to a group receiving motorized lumbar traction and massage, and not a placebo group. In contrast to our results, van der Heijden et al. found no effect of IFC on soft tissue shoulder disorders.¹⁰ However, this study excluded subjects with any inflammation in the glenohumeral joint and did not involve post-operative subjects. Our study is based on the

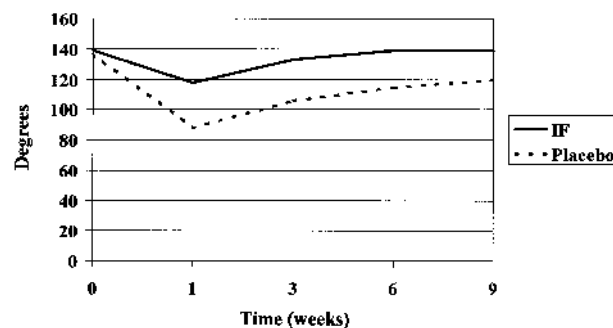


FIG. 7. ACL Reconstruction: ROM.

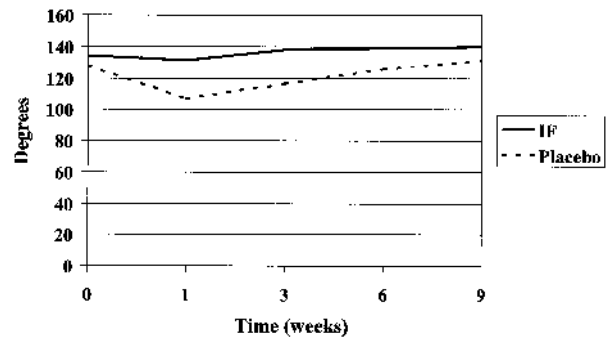


FIG. 8. Chondroplasty: ROM.

premise that IFC helps to reduce the pain associated with inflammation in and around the joint. Some degree of inflammation will be present in all of the post-operative subjects.

A problem with the pain data is that the treatment groups did not report similar values pre-operatively. Ideally all groups would be the same upon entering the study. ACL and meniscectomy IFC subjects reported significantly more pain. Although this was undesired, it does not weaken the results, since the IFC subjects still reported significantly less pain at day 1 despite starting with more pain.

We would expect that the data for pain medication taken would correlate closely with the pain data. However, since pain magnitude was not measured at the same time points as pain medication data, it is difficult to completely assess the correlation. We would still expect significant differences in the amount of pain medication taken on days 1-10 based on the amount of pain reported on days 1, 2, 3, and 7. While placebo subjects did take more medication at all time points, the difference was only significant at some points. This may just indicate that one cannot directly correlate pain reported with pain medication taken due to differences in individual pain tolerance and need for medication among study subjects.

Because all IFC subjects had decreased pain at all points, then it is expected that they would be able to tolerate more physical therapy and achieve greater range of motion as well. This was the case and is the major theory behind the benefits of IFC. It is surprising to see such a large difference at nine weeks between the treatment groups. For example, ACL IFC subjects had a

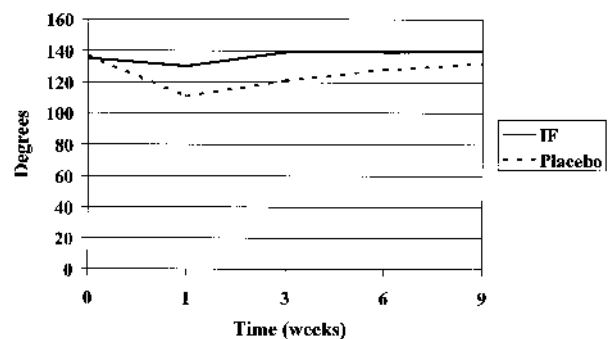


FIG. 9. Meniscectomy: ROM.

mean of 19 degrees greater range of motion at that time. We suspect that these results are partially due to the effects of IFC and partially due to the placebo effect.

We would similarly expect significantly decreased edema at all time points for the IFC subjects, and this was the case except for the chondroplasty subjects in weeks 5 to 9. A potential shortcoming of this aspect of the study was that the subjects measured the knee circumference themselves. Since the data shows a progressive decrease in edema over the nine weeks, with all data points fitting the progression, it is likely that the subjects were measuring correctly. In addition the edema results were consistent with the results for the other parameters. For meniscectomy and chondroplasty IFC subjects, the knee circumference became less than the pre-operative value. This may be explained by the presence of pre-operative edema due to the original injury.

Applying IFC as soon after surgery as possible and giving patients home IFC units appears to be of great benefit to subjects. As soon as 24 hours after surgery, IFC subjects had significant improvements over placebo subjects. This suggests that patients with immediate IFC followed by home IFC will return to regular activities and perhaps athletic activities sooner than non-IFC subjects. Our study could have been enhanced by the use of a functional assessment scale with these parameters as endpoints. This may have added further support to our conclusions. Although these functional parameters were not used as clinical endpoints for this study, they may serve as useful endpoints for a subsequent study. The magnitude of the significance of the results at 24 hours also suggests that home IFC may be useful in the pre-operative setting, which could be the subject of another randomized controlled trial.

It is possible that the main benefit of IFC is in the first few weeks of treatment. This would allow the IFC subjects to progress more rapidly in physical therapy, and could account for the continued differences in pain, edema, and ROM that the IFC subjects experienced. A useful study could have one IFC group receive 3 weeks of home IFC and the other receive 9 weeks of home IFC. A study of this type may help determine the cost-effectiveness of using home IFC. The potential cost savings due to a decrease in the amount of medication taken and the number of physical therapy visits needed may be much more than the cost of the home units. If a follow-up study proves that the home unit is only needed for the first three weeks, then home IFC may prove to be even more cost-effective.

CONCLUSION

We recommend that physicians performing knee surgery consider using IFC immediately after the surgery and then supplying home IFC for the patient. Home IFC allows the patient to receive IFC three times per day as opposed to three to five times per week. The decrease in pain and associated increase in ROM and decrease in edema can help the patient to return to regular activities of daily living and possibly even athletics sooner than if they do not use home IFC. The decrease in amount of pain medication taken and number of physical therapy visits needed could also prove to decrease costs.

In this study we have not compared IFC to other modalities and we do not claim that IFC is preferred over those modalities. We are simply stating that home IFC is more effective than placebo. Home IFC serves as yet another tool to help patients recover quickly and regain function. It is our recommendation that home IFC combined with several other physical therapy modalities would deliver the greatest therapeutic effect.

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