Original Article

Impact of interferential current on recovery of pressure ulcers grade 1 and 2

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Abstract

Background: Pressure ulcers' treatment imposes a considerable cost on health system and patients. Electrical stimulation has already been introduced as an effective method for promoting wound healing. This study was conducted to determine the impact of interferential current (IF) on healing of pressure ulcers (grade1 and 2).

Materials and Methods: In this clinical trial, 23 patients (12 as cases and 11 as controls) were recruited. The study group was treated with IF daily for 10 days. IF current was applied via isoplanar current with a sweep frequency of 30–99 Hz and with tolerable intensity for 15–20 min. Before intervention, condition of the wounds was assessed and recorded. Routine characteristics of the ulcers in both groups were recorded before intervention (first day) and on the fifth and tenth days after intervention. SPSS (ver. 13) with paired *t*-test and Fisher's exact test was also used to analyze the data. A P-value of 0.05 was considered significant.

Results: According to one-sample Kolmogorov–Smirnov test, demographic characteristics, features of ulcer, as well as the intensity of pain were not significantly different between the study and control groups. All patients in the control and study groups were complaining of pain (7.25 ± 1.21 in the intervention group vs. 6.35 ± 1.28 in the control group). Ulcer size decreased significantly in the study group ($P = 0.012$) with a significant reduction in pain intensity ($P = 0.000$), amount of discharge ($P = 0.008$), and level of edema ($P = 0.000$), compared to controls.

Conclusion: As a first study in this field, the results showed that the use of IF current can accelerate pressure ulcer healing and reduce its size. As IF current can be considered as a deeper form of Transcutaneous Electrical Nerve Stimulation (TENS), it seems to be a safe method with no side effects.

Key words: Healing, interferential current, pressure ulcer

Introduction

Pressure ulcers pose a serious problem challenge for the health care providing system and all health care team members because of their impact on quality of care and patients' satisfaction. Treatment of pressure ulcers imposes a considerable cost on health care system and patients. Moreover, it needs considerable resources and expertise manpower.[1,2] Pressure ulcers are more common in patients who have impaired physical mobility, bladder and bowel incontinency, malnutrition, or loss of consciousness. These ulcers are experienced not only by long-term bed-rested patients but also by paraplegic or quadriplegic patients who sit constantly on wheelchair for a long period of time. In addition, factors such as permanent pressure and moisture on intact skin, skin lesions, malnutrition, dehydration, cachexia, and poor blood circulation of the skin make a patient prone to pressure ulcers.[3]

Pressure ulcer is a necrotized area (skin and underneath tissues) over under-pressurized part of the body due to insufficient circulation. The major cause of ulcers is topical pressure and impaired blood circulation. Therefore, the pathological changes in wound area occur through obstruction of blood vessels, particularly arterioles and capillaries. Pressure-induced vascular injuries are generally due to body weight. In case of obstructed blood flow, cellular nutrition is deteriorated and the cells' excretions accumulate, and finally cell necrosis occurs and ulcers appear.[4]

Most pressure ulcers are preventable. The most important principle of health care in patients who are at risk of pressure ulcer is to prevent it, but the wound might worsen and change to stage III and IV, if it was not controlled or treated in early stages (grade I and II). Consequently, Severe pressure

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ulcers have a major impact on the patient and health care team, as they require more invasive therapeutic procedures like surgical debridement.[5] These conditions not only result in physical and mental complications in patients, but also impose significant costs to individuals and the society.

Various methods are used for the treatment of pressure ulcers, including different kinds of biological dressings, different surgical procedures such as flaps, use of growth factors, gene therapy, and so on.[1,2,6-9] One of the promising methods in treatment of pressure ulcers is the application of electrical stimulation.[8] Electrical stimulation has been already used as an effective method for promoting wound healing and controlling tissue edema.[10] In many researches, electrical simulations have been applied to promote wound healing and positive results have been reported.[10-17]

Houghton *et al*. reported that electrical stimulation can induce cellular functions in all stages of wound healing, Which include influencing on fibroblast activity such as synthesis of collagen and ribonucleic acid dioxide synthesis, production of adenosine triphosphate, and improving calcium shift into the cell.[18] Interferential (IF) current is a kind of electrical stimulation that reduces the pain intensity by producing an alternative current with a variable frequency (1–150 Hz).

IF current is a high-frequency electrical current (4000 Hz) produced by topical electrodes, which can penetrate deeper layers of the skin, and therefore relieves the pain and discomfort of patients who have musculoskeletal pain.[19] In this, the current is produced by the intersection and interaction of two mid-frequency generator circuits apart from each other inside the body tissues. The frequency of these two currents is about 4000 Hz, but one of them is fixed and the other one is in the range of 4000–42,50 Hz. Wherever these two circuits intersect each other inside the body, they produce a low-frequency current (0–250 Hz) called "beat frequency," which can stimulate sensory and motor neurons.[20]

Researchers have reported different effects for IF currents, such as increase in blood flow due to impact of IF on parasympathetic nerve fibers and muscle contractions induced by electrical stimulation that result in better venous and lymphatic return. These currents also can be applied to expedite healing of wounds and bone fracture through improving cellular function and increasing the cell proliferation.[10] It seems that IF current alters the concentration of intracellular enzymes and other molecules which are important in several metabolic processes. In many researches, changes have been reported in the titer of cyclic adenosine monophosphate, acetylcholine esterase, alkaline phosphatase, and lysosomal enzymes. Such effects were utilized to improve healing of fractured bone, regeneration of the nerves, tendons, and ligaments, and even improving liver regeneration.[10] IF current may temporarily reduce patients' pain by acting as a competing stimulus which can facilitate healing of the lesions because of pain reduction. In healthy condition, the body cells act in a way that causes the establishment of an alternating current with a determined frequency that is called biological frequency. However, following any tissue injury, function of the cells is changed, and they may configure in an abnormal pathway and may even cause damage to the tissue; hence, they threaten the general health of an organ or body. Meanwhile, changes in biological potential frequency may occur, which is known as the "standing potential."

Fortunately, several researches have been conducted in the field of expediting tissue repair and relieving uncomfortable symptoms like musculoskeletal pain, diabetic ulcers, soft tissue injuries, osteoarthritis, etc. These researches have shown that the utilization of IF current is beneficial. Of course, there is a special treatment regimen for each one of the mentioned cases.[21,22] Application of IF current can be a safe and inexpensive method for the healing of pressure ulcers. We did not find any clinical trial about the effect of IF current on pressure ulcers, so it seems that this study might be the only one conducted in this field.

Pressure ulcers have been found to be a major problem in immobile patients, as without proper treatment, they may be complicated by enormous physical, psychological, and economic difficulties. So, researchers sought to study IF currents' effects on the healing of grade 1 and 2 pressure ulcers. Therefore, this study was performed to determine the impact of IF currents on the healing of pressure ulcers (grade 1 and 2) in Shahid Rajaei teaching hospital in Qazvin University of Medical Sciences.

Materials and Methods

This study was a non-randomized clinical trial that was conducted after obtaining approval of the ethics committee of Qazvin University of Medical Sciences. In this quasi-experimental study, patients with grade 1 and 2 pressure ulcers who were hospitalized in the orthopedic and surgical wards of Shahid Rajaei teaching hospital (affiliated to Qazvin University of Medical Sciences) were recruited. The age range of the selected patients was 40–80 years, and they were immobile but alert. Moreover, they did not have urinary and fecal incontinence, and they were given hospital food. An informed consent was signed by all participating patients. Then, the patients were randomly divided into two groups of intervention (study) and control, so that from the beginning of the project, every patient meeting

the inclusion criteria was allocated alternately to the study and control groups. At first, demographic characteristics and data relating to the ulcer condition were collected by the evaluator and the staging of the ulcer was determined. Then the diameter of the ulcer was measured with a ruler and other features of the ulcer such as color, edema, and discharge were recorded.

Patients were asked to express the intensity of their pain based on a 10-point scale of pain intensity. Routine treatment (including massaging the skin around the ulcer, irrigating the ulcer with normal saline, and putting gas dressing on the ulcer) was performed for both groups. In addition to these treatments, the study group was also treated with IF current for 10 sessions (10 days). Treatment with IF current was performed via isoplanar current with a sweep frequency of 30–99 Hz and tolerable intensity. It was applied once a day for 15–20 min. In this study, four 3 × 2 cm bipolar superficial electrodes were used and while applying the current, disposable sterile covers were put on the electrodes. Electrodes were placed on the four sides of the ulcer, so that electrodes of each channel were made to face each other in a crossed form.

Intensity of the pain and other characteristics of the ulcers of patients in both groups were evaluated before the intervention and then on the fifth and tenth days of the study and data were recorded. Reduction in the mean of the ulcer size was compared in order to evaluate the changes in the size of the ulcers. Paired *t*-test and Fisher's exact test were also used to analyze data. A *P*-value of 0.05 was considered significant.

Results

All data of this study were statistically analyzed using SPSS software (ver. 13). Before conducting any statistical test, the data distribution was evaluated using one-sample Kolmogorov–Smirnov test in both groups and the results showed that demographic characteristics, features of ulcer, as well as the intensity of pain were not significantly different in the study and control groups. A total of 23 patients were examined in this study, of which 11 patients were assigned to the control group and 12 patients to the study group. Also, 65.2% of patients were female and the rest (34.8%) were male. Mean age in the study and control groups was 64.2 ± 26.9 and 62.9 ± 23.2 years, respectively. Most subjects in both groups (54.5%) had undergone surgery. Most ulcers in both groups (65.2%) were in the gluteal region. Demographic characteristics of the patients and their ulcers, before and after the intervention, are presented in Tables 1 and 2, respectively.

Table 1: Characteristics of patients and their ulcers in the study (n=12) and control (n=11) groups

Patients' characteristics	Study group (n=12)		Control group (n=11)		Total	
	n	%	*n*	%	*n*	%
Gender						
Female	7	41.7	8	72.7	15	65.2
Male	5	58.3	3	27.3	8	34.8
Reason of hospitalization						
Orthopedic reason	6	50	5	45.5	11	47.8
Surgery	6	50	6	54.5	12	52.2
Region of ulcer						
Heel	0	0	1	9.1	1	4.3
Gluteus	8	66.7	7	63.6	15	65.2
Sacrum	4	33.3	2	18.2	6	26.1
Thigh	0	0	1	9.1	1	4.3
Grade of ulcer						
Grade I	3	25	6	54.5	9	39.1
Grade II	9	75	5	45.5	14	60.9
Color of ulcer						
Pink	2	16.7	4	36.4	6	26.1
Red	10	83.3	7	63.6	17	73.9
Edema						
Yes	8	66.7	5	45.5	13	56.5
No	4	33.3	6	54.5	10	43.5
Discharge						
Serous	3	25	4	36.4	7	30.4
Serosanguineous	5	41.7	3	27.2	8	34.8
No discharge	4	33.3	4	36.4	8	34.8

In the control group, most ulcers (54.5%) were grade I, but in the intervention group, 75% of the ulcers were grade 2. Also, 83.3% and 63.6% of ulcers in the study and control groups, respectively, were red-colored ulcers. 45.5% of the ulcers in the control group and 66.7% of ulcers in the study group had edema. 66.7% of ulcers in the study group and 63.6% of the ulcers in the control group had discharge. In the study group, most ulcers (62.5%) had serosanguineous discharge, but in the control group, most ulcers (57.1%) had serous discharge. All patients in the control and study groups were complaining of pain. The mean and standard deviation of the pain intensity in the intervention group was 7.25 ± 1.21 and in the control group was 6.35 ± 1.28.

- Size of the ulcer: Comparison of the size of the ulcer on the first and fifth days between groups showed that the ulcer size in the intervention group had reduced by a mean reduction of 10.94 ± 12.5 mm, whereas in the control group, the size had increased by a mean of 9.9 ± 16.5 mm. Paired *t*-test showed a significant

difference between the size of the ulcer on the first and fifth day ($t = 3.34$, $P < 0.003$) [Tables 2 and 3]

- Ulcer had reduced in size between the first and tenth days in the study group by a mean of 14.5 ± 14.1 mm, but in the control group, it had increased by a mean of 13.8 ± 29.2 mm. So, paired *t*-test showed a significant difference in ulcer size at the 1st and 10th sessions. It means that the ulcer size has decreased significantly in the study group ($t = 2.78$, $P < 0.012$) [Tables 2 and 3]
- Pain intensity: Pain intensity reduced on the first and fifth days in the study group by a mean of 2.58 ± 1.37, whereas it increased in the control group by a mean of 0.45 ± 1.91. Paired *t*-test ($t = 4.39$, $P = 0.000$) showed a significant difference in the pain intensity of patients between the study and control groups at the first and second time of data collection
- Pain intensity of the patients in the study group reduced by 4.36 ± 1.56, while in the control group, it showed a mean increase of 0.81 ± 3.31. Paired *t*-test showed a significant difference between the pain intensity at the first and third time of data gathering ($t = 4.7$, $P = 0.000$) [Tables 2 and 3]
- Discharge: Ulcer discharges in patients receiving IF currents had reduced. Thus, comparison of the amount of discharges on the first, fifth, and tenth days between the study and control groups showed significant difference ($P = 0.008$) [Table 2]
- Wound edema: Comparison of edema in patients with pressure ulcers on the first, fifth, and tenth days between the study and control groups showed that edema was significantly decreased at the end of the tenth day in the study group and this difference was statistically meaningful ($P = 0.000$) [Table 2]
- Wound color: At the end of the treatment, half of the patients had pink or colorless ulcers in the study group, while no noticeable changes in color were observed in the control group. Comparison of the colors of pressure ulcers between the two groups using Cochran's test showed a significant difference ($P = 0.022$) [Table 2].

Table 2: Characteristics of patients' ulcers during the intervention in the study (n=12) and control (n=11) groups

Characteristics of ulcers	Study group			Control group		
Ulcer size	Mean (mm)	SD		Mean (mm)	SD	
1st day	25.06	19.06		24.82	37.17	
5th day	16.44	13.78		34.73	42.35	
10th day	9.98	9.35		38.65	50.02	
Pain intensity (0-10)	Mean	SD		Mean	SD	
1st day	7.25	1.22		5.64	1.29	
5th day	4.67	1.78		6.09	1.76	
10th day	2.82	2.14		6.45	2.88	
Ulcer color (*n*)	Pink	Red	Colorless	Pink	Red	Colorless
1st day	2	10	0	4	7	0
5th day	2	10	0	2	9	0
10th day	4	6	2	2	9	0
Edema (*n*)	Yes	No		Yes	No	
1st day	8	4		5	6	
5th day	5	7		8	3	
10th day	4	8		9	2	
Discharge (*n*)	Yes	No		Yes	No	
1st day	8	4		7	4	
5th day	6	6		9	2	
10th day	4	8		9	2	

Discussion

This is the first study conducted on utilizing IF currents to control and improve the healing process of pressure ulcers. The results of this study showed that the use of IF current on the area of pressure ulcers accelerates wound healing and reduces their sizes.

Houghton *et al*. showed that electrical currents can induce cellular functions in all phases of wound healing. These

Table 3: Comparison of the mean of changes in ulcer size and pain intensity between study (n=12) and control (n=11) groups

	Study group		Control group		*P* value
	Mean±SD	95% CI	Mean±SD	95% CI	
Ulcer size (mm)					
Before-5th day	10.94±12.49	2.54-19.33	−9.9±16.51	−21.0 to 1.18	0.003
5th day-10th day	5.77±8.81	−0.15 to 11.69	−3.92±19.61	−17.1 to 9.25	0.150
Before-10th day	14.53±14.10	4.44-24.62	−13.83±29.23	−33.47 to 5.8	0.120
Pain intensity (0-10)					
Before-5th day	2.58±1.37	1.70-3.45	−0.45±1.91	−1.74 to 0.83	<0.001
5th day-10th day	1.72±0.78	1.19-2.25	−0.36±1.5	−1.37 to 0.64	0.001
Before-10th day	4.36±1.56	3.31-5.41	−0.81±3.31	−3.04 to 1.4	<0.001

SD: Standard deviation

functions include stimulating fibroblast activities such as promoting collagen and ribonucleic acid dioxide synthesis, production of adenosine triphosphate, improving calcium shift into the cell, and increasing the number of locations of growth factor receptors. Also, the results of laboratory studies performed on macrophages, epithelial cells, and fibroblasts showed that the electrical stimulation causes activation and migration of key cells into the ulcer area.

Studies on animal models indicate that the electrical stimulations on ulcers result in more collagen deposition, increasing the angiogenesis, improving the tensile ability of the wound, and accelerating the ulcer healing process. In addition to the direct cellular effects, electrical stimulation improves tissue perfusion and, therefore, reduces swelling.[18] Increased blood flow following the use of IF current has also been confirmed by other researchers including Johnson. He reported in his study that the use of IF current increases regional blood perfusion and reduces ischemic pain.[23] Ebrahimi *et al*. also showed in their study that following the use of IF current, the mean of pulse rate is increased.[21] Goats reported in a review study that following the use of IF current of frequency between 90 and 100 Hz for 8 min in patients with Raynaud's syndrome in the area of cervical satellite ganglion, Pulse strength in the digital vessels doubled. Also, in another study, positive results were reported about the blood flow increase in the ulcerated area of patients with peripheral vascular disease who received IF currents with frequencies of 0–100 Hz for 10 min.[10] It seems that such effects could have accelerated wound healing in patients of the present study.

Findings of this study showed that the pain intensity was significantly decreased after 10-day therapeutic sessions with IF current. Comparing the effects of IF, Transcutaneous Electrical Nerve Stimulation (TENS), and electrotherapy, Johnson found that IF current had greater analgesic effect compared to the other two methods. So, the IF current stimulates nerves and underlying tissues by sending small electrical impulses through the skin and causes pain relief.[23] After evaluation of palliative effects of IF, Ebrahimi showed higher pain threshold in patients treated with these currents.[21]

Arbabzadeh *et al*. also conducted a study on the impact of IF current on pain in patients with rheumatoid arthritis and showed that IF currents cause reduction in the knee pain.[24] One of the effects found in the present study was the reduction in the amount of edema in pressure ulcers following the use of IF current. IF currents of frequency 100 Hz are recommended to reduce edema; this kind of stimulation will activate the skeletal muscle pump and inhibit sympathetic activity. Hence, it helps the drainage of fluid from the treatment area. IF currents have a direct effect on the cell membrane, so they reduce the escape of intracellular fluid to the interstitial space. To reduce chronic edema, a two-step treatment session has been recommended. At the first step, the IF current with a frequency of 100 Hz is used to increase vasodilatation; thereafter, treatment with a frequency of 10 Hz activates the skeletal muscle pump and causes return of the fluids to venous and lymphatic vessels.[10]

Greg examined the effect of IF current on pain, edema, and knee range of motion in patients undergoing knee surgery. He found that the postoperative knee swelling has reduced in the intervention group. In general, all patients who had received IF currents showed substantial reduction of pain and edema and increased range of motion.[25] Basically, IF currents can reduce local edema, reducing pain as well as improving the muscle tonicity.[26] In a study conducted on the effects of IF currents on two experimental models of pain, McManus *et al*. showed that these currents are effective on mild pain(before patient reaches pain threshold) particularly when the origin of the pain is cold or mechanical.[27]

In a systematic review of 103 randomized clinical trials about the treatment of pressure ulcers, Reddy *et al*. mentioned 21 studies in which adjuvant treatments such as using electrical currents, ultrasound, and light therapy had been used but no considerable effect was observed,[28] while the present study has shown significant effects of the IF currents on healing of pressure ulcer. It is, of course, crucial to mention that this study has limitations, including the small sample size which prevents the possibility of achieving a definitive conclusion and generalization. But perhaps reliable results could be achieved by repeating the study as a randomized clinical trial and with precise control of samples. As IF current is considered as a deeper form of Transcutaneous Electrical Nerve Stimulation (TENS) with no side effects, it can be used as a method of treatment for pressure ulcers.

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