Transcutaneous Spinal Electroanalgesia (TSE) in Chronic Osteoarthritis of Knee Joint

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ABSTRACT

Transcutaneous spinal electroanalgesia (TSE) is a newly discovered method for control of chronic pain. The current study was conducted to investigate the effect of TSE on pain control in cases of unilateral chronic osteoarthritis of knee joint. Forty female patients suffering from unilateral chronic osteoarthritis of knee joint were included in the study. Their age ranged from 50 to 60 years (X=54, SD=1.2). The subjects were divided into two equal groups, study or TSE group and control group. In the study group TSE was applied through two electrodes placed transcutaneously, one electrode was placed on the mid line of the back at the level of T1 and the other electrode put over the spinous process of T12 to induce spinal cord stimulation using a monophasic
frequency of 600 Hz at 120 volt. The control group received shame TSE. The duration of treatment was 60 minutes repeated three times per week for two weeks. Pressure threshold, pain intensity and active range of motion (AROM) of knee flexion and extension were measured at four occasions, before treatment, after first session, after one week, and after two weeks. The results of the study demonstrated that TSE produced a significant increase in pressure threshold, significant reduction of pain intensity, a significant increase of AROM of knee flexion and non significant increase of AROM of knee extension. Control group showed no placebo effect. Significant difference in all measurements at the four occasions were found between the two groups except in AROM of knee extension, significant difference was found only after two weeks measurements. Non significant increase in AROM of knee extension may be attributed to muscle weakness and soft tissue changes that requires strengthening and ROM exercises. This study confirmed that TSE could produce non-segmental analgesia of painful sites remote from the site of application and it is an effective method of control of chronic osteoarthritic pain.

Key Words: *Transcutaneous spinal electroanalgesia, Spinal stimulation, Pain, Osteoarthritis.*

INTRODUCTION

Pain is necessary for survival but chronic pain is disabling and causes significant health and economic problems[29]. Several physical modalities have been used to control or alleviate the pain associated with a wide range of musculoskeletal and neurological disorders including electrical stimulation[28], trans-cutaneous electrical nerve stimulation[18,26], ice[5], heat[2], and exercise[4]. All these modalities are applied peripherally to the tender regions and produce analgesia by increasing cutaneous

- Pressure threshold measurement. The pressure threshold meter was calibrated before measurement. The maximum painful area was located (usually at the joint lines) and marked with a felt tipped marker, then the pressure gauge was applied at right angle vertical to the skin on most painful area. The pressure is increased continuously at an even rate at 1Kg /sec/cm^2 using a stop watch to ensure controlled rate.[3,6] The pressure is stopped at the point the patient felt discomfort. Three successive trials were made with five minutes apart[6]. The mean of the three trials was recorded.
- Pain intensity measurement. Visual numerical scale (VNS) was used, the patient was asked to choose a number between 0 to 10, with 0 indicated no pain and 10 untolerable pain. The patient marked the number corresponded to her pain intensity.
- Range of motion measurement. Active range of motion (AROM) of knee flexion and extension was measured using universal goniometer. Each patient during assessment lied supine for flexion and prone for extension. The test position for knee flexion was from supine with flexed hip to 90° to eliminate rectus femorus effect on AROM of knee flexion. The stationary arm of the goniometer was placed parallel to the lateral mid line of the femur and the moving arm placed parallel to the lateral mid line of the fibula pointed towards the lateral maleolus. The axis was placed over the lateral condyle of femure[15]. One goniometer was utilized to reduce error and a mean of three trials was taken for each measurement[12]. ROM of knee extension measurement was recorded as extensor lag.

Treatment procedures

Following the protocol suggested by Macdoland and Coates (1995), A portable battery operated electrical stimulator was used to deliver monophsic interrupted direct current with rectangular wave which stimulates the spinal cord, using two self adhesive electrodes 50 mm in diameter, the anode was placed on the mid-line of the back at the level of T1 while the cathode was positioned over the spinous process of T12. The stimulation parameters were, a rectangular wave with pulse duration 4 sec and frequency 600 Hz at a high voltage (120volt) delivered at sub-threshold level for tingling sensation[13]. The duration of treatment was 60 minutes repeated three times per week for two weeks. For the control group, the previous procedures were performed but the device was not operated.

Data analysis

Data were collected and statistically analyzed using descriptive statistics of mean, standard deviation (SD) and mean percentage difference (M%D). Repeated measure ANOVA was used to test the difference in M%D of tested parameter among those recorded before and after the first ression, after the first week and after the second week for each group. Independent t-test was applied to test the difference in mean tested parameters between the two groups at the studied intervals seperately. Level of significance was ($P<0.05$).

RESULTS

Before treatment, there was no significant differences between TSE group and control group in all the tested parameters. But, TSE produced a fascinating and cumulative improvements in all measured parameters as compared to the control shame TSE group, figure (1).

Table (1): Mean, SD, M % D, and ANOVA values for both study and control group.

	TSE Group				Control Group			
	Pre	After 1st session	After 1 week	After 2 week	Pre	After 1st session	After 1 week	After 2 week
Pressure threshold Mean ± SD	1.49 ±0.65	2.58 ±0.77	3.85±0.8	5.29 ±1.17	1.61 ±0.99	1.94 ±2.3	1.67 ±1.6	2.3 ±0.37
M% D		98.84%	140.2%	184.4%	-	24.3%	5.2%	-4.8%
F test & P value	F = 64, P< 0.0001*				F= 2.2, P= 0.1			
Pain intensity Mean ± SD	8± 0.89	3.66 ±0.66	1.45 ±1.08	0.8 ±0.82	7.3 ±0.78	7 ±1.8	7.8 ±0.89	8.2 ±1.4
M% D	-	70%	105%	129%	-	5%	1%	-.8
% of complete relief	-	3%	30%	64%	-	-	-	-
F test & P value	F= 41, P< 0.0001*				F= 1.9, P= 0.2			
AROM/ Flexion Mean ± SD	100 ±4.6	107 ±5.2	115.8 ±2.7	118 ±4.3	102.4 ±4.9	105 ±2.1	98.7 ±4.3	100.4 ±6.5
M%D	-	6%	20%	25%	-	2%	-0.5%	-0.3%
F test & P value	F= 6.3, P< 0.001*				F= 0.6, P= 0.2			
AROM/ Extension Mean ± SD	4± 1.2	3.8 ±3.7	3.4 ±1.5	3± 2.4	4.3 ±3.2	4±1.4	4.2 ±1.3	4.5 ±2.2
M%D	-	6%	20%	23%	-	4%	-0.7%	-0.4%
F test & P value	F= 2.4, P> 0.08				F= 2.03, P=0.1			

SD: Standard deviation, M % D: mean percentage difference, and *: significant.

Pressure threshold

Repeated measures ANOVA, demonstrated that TSE produced a significant increase of the pressure threshold of the most tender area (P<0.0001). The M%D of the increase of the pressure threshold as compared to the pre values were 98.84% after first session, 140.2 % after the first week and 184.4% after the second week, while there was no significant difference in of pressure threshold within the control group (P=0.1) as shown in table (1). When comparing with the control group, TSE demonstrated significant higher pressure threshold in all the measured intervals, after 60 minutes of treatment with TSE (P< 0.05), after one week (P<0.0001), and after two weeks (P<0.0001), figure (2).

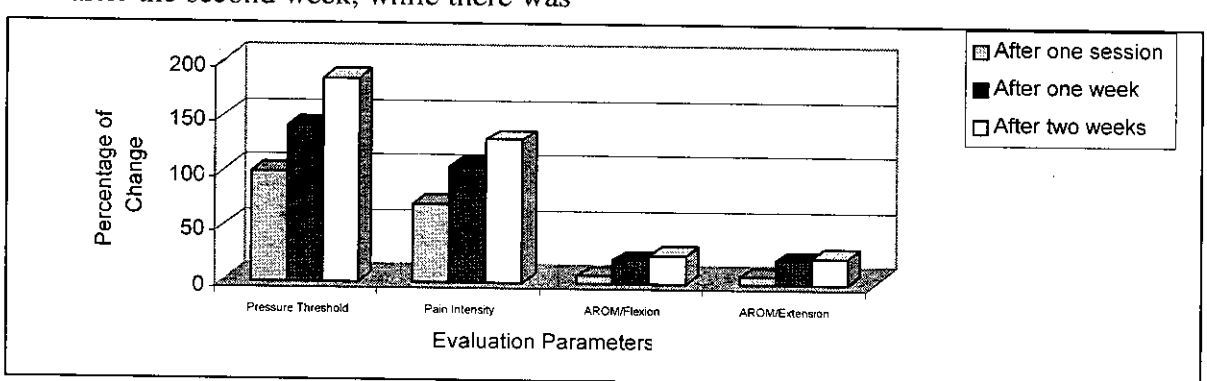

Fig. (1): The mean percentage difference of pressure threshold, pain intensity and flexion and extension AROM in TSE group.

Pain intensity

Data analysis revealed a significant reduction of pain in the TSE group (P<0.0001) and non significant changes in the control group (P = 0.2). Immediately following application 3% of the patients in the TSE group reported complete pain relief, by the end of first week 30% of the patients reported complete pain relief and by the end of the second week 64% of the patients reported complete relieve of pain, table (1). Through the treatment periods, TSE causes a significant reduction in pain intensity as compared to the shame TSE group after one session, one week, and two weeks where (P< 0.01, 0.002, 0.0001) respectively, figure (3).

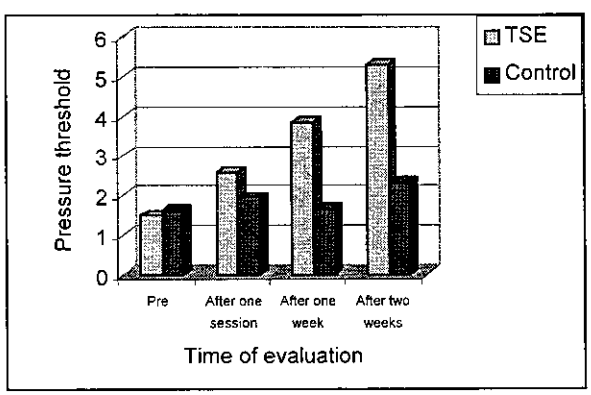

Fig. (2): Mean pressure threshold in TSE and control groups.

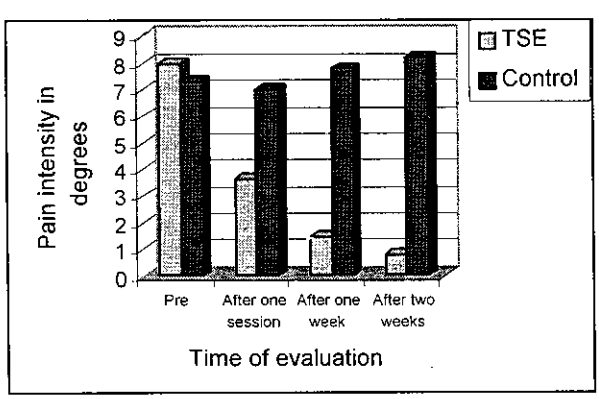

Fig. (3): Mean pain intensity in TSE and control groups.

Active range of motion of knee joint

TSE caused a significant increase in knee flexion AROM (P<0.001) and non significant increase in extension AROM (P>0.08). On the other hand in the control group which received shame TSE, there were no significant changes in both flexion and Extension AROM, where (P=0.2) and (P=0.1) respectively, table (1). When comparing TSE and control group at each test interval, there were significant difference in flexion AROM only after one week and two weeks (P<0.0001and 0.0001), figure (4), while extension AROM the significant difference was found only after two weeks measurements (P<001), figure (5).

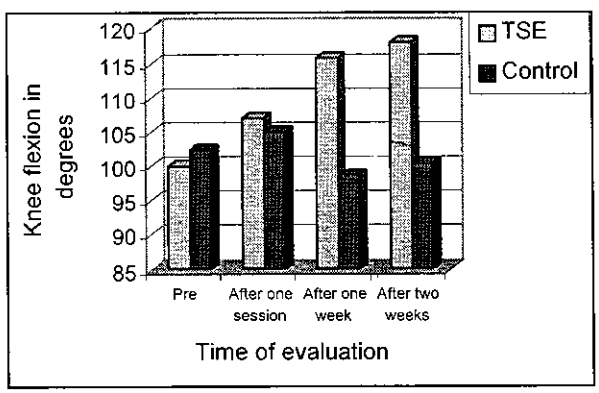

Fig. (4): Mean AROM of flexion of knee joint in TSE and control groups.

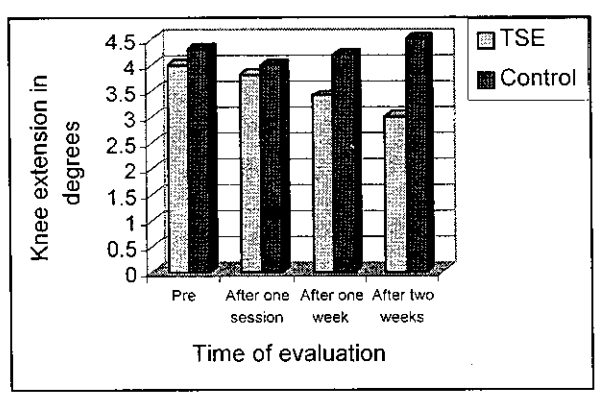

Fig. (5): Mean AROM of extension of knee joint in TSE and control groups.

DISCUSSION

The current study was conducted to investigate the effect of TSE on control of chronic pain of osteoarthritic origin. In the light of the presented results this method is supported as a new means of pain control.

Several methods had been established for pain control of acute or chronic nature from neurological or musculoskeletal origin[2,4,18,20,26,28]. These methods produced analgesia through increasing input from the painful area which inhibit pain at the level of the spinal cord, so inhibiting pain at segmental level.[7] Effect at the cellular level involves excitation of sensory, motor and pain modulating nerve fibers. Pain alleviation takes place through indirect effect on the biological system of the tissue of segmental and systemic levels[14].

The results of this study indicated that TSE was effective in reducing joint pain intensity which was reflected in increasing pressure threshold of tender areas, decreasing pain intensity and improving active range of motion of knee flexion. Statistical analysis showed that the improvement started immediately after 60 minutes of TSE stimulation and continued to be surprisingly increasing through two weeks of treatment.

The analgesic effect of transcutaneous spinal cord stimulation was discovered by Macdoland and Coates (1995), based on the spinal cord stimulation through surgical implantation of electrodes in the spinal cord. The authors of this study provided a non invasive, painless method for spinal cord stimulation to provide a widespread analgesia by making the stimulation central rather than peripheral as in other methods of pain control[13].

In the current study, a very high pulse frequency was used (600Hz) to allow deeper penetration of the current to reach the level of the spinal cord. It was reported that high frequency pulses penetrate deeper by passing the superficial nerve ending and offering more comfortable treatment. The impedance of the skin and adipose layer can be minimized by the use of high frequency signals because in general the higher the frequency the lower the impedance to the current flow[16]. In addition the use of current at relatively high voltage (120 Volts) also permit deeper current penetration. It was documented that high voltage of approximately 100 Volts can cause sudden spontaneous breakdown in skin impedance and this initial resistance drop is followed by a continued lower decrease in skin impedance[14].

In the current study, it appeared that TSE provided commulative effect of analgesia which was demonstrated in the progressive improvement in the tested parameters and supported by the percentage of the patients reported complete pain relief. After one session it was 3%, after one week was 30% and after two week of treatment the percentage number of patients reported pain free reached to 64%.

In the present study, there was no significant reduction in pain level in control group which received sham TSE. This eliminated the possible placebo effect.

The precise mechanism underlying the analgesic effect of TSE is not fully understood but it was suggested that as the stimulating electrodes were transcutaneously placed over the spinal cord, it works through central stimulation and central mechanism of pain inhibition[13]. In addition the pulse duration used was 4 μsec which is too small to stimulate peripheral nerve i.e. the current was not of sufficient amplitude to cause stimulation (action potential) of any peripheral nerve.[27] Mechanism of analgesic effect may be similar

to that proposed in percutaneous or implanted electrodes used for spinal cord stimulation. It was proposed that spinal cord stimulation induced analgesic effect through endogenous pathways mechanism and augmentation of CNS[8]. TSE might produce central stimulating effect. It may affect specific segment as well as spinal cord from T1, to T12.

In this study, although the electrodes were placed at standard position over the spinal cord, yet the inhibition of pain was at site remote from the site of stimulation which indicated that this new method of TSE could be of value in treatment of conditions with multiple painful areas as in osteoarthritis of many joints. This result support the study that performed on 100 suffered from pain of different origin and locations. It was reported that TSE produced widespread analgesia regardless the site of pain providing it is of chronic type[13].

The results of this study showed that TSE had neither an overall effect on AROM of knee extension nor superior effect to the shame TSE except only after two weeks of treatment. This result might be attributed to pain - inhibited quadriceps[24] which might result in muscle weakness because of prolonged lack of activation. Patient in this study suffered from knee pain from 1-2 years. The supposed weakness of quadniceps for a prolonged period of time might indirectly induce soft tissue changes as a result of lack of activity that impaired AROM. That is why full extension range was not achieved which is important for lower limb function activity. Better extension in TSE group after two weeks, as compared with control groups, is suggested to be a result of more capacity of activity of daily living because of less pain. Less pain with increased capacity of activity of daily living might affect AROM. So range of motion exercise as well as strengthening exercise are suggested as a complement measure to pain amelioration method. It is suggested that early strengthening and ROM exercises and in concomitant with pain alleviating method are of great important. Another possible cause of the observed significant difference between the studied groups after two weeks is that in TSE group, there was non significant increase and in shame group there was non significant decrease in AROM of knee extension. The algebraic sum of differences could be significant.

In a recent study, Shelyakin (2000) succeeded in inducing spinal cord stimulation using direct current applied via skin electrodes. The results of the study demonstrated that the use of local direct current passes via skin electrodes promoted improvement of motor and autonomic function.[21] Further researches are required to investigate the effect of TSE on motor and autonomic function.

Only chronic conditions was selected for this study, as it was reported that TSE did not relief acute pain. TSE was reported to reduce the facilitation or sensitisation of spinal cord interneurones that remain a cause of chronic pain when the original inflammation has subsided[12]. This theory requirs further research.

The hypothesis put for this study was partially accepted as TSE had significant effect on pain level and AROM of knee flexion but not of knee extension.

CONCLUSIONS AND RECOMMENDATIONS

TSE is a useful method for pain relief in chronic osteoarthritis. Based on the results of the current study, TSE could provide a mew method for generalized non-segmental pain

control with commulative analgesic effect and could be of great value in cases of multiple painful areas.

Further neurophysiological studies are needed to give full explanation of the underlying mechanism for this new method of pain control, in addition studies to examine the long term effect of TSE and its effect on other types of pain as neurological and cancer pain are recommended.

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الملخص العربي

تسكين ألم التهاب مفصل الركبة العظمي المزمن بكهربة النخاع عن طريق الجلد

إن تسكين الألم بكهربة النخاع عن طريق الجلد وسيلة جديدة لضبط الألم المزمن. أجريت هذه الدراسة لبحث تأثيرها على التحكم في ألم التهاب الركبة العظمي المزمن بطرف واحد ، شارك في هذه الدراسة أربعون مريضة يعانون من التهاب الركبة العظمي المزمن بطرف واحد ، وتراوحت أعمارهن بين 50-60 عاما بمتوسط 54 عاما 1.2 ، وقد قسموا إلى مجموعتين: مجموعة تسكين الألم بكهربة النخاع عن طريق الجلد والمجموعة الضابطة . خضعت مجموعة تسكين الألم بكهربة النخاع عن طريق الجلد لهذه الطريقة للعلاج بوضع قطبين على الجلد إحداهما على خط منتصف الظهر عند الفقرة الصدرية الأولى والأخرى على الشاخصة الفقارية الخلفية عند للفقرة الصدرية الثانية عشر ، كان وقت نبضة التيار الكهربائي المستخدم أربعة ميكرون من الثانية والتردد 600 نبذبة والجهد 120 فولت ، أما المجموعة الضابطة طبق عليها العلاج الإيحائي لنفس التيار واستغرق وقت الجلسة 60 دقيقة وكررت ثلاثة مرات في الأسبوع ولمدة أسبوعين ، اخذ قياس عتبة الضغط وشدة الألم والمدى الحركي الإرادي لثني وفرد مفصل الركبة أربع مرات قبل العلاج ، وبعد أول جلسة وبعد أسبوع ثم بعد أسبوعين . وقد أسفرت النتائج عما يلي: 1- بعد العلاج بتسكين الألم بكهربة النخاع عن طريق الجلد كان هناك زيادة ذات دلالة إحصائية في عتبة الضغط والمدى الحركي الإرادي لثني الركبة وانخفاض في شدة الألم ذو دلالة إحصائية . يوجد تغير ليس ذو دلالة إحصائية في المدى الحركي الإرادي لفرد الركبة . 2- عند مقارنة المجموعتين وجد أن هناك زيادة ذات دلالة إحصائية في عتبة الضغط وزيادة في المدى الحركي الإرادي لثني الركبة وكذلك انخفاضا ذات دلالة إحصائية في شدة الألم في مجموعة العلاج بتسكين الألم بكهربة النخاع عن طريق الجلد مقارنة بالمجموعة الضابطة 3- ليس هناك فرق بين المجموعتين في المدى الحركي الإرادي لفرد الركبة إلا بعد أسبوعين من العلاج . توضح هذه النتائج إن كهربة النخاع عن طريق الجلد لها تأثير على الألم وربما نتج هذا التأثير من التأثير المركزي (على النخاع الشوكي) أما عدم تأثيره قبل أسبوعين على المدى الحركي لفرد مفصل الركبة ربما يرجع إلى أن هناك تغير في الأنسجة الرخوة المحيطة بمفصل الركبة مما يتطلب ضرورة إضافة التمارين العلاجية إلى برنامج العلاج . يستخلص من هذه الدراسة إن طريقة تسكين الألم بكهربة النخاع عن طريق الجلد يمكن أن تضبط ألم الركبة لمرضي التهاب مفصل الركبة العظمي المشابهين لمجموعة الدراسة ولكن هناك حاجة إلى بحث تأثير هذه الطريقة على حالات الألم المختلفة .