

## Original Article

# Acupuncture like transcutaneous electrical nerve stimulation (Tens) on knee osteoarthritis (KOA) with low pain: a pilot study

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Received May 1, 2016; Accepted July 26, 2016; Epub January 15, 2017; Published January 30, 2017

**Abstract:** Objective: To investigate acupuncture-like transcutaneous electrical nerve stimulation (TENS) on improving the condition of knee osteoarthritis (KOA) in different pain level patients. Materials and methods: After assessed by the visual analogue scale (VAS), A total of 98 eligible KOA patients (82 patients were final analyzed) were divided into low pain (LP) group (VAS<5) and high pain (HP) group (VAS≥5). Dysfunctional knees were received TENS everyday in the twelve weeks. ST-36 (Zusanli), ST-34 (Liangqiu), SP-10 (Xuehai), SP6 (Yinlingquan), GB34 (Yanglingquan), BL40 (Weizhong) were the stimulating areas. The VAS, Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and Timed-Up-and-Go Test (TUG) were evaluated in the pre- and post-treatment. Results: At the pre-treatment period, the VAS and WOMAC pain in the LP and HP group were different (P<0.05). Contrary to the pre-intervention, LP performed great improvement in VAS, WOMAC and TUG (P<0.05), while the HP only had positive activity on WOMAC stiffness, function and TUG (P<0.05). Based on the group comparison, LP displayed more positive benefit on WOMAC stiffness, function and TUG (P<0.05) than HP. The changes of each outcome in the LP were larger than that in the HP (P<0.05). Conclusion: In the low pain level patients, TENS performed better analgesia effect and knee function improvement.

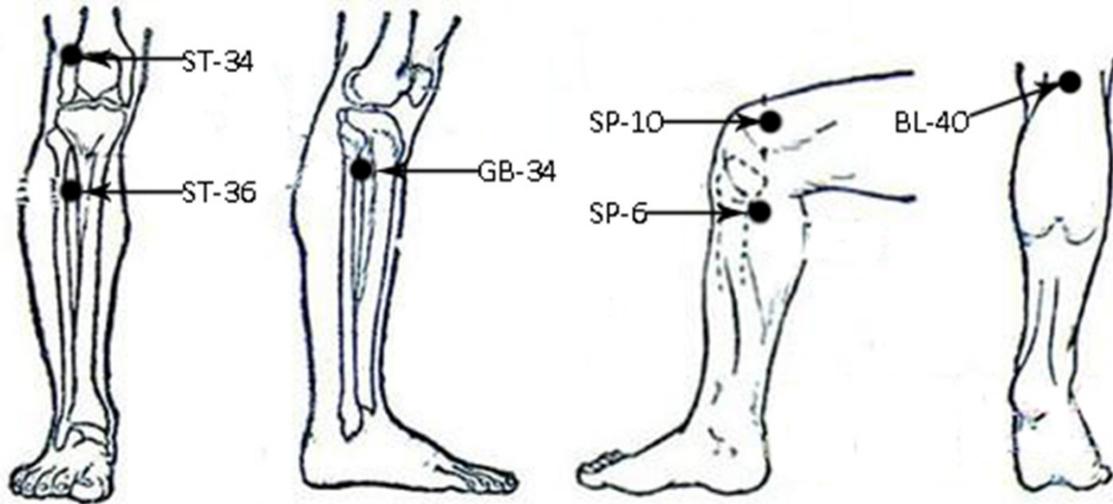
**Keywords:** Transcutaneous electrical nerve stimulation, knee osteoarthritis, pain, knee function, analgesia

## Introduction

Nowadays the knee osteoarthritis (KOA) among elder people appears high prevalence. It is estimated that approximately 15.8 million KOA patients in clinic have severe pain and physical impairment [1] including stiffness, crepitation, instability, loss of function, joint enlargement, and impaired muscle strength. Up to now, Although different kinds of nonsurgical options including analgesics, steroid and nonsteroid anti-inflammatory drugs, glucosamine, chondroitin sulphate and hyaluronic acid are currently available for the treatment of KOA, they are mainly aimed at the symptomatic relief, but not joint cartilage regeneration [2]. Joint replacement is typically recommended to treat the end-stage KOA. The care gap between more conservative treatments and joints replacement leaves many patients with unresolved pain and loss of function for long periods.

Transcutaneous electrical nerve stimulation (TENS) was considered as an effective approach for fighting the pain in KOA [3, 4], which is a neuromodulation approach basing on the "Gate-Control theory" [5]. However some researches did not report positive results [6, 7]. On the other hand, for the physical impairment, it was reported that TENS only had temporary physical function repairmen [8, 9]. The argument whether TENS is benefit to KOA is still troubling the scholars. Acupuncture-like TENS is one of the typical TENS approach in clinic, which combines the theory of acupuncture and TENS. This approach is considered that the stimulus is able to trigger both sensory and motor fibers [10].

At present, it is difficult to assess whether TENS is optimal in KOA management due to many studies have conflicting results. Although it was considered that a large-scale randomized con-



**Figure 1.** The map of acu-points in this study. ST-34 is located at the line joining the anterosuperior iliac spine and lateral border of the patella, and 4 cm above the upper border of the patella. ST-36 is located at the lower bilateral extremity which are slightly below the patella at a depth of 5 cm. GB-34 is located at the depression anteroinferior to the head of the fibula. SP-6 is located at the posteroinferior to the medial condyle of the tibia. SP-10 is located 4 cm above the upper border of the medial patella. BL-40 is located at the midpoint of the transverse crease of the popliteal fossa.

trolled trial was needed to evaluate the effect of TENS on KOA [4, 8], in view of our experiences in clinic, TENS may produce different effect in pain relieve and physical improvement in condition of different pain level. The objective of this study was to assess the changes of TENS on pain and physical function of KOA on the patients with low pain and high pain.

## Materials and methods

### Study design and subjects

This was a single blind controlled cohort trial. Visual analogue scale (VAS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and Timed-Up-and-Go Test (TUG) were identified as the primary outcomes. The sample size was calculated based on a previous study power of 80% ( $\beta=0.2$ ), a false-positive rates of 5% ( $\alpha=0.05$ ), and a predicted difference of 2 points on WOMAC stiffness. Together these parameters with multiple comparisons including the possible loss of 20% of the samples during the study, the results indicated at least 40 participants in each group.

A total of 147 patients were recruited in this study. Finally 98 patients meeting the inclusion and exclusion criteria were involved in this study. After assessed by VAS, those eligible patients ( $n=47$ ), whose VAS were less than 5,

were allocated in the low pain group (LP); on the contrary, those VAS were equal or larger than 5 ( $n=51$ ) were allocated into the high pain group (HP). The total treatment duration lasted 12 weeks.

The VAS and WOMAC pain were the primary outcome to evaluate the pain sensitivity, and the WOMAC stiffness, function and TUG were used to assess the physical function of KOA both in the pre- and post-treatment. The baseline of each outcome was evaluated by a doctor (G. Yang) who also took the TENS operation, but the final outcomes were assessed by another operator (Y.X. Sun) who did not take part in TENS process.

### TENS intervention

All the participants both in the LP and HP will receive the TENS intervention (Hans 100, Nanjing, China) with the same parameter (2/100 Hz, 3 mA). The stimulation areas were selected as acupuncture and moxibustion theory including ST-36 (*Zusanli*), ST-34 (*Liangqiu*), SP-10 (*Xuehai*), SP-6 (*Yinlingquan*), GB-34 (*Yanglingquan*), BL-40 (*Weizhong*) in the bilateral limbs (**Figure 1**). The electrode slices connecting the stimulation device by the wires were pasted on the surface of the corresponding acupoints by the licensed acupuncturists. Patients were asked to come to the outpatient

## TENS on pain of knee osteoarthritis

**Table 1.** The inclusion, exclusion criteria and the contraindications of TENS in this trial

Inclusion criteria
1. No history of steroids and coagulation drugs 1 month before the experiment;
2. No participation of other clinical trial during treatment;
3. Being naïve to TENS;
4. Voluntary signature of Informed Consent;
5. Being able to accomplish the whole treatment;
6. Grade 1 or 2 of Kellgren-Lawrence by the X ray assessment.
Exclusion criteria
1. The failure to insist on this treatment program;
2. The failure to judge the efficacy or incomplete data that impacted efficacy observation;
3. Significant narrowing of joint space;
4. A large amount of osteophytes or the formation of bone bridge in joint space suggested in X-ray images;
5. Presenting bony stiffness;
6. Bvious genu varum and genu valgum
7. Having received operation or arthroscopic treatment
The contraindications of TENS
1. Being complicated with serous disorders in cardio-cerebral vessels, liver, kidney or gastrointestinal tract, and mental disease;
2. Being sensitive to the electrical slices;
3. Being somatic motor and sensory disturbance after stroke;
4. The damages of vessels and nerves on the affected limbs;
5. Having bleeding tendency or having the medication for coagulation;
6. In the period of pregnancy and lactation.

department from Monday to Friday every week and received continuous TENS intervention for 1 hour. The whole treatment period was twelve weeks.

### *Inclusion and exclusion criteria*

Patients with KOA as diagnosed by American College of Rheumatology criteria [11] were potential targets. 98 patients who had KOA according to the criteria were selected as pre-defined inclusion, exclusion criteria and the contraindications of TENS (**Table 1**).

### **Outcome evaluation**

#### VAS

The pain intensity of patients were assessed by VAS for grouping in the pre-treatment. After the whole treatment, VAS was evaluated again. The changes between pre-VAS and post-VAS were the primary outcomes for indicating the effect of analgesia.

#### WOMAC

The WOMAC is a complex index to assess the pain and physical function of KOA in the world.

It consists of 24 items, grouped into 3 subscales (pain, stiffness and physical function) [12]. For each item, there are five alternative answers (0=none, 1=mild, 2=moderate, 3=severe, 4=extreme). The maximum scores in each subscale is 20 points for pain, 8 points for stiffness, 68 points for physical function. If the total scale is higher, that means the disease is worse. WOMAC was assessed in the pre- and post-treatment. The changes of WOMAC, and the post-WOMAC stiffness and physical function were considered as the primary outcomes.

#### TUG

TUG was used to assess the physical function of KOA. Patients was required to seat in a standard chair (height 49.5 cm, width 51 cm) with armrests (height 68.5 cm). The details test process: "when one instructor say 1, 2, 3 go. Subjects have to stand up from the chair, walk toward a line, and then return back and sit down". The line was 3 m from the chair. The total process was recorded by a digital watch (the nearest 1/100). Every participant was tested twice, and the average score would be calculated [13]. The post-TUG and the differences

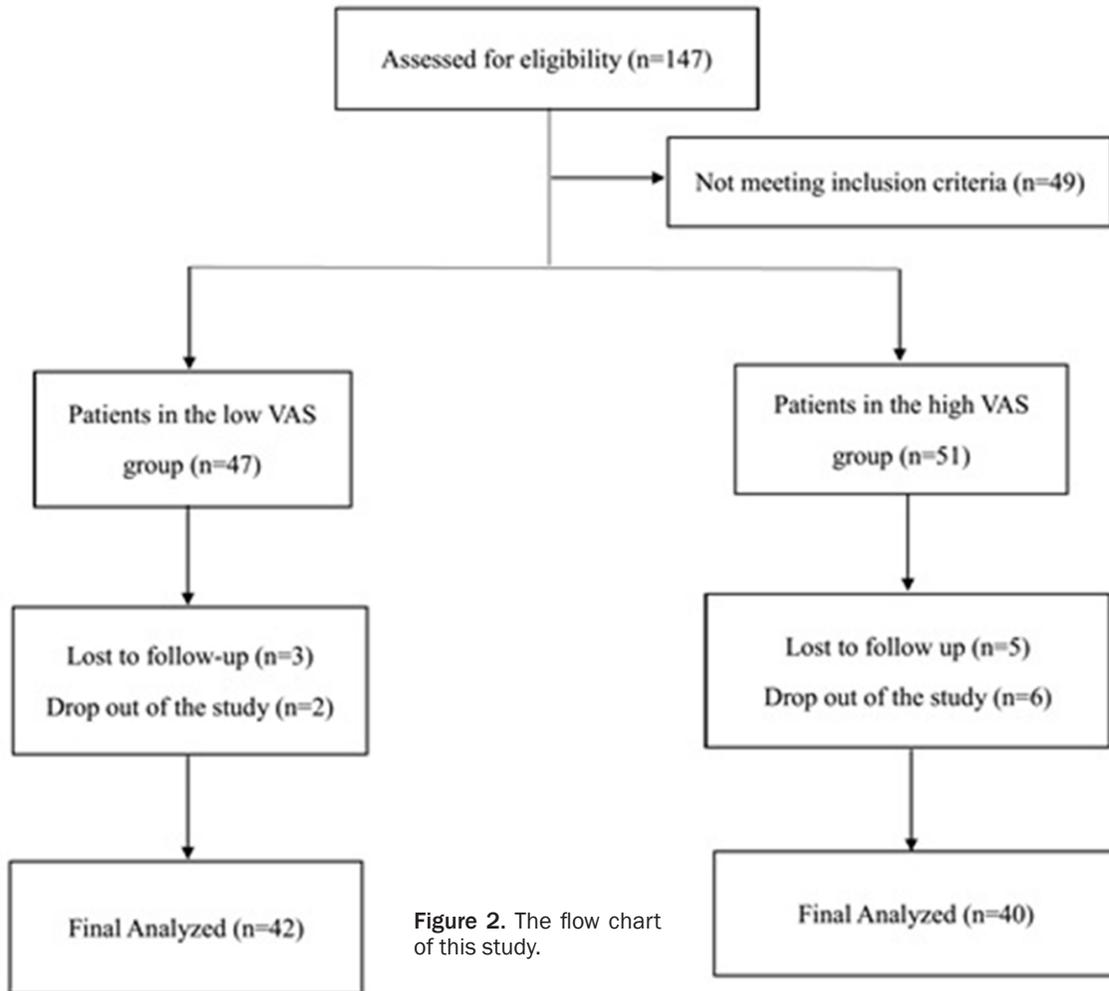


Figure 2. The flow chart of this study.

between pre- and post-treatment were the main outcomes.

This trial was approved by the ethics committee of Fujian university of traditional Chinese medicine (Ref. 201207202). All enrolled patients were requested to sign the Patients' informed consent before the experiment.

*Statistical analyses*

All statistical analyses were calculated by the SPSS 18.0 (SPSS Inc. Chicago, US). Mean and standard deviation were calculated for all data. The Kolmogorov-Smirnov test was used to determine normality of distributions. If the data was non-normal distribution, median data would be reported. Fortunately all data were normally distribution. The sexual and Kellgren-Lawrence assessment were compared using a  $\chi^2$  test. Paired t test was used to analyze the

differences between pre- and post-treatment. Independent t test was used in the group comparison.  $P < 0.05$  was considered as statistical significant.

**Results**

*Basic characteristic*

A total of 147 patients were enrolled in this study in the first stage. 98 eligible participants were included in this trial. As time goes, 5 patients in the LP and 11 patients in the HP withdrew this trial. Of 16 patients, 8 patients might be dissatisfied with this effect of TENS and informed us to drop out of the study. The others were lost without any response. In final, 42 patients in the LP and 40 patients in the HP were analyzed (Figure 2). Based on the analyses of basic information, there was no differences in the gender, age, body mass index

## TENS on pain of knee osteoarthritis

**Table 2.** The basic information of enrolled patients

Demographic Characteristics of the included subjects			
	Low Pain (n=42)	High Pain (n=40)	P value
Gender (Male: Female)	22:20	17:23	0.37 (X <sup>2</sup> =0.80)
Age (years)	60.1 ± 11.7	59.7 ± 11.8	0.88
BMI	29.11 ± 5.44	29.99 ± 5.46	0.47
History of knee osteoarthritic (years)	5.85 ± 3.28	5.74 ± 2.49	0.87
Kellgren-Lawrence assessment (Grade 1: Grade 2)	21:21	18:22	0.65 (X <sup>2</sup> =0.21)

**Table 3.** The VAS in the pre- and post-intervention

	Low Pain (n=42)	High Pain (n=40)	P value*
VAS of pre-intervention	3.33 ± 1.29	7.35 ± 1.25	0.00
VAS of post-intervention	2.43 ± 1.34	7.41 ± 1.28	0.00
The changes of VAS	0.89 ± 0.56	-0.06 ± 0.25	0.00
P value#	0.00	0.12	

VAS: visual analogue score; \*: The comparison between Low pain group and High pain group; #: The comparison of VAS between the pre-intervention and post-intervention in the same condition.

**Table 4.** The WOMAC in the pre- and post-intervention

	Low Pain (n=42)	High Pain (n=40)	P value*
WOMAC pain of pre-intervention	8.88 ± 4.72	15.48 ± 2.56	0.00
WOMAC pain of post-intervention	4.62 ± 3.04	15.28 ± 2.79	0.00
P value#	0.00	0.42	
The changes of WOMAC pain	4.25 ± 3.07	0.20 ± 1.22	0.00
WOMAC stiffness of pre-intervention	5.67 ± 1.39	5.38 ± 1.48	0.36
WOMAC stiffness of post-intervention	3.07 ± 2.28	4.60 ± 1.66	0.01
P value&	0.00	0.00	
The changes of WOMAC stiffness	2.60 ± 1.41	0.78 ± 0.92	0.00
WOMAC function of pre-intervention	43.40 ± 14.06	44.33 ± 14.07	0.77
WOMAC function of post-intervention	22.71 ± 14.38	37.98 ± 14.25	0.00
P value%	0.00	0.00	
The changes of WOMAC function	20.69 ± 5.71	6.35 ± 4.58	0.00

WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index; \*: The comparison between Low pain group and High pain group; #: The comparison of WOMAC pain between the pre-intervention and post-intervention in the same condition; &: The comparison of WOMAC function between the pre-intervention and post-intervention in the same condition; %: The comparison of WOMAC function between the pre-intervention and post-intervention in the same condition.

(BMI), history of KOA and Kellgren-Lawrence assessment [14] (**Table 2**).

### VAS

In view of different VAS scale, patients were divided into two group. Of course, the VAS in the pre-treatment was difference (P<0.01) (**Table 3**). And the comparison in the post-treatment is unmeaningful. However, the changes

of VAS was statistical difference between LP and HP (P<0.01). This may indicated that TENS in the LP may perform better analgesia. Only LP had analgesia effect from the analyses of VAS between pre- and post-treatment (P<0.01).

### WOMAC

The WOMAC (**Table 4**) were divided into three part. For the WOMAC pain, in the pre-treatment, LP was lower than HP (P<0.01). The changes of WOMAC pain in the LP was larger than that in the HP (P<0.01). Just as VAS analyses, the WOMAC pain in the LP had significant difference between pre- and post-treatment.

On the other hand, the WOMAC stiffness and function were similar in these two groups at the pre-treatment. After TENS intervention, LP performed better improvement than HP at these two indexes

(Both P<0.01). Comparing with HP, The changes of WOMAC stiffness and function of LP were greater (Both P<0.01).

### TUG

TUG means the balance of KOA patients during the standing and walking (**Table 5**). From the group analyses, there is no difference in the pre-intervention, while LP was lower than HP in

**Table 5.** The TUG in the pre- and post-intervention

	Low Pain (n=42)	High Pain (n=40)	P value*
TUG of pre-intervention (s)	30.52 ± 2.69	30.30 ± 2.86	0.71
TUG of post-intervention (s)	25.55 ± 4.35	29.13 ± 3.22	0.00
The changes of TUG (s)	4.97 ± 2.84	1.17 ± 1.35	0.00
P value#	0.00	0.00	

TUG: Timed-Up-and-Go Test; \*: The comparison between Low pain group and High pain group; #: The comparison of TUG between the pre-intervention and post-intervention in the same condition.

the post-treatment ( $P < 0.01$ ). The changes of TUG in the LP was larger ( $P < 0.01$ ). These two group in the self comparison had greater improvement ( $P < 0.01$ ).

### Discussion

This is the first report about the effect of TENS in different pain level. In view of differing from pain level, TENS had more positive effect on analgesia and function repairmen in the low pain patients comparing with high pain. The guideline of this trial supported the evidences of individual treatment of TENS on KOA. Maybe TENS only take effect on the low pain level.

KOA is a kind of chronic arthritis commonly found in clinic, and according to western medicine it is often related with injury, inflammatory reaction, body weight, profession, and nutrition in etiology. It shows disappearance of local knee joint cartilage, accompanied by hyperplasia and sclerosis on the bone edge and subchondral bone as well as thickening of synovium and articular capsule, and contracture of ligament around the joint [15]. Some scholars suggested that the pain relieve was the most important management in the KOA administration [16]. Up to now, some TENS of KOA reports had negative results in pain relieve during the follow up period [9, 17].

However in view of my previous clinical experience, acupuncture like TENS had effect on the KOA to some extend. In this study, through differing the pain level, patients were received the same intervention. Interestingly the low pain group had much better improvement in the KOA, not high pain group, in view of the VAS and WOMAC pain analyses. Furthermore, it is reported that acupuncture like TENS prolonged post-stimulation hypoalgesia than conventional TENS [10]. Maybe the acupuncture like TENS took better effect.

WOMAC stiffness, function and TUG were adopted to assess the function of KOA. Due to the basic pathology of KOA, function disability is the other main symptoms. Pain relieve was corresponding to the function improvement [18]. The pain relieve and functional improvement must be observed together. Although patients

in these two groups both had functional repairmen, the changes of each functional indexes in the low pain group had significant difference comparing that in the high pain group.

Together with above points, it is suggested that acupuncture-like TENS in the low pain level not only has better analgesia but also performs greater functional improvement.

### Limitation

In this study, patients with low pain had much better analgesia and functional improvement. Later clinical studies about TENS on the KOA have to pay more attention on the subjects' pathological condition, such as the hormones in the serum and the central hypersensitive. Although this study have proved the low pain level had more improvement, the detailed mechanisms of the study have to be studied. Previous TENS studies focus on the different parameter comparison [19]. But there is still less of uniform parameter [20]. The parameter in this study have better effect in the low pain group, but there may be another parameter will have better improvement in the high pain. Later our research will take some deep research about this.

### Conclusion

Together with above research, acupuncture like TENS have much better analgesia and function improvement in the low pain of KOA patients. The TENS on KOA research should be more attention on the basic condition of KOA.

### Disclosure of conflict of interest

None.

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