Effectiveness of transcutaneous electrical nerve stimulation (TENS) on post-laminectomy and discectomy pain: Preliminary study

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Objective
To determine the effectiveness of TENS on post laminectomy and discectomy pain and the effectiveness of TENS as patient-controlled analgesia (PCA) on post laminectomy and discectomy pain.

Study design
Randomized patient-blind controlled trial.

Setting
Department of Orthopedics, King Chulalongkorn Memorial Hospital

Materials and Methods
Patients post-laminectomy or discectomy less than 3 level were randomly assigned as patient-blind into 3 groups; each group had 10 patients: placebo TENS, time-scheduled TENS and PCA TENS. The placebo TENS group received sham TENS with no electrical stimulation but the indicator lights were flashing normally. The time-scheduled TENS group received TENS for 1 hour 3 times/day for 2 days post operatively. The PCA TENS group received TENS for at least 15 minutes whenever they felt pain. If the pain did not subside PCA morphine was used as needed in all groups. Pain scores were recorded before administration of TENS and at 48-hour post operation. Satisfaction scores and PCA morphine requirement were recorded at 48-hour post-operation.

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| Result | There was no statistically significant difference in pain scores, satisfaction scores and amount of PCA morphine used among the 3 groups at p < 0.05. Both the time - scheduled TENS and PCA TENS groups had tendency to receive PCA morphine less than the placebo TENS group. No serious complication was found in all groups. |
| Conclusion | There was no statistically significant difference in pain scores, satisfaction scores and amount of PCA morphine used among the 3 groups. Time-scheduled TENS and PCA TENS in post - laminectomy and dissection pain had tendency to decrease the amount of morphine used. |
| Keywords | TENS, post laminectomy and dissection pain, patient - controlled analgesia (PCA). |

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ขวัญยุทธ สุคนธมาน, ณฤควร ชัยประกาย, อาวรรษ ศุภฤทธิ์, ศุภวิต บุญศิริ, สนองศักดิ์ อนุวัลศิริ. ผลในการทดลองหลังผ่าตัดกระดูกสันหลังด้วยเครื่องกระตุ้นไฟฟ้าชนิด TENS. จุฬาลงกรณ์เวชสาร 2552 ม.ศ. – ก.พ. ; 53(1): 13 – 22

วัตถุประสงค์: เพื่อศึกษาถึงประสิทธิผลของ TENS ในการลดปวดผู้ป่วยหลังผ่าตัดกระดูกสันหลังและประสิทธิผลของการใช้ TENS แบบ patient - controlled analgesia (PCA)

รูปแบบการวิจัย: การศึกษาเป็นทดลองชนิดมีกลุ่มควบคุมแบบสุ่ม และผู้ป่วยไม่ทราบว่าตนอยู่ในกลุ่มใด

สถานที่ทำการวิจัย: แผนกศัลยกรรมกระดูก โรงพยาบาลจุฬาลงกรณ์

วิธีการศึกษา: ผู้ป่วยหลังผ่าตัดชนิด laminectomy และ dissection ไม่เกิน 3 ระดับได้รับการสุ่มเป็น 3 กลุ่ม กลุ่มละ 10 คน ได้แก่ กลุ่มควบคุม Placebo TENS คือการติดเครื่อง TENS และมีไฟแสดงผลการถึงงานของเครื่องแต่ไม่มีกระแสไฟกระตุ้นจริง Time - scheduled TENS คือ กระตุ้น TENS 1 ชั่วโมง 3 ครั้ง/วัน ทำกัน 8 ชั่วโมง จนครบ 48 ชั่วโมงหลังผ่าตัด และ PCA TENS คือกระตุ้น TENS อย่างน้อย 15 นาที เมื่อผู้ป่วยเริ่มรู้สึกปวดแล้ว หากยังไม่บรรเทา agendas จะให้ PCA morphine ในทุกกลุ่มประเมินระดับความรู้สึกปวด กลุ่มกระตุ้นและหลังผ่าตัดครบ 48 ชั่วโมงประเมินความพอใจสัมผัสของการลดปวด และปริมาณ PCA Morphine ที่ต้องการใน 48 ชั่วโมงหลังผ่าตัด

ผลการศึกษา: ระดับความปวด ความพึงพอใจ และบริบทการใช้ Morphine ในผู้ป่วยทั้ง 3 กลุ่มไม่มีความแตกต่างอย่างมีนัยสำคัญทางสถิติที่ ป<0.05 แต่ในกลุ่ม Time-scheduled TENS และ PCA TENS มีแนวโน้มการใช้ยา Morphine น้อยกว่ากลุ่ม Placebo TENS

สรุป: Time-scheduled TENS และ PCA TENS ในผู้ป่วยหลังผ่าตัด laminectomy และ dissection มีแนวโน้มที่จะลดปริมาณการใช้ Morphine ได้

คำสำคัญ: TENS, ปวดหลังผ่าตัด laminectomy และ dissection, Patient- controlled analgesia (PCA)
In the management of postoperative pain, opioids and non-steroidal anti-inflammatory drugs (NSAIDs) have remained in the focus in most hospitals. Opioids are effective for pain control but they also have many undesirable side effects, such as nausea and vomiting, sedation, respiratory suppression, constipation and urinary retention.

In 1965, Gate control theory by Melzack and Wall (1) explains the pain mechanism via the spinal cord. The spinal cord is not just a passive conduit for pain transmission, but an active modulator of pain signals. This hypothesis led Wall and Sweet (2) to employ electrical current applied to the skin in an effort to activate large-diameter afferents that inhibit small-diameter fibers which results in relief of pain.

Many trials have showed that transcutaneous electrical nerve stimulation (TENS) could reduce the incidence of postoperative complications(3) including pain level after operation(4) such as post cardiac bypass graft (CABG)(5), spinal fusion(6), lumbar spine surgery(7), thoracic surgery(8), and abdominal surgery. Therefore, post-operative TENS should reduce the total requirement for post-operative narcotics and undesirable side effects after abdominal surgery.(9 - 12) and hip prosthesis installation.(13) In contrast, some studies showed lower incidence of pain reduction and reducing of narcotics used.(14 - 17)

In Thailand, Veerawatana et al. studied the effect of TENS in pain reduction with the patients after orthopedic surgery.(16) Two groups were comparable for post-operative pain level. Using continuous TENS for 48 hours, the experimental group showed lower pain level than the placebo group. However, this study had different types of surgery that could affect post-operative pain evaluation.

Previously, there have been different types of surgery and different techniques in the use of TENS. The results, therefore, showed controversy in the effectiveness of TENS in postoperative pain reduction. In Thailand, there has been no study of TENS in post-operative spine surgery. This study is aimed to evaluate the effectiveness of time-scheduled and PCA TENS on post-laminectomy and disectomy pain.

**Materials and Methods**

The study has been approved by the Institution Review Board of the Faculty of Medicine, Chulalongkorn University. After signed their informed consent form, patients who were scheduled to receive laminectomy or disectomy at the Department of Orthopedics, King Chulalongkorn Memorial Hospital were enrolled into the study under the inclusion and exclusion criteria.

**Inclusion criteria:**

1. In patient who is undergoing laminectomy or disectomy that does not extend more than 3 levels (moderate pain)
2. The patient has good consciousness and is well co-operative

**Exclusion criteria:**

1. The patient has infection, tumor or malignancy of the spine
2. The patient has spinal cord compression
3. The patient has history of allergy or severe side effect from opioids
4. The patient has history of opioid abuse
5. The patient has previously used TENS
6. The patient is on cardiac pacemaker
Thirty patients were randomly allocated into three groups by block randomization as the followings:

Group 1: Placebo TENS
Group 2: Time-scheduled TENS
Group 3: PCA TENS

All patients were received the same anesthetic protocol and operation technique. Standard transcutaneous electrical nerve stimulation (TENS) and PCA morphine machines were used in this study.

After the incision wound was closed, two 4 x 3.5 cm. sterile electrodes were placed longitudinally on either side of the incision. The electrodes were positioned 2 inches away from the suture line. Conductive gel was applied under the electrode and fixed on the skin with adhesive tape. Four AA batteries were used to produce the electrical stimulation for each TENS machine. The batteries were scheduled to be changed every 24 hours. Pain was measured using 100 mm visual analog scale before administration of TENS machine, and at 48 hours post-operation. Satisfaction score was measured at 48 hours post-operation using 100 mm visual analog scale.

In group 1, the placebo TENS, there was no electrical stimulation, but the functional indicator lights were flashing normally. The patients were told that they may not be able to feel the electrical stimulation. The machine was turned on for 1 hour, 3 times per day. In group 2, the time-scheduled TENS, the frequency of the electrical stimulation was set at 100 Hz, the amplitude was set at the highest tolerated amplitude of electrical stimulation. This group received TENS for 1 hour, 3 times per day. In
group 3, the PCA TENS, the frequency of the electrical stimulation was set at 100 Hz, the amplitude was set at the highest tolerated amplitude of electrical stimulation. TENS was started and continued for at least 15 minutes whenever the patients felt their pain. If the pain did not subside, the patients in all groups could use PCA morphine when needed. The patients were visited 3 times each day by a trained nurse who evaluated the machine and its function. The patients were received only PCA morphine and acetaminophen as analgesic drugs. The pain score, satisfaction score, total morphine used from PCA machine and acetaminophen used were recorded by a trained nurse during the study period.

2. Visual analog scale scores for pain and satisfaction were analyzed:
   - using paired t-test comparing between pre- and post-treatment in both the control and experimental groups.
   - using One-way ANOVA comparing between the control and experimental groups both pre- and post-treatment.

3. The amount of analgesic drugs were analyzed by One-way ANOVA comparing between the control and experimental groups.

4. The statistical significance was set at p < 0.05

**Results**

Thirty patients participated in the study after informed consent had been obtained. There were 28 female and 2 male patients. There was no statistical difference in the mean age, body mass index (BMI), surgical wound length, duration of operation, and postoperative duration before using TENS as shown in table 1.

**Table 1.** Demographic data, surgical wound length, duration of operation, and postoperative duration before using TENS.

<table>
<thead>
<tr>
<th>Patients</th>
<th>Placebo TENS</th>
<th>Time - schedule TENS</th>
<th>PCA TENS</th>
<th>P - Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>n = 10</td>
<td>n = 10</td>
<td>n = 10</td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>57.6 (10.00)</td>
<td>60.50 (10.36)</td>
<td>48.80 (11.99)</td>
<td>0.058</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>24.77 (2.64)</td>
<td>26.47 (3.53)</td>
<td>24.66 (2.37)</td>
<td>0.307</td>
</tr>
<tr>
<td>Wound length (cm.)</td>
<td>14.65 (4.01)</td>
<td>15.95 (2.80)</td>
<td>12.90 (3.20)</td>
<td>0.412</td>
</tr>
<tr>
<td>Duration of operation (min)</td>
<td>254.50 (94.14)</td>
<td>257.00 (42.11)</td>
<td>219.00 (64.36)</td>
<td>0.148</td>
</tr>
<tr>
<td>Postoperative duration before using TENS (min)</td>
<td>144.50 (43.36)</td>
<td>147.00 (50.89)</td>
<td>130.50 (17.07)</td>
<td>0.412</td>
</tr>
</tbody>
</table>
All patients received the same anesthetic protocol and operation technique. Pain was measured before administration of TENS machine, and at 48 hours post operation by using 100 mm visual analog scale. The mean score of visual analog scale before administration of TENS were between 60 - 70 in all the three groups. After administration of TENS, there was statistically significant reduction of pain score (p < 0.05) at 48 hours post-operation in both the control and experimental groups as shown in table 2.

No statistical significance of pain score comparing between each group both before administration of TENS and at 48 hours postoperative (p > 0.05).

All patients also received PCA morphine and acetaminophen as analgesic drugs for postoperative pain control. There was no statistical significance in analgesic requirements in all groups as shown in table 3.

The satisfaction of pain reduction were also evaluated in all patients by using visual analog scale. They were satisfied in postoperative pain control without statistical significance between each group as shown in table 4.

Table 2. Postoperative pain evaluation by visual analog scale, VAS (100).

<table>
<thead>
<tr>
<th>Patients</th>
<th>VAS before administration of TENS Mean (SD)</th>
<th>VAS at 48 hours post operation Mean (SD)</th>
<th>P - Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Placebo TENS</td>
<td>68.30 (16.63)</td>
<td>30.70 (24.53)</td>
<td>0.002</td>
</tr>
<tr>
<td>n = 10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time-schedule TENS</td>
<td>62.80 (19.78)</td>
<td>28.00 (14.65)</td>
<td>0.001</td>
</tr>
<tr>
<td>n = 10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PCA TENS</td>
<td>70.00 (22.85)</td>
<td>36.50 (14.47)</td>
<td>0.004</td>
</tr>
<tr>
<td>n = 10</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3. Postoperative analgesic requirements (morphine and acetaminophen).

<table>
<thead>
<tr>
<th>Patients</th>
<th>Placebo TENS Mean (SD)</th>
<th>Time-schedule TENS Mean (SD)</th>
<th>PCA TENS Mean (SD)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n=10</td>
<td>n=10</td>
<td>n=10</td>
<td></td>
</tr>
<tr>
<td>Amount of morphine (mg.)</td>
<td>60.70 (37.62)</td>
<td>38.30 (17.96)</td>
<td>43.30 (25.57)</td>
<td>0.196</td>
</tr>
<tr>
<td>Amount of morphine per kg</td>
<td>1.03 (0.72)</td>
<td>0.49 (0.21)</td>
<td>0.69 (0.43)</td>
<td>0.075</td>
</tr>
<tr>
<td>Body weight (mg/kg)</td>
<td>1.60 (1.83)</td>
<td>3.00 (3.30)</td>
<td>1.60 (2.06)</td>
<td>0.361</td>
</tr>
<tr>
<td>Amount of acetaminophen (tabs)</td>
<td>1.60 (1.83)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 4. Visual analog scale (100) for satisfaction in postoperative pain control.

<table>
<thead>
<tr>
<th>Patients</th>
<th>Placebo TENS Mean (SD) n = 10</th>
<th>Time-schedule TENS Mean (SD) n=10</th>
<th>PCA TENS Mean (SD) n=10</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAS for satisfaction</td>
<td>79.70 (17.74)</td>
<td>85.30 (9.75)</td>
<td>71.20 (17.38)</td>
<td>0.139</td>
</tr>
</tbody>
</table>

No serious complication was found in all groups. Two patients (one patient in the placebo and the other in the time-scheduled group) complained of mild discomfort from the hard electrode wire.

Discussion

There was no significant difference of pain scores and satisfaction scores among the three groups, this indicated a well controlled of postoperative pain level in all groups. The time-scheduled TENS and PCA TENS groups had tendency to use morphine lesser than the placebo group in both total used and amount per body weight, but had no statistically significant difference. In both the time-scheduled and PCA TENS groups, we used TENS machine in a short period that might not be enough for reduce morphine requirement for pain controlled. In other studies, they used continuous TENS and found that there were statistical significant reduction of analgesic requirement. However, this study only had 30 patients that might not enough to found the statistical significant difference between the control and the experimental groups. We would like to introduce the time-scheduled or PCA TENS for more convenience and less discomfort to the patient. We decided to have PCA TENS to avoid the problem of insufficient time. Nevertheless, future study with sample-size calculation should be done.

Conclusion

There was no statistically significant difference in pain control between the control and the experimental groups. Time-scheduled and PCA TENS used in patients who received laminectomy and disectomy have tendency to reduce the amount of morphine but the difference shows no statistical significance. This might due to small number of the subjects in this study or short period of TENS stimulation.

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