Transcutaneous electric acupoint stimulation reduces intra-operative remifentanil consumption and alleviates postoperative side-effects in patients undergoing sinusotomy: a prospective, randomized, placebo-controlled trial

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Editor’s key points
• Transcutaneous electroacupuncture stimulation (TEAS) may provide non-invasive analgesia with minimal side-effects.
• Well-designed trials are needed to assess acupuncture-based techniques, such as TEAS, over placebo.
• This double-blind randomized controlled trial assesses the use of TEAS for acute perioperative pain.
• TEAS reduced remifentanil requirements and some side-effects compared with placebo.
• This simple, non-invasive technique needs further study of its role in acute pain management.

Background. Although opioids are widely used as analgesics in general anaesthesia, they have unpleasant side-effects and can delay postoperative recovery. Acupuncture and related techniques are effective for acute and chronic pain, and reduces some side-effects. We assessed the effect of transcutaneous electric acupoint stimulation (TEAS) on intra-operative remifentanil consumption and the incidences of anaesthesia-related side-effects.

Methods. Sixty patients undergoing sinusotomy were randomly assigned to TEAS or control group. TEAS consisted of 30 min of stimulation (6–9 mA, 2/10 Hz) on the Hegu (LI4), Neiguan (PC6), and Zusanli (ST36) before anaesthesia. The patients in the control group had the electrodes applied, but received no stimulation. Bispectral index was used to monitor the depth of anaesthesia. Perioperative haemodynamics were recorded, and peripheral blood samples were collected to measure the levels of mediators of surgical stress. The primary end point was intraoperative remifentanil consumption and the secondary endpoints were recovery quality and anaesthesia-related side-effects.

Results. Patients in the TEAS group required 39% less remifentanil during surgery than controls (0.0907 (SD 0.026) μg kg⁻¹ min⁻¹ vs 0.051 (0.018) μg kg⁻¹ min⁻¹). There were no differences in intra-operative haemodynamics or surgical stress between groups. However, the time to extubation and recall in the control group was 16.8 (6.8) min and 23.0 (5.0) min, respectively, significantly longer than that in the TEAS group (P<0.01). TEAS also decreased the incidence of dizziness and pruritus within the first 24 h after surgery (P<0.01).

Conclusion. The use of TEAS significantly reduced intra-operative remifentanil consumption and alleviated postoperative side-effects in patients undergoing sinusotomy.

Clinical trial registration. The trial was registered at clinicaltrials.gov (NCT01700855).

Keywords: electroacupuncture; nausea; remifentanil; vomiting

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Pain relief during surgery is mainly achieved by the use of opioids, which are associated with undesirable side-effects such as nausea, vomiting, and decreased level of consciousness, leading to delayed postoperative recovery. 1 Acupuncture, needling the specific points that restore health, has been used for more than 2500 yr in China. It has been shown to alleviate pain and regulate the physiological functions of the body. 2, 3 In the past decades, there has been an increasing number of clinical trials evaluating the efficacy of acupuncture or electroacupuncture (EA) as a method supplementary to anaesthesia 4 and postoperative analgesia. 5–7 A randomized controlled trial (RCT) conducted by Sahmeddini and colleagues 6 found that either EA or morphine 0.1 mg kg⁻¹ given intra-operatively resulted in similar postoperative pain scores and analgesic requirements after nasal septoplasty. Wetzel and colleagues 4 found that

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auricular acupuncture reduced fentanyl requirement during hip arthroplasty. However, they stated that the difference in fentanyl requirement was statistically significant, but not clinically important.

So far, the conclusions of studies have been conflicting. Several controlled clinical trials showed that acupuncture had no effects on postoperative pain or analgesic requirements after thoracotomy, 8 abdominal surgery, 9 and third molar extraction. 10 On the other hand, others have demonstrated that acupuncture or EA has the potential to reduce perioperative side-effects such as postoperative nausea and vomiting (PONV), dizziness, and pruritus was also not examined.

Sinusotomy is now generally performed during total i.v. anaesthesia (TIVA) owing to its reliability and improved recovery profile. Transcutaneous electric acupuncture stimulation (TEAS) can produce the same effects as those elicited by acupuncture or EA treatment. Compared with acupuncture or EA, TEAS is a non-invasive technique. It has no risk of infections, needle-induced contagious disease, and fear to stimulation. Thus, TEAS is an extremely reductionistic acupuncture technique and more ‘user friendly’. Furthermore, it can potentially be applied by any anaesthesiologist or preoperative personnel with minimal training. We hypothesized that TEAS could reduce the intra-operative consumption of general anaesthetics and the incidence and severity of postoperative side-effects. We conducted a randomized controlled clinical trial to evaluate the influence of TEAS on the consumption of remifentanil and incidence of side-effects in patients undergoing sinusotomy surgery.

Methods

This is a double-blind RCT. The study was conducted in accordance with the Declaration of Helsinki and was approved by the local Clinical Research Ethics Committee. The trial was registered at clincialtrials.gov (NCT01700855). Written informed consent was obtained from each participant.

Patient population

Sixty patients undergoing elective sinusotomy at Xijing Hospital with an ASA physical status of I–II were recruited between August 2012 and November 2012. Their ages ranged from 29 to 60 yr. Exclusion criteria were pre-existing coagulopathy, peptic ulcer, hepatic dysfunction, confirmed renal impairment, use of β-blocker or anti-hypertensive drugs, and regular use of opioids.

Randomization and blinding

Patients were assigned to either TEAS stimulus (TEAS group) or control group (Con group) on the basis of random numbers generated by a computer. Only the acupuncturist was informed the randomization allocation, just before the onset of TEAS. None of the anaesthesiologists, surgeons, physicians in the post-anaesthesia care unit (PACU), or participants were aware of the allocation. Blinding of the patients was ensured by using gel electrodes in the same therapeutic setting, which has previously been proved to be a successful strategy. 12

TEAS protocol

An experienced acupuncturist performed TEAS for 30 min before anaesthesia. According to the theory of traditional Chinese medicine, bilateral Hegu (LI4), Neiguan (PC6), and Zusanli (ST36) were chosen as the acupuncture points. These acupoints were identified according to the traditional anatomic localization (Fig. 1). Gel electrodes were applied to the skin after it had been cleaned with ethyl alcohol. The acupoints were then stimulated electrically with an intensity of 6–9 mA and dense-disperse frequency of 2/10 Hz for 30 min, using the Hwato electronic acupuncture treatment instrument (model No. SDZ-V, Suzhou Medical Appliances Co., Ltd, Suzhou, China). The intensity was adjusted to maintain a slight twitching of the local muscles according to individual maximum tolerance, indicating a satisfactory De-Qi phenomenon and thus adequate stimulation. The patients in the control group had the electrodes applied, but received no stimulation.

Anaesthesia and perioperative management

One surgeon conducted all surgeries according to a standard protocol; surgery commenced between 8:30 and 9:00 a.m. Anaesthesia was induced i.v. with propofol and remifentanil using a target-controlled infusion (TCI) system. After loss of consciousness, vecuronium (0.1 mg kg−1) was administered i.v., and patients were orotracheally intubated 5 min later. Anaesthesia was maintained with TCI of propofol and remifentanil. The depth of anaesthesia was monitored using bispectral index (BIS). Effect site concentrations of propofol and remifentanil were adjusted to the haemodynamics and BIS, according to the Marsh and colleagues 13 and Minto and colleagues 14 models. The cumulative dosage of propofol and remifentanil was recorded in TCI pump. The surgeon did not use vasoconstrictors or local anaesthetics in the nose. Patients’ lungs were mechanically ventilated in a volume-controlled mode with a tidal volume of 6 ml kg−1 body weight during the operation. In both groups, remifentanil and propofol infusions were stopped 5 min before the end of surgery. Meanwhile, prophylactic parecoxib (40 mg) and tropisetron (2 mg) were administered for postoperative pain and PONV, respectively. Patients were extubated and transferred to the PACU when extubation criteria had been achieved. 15 Patients who suffered from PONV 24 h after operation were treated with antiemetics.

Data collection

Heart rate; mean arterial pressure (MAP); leads I–III of the electrocardiogram; end-tidal carbon dioxide pressure; and peripheral oxygen saturation of all patients were recorded before the onset of TEAS (baseline, T0), at the end of TEAS (T1), at the
start of surgery (T2), 30 min after surgery (T3), at the end of surgery (T4), and 5 min after extubation (T5). Lactated Ringer's solution 10 ml kg\(^{-2}\) h\(^{-1}\) was administered to all patients during anaesthesia. Serum concentrations of epinephrine, norepinephrine, adrenocorticotropic hormone (ACTH), glucose, cortisol, and \(\beta\)-endorphin were measured to determine the stress response in all patients. Peripheral venous blood samples were collected in pre-cooled anticoagulant tubes containing trasylol at T0, T2, T3, and T4. The samples were centrifuged at 3000\(g\) for 10 min, and the serum was transferred into polyethylene tubes and stored at \(-80^\circ\text{C}\) until analysis.

The concentrations of epinephrine, norepinephrine, ACTH, cortisol, and \(\beta\)-endorphin were measured with commercially available immunosorbent kits (Shanghai Westang Biological Technology Co., Ltd). Blood glucose was measured with the glucose oxidase technique.

**End points**

The primary endpoint was intra-operative remifentanil consumption and secondary endpoints were the effects of TEAS at the time to extubation, the time to recall, and postoperative side-effects, including respiratory depression, PONV, dizziness, and pruritus 24 h after surgery.

The time to recall was defined as recollection of birthday, the patient’s mobile phone number (this is a common practice and accepted by the local Clinical Research Ethics Committee), and the surgeon’s name. Respiratory depression was defined as a respiratory rate < 8 bpm. Nausea was defined as a subjective unpleasant sensation associated with awareness of the urge to vomit; vomiting was defined as the forceful expulsion of gastric contents from the mouth brought about by the powerful sustained contraction of the abdominal muscles. Dizziness was defined as a sensation of spinning or having one’s surroundings spin about.

**Sample size**

Sample size calculation was based on the primary outcome of remifentanil consumption during the operation. In our preliminary study, dosage of remifentanil in the control group was 0.101 (0.031) \(\mu\text{g}\) kg\(^{-1}\) min\(^{-1}\). We calculated that 17 patients for each group were required to detect a 30% decrease between the groups, assuming a two-sided Type I error (\(\alpha\)) of 0.05 and a power of 80%. To account for potential loss to the follow-up and enable greater statistical power for secondary analyses, the sample size was increased to 60 patients (30 per group).

**Statistical analysis**

All statistical analyses were performed using SPSS 13.0 (SPSS, Inc., Chicago, IL, USA). Continuous variables are presented as mean (SD) and compared using the unpaired Student’s \(t\)-test. Dichotomous variables were presented as the number of patients (per cent) and analysed using the \(\chi^2\) test. The level of significance for all statistical tests was set at 0.05.

**Results**

**Patient characteristics**

Complete datasets were collected for all the 60 participants and all the data were analysed (Fig. 2). None of the patients had previously received acupuncture or TEAS. The characteristics of patients such as age, gender, height, body mass index, and ASA class did not differ between the groups. There were no differences in pre- or intra-operative variables, including anaesthesia duration, operating duration, and fluid balance (Table 1).
**Primary outcome**

The cumulative dosage of remifentanil required in the TEAS group was significantly less than that in the Con group (P<0.001). Patients in the TEAS group required 39% less remifentanil during surgery than those in the Con group (Table 2).

**Secondary outcomes**

The cumulative dosage propofol were similar between the groups (P=0.573). Time to extubation and recall was significantly shorter in the TEAS group than in the Con group, and the incidence of dizziness and pruritus was significantly reduced in the TEAS group. Although fewer patients in the TEAS group reported PONV, the difference in the two groups was not significant (Table 2).

**Intra-operative haemodynamics and surgical stress**

The heart rate and MAP remained stable and within normal ranges. The BIS value was maintained at 40–55, considered an optimal range for surgery. There were no significant differences in the intra-operative heart rate, MAP, or BIS values between the groups (Table 3).

All patients showed a significant increase in the serum concentration of norepinephrine from baseline to start of surgery, but there was no difference between the groups. The concentration of epinephrine, ACTH, blood glucose, and cortisol barely changed at all four time points, and no significant difference was observed between the two groups, suggesting that the levels of surgical stress were similar. The serum β-endorphin concentration varied little between the groups, and there were no significant differences (Table 4).

**Discussion**

In China, acupuncture has been used to treat a wide variety of diseases, particularly pain. Its major advantages are that it is

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**Table 1** Patient characteristic and clinical characteristics of participants. Data presented as mean (SD)

<table>
<thead>
<tr>
<th></th>
<th>Con group (n=30)</th>
<th>TEAS group (n=30)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (yr)</strong></td>
<td>39.9 (15.7)</td>
<td>43.1 (15.0)</td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>19</td>
<td>16</td>
</tr>
<tr>
<td>Female</td>
<td>11</td>
<td>14</td>
</tr>
<tr>
<td><strong>Height (cm)</strong></td>
<td>167.3 (7.5)</td>
<td>166.1 (7.7)</td>
</tr>
<tr>
<td><strong>BMI</strong></td>
<td>22.2 (3.4)</td>
<td>22.0 (2.8)</td>
</tr>
<tr>
<td><strong>ASA Class</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>23</td>
<td>22</td>
</tr>
<tr>
<td>II</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td><strong>Anaesthesia duration (min)</strong></td>
<td>83.7 (28.1)</td>
<td>85.1 (25.1)</td>
</tr>
<tr>
<td><strong>Operation duration (min)</strong></td>
<td>57.7 (23.8)</td>
<td>57.4 (21.4)</td>
</tr>
<tr>
<td><strong>Intra-operative fluids (ml)</strong></td>
<td>587 (172)</td>
<td>577 (163)</td>
</tr>
</tbody>
</table>
minimally invasive, is safe for high-risk patients, and provides pain relief with a low risk of complications.16 EA is the combination of traditional Chinese acupuncture and modern electrical techniques. An increasing number of clinical trials indicate that acupuncture and EA may be effective in reducing perioperative analgesic requirements, postoperative pain,17 and PONV.4671819

We found that patients in the TEAS group received 39% less remifentanil than those who received control treatment, which is consistent with a previous study.4 However, the results of several trials that have examined the analgesic effect of EA have been conflicting: several studies found that EA did not reduce pain or analgesic requirement after surgery and had no apparent influence on PONV. There could be several explanations for this. First, the acupuncture technique used in other studies may not have delivered sufficiently strong stimulation to produce an analgesic effect. Secondly, using a single frequency of 10 Hz rather than 2

### Table 2: Consumption of anaesthetics, recovery outcomes, and postoperative side-effects. Data presented as mean (σ) or n (%). *P<0.05 vs control group. PONV, postoperative nausea and vomiting

<table>
<thead>
<tr>
<th></th>
<th>Con group (n=30)</th>
<th>TEAS group (n=30)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary outcome</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumption of remifentanil (µg kg⁻¹ min⁻¹)</td>
<td>0.0907 (0.026)</td>
<td>0.051 (0.018)*</td>
<td>0.001</td>
</tr>
<tr>
<td><strong>Secondary outcomes</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Consumption of propofol (mg kg⁻¹ h⁻¹)</td>
<td>7.038 (2.223)</td>
<td>6.901 (2.441)</td>
<td>0.573</td>
</tr>
<tr>
<td>Time to extubation (min)</td>
<td>17.3 (6.7)</td>
<td>12.5 (3.5)*</td>
<td>0.001</td>
</tr>
<tr>
<td>Time to recall (min)</td>
<td>21.8 (8.7)</td>
<td>16.4 (5.9)*</td>
<td>0.007</td>
</tr>
<tr>
<td>Respiratory depression</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>1</td>
</tr>
<tr>
<td>PONV</td>
<td>4 (13.3%)</td>
<td>2 (6.7%)</td>
<td>0.240</td>
</tr>
<tr>
<td>Dizziness</td>
<td>17 (56.7%)</td>
<td>7 (23.3)*</td>
<td>0.010</td>
</tr>
<tr>
<td>Pruritus</td>
<td>12 (40.0%)</td>
<td>4 (13.3%)*</td>
<td>0.020</td>
</tr>
</tbody>
</table>

### Table 3: Intra-operative measurements. Data presented as mean (σ). HR, heart rate; MAP, mean arterial pressure; ECO₂, end-tidal carbon dioxide pressure; BIS, bispectral index. T₀, baseline; T₁, at the end of EA; T₂, at the start of surgery; T₃, 30 min after surgery; T₄, at the end of surgery; T₅, 5 min after extubation

<table>
<thead>
<tr>
<th></th>
<th>Con group (n=30)</th>
<th>TEAS group (n=30)</th>
<th>BIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR (bpm) MAP (mm Hg) ECO₂ (mm Hg) BIS</td>
<td></td>
<td></td>
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<tr>
<td>T₀  77.4 (12.1) 88.7 (7.8) 96.4 (2.2) 96.9 (2.2)</td>
<td></td>
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<tr>
<td>T₁ 77.5 (12.7) 88.2 (8.0) 96.5 (2.1)</td>
<td>75.8 (8.6) 86.8 (7.8) 96.6 (3.1)</td>
<td></td>
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<tr>
<td>T₂ 62.9 (14.4) 90.3 (10.3) 33.8 (5.6) 45.8 (13.4)</td>
<td>61.1 (11.5) 89.5 (9.3) 31.8 (3.7) 42.9 (11.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T₃ 66.1 (11.5) 76.5 (11.3) 32.2 (3.9) 51.0 (14.4)</td>
<td>64.9 (11.7) 78.5 (9.8) 29.9 (3.6) 52.1 (12.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T₄ 73.4 (11.9) 86.5 (7.3) 35.4 (4.7) 63.4 (12.9)</td>
<td>70.8 (9.5) 84.5 (7.3) 34.9 (4.3) 61.7 (10.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T₅ 81.5 (12.3) 86.4 (8.6) 88.1 (7.4)</td>
<td>78.0 (8.7) 88.5 (9.3) 86.5 (10.3)</td>
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</tr>
</tbody>
</table>

### Table 4: Serum concentrations of mediators of surgical stress. Data presented as mean (σ). *P<0.05 vs baseline. ACTH, adrenocorticotropic hormone

|                   | Con group (n=30) | TEAS group (n=30) | T₀ T₂ T₃ T₄ T₀ T₂ T₃ T₄ |
|-------------------|-----------------|------------------|-----|-----|-----|-----|-----|-----|
| Epinephrine (ng ml⁻¹) | 25.2 (4.4) | 26.4 (5.3) | 24.6 (4.5) | 27.0 (4.6) | 27.4 (5.4) | 28.6 (4.4) | 26.8 (4.0) | 29.2 (5.5) |
| Norepinephrine (pg ml⁻¹) | 317.9 (70.9) | 358.2 (78.7)* | 311.6 (75.4) | 314.5 (82.3) | 313.4 (70.1) | 372.6 (80.5)* | 314.5 (84.7) | 320.3 (77.3) |
| ACTH (pg ml⁻¹) | 29.4 (5.4) | 30.7 (5.9) | 32.6 (6.1) | 29.3 (5.4) | 32.2 (6.7) | 32.6 (5.4) | 32.3 (4.8) | 30.5 (5.5) |
| Blood glucose (mmol litre⁻¹) | 5.5 (0.6) | 5.2 (0.4) | 5.7 (0.6) | 5.4 (0.5) | 5.4 (0.7) | 5.5 (0.5) | 5.3 (0.4) | 5.4 (0.3) |
| Cortisol (ng ml⁻¹) | 25.5 (4.7) | 22.7 (5.0) | 23.6 (4.5) | 22.7 (5.1) | 24.5 (5.4) | 21.2 (4.4) | 22.1 (4.6) | 22.5 (5.7) |
| β-endorphin (ng ml⁻¹) | 2.39 (0.42) | 2.08 (0.47) | 2.21 (0.38) | 2.49 (0.43) | 2.47 (0.38) | 2.27 (0.40) | 2.20 (0.34) | 2.42 (0.32) |
and 10 Hz may have had a different influence on neurotransmitter release. Another high-quality randomized clinical trial enrolled 90 patients undergoing nasal septoplasty and randomized them to receive no EA or preoperative EA to the LI4 (Hegu), LI11 (Quchi), HT7 (Shenmen), and PC6 (Neiguan) before surgery. EA was found to be equi-analgesic with i.v. morphine (0.1 mg kg⁻¹). Unfortunately, in their study, general anaesthesia was adjusted and monitored in a conventional way, that is, according to the heart rate and arterial pressure, whereas in our study, all patients were anaesthetized by the same anaesthesiologist, who used BIS to monitor depth of anaesthesia. Therefore, we avoided possible bias that could have resulted from using different medical staff, modes of anaesthesia, or depth of anaesthesia, as the study was meticulously blinded and BIS was maintained between 40 and 55 during all operations. The consumption of propofol, however, was similar in the two groups. We observed that the time to extubation and recall was significantly shorter in the TEAS group. Although there have been several randomized controlled clinical trials showing that perioperative EA lowers the incidence of PONV, we did not find a statistically significant difference. This may be attributable to the low incidence of PONV after TIVA, or the anetetics we used. Postoperative dizziness may cause falls or other injuries, and pruritus may also complicate recovery. We found that the incidences of dizziness and pruritus were significantly lower in the TEAS group than in the control group. Supporting our hypothesis that TEAS reduces the incidence of PONV, we observed that the time to extubation and recall was significantly shorter in the TEAS group.

In conclusion, we found that TEAS significantly reduced the incidence of PONV after TIVA. Preoperative EA to the LI4, ST36, and PC6 acupoints can effectively alleviate pain, compared with patients who were administered fentanyl and propofol. In another clinical trial, patients undergoing supratentorial craniotomy received EA stimulation at the LI4, LI11, ST36, BL63, and GB40. The results demonstrated that patients administered EA required 9.62% less sevoflurane than those in the sham EA group and that the times taken for restoration of spontaneous breathing, extubation, eye opening, return of voluntary movement, recovery of orientation force, and departure from the operating theatre were significantly shorter. These findings suggest that the dosage of anaesthetic drugs required to maintain general anaesthesia was decreased when a combination of different acupoints was stimulated. They also suggest that Hegu (LI4), Neiguan (PC6), and Zusanli (ST36) could act together and produce synergistic effects. Thus, we chose these acupoints for our study.

Previous studies have demonstrated that the efficacy of acupuncture or EA has the specificity of acupoints. Compared with ‘sham acupoints’, in which acupuncture at random points on the body surface that are thought to be inactive and are not located in the meridian, the results from functional magnetic resonance imaging showed that real acupuncture induces specific patterns of brain activity different from sham acupuncture, which may explain the therapeutic specificity of real acupuncture. Another randomized study observed impact of EA on quality of life for patients with Relapsing-Remitting Multiple Sclerosis under treatment with immunomodulators. In the sham EA group, needle insertion was more superficial (<0.2 cm) and 1 cm to the side of the critical points used for the true EA group. Their data indicated that EA significantly reduced the pain and improved the quality-of-life compared with sham EA. According to the specificity of acupoints, we chose sham stimulation on the same acupoints as the control group instead of non-acupoints stimulation as positive placebo in the present study. Furthermore, the effects of TEAS in producing the same effects as those elicited by acupuncture or EA treatment have been proved by several animal experiments and clinical trials.

There is evidence supporting the analgesic effect of acupuncture via activation of endogenous pathways, both by exerting a direct inhibitory effect on opioid-sensitive spinal cord interneurones and by stimulating the release of endogenous opioid peptides. We have previously shown that EA stimulation at the Baihui (GV20) acupoint promotes enkephalin release in rats. Although we found that TEAS did not increase serum β-endorphin concentration in this study, there is evidence that analgesia produced by EA may be mediated by endogenous opioids. We speculate that TEAS induce analgesia effects at central level directly by increasing endogenous analgesia mediators, but changes could not be detected because the increased amount of these substances is insufficient to affect its concentration in the peripheral vein. In addition, our previous studies showed that EA induced neuroprotection by increasing the release of endocannabinoid ligands and activation of adenosine A1 receptors. The adenosine A1 receptor may also mediate the local anti-nociceptive effect of acupuncture and endocannabinoids have been studied as potential analgesics for acute perioperative pain. The findings of this study appear to confirm one of these potential underlying mechanisms.

Importantly, we also measured the serum concentrations of mediators of surgical stress. Unsurprisingly, surgery caused a slight increase in catecholamine, but there were no significant differences between the groups. It suggested that either the control group or the TEAS group repressed surgical stress effectively. The strength of our study lies in its meticulous blinding, TEAS protocol, standardized anaesthetic management, and comparable levels of surgical stress.

In conclusion, we found that TEAS significantly reduced intra-operative remifentanil consumption, the time to extubation and recall, and the incidence of dizziness and pruritus within the first 24 h of surgery. This suggests that TEAS can significantly reduce the consumption of intra-operative opioids and alleviate the incidence of anaesthesia-related side-effects in patients undergoing sinusotomy, implying its potential benefit as an adjunct to general anaesthesia. In future
studies, different acupoints could be used for different operations on other parts of the body. We also plan to investigate the underlying mechanisms of TEAS-mediated analgesia, ultimately to reduce reliance on opioid analgesics and to broaden the clinical appeal of the technique.

Declaration of interest
None declared.

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