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Abstract

According to the theory of traditional Chinese medicine, Qi flows through the body along specific paths known as meridians. Any disturbance in Qi evokes a Ying–Yang imbalance in the body, and consequently leads to disease. Pain results from blood stasis and Qi stagnation. Laser acupuncture (LA), first introduced clinically in the 1970s, combines the advantages of traditional acupuncture and modern laser medicine and has been applied for the treatment of various diseases. Here, we investigated studies on the use of LA for pain management according to current evidence. Articles including English keywords related to the use of LA for pain, published between January 2006 and August 2015 were sourced from PubMed, Medline, and Cochrane Library databases. On the basis of these papers, we explored the modern applications, mechanisms, and analgesic effects of LA. LA integrates the positive effects of acupuncture and low-level laser therapy, and is therefore effective in activating blood and in moving Qi. LA relieves pain through both anti-inflammatory and analgesic effects. No adverse effects or complications resulting from LA were reported in the literature. In the hands of an experienced physician, LA can be a useful and safe method for pain management.

Keywords: laser acupuncture, low-level laser therapy, acupuncture, pain, traditional Chinese medicine

1. Introduction

Although written accounts of acupuncture date back over 2000 years, archaeological evidence suggests more than 3000 years of practice. According to the principles of traditional Chinese medicine (TCM), energy (or Qi) flows through the body along specific paths known as meridians. Balanced Qi contributes to the maintenance of good health. On the other hand, any
disturbance in Qi results in an energy imbalance in the body. This imbalance, either an excess or a deficiency, may then result in disease [1]. Both blood stasis and Qi stagnation will lead to pain [2]. In 1996, the World Health Organization (WHO) confirmed 64 indications for acupuncture treatment. Acupuncture treats the underlying diseases by stimulating specific acupuncture points along the meridians. Acupuncture is one of the most common types of alternative treatments for patients who suffer from long-term pain. Moreover, it is a relatively safe procedure with minimal adverse effects [3]. Even though acupuncture has been proven to be effective for many therapeutic applications, metal needling is not widely accepted owing to fear of possible contamination or transcutaneous lesions [4]. Consequently, following the theory of TCM, the use of low-level laser on acupuncture points has been developed as a new therapeutic approach called laser acupuncture (LA) [5, 6].

LA was first introduced clinically in the 1970s [7]. It has been widely studied over several years to turn it into an evidence-based clinical practice. The use of low-intensity and nonthermal laser irradiation stimulation of acupuncture points is an effective alternative to traditional metal needling; it is a safe technique because it is noninvasive and is acceptable to needle-phobic persons. Thus, LA can be used at acupuncture points that require complicated applications of needles [1, 8]. The laser beam is an electromagnetic wave and can stimulate acupuncture points in the human body by depositing energy without causing heating. In contrast to needling, acupuncture points irradiated by a laser beam need to receive sufficient energy to induce a physiological effect at the cellular level based on the principle of “photobiomodulation.” The beam excites the relevant channels and activities, regulates the function of organs, and promotes metabolism. Recently, several papers have reported that the decisive factor in the efficacy of LA is the applied dosage [5, 9–11].

Although the mechanisms underlying LA are not well understood, LA is widely applied clinically. LA is also referred to as low-level laser therapy (LLLT), with 0.1–0.5 J/cm² deposited per acupuncture point, or 1–4 J/cm² per Ashi point [12]. LLLT has an anti-inflammatory function because it can reduce the levels of certain biochemical factors (prostaglandin E2, messenger ribonucleic acid cyclooxygenase-2, interleukin (IL)-1β, and tumor necrosis factor (TNF)-α), neutrophil influx, oxidative stress, edema, and hemorrhaging [13]. Analgesia induced by laser phototherapy is mediated by peripheral opioid receptors [14]. Nevertheless, LA has both local and distant analgesic effects, which may be mediated by different mechanisms. LA combines the advantages of traditional metal-needle acupuncture and LLLT. This chapter on managing pain by LA focuses on how LA may be an alternative method of relieving pain and improving functional outcomes.

2. Review of the clinical literature

Clinical literature in electronic databases—PubMed, Medline, and Cochrane library—was surveyed using the terms “laser acupuncture”, “low level laser therapy”, and “pain”, published from January 2006 to August 2015. All papers had to meet the following criteria: randomized controlled trials (RCTs) that considered a control group (either placebo, sham LA,
nonstandard traditional acupuncture, or other therapeutic equipment) and retrospective/retrospective/prospective clinical studies in which LA/LLLT was used. Studies cited in review articles were also included. Papers published in languages other than English were excluded. Conference abstracts, single-case studies, and papers for which full text was not available were also excluded.

Among the reviewed literature, most studies targeted myofascial pain, fibromyalgia, tendinopathy, radiculopathy, osteoarthritis (OA), low back pain, temporomandibular joint dysfunction (TMD), and headache. These are discussed below.

2.1. Myofascial pain

Kiralp et al. [15] reported a RCT in which 43 patients with myofascial pain were enrolled, and showed the positive effect of LA as compared to prilocaine injection. Eight other RCTs also showed the pain-relieving effect of LA; some of these focused on myofascial pain over the cervical region [16, 17], masseter [18], masticatory muscles [19, 20], trapezius [21, 22], or trigger points [23]. The consistency of these trials highlighted the efficacy of LA in the treatment of myofascial pain.

2.2. Fibromyalgia

Two RCTs showed different results for LA treatment of fibromyalgia [24, 25]. Both of these studies obtained subjective pain presentation using a visual analog scale (VAS), the Fibromyalgia Impact Questionnaire (FIQ), and other measures. Armagan et al. [24] reported positive results of LA for treating the pain of fibromyalgia. The difference between these studies was the dose and power density. Armagan et al. set the parameters of LA to 830 nm, 2 J/point, and 50 mW. These results suggested that the treatment effect of LA was inconclusive in fibromyalgia or that the power density used should be sufficiently high to manage the pain in this disease group.

2.3. Tendinopathy

Two RCTs showed positive results of LA in pain management of lateral epicondylitis (LE) [26, 27], also known as tennis elbow. Emanet et al. [27] reported that even though LA had no short-term advantage over the placebo in patients with LE, there was a significant long-term improvement, especially in functional parameters. Another RCT reported that LA had a treatment effect equal to that of ultrasound [28]. Moreover, a systemic review revealed that applying LLLT to myofascial trigger points of LE patients was an effective treatment for pain reduction and also led to an increase in grip force, range of motion (ROM), and weight test [9]. As for tendomyopathy of the masticatory musculature, the pilot study showed inconclusive results because there were few participants [19].

2.4. Radiculopathy

Konstantinovic et al. [29] performed an RCT that enrolled 60 patients with acute neck pain with cervical radiculopathy. After a 3-week LA treatment, VAS, neck movement, neck
disability index, and quality of life indicated the positive effect of LA. Radiculopathy of other spinal segments was not reported.

2.5. Osteoarthritis

Among the four RCTs on the use of LA in treating the pain of knee OA, two showed a positive result [30, 31], one was inconclusive [32], and the other one reported efficacy after 2 weeks of treatment but not at the 4-week assessment [33]. However, the RCT showed the inconclusive result for only one point, ST35. An inappropriate dose or insufficient irradiation at a point may be the reason for the poor treatment effect.

2.6. Low back pain

Glazov et al. [34] had reported negative result for the use of LA to relieve low back pain in their study, in which LA was applied to local points of three meridians (Bladder, Gallbladder, and Governor vessel) and Ashi points. Subsequently, Glazov [35] reported another RCT, in which 100 patients with low back pain were enrolled, and found a positive result for pain management with LA. However, the parameter settings used for the second RCT were not described. Therefore, we were not able to determine the differences that contributed to the successful treatment. Nevertheless, further two RCTs showed a positive response for low back pain treated with LA [36, 37].

2.7 Temporomandibular joint disorder

In our literature search, all four RCTs suggested a positive treatment effect for LA in treating the pain associated with TMD [4, 38–40]. Occlusal splinting is the nonsurgical standard treatment for this condition in dental clinics. In two RCTs, LA was found to be as effective as occlusal splinting in relieving TMD-associated pain [39, 40]. LA could be an alternative treatment choice to occlusal splinting. Sattayut and Bradley [41] compared low- and high-grade LA and found that high-grade LA, i.e., 820 nm, 107 J/cm^2, and 300 mW, showed a superior treatment effect. More recently, Hu et al. [42] clearly showed the therapeutic effects of LA in managing treatment-resistant TMD. In our literature review, another two clinical trials revealed the benefit of LA therapy for TMD patients [43, 44].

2.8. Headache

Gottschling et al. [45] reported an RCT in which LA was used to treat headache in children and showed a decrease in the VAS score and monthly hours with headache. Interestingly, the treatment in this study consisted of only four treatment episodes, at a frequency of once a week, yet the improvement of symptoms was excellent. This study also focused on the meridian-based selection of irradiation points. The basic points for patients with frontal headache were LI4 and ST36; for lateral pain, they were TE6 and GB34; for occipital pain, they were SI3 and BL60, and for holoccephalic pain, it was GV20. Additional body acupuncture points and ear acupuncture points were chosen individually. The combination of TCM meridian theory with
LA energy treatment seemed to provide a better effect than simply irradiating the tender points.

2.9. Others

Chow et al. [17] reported that chronic neck pain of any etiology could be treated successfully with a program of 14 LA treatments over a period of 7 weeks. Ip and Fu [46] reported a prospective cohort study that proved the treatment efficacy of LA in painful adhesive capsulitis of the shoulder.

3. Conclusions

We have presented evidence supporting the use of LA in the management for various types of pain (Table 1). LA is a noninvasive technique involving the stimulation of traditional acupuncture points with low-intensity laser irradiation. LA has the advantages of being painless and safe as no heat is generated during the procedure, and it is more effective in some medical conditions and requires less time than needle-based acupuncture [47]. No adverse effects or complications resulting from LA have been reported in any study to date. The effectiveness of LA in managing pain depends on the selection of appropriate points and frequencies. Insufficient energy and very few therapeutic sessions will result in ineffective therapy. In conclusion, LA combines the positive effects of traditional Chinese acupuncture and LLLT, and is therefore effective in both activating blood and moving Qi. LA relieves pain through both anti-inflammatory and analgesic effects. As experienced physicians, we should optimize laser parameters, treatment intervals, and long-term follow-up for LA therapy.

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<td>VAS, 50-foot walking time, KC, MTA, HOMA, NIH</td>
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<td>--</td>
<td>VAS, Dolorimeter at tender points, EQ, SF-36</td>
<td>Negative</td>
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<td>Lam and Cheing 26]</td>
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<td>Cervical Myofascial pain</td>
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<td>3 weeks (15 sessions)</td>
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<td>7 J/cm²</td>
<td>50 mW</td>
<td>120</td>
<td>Trigger points</td>
<td>VAS, ROM</td>
</tr>
<tr>
<td>Study</td>
<td>Study design</td>
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<tr>
<td>Shen et al. [31]</td>
<td>RCT 48 Knee OA</td>
<td>Combined laser versus light</td>
<td>3 times/week for 4 weeks</td>
<td>450 nm</td>
<td>nanosecond laser</td>
<td>30 J/cm²</td>
<td>60 mW/cm²</td>
<td>Positive for knee flexibility index</td>
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<td>WOMAC</td>
<td>Positive but in-conclusive difference</td>
</tr>
<tr>
<td>Gottschling et al. [40]</td>
<td>RCT 43 Headache in children</td>
<td>Placebo</td>
<td>7 days</td>
<td>650 nm</td>
<td>semiconductor laser</td>
<td>1.2 J/cm²</td>
<td>0.5 W</td>
<td>Positive for headache</td>
<td>LI4, SI3, GB34, SI3, GV meridians</td>
<td>VAS</td>
<td>Positive</td>
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<tr>
<td>Skier et al. [39]</td>
<td>RCT 60 Myofascial pain of the neck</td>
<td>Placebo</td>
<td>3 weeks</td>
<td>40 J/cm²</td>
<td>Laser acupuncture</td>
<td>10 points on LI4, ST36, TE6, GB34, ST7</td>
<td>Positive</td>
<td>Positive in long-term follow-up</td>
<td>ST5, Y-interaction</td>
<td>WOMAC</td>
<td>Positive</td>
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<tr>
<td>Zhao et al. [33]</td>
<td>RCT 40 Knee OA Non-acupoint</td>
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<td>4 weeks</td>
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<td>nanosecond laser</td>
<td>3 J/cm²</td>
<td>0.3 W</td>
<td>Positive for VAS</td>
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<tr>
<td>Chae et al. [34]</td>
<td>Pilot study 11</td>
<td>Tendomyopathy of the neck</td>
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<td>904 nm</td>
<td>Laser plus 10.6 μm CO₂ laser</td>
<td>1929 J/cm²</td>
<td>1200 ST35</td>
<td>Positive for WOMAC</td>
<td>ST5, Y-interaction</td>
<td>WOMAC</td>
<td>Positive after 2 weeks treatmen, but not at 6 weeks</td>
</tr>
<tr>
<td>Glazov et al. [35]</td>
<td>RCT 100 Low back pain Placebo</td>
<td>5–10 sessions</td>
<td>830 nm</td>
<td>0.2 J/point</td>
<td>10 mW</td>
<td>20 Points on BL, GB, CV meridians, Ashi points</td>
<td>Positive for pain</td>
<td>VAS</td>
<td>Negative</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Konstantinovic et al. [29]</td>
<td>RCT 30 Acute neck pain</td>
<td>Placebo</td>
<td>3 weeks</td>
<td>905 nm</td>
<td>2 J/cm²</td>
<td>120</td>
<td>Laser, TENS, Acupoint, trigger points and the neck disability</td>
<td>Positive for neck movement, pain and the neck disability</td>
<td>ST5, Y-interaction</td>
<td>WOMAC</td>
<td>Positive</td>
</tr>
<tr>
<td>Lee and Han [21]</td>
<td>RCT 24 Myofascial trigger point</td>
<td>Placebo</td>
<td>End of intervention</td>
<td>850 nm</td>
<td>40 mW/cm²</td>
<td>1, 2, 5 min</td>
<td>Trigger point</td>
<td>Positive in 5 min</td>
<td>ST5, Y-interaction</td>
<td>WOMAC</td>
<td>Positive</td>
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<tr>
<td>Stein et al. [27]</td>
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<td>Placebo</td>
<td>3 weeks</td>
<td>905 nm</td>
<td>1 J/cm²</td>
<td>120</td>
<td>Two most sensitive points DASH questionnaire, PPT, VAS, pain-free grip strength, MP, questionnaire of grip strength</td>
<td>Positive for VAS and pain-free grip strength</td>
<td>ST5, Y-interaction</td>
<td>WOMAC</td>
<td>Positive in long-term evaluation (12 weeks)</td>
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<tr>
<td>Skorupska et al. [26]</td>
<td>RCT 80 Tenosynovitis</td>
<td>Ultrasonography ultrasound of the elbow</td>
<td>10 days with a complete break (10 sessions)</td>
<td>820 ± 10 nm</td>
<td>CO₂ laser</td>
<td>1.5 J/cm²</td>
<td>400 mW</td>
<td>Trigger point</td>
<td>Allograft, VAS</td>
<td>Ultrasound, questionnaire of grip strength, MP, questionnaire, and hand grip strength</td>
<td>Equally effective</td>
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<td>Kanna [22]</td>
<td>RCT 45 Myofascial pain of upper trapezius</td>
<td>Ultrasonography of therapy</td>
<td>5 days (5 sessions)</td>
<td>905 nm</td>
<td>78 mJ/cm²</td>
<td>30</td>
<td>Trigger point</td>
<td>VAS, provocative pain test, active lateral bending of the cervical spine</td>
<td>ST5, Y-interaction</td>
<td>WOMAC</td>
<td>Positive</td>
</tr>
<tr>
<td>Natividad and Beddley [4]</td>
<td>RCT 30 Temporomandibular joint disorder</td>
<td>Low-energy laser</td>
<td>5 weeks</td>
<td>810 nm</td>
<td>semiconductor laser</td>
<td>254 J/cm²</td>
<td>300 mW</td>
<td>Trigger point</td>
<td>3 points around PPT, MP1, SHT, SHT</td>
<td>Positive in higher energy group</td>
<td>Positive</td>
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<tr>
<td>Liu et al. [16]</td>
<td>RCT 40 Low back pain</td>
<td>Placebo</td>
<td>5 days (5 sessions)</td>
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<td>15 J/cm²</td>
<td>60 Hz</td>
<td>Trigger point</td>
<td>VAS, Ryodoraku</td>
<td>Positive</td>
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<td>Fernández et al. [4]</td>
<td>RCT 40 TMD</td>
<td>Placebo</td>
<td>3 months</td>
<td>780 nm</td>
<td>CO₂ laser</td>
<td>202 J/cm²</td>
<td>90</td>
<td>Positive</td>
<td>ST5, SHT, GB34, LI4, LR1, NT3, EX-HN3</td>
<td>VAS</td>
<td>Positive</td>
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<tr>
<td>Carrasco et al. [23]</td>
<td>RCT 60 Myofascial pain Placebo 4 weeks</td>
<td>Placebo</td>
<td>3 weeks</td>
<td>40 J/cm²</td>
<td>Laser acupuncture</td>
<td>15 points on LI4, ST36, TE6, GB34, ST7</td>
<td>Positive</td>
<td>Positive</td>
<td>ST5, Y-interaction</td>
<td>WOMAC</td>
<td>Positive</td>
</tr>
<tr>
<td>Zhao et al. [33]</td>
<td>RCT 40 Knee OA</td>
<td>Placebo</td>
<td>4 weeks</td>
<td>650 nm</td>
<td>nanosecond laser</td>
<td>10 J/cm²</td>
<td>10 mW</td>
<td>Positive for WOMAC</td>
<td>ST5, Y-interaction</td>
<td>WOMAC</td>
<td>Positive</td>
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Pain Management


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<td>Clinical trial</td>
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<td>TMD</td>
<td>Placebo</td>
<td>Once a week till symptom relief or 3 weeks of no improvement</td>
<td>656 nm</td>
<td>160 cm²</td>
<td>375 W/cm²</td>
<td>0.75 W/cm²</td>
<td>20</td>
<td>ST6, ST7, LI4 and one local Ashi point</td>
<td>VAS</td>
</tr>
<tr>
<td>RCT</td>
<td>30</td>
<td>Myofascial pain due to TMD</td>
<td>occlusal splint; placebo</td>
<td>4 weeks (12 sessions)</td>
<td>730–2,662 nm</td>
<td>5–10 J/cm²</td>
<td>250 mW</td>
<td>20</td>
<td>Trigger points</td>
<td>VAS, MMO</td>
<td>Positive</td>
</tr>
<tr>
<td>Clinical trial</td>
<td>20</td>
<td>Treatment-resistant TMD</td>
<td>—</td>
<td>6 weeks (12 sessions)</td>
<td>810 nm</td>
<td>7.5–26.25 J/cm²</td>
<td>5 W/cm²</td>
<td>5 sec (at points) 40 sec (Ashi point)</td>
<td>ST6, ST7, LI4 and Ashi point</td>
<td>VAS, MMD</td>
<td>Positive</td>
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<tr>
<td>Prospective cohort study</td>
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<td>Painful adhesive capsulitis of shoulder</td>
<td>Sham laser</td>
<td>8–24 weeks (3 sessions)</td>
<td>810 nm</td>
<td>5.4 J/point</td>
<td>20 mW/cm²</td>
<td>20–30</td>
<td>6 anatomic points; SI11, SI12</td>
<td>Constant pain, Constant pain, Constant pain</td>
<td>Positive</td>
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</tbody>
</table>

DASH: disabilities of the arm, shoulder, and hand; DASS-21: Depression Anxiety Stress Scale; EMG: electromyography; EQ-5D: Euro-Quality-of-Life Five Dimensions questionnaire; FIQ: Fibromyalgia Impact Questionnaire; KC: knee circumference; MOSP: maximum mouth opening (MMO) without pain; MTS: medial tenderness score; NHP: Nottingham Health Profile; NTP: number of tender points; ODI: Oswestry Disability Index; PGIC: Patient Global Impression of Change; PPT: pressure pain threshold; PRTEE: Patient-Related Lateral Epicondylitis Evaluation; SF-36: 36-item Short-Form Health Survey; VPS: verbal pain scale; VSGI: global improvement on a verbal scale; WOMAC: Western Ontario and McMaster Universities osteoarthritis index.

Table 1. Summary of clinical studies into pain management with laser acupuncture.

### Abbreviations

- **DASH**: disabilities of the arm, shoulder and hand
- **DASS-21**: Depression Anxiety Stress Scale
- **EMG**: electromyography
- **EQ-5D**: Euro-Quality-of-Life Five Dimensions questionnaire
- **FIQ**: Fibromyalgia Impact Questionnaire
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- **KC**: knee circumference
- **LA**: laser acupuncture
- **LE**: lateral epicondylitis
- **LLLT**: low-level laser therapy
- **MOSP**: maximum mouth opening (MMO) without pain
- **MTS**: medial tenderness score
- **NHP**: Nottingham Health Profile
NTP number of tender points
OA osteoarthritis
ODI Oswestry Disability Index
PGIC Patient Global Impression of Change
PPT pressure pain threshold
PRTEE Patient-Related Lateral Epicondylitis Evaluation
PWI-A Personal Wellbeing Index
RCT randomized controlled trial
ROM active range of motion
SF-36 36-item Short-Form Health Survey
SSI symptom severity index
TCM traditional Chinese medicine
TMD temporomandibular joint (TMJ) disorder
VAS visual analogue scale
VPS verbal pain scale
VSGI global improvement on a verbal scale
WHO World Health Organization
WOMAC Western Ontario and McMaster Universities osteoarthritis index

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