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The Effectiveness of Laser Acupuncture in Pain Management: a Systematic Review

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THE EFFECTIVENESS OF LASER ACUPUNCTURE IN PAIN
MANAGEMENT: A SYSTEMATIC REVIEW

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Paper Submitted in Partial Fulfillment
Of the Requirements for the Degree of
Master of Science in Physician Assistant Studies
Augsburg University

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THE EFFECTIVENESS OF LASER ACUPUNCTURE IN PAIN MANAGEMENT: A SYSTEMATIC REVIEW

Abstract

Background: Pain is a common symptom across many medical conditions that patients experience. Pain management is complex and may need a combination of several management techniques. Laser acupuncture(LA) has been previously used as an adjunct to conventional pain treatments.

Objective: This systematic review aims to evaluate the effectiveness of laser acupuncture in various fields of medical situations such as chronic pain, low back pain, osteoarthritis, osteoporosis, postoperative pain and dental procedures.

Methods: A computer based literature search of databases through GoogleScholar and PubMed was used to identify randomized controlled trials(RCTs) published after 2018 that studied the effect of LA in pain management.

Result: It was observed that LA was effective at decreasing the pain levels and found most effective with musculoskeletal disorders. The reviewed papers had the most success when the laser parameters that were set at minimum of 3J of energy per acupoints with 5 acupuncture sites received over at least 3 sessions. The final result of pain relief and recurrence rate was lower than the standard care.

Conclusions: LA has several appealing attributes that make it a favorable treatment modality. The minimal sensation experienced by patients allows ease of integration in their treatment plan in all ages, the short treatment duration, low risk of infection and complications marks itself as a viable adjunct process of pain management. To enhance the understanding and fully take advantage of LA's potential, future studies are required with standardized high-quality methodologies with consistent laser parameters to establish future clinical applications.

Keywords: Laser acupuncture, pain, review

THE EFFECTIVENESS OF LASER ACUPUNCTURE IN PAIN MANAGEMENT: A SYSTEMATIC REVIEW

1. Introduction

Pain is the most common symptom in various medical conditions, significantly impacting patients' quality of life that can be seen in different forms such as acute and chronic pain.¹

Chronic pain often leads to limited mobility, depression, anxiety, sleep disturbances, and social isolation. However, addressing pain is challenging due to its complexity and the unique experiences of individuals dealing with it.² The International Association for the Study defines pain as ““An unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage.”³ In the United States alone, it was estimated that 20.9% of all adults in 2021 experienced chronic pain leading to significant financial burdens and raising the concern about the effectiveness of current traditional medical pain management.⁴

In addition to concern about the effectiveness of conventional medical pain management, the prolonged use of pain medication often leads to unwanted side effects. Commonly used medications like nonsteroidal anti-inflammatory pose risk such as gastric ulcers, gastric bleeding, and kidney failure particularly for older patients.⁵ Opioids is another frequently prescribed pain medication that has adverse side effects including nausea, vomiting, sedation, dizziness, constipation, and respiratory depression.⁶ Repeated uses of prescription opioids can potentially lead to substance use disorder, which can in turn raise additional problems such as muscle and bone pain, diarrhea and vomiting, cold flashes and sleeping problems when attempting to discontinue the medication.⁷ Therefore, ensuring safe, effective, and affordable pain management care is crucial for public health practice.

Among the non-pharmacological pain management, laser acupuncture(LA) has increased interest over the years. LA is based on one of the oldest healing practices from Traditional Chinese Medicine, Acupuncture. The idea of acupuncture technique revolves around that idea on individuals having flow of inner energy, Qi. When Qi is disturbed or interrupted, it causes illness and disease. Traditional acupuncture involves inserting thin, sterile, metal needles into specific points on the body known as the acupoints to rebalance the flow of Qi.⁸ There are currently many theories to explain how acupuncture works, including Gate Control Theory of pain, Endorphin Model and Neurotransmitter Model. However, when acupuncture is not performed by a trained professional, adverse effects can be devastating and can cause organ or tissue injuries, infection, local reactions, and syncope.⁹

LA provides a safer and pain-free alternative to traditional acupuncture by utilizing nonthermal, low intensity lasers to stimulate the acupuncture points. By avoiding skin penetration, the technique reduces adverse side effects and it is more sought after from geriatric and pediatric patients. The treatment length is also shorter compared to the traditional metal needles, only requiring 10-60 seconds per acupuncture site as opposed to the 10-20 minutes of metal needle retention time.¹⁰ Studies have shown that lasers have a comparable anti-inflammatory effect to pharmacological options¹¹, neural modulation influencing peripheral and central nervous system activity, and cellular effect that benefit would healing.¹² To the current author's knowledge, the use of LA appears to be a safe adjunct to pain management for patients. Therefore, this review systematically collected previous published randomized controlled trials within 5 years regarding the effectiveness of pain management with LA.

2. Methods

2.1 Search Strategy

A comprehensive search was conducted via Google Scholar and PubMed in June 2023, using keywords that were published within the last 5 years. The key search terms included ‘laser acupuncture’ or ‘laser acupuncture therapy’ and ‘pain’. In addition to the above search, a manual search was conducted in the references.

2.2 Inclusion and exclusion criteria

A study was considered eligible if it focused on the application of laser acupuncture for pain control, encompassing various pain conditions such as musculoskeletal pain, chronic pain, and postoperative pain. Only randomized controlled trials published from 2018 to 2023 were considered for inclusion. The study was excluded when the focus of the paper did not answer the research question, did not present laser acupuncture as one of the experimental groups, or if studies older than 2018. Additionally, reviews, Non-English studies, or studies whose full texts could not be accessed were also excluded.

2.3 Data extraction

The author independently screened the titles and abstracts of the identified articles to assess their relevance. Full text articles of potentially relevant studies were retrieved and further evaluated based on the inclusion and exclusion criteria, study design, sample size, intervention type, and outcomes.

2.4 Data Synthesis

The data from the extracted sources were summarized in a qualitative analysis based on the level of pain reduction using visual analog scale (VAS) pain score. Secondary outcome of function scores and the quality of life questionnaire were also analyzed.

2.5 Interpretation of results

The findings will be interpreted to determine the necessity of alternative medicine strategies in managing pain with laser acupuncture. The results will be presented in a comprehensive report that includes a summary of the findings, limitations of the study, and recommendations for future research.

The study's limitations include the potential for publication bias, as only published studies will be included, and the exclusion of studies published before 2018. Additionally, the study will rely on the quality of the selected studies' methodology and data reporting.

3. Results

3.1 Search Results

Figure 1 illustrates the process of selecting studies for this literature review. Initially, 389 articles were identified through database searching. During screening, 360 articles were excluded based on the relevance to the proposed question. Out of the 29 remaining articles, 24 articles were retrieved to assess their eligibility based on the full text. Eight articles were excluded because they did not include laser acupuncture as a clinical intervention and one article was excluded as it was a proposed RCT trial. Finally, a total of 15 articles were included in this literature review.

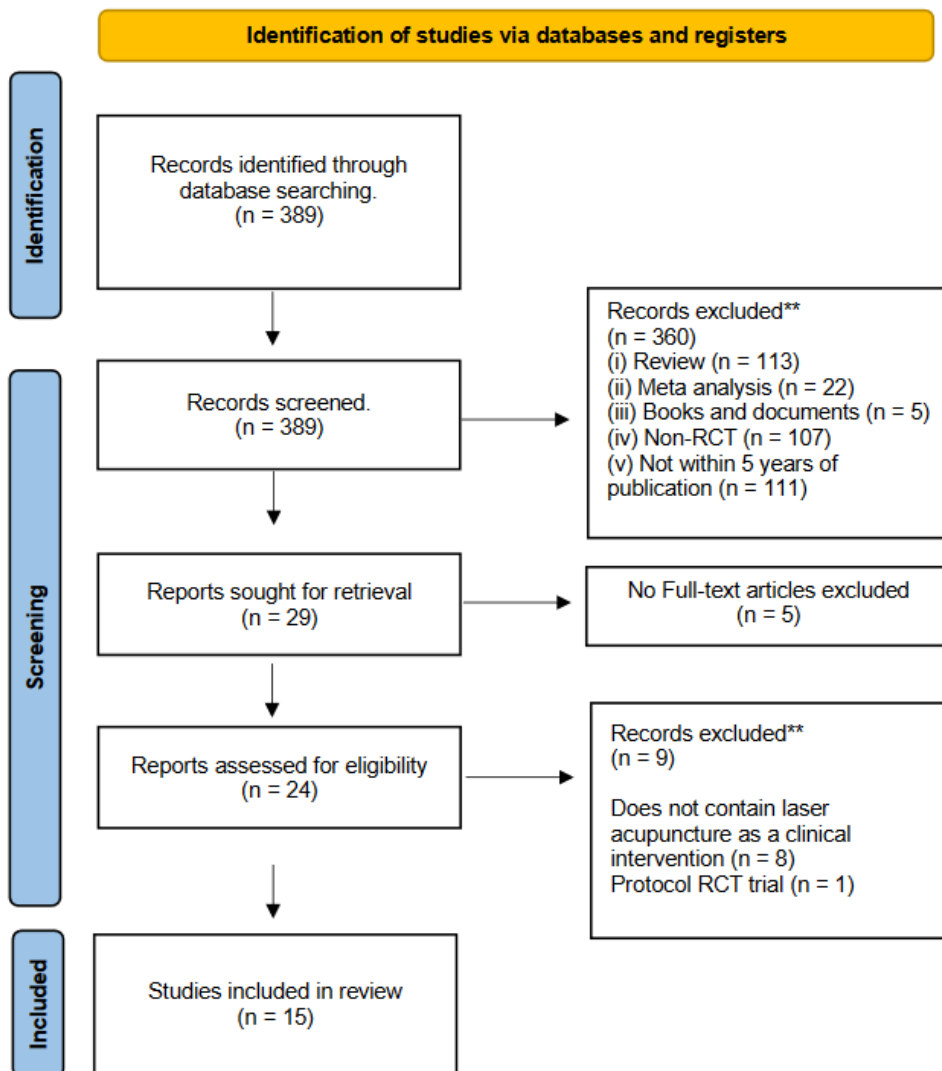


Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow chart to show the selection process of the review.

A specific data extraction form was created using Google Sheet for data management. Table 1 describes the characteristics of each reviewed RCT study (Author, year, sample number, Country, condition, laser type, wavelength, dose, power density, and authors' conclusions).

Table 1.

Characteristics of included RCTs: Trial Conditions, Laser Parameter, and Efficacy

1st Author	Year	Country	N	Condition	Laser Type	Wave Type	Wavelength	Output	Density	Dose	Efficacy
Kim ¹³	2022	Republic of Korea	45	Chronic non-specific low back pain	Low level infrared laser	-	650 nm, 830 nm	20 mW	38216.56 J/cm ²	12 J/point	Positive
Cheng ¹⁴	2023	Taiwan	106	Postpartum Low Back Pain	Low level infrared laser	-	-	-	4.5 J/cm ²	-	Positive
Yang ¹⁶	2023	Taiwan	76	Low back pain in nurses	Low level infrared laser	-	810 nm	200 mW	3 J/cm ²	-	Positive
Madani ¹⁷	2019	Iran	45	Temporomandibular disorder	Low level infrared laser	Continuous	810 nm	200 mW	21 J/cm ²	6J/point	Positive
Bozchelooee ¹⁸	2022	Iran	30	Chronic cervical myofascial pain syndrome	Low level infrared laser	-	905 nm	100 mW	10 J/cm ²	-	Negative
Menezes ¹⁹	2022	Brazil	50	Chronic spinal pain	Low level infrared laser	-	808 nm	100 mW	-	4J/point	Positive
Mohammed ²⁰	2018	Egypt	40	Knee Osteoarthritis	Low level infrared laser	-	808 nm	90 mW	2.8 W/cm ²	21.6J/point	Positive
Hassan ²²	2023	Egypt	68	Osteoporotic postmenopausal	Low level infrared laser	-	905 nm	12 mW	2 J/cm ²	-	Positive
Brase ²³	2022	Germany	95	Cesarean section under spinal anesthesia	Low level infrared laser	Continuous	830 nm	30 mW	3.8 W/cm ²	-	Negative
Huang ²⁴	2022	Taiwan	82	Postoperative pain with total knee arthroplasty	Low level infrared laser	-	808 nm	300 mW	-	3J/point	Positive
Sampaio-Filho ²⁵	2018	Brazil	84	Postoperative pain in third molar surgery	Low level infrared laser	-	660 nm	100 mW	35.4 mW/cm ²	6J/point	Negative
Oliveira ²⁶	2021	USA	60	Paraesthesia after extraction of lower third molars	Low level infrared laser	-	808 nm	100 mW	-	4J/point	Positive
Mozafari ²⁸	2022	Iran	30	Dental Impressions	Low level infrared laser	Continuous	810 nm	200mW	31 J/cm ²	-	Positive
Pooja ²⁹	2023	USA	112	Dental local anesthetic	Low level infrared laser	-	650 nm	5 mW	-	-	Positive
Stadler ³⁰	2021	Austria	96	Neonate pain prevention	Low level infrared laser	Continuous	675 nm	10 mW	34 J/cm ²	0.6J/point	Negative

3.2 Characteristics of the eligible studies

A total of 1019 participants were included in the 15 studies evaluated for this review. The participants were subdivided into the groups depending on the treatment received. Total of 493 in the laser acupuncture group and 479 in the placebo laser acupuncture group. A few studies also reported on the effectiveness of low-level laser therapy (LLLT) and Electroacupuncture (EA). There were a total 35 participants in the LLLT group and 10 in the EA group.

3.3 Low back pain

From the reviewed studies, low back pain management was one of the many uses of laser acupuncture.^{13, 14, 15}

Kim et al. analyzed 45 patients with chronic non-specific low back pain (CNLBP) to study the efficacy of laser acupuncture. The participants were randomly assigned to three groups: control group (n=15) receiving sham laser, the second group (n=15) received 650 nm-wavelength laser acupuncture, and the last group (n=15) received 830 nm-wavelength laser acupuncture. All three groups received acupuncture for 10 min once a day, twice a week for 4 weeks, targeting BL23, BL24, BL25, and GB30 acupoints bilaterally. The primary outcomes, visual analog scale (VAS) score, and secondary outcomes, including Oswestry Disability index (ODI), European Quality of Life Five-Dimension-Five-Level (EQ-5D-5L), were measured at 0 week, 4 week (at the end of the intervention), and at 8 weeks. The VAS score for the 650nm group was significantly lower compared to the control group ($p < 0.05$). ODI scores were significantly lower in both 650nm and 830nm groups ($p < 0.05$) compared to the control group.¹³ The 650nm group exhibited significant improvement in both pain intensity and functional disability while the 850nm group showed improvement in functional disability.¹³ This study highlights the efficacy, safety, and easy usages of LA in treating CNLBP.

Similarly, Cheng et al. conducted a randomized controlled study in 106 participants suffering from postpartum low back pain at the Kaohsiung Chang Gung Memorial Hospital. The participants were postpartum women aged 20 years old or older experiencing low back pain defined by visual analogue scale (VAS) score ≥ 1 that does not alleviate with 30 minutes of rest in the lumbar area. The patients were randomly divided into two groups ($n = 53$): the control group received standard postpartum care while the intervention group received laser acupuncture therapy (LAT). The LAT therapy consisted of 10 sessions of daily morning acupuncture with a gallium aluminum arsenide laser pen of 0.375 j at specific acupoints based on the Traditional Chinese Medicine (TCM) at BL23, BL25, BL 26, BL40, and SP6. Each LAT session was conducted by the same Chinese medicine practitioner to ensure consistency between participants and sessions. The primary outcomes of intensity of low back pain and secondary outcomes of limitations of daily and physical activity, perceived stress, and salivary cortisol values were measured at baseline and at the end of the treatment. Both groups had a statistically significant decrease in VAS score ($p < 0.001$) however LAT groups's VAS score was significantly lower than the control group ($p < 0.001$).¹⁴ The LAT group exhibited lower limitation of daily activities ($p < 0.001$), Oswestry Disability Index (ODI) scores ($p < 0.05$), limitation of physical activity ($p < 0.001$), perceived stress scale (PSS) ($p < 0.01$), and lower salivary cortisol values ($p = 0.02$) compared to the control group.¹⁴ This study emphasizes the positive impact of combining laser acupuncture therapy to standard care to postpartum patients with LBP without severe side effects.

Work related back pain is very common, with NIOSH reporting that 1 in 4 working adults experiences low back pain and among all workers with back pain, 20% are health professionals.¹⁶ Yang et al. conducted a randomized controlled trial to utilize laser acupuncture to nurses

experiencing low back pain. The study included 38 nurses assigned to low level laser acupuncture combined with laser auricular acupressure (LAA), while the other 38 received only sham laser acupuncture treatment as the control group. The treatment consisted of twice weekly acupuncture intervention for 4 weeks targeting LI4, SI1, SI3, BL40, BL60, GB34, and KI3 acupoints using a gallium aluminum arsenide laser diode at 810 nm wavelength. Each acupoint received laser application for 30 seconds. For auricular acupoints, TF4, AH9, and AT4 were utilized to help relieve pain. To replicate the *deqi* sensation, a seed was placed in the patient's ear for 5 days, once a week for 4 weeks. The interventions were performed by a TCM practitioner. As an outcome, the study collected VAS scale everyday and measured life dysfunction using the Roland-Morris Disability Questionnaire (RMDQ). The LAA intervention showed significant difference in the pain level, pain interference and life dysfunction over time with the most significant difference observed at weeks 2 and 4 ($p < 0.001$).¹⁶ In addition to reducing pain, LAA also contributed to decrease in the usages of analgesic medication. The control group's medication usage increased from 22.22% to 25.00%, while the LAA group's usage decreased from 28.90% to 5.26%.¹⁶ Furthermore, in the control group, the recurrence rate of LBP after the intervention at 4th week was 69.44% and 36.11% at 8th week. In contrast, the LAA group demonstrated a recurrence rate of 0% at 4th and 36.89% at the 8th week.¹⁶ This study provides evidence that LA is an effective non pharmacological intervention that can expand the current treatment option to manage low back pain.

3.4 Chronic pain

Chronic pain such as temporomandibular disorder (TMD), chronic cervical myofascial pain syndrome, and chronic spinal pain were studied in a randomized controlled trial setting with laser acupuncture in managing pain.^{4, 9, 15}

Madani et al. conducted a randomized clinical trial to compare the ability of low-level laser therapy (LLLT) versus laser acupuncture therapy (LAT) in managing pain with temporomandibular disorder. The study included 45 participants divided into three groups: LLLT group (n=15), LAT group (n=15), and the control group (n=15). In the LLLT group, a low power gallium aluminum arsenide diode laser was applied to the painful points indicated by the participants for 30 seconds with 6J of energy. The LLLT group received the treatment two times a week for 5 weeks. The LAT group received 810 nm diode laser at acupoint ST6, ST7, and LI4 with the same laser probe and setting as the LLLT group, twice a week for 10 sessions. The control group received a similar treatment as the LLLT group but the laser was off and no energy was applied. Pain levels were assessed using Visual Analog Scale (VAS), the range of mouth opening with and without pain, right and left laterality, and protrusion were measured at baseline (T1), after 5 sessions (T2), at the end of the treatment (T3), and 1 month after the intervention (T4). The overall pain intensity at rest showed a significant difference between groups T2, T3, and T4 ($p < 0.05$) in both the experimental groups.¹⁷ After 10 sessions of treatment, the average pain score of 6.1-6.3 reduced to 1.20 in the LLLT group, 1.77 in the LAT group and 5.06 in the control group. The pain score at the origin, body and insertion of masseter muscles showed significant difference at group T2, T3, and T4 for the experimental groups ($p < 0.05$).¹⁷ LLLT and LAT improved pain in the face and neck area significantly after 5 and 10 sessions, with pain not recurring at 4 weeks. However, neither method improved the range of mouth opening in patients, only lateral movement showed improvement. This study demonstrates the effectiveness of reducing overall pain intensity with both LLLT and LAT in TMD patients. Masticatory muscles respond well to the therapy as evidenced by VAS scores. Both LLLT and LAT provide a safe, pain free, cost effective method to improve pain in TMD. LAT was more favorable due to

the three easily identifiable acupoints and short treatment time(180s) with similar efficiency with LLLT. It is noteworthy that laser application has its limitations as the paper only found improvement in pain level and not in the function of the TMD patients.

Similar to TMD, patients with chronic cervical myofascial pain syndrome experience chronic pain that is not easily relieved by pharmacological methods. Bozchelooee et al. studied the effectiveness of Electro Acupuncture(EA) versus Laser Acupuncture(LA) on patients who are experiencing symptoms from cervical myofascial pain syndrome. In a randomized controlled clinical trial, the study conducted a pilot study on 30 participants. The patients were divided into three groups: the first group (n=10) received EA, the second group (n = 10) received LA, and the last group (n = 10) served a control group receiving a LA with no energy emission. The EA group received an intramuscular electrical stimulation through a needle insertion for 20 minutes at acupoints GB20, GB21, BL43, LI4, and LI11. The LA group received an energy density of $10\text{J}/\text{cm}^2$ at the same acupoints as EA using a 905 nm wavelength laser in a pulsed mode. All the group received the treatment once. The pain intensity, pain pressure threshold (PPT), active range of cervical spine and neck disability index (NDI) were measured at baseline, immediately after the intervention and one week after the treatment. There was a significant reduction in VAS score in the EA group immediately after the intervention and at the follow up.¹⁸ In the LA group, pain reduction was observed but not as effective as EA. The PPT, NDI score was also improved significantly in the EA group after the treatment.¹⁸ Bozchelooee discusses the result of the study differing from the previous studies as other studies have shown improvement with LA treatment in patients with neck pain. The study attributes the study participant size and the low applied laser density as factors that could have impacted the result. This study demonstrates that acupoints can be utilized to help with patient's pain management in chronic cervical myofascial

neck pain. In a single session, EA is more effective than LA. When utilizing LA, multi-session is recommended for an appropriate energy density to relieve symptoms.

Menezes studied the effect of low-power laser auriculotherapy in patients experiencing chronic spinal pain. 50 participants were randomly assigned to two groups. The control group (n= 25) received standard of care while the experimental group (n=25) received 10 sessions of auricular laser acupuncture of 808 nm wavelength for 40 seconds. The acupoints stimulated were TF4, CO10, AH6a, CO9, CO12, AT1, AH13, AH11, and AH9. Pain intensity and pain threshold were measured at baseline, immediately after the last session, and 15 days after the treatment. The pain intensity decreased in the experimental group immediately and 15 days after the treatment. There was a significant increase in the pain threshold with patients who received auriculotherapy ($p < 0.01$).¹⁹ Additionally, there was a significant percentage clinical pain intensity improvement in the experimental group compared to the control group.¹⁹ The study emphasizes that in chronic pain cases, both subjective and physiological issues need to be evaluated using pain intensity and pain threshold. Laser auriculotherapy is an affordable, painless procedure that can aim at both aspects of chronic pain. Menezes also agrees with Bozchelooee with laser acupuncture needing enough energy dose for the patients to benefit from the treatment. Menezes concludes that laser auriculotherapy is an effective technique to assist in treating chronic spinal pain but further studies are needed to determine the ideal energy dose for the therapy.

3.5 Osteoarthritis/Osteoporosis

Osteoarthritis(OA) and osteoporosis(OP) are the two most common skeletal disorders that affect millions of people globally and are typically treated with pharmacological

management. In the literatures, laser acupuncture has been studied for its effect of pain management in patients with OA and OP.^{16,8}

Mohammed investigated the effect of LA in patients with grade 2 knee osteoarthritis, evaluating pain level via VAS, serum beta-endorphin, and substance P. Forty participants were divided into two groups. The first group (n=20) received LA through an 808 nm wavelength laser pen for 1 min at each acupoint (ST35, ST36, SP6, SP10, GB34) for a total of 70.2 j of energy in each knee 3 times per week for 4 weeks. The second group (n=20) received the same treatment as the first group but with a sham laser pen that does not emit any energy. After the intervention, there was a significant decrease in VAS in the LA group ($p = 0.001$).²⁰ Beta endorphin level was also significantly higher after the LA treatment ($p = 0.004$) indicating the increase in analgesic effect.²⁰ Furthermore, there was a significant decrease in substance P level after the LA treatment ($p = 0.076$) which suggests LA played a role in decreasing pain perception.²⁰ The finding suggests that LA therapy modulates neurotransmitters to decrease pain and future research should explore the effect of LA in a quantitative way.

Severe cases of OA can lead to increased pain and further bone loss, which can be diagnosed as OP. OP is very common among postmenopausal women as estrogen level drop.²¹ Hassan et al. conducted a randomized controlled trial to determine the impact of LA on forearm bone mineral density (BMD) and wrist pain in postmenopausal women with osteoporosis. 68 postmenopausal women with diagnosed osteoporosis were randomly divided into two groups. The control group(n=34) received drug treatment consisting of oral calcium and vitamin D3 supplement with fluoride once a day for 12 weeks. The experimental group (n=34) received the same medication with addition of LA therapy. The LA therapy was conducted with a 905 nm wavelength, energy density of 2 J/cm, 60 seconds per acupoint at BL11, BL18, BL20, BL23,

ST36, SP6, GB25, GB34, GB39, CV4, and GV4. The sessions were held three times a week for 12 weeks. T-score of BMD were measured by DEXA as well as wrist pain score using VAS at baseline and post-treatment. Results showed that both of the groups had significant increase in bone density ($p < 0.0001$) and decrease in pain level ($p < 0.0001$).²² The BMD and pain improved more significantly with the group that received LA therapy alongside medication ($p < 0.0001$).²² The study states that LA is a favorable treatment choice compared to standard acupuncture for its noninvasive, painless nature, and shorter treatment duration. The combination of LA with standard care of osteoporotic postmenopausal women demonstrated to be an effective modality.

3.6 Postoperative pain management

Postoperative pain such as cesarean delivery, total knee arthroplasty(TKA), third molar removal surgery were studied to examine the effect of LA in pain management.^{23, 24, 25}

For postoperative pain management, Brase conducted a double blinded, randomized placebo controlled trial to investigate the usages of LA as a postoperative pain therapy following cesarean section under spinal anesthesia. 95 female patients were randomly divided into group A and B. Group A (n=48) received 830nm, continuous wave, 3.8W/cm² laser beam at Di-4 and Shen-Men of the ear acupoint for 1 min for 3 days starting from the operation day. Group B (n=47) received a placebo laser treatment. Both groups received standard care of NSAIDs and opioids. Pain intensity, and consumption of pain medications were measured using Numeric Rating Scale (NRS). The study did not find any statistically significant difference between the groups regarding the pain intensity, opioid or NSAIDs consumption, or the mobilization and length of stay between the two groups.²³ The author states that many literature trials show postoperative pain reduction with the same acupoints used in the study. However, the study's

data was complex due to the non-standardized pain medication between the patients. Although the study did not find statistically significant data, it highlighted the ease of incorporating LA in patients' management plan and its overall high acceptance as a therapeutic approach.

Similarly, Huang conducted a randomized placebo controlled trial with patients who underwent TKA to study the effect of LA in postoperative pain relief. 82 patients were randomly assigned to the LA group (n=39) and placebo acupuncture (PA) group (n=41). The LA group received laser light at six acupuncture points (SP6, KI3, BL60, GB31, ST32, PC6) using gallium aluminum arsenide semiconductor diodes at 808 nm with 3-8 J per acupuncture point for 10 seconds. The acupuncture was performed at hours 2, 6, 10, 24, 48, and 72 after surgery. The PA group underwent the same procedure but with a sham laser pen that did not emit laser light. Pain intensity, relative pain, pain with daily activities, consumption of morphine and side effects of morphine were measured. The pain intensity decreased over time for both groups, but the LA had a more significant decrease in pain after the baseline ($p < 0.05$).²⁴ The consumption of morphine also decreased and the LA group had a significant decrease in consumption at hour 48 and 72 ($p < 0.001$).²⁴ At hour 72, there was a significant difference between the groups on the activities in daily life ($p < 0.05$).²⁴ This study not only demonstrated the effectiveness of LA in managing postoperative pain but also highlighted the potential for reducing the overall need for standard pain medication following post operation.

Furthermore, Sampaio-Filho applied laser treatment on auriculotherapy points to evaluate the effectiveness of reducing postoperative pain after a third molar surgery, which is another common surgery. 42 patients participated in the randomized controlled single blinded study and they were divided into two groups. The experimental group (n=42) received LA at 6 auriculotherapy points postoperatively, 24 hours and 48 hours after the surgery with a 660 nm

wavelength laser with 1J of energy over 10 seconds. The control group (n=42) underwent the same procedure as the experimental group but without the laser emitted energy. Postoperative pain was measured using VAS, measurements of mouth opening, edema, local temperature, dysphagia, and any presence of infection were taken at baseline, day 1,3, and 7. There were no significant differences between the groups in the postoperative pain level.²⁵ The study states that third molar removal surgery is unpredictable and difficult to control for standardization.²⁵ The choice of wavelength, output power, power density, dose and exposition time could have also influenced the outcome of the LA. This study highlights the difficulty of studying the effect of laser treatment and emphasizes the continuous need for research.

While some trials with postoperative pain management with LA showed significant pain reduction, others highlighted the complexities in standardization and the necessity for continued research.

3.7 Dental procedures

Laser acupuncture was also utilized in dental procedures to reduce pain.^{26, 28, 29}

Oliveira et al. conducted a study to compare the effect of laser therapy(LT) and laser acupuncture(LA) in patients who experience paraesthesia after lower third molar removal surgery or an implant surgery. The study included 60 patients scheduled for surgery or implant placement were divided into three groups. Group LT (n=20) and group LA (n=20) received their respective treatment twice a week for 10 weeks and were evaluated at baseline, 5 weeks and after the 10 week intervention. The LT group received a low power laser along the LAN path while the LA group received lasers on ST4, M-HN-18, CV24, ST5, ST6, and A1. Both LT and LA groups were treated with 808 nm wavelength laser 40 second per point, delivering 4 J of energy. The control group received standard care and was evaluated after baseline, 4 weeks and 30 days

after the intervention. The general perception of paresthesia was collected using VAS, while thermal perception threshold, vibratory mechanical perception threshold, two point discrimination, and pain perception threshold were also assessed. The results showed a significant difference between the general perception of paresthesia at week 8 ($p < 0.003$).²⁶ Patients undergoing photobiomodulation therapies(LT and LA) had better general and thermal perception results compared to the control group ($p < 0.05$).²⁶ This study provides insight into the effectiveness of multiple session of LA in managing postoperative paresthesia in patients undergoing dental surgery.

Another common dental procedure is dental impressions; however, patients find the process uncomfortable as it often triggers the gag reflex.²⁷ In a randomized double blinded clinical trial, Mozafari investigated the effect of LA on controlling gag reflex during dental impressions and reducing pain during the procedure. 30 patients were divided into 2 groups. The intervention group received LA at PC6 and CV24 acupoints for 4 seconds with 0.8 J of energy during dental impression while the control group underwent a simulated without real laser. Gagging Severity Index (GSI), Subjective Severity of Gag reflex (SSGR), Vomiting Number(VN), and improvement index was measured. The intervention group was seen with elevated GSI ($p < 0.001$), decreased SSGR ($p < 0.001$), and lessened VN ($p = 0.001$).²⁸ This study demonstrated that laser acupuncture can effectively reduce gag reflex during dental impressions and alleviate discomfort and pain, offering a noninvasive approach to improving patient experience.

Furthermore, Pooja et al. studied the effectiveness of LA to reduce pain perception in 112 children receiving dental local anesthetics using a randomized clinical trial. Group 1 received LA at LI4 acupoint for 2min with the routine behavioral guidance while group 2 received routine

behavioral guidance techniques only. Baseline measurements of Faces Pain Scale-Revised(FPS-R), Faces, Legs, Activity, Cry and Consolability scale(FLACC) and Modified Child Dental Anxiety Scale(MCDAS) were taken and these measurements were repeated after the LA administration. The results indicated a significant reduction in anxiety among children receiving dental local anesthetic in group 1($p < 0.001$), and the pain and FLACC scores were also lower in group 1 ($p < 0.001$).²⁹ This study demonstrates the effectiveness in reducing pain and anxiety in children receiving the dental block anesthesia procedure, and highlights its safety, noninvasive nature, and friendly adjunct to pain management in pediatric patients.

Collectively, these studies highlight the promising role of LA in pain management across various dental procedures and patient populations.

3.8 Pediatrics

As discussed in the dental section, LA is a safe and noninvasive option that is friendly to children. Stadler et al. studied the uses of LA in term neonates to prevent pain during heel lances. 96 term neonates were randomly assigned to two groups. The LA group ($n=48$) received a 10mW laser at LI4 bilaterally. The control group ($n=48$) received the standard care of 30% oral glucose solution before heel lance. Pain assessment was done using the premature infant pain profile(PIPP) score, heart rate, and crying time. Although there were no significant differences in the PIPP between the groups, the LA group showed a significantly lower heart rate in neonates after the intervention compared to the control group.³⁰ Which demonstrates the effect of LA on term neonates and possibly helping with their anxiety. Both of the groups showed equal medians of PIPP scores and the author states that even though LA did not perform better than the oral glucose, LA therapy should not be considered inferior.³⁰ The finding suggests the potential of LA

in helping to alleviate anxiety in term neonates during painful procedures, making it a promising noninvasive option for neonates.

4. Discussion

Although clinical evidence supports the therapeutic benefits of laser acupuncture for various diseases^{14, 15, 17,22, 16, 29, 13, 1, 19}, this systematic review represents the first comprehensive comparison of laser acupuncture's effect in pain management across different medical conditions. The analysis reveals that LA offers a safe, pain-free and low-risk treatment option, particularly in musculoskeletal disorders, when used in conjunction with standard pain management. Importantly, LA was easily integrated into standard of care for all patients without major side effects, demonstrating successful application in neonates, children, and elderly individuals. For effective pain control and sustained outcomes, administering an appropriate dosage of LA is crucial. Studies involving multiple sessions of LA therapy with an adequate number of acupoints reported more favorable results in pain management.

4.1 Primary outcomes

The majority of the studies included in the review demonstrated a significant reduction in pain when standard of care was combined with LA therapy. However, in contrast, four of the fifteen studies reported no benefit. Due to the complexity and the variability between the studies included, meta-analyses were conducted by grouping the studies based on their study populations and follow up time points.

4.1.1. Low back pain

The review included three studies that evaluated the effect of LA on low back pain in diverse populations: postpartum LBP, LBP with nurses, and chronic non-specific LBP. They utilized

VAS scale to determine the research outcomes. The methods differed in the frequency and the placement of the acupuncture (4 acupoints 8 sessions, 6 acupoints 10 sessions, 7 acupoints 8 sessions). The findings from the reviewed studies collectively demonstrate the effectiveness of LA in managing LBP across diverse populations. The LA therapy significantly made a difference in the pain level and improved overall function in patients and supports the notion that LA offers a valuable non-pharmacological intervention. Yang et al. also studied that the patients receiving LA therapy had a lower recurrence rate and reduced usage of analgesic medication. NSAIDs and opioids have side effects after long term uses. Patients experiencing chronic LBP can utilize LA therapy to low the use of analgesic medication, improve pain, and life function.

4.1.2 Chronic pain

Three studies showed reduction in pain when LA therapy was applied to patients experiencing chronic pain such as TMD, myofascial pain, and spinal pain.^{17, 18, 19} Despite all three studies focusing on chronic pain, they employed different methods of therapy involving varying numbers of acupoints and treatment sessions (3 acupoints 10 sessions, 5 acupoints one session, and 9 acupoints 10 sessions). One study out of the three explored the use of auriculotherapy, which stimulates acupoints on the ear auricles. The study had the 9 acupoints for 10 sessions with auriculotherapy reported a significant percentage of clinical pain intensity improvement which indicates the importance of multi-session and multiple acupoints for LA therapy. However, it is important to note that none of the studies included a follow up assessment.

Chronic pain poses a significant challenge to conventional pharmacological treatment options due to its complex and multifaceted nature. Pharmacological therapies often rely on the use of analgesic medications, such as NSAIDs and opioids, which are associated with adverse effects. Moreover, chronic pain conditions are not always responsive to standard

pharmacological approaches. By stimulating specific acupoints with low level laser light, LA targets the body's natural healing mechanisms and modulates pain perception.⁶ This non-invasive and painless method is well tolerated by patients.

4.1.3. Osteoarthritis/Osteoporosis

Two studies were examined, focusing on OA and OP that used LA to study the effect on pain level.^{20, 22} In the study involving OA patients, LA therapy was administered at 5 acupoints for 12 sessions. As a result, there was a decrease in pain and changes in the serum beta-endorphin and substance P. On the other hand, OP patients received 11 acupoints for 36 sessions, also leading to a decrease in pain level and significant increase in bone density. Both the OA and OP study utilized multiple acupoints, impacting different portions of the body over several sessions. The effect of LA therapy in managing musculoskeletal disorder has been well documented and clinically seen in the past.³¹ However, further research is needed to optimize LA protocols, standardize treatment regimens, and elucidate the underlying mechanisms involved in its therapeutic effects of LA for OA and OP.

4.1.4. Post-operative pain

Post-operative pain is a common issue and three studies in the review utilized LA to study its effect on the pain management process. However, this section had the least supported literature. For instance, in postoperative pain following cesarean section, the addition of LA therapy did not result in improvement in pain intensity or show decreased in opioid or NSAIDs consumption. The study involved 2 acupoints for 3 sessions, which is one of the fewer numbers of acupoints and sessions in this review. The author states that the data interpretation was challenging due to the non-standardized pain medication between participants.²³ Similarly, in patients undergoing third molar surgery, LA was administered at 6 acupoints for 3 sessions.

However, there were no changes in the pain level. It is noteworthy that this study utilized the lowest wavelength of 660 nm from the literature review with only 1 J of energy over 10 seconds.²⁵ Through these studies, it is suggested that the choice of wavelength, output power, power density, dose and exposure time influences the outcome of the LA therapy. Conversely, in patients who underwent TKA, LA was delivered at 6 acupoints for 6 sessions at 3-8 J of energy per point. The study demonstrated a significant pain reduction in patients who received LA along with improved activities in daily life. Overall, these studies highlight the challenges of studying the effects of LA treatment on postoperative pain management, given the variability of acupoints, number of sessions, and the laser parameters. Understanding the influence of different laser parameters is crucial for optimizing the effectiveness of LA therapy in pain management.

4.1.5 Dental procedure

LA has been studied in many dental procedures in the recent literature, mainly due to its ease of use and cost effectiveness. This literature review analyzed three studies that highlight the promising role of LA in management during the dental local anesthetic, controlling gag reflex, and reducing paraesthesia after a dental surgery. As a noninvasive and effective method, LA shows great potential for improving patient comfort and warrants further exploration and consideration for broader implementation in dental practice.

4.2. Weakness of negative studies

The studies utilized different wavelength and strength of the laser, making it difficult to standardize and compare between the results of the papers. Many researchers acknowledged the lack of standardization in the power, wavelength and duration of the laser to be the limitation of the research. Chon explains that individuals have different skin pigments and thickness that

makes light penetration inconsistent,⁸ resulting in different outcomes even with the same laser parameters.

Another common trend in the studies that had no significant result with LA therapy was the use of few acupoints with a small number of treatment sessions. This approach may limit the therapeutic effects of LA as the limited number of acupoints may not fully target the underlying structures or provide sufficient stimulation for pain relief. Additionally, a limited number of sessions might not allow enough time for the cumulative effects of LA therapy to the patient.

4.3 Clinical relevance of Laser parameter

The variation in the application of the laser acupuncture therapy is likely responsible for the different outcomes observed in the review. When assessing the LA's effectiveness in pain management, the difference in the methodology such as wavelength, power density, pulse duration, and treatment duration should be considered. Some study suggests that LA should be dependent on individuals and each target point to achieve the desired effect.⁸ Therefore, accurate selection and control of these laser parameters are vital to ensure consistent and reliable therapeutic outcomes in LA therapy that can be analyzed and interpreted.

4.4 Limitations

The limitations of this review include the variability between each of the studies. Each study had different acupoints and differences in laser parameters(wavelength, pulse duration, power) and treatment durations, making it challenging to directly compare and standardize the result. Additionally, the relatively small sample sizes in the studies could limit the generalizability of the findings. Moreover, the lack of long term follow up assessments in several studies hinders the understanding of the sustained effects of LA therapy. Another limitation includes the potential bias in the publication bias. Lastly, restricting the search to English

language publications could introduce bias towards countries that primarily publish in English..

As acupuncture originates from China and east asian countries, not being able to access the research papers from around the world can bring potential bias into the included studies.

5. Conclusions

Based on the results of the current review, laser acupuncture has demonstrated its effectiveness in reducing pain level and enhancing the patient's quality of life when sufficient energy is used in each therapy and across multiple sessions. Although the effect of laser acupuncture gradually diminishes over time, it offers a valuable non pharmacological approach to help patients rely less on medication and experience pain relief through a safe, easy and painless method. To ensure robust and comparable results in the future trials, it is crucial to consider more standardized parameters, including consistent acupoint selection and laser parameters. Incorporating long-term follow-up assessments will also provide valuable insights into the sustained effects of LA therapy. Furthermore, adopting quantitative measures such as beta-endorphin, and substance P level, alongside pain assessments using VAS, will strengthen future studies. With continued research and refinement, LA holds promising prospects as a complementary therapy in pain management across different fields, offering a way to improve patient's outcomes and well-being.

6. Disclosure

Author declares that they have no conflicts of interest regarding the publication of this paper.

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