Clinical Practice Guideline: **Laser Therapy (LT)**

Date of Implementation: **February 9, 2006**

Product: **Specialty**

GUIDELINES

Low-level laser therapy is considered medically necessary for prevention of oral mucositis in patients undergoing cancer treatment associated with increased risk of oral mucositis, including chemotherapy and/or radiotherapy, and/or hematopoietic cell transplantation.

Low-level laser therapy (LLLT) is considered unproven for all other indications, including but not limited to:

- Wound healing
- Musculoskeletal pain; (e.g., back and neck pain, carpal tunnel syndrome, lateral epicondylitis, shoulder impingement, myofascial pain syndrome, fibromyalgia, and others)
- Osteoarthritis and rheumatoid arthritis
- Temporomandibular joint disorders

High-power Class IV therapeutic laser light therapy or similar therapeutic laser light therapy is considered unproven for all indications.

CPT/HCPCS Code	CPT/HCPCS Code Description
97037	Application of a modality to 1 or more areas; low-level laser therapy (i.e., nonthermal and non-ablative) for post-operative pain reduction.
S8948	Application of a modality (requiring constant provider attendance) to one or more areas; low-level laser; each 15 minutes

Patients must be informed verbally and in writing of the nature of any procedure or treatment technique that is considered experimental/investigational or unproven, poses a significant health and safety risk, and/or is scientifically implausible. If the patient decides to receive such services, they must sign a Member Billing Acknowledgment Form (for Medicare use Advance Beneficiary Notice of Non-Coverage form) indicating they understand they are assuming financial responsibility for any service-related fees. Further, the patient must sign an attestation indicating that they understand what is known and unknown about, and the possible risks associated with, such techniques prior to receiving

these services. All procedures, including those considered here, must be documented in the medical record. Finally, prior to using experimental/investigational or unproven procedures, those that pose a significant health and safety risk, and/or those considered scientifically implausible, it is incumbent on the practitioner to confirm that their professional liability insurance covers the use of these techniques or procedures in the event of an adverse outcome.

DESCRIPTION

This guideline addresses low-level laser therapy (LLLT), also referred to as cold laser therapy, low-power laser therapy (LPLT), low-intensity laser and low-energy laser therapy and high-power Class IV therapeutic laser light therapy.

This guideline does not address surgical lasers, which involve vaporizing tissue with hot lasers.

GENERAL BACKGROUND

Laser or low-level laser therapy (LLLT) has been proposed as a modality used to accelerate and optimize the tissue repair process (Rocha et al., 2007). Laser stands for Light Amplification by Stimulated Emission of Radiation. LLLT is theoretically applied to photoactivate cellular mechanisms, leading to healing and normalization of tissue. The proposed result is reduced pain, inflammation, swelling, and accelerated tissue repair. Therapeutic lasers emit low-energy density but high enough to stimulate target cells with energy. Laser radiation is thought to be absorbed through cytochromes in the mitochondria and converted into ATP by the cell which acts to synthesize protein, mRNA and DNA, and accelerate cell proliferation based on the tissue receiving the light energy (Reddy 2004; Enwemeka et al., 2004).

In 2004, U.S. Food and Drug Administration (FDA) approved a higher power, Class IV therapeutic laser, for the safe and efficacious reduction of pain. Also called photobiomodulation, Class IV laser light therapy produces 7,500 milliwatts of continuous power. It is administered with a handheld device and is thought to provide deeper penetration over a larger surface area. According to the manufacturer, Diowave (formerly Avicenna Laser Technology, Inc): the Class IV therapeutic laser technology is used as a stand-alone modality to produce increased circulation, decreased inflammation, relaxation of muscle spasms and trigger points, accelerated tissue repair, and decreased pain at tissue sites previously unreachable by low-level stimulation. They are purported to stimulate accelerated healing energy from superficial to deep levels and a larger surface treatment area. Its proposed use includes conditions such as arthritis, carpal tunnel syndrome, epicondylitis, sprains/strains, trigger points and various other musculoskeletal disorders.

LLLT may be administered by several different types of providers, including physicians, chiropractors, physical therapists, or occupational therapists. It is generally provided in an office or other outpatient setting with no anesthesia or sedation needed.

EVIDENCE REVIEW

There are numerous randomized trials on various applications of LLLT and some show positive results. However, it is difficult to interpret these results because these studies include a wide range of conditions and methods of application, and because of the varied characteristics of the laser instruments utilized. As such, it is difficult to come to any general conclusions regarding the effectiveness of LLLT. In 2006, the World Association of Laser Therapy (WALT) established effective parameters and methods of application as a guideline for investigators to follow. These guidelines state that power densities below 100 mW/cm2 should be used for superficial tendons with an energy dose range of 1-8 Joules. For deeper tendons of the rotator cuff, power densities can go as high as 600 mW/cm2, with an energy dose of 3-9 Joules. Wavelengths should be in the range of 780-904 nm. These guidelines allow researchers to selectively analyze studies that fall into these parameters to evaluate effectiveness (WALT, 2006).

Joint Pain and Osteoarthritis (OA)

Several systematic reviews have been published regarding LLLT for treatment of joint pain and osteoarthritis. In general, they are inconsistent in the findings and do not substantiate the effectiveness of this treatment for these conditions.

Bjordal et al. (2003) performed a systematic review that included seven (7) randomized, placebo controlled trials where an adequate dose of laser therapy was applied to a chronic joint disorder. These authors found a weighted mean difference of 29.84 mm on the pain visual analog scale (VAS) following laser treatment for knee pain, temporomandibular pain, or zygapophyseal joints. They concluded that LLLT significantly reduces pain and improves health status in chronic joint disorders when parameters are within the suggested dose range. However, the review also notes that the results should be cautiously interpreted due to the heterogeneity in patient samples, treatment procedures, and trial design.

A systematic review of rehabilitative interventions was conducted to assess various rehabilitative interventions on pain, function, and physical impairments in hand osteoarthritis (Ye et al., 2011). There were 2 studies included in the review that addressed LLLT. It was found that there was no effect on pain with LLLT, but it may be useful for improving range of motion.

A systematic review of conservative interventions for osteoarthritis of the hand concluded that there is moderate evidence that low-level laser therapy is no better than placebo in improving hand function or decreasing hand pain or stiffness (Valdes and Marik, 2010). An overview of systematic reviews for physical therapy interventions for knee

osteoarthritis (OA) did confirm moderate evidence to support the effectiveness of low-level laser therapy for knee OA (Ottawa Panel Evidence-Based Clinical Practice Guidelines, 2004; Jamtvedt et al., 2008).

In a systematic review, Jang and Lee (2012) investigated the clinical effectiveness of LLLT on joint pain. Twenty-two trials were included involving 1,014 patients. Eleven trials were positive and 11 were negative. The change in pain ratings was in favor of the active LLLT groups. In trials where the WALT guidelines were followed, the mean effect sizes were in favor of the true LLLT groups. This review supported the use of laser therapy for reduction of joint pain, especially when restricting the energy doses to the ranges stated in WALT guidelines.

Huang et al. (2015a) investigated the efficacy of low-level laser therapy (LLLT) treatment of knee osteoarthritis (KOA) by a systematic review with meta-analyses on selected studies. Nine studies included were randomized controlled trials (RCTs) written in English that compared LLLT (at least 8 treatment sessions) with sham laser in KOA patients dated from January 2000 to November 2014. No significant difference was identified in studies conforming to the WALT recommendations (4 studies) or on the basis of OA severity. There was no significant difference in the delayed response (12 weeks after end of therapy) between LLLT and control in VAS pain (5 studies). Similarly, there was no evidence of LLLT effectiveness based on Western Ontario and McMaster Universities Arthritis Index (WOMAC) pain, stiffness, or function outcomes (5 and 3 studies had outcome data right after and 12 weeks after therapy respectively). Authors concluded that their findings indicated the effectiveness of LLLT for patients with KOA is not supported based on the best available current evidence.

Dima et al. (2017) presented a summary of the possible pain management benefits of LLLT. It has been seen to produce pain relief and fibroblastic regeneration in clinical trials and laboratory experiments. LLLT has also been seen to significantly reduce pain in the acute setting; it is proposed that LLLT is able to reduce pain by lowering the level of biochemical markers and oxidative stress, and the formation of edema and hemorrhage. Many studies have demonstrated analgesic and anti-inflammatory effects provided by photobiomodulation in both experimental and clinical trials. Authors concluded that based on current research, the utilization of LLLT for pain management and osteoarthritic conditions may be a complementary strategy used in clinical practice to provide symptom management for patients suffering from osteoarthritis and chronic pain.

Alfredo et al. (2018) assessed the long-term effects of LLLT in combination with strengthening exercises in patients with osteoarthritis of the knee. Forty participants of both genders aged 50-75 years, with knee osteoarthritis participated in the study. The LLLT group received 10 LLLT treatments with invisible infrared laser (904 nm, 3 Joules/point) over three weeks followed by an eight-week supervised strengthening exercise program.

The placebo LLLT group received identical treatment, but the infrared laser output was disabled. The new data obtained during the follow-up period showed that all outcomes remained stable and there were no significant differences between the groups at three and six months. However, daily consumption of rescue analgesics was significantly lower in the LLLT group throughout the follow-up period, ending at a group difference of 0.45 vs. 3.40 units ($P < 0.001$) at six months follow-up. Authors concluded that within the limitations of this small study, the previously reported immediate post-intervention improvement after LLLT plus exercise was maintained for a period of six months.

Song et al. (2020) performed a systematic review and meta-analysis of randomized controlled trials to assess the effectiveness of high-intensity laser therapy (HILT) in patients with knee osteoarthritis. Six randomized controlled trials were included in this meta-analysis. For VAS pain, 334 patients from four studies showed that HILT significantly decreased pain compared to the control. HILT significantly improved WOMAC stiffness and function compared to the control. Authors concluded that the effectiveness of HILT on pain, stiffness, and function in patients with knee osteoarthritis is promising. However, due to the limited number of studies, further randomized controlled trials with large, well-designed samples are needed.

Cantero-Téllez et al. (2020) examined the effects of high-intensity laser therapy (HILT) on pain sensitivity and motor performance in patients with thumb carpometacarpal (CMC) osteoarthritis (OA). Forty-three patients (mean ± SD age = 71 ± 12 years) with a diagnosis of thumb CMC OA grade 1-2 were randomized to the control group (N = 21) or experimental group (N = 22). The experimental group received high-intensity laser therapy (HILT), and the control group received a placebo treatment. The outcome measures were pain intensity (visual analog scale) and key pinch strength measurements (dynamometer). All outcome measures were collected at baseline, immediately following the intervention, at 4 weeks, and at 12 weeks following the intervention. Authors reported that HILT effectively diminishes pain intensity when used as an isolated treatment for patients with thumb CMC OA, but the effect of treatment decreases after 12 weeks.

Ahmad et al. (2022) examined the effects of LLLT or HILT combined with rehabilitation exercise (LLLT+E or HILT+E) on pain, stiffness, and function in KOA. Of the 10 retrieved studies, 6 investigated LLLT+E, three on HILT+E, and 1 evaluated both. All the studies had high PEDro scores. However, as most of the studies employed a single type of laser therapy, only indirect comparison of LLLT+E and HILT+E was possible. This study found all treatment modalities were effective in reducing KOA symptoms. Interestingly, relative to control, the meta-analysis showed significant improvements in knee pain, stiffness, and function for the HILT+E. Authors concluded that both LLLT and HILT are beneficial as adjuncts to rehabilitation exercise in the management of KOA. Based on an indirect comparison, the HILT+E seems to have higher efficacy in reducing knee pain and stiffness,

and in increasing function. To confirm this finding, a direct comparative investigation of the two types of laser therapy may be necessary.

Malik et al. (2023) investigated the effectiveness of LLLT plus exercise therapy (ET) on pain, ROM, muscle strength, and function in KOA immediately after therapy and sought to determine whether the effectiveness of LLLT plus ET could be sustained at follow-up (4 - 32 weeks) in a systematic review. Of the 6,307 articles, 14 RCTs (820 patients) met the inclusion criteria. The results demonstrated that there was a significant difference in pain immediately after therapy and at follow-up in LLLT plus ET group. There were no significant differences in knee ROM, muscle strength, and knee function outcomes immediately and at follow-up. Authors concluded that their findings indicate that LLLT plus ET could be considered to alleviate pain in the KOA. LLLT reduces pain at 4-8J with a wavelength of 640-905nm per point applied for 10-16 sessions at a frequency of 2 sessions/week. An exercise therapy program at prescribed dosage involving major muscle groups might help. However, LLLT plus ET is no more effective than placebo LLLT plus ET in improving ROM, muscle strength, and function in KOA.

Shoulder Pain

Several systematic reviews have been published regarding LLLT for treatment of shoulder pain. In general, they are inconsistent in the findings and do not substantiate the effectiveness of this treatment for these conditions.

Haslerud et al. (2015) performed a systematic review with meta-analysis on shoulder tendinopathy and LLLT. The primary outcome measure was pain using the visual analogue scale (VAS) and relative risk for global improvement. Intervention quality assessments were performed of LLLT dosage and treatment procedures according to WALT guidelines. Seventeen randomized controlled trials (RCTs) met the inclusion criteria; 13 RCTs were of high and 4 RCTs of moderate methodological quality. Trials performed with inadequate laser doses were ineffective across all outcome measures. Otherwise, this review demonstrated that optimal LLLT offers clinically relevant pain relief and improvement alone and in combination with other physical therapy interventions.

A systematic review for treatment of subacromial impingement did find laser therapy effective compared to placebo based on 2 RCTs, but it added no benefit when added to ROM exercises (Michener et al., 2004). Several randomized studies conducted for shoulder pain did not find significant results from the treatment with LLLT (Bal, et al., 2009; Dogan, et al., 2010; Abrisham, et al., 2011).

Aceituno-Gómez et al. (2019) evaluated the effectiveness of high-intensity laser therapy on shoulder pain and function in subacromial impingement syndrome. A total of 46 participants with subacromial impingement syndrome were included in the study, with a total of 21 patients in high-intensity laser therapy group and 22 patients in sham-laser group

concluding the study. No differences were found between groups for pain and disability ($p > 0.05$). Authors concluded the effect of high-intensity laser therapy plus exercise is not greater than exercise alone to reduce pain and improve functionality in patients with subacromial syndrome.

Pieters et al. (2020) updated a systematic review published in 2013 that focused on evaluating the effectiveness of interventions within the scope of physical therapy, including exercise, manual therapy, electrotherapy, and combined or multimodal approaches to managing shoulder pain. Sixteen systematic reviews were retrieved. Results were summarized qualitatively. Relative to laser therapy, there was moderate evidence of no effect. Zhang et al. (2020) compared the efficacy of different nonsurgical interventions and identify potential patient-specific moderating factors for frozen shoulder. Of 3,136 records identified, 92 trials were eligible, evaluating 32 nonsurgical interventions in 5946 patients. Laser therapy showed benefits for pain relief and functional improvement. Authors concluded that laser therapy show potential benefits for multiple outcomes.

Alfredo et al. (2021) investigated the effect of LLLT combined with exercise on shoulder pain and disability in patients with sub-acromial impingement syndrome. Patients (*N*=120) were enrolled and split into three groups with one group receiving LLLT and exercise, another with just exercise, and the third group only receiving LLLT. Interventions were provided 3x per week for 8 weeks. Based on results, authors concluded that LLLT combined with exercise reduced pain and improved function over the 3 months to a greater degree than either alone.

de la Barra Ortiz et al. (2023) evaluated the effects of high-intensity laser therapy (HILT) in patients with frozen shoulder. The inclusion criteria encompassed RCTs comparing HILT with other physical therapy interventions in frozen patients with frozen shoulders, with or without sham HILT, assessing pain intensity, shoulder ROM, and disability outcomes. Five trials met the eligibility criteria and were included in the review and meta-analysis, which pooled results from the visual analog scale (VAS), goniometry, and the shoulder pain and disability index (SPADI). Mean differences (MDs) for pain intensity and disability show a pooled effect in favor of HILT both for VAS and SPADI, changes that are statistical ($p < 0.01$) and clinical. The MD for flexion, abduction, and external rotation range of motion does not show statistical and clinical differences between groups after treatment. Authors concluded that adding HILT into a physical therapy plan may reduce pain and disability, but it does not outperform conventional physical therapy in improving shoulder ROM.

Carpal Tunnel Syndrome

Several systematic reviews have been published regarding LLLT for treatment of carpal tunnel syndrome. In general, they are inconsistent in their findings and do not substantiate the effectiveness of this treatment for these conditions.

The American Academy of Orthopaedic Surgeons (AAOS) published clinical practice guidelines on the treatment of carpal tunnel syndrome (AAOS, 2016). In the guidelines, regarding laser treatment, it is noted that, “Limited evidence supports that laser therapy might be effective compared to placebo.”

(Strength of Recommendation: Limited Evidence. Evidence from one or more "Low" quality studies with consistent findings or evidence from a single "Moderate" quality study for recommending for against the intervention or diagnostic or the evidence is insufficient or conflicting and does not allow a recommendation for or against the intervention)

Peters et al. (2013) reported on a Cochrane review that examined the effectiveness of rehabilitation following carpal tunnel syndrome (CTS) surgery compared with no treatment, placebo, or another intervention. The review found limited and low-quality evidence for the benefit of the reviewed treatments, including laser therapy. The review included 1 quasi-randomized trial which compared LLLT to a placebo laser. This study found that there was no statistically significant difference in CTS symptoms with LLLT compared with a placebo. An update to this review (Peters et al., 2016) included no new studies and similar findings regarding LLLT for rehabilitation following CTS.

Li et al. (2016) reported on a meta-analysis that was conducted to evaluate the effectiveness of low-level laser in the treatment of mild to moderate CTS using a Cochrane systematic review. The review included 7 randomized clinical trials with 270 wrists in the laser group and 261 wrists in the control group with high heterogeneity noted when the analysis was conducted. Hand grip (at 12 weeks) was stronger in the LLLT group than in the control group and there was better improvement in the visual analog scale (VAS) (at 12 weeks) in the LLLT group. The sensory nerve action potential (SNAP) (at 12 weeks) was better in the LLLT group. It was noted that one included study was weighted at >95% in the calculation of these three parameters. There were no statistically significant differences in the other parameters between the two groups. The authors concluded that that low-level laser improved hand grip, VAS, and SNAP after three months of follow-up for mild to moderate CTS, however, additional high-quality studies using the same laser intervention protocol are needed to confirm the effects of low-level laser in the treatment of CTS.

Bekhet et al. (2017) performed a meta-analysis to investigate the efficacy of low-level laser therapy (LLLT) with anti-inflammatory and analgesic effects, in the management of mild-to-moderate carpal tunnel syndrome (CTS). Eight RCTs (473 patients/631 wrists) were eligible for the final analysis. The overall effect estimates did not favor LLLT therapy group over placebo in all primary outcomes: visual analogue scale, symptom severity scale score, and functional status scale score. However, LLLT was superior to placebo in terms of grip strength and inferior to placebo in terms of sensory nerve action potential. Authors concluded that laser therapy is superior to placebo in terms of improving the grip strength; however, no significant difference was found between both groups in terms of functional

status improvement, pain reduction, or motor electrodiagnostic evaluations. Further high-quality trials with longer follow-up periods are required to establish the efficacy of LLLT for CTS treatment.

Franke et al. (2018) systematically reviewed the literature on the effectiveness of low-level laser therapy for patients with carpal tunnel syndrome. Strong evidence was found for the effectiveness of low-level laser therapy compared to placebo treatment in the very short term ($0 \leq 5$ weeks). After five weeks, the positive effects of low-level laser therapy on pain, function, or recovery diminished over time (moderate and conflicting evidence was found at seven and 12-weeks follow-up, respectively). Authors concluded that in the very short-term low-level laser therapy is more effective as a single intervention than placebo low-level laser therapy in patients with carpal tunnel syndrome, after which the positive effects of low-level laser therapy tend to subside. Evidence in the mid and long term is sparse.

Cheung et al. (2020) performed a network meta-analysis (NMA) for evaluating the effectiveness of LLLT compared with other conservative treatments for CTS. Six RCTs (418 patients) were included. NMA suggested that LLLT plus splinting has the highest probability (75%) of pain reduction, compared with sham laser plus splinting (61%), ultrasound plus splinting (57%) and splinting alone (8%). However, while LLLT plus splinting is significantly more effective than sham laser plus splinting for pain reduction, the magnitude is not clinically significant. Authors concluded that the effect of LLLT plus splinting on symptom severity and functional status was not superior to splinting alone. In an American Family Physician paper on nonpharmacologic, noninvasive treatments for chronic musculoskeletal pain, Flynn (2020) reported that low reactive level laser therapy may provide short-term relief of chronic neck and low back pain, and ultrasound may provide short-term pain relief for knee osteoarthritis.

Myofascial Pain

For myofascial pain, a randomized controlled study comparing laser treatment with placebo for treatment of myofascial pain found no differences in results between the groups, with both groups achieving some analgesic effect (Carrasco et al., 2009). In a randomized controlled trial of 63 participants with myofascial pain syndrome of the shoulder and neck area, Rayegani et al. (2011) compared LLLT, sham LLLT, and ultrasound (US) and measured pain using the VAS, disability using the Neck Disability Index (NDI), and improvement using an algometric assessment. Each group also received exercises. After 10 sessions of daily treatment, results demonstrated that use of laser therapy demonstrated significant improvements when compared with the sham laser group and also between pre- and post-intervention scores in pain and NDI. There were no significant differences related to pain between LLLT and US; however, the NDI showed more improvement with laser treatment. The authors recommended further study with larger patient populations (Rayegani et al., 2011).

Tehrani et al. (2022) evaluated the effectiveness of LLLT on mechanical neck pain (MNP). A total of 13 randomized controlled trials were included in this systematic review and meta-analysis. The data assessing laser effectiveness on different outcomes of 556 patients were considered for meta-analysis. Pooled results revealed that LLLT was significantly effective in pain reduction. Also, secondary outcomes including pain pressure threshold (PPT) and right bending ROM were improved, while disability did not improve significantly after LLLT. Authors concluded that this meta-data revealed that LLLT may reduce myofascial neck pain and its related outcomes. Alayat et al. (2022) aimed to investigate the efficacy of photobiomodulation therapy (PBMT) on pain and pressure pain threshold (PPT) in patients with myofascial pain syndrome (MPS) of the upper trapezius muscle in a systematic review. A total of 17 studies (944 patients) were included. A meta-analysis was performed on 16 studies. Assessment according to the PEDro scale revealed 12 high-quality, 3 fair-quality, and 2 low-quality studies. Authors conclude that the present systemic review revealed that PBMT is an effective PT modality for reducing pain and increasing PPT in patients with MPS of the upper trapezius. PBMT, when combined with EX, had more significant effects in reducing pain and increasing PPT compared with controls. The low-quality studies with low to moderate quality of evidence limit the confidence of findings and recommend further high-quality studies for standardization of treatment protocols and irradiation parameters.

Low Back Pain

Several systematic reviews have been published regarding LLLT for treatment of low back pain. In general, they are inconsistent in the findings and do not substantiate the effectiveness of this treatment for these conditions.

Yousefi-Nooraie et al. (2008) conducted a Cochrane review that included seven studies and examined LLLT for nonspecific low-back pain. The authors concluded that based on the heterogeneity of the populations, interventions, and comparison groups, "that there are insufficient data to draw firm conclusion on the clinical effect of LLLT for low-back pain." In addition, the authors note that there is a need for further methodologically rigorous randomized, controlled trials to evaluate the effects of LLLT compared to other treatments, different lengths of treatment, wavelengths, and dosage.

A review of evidence was conducted for the development of an American Pain Society/American College of Physicians clinical practice guideline for diagnosis and treatment of low back pain (Chou and Huffman, 2007). The review examined nonpharmacologic therapies for acute and chronic low back pain and included only systematic reviews and randomized trials, with seven trials that included LLLT. Four trials found laser therapy superior to sham for pain or functional status up to one year after treatment, but another higher-quality trial found no differences between laser and sham in patients receiving exercise. One lower-quality study reported found similar results for laser, exercise, and the combination of laser plus exercise for pain and back-specific functional

status. It was noted that optimal treatment parameters, wavelength, dosage, dose intensity are uncertain.

Glazov et al. (2016) reported on a systematic review to determine if LLLT (including laser over acupuncture points) has specific benefits in chronic non-specific low back pain. The review included 15 studies with 1039 participants. The results at immediate and short-term follow-up there was significant pain reduction of up to weighted mean difference -1.40 cm in favor of laser treatment, occurring in trials using at least 3 Joules (J) per point, with baseline pain <30 months and in non-acupuncture LLLT trials. Global assessment showed a risk ratio of 2.16 (95% CI 1.61 to 2.90) in favor of laser treatment in the same groups only at immediate follow-up. While there appears to a benefit with LLLT in the short term, further randomized studies with blinding and longer follow-up are needed to determine the appropriate laser dosage.

Huang et al. (2015b) completed a systematic review and meta-analysis on the effectiveness of low-level laser therapy for nonspecific chronic low back pain. Among 221 studies, 7 trials met inclusion criteria. Based on five studies, pain outcome scores were significantly lower for the LLLT group compared with placebo. No significant treatment effect was identified for disability scores or spinal range of motion. The authors concluded that findings indicate LLLT is an effective method for relieving pain in non-specific chronic low back pain (NSCLBP) patients, which contradicts other previous findings.

The Agency for Healthcare Research and Quality (AHRQ) published a review of the comparative effectiveness of non-invasive treatments for low back pain (Chou et al., 2016). The review included randomized, controlled trials, along with systematic reviews of randomized controlled trials. Regarding LLLT for acute back pain, the strength of evidence (SOE) was found to be insufficient, and for LLLT for chronic back pain, the SOE was found to be low to insufficient. Among the findings of the review for LLLT for back pain:

- For acute low back pain, insufficient evidence from one trial to determine effectiveness of low-level laser therapy versus sham laser, due to serious methodological shortcomings and imprecision (Strength of evidence [SOE]: insufficient).
- For chronic low back pain, three of four trials found low-level laser therapy more effective than sham laser for pain, with the methods for assessing pain and duration of follow-up varied; two trials found low-level laser therapy more effective than sham laser for function, with small magnitude of effects (SOE: low for pain and function).
- For chronic low back pain, there was insufficient evidence from three trials to determine effects of low-level laser therapy plus exercise versus the other sham laser plus exercise alone, due to methodological shortcomings and inconsistency (SOE: insufficient).

- There was insufficient evidence to determine effects of low-level laser therapy versus another intervention, due to methodological shortcomings and imprecision (SOE: insufficient).
- There was insufficient evidence to determine effects of different wavelengths of low-level laser therapy or different doses, due to methodological limitations and imprecision (SOE: insufficient).

Choi et al. (2017) examined the effects of High Intensity Laser Therapy on pain and function of patients with chronic back pain. This study evenly divided a total of 20 patients with chronic back pain into a conservative physical therapy group that received conservative physical therapy, and a high intensity laser therapy group that received High Intensity Laser Therapy after conservative physical therapy. All patients received the therapy three times a week for four weeks. For the high intensity laser therapy group, treatment was applied to the L1-L5 and S1 regions for 10 minutes by using a high intensity laser device while vertically maintaining the separation distance from handpiece to skin at approximately 1 cm. A visual analog scale was used to measure the pain and Oswestry Disability Index was used for functional evaluation. In a within-group comparison of the conservative physical therapy and high intensity laser therapy groups, both the visual analog scale and Oswestry Disability Index significantly decreased. In a between-group comparison after treatment, the high intensity laser therapy group showed a significantly lower visual analog scale and Oswestry Disability Index than the conservative physical therapy group. Authors concluded that High Intensity Laser Therapy can be an effective nonsurgical intervention method for reducing pain and helping the performance of daily routines of patients who have chronic back pain. In a report published by the Agency for Healthcare Research and Quality on Noninvasive Nonpharmacological Treatment for Chronic Pain, authors state that function improved over short and/or intermediate term for exercise, low-level laser therapy (Skelly et al., 2020) (SOE: low). This report included 233 RCTs (31 new to this update). Many were small (N<70), and evidence beyond 12 months after treatment completion was sparse. The most common comparison was with usual care. Evidence on harms was limited, with no evidence suggesting increased risk for serious treatment-related harms for any intervention. Effect sizes were generally small for function and pain.

Abdildin et al. (2023) evaluated the effect of high intensity laser therapy (HILT) in adult LBP patients. The primary outcome was pain intensity and secondary outcomes included disability and flexibility scores. The results favored the HILT group over the control group in terms of pain intensity after treatment, Oswestry Disability Index, and Roland Disability Index. The patients in the high-intensity laser therapy had statistically significantly lower (low back) pain intensity compared to the patients in the control group. Based on 3 RCTs, authors noted a positive effect of the HILT on LBP in terms of pain and function.

Neck Pain

Several systematic reviews have been published regarding LLLT for treatment of neck pain. In general, they are inconsistent in the findings and do not substantiate the effectiveness of this treatment for these conditions.

A meta-analysis and systematic review by Chow et al. (2009) concluded that there is moderate evidence that low level laser therapy reduces pain immediately after treatment in subjects with chronic neck pain and up to 22 weeks after treatment. Low level laser therapy compares favorably with pharmacologic interventions, with no adverse reactions or side effects (Chow et al., 2009). However, reviewers of the systematic review have expressed concerns regarding statistical application and the highly heterogeneous nature of the groups in terms of diagnosis and treatments (Verhagen and Schellingerhout, 2010; Shiri and Viikari-Juntara et al., 2010).

In 2013, Kadhim-Saleh et al. attempted to determine the efficacy of LLLT in reducing acute and chronic neck pain. Eight RCTs involving 443 patients were selected. Five trials included patients with cervical myofascial pain syndrome, and three trials had a variety of patient conditions. Results of the review provided inconclusive evidence because of heterogeneity and potential risk of bias. Any benefit noted, although significant from a statistical standpoint, did not reach the threshold of a minimally important clinical difference.

Gross et al. (2013) evaluated LLLT for adults with neck pain. Their systematic review noted moderate quality evidence for chronic neck pain supporting LLLT over placebo to improve pain and disability, and quality of life into the intermediate term. Low quality evidence suggested LLLT improved short term pain and function over placebo for acute radiculopathy, cervical osteoarthritis, or acute neck pain. For chronic myofascial neck pain (5 trials, 188 participants), evidence was conflicting. Authors conclude that LLLT may be beneficial for chronic neck pain, function and improvement of quality of life but long-term trials are needed.

Wong et al. (2016) aimed to update the findings of the Neck Pain Task Force, which examined the effectiveness of manual therapies, passive physical modalities, and acupuncture for the management of neck pain and associated disorders (NAD). The review found evidence suggesting that LLLT is not effective for persistent NAD grades I–II. However, prior to publication, the authors discovered new evidence that was not consistent with their Task Force findings and when combining this new evidence with Neck Pain Task Force findings from the 5 studies, the preponderance of evidence suggested that clinic based LLLT is effective for persistent NAD.

In the American Physical Therapy Association Orthopedic Section Clinical Practice Guideline on Neck Pain revised I 2017, it is recommended that for patients with chronic

neck pain with mobility deficits, clinicians should provide a multimodal approach of the following: thoracic manipulation and cervical manipulation or mobilization; mixed exercise for cervical/scapulothoracic regions: neuromuscular exercise (e.g., coordination, proprioception, and postural training), stretching, strengthening, endurance training, aerobic conditioning, and cognitive affective elements; dry needling, laser, or intermittent mechanical/manual traction (Grade B) (Blanpied et al., 2017).

In a report published by the Agency for Healthcare Research and Quality on Noninvasive Nonpharmacological Treatment for Chronic Pain, authors state that short-term low-level laser therapy was associated with moderate improvement in function and pain (Skelly et al., 2018). This report was updated in 2020 that included 233 RCTs (31 new to this update). Many were small (N<70), and evidence beyond 12 months after treatment completion was sparse. The most common comparison was with usual care. Evidence on harms was limited, with no evidence suggesting increased risk for serious treatment-related harms for any intervention. Effect sizes were generally small for function and pain. For chronic neck pain, in the short term, low-level laser therapy (SOE: moderate) improved function and pain.

Plenar et al. (2023) assessed the effectiveness and safety of conservative interventions compared with other interventions, placebo/sham interventions, or no intervention on disability, pain, function, quality of life, and psychological impact in adults with cervical radiculopathy. Of the 2,561 records identified, 59 trials met inclusion criteria (n = 4108 participants). Due to clinical and statistical heterogeneity, the findings were synthesized narratively. There is very-low certainty evidence supporting the use of acupuncture, prednisolone, cervical manipulation, and low-level laser therapy for pain and disability in the immediate to short-term, and thoracic manipulation and low-level laser therapy for improvements in cervical range of motion in the immediate term. Authors stated that there is a lack of high-quality evidence, limiting the ability to make any meaningful conclusions.

Ince et al. (2024) researched the clinical effectiveness of high-intensity laser therapy combined with exercise on pain, quality of life, and disability in patients with cervical radiculopathy and compared it with that of placebo and exercise alone. Ninety participants with cervical radiculopathy were randomized into the following 3 groups: high-intensity laser therapy + exercise (n = 30), placebo + exercise (n = 30), and exercise only (n = 30). Pain, cervical range of motion, disability, and quality of life (36-item Short Form Health Survey) were assessed at baseline and weeks 4 and 12. The mean age of the patients (66.7% female) was 48.9 ± 9.3 yrs. Pain intensity in the arm and neck, neuropathic and radicular pain levels, disability, and several parameters of the 36-item Short Form Health Survey showed an improvement in the short and medium term in all three groups. These improvements were greater in the high-intensity laser therapy + exercise group than in the other two groups. Authors concluded that high-intensity laser therapy + exercise was much more effective in improving medium-term radicular pain, quality of life, and functionality

in patients with cervical radiculopathy. Thus, high-intensity laser therapy should be considered for the management of cervical radiculopathy.

Achilles Tendinopathy

One study of 52 recreational athletes with Achilles tendinopathy compared eccentric exercise plus either laser or placebo treatments administered twice per week for 4 weeks, followed by once per week for 4 weeks. The laser group had significantly greater improvements in pain VAS, stiffness, ROM, and tenderness at 4, 8, and 12 weeks (Stergioulas et al., 2008). Tumilty et al. (2008) used low level laser therapy applied to points on the tendon 3 times a week for 12 weeks and noted significant improvement in all outcome measures at 4 and 12 weeks. However, the authors determined that conclusions regarding effectiveness could not be made due to the low statistical power of the study.

The Orthopaedic Section of the American Physical Therapy Association (APTA) published clinical practice guidelines for Achilles pain, stiffness, and muscle power deficits (Carcia, et al., 2010). The guidelines note that based on limited works, the future of LLLT is promising for patients suffering from Achilles tendon pain. Given the limited number of studies employing LLLT in this population, additional study is warranted. Clinicians should consider the use of low-level laser therapy to decrease pain and stiffness in patients with Achilles tendinopathy. (Level B*).

*Level B: Moderate evidence - A single high-quality randomized controlled trial or a preponderance of level II studies support the recommendation.

Martimbianco et al. (2020) determined the benefits and harms of low-level laser therapy for Achilles tendinopathy. Four trials (119 participants) were analyzed. Laser therapy associated to eccentric exercises when compared to eccentric exercises and sham had very low to low certainty of evidence in pain and function assessment. The function assessment showed an improvement favoring the placebo group at one month and non-significant difference between groups at 3 and 13 months. Adverse events were poorly reported but restricted to minor events related to the exercises. Authors concluded that the certainty of evidence was low to very low, and the results are insufficient to support the routine use laser therapy for Achilles tendinopathy.

Plantar Fasciitis

Guimarães et al. (2022) investigated the effects of low-level laser therapy (LLLT) on pain and disability in patients with plantar fasciitis (PF). Three comparisons were made: LLLT compared with placebo, LLLT combined with conventional rehabilitation (CR) compared with CR and LLLT compared with extracorporeal shock wave therapy. Fourteen studies (817 patients) met the study criteria. Compared to the placebo group, LLLT improved pain (moderate-quality evidence) in the short term (0-6 weeks). No significant difference in short-term disability was found for participants in the LLLT group compared to the placebo

group. Compared to the CR group, LLLT combined with CR improved pain (moderate-quality evidence) in the short term (0-6 weeks). Compared to extracorporeal shock wave therapy, LLLT did not significantly reduce pain intensity in the short term (low-quality evidence). Authors concluded that LLLT may improve pain in the short term and can be considered as a component of care of patients with PF. However, this superiority disappeared compared to extracorporeal shock wave therapy. Naterstad et al. (2022) investigated the effectiveness of low-level laser therapy (LLLT) in lower extremity tendinopathy and plantar fasciitis on patient-reported pain and disability. Only randomised controlled trials involving participants with lower extremity tendinopathy or plantar fasciitis treated with LLLT were included. LLLT was compared with placebo (10 trials), other interventions (5 trials) and as an add-on intervention (3 trials). The study quality was moderate to high. Overall, pain was significantly reduced by LLLT at completed therapy and 4-12 weeks later. Overall, disability was significantly reduced by LLLT at completed therapy and 4-9 weeks later. Compared with placebo control, the recommended doses significantly reduced pain at completed therapy and 4-8 weeks later. The recommended doses significantly reduced pain as an add-on to exercise therapy versus exercise therapy alone at completed therapy and 4-9 weeks later. No adverse events were reported. Authors concluded that LLLT significantly reduces pain and disability in lower extremity tendinopathy and plantar fasciitis in the short and medium term. Long-term data were not available.

Guimarães et al. (2023) sought to determine the effects of different therapeutic interventions that have ever been evaluated in randomized controlled trials on pain due to plantar fasciitis. A total of 236 studies met the study criteria, including 15,401 patients. LLLT resulted in being effective treatments for pain when compared to the control in the short term, relative to only LLLT.

Ferlito et al. (2023) reviewed the effects of photobiomodulation therapy (PBMT) on pain intensity and disability in people with plantar fasciitis (PF) when compared with control conditions, other interventions, and adjunct therapies. Only randomized controlled trials (RCTs) in adults with PF that compared PBMT to placebo, as well as RCTs that compared PBMT to other interventions; and as an adjunct to other therapies were included. Nineteen RCTs involving 1,089 participants were included in this review. PBMT alone or with exercise improved pain intensity in short-term treatment. PBMT was superior to (extracorporeal shock wave therapy) EWST for relief of pain. In the follow-up, PBMT plus exercise had a superior to exercise therapy alone. PBMT may be superior to ultrasound therapeutic in medium- and long-term follow-ups for disability but can be not clinically relevant. There is uncertainty that PBMT is capable of promoting improvement in disability. PBMT when used with adjuvant therapy does not enhance outcomes of interest. PBMT improves pain intensity with or without exercise. PBMT has been shown to be superior to ESWT for pain relief, but not superior to other interventions for pain intensity

and disability. The evidence does not support PBMT as an adjunct to other electrotherapeutic modalities.

Lateral Epicondylitis

Several systematic reviews have been published regarding LLLT for treatment of lateral epicondylitis. In general, they are inconsistent in the findings and do not substantiate the effective ness of this treatment for these conditions.

Dingemanse et al. (2013) performed a systematic review of the effectiveness of electrophysical modalities for the treatment of medial and lateral epicondylitis. A total of 2 reviews and 22 RCTs were included and evaluated, all of which concerned lateral epicondylitis. Ultrasound plus friction massage showed moderate effectiveness over LLLT on short term follow up. Moderate evidence was found in favor of LLLT over plyometric exercises on short term follow up (Dingemanse et al., 2013).

Sims et al. (2014) completed a systematic review of treatments for lateral epicondylitis. They noted that LLLT demonstrates superiority over placebo in some studies and not in others. They determined that the evidence is insufficient to draw conclusions that there is one preferred method of non-surgical treatment for this condition.

Akkurt et al. (2016) investigated short- and long-term effects of high-intensity laser therapy (HILT) in lateral epicondylitis (LE) patients. Thirty patients with LE diagnosis (23 unilateral and 7 bilateral in total 37 elbows) were treated using HILT. LE patients were evaluated before, right after, and 6 months following HILT intervention post-treatment using visual analogue scale for pain (VAS) during activity and resting. Disabilities of the Arm, Shoulder, and Hand (DASH) Score and hand grip strength test (HGST) were used. The participants of the present study were also evaluated using Short-Form 36 (SF-36) before and 6 months after the treatment. Out of the 30 patients, 8 were male and 22 female with a mean age of 47.2 ± 9.7. The activity and resting VAS, DASH, and HGST scores revealed statistically significant improvement following treatment. Whereas VAS activity, DASH, and HGST scores increased significantly after treatment until post-treatment 6 months, VAS resting scores remained unchanged. A statistically significant improvement was also evident in the physical and mental components of SF-36 scores following treatment until post-treatment 6 months compared to pre-treatment scores. In conclusion, the results of the present study suggest that HILT is a reliable, safe, and effective treatment option in LE patients in the short and long term considering pain, functional status, and quality of life.

Dion et al. (2017) evaluated the effectiveness of passive physical modalities for the management of soft tissue injuries of the elbow. Twenty-one were eligible for critical appraisal and (reporting on eight randomized controlled trials) had a low risk of bias. Authors found that adding transcutaneous electrical nerve stimulation to primary care does

not improve the outcome of patients with lateral epicondylitis. They found inconclusive evidence for the effectiveness of: (1) an elbow brace for managing lateral epicondylitis of variable duration; and (2) shockwave therapy or low-level laser therapy for persistent lateral epicondylitis. Authors conclude that their review found little evidence to inform the use of passive physical modalities for the management of elbow soft tissue injuries.

A systematic review concluded that low-level laser therapy administered directly to the lateral elbow tendon insertions may offer short-term pain relief and decreased disability, both alone and in conjunction with an exercise program (Bjordal et al., 2008). A systematic review of literature on treatments for lateral epicondylitis did not support the use of low-level laser therapy (Trudel et al., 2004).

Lian et al. (2018) compared the efficacy and safety of nonsurgical treatment options for enthesopathy of the extensor carpi radialis brevis (eECRB) described in randomized placebo-controlled trials at short-term, midterm, and long-term follow-up and evaluated outcomes in patients receiving placebo. Thirty-six randomized placebo-controlled trials, evaluating 11 different treatment modalities, with a total of 2746 patients were included. At midterm follow-up, laser therapy and local botulinum toxin injection improved pain.

Rheumatoid Arthritis

A Cochrane systematic review (Brosseau, et al., 2005) was performed for the purpose of reviewing literature regarding the use of LLLT as treatment for rheumatoid arthritis (RA). Six studies with 220 patients with rheumatoid arthritis were included in the review. The main limitation with the studies is the heterogeneity of clinical application. In addition, the results are subject to publication bias, if negative trials have not been published. It was concluded in this review that "this meta-analysis found that pooled data gave some evidence of a clinical effect, but the outcomes were in conflict, and it must therefore be concluded that firm documentation of the application of LLLT in RA is not possible. Conversely, a possible clinical benefit in certain subgroups cannot be ruled out from the present meta-analysis and further large scaled studies are recommended with special attention to the findings in this meta-analysis (e.g., low versus high dose wavelength, nerve versus joint application, and treatment duration)."

The Ottawa Panel Evidence-Based Clinical Practice Guidelines reviewed the same set of RCTs using the Cochrane method and concluded there was strong evidence in support of a clinically important benefit for low level laser treatment of foot, knee, or hand pain for patients with rheumatoid arthritis (RA) (Ottawa Panel Evidence-Based Clinical Practice Guidelines, 2004). Their findings were based on positive findings in 4 out of 5 placebo-controlled RCTs, with pain reduction ranging from 19 – 28%. A later review of systematic reviews concluded that there is evidence that low-level laser therapy generally reduces pain and improves function (Christie et al., 2007). A randomized controlled study of LLLT

concluded that it was not specifically effective for the treatment of hand pain in patients with rheumatoid arthritis (Meireles, et al., 2010).

Lourinho et al. (2023) evaluated the efficacy of low-level laser therapy in adults with RA. Currently available evidence was from 18 RCTs, with a total of 793 participants. Authors found low-quality evidence suggesting there may be no difference between using infrared laser and sham in terms of pain, morning stiffness, grip strength, functional capacity, inflammation, ROM, disease activity and adverse events. The evidence is very uncertain about the effects of red laser compared to sham in pain, morning stiffness. Authors concluded that infrared laser may not be superior to sham in RA patients. There is insufficient information to support or refute the effectiveness of red laser, laser acupuncture and reflexology for treating patients with RA.

Temporomandibular Joint Dysfunction (TMJ or TMD)

Several systematic reviews have been published regarding LLLT for treatment of temporomandibular joint dysfunction (TMJ or TMD). In general, they are inconsistent in the findings and do not substantiate the effectiveness of this treatment for these conditions. Chang et al. (2014) completed a systematic review of selected studies of randomized controlled trials and calculated the effect size (ES) of the pain relief to evaluate the effect of LLLT. Seven studies met inclusion criteria. Results indicated a moderate effect of pain relief. Also, the dosages and treatments with wavelengths of 780 and 830 nm created moderate and large pain relief effects. Authors concluded that use of LLLT for TMJ pain had a moderate analgesic effect. They agree that the optimal parameters for LLLT to treat TMJ pain have not been confirmed.

A systematic review and meta-analysis assessed the evidence for LLLT for Temporomandibular Disorders (TMD) (Petrucci, et al., 2011). Six randomized clinical trials were included in the review. The primary outcome was the change in pain from baseline to endpoint. The pooled effect of LLLT on pain, measured through a visual analog scale was not statistically significant from placebo. The authors concluded that there is no evidence to support the effectiveness of LLLT in the treatment of TMD.

Maia et al. (2012) reported on a systematic review of LLLT on pain levels in patients with temporomandibular disorders (TMD). The review included 14 studies, with 12 studies utilizing a placebo group. The number of sessions varied along with the frequency of applications. There was a range in the energy density and power density used. It was found that there was a reduction in pain levels reported in 13 studies, with nine of these occurring only in the experimental group and four studies reporting pain relief for both experimental and placebo group. The authors concluded that while LLLT appeared to be effective in reducing pain, due to the heterogeneity in standardization of parameters of laser there should be caution in interpretation of the results. Further research is needed regarding appropriate application laser protocol.

Xu et al. (2018) systematically reviewed randomized controlled trials (RCTs) of the effect of low-level laser therapy (LLLT) versus placebo in patients with temporomandibular disorder (TMD). A total of 31 RCTs were included. Combining data from all clinically heterogeneous studies revealed positive effects of LLLT on pain relief, regardless of the visual analogue scale (VAS) score or the change of VAS score between the baseline and the final follow-up time point, while dosage analyses showed discrepant results about the effects of high or low doses for patients with TMD. Follow-up analyses showed that LLLT significantly reduced pain at the short-term follow-up. Temporomandibular joint function outcomes indicated that the overall effect favored LLLT over placebo. Authors suggest that from this review, LLLT effectively relieves pain and improves functional outcomes in patients with TMD.

In a systematic review, de Pedro and colleagues (2020) examined the efficacy of LLLT for the management of neuropathic orofacial pain. The primary outcome was measurement of pain intensity. A total of 997 studies were obtained with the initial search; 13 (8 RCTs, 2 prospective studies, and 3 case series) met the inclusion criteria and were analyzed for data extraction; 3 provided data for the treatment of trigeminal neuralgia (TN), 1 for occipital neuralgia, and 10 for BMS. All studies showed a reduction in pain intensity (most of them significant). The different studies analyzed LLLT alone and compared to placebo, to another treatment, or to different LLLT application protocols. The authors concluded that LLLT appeared to be effective as a therapeutic option for different neuropathic orofacial pain entities such as TN, occipital neuralgia, and BMS as a single or combined treatment. Moreover, these researchers stated that more quality studies assessing all outcome measures of chronic pain are needed in the medium- and long-terms. Furthermore, due to the lack of standardization of the application technique, more well-designed studies are needed to confirm the results of this systematic review.

Ahmad et al. (2021) evaluated the efficacy of LLLT in the treatment of temporomandibular joint disorder within a systematic review. Thirty-seven articles were considered eligible for this systematic review. Out of 37 studies, 33 (89.18%) are high methodological studies, which have an overall low risk of bias or with some concerns, while only 4 studies have a high risk of bias. Eighteen studies showed that LLLT was efficacious in diminishing TMD pain, whereas 12 studies showed that LLLT had similar efficacy as of placebo/controls/other intervention in TMD pain diminution. Four studies presented varied effects of LLLT on pain intensity, mandibular motion, EMG activity, and masticatory efficiency. Two studies revealed that LLLT improved the psychological and emotional aspects associated with TMDs, joint noises, masticatory efficiency, and EMG parameters, respectively. One study focused on subjective tinnitus, whereas another study suggested laser acupuncture (LAT) therapy as a suitable alternative to LLLT. The results demonstrate that LLLT appears to be efficient in diminishing TMD pain with variable effects on the outcome of secondary parameters. The results demonstrate that LLLT appears to be efficient in diminishing TMD pain with variable effects on the outcome of secondary

parameters. Also, LLLT provides advantages as the therapeutic regimen is non-invasive, reversible, with fewer adverse effects, and may also improve the psychological and emotional aspects associated with TMDs. Therefore, this systematic review highlights the role of LLLT as a promising therapeutic regimen for TMDs.

Ren et al. (2022) assessed the efficacy of low-level laser therapy (LLLT) with different wavelengths and transcutaneous electric nerve stimulation (TENS) and explore the optimal wavelength range of laser application in the treatment of pain caused by temporomandibular disorders (TMD). Twenty-seven RCTs with 969 patients with TMD were included. In the meta-analysis, all treatment groups showed an overall improvement in pain scores, when compared with the placebo group. LLLT with wavelength ranging from 910 nm to 1100 nm produced more pain relief in the visual analogue scale (VAS) immediately after treatment. After one-month follow-up, LLLT with wavelength ranging from 910 nm to 1100 nm also showed superior pain-relieving effects. However, no significant difference was observed. Authors concluded that the results of the meta-analysis showed the LLLT had better short-term efficacy than TENS in the treatment of pain caused by TMD. Better results can be achieved with higher wavelengths. Therefore, authors recommended to treat TMD using LLLT with wavelength ranging from 910 nm to 1100 nm.

Zhang et al. (2023) evaluated the efficacy of laser therapy in temporomandibular disorders (TMD) in a systematic review. The primary outcome measure was the degree of pain, reported on a visual analog scale (VAS), and the secondary outcome measures were TMJ function, including maximum active vertical opening, maximum passive vertical opening, left and right lateral movement (LLE, RLE). A total of 28 randomized controlled trials were included. Laser therapy had a more significant effect in terms of VAS and RLE as compared to placebo group. However, there was no significant difference in LLE between two groups. Authors concluded that laser therapy can effectively reduce pain but have small effect on improving mandibular movement of TMD patients. More well-designed RCTs with large sample sizes are needed for further validation. And these studies should report detailed laser parameters and provide complete outcome measure data.

de Oliveira-Souza et al. (2023) sought to determine the effectiveness of laser therapy for managing patients with orofacial pain (OFP). They also sought to determine which parameters provide the best treatment effects to reduce pain, improve function, and quality of life in adults with OFP. Eighty-nine studies were included. Most studies (n = 72, 80.9%) were considered to have a high risk of bias. The results showed that laser therapy was better than placebo in improving pain, maximal mouth open (MMO), protrusion, and tenderness at the final assessment, but with a low or moderate level of evidence. The best lasers and parameters to reduce pain are diode or gallium-aluminum-arsenide (GaAlAs) lasers, a wavelength of 400-800 or 800-1500 nm, and dosage of <25 J/cm2. Authors concluded that laser therapy was better than placebo to improve pain, MMO, protrusion, and tenderness.

Also, it was better than occlusal splint to improve pain, but not better than TENS and medication. For patients with all types of temporomandibular disorders (TMDs) (myogenous, arthrogenous, and mixed), the following lasers and parameters are recommended: diode or gallium-aluminum-arsenide (GaAlAs) laser, wavelength of 400-800 or 800-1500 nm, and a dosage <25 J/cm2.For patients with arthrogenous TMDs, the following lasers and parameters are recommended: Diode laser and a wavelength between 400 and 800 nm. For patients with myogenous TMDs, the following lasers and parameters are recommended: diode laser, wavelength between 800 and 1500 nm, and dosage of <25 J/cm2.For patients with mixed TMDs, the following lasers and parameters are recommended: diode, GaAlAs, or infrared laser, a wavelength of 800-1500 nm, a dosage >100 J/cm2, and an application time between 15 and 30 s or >60 seconds.

Busse et al. (2023) completed a comparative effectiveness study of available therapies for chronic pain associated with temporomandibular disorders (TMD). Recommendations: For patients living with chronic pain (≥3 months) associated with TMD, and compared with placebo or sham procedures, the guideline panel issued: (1) strong recommendations in favor of cognitive behavioral therapy (CBT) with or without biofeedback or relaxation therapy, therapist-assisted mobilization, manual trigger point therapy, supervised postural exercise, supervised jaw exercise and stretching with or without manual trigger point therapy, and usual care (such as home exercises, stretching, reassurance, and education); (2) conditional recommendations in favor of manipulation, supervised jaw exercise with mobilization, CBT with non-steroidal anti-inflammatory drugs (NSAIDS), manipulation with postural exercise, and acupuncture; (3) conditional recommendations against reversible occlusal splints (alone or in combination with other interventions), arthrocentesis (alone or in combination with other interventions), cartilage supplement with or without hyaluronic acid injection, low level laser therapy (alone or in combination with other interventions), transcutaneous electrical nerve stimulation, gabapentin, botulinum toxin injection, hyaluronic acid injection, relaxation therapy, trigger point injection, acetaminophen (with or without muscle relaxants or NSAIDS), topical capsaicin, biofeedback, corticosteroid injection (with or without NSAIDS), benzodiazepines, and β blockers; and (4) strong recommendations against irreversible oral splints, discectomy, and NSAIDS with opioids. These recommendations apply to patients living with chronic pain (≥3 months duration) associated with TMD as a group of conditions, and do not apply to the management of acute TMD pain. Authors concluded that when considering management options, clinicians and patients should first consider strongly recommended interventions, then those conditionally recommended in favor, then conditionally against. In doing so, shared decision making is essential to ensure patients make choices that reflect their values and preference, availability of interventions, and what they may have already tried. Further research is warranted and may alter recommendations in the future.

Tournavitis et al. (2023) evaluated the effectiveness of conservative different therapeutic modalities for temporomandibular disorders (TMD) pain in a systematic review. Studies

included must have patients older than 18 years, with painful TMD, which diagnosis was performed by Research Diagnostic Criteria for TMD or Diagnostic Criteria for TMD. Outcome variables were pain relief and post treatment pain intensity reduction. Of 1,599 articles obtained, 28 RCTs fulfilled all selection criteria and were included. The results of this study show that there was a significant decrease in short-term post-treatment TMD pain with the use of occlusal splint alone or in combination with other therapeutic modalities when compared with the control group. Statistically significant differences were also detected between laser and photobiomodulation group and the control, in short-term treatment TMD-related pain. Authors concluded that the primary findings of the present systematic review showed that the occlusal splint alone or combined with other therapeutic intervention presented positive effect on short-term TMD pain reduction. Secondary outcome suggests that laser and photobiomodulation therapy had, also, a significant role in short term pain relief.

Tanhan et al. (2023) aimed to investigate the efficacy of different types of physiotherapy approaches in individuals with cervical myofascial painful temporomandibular disorders (TMDs). Seventy-five participants with myofascial pain of jaw muscles and cervical myofascial pain were randomized into three groups: exercise group, low-level laser therapy group (LLLT), and manual pressure release group (MPR). All patients were assessed before treatment and after 12 sessions of treatment. Significant improvement was seen in all groups' pressure pain threshold (PPT) values. Some masticatory and neck muscles' PPT changes in MRP and LLLT groups were significantly higher than the exercise group ($p < 0.05$). Authors concluded that exercise therapy is an effective approach for treatment of TMDs. Additionally, LLLT combined with exercise and MPR combined with exercise have better effects than only exercise therapy. Multimodal treatment approaches should include exercise to achieve better results in clinical practice.

Al-Moraissi et al. (2024) compared and ranked all treatments for disc displacement with reduction (DDwR), including conservative treatments, occlusal splints, low-level laser therapy (LLLT), manual therapy, no treatment (control), arthrocentesis (Arthro) alone, Arthro plus intra-articular injection of platelet-rich plasma (Arthro-PRP) or hyaluronic acid (Arthro-HA), and Arthro plus occlusal splint. Predictor variables were pain intensity and maximum mouth opening (MMO). Twenty RCTs reporting 1,107 patients were identified in the literature search; 980 of these patients were included in the network meta-analysis. Direct meta-analysis showed that Arthro-PRP significantly reduced pain intensity compared to Arthro alone, while occlusal splint and manual therapy were superior to conservative treatment (all very low quality evidence). Arthro with intra-articular injection of PRP/HA ranked as the most effective treatment in terms of pain reduction, whereas LLLT ranked the best choice for increasing MMO for patients with DDwR. Authors emphasized that it is important to note that the evidence for the superiority of these treatments is generally of very low quality. Therefore, further high-quality research is

needed to confirm these findings and provide more reliable recommendations for the treatment of DDwR.

Wound Healing

There are several systematic technical reviews published regarding the use of low-level laser for wound healing. The Agency for Healthcare Research and Quality (AHRQ) published a review of the comparative effectiveness and harms of different therapies and approaches to treating pressure ulcers (Saha, et al., 2013). Regarding low-level laser therapy, the review found low strength of evidence for laser therapy and that wound improvement was similar with laser therapy compared with sham treatment or standard care (4 studies). Beckmann et al. (2014) completed a systematic literature review of LLLT for wound healing of diabetic ulcers. They concluded that although the majority of clinical studies show a potential benefit of LLLT in wound healing of diabetic ulcers, there are several aspects in these studies limiting final evidence about the actual outcomes. In summary, all studies give enough evidence to continue research on laser therapy for diabetic ulcers, but clinical trials using human models do not provide sufficient evidence to establish the usefulness of LLLT as an effective tool in wound care regimes at present. Further well-designed research trials are required to determine the true value of LLLT in routine wound care.

Huang et al. (2021) performed a meta-analysis to evaluate the effect of LLLT on diabetic foot ulcers (DFUs). A total of 13 randomized controlled trials (RCTs) and 413 patients were analyzed. Compared with the control group, LLLT significantly increased the complete healing rate, reduced the ulcer, and shortened the mean healing time of patients with DFUs. The quality of the evidence was very low according to the GRADE system. Authors concluded that LLLT is a promising and effective adjuvant treatment to accelerate the healing of DFUs. Further evidence from larger samples and higher quality RCTs is needed to prove the effect of LLLT and to determine the most appropriate parameters for the healing of DFUs.

Liu et al. (2023) implemented a meta-analysis to review diabetic foot wound ulcer (DFWU) management by laser therapy (LT). The 26 elected studies included 1,067 individuals with DFWU, 540 utilizing LT and 527 as controls. LT demonstrated significantly higher ulcer size decreases and complete healing rate compared with control in individuals with DFWU. LT had significantly higher ulcer size decreases, and complete healing rate compared to control individuals with DFWU. Nevertheless, authors state to exercise caution when interpreting results given low sample size for the comparisons in the meta-analysis.

Oral Mucositis

A systematic review and meta-analysis were conducted to examine the effect of LLLT in cancer therapy-induced oral mucositis (OM). The review included 11 randomized, placebo-controlled trials with 415 patients (Bjordal, et al., 2011). The study found

consistent evidence from small high-quality studies that red and infrared LLLT can partially prevent development of cancer therapy-induced OM. LLLT also significantly reduced pain, severity, and duration of symptoms in patients with cancer therapy-induced OM. The limitation of the study included the small sample size of the included trials and the heterogeneity of the treatment procedures and dosing.

Clarkson et al. (2010) reported on a Cochrane review to assess the effectiveness of interventions for treating oral mucositis or its associated pain in patients with cancer receiving chemotherapy or radiotherapy or both. The review found that there is limited evidence from two small trials that low level laser treatment reduces the severity of the mucositis. The authors concluded that there is weak and unreliable evidence that low level laser treatment reduces the severity of the mucositis with a need for further, well designed, placebo or no treatment-controlled trials assessing the effectiveness of interventions for mucositis.

Lalla et al. (2014) updated a previous version of the Multinational Association of Supportive Care in Cancer and International Society of Oral Oncology (MASCC/ISOO) Clinical Practice Guidelines for mucositis in a systematic review. The literature search identified 8279 papers, 1032 of which were retrieved for detailed evaluation based on titles and abstracts. Of these, 570 qualified for final inclusion in the systematic reviews. Sixteen new guidelines were developed for or against the use of various interventions in specific treatment settings. In total, the MASCC/ISOO Mucositis Guidelines now include 32 guidelines: 22 for oral mucositis and 10 for gastrointestinal mucositis. Authors reviewed 24 studies evaluating the effects of laser or other light therapy on oral mucositis. The evidence supported the development of 2 new guidelines: a recommendation in favor of low-level laser therapy (LLLT) for the prevention of oral mucositis in patients receiving high-dose chemotherapy (CT) for hematopoietic stem cell transplantation (HSCT) with or without total body irradiation, and a suggestion for LLLT in the prevention of oral mucositis in patients receiving head and neck radiation therapy (H&N RT) without concomitant chemotherapy.

This clinical practice guideline was updated again in 2021 (Elad et al.). This current guideline update has several new insights:

- A recommendation for the prevention of OM with intraoral photobiomodulation (PBM) therapy (previously laser or light therapy) in patients who undergo HSCT
    - Current systematic review reiterates the 2014 guidelines in this patient population and increases the range of PBM settings that may be used;
- A recommendation for the prevention of OM with intraoral PBM therapy in patients with cancer who receive H&N RT (without CT)
    - This is an upgrade of the 2014 guidelines from a suggestion to a recommendation

- A recommendation for the prevention of OM with intraoral PBM therapy in patients with cancer who receive H&N RT with CT
    - This new guideline is based on recent evidence.

The authors also identified several RCTs aimed at the treatment of OM in pediatric patients undergoing mixed RT/RT-CT, mixed HSCT/CT, or CT for several types of cancer. The results were promising; however, it was too early to base a guideline on these findings. Authors also reported that recent long-term follow-up studies on patients treated with PBM for the prevention of OM showed no increase in cancer recurrence. However, the analysis of these data is challenging. Considering the conflicting evidence from animal models regarding the effect of PBM on tumor behavior, the clinician is advised to inform patients about the expected benefits and potential risks of PBM. They also state that PBM protocols described in this guideline should be followed exactly to optimize clinical efficacy.

He et al. (2018) aimed to synthesize the available clinical evidence on the effects of low-level laser therapy (LLLT) in the prevention and treatment of chemotherapy-induced oral mucositis (OM). Authors found 8 qualified clinical trials with a total of 373 pediatric patients; Authors concluded that prophylactic LLLT reduces mucositis and severe mucositis and decreases the average severity of oral mucositis in pediatric and young patients with cancer. Therapeutic LLLT also reduces the average severity of oral mucositis and oral pain.

de Lima et al. (2020) sought to determine the effectiveness of low-level laser therapy in preventing oral mucositis in patients undergoing chemoradiotherapy for head and neck cancer in a systematic review and meta-analysis. From 14,525 records, only 4 studies were included in the review and 3 studies were included in meta-analysis. Data from 500 patients (mean age of 53.595 and 54.14 for intervention and control groups, respectively) were analyzed. Meta-analysis showed that laser therapy prevents oral mucositis incidence in 28% and 23% of cases during the third and fourth follow-up week, respectively, in comparison to a placebo-treated control group. There was no statistically significant difference the prevention of pain. Dysphagia and quality of life were not analyzed due to missing data. The authors concluded that laser therapy was effective in preventing oral mucositis from the 15th to the 45th days of chemoradiotherapy. However, new primary studies with low risk of bias are needed so a higher level of scientific evidence can be obtained.

Patel et al. (2021) updated the 2015 clinical practice guideline for the prevention of oral mucositis in pediatric cancer or hematopoietic stem cell transplant (HSCT) patients. They performed seven systematic reviews of mucositis prevention. Three reviews included randomized controlled trials (RCTs) conducted in pediatric and adult patients evaluating cryotherapy, keratinocyte growth factor (KGF) or photobiomodulation therapy with a focus on efficacy. Authors included 107 unique studies of cryotherapy (22 RCTs and 4

pediatric studies); KGF (15 RCTs and 12 pediatric studies); photobiomodulation therapy (29 RCTs and 8 pediatric studies) and any intervention (31 pediatric RCTs). Effect on severe mucositis reduction from RCTs was photobiomodulation therapy Risk Ratio 0.40 and 95% CI 0.27-0.60. Cryotherapy was not feasible in young children while photobiomodulation therapy was feasible across age groups. Relative to Intraoral photobiomodulation therapy (620-750 nm spectrum) only, this intervention should be used in pediatric patients undergoing autologous or allogeneic HSCT and for pediatric head and neck carcinoma patients undergoing radiotherapy.

Redman et al. (2022) assesses the efficacy of oral low-level laser therapy (LLLT) - also known as photobiomodulation - in the reduction of oral mucositis experienced by children and young people with cancer undergoing chemotherapy. Primary outcomes included severity of oral mucositis, oral pain and adverse events. 14 studies (n>416 children) were included in the narrative synthesis of LLLT efficacy. 5 studies (n=380 children and young people) were included in the meta-analyses. Results demonstrate that LLLT may reduce the severity of oral mucositis and the level of oral pain, but further randomized controlled trials are needed to confirm or deny this. There is vast variation in different trial protocols. Insufficient blinding between LLLT or sham therapy/control led to a strong risk of performance bias. 75 studies (encompassing 2712 patients of all ages who had undergone LLLT) demonstrated minor and infrequent adverse reactions, but most studies had significant areas of weakness in quality. Authors concluded that LLLT appears to be a safe therapy, but further evidence is needed to assess its efficacy as a prevention or treatment tool for oral mucositis in children with cancer.

Biala (2022) reviewed evidence on the effectiveness of LLLT using diode lasers on the prevention and reduction in severity of OM in patients with cancer undergoing HSCT. Six randomized controlled trials and one cohort study met the inclusion criteria. The author concluded that the data demonstrate promising outcomes for reducing the incidence and severity of OM using LLLT. Larger, tightly controlled clinical trials are needed in the future.

Franco et al. (2023) evaluated the efficacy of laser therapy in treating post-transplant mucositis in a systematic review and meta-analysis. There were 230 papers included in this review. Two hundred twenty-seven were excluded. Furthermore, a manual search was performed. After the search phase, three articles were considered in the study. The overall effect showed differences in the degree of mucositis in the laser-treated patients compared with the placebo group. The meta-analysis shows a reduction in the degree of mucositis in the patients treated with laser therapy. The application of laser therapy results in decreased severity of oral mucositis from radiation and chemotherapy. Authors conclude that their study shows that the application of low-level laser therapy in the treatment of transplant mucositis has excellent efficacy in relieving the symptoms and severity of mucositis.

Musculoskeletal Conditions

Several studies have been published regarding LLLT for musculoskeletal conditions. Limitations of the studies included small study size, short follow-up time periods, and heterogeneity in terms of laser, dose, duration, and frequency of treatments (Dakowicz, et al., 2011; Tascioglu, et al., 2012; Konstantinovic, et al., 2010; Ay, et al., 2010; Oken, et al., 2008; and Djavid, et al., 2007).

Clijsen et al. (2017) completed a systematic review and meta-analysis on the effects of low-level laser therapy on pain in patients with musculoskeletal disorders. A random-effects model was used for this meta-analysis. Subgroup meta-analyses were conducted to evaluate the influence of the adherence of the applied LLLT to the World Association of Laser Therapy (WALT) guidelines, the anatomical site under investigation and the study design on the overall weighted mean effect size. Meta regression was used to assess the possible influence of the study quality on the individual study effect sizes. Eighteen studies allowing for 21 head-to-head comparisons (totaling *n*=1462 participants) were included. The pooled raw mean difference (D) in pain between LLLT and the control groups was -0.85. There was high and significant between-study heterogeneity. The subgroup meta-analysis of the comparisons not following the WALT guidelines revealed a D = -0.68. In this group, heterogeneity decreased. In the WALT subgroup D equaled -1.52. This between groups difference was clinically relevant although statistically not significant. Authors conclude that this meta-analysis presents evidence that LLLT is an effective treatment modality to reduce pain in adult patients with musculoskeletal disorders. Adherence to WALT dosage recommendations seems to enhance treatment effectiveness.

The Royal Dutch Society for Physical Therapy (KNGF) issued a clinical practice guideline for physical therapists that addresses the assessment and treatment of patients with nonspecific neck pain, including cervical radiculopathy, in Dutch primary care. Recommendations were based on a review of published systematic reviews. The physical therapist is advised not to use dry needling, low-level laser, electrotherapy, ultrasound, traction, and/or a cervical collar (Bier et al., 2018).

Song et al. (2018) investigated the effectiveness of high intensity laser therapy (HILT) for musculoskeletal disorders using a systematic review and meta-analysis. Twelve studies were selected for this systematic review. In 11 studies, comprising 736 patients, pain was significantly improved by HILT compared with a control group. From the analysis of 688 patients from 10 studies, HILT showed a significant improvement in disability scores compared with those in the control group. The results of this study show that HILT treatment for back and neck pain significantly improved pain and disability scores compared with controls.

The National Institute for Health and Care Excellence (NICE) (2021) completed an evidence review to explore the effectiveness of electrical physical modality interventions

for chronic primary pain, including low level laser therapy. LLLT, was defined as the non-invasive application of a single wavelength of light to the skin over the injured area using a probe. When assessing LLLT versus sham laser therapy for quality of life, very low quality evidence from 6 studies with 276 participants showed a clinically important benefit of laser therapy compared to sham laser therapy at ≤3 months. Low to moderate quality evidence from 2 studies with 110 participants showed both a clinically important benefit of laser therapy (physical subscale) and no clinically important difference (mental subscale) compared to sham laser therapy at ≤3 months. Low quality evidence from 2 studies with 117 participants showed no clinically important difference compared to sham laser therapy at >3 months. For pain reduction, very low quality evidence from 13 studies with 558 participants showed a clinically important benefit of laser therapy compared to sham laser therapy at ≤3 months. Moderate quality evidence from 2 studies with 71 participants showed a clinically important benefit of laser therapy compared to sham laser therapy at >3 months. For Psychological distress, low to moderate quality evidence from 1 study with 44 participants showed no clinically important difference between laser therapy and sham laser therapy at ≤3 months. No evidence was identified for physical function, pain interference, pain self-efficacy, use of healthcare services, and sleep.

DE Oliveira et al. (2022) presented the up-to-date evidence about the effects of low-intensity Light Amplification by Stimulated Emission of Radiation (LASER) and light-emitting diode (LED) (photobiomodulation therapy) on pain control of the most common musculoskeletal conditions. In the rehabilitation setting, patients benefit most when their health providers utilize a multimodal approach combining different types of therapies and when patients take on a significant role in optimal management of their own pain. The use of light as a therapeutic alternative form of medicine to manage pain and inflammation has been proposed to fill this void. LASER and LED has been shown to reduce inflammation and swelling, promote healing, and reduce pain for an array of musculoskeletal conditions. Authors note that there is evidence that photobiomodulation therapy reduces pain intensity in non-specific knee pain, osteoarthritis, pain post-total hip arthroplasty, fibromyalgia, temporomandibular diseases, neck pain, and low back pain. Therefore, the purpose of this paper was to present the up-to-dated evidence about the effects of low-intensity LASER and LED (photobiomodulation therapy) on pain control of the most common musculoskeletal conditions. We observed that the photobiomodulation therapy offers a non-invasive, safe, drug-free, and side-effect-free method for pain relief of both acute and chronic musculoskeletal conditions as well as fibromyalgia.

Other

An evidence-based guideline for the treatment of painful diabetic neuropathy published by American Academy of Neurology, the American Association of Neuromuscular and Electrodiagnostic Medicine, and the American Academy of Physical Medicine and Rehabilitation (Bril, et al., 2011) notes LLLT is probably not effective for the treatment of this condition and is not recommended. Wang et al. (2022) critically analyzed the evidence

from existing systematic reviews investigating the effectiveness and safety of low-level laser therapy (LLLT) in patients with breast cancer-related lymphedema (BCRL). In addition, an updated and comprehensive systematic review was conducted, which aimed to provide updated evidence about this topic. Seven systematic reviews and ten RCTs met the eligibility criteria. Conflicting results regarding the effectiveness of LLLT were presented by the overview of systematic reviews. The AMSTAR 2 showed that the methodological quality of included systematic reviews was low or critically low quality due to one or more critical weaknesses. The GRADE and GRADE-CERQual showed that the evidence quality was low to very low for most outcomes. The updated systematic review showed that LLLT may offer additional benefits as compared to compression therapies (pneumatic compression or compression bandage), placebo laser, or no treatment for patients with BCRL. However, when compared to other types of active interventions, LLLT did not improve outcomes significantly. None of the treatment-related adverse event was reported. Many trials had a high or unclear risk of bias for two or more items, and our updated systematic review showed low quality of evidence per outcome using GRADE approach. Due to insufficient data and poor quality of evidence, there is uncertain to reach these conclusions that LLLT is superior to another active or negative intervention and is safe. More RCTs of high methodological quality, with large sample sizes and long-term follow-up, are needed to inform clinical guidelines and routine practice. Mahmood et al. (2022) also investigated the efficacy of clinical use of LLLT in the treatment of metastatic breast cancer-related lymphedema. The primary objectives were arm circumference or arm volume, whereas the secondary goals were to assess shoulder mobility and pain severity. Eight clinical trials were analyzed in total. Typically, the included RCTs had good research quality. At four weeks, there was a considerable reduction in arm circumference/volume, and this continued with long-term follow-up. However, no statistically significant change in shoulder mobility or pain severity was seen between the laser and placebo groups at 0-, 1-, 2-, and 3-month short-term follow-up. According to authors and contradictory to the previous review, findings demonstrated that LLLT was successful in diminishing arm circumference and volume than improving shoulder mobility and pain. Based on their analysis, data indicated that laser therapy may be a beneficial treatment option for females with postmastectomy lymphedema. Because of the scarcity of evidence, there is a strong need for well-conducted and longer-duration trials in this field.

Chiu et al. (2023) aimed to organize existing research and determine the optimal combination of LLLT parameters for BCRL treatment in a meta-analysis. Authors focused on the aspects of the treatment area, treatment regimen, and total treatment sessions across the included studies. The comparisons between LLLT and non-LLLT were performed through a meta-analysis. Post-treatment quality of life (QOL) was significantly better in the axillary group. The group treated "three times/week with a laser density of 1.5-2 J/cm2" had significantly better outcomes in terms of swelling reduction, both immediately post-treatment and at 1-3 months follow-ups. The group with > 15 treatment sessions had significantly better post-treatment outcomes regarding reduced swelling and improved grip

strength. According to these results, LLLT can relieve the symptoms of BCRL by reducing limb swelling and improving QOL. Further exploration found that a treatment approach targeting the axilla, combined with an increased treatment frequency, appropriate laser density, and extended treatment course, yielded better outcomes. However, further rigorous, large-scale studies, including long-term follow-up, are needed to substantiate this regimen.

Lutfallah et al. (2023) aimed to summarize current knowledge on the use of low-level laser therapy (LLLT) in managing acute pain. LLLT is a proposed alternative to control postoperative pain and acute pain compared to the use of medications. Studies included in this review included the following conditions: total knee arthroplasty, knee OA, low back pain, lumbar radiculopathy, root canal, removal of impacted molar, and neck/shoulder stiffness. Authors concluded that laser therapy should be considered an alternative to treating acute pain with more research needed to further evaluate the safety and efficacy. However, this review had several limitations. No statistical analysis was done, several studies included did not describe acute pain and also had methodological weakness, and there was a high degree of heterogeneity. Given this, conclusions should be considered with caution.

U.S. Food and Drug Administration (FDA)

Since 2002, the U.S. Food and Drug Administration (FDA) granted 510(k) approval to several companies to market lasers that provide LLLT. The LLLT lasers are classified as class II devices under the physical medicine devices section as "Lamp, Non-heating, for Adjunctive Use in Pain Therapy."

Several devices that provide LLLT have been approved under the 501(k) approval process for various indications. These devices include but are not limited to:

- MicroLight 830™ (MicroLight Corporation of America, Missouri City, TX)
- Thor Laser System (Thor International Ltd, Amersham, UK)
- Luminex LL Laser System® (Medical Laser Systems, Inc, Branford CT)
- Vectra Genisys Laser System® (Chattanooga Group, Hixson, TN)

In the data submitted to the FDA as part of the FDA 510(k) approval process in 2002, the manufacturer of the MicroLight device conducted a double-blind, placebo-controlled study of 135 patients with moderate to severe symptoms of carpal tunnel syndrome who had failed conservative therapy for at least a month. However, the results of this study have not been published in the peer-reviewed literature, and only a short summary is available in the FDA Summary of Safety and Effectiveness, which does not permit scientific conclusions.

High power therapeutic laser systems granted FDA 510(k) approval as "Infrared lamp," for therapeutic healing and to provide topical heating for the purpose of elevating tissue

temperature for temporary relief of minor muscle and joint pain, muscle spasm, pain and stiffness associated with minor arthritis, promoting relaxation of muscle tissue, and to temporarily increase local blood circulation. These devices include but are not limited to:

- Diawave Lasers (formerly Avicenna Laser Technology Inc.) (Riviera Beach, FL): Diowave Laser System, AVI HP-7.5, AVI HPLL-12
- Zimmer MedizinSystems (Irvine, CA): OptonPro

PRACTITIONER SCOPE AND TRAINING

Practitioners should practice only in the areas in which they are competent based on their education, training, and experience. Levels of education, experience, and proficiency may vary among individual practitioners. It is ethically and legally incumbent on a practitioner to determine where they have the knowledge and skills necessary to perform such services and whether the services are within their scope of practice.

It is best practice for the practitioner to appropriately render services to a member only if they are trained, equally skilled, and adequately competent to deliver a service compared to others trained to perform the same procedure. If the service would be most competently delivered by another health care practitioner who has more skill and training, it would be best practice to refer the member to the more expert practitioner.

Best practice can be defined as a clinical, scientific, or professional technique, method, or process that is typically evidence-based and consensus driven and is recognized by a majority of professionals in a particular field as more effective at delivering a particular outcome than any other practice (Joint Commission International Accreditation Standards for Hospitals, 2020).

Depending on the practitioner's scope of practice, training, and experience, a member's condition and/or symptoms during examination or the course of treatment may indicate the need for referral to another practitioner or even emergency care. In such cases it is prudent for the practitioner to refer the member for appropriate co-management (e.g., to their primary care physician) or if immediate emergency care is warranted, to contact 911 as appropriate. See the *Managing Medical Emergencies (CPG 159 – S)* clinical practices guideline for information.

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