

High-intensity laser therapy in pain conditions related to musculoskeletal diseases – overview

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Abstract— Musculoskeletal diseases indicate conditions that have an impact on muscles, bones, joints and surrounding tissues, usually accompanied by pain and functional disability. Hence, prevention and proper treatment may have a significant role. High intensity laser therapy (HILT) has been recently introduced in the treatment of musculoskeletal system diseases and given its analgesic, anti-inflammatory and biostimulating effects, it becomes a preferable treatment for these diseases. As a simple, non-invasive and almost side effect free physical modality, HILT attracted our attention and we prepared this result overview for the papers published in a period between 2009 and 2021 that include analgesic effects of HILT. The analysis of the accessed articles related to HILT effects in musculoskeletal disorders has provided us information that this therapy is mostly applied in pain reduction, either solely or in combination with some other physical treatment. Considering the remarkable effects it has on pain relief and better functionality of patients which further result in improved quality of life, HILT deserves much more attention and research.

Keywords — analgesic effects, high intensity laser therapy, long-term effects, musculoskeletal disorders, pain, physical therapy, quality of life, short-term effects.

1 INTRODUCTION

Musculoskeletal diseases indicate conditions that have an impact on muscles, bones, joints and surrounding tissues (tendons and ligaments). There are numerous forms of these conditions, some of them developing suddenly, such as fractures, sprains and strains, and some being permanent conditions usually continuously accompanied by pain and functional disability [1].

Pain and limitations in both, mobility and functional ability are dominant characteristics of musculoskeletal conditions. Not only that they reduce functionality and adversely affect quality of life, but they also present an economic issue worldwide considering that there are numerous musculoskeletal disorders that are chronic and that many affect working age population. Therefore, prevention and proper treatment may have a significant role [1].

As per body structures they affect, most common conditions include the following:

- osteoarthritis, rheumatoid arthritis, psoriatic arthritis, gout, ankylosing spondylitis - affecting joints;
- osteoporosis, osteopenia and associated fragility fractures, traumatic fractures - affecting bones;
- sarcopenia - affecting muscles;
- back and neck pain - affecting the spine;
- connective tissue diseases - affecting multiple body areas or systems and vasculitis that have musculoskeletal manifestations (eg systemic lupus erythematosus) [1].

Some musculoskeletal conditions require administration of medicines, but wherever possible, physical treatment should

be applied as well, given its proved benefits and a fact that it commonly stimulates natural human processes in the body. Physical rehabilitation and medicine deals with a wide range of these conditions. Its physical treatment modalities are widely used to reduce pain and improve mobility and flexibility and above all, improve our performance in Activities of Daily Living (ADL) [2]. HILT is one of these modalities and providing the positive effects it may have on body structures, it may be said that it is quite powerful therapy.

1.1 High-intensity laser therapy – background and effect mechanism

Light has always been considered as a source of life and hence it has motivated scientists to study it in various manners. Its therapeutic features have been analyzed since the 6th century B.C. and finally, in 1960, the first laser was developed. Due to its fast healing properties, by the early 1970's, laser therapy was seen as a physical therapy modality in Eastern Europe, the Soviet Union, and China [3]. Now it is successfully applied worldwide depending on experience and approved protocols.

Laser is the acronym of Light Amplification by Stimulated Emission of Radiation. As indicated by the name itself, it is a form of radiation originating from solid, liquid or gaseous material, which emission occurs after being stimulated by the activation source, and the system of mirrors, embedded in the optic resonator, amplify the electromagnetic waves of the laser light. Three parameters are taken into account when defining the physical characteristics of laser: the wavelength, intensity and emission mode. The wavelength ranges between 180 and 10,600 nm and laser penetration power depends on it - the greater wavelength the greater penetration. The depth of penetration is regulated by the intensity of laser. By increasing the laser power, the penetration depth is also increased. The emission mode is a way in which the laser is distributed. Therefore, it may be continuous, pulsed, flash or Q-switched (brief emissions at high peak intensity). With different pulsations and frequencies we get different effects on the substrate – as fre-

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quency decreases there is greater interaction with the conduction structures and vice-versa [4].

HILT has been recently introduced in the treatment of musculoskeletal system diseases. It is a laser mode with a 1064 nm wavelength with an analgesic effect and reactive vasodilatation, as primary effect and these are created by affecting the cutaneous nerve endings [5]. Another significant mechanism of action is based on tissue stimulation which is formed at various levels: cell, vascular tissue, interstitial tissue and immune system level. It enhances regeneration and beta-endorphin release by inducing the protein synthesis in synovial fluid and hence exhibits analgesic and anti-inflammatory effect [6]. HILT provides quick reduction of inflammation and painful symptoms [7]. A particular waveform including regular peaks of elevated values of amplitude and time distances between them is used to decrease phenomena of thermal accumulation, and it is able to rapidly induce photochemical and photo-thermic effects in the deep tissue, that increase cell metabolism, vascular permeability and blood flow [8].

2 METHODS

As a simple, non-invasive and almost side effect free physical modality, HILT attracted our attention and we became interested in finding more information included in the published papers dealing with it within the scope of musculoskeletal conditions. Based on accessible resources and records, we prepared this result overview of the papers published in a period between 2009 and 2021 that include analgesic effects of HILT.

Articles related to HILT were searched through electronic databases, such as PubMed, Web of Knowledge, Lilacs, Cochrane, Research Gate and through available website search tools, by the following keywords: high intensity laser therapy, high power laser therapy, laser physiotherapy modalities. Within accessible full text papers, 57 records were identified and screened. After excluding records that are not clinical trials, case reports and studies (such as review articles, patient information, PhD papers etc.) and articles which did not deal with pain in musculoskeletal disorders (in total n=18), 39 papers were eligible and included in the overview (Table 1).

3 RESULTS

The analysis of the accessed articles related to HILT effects in musculoskeletal disorders has provided us information that this therapy is mostly applied in pain reduction, either solely or in combination with some other physical treatment. In addition to its positive effects it has on this widespread discomfort, it also has anti-edematous, anti-inflammatory and reparative effect [9], [10].

3.1 Analgesic effect of HILT

HILT has been largely used in the treatment of the most common symptom in musculoskeletal disorders - pain. The pain relieving effect is achieved by the "gate control system" and it is a result of the irradiation stimulating effect on regeneration of nerve fibers [11], [12]. Within the selected articles, the most of them deal with pain in knees, n=10 (25.64%), then with pain in shoulders n=9 (23.08%), spine n=8 (20.51%), elbows n=3 (7.69%), hands n=2 (5.13%), skeletal system n=2 (5.13%), muscles n=2 (5.13%), neck n=1 (2.56%), feet n=1 (2.56%), tendons and ligaments n=1 (2.56%) (Fig. 1).

The most involved condition is knee osteoarthritis n=9 (23.08%), low back pain n=8 (20.51%), subacromial impingement syndrome n=4 (10.26%), lateral epicondylitis n=3 (7.69%), then cervical spondylosis, shoulder injury, shoulder chronic pain, frozen shoulder, myositis ossificans, trapezius focal myositis, carpal tunnel syndrome, hand arthropathy, patellar tendinopathy, plantar fasciitis, injury of tendons and ligaments, myofascial trigger point, fibromyalgia, osteoarthritis, osteopenia/osteoporosis - each n=1 (2.56%) (Fig. 2).

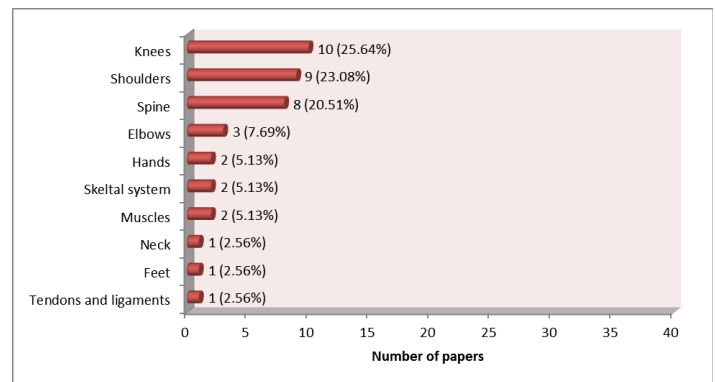


Figure 1 Distribution of pain location per articles

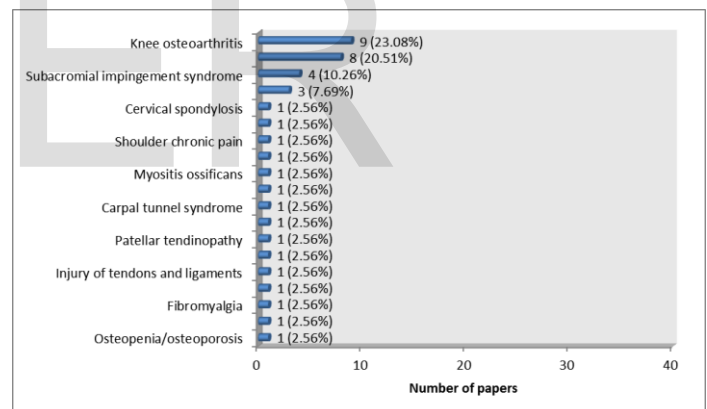


Figure 2 Distribution of musculoskeletal disorders

Considering that there is no other applicable method for determining pain level except for a subjective assessment, the pain was assessed by commonly approved and accepted Visual Analogue Scale - VAS (29 papers), Numeric Pain Rating Scale - NPRS (2 papers), Western Ontario and MacMaster Universities Osteoarthritis Index - WOMAC (2 papers), Verbal Rating Scale - VRS (1 paper) and Victorian Institute of Sport Assessment questionnaire - VISA-P (1 paper). There are 4 papers where both, VAS and WOMAC were used. Given the fact that vast majority of studies use questionnaires, scales and surveys, Taradaj et al. were eager to find a more objective way for pain assessment in the HILT application. They tried to analyze the posture stability parameters considering that posture stability is partially conditioned by pain level. They used double-plate stabilometric platform and unfortunately the results

did not meet their expectations, but they believe that this could be used in further studies [13]. Anyhow, regardless subjectivity, it has to be noted that all studies, carried out within various settings and under various conditions, through subjective pain assessment scales showed that HILT brings significant analgesic effect.

3.2 HILT effects depending on the therapy combination

Physical therapy is rarely applied as a single-procedure treatment and hence it usually represents a combination of at least two therapies. Each physical therapy modality has some effect and it is not wrong to apply it solely, but most authors agree that combination with other modalities yields faster, more efficient and longer-term results. The studies selected for this paper evidence that this is also a case with HILT where almost one third of papers, $n=11$ (28.21%), deal with combination of HILT and some other physical modality(s), $n=25$ (64.10%) deal with HILT applied solely, and there are 3 papers (7.69%) where HILT was applied both, solely and combined with some other therapies. Antonio Ammendolia et al., made a combination of physical therapy and a medicine (Glucosamine Sulfate) in a knee osteoarthritis case. The synergy of these two can bring off a long-term effect being even up to 6 months after the treatment [14].

3.3 Long-term and short-term effects of HILT

Further to severity and complexity of conditions involved, most authors also searched for duration of analgesic effect. For this purpose, in most cases, the pain assessment tools were taken at the beginning and at the end of the therapy cycle and these proved that HILT has an excellent effect in short-term sense. However, some therapeutical settings and possibility to invite patients for follow-up showed that long-term effects are also present in many cases. Given that most of the conducted studies dealt either with short-term (14 to 15 days) or long-term (2 to 6 months) effects, Shin-Tsu Chang et al., investigated immediate effects of HILT on pain relief and shoulder function in patients with subacromial impingement syndrome (SAIS). HILT was applied solely, as per the protocol for biostimulation and comparison of the VAS, shoulder range of motion in flexion, and Constant-Murley Scale presented a remarkable difference prior and post treatment [15]. A quite interesting case was reported by Maryam Ghanbarnasab et al., presenting a "rare case report" dealing with the effects of HILT on trapezius focal myositis. The patient was first subjected to medicines, and since they did not yield satisfactory results, 4 weeks later, the high-intensity laser was applied in 8 sessions. Impressively, the pain was considerably reduced after 3-4 sessions where VAS declined to 3/10. At the end of the treatment, there was an impressive decrease in the VAS score - 1/10, followed by complete pain relief after 1 week. Even after three months, the patient was free of pain and there were also changes in shoulder MRI which viewed the lesion smaller than before. After 6 months, the patient was still free of pain and tenderness and was able to perform Activities of Daily Living without any pain [16].

4 CONCLUSION

The aim of this paper was to present an analgesic effect of high-intensity laser therapy in case of musculoskeletal disorders, by overviewing the recent studies. The selected papers deal mostly with pain in knee, shoulder and spine due to some impairments, all being rather common conditions, and all of them brought some positive results. An exception is a study by Taradaj et al. which did not yield the results which the authors expected to have. They tried to evidence analgesic effects of HILT in an objective manner. Given that there is no equipment for measuring pain, analgesic effects will still be evaluated through subjective assessment.

Regardless that the selected studies have different settings and conditions, that some of them searched for short-term, some for long-term and some for any effect, it may be noticed that the first analgesic effects were noticed quite immediately following application of HILT. It should be noted that long-term effects are usually achieved by applying HILT combined with some other physical procedures or medicines. This is probably due to all effects achieved by HILT - anti-inflammatory, analgesic and biostimulating. But one should not neglect a fact that HILT's effects are quite satisfactory even when it is applied solely.

Although there are no precisely defined protocols for its application in the selected papers, they report positive and encouraging effects. There is still a small and insufficient number of clinical studies and subjects involved in them, and considering the remarkable effects it has on pain relief and better functionality of patients which further result in improved quality of life, HILT deserves much more attention and research. Considering that most studies are related to knee, spine and shoulder impairments, it is necessary to carry out some research within the scope of other affected body areas which also may have a negative impact on quality of life. Learning and understanding all aspects of this therapy would enable those administering physical therapies not only to set a corresponding protocols for various therapy applications, but also to make adequate combinations with other physical therapies and medicines in order to get faster and more efficient results. Pain as a dominant characteristic of musculoskeletal conditions not only that reduces person's functionality and adversely affect quality of life, but also presents an economic issue. Hence, proper and prompt treatment may have a significant role in both for an individual and society as whole. Therefore, further research and studies related to the effects of high-intensity laser therapy and for evidencing its results are needed.

Table 1 Overview of the selected studies and results

No.	Citation	Aim	Result
1	Short-term Effects of High-Intensity Laser Therapy Versus Ultrasound Therapy in the Treatment of People With Subacromial Impingement Syndrome: A Randomized Clinical Trial Andrea Santamato, Vincenzo Solfrizzi, Francesco Panza, Giovanna Tondi, Vincenza Frisardi, Brian G. Leggin, Maurizio Ranieri, Pietro Fiore Italy, 2009	To evaluate the short-term effectiveness of high-intensity laser therapy (HILT) versus ultrasound (US) therapy in the treatment of subacromial impingement syndrome (SAIS)	Seventy patients with SAIS were randomly assigned into 2 groups: 1) a HILT group or 2) a US therapy group. After 2 weeks' intervention, participants in the HILT group showed a significant pain decrease in comparison to participants in the US therapy group. Statistically significant differences in change of pain, articular movement, functionality, and muscle strength were observed after 10 treatment sessions from the baseline for participants in the HILT group compared with participants in the US therapy group. Only the difference in change of VAS score between groups (1.65 points) surpassed the accepted minimal clinically important difference for this tool.
2	Analgesic Effect of High Intensity Laser Therapy in Knee Osteoarthritis Nives Štiglic-Rogoznica, Doris Stamenković, Ljubinka Frlan-Vrgoč, Viviana Avancini-Dobrović and Tea Schnurrer-Luke Vrbanić Croatia, 2011	To investigate the prompt analgesic effect of HILT on patients with knee osteoarthritis	There was statistically significant decrease in VAS after the treatment ($p < 0.001$). HILT enables prompt analgesic effects in the treatment of knee osteoarthritis and hence it is a reliable option in physical therapy in patients with knee osteoarthritis.
3	Short-term effects of high-intensity laser therapy versus ultrasound therapy in the treatment of low back pain: a randomized controlled trial Pietro Fiore, Francesco Panza, G. Cassatella, A. Russo, Vincenza Frisardi, Vincenzo Solfrizzi, M. Ranieri, L. Di Teo, Andrea Santamato Italy, 2011	To evaluate the short-term effectiveness of high-intensity laser therapy (HILT) versus ultrasound (US) therapy in the treatment of low back pain (LBP).	Thirty patients with LBP were randomly assigned into 2 groups 1) a HILT group or 2) a US therapy group. At the end of the 3 weeks' intervention, participants in the HILT group showed a significantly greater decrease in pain (measured by the VAS) and an improvement of related disability (measured by the OLBPDQ) compared with the group treated with US therapy. The findings obtained after 15 treatment sessions with the experimental protocol suggested greater effectiveness of HILT than of US therapy in the treatment of LBP, proposing HILT as a promising new therapeutic option into the rehabilitation of LBP.
4	High Intensity Pulsed Nd:YAG Laser in painful knee osteoarthritis: the biostimulating protocol. T. Viliani, C. Carrabba, G. Mangone, P. Pasquetti Italy, 2012	To analyze the clinical efficacy and the safety of HILT, using a biostimulating protocol in patients with symptomatic knee osteoarthritis.	34 out-patients with symptomatic knee osteoarthritis were assigned into 2 groups: A) a treatment group and B) waiting list. The treatment included HILT biostimulating treatment (10 sessions, three times a week) for Group A and no treatment for Group B. The patients were assessed by WOMAC Scale, before treatment (t0), after treatment (t1) and after 4 months (t2). At the same time intervals, the patients in the waiting list were assessed. Patients in Group A showed a highly statistically significant improvement between t0 and t1 in WOMAC scale, and the improvement was kept at follow-up (t2). The patients in the waiting list showed a worsening tendency. No side effect was found in the treated group. The HILT group showed good clinical results regarding pain and functional issues. It is concluded that this HILT protocol seems a good medical instrument for pain control in knee osteoarthritis and for improvement of quality of life.
5	Long-term effect of high-intensity laser therapy in the treatment of patients with chronic low back pain: a randomized blinded placebo-controlled trial Mohamed Salaheldien Mohamed Alayat, Azza Mohamed Atya, Mohamed Mohamed Ebrahim Ali, Tamer Mohamed Shosha Egypt, 2013	The aim of this study was to compare the effect of high-intensity laser therapy (HILT), alone or combined with exercise, in the treatment of chronic low back pain (CLBP).	Patients were randomly assigned into three groups: 1) HILT plus exercise (HILT + EX), 2) placebo laser plus exercise (PL + EX), and 3) HILT alone. The range of motion significantly increased after 4 weeks of treatment in all groups, then decreased after 12 weeks at follow-up, but was still significantly more than the baseline value in groups 1 and 2. Visual analog scale (VAS), and functional disability by both the Roland Disability Questionnaire (RDQ) and the Modified Oswestry Disability Questionnaire (MODQ) results showed significant decrease post-treatment in all groups, although the RDQ and MODQ results were not significantly different between groups 2 and 3. It appears that HILT combined with exercise is more effective in patients with CLBP than either HILT alone or placebo laser with exercise.
6	High-intensity versus low-level laser therapy in the treatment of patients with knee osteoarthritis: a randomized controlled trial Abdullah Raddah Kheshie, Mohamed Salaheldien Mohamed Alayat, Mohamed Mohamed Ebrahim Ali Saudi Arabia, 2014	To compare the effects of low-level laser therapy (LLLT) and high-intensity laser therapy (HILT) on pain and functional improvement in case of knee osteoarthritis (KOA).	There were three groups of patients: 1) HILT and exercise (HILT+EX), 2) LLLT and exercise (LLLT+EX), and 3) placebo laser plus exercise (PL+EX). The result was that HILT and LLLT combined with exercise were effective in decreasing the VAS and WOMAC scores after 6 weeks of treatment. HILT with exercises was more effective than LLLT with exercises, and both treatment modalities were better than exercises alone in case of KOA.
7	Hilterapia® - high intensity laser therapy in the treatment of severe tendon and ligament injuries	To objectify the effect of high intensity laser therapy (HILT) in the treatment of	The results showed that high intensity laser therapy promoted normalization of temperature patterns in most cases, reparation of tendon and ligament structures in all cases, reduction of pain and the improved musculoskeletal

No.	Citation	Aim	Result
	Gabrhel J, Popracová Z, Tauchmannová H, Nemšák M Slovakia, 2014	severe tendon and ligament lesions by thermovision assessment, structural changes detected by musculoskeletal sonography, degree of pain using Visual Analog Scale (VAS) and musculoskeletal changes before and after the series of HILT sessions.	condition in all cases.
8	Nd:YAG laser in the management of low back pain A. Vervainioti Greece, 2014	To compare the efficacy of high intensity laser therapy (HILT) with a standard physiotherapy protocol on low back pain and a combination of the two methods. This study also addressed the variation of pain through pain type and localization.	Forty-five patients suffering from non-specific low back pain were assigned into three groups: A) physiotherapy, B) HILT and physiotherapy, C) HILT. Each group was administered 10-session treatments in four weeks. The results showed that a significant percent of patients with acute pain gained full recovery (28.8%), while there was a significant improvement (31.1%) of pain symptoms in patients affected by chronic pain, but healing was not achieved. Focal pain was alleviated more effectively than distributed pain. Final assessment showed that in group A there was no full recovery of patients, but just improvement. HILT (group C) had better results in comparison with the standardized physiotherapeutic approach and showed early analgesic effects. Patients in group B showed higher clinical and functional improvement when compared to the other groups. The results showed that a therapeutic protocol based on the combination of HILT and standardized physiotherapy may be successfully used to obtain improvement of pain symptoms and early healing in patients with non-specific pain of the lumbar area.
9	Effects of high-intensity laser on gonarthrosis P. Šifta, D. Danilov Czech Republic, 2015	To verify the effectiveness of high intensity laser therapy (HILT) administered by a high-power Nd:YAG laser in alleviating pain and increasing the range of motion in the affected joint of patients suffering from arthrosis of the knee joint of higher grades.	After the HILT, there was a statistically significant decrease in the WOMAC, WOMAC-A, WOMAC-B, WOMAC-C indexes. The summary WOMAC index on average decreased by 24%. The t-test proved, with a probability of 99%, that HILT significantly reduced pain, stiffness and problems with normal daily activities. The study resulted in the following findings: <ul style="list-style-type: none"> An analgesic effect of a high-intensity laser was observed after the first application Pain at rest and at night alleviated soon. None of the patients noticed any side effect of the HILT.
10	Effectiveness of high-intensity laser therapy and splinting in lateral epicondylitis; a prospective, randomized, controlled study Umit Dunder, Utku Turkmen, Hasan Toktas, Alper Murat Ulasli, Ozlem Solak Turkey, 2015	To investigate the effects of high-intensity laser therapy (HILT) in patients with lateral epicondylitis (LE) and to compare the results with those of a brace and placebo HILT.	Patients were to three treatment groups: 1) HILT group, 2) placebo HILT group, 3) brace group. HILT and brace groups showed significant improvements pain scores, grip strength, disability scores, and several subparts of the short-form 36 health survey (physical function, role limitations due to physical functioning, bodily pain, general health, and vitality) after treatment - after 4 and 12 weeks. The improvements in evaluation parameters of the patients with LE in HILT and brace groups were not reflected to ultrasonographic findings. Comparison of the parameters percentage changes after treatment in relation to pretreatment values did not present a significant difference between HILT and brace groups. It is concluded that HILT and splinting are effective physical therapy modalities for patients with LE in reducing pain and improving disability, quality of life, and grip strength.
11	Long term effects of high intensity laser therapy in lateral epicondylitis patients Ekrem Akkurt, Sami Kucuksen, Halim Yilmaz, Selman Parlak, Ali Salli, Gülten Karaca Turkey, 2015	To investigate short and long-term effects of high-intensity laser therapy (HILT) in lateral epicondylitis (LE) patients.	30 participants were evaluated prior and 6 months after the treatment. The activity and resting VAS, Disabilities of the Arm, Shoulder, and Hand (DASH), and hand grip strength test (HGST) scores presented statistically significant improvement (p= 0.001) following treatment. Whereas VAS activity, DASH, and HGST scores increased after treatment until post-treatment 6 months significantly (p= 0.001), VAS resting scores remained stable (p= 0.476). A statistically significant improvement was also evident in the physical and mental components of SF-36 scores following treatment until 6 months after treatment compared to pre-treatment scores (p= 0.001). The results of the 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.
12	Short-term effects of high-intensity laser therapy on frozen shoulder: A prospective randomized control study Sae Hoon Kim, Yeon Ho Kim, Hwa-Ryeong Lee, Young Eun Choi Republic of Korea, 2015	To evaluate the clinical efficacy of high-intensity laser therapy (HILT) in patients with frozen shoulder	Patients were assigned into 2 groups: 1) HILT group and 2) a placebo group. The results showed that the HILT group had a lower pain VAS score at 3 weeks (3.2 ± 1.7 vs. 4.3 ± 2.2, p = 0.033) and 8 weeks (2.2 ± 2.0 vs. 3.4 ± 2.7, p = 0.042) but no statistically significant difference in the VAS was observed at the final follow-up (12 weeks) between the two groups. No statistical difference in the range of motion ROM and the satisfaction VAS was observed between the 2 groups at serial follow-ups. It is concluded that HILT provided significant pain relief at 3 and 8 weeks in the management of frozen shoulder, but not at the final follow-up time point.

No.	Citation	Aim	Result
13	Effectiveness of High Intensity Laser Therapy for Reduction of Pain in Knee Osteoarthritis Anna Angelova and Elena M. Ilieva Bulgaria, 2016	To present the effect of high intensity laser therapy in patients with knee osteoarthritis.	There were two groups: 1) therapeutic (test) treated with HILT and 2) control group received sham laser. Pain levels measured by VAS and dolorimetry significantly decreased in the therapeutic group after seven days of treatment ($p < 0,001$). This is the reason why HILT can be a method of choice in the treatment of gonarthrosis
14	Short-term effects of high-intensity laser therapy, manual therapy, and Kinesio taping in patients with subacromial impingement syndrome Nihan Ozunlu Pekiavas, Gul Baltaci Turkey, 2016	To compare the effects of Kinesio® taping (KT), Exercise (EX), manual therapy (MT), and high-intensity laser therapy (HILT) on the pain, the range of motion (ROM), and the functioning in patients with subacromial impingement syndrome (SAIS)	Seventy patients with SAIS were assigned into four groups: 1) EX, 2) KT + EX, 3) MT + KT + EX, and 4) MT+ KT+HILT + EX. Statistically significant differences were found in the treatment results of all parameters in MT+ KT+EX and HILT +MT+ KT+EX groups ($p < 0.05$). Statistically significant differences were found between all the groups ($p < 0.05$) when comparing the means of range of motion (ROM) and Shoulder pain and disability index (SPADI). These differences were significant especially between the groups MT + KT+EX and KT + EX ($p < 0.05$) and HILT +MT + KT + EX and KT + EX ($p < 0.05$). HILT and MT were found to be more effective in minimizing pain and disability and increasing ROM in patients with SAIS.
15	Use of Class IV, High Intensity Laser Therapy as an Adjunct in Treating a Patient with an Acute Shoulder injury: A Case Report Lindy Pins USA, 2017	To present a case in which high intensity laser therapy was used successfully to treat a patient with acute shoulder pain. The author also aimed to present evidence supporting the use of high intensity laser therapy as a supplement to conservative interventions in patients with musculoskeletal injuries.	After the treatment, the patient demonstrated an increase of 20 points on the questionnaire - Focus on Therapeutic Outcomes (FOTO) - representing improved functional status. Further, the patient demonstrated improved ROM, and had a notable decrease in pain levels. This case report supports the use of high intensity laser therapy combined with physical therapy for improving ROM, pain levels and overall functional status.
16	Comparison of the Efficacy of High Intensity Laser and Ultrasound Therapies in Chronic Shoulder Pain; Randomized Controlled Single Blind Study Burcu Metin Ökmen, Korgün Ökmen, Kağan Özkuk, Bilal Uysal, Refia Sezer, Engin Koyuncu Turkey, 2017	To compare the efficacy of the high Intensity laser therapy (HILT) and ultrasound therapy (US) for pain and daily activities of patients with chronic shoulder pain.	141 patients were assigned into two groups: 1) US (n=70) and 2) HILT (n=71). In Group 1 and Group 2, statistically significant improvements were found in all the evaluation parameters both post-treatment 1st day and post-treatment findings 30th day ($p < 0.05$). When the groups are mutually compared, statistically significant difference was found in Group 2 both post-treatment 1st day and post-treatment findings 30th day, in all evaluation parameters ($p < 0.05$). The study demonstrates that HILT is superior to US therapy in decreasing pain and improving function in short term in chronic shoulder pain.
17	Effect of High-Intensity Laser Treatments on Chronic Pain Related to Osteoarthritis in Former Professional Athletes: A Case Series Paul F White, Xuezhao Cao, Loani Elvir-Lazo and Hector Hernandez USA, 2017	To evaluate the use of a higher intensity cold laser for treating chronic pain related to osteoarthritis (OA) in former NFL football players.	The chronic pain scores were significantly reduced both at rest and with activity after each treatment. After the initial treatment, the pain scores were reduced to 1.2 ± 1.8 ($p < 0.01$) at rest and to 2.0 ± 2.0 ($p < 0.01$) with activity. The overall beneficial effect was 7.2 ± 1.8 on a scale from 0=no relief to 10=complete relief, and the duration of the beneficial effect lasted 1-3 weeks in 64% of the players treated.
18	Effects of high intensity laser therapy on pain and function of patients with chronic back pain Hyeun-Woo Choi, Jongmin Lee, Sangyong Lee, Jioun Choi, Kwansub Lee, Byung-Kon Kim, Gook-Joo Kim Republic of Korea, 2017	To examine the effects of High Intensity Laser Therapy on pain and function of patients with chronic back pain.	A total of 20 patients were assigned into two groups: 1) a conservative physical therapy group that received conservative physical therapy, and 2) a high intensity laser therapy group that received High Intensity Laser Therapy after conservative physical therapy. In a comparison between the groups, both VAS and Oswestry Disability Index significantly decreased. In a 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. It is 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 suffering from chronic back pain.
19	Efficacy of high intensity laser therapy in the treatment of male with osteopenia or osteoporosis: a randomized placebo-controlled trial Mohamed Salaheldien Mohamed Alayat, Ehab Mohamed Abdel-Kafy, Ahmed Mohamed Elsoudany, Omar Farouk Helal, Mansour Abdullah Alshehri Saudi Arabia, 2017	To investigate the effect of high intensity laser therapy (HILT) on pain, health related quality of life and fall risk in male with osteopenia or osteoporosis, applied either solely or combined with exercise	There were four groups of patients: 1) laser with exercise, 2) placebo laser with exercise, 3) laser alone and 4) placebo laser. All measured values significantly decreased after treatment in all treatment groups. Laser with exercises showed a higher significant effect than exercises with a least significant effect in the laser group in reduction of pain and quality of life. It is concluded that high intensity laser is an effective treatment for male patients with osteopenia or osteoporosis. Laser combined with exercise is more effective than exercises or laser alone in decreasing pain, fall risk an increasing quality of life 12 weeks after the treatment.

No.	Citation	Aim	Result
20	The Difference on Pain and Range of Motion After High-Intensity Laser Therapy on Myositis Ossificans of the Right Deltoid Muscle: A Case Report Dian Herdiansyah, Tertianto Prabowo, Rachmat Z. Goesasi Indonesia, 2017	To show effects of high intensity laser therapy (HILT) on pain and range of motion (ROM) in a patient suffering from myositis ossificans (MO).	The pain decreased after the therapy and the right shoulder movements were easier. After two times/week for four weeks of therapy, there was no pain, and the x-ray showed reduced the scope of calcification.
21	The Effectiveness of Cervical Spondylosis Therapy with Saunders Traction Device and High-Intensity Laser Therapy: A Randomized Controlled Trial Robert Haładaj, Mariusz Pingot, Mirosław Topol Poland, 2017	To evaluate analgesic effect and improvement of active mobility of the cervical spine after having been subjected to traction therapy with the Saunders device and high-intensity laser therapy (HILT) immediately after therapy, and in short-, medium-, and long-term follow-up in patients with cervical spondylosis.	174 patients were assigned into 2 groups: 1) Group I where traction therapy with the Saunders device was applied, and 2) Group II HILT was applied. The results obtained in the two groups were similar immediately after the therapy and after 4 weeks (the medium-term follow-up). However, in long-term follow-up, therapeutic effects of HILT maintained positive. Both therapeutic methods improved the efficiency and demonstrated analgesic efficacy in patients with cervical spondylosis immediately and in the medium term after the therapy. HILT was more effective than the Saunders method in long-term follow-up.
22	Treatment of drug-resistant fibromyalgia symptoms using high-intensity laser therapy: a case-based review Paul F. White, Jason Zafereo, Ofelia Loani Elvir-Lazo, Hector Hernandez USA, 2017	To evaluate low (1 W), intermediate (42 W) and high level (75 W) high-intensity laser therapy (HILT) in a woman with long-standing fibromyalgia syndrome which was resistant to both standard pharmacotherapy and treatment in an interdisciplinary pain management program.	The 1 W treatment produced minimal symptom relief, both the 42 and the 75 W treatments produced a dramatic reduction in overall pain, improved quality of sleep, and increased the level of physical activity for 4–10 days after these treatment sessions. This case illustrates the potential beneficial effects of using higher power levels of HILT for patients with fibromyalgia syndrome who did not respond to conventional interdisciplinary treatment regimens
23	Efficacy of High-Intensity Laser Therapy and Silicone Insole in Plantar Fasciitis Ferit Akkurt, Halil Ekrem Akkurt, Halim Yılmaz, Yücel Olgun and Zafer Sen Turkey, 2018	To investigate the short-term efficacy of high intensity laser therapy (HILT) and silicone insole in the treatment of plantar fasciitis (PF) and to compare it with a full-length silicone insole alone.	Both groups showed a significant improvement regarding all parameters (pain scores, function and quality of life scores, and fat pad thickness) one month after treatment. When the pre and post-treatment percentage changes were compared, a significant difference was found between both groups regarding all VAS score parameters, Foot and Ankle Outcome Score for quality of life and pain, and Heel Tenderness Index scores in HILT and insole group. Conjunction of HILT and insole therapy was considered to be more effective than only silicone insole with regard to decrease in pain and increase in quality of life.
24	Efficiency of high intensity laser therapy in patients with knee osteoarthritis Ezgi Deniz Ciplak, Semra Akturk, Raikan Buyukavci, Yuksel Ersoy Turkey, 2018	To compare the effects of high-intensity laser treatment (HILT) and the transcutaneous electrical nerve stimulation (TENS) and ultrasound (US) combined treatment on pain, functionality, and quality of life in the patients suffering from knee osteoarthritis.	The first group was administered a combination of hot pack, TENS and US, and HILT was administered to the second group for 2 weeks. In both groups, a statistical significant change was observed in all the parameters after the treatment. In the comparison between the groups, it was observed that HILT provided a significant improvement in pain scores both after the treatment and in the 6th week than TENS and US combined treatment. HILT in knee osteoarthritis is a statistically significant efficient method for pain and functional scales compared to combination of TENS and US.
25	Treatment of chronic patellar tendinopathy using an exercise program consisting of eccentric training and static stretching exercises combined with high intensity light therapy. A pilot study Evangelos Nicolaou PT, Stasinopoulos Dimitrios, Demetris Lamnisis Cyprus, 2018	To investigate the effects of an exercise program consisting of eccentric training and static stretching exercises combined with High Intensity Light Therapy (HILT) in patients with Chronic Patellar tendinopathy (CPT)	At week 4, there was a rise in VISA-P score of about 37 units. This rise was kept at one month follow-up. The results suggest that the combination of an exercise program with HILT is an adequate treatment for patients with CPT
26	Comparison of high-intensity laser therapy and combination of transcutaneous nerve stimulation and ultrasound treatment in patients with chronic lumbar radiculopathy: A randomized single-blind study Emine Kolu, Raikan Buyukavci, Semra	To compare the effects of high-intensity laser therapy (HILT) and a combination of transcutaneous nerve stimulation (TENS) with ultrasound (US) therapy on pain and functionality	A total of 54 patients were divided into two groups: Group 1 received 10 sessions of a combination of hot pack, TENS, US and exercise, and Group 2 received hot pack, HILT and exercise. In two groups, VAS and Oswestry Disability Index scores showed significant changes. At the end of the 2 weeks intervention, participants in Group-1 showed a significantly greater decrease in pain than participants in Group-2. Statistically significant differences in pain variation and functionality (VAS and ODI) were observed four weeks after

No.	Citation	Aim	Result
	Akturk, Fatma Eren, Yuksel Ersoy Turkey, 2018	in patients with chronic lumbar radiculopathy.	treatment sessions for participants in the TENS+US therapy group compared with participants in the HILT group. HILT and TENS+US combined with exercise were effective treatment modalities in decreasing the VAS and ODI scores. TENS+US combined with exercises were more effective than HILT combined with exercise.
27	Effect of laser treatment on postural control parameters in patients with chronic nonspecific low back pain: a randomized placebo-controlled trial J. Taradaj, K. Rajfur, J. Rajfur, K. Ptaszkowski, L. Ptaszkowska, M. Sopol, J. Rosińczuk, R. Dymarek, Poland, 2019	The main objective was to evaluate static postural stability by using an objective tool in patients with chronic non specific lumbar pain after laser treatment with different doses and wavelengths.	Low- and high-intensity laser therapy did not lead to a significant improvement in postural sway in patients with chronic non specific lumbar pain compared with standard stabilization training based on short- and long-term observation.
28	Efficacy of high-intensity laser therapy in comparison with conventional physiotherapy and exercise therapy on pain and function of patients with knee osteoarthritis: a randomized controlled trial with 12-week follow up Ahmad Nazari, Azar Moezy, Parisa Nejati, Ali Mazaherinezhad Iran, 2019	To compare the effects of high-intensity laser therapy (HILT), conventional physical therapy (CPT), and exercise therapy (ET) on pain and function in patients with knee osteoarthritis.	In comparison to other groups, HILT was more efficient in decreasing the VAS, increasing FROM and improving the WOMAC scores both after treatment and after 12 weeks. The effect of HILT and CPT on the knee flexion range of motion, timed up and go test, 6-min walk test, and Western Ontario and McMaster Universities Osteoarthritis pain subscale, was not significantly different after treatment, and both were better than ET. However, HILT was significantly better than the others at follow-up, particularly on the WOMAC stiffness subscale. HILT combined with exercise therapy, could have positive impacts on knee osteoarthritis patients.
29	Effects of High - Intensity Laser in Treatment of Patients with Chronic Low Back Pain Marija Gocevska, Erieta Nikolikj-Dimitrova, Cvetanka Gjerakaroska-Savevska Republic of North Macedonia, 2019	To compare the effects between high-intensity laser (HILT) and ultrasound (US) therapy in the treatment of patients with chronic low back pain.	A group of 54 patients was divided into two groups: 1) HILT and exercises group and 2) US and exercises. The first group showed statistically significantly better results than the second group after completion of the treatment (at two weeks) and at follow up after 3 months. This study has shown that pain and disability in patients with chronic low back pain treated with a high-intensity laser have been significantly reduced, range of motion has been improved. The positive effect was kept for 3 months. It appears to be an effective, safe and useful physical modality in the treatment of a patient with chronic low back pain.
30	The Effect of High-Intensity Laser Therapy on Trapezius Focal Myositis: A Rare Case Report Maryam Ghanbarnasab, Parisa Nejati, Reza Moeinoddin, Lida Nejati Iran, 2019	To present a case of a patients suffering from focal myositis (FM) in the left trapezius muscle who had an excellent response to high intensity laser therapy (HILT)	The pain level was significantly lower after 3-4 sessions (the VAS declined from 9/10 to 3/10). At the end of the 8th session, there was a dramatic decrease in the VAS score (1/10), and finally, the pain completely disappeared after 1 week. After three months, the patient had no pain. The shoulder MRI viewed lesion smaller than before. After 6 months, she had no pain or tenderness in that area and was able to perform all daily tasks without any pain.
31	A comparative study of the dose-dependent effects of low level and high intensity photobiomodulation (laser) therapy on pain and electrophysiological parameters in patients with carpal tunnel syndrome: A randomized controlled trial Kamran Ezzati, E-Liisa Laakso, Alia Saberi, Shahrokh Yousefzadeh Chabok, Ebrahim Nasiri, Babak Bakhshayesh Eghbali Iran, 2019	To compare the dose dependent effects of low level laser therapy (LLLT) and high intensity laser therapy (HILT) on pain and electrophysiology studies in patients with carpal tunnel syndrome (CTS).	There were 5 groups: A: Exercise therapy and LLLT with low fluence, B: Exercise therapy and LLLT with high fluence, C: Exercise therapy and HILT with low fluence, D: Exercise therapy and HILT with high fluence, E: Control group: patients who received exercise therapy alone. After 3 weeks, in all groups, VAS was significantly lower ($P<0.05$), compound muscle action potential (CMAP) latency decreased. The interaction of group and time (5×2) was significant for pain ($P<0.001$), the latency of CMAP ($P=0.001$) and CMAP amplitude ($P=0.02$). The interaction of group and time was not significant for the CMAP conduction velocity, sensory nerve latency and amplitude ($P>0.05$). HILT with a power of 1.6 W and low fluence of 8 J/cm ² was superior in reduction of pain and improvement of the median motor nerve conduction compared to LLLT and exercise-only control groups.
32	Short-Term Efficacy Comparison of High-Intensity and Low-Intensity Laser Therapy in the Treatment of Lateral Epicondylitis: A Randomized Double-Blind Clinical Study Ercan Kaydok, Banu Ordahan, Sezin Solum, Ali Yavuz Karahan Turkey, 2020	To evaluate and compare the short-term efficacy of high-intensity laser therapy and low-intensity laser therapy in the treatment of lateral epicondylitis.	After 3 weeks, there were significant improvements in all of the parameters ($p<0.05$). However, in the high-intensity laser therapy group, the QDASH, hand grip strength, and SF-36 physical component summary (PCS) scores showed superior improvement compared to the low-intensity laser therapy group ($p<0.05$). However, each treatment modality was found to be effective and safe for the short-term treatment of lateral epicondylitis.
33	High intensity laser therapy effect on pain in patients with myofascial trigger points Hatem M. Ahmed, Enas Abu Taleb, Mohamed T. Eldesoky, Yasser R. Lasheen, Fayrouz H. Ameen	To investigate the effect of high intensity laser therapy on pain intensity in patients with acute cervical myofascial trigger points in the upper trapezius muscle.	The results showed that there was significant difference between the two groups in the post treatment outcome measures where the effect in group (B) is more significant than in the control group (A) at ($p >0.001$). High intensity laser therapy was found to be quite effective as a physical treatment for patients with cervical myofascial trigger points.

No.	Citation	Aim	Result
	Egypt, 2020		
34	A Randomized Comparative Study between High-Intensity and Low-Level Laser Therapy in the Treatment of Chronic Nonspecific Low Back Pain Walid Kamal Abdelbasset, Gopal Nambi, Saud F. Alsubaie, Ahmed M. Abodonya, Ayman K. Saleh, Nahla N. Ataalla, Ahmed A. Ibrahim, Sayed A. Tantawy, Dalia M. Kamel, Anju Verma, and Samah A. Moawd Egypt, 2020	To compare the effects of high-intensity laser therapy (HILT) versus low-level laser therapy (LLLT) on chronic nonspecific low back pain.	Both LLLT and HILT groups showed a significant improvement of the Oswestry Disability Index (ODI), visual analogue scale (VAS), lumbar range of motion (ROM), and European Quality of Life (EuroQol) scores ($p>0.05$), while the control group did not show significant changes ($p>0.05$). Comparison among the three study groups postintervention showed significant differences in the outcome measures ($p>0.05$), while comparison between the LLLT and HILT groups showed nonsignificant differences ($p>0.05$).
35	The Immediate Effect of High-Intensity Laser Therapy on Pain Relief and Shoulder Function in Patients with Subacromial Impingement Syndrome Yan-Wen Chen, Yuan-Yang Cheng, Yuchun Lee and Shin-Tsu Chang Taiwan, 2020	To evaluate the immediate effects of High-Intensity Laser Therapy (HILT) on patients with Subacromial Impingement Syndrome (SAIS)	At the end of the evaluation period, comparisons before and after treatment in the HILT group showed significant improvements in all outcome measures, including VAS, shoulder ROM, and CMS ($P<0.05$). HILT can immediately reduce pain and disability and improve shoulder flexion range of motion in patients with SAIS.
36	Effect of High-Power Laser on Shoulder Mobility in Sub Acromial Impingement Syndrome: Randomized Controlled Trial Walid Ahmed Kamal, Mahmood Saber, Khalid Aiad, Mohamed Serag Eldein Mahgoub Mostafa, Heba A. Bahey El-Deen Egypt, 2020	To investigate effects of high-intensity laser therapy (HILT) on shoulder mobility in case of subacromial impingement syndrome.	Comparing HILT and exercise groups after the treatment revealed a statistically significant reduction in Ultrasonography Dimension of supraspinatus and VAS and significant increase in range of motion of shoulder flexion and abduction in favor to HILT group compared to exercise group ($p > 0.05$). It is concluded that HILT yielded more improvement for shoulder mobility in case of impingement syndrome.
37	Efficacy of high-intensity laser therapy on arthropathy of the hands in patients with systemic lupus erythematosus: a double-blinded, randomized controlled trial Nabil Mahmoud Abdel-Aal, Khadra Mohamed Ali, Hadaya Mosaad Eladi Egypt, 2020	To find the efficacy of high-intensity laser therapy (HILT) on hands arthropathy in patients with systemic lupus erythematosus	50 patients, suffering from hands arthropathy were randomly assigned into 2 groups: 1) the therapy group, received HILT with the routine physical therapies and 2) the control group, received sham HILT with the same routine physical therapies. There were statistically significant differences in handgrip strength, joint swelling count, joint tenderness count and VAS in favor of the study group ($P<0.05$). After eight weeks of intervention, the mean (SD) for handgrip strength, joint swelling counts, joint tenderness count, and pain score was 28.34 ± 8.3 kg, 4.4 ± 2.18 , 5 ± 2.1 , and 35.6 ± 13.87 mm in the study group, and 22.96 ± 8.76 kg, 7.36 ± 2.14 , 9.08 ± 1.63 , and 58.8 ± 10.54 mm in the control group, respectively. The MD (95%CI) for handgrip strength, joint swelling counts, joint tenderness count, and pain score was $5.38(0.53,10.23)$ kg, $-2.96(-4.19, -1.73)$, $-4.08(-5.15, -3.01)$, and $-23.2(-30.2, -16.2)$ mm between groups, respectively. Adding HILT to the standard physical therapies might be more effective than standard physical therapies alone in improving handgrip strength, decreasing joint swelling counts, joint tenderness counts, and pain in patients with hands arthropathy.
38	The synergic use of the High Power Laser Therapy and Glucosamine sulfate in Knee osteoarthritis: A Randomized Controlled Trial Antonio Ammendolia, Nicola Marotta, Cinzia Marinario, Andrea Demeco, Paolo Mondardini, Cosimo Costantino Italy, 2021	To determine the efficacy of High Power Laser Therapy (HPLT) applied together with glucosamine sulfate (GS) in knee osteoarthritis	90 subjects were assigned into 2 groups: A) HPLT and GS 1500 mg, B) HPLT and placebo. VAS score in Activities of day Living (ADL), Standardized stair climb test (SSCT), Zohlen's sign (RASPING) and Rabot test were used, for evaluation at the beginning of the study (T0), at 2 months (T1) and at 6 months (T2). In the mean scores for VAS in ADL, SSCT, RABOT and RASPING at T1, no significant differences were found between the two groups with paired T and ANOVA test. But significant differences between the groups ($p<0.05$) in all outcomes were observed at 6 months (T2). It is concluded that HPLT is useful in treating knee osteoarthritis, but when combined with Glucosamine Sulfate, it may achieve a long-term effect up to 6 months after treatment.
39	Application of high-intensity laser in pain treatment of patients with knee osteoarthritis Valentina Koevska, Erieta Nikolic-Dimitrova, Biljana Mitrevska, Cvetanka Gjerakaroska-Savevska, Marija Gocevaska, Biljana Kalcovska Republic of North Macedonia, 2021	To compare the effect of HILT with LILT in the treatment of knee osteoarthritis	There were 72 patients assigned into 2 groups: 1) HILT group and 2) LILT group. There is a significant difference between the two groups in VAS score after 10 therapies where significantly lower score was in the HILT group ($p = 0.0035$). The comparison of the VAS score between the two times in the two groups separately showed that in both, the HILT and the LILT groups, the VAS score after 10 days of therapy was significantly lower compared to that at 0 time, for consequently $p = 0.00001$ vs $p = 0.00001$. Patients treated with HILT had better results, i.e., had a significant reduction in pain than patients treated with LILT. HILT was more effective than LILT.

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