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ORIGINAL ARTICLES

Low Level Laser Therapy in patients with chronic foot and ankle joint pain

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Background and Aims: Chronic foot and ankle joint pain is one of the most frequent complaints which is regularly seen in the out-patient clinic of our medical institute. In previous studies we have reported on the benefits of low level laser therapy (LLLT) for chronic pain in the elbow, hand, finger and the lower back. The present study examined the effects of LLLT on chronic foot and ankle joint pain.
Materials and Methods: Over the past 5 years, 17 subjects visited the out-patient clinic with complaints of chronic foot and ankle joint pain of a variety of aetiologies. The patients received LLLT using a 1000 mW semi-conductor laser device, delivering 20.1 J/cm^2 per point at 830 nm in continuous wave. Each patient was given four shots per session per foot twice a week for 4 weeks.
Results: A visual analogue scale (VAS) was used to determine the effects of LLLT for the chronic pain and after the end of the treatment regimen a significant improvement was observed ($p < 0.01$). All but 2 of the patients showed improvement: excellent (2) and good (13). After treatment, no significant differences were observed in the ankle joint range of motion, however. Discussions with the patients revealed that it was important for them to learn how to avoid overuse of the ankle when walking, poor walking posture and a poor pacing technique that would caused them foot and ankle pain in everyday life. Following these postural guidelines could ensure continuous benefits from the treatment.
Conclusion: The present study demonstrated that LLLT was an effective form of treatment for chronic foot and ankle joint pain, in conjunction with postural education during all activities of daily living.

Keywords: Low level laser therapy · Chronic joint pain · Postural education · Activities of daily living

Introduction

Chronic foot and ankle joint pain is one of the most frequent complaints which we experience in the out-patient clinic in our hospital. We define chronic pain in this report as "pain which has lasted for 6 months or more, in which inflammation, trauma or tumor can be excluded by medical check-ups, and the cause of the pain is not something that requires surgery". Chronic pain can be very debilitating, decreases patients' ability to perform activity of daily living (ADL) and lowers their quality of life (QOL). Very often patients are required to reduce their social, and occupational activities as well. This study was designed to examine the efficacy of low level laser therapy (LLLT) on chronic foot and ankle joint pain, combined with lifestyle guidance and postural education for the patients.

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Subjects and Methods

Subjects

Seventeen patients (6 males and 11 females) between

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the age of 26 and 93 years (average age 58 yr) took part in this study. All subjects were out-patients who visited the rehabilitation department of our hospital between April, 2011 and March, 2015 **(Table 1)**. They all had a definitive diagnosis of chronic foot and ankle joint pain without surgical indication. Diagnosis of the disease was based on physical symptoms and the X-ray findings were within normal limits. The diagnoses comprised chronic achilles tendovaginitis (6 patients), chronic plantar tendovaginitis (5), ankle torsion (5) and hallux valgus (1).

Methods

LLLT system

We used a gallium aluminium arsenide (GaAlAs) semiconductor laser device delivering 1000 mW at 830 nm in continuous wave (MDL-2001, Matsushita Electric Corporation, Tokyo, Japan, **Table 2**). The system delivered a defocused spot of 14 mm in diameter, giving an irradiated area of 1.5 cm^2, and an incident power density of 667 mW/cm^2. We treated the chronic foot and

Table 1: Patient demographics, diagnoses, VAS scores and evaluation

Cases	Age	Sex	Diagnosis	Pain score (VAS) (Visual Analogue Scale) Pre	Post	Evaluation (*)
1:	63	F	Chronic Achilles tendovaginitis (A)	70	30	Good (G)
2:	72	M	Chronic plantar tendovaginitis (B)	70	30	G
3:	65	F	A	80	30	Excellent (E)
4:	39	F	A	80	10	E
5:	53	M	B	60	20	G
6:	87	F	Ankle torsion (C)	40	30	Poor/Unchanged
7:	62	F	B	60	30	G
8:	93	M	C	80	60	G
9:	40	F	Hallux valgus	70	60	Poor/Unchanged
10:	37	F	B	60	20	G
11:	55	F	A	90	50	G
12:	35	M	B	60	30	G
13:	29	M	A	70	40	G
14:	73	F	C	80	50	G
15:	26	M	C	80	50	G
16:	84	F	C	60	20	G
17:	71	F	A	70	30	G

* Evaluation: Table 3

Table 2: Specifications and characteristics of the LLLT device used in the present study.

Laser Element	Semiconductor Laser Diode
	Ga-Al-AS : Gallium-Aluminum-arsenide
Model &	MDL-2001 model
Manufacturer	Matsushita Electric Corporation, Tokyo, Japan
Wavelength	830nm ± 15nm
Output	1000mW ± 20%
Mode	continuous wave mode
	contact mode with positive pressure
Irradiation area	diameter in 14mm : actual area in 1.5 cm
Irradiation time	30sec
Energy density	20.1 J/cm
Power supply	100VAC, 50-60H z

ankle joint pain with LLLT over 4 points on each foot and ankle **(Figure 1)**, irradiation time 30 s per point, delivering an energy density of 20.1 J/cm² per point, for each treatment session. Two sessions were given each week for 4 weeks.

Evaluation of pain and ankle joint range of motion:

Pain was assessed after each treatment session using a visual analogue scale (VAS) which was modified from Shiroto and Ohshiro's, pain attenuation methods, and was used to evaluate the efficacy of LLLT through comparing VAS scores at baseline with those after the 8th and final session **(Table 3)**. [1] After treatment, ankle joint dorsal flexion and plantar flexion mobility levels were measured to assess any changes in range of motion (ROM).

Lifestyle guidance for the patients:

Patients were advised to continue to take care during their activities of daily living (ADL) to ensure optimum efficacy of the LLLT on their chronic foot and ankle pain. We gave them written advice sheets on maintaining a good posture; to avoid long distance walking as part of their ADL; to avoid torsion of the foot and ankle joint; to perform gentle flexion of ankle joint, and so on.

Statistical Analysis:

The VAS score was measured before treatment started (baseline) and after the final 8 full LLLT sessions, and these two sets of scores were averaged and compared. All values were expressed as the means ± standard deviation. Comparisons of values were performed with the Wilcoxon signed rank test (nonparametric score),

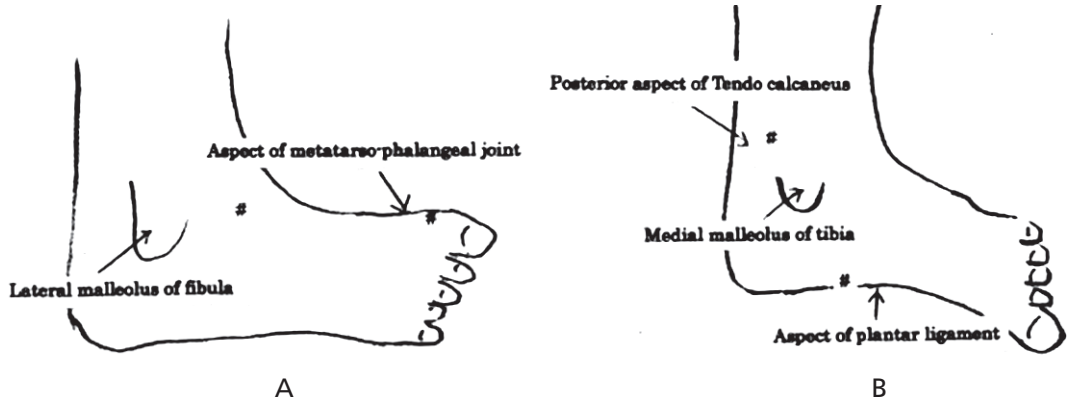

Fig. 1: Lateral (A) and medial (B) aspects of the ankle joint and foot illustrated. Irradiation points denoted by #

Table 3: Evaluation of efficacy with the VAS (most severe pain scored at 100, pain-free scored at zero: see Table 1 for individual scores and evaluations)

Evaluation	Improvement in the VAS pain score after LLLT	Number of Cases
• Excellent	35 and over	2
• Good	20-34	13
• Fair	15-19	0
• Poor/Unchanged	14 or under	2
• Worse	0	0

using SPSS Statistics Ver. 17.0 j, with a value of less than 5% considered significant. The study was conducted under the principles of the Declaration of Helsinki (2004). The trial was conducted with the approval of the Ethics Committee of the Toho University School of Medicine, Institutional Review Board (IRB). The purpose and potential outcomes of the trial were explained to all participants, and they gave written informed consent to participate in the study.

Results

Pain Evaluation

The VAS scores at baseline and at the final assessment are shown in **Table 1** and summarized in **Table 3**. The results were Excellent in 2 patients, Good in 13 patients, and little or no change was seen in 2 patients. No side effects were noted and pain was not exacerbated in any patient. The average VAS score before treatment was 69.4 ± 11.9, and after treatment the average VAS score was 34.7 ± 14.6. The improvement in the VAS scores was statistically significant ($p < 0.01$).

Ankle Joint Mobility

Ankle joint dorsal and plantar flexion were measured, but no significant differences were observed after LLLT treatment (data not shown).

Patient Lifestyle Guidance

Patients were advised to avoid postures that induce pain, and we advised the patients how to avoid incorrect foot and ankle joint positions during their ADL, as already mentioned in the Materials and Methods section. After discussions with the patients, it was reported in all cases that the lifestyle guidance was well understood, and the advice that was given was realized in practice.

Discussion

Human beings are endowed with 3 unique characteristics: bipedalism, the ability to finely control the use of their hands, and a highly developed use of language. From the standpoint of balancing gravitational forces in bipeds, of all the joints in the human body, the foot and ankle joints play a continuous major role in maintaining balance during standing and walking. With respect to locomotive activities of daily living and quality of life, foot and ankle joint disturbance is therefore a serious disadvantage and a social handicap.

From the standpoint of gravitational forces, the human body is a complex mechanical unit composed of many joints held together by articular tissues. Gravitational forces must be continuously balanced at each link. The line of gravity, one of the body's most important factors, passes through the acoustic meatus of the ears and intersects the center of gravity of the human body (located adjacent to the sacrum), ankle joint and the foot. [2]. Moreover the understanding of the function of the locomotive apparatus in the upright position and the dynamics of the body is one of the most important factors, so that the gravitational torque has a tendency to extend the ankle joint and foot in our way of life.

In many cases chronic foot and ankle joint pain at a moderate stage is caused by repeatedly and incompletely tearing the ligament and ankle joint capsule, and the pain is further induced by degenerative changes in the ankle joint cartilages. Generally, we treat chronic foot and ankle joint pain with medication, bracing (insole orthopedic devices), education of life style, physical therapy, and surgery.

In many cases, it is difficult for patients to attend the out-patient department as frequently as required due to a busy life style through ADL or work. To deal with such patients we consider that using an insole brace is effective when LLLT treatment does not have sufficient latency. [3-5] Moreover, we think that insole brace treatment is found to be especially effective with patients whose chronic foot and ankle joint pain has lasted for a long period due to working at a particular job or housework.

There is a large body of basic research [6-8] and many clinical studies have been carried out on LLLT. [9-15] Some previous reports have discussed the type of LLLT device, [16] wavelength-specific benefits [17] and evaluation of treatment methods. Recently, basic research on LLLT has been gaining validity. There are various possible explanations for the positive effects of LLLT treatment. [18-20] The authors believe that a rise in the pain threshold, improved blood flow and regeneration of ankle joint cartilage are the main contributing factors. [21, 22] In the present study, we treated the disease with LLLT irradiation, as part and parcel of physical therapy and the four irradiation points were chosen as the optimum approach, based on our previous clinical experience and results. LLLT is simple and easy to administer without any side effects. Regarding the evaluation of the efficacy of LLLT in chronic pain attenuation in the present study, a statistically significant effect was observed in the VAS scores after irradiation ($p < 0.01$). However, there was no significant change in

ankle joint range of motion after LLLT treatment.

It must be noted that one limitation of this cross-sectional study was the lack of a demographically-matched control and/or placebo (sham irradiation) group. Another limitation was the lack of a long-term follow-up after the final treatment session to assess the latency of the efficacy. To validate the promising results of this study, more controlled and placebo arm studies with a long-term follow-up are required and warranted in the future.

Conclusion

Our results in the present study confirmed that LLLT was an effective treatment for pain related to chronic foot and ankle joint pathologies. Moreover, for patients to continue to reap the benefits of LLLT treatment, we discovered that education regarding the patients' posture during their ADL was also very important.

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