APPLICATION OF LOW REACTIVE-LEVEL LASER THERAPY (LLLT) IN THE FUNCTIONAL TRAINING OF CEREBRAL PALSY PATIENTS

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In rehabilitative training and treatment of patients with cerebral palsy, return and maintenance of good muscle tone and suppression of tonic muscle spasm is crucial. However, an effective method that is reliable, simple, painless and noninvasive has yet to be reported. In the present study, 150 cerebral palsy patients were treated on their limbs and trunk with infrared diode low reactive-level laser therapy (LLLT) (810 nm, 60 mW and 100 mW, continuous wave). The treatment sites were those normally associated with conventional therapies such as nerve block or acupuncture, and where muscular hyperactivity was particularly evident. In the majority of the patients, spasm was successfully suppressed by LLLT, with the notable exception of those patients suffering from severe joint contracture. Compared with conventional methodology, laser therapy has proved to be a simple, reliable and noninvasive method which enabled painless suppression of spasm. Another of the advantages of LLLT is that multiple repeated application is possible on any site selected by the physician, with an almost unlimited choice of treatment sites. The effect of LLLT lasted from one to several hours in patients with severe spasticity. Although it may be argued that this variable length of effect is one of the limitations of LLLT, the authors feel that LLLT is particularly useful as a supplementary or adjunctive therapeutic modality to improve the overall efficacy of physical rehabilitation and functional training in children with cerebral palsy.

Key words: low reactive-level laser therapy; cerebral palsy; relaxation of muscle spasm; rehabilitation; functional training

Introduction

During functional training and rehabilitation of patients with cerebral palsy (CP), muscle relaxation is important to improve the rehabilitative effect. Although various methods have been advocated to obtain a good level of muscle relaxation, no consistently successful single method has so far been reported.

Low reactive-level Laser Therapy (LLLT) has been reported in the literature as an efficient and painless method of attenuating intractable pain.10 As an adjunctive therapeutic method, we incorporated LLLT into our CP rehabilitation and training program in 1991, and have to date used it in approximately 500 patients. With the exception of severe cases, LLLT noticeably improves the efficacy of the rehabilitation and training program by easing muscle tension and spasm of the extremities and trunk. The present study reports on the results achieved in 150 selected patients.

Patients and Methods

The study involved a patient population of 150, with spastic CP. Eight patients had hemiplegia, 61 diplegia and 81 quadriplegic. The age of the patients ranged from 10 months to 20 years.

The laser used was a gallium aluminium arsenide (GaAlAs) diode laser, (JQ305, Minato Medical Science, Co., Ltd., Japan) giving output powers in continuous wave of 60 mW and 100 mW, at a wavelength of 810 nm. The laser was applied to the target points in the contact method for 15 to 30 seconds per point. The spot size at the tissue was 1.04 mm² giving power densities of 9.61 W/cm² and 5.77 W/cm² at 100 mW and 60 mW, respectively. Energy densities per point ranged from 86.55 J/cm² to 288.3 J/cm², depending on the combination of output power and irradiation.

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Manuscript received: October 27, 1994
Accepted for publication: November 10, 1994
time. The points selected corresponded to the standard points used for acupuncture or nerve blocks, and treatment points were also selected on the bellies of the major spastic muscles based on the degree of tension and tonic spasm present in those muscles.

For the suppression of spasm in the neck and trunk, the laser was applied for 2–3 s on successive points on the right and left paravertebral muscles from the cervical to the lumbar vertebrae, corresponding to Ohshiro’s sweep method, or from the centre to the periphery at approximately 4 cm intervals, using Ohshiro’s proximal priority method. Muscle spasm of the upper extremities was treated by applying LLLT to the points over the stellate ganglion, the suprascapular nerve, m. pronator teres and the gobkoku acupuncture point, situated between the bases of the first and second metacarpal bones.

For lower extremity spasm, LLLT was applied on points over the adductor muscles, the ingob acupuncture point (between m. vastus medialis and m. sartorius, and the medial condyle of the femur), medial hamstring tendons, tibial nerve and the Achilles tendon (Figure 1).

In patients with flexion contracture of the hip and knee joints, the efficacy of LLLT applied to the lumbar paravertebral muscles and the ingob point was assessed before and after therapy by Thomas’s test and the differences in the popliteal angle. In each patient, motor function was videotaped to assess the effect before and after each LLLT session. In these patients, LLLT only was indicated. The effect of laser therapy in combination with conventional physical therapy was also evaluated in some patients who received both therapeutic methods for a certain period.

Results

Efficacy of LLLT

LLLT applied to the paravertebral muscles effectively reduced muscle spasm of the neck and trunk with a resultant improvement in both neck and trunk rotation. LLLT applied to the lumbar paravertebral muscles helped suppress muscle spasm in the hip joint flexors. Laser therapy of the stellate ganglion effectively reduced muscle spasm of the upper extremities, and LLLT of the suprascapular nerve suppressed spasms which tended to pull back the shoulders. LLLT of the m. pronator teres enabled easier pronation of the forearm, and laser therapy on the gobkoku point allowed patients to flex and extend their fingers more smoothly.

As for the lower extremities, LLLT of the adductor muscles, the ingob point and hamstring eased tonic spasm of the adductors and the hamstring, respectively. Laser therapy applied to the tibial nerve and the Achilles tendon improved cases of talipes equinus. Suppression of muscle spasm was achieved in all patients with the exception of those with severe contracture.

Motor disturbance improved after a single LLLT session, with a tendency for better results to be seen in the upper than the lower extremities. Of 42 patients whose hands were normally involuntarily clenched, 34 were able to open their hands with less effort following LLLT.

In patients with gait pattern disturbance, it was necessary to combine LLLT with conventional physical therapy. Many such patients, especially those with
talipes equinus, had to use some additional form of orthopaedic appliance.

**Suppression of Muscle Spasm in the Hip Flexors**

LLLT was used on the lumbar paravertebral muscles to improve flexion contracture of the hip joint. Decreases in Thomas's test of 15° or more after a single laser exposure were graded as 'improved'. Improvement of an average of 18° up to 30° (the best result) was achieved in 91 of the 192 limbs with hip flexion contracture. The younger the patient, the better the improvement. All patients showed some improvement in Thomas's test, even those whose improved mobility was less than 15°, with the exception of those patients with severe contracture (Table 1).

**Suppression of Hamstring Spasm**

After a single dose of LLLT to the inguinal point, an increase in the popliteal angle of more than 15° was graded as 'improved'. 98 limbs from the total of 176 demonstrated an average increase of 23°, with 45° being the best result. Once again, the younger the patient, the greater the increase in the popliteal angle. An increased angle following LLLT was seen in all patients, although in some the increase was less than 11°. Cases of severe knee contracture were resistant to LLLT. These data can be seen in Table 2.

**Case Reports**

**Patient 1:** A 10 month old female infant presented with right hemiplegia. Before LLLT, the patient's right shoulder was drawn back, the right elbow was extended, and she could not use her right upper arm. In the prone position, her right forearm was not able to support her body (Figure 2a, 2b). After a single session of LLLT, the patient was able to extend her fingers more easily, and started to use her right upper arm, although only with assistance. She was also able to support herself in the prone position with her right forearm (Figure 2c, 2d). LLLT was combined with conventional physical therapy and rehabilitation twice monthly, and after one year the patient was able to use her right arm almost as normally as any child of her age (Figure 2e).

**Patient 2:** A 4 year old boy presented with spastic cerebral palsy (CP). Before LLLT, in the supine position the lower limbs were scissored in extension, and demonstrated no voluntary movements. He was unstable even in the sitting position. In particular he could not sit for any period of time with his knees extended because of hypermyotonia of the hamstring. His pelvis was angled back, and he easily fell backwards from the sitting position with his legs forward. Even with his hand placed on the floor for support, he was unable to maintain the sitting position for any length of time (Figure 3a, 3b).

After LLLT, voluntary motion of the lower extremities became more active, although the pattern tended to be synergistic. Compared to the pre-LLLT state, the patient was more stable in the sitting position, with greater ability to sit with his knees extended for a longer period; he was able to support his body in

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**Table 1:** Changes in Thomas's test following LLLT, related to the age of the patient.

<table>
<thead>
<tr>
<th>Age (yrs)</th>
<th>Under 10</th>
<th>10 - 14</th>
<th>15</th>
<th>Total (legs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Change</td>
<td>3</td>
<td>56</td>
<td>42</td>
<td>101</td>
</tr>
<tr>
<td>Improved</td>
<td>44</td>
<td>41</td>
<td>6</td>
<td>91</td>
</tr>
</tbody>
</table>

**Table 2:** Changes in popliteal angle following LLLT, related to the age of the patient.

<table>
<thead>
<tr>
<th>Age (yrs)</th>
<th>Under 10</th>
<th>10 - 14</th>
<th>15</th>
<th>Total (legs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Change</td>
<td>0</td>
<td>43</td>
<td>35</td>
<td>78 legs</td>
</tr>
<tr>
<td>Improved</td>
<td>36</td>
<td>51</td>
<td>11</td>
<td>98 legs</td>
</tr>
</tbody>
</table>

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**Fig 2:** A 10 month old baby girl with right hemiplegia. (a, b): Before LLLT. (c, d): After LLLT. The patient could extend her fingers more easily, although only with assistance started to use her right upper extremity and could support her body in the prone position with her forearm. (e): One year following the first LLLT session, the patient had almost as normal use of her right arm as a child of her age.
Fig 3: A 4 year old boy with spastic cerebral palsy. (a, b): Before LLLT. Note the involuntarily scissoring of the legs and inability to remain in the sitting position. (c, d): After LLLT. In the supine position, voluntary movements of the lower extremities became more active, although they tended to be synergistic in pattern. Compared to the pre-LLLT state, the patient was more stable in the sitting position.

Fig 4: A 3 year old boy with spastic cerebral palsy. (a-c): Before LLLT. Note the tendency to adopt a crouching posture, and the inability to take alternate steps while walking with assistance. (d-f): After 3 weeks of LLLT combined with conventional physical therapy and training, the crouching posture is less marked, and the ability to take alternate steps in assisted walking has improved.

Fig 5: A 5 year old girl with spastic cerebral palsy. (a-c): Before LLLT. The patient is virtually unable to stand by herself, with scissoring of the lower limbs. (d-f): One month after starting LLLT, and in combination with conventional physical therapy, the patient is able to walk on her own, with the assistance of a short leg brace and a walking frame.
the sitting position using his upper extremities (Figure 3c, 3d).

**Patient 3:** A 3 year old boy presented with spastic CP. Before LLLT the patient adopted a severe crouching posture. When walking with assistance, he held his lower extremities in a crossed-over position and was scarcely able to take alternate steps (Figure 4a, 4b, 4c). He had LLLT on his lower extremities daily and conventional physical therapy three times per week. After three weeks of this combination treatment approach the crouching posture was less marked, and his ability to take alternate steps while walking with assistance improved, suggesting that the combination treatment was having some success (Figure 4d, 4e, 4f).

**Patient 4:** A 5 year old girl presented with a diagnosis of spastic CP. Pre-LLLT there was scissoring of the patient's lower extremities and she was virtually unable to support herself. She could hardly stand even with support. (Figure 5a, 5b, 5c). She underwent a daily regimen involving a combination of LLLT and conventional physical therapy focusing on all four limbs and the trunk. One month after the start of her therapy, the patient could walk with the aid of a short leg brace and walking frame (Figure 5d, 5e, 5f).

**Patient 5:** A 20 year old male presented with left hemiplegia. Before LLLT he was unable to grasp an object in his left hand, and demonstrated severe sensory disturbance in the left upper extremity (Figure 6a, 6b). He had twice-monthly LLLT of both upper extremities. Immediately after each LLLT session the spasm in the muscles of his fingers decreased. After 2 months' treatment the patient was able to grasp objects with his left hand and 2 months later the sensory disturbance in his left arm also improved (Figure 6c, 6d).

**Side Effects:**
No serious side effects were observed in any of the patients. Two infants however demonstrated elevated body temperature, and a further 2 patients complained of general fatigue. These were the only noticeable side effects, and even these were only temporary.

**Discussion**

Toshio Ohshiro of the Japan Medical Laser Laboratory first developed a prototype GaAlAs diode laser system for laser therapy in 1980, in collaboration with Matsushita Electric Company. Since then, LLLT systems have been widely used, especially for the attenuation of acute and chronic pain. Suppression of muscle spasm in cerebral palsy patients with laser therapy has, however, been only sparsely reported, an exception to which is the work of Walker and her coworkers on muscle clonus.

In our clinic, we have been accustomed to use conventional physical therapy and training on their own. Following the introduction of dedicated LLLT systems, we investigated the ideal application points and methods in our own series of experiments, and

**Fig 6:** A 20 year old male with left hemiplegia. (a, b): Before LLLT. Note the inability of the patient to grasp objects with the left hand. There was also severe sensory disturbance of the left arm. (c, d): After LLLT. Immediately after the first and subsequent LLLT session, tonic spasm of the left arm decreased. 2 months after the first therapy session, the patient was able to grasp objects in his left hand, and after a further two months, the sensory disturbance of the left arm improved noticeably.
have proved for ourselves that by combining laser therapy with conventional rehabilitation methods, the end result is better and achieved faster than by using conventional methods alone. LLLT alone may in some patients bring about a better result than conventional methodologies. In other patients, the combination of LLLT and functional rehabilitation gave unexpectedly good results.

With respect to the actual treatment points, we have found it important to start with the neck and trunk and work out towards the extremities. This is in accord with Ohshiro's proximal priority technique, and his concept of 'cerebral vitalization'. By using these techniques it is possible to achieve relaxation of muscle spasm in the trunk and extremities, which leads in turn to more effective application of conventional physical rehabilitation methods.

In the series of patients reported here, muscle spasm of the neck and trunk was first treated by LLLT applied to the neck region and the upper paravertebral muscles. In general, overall muscle spasms were further suppressed by applying LLLT to a selection of points including some chosen from the standard acupuncture points, and the anatomical paths already mentioned in detail above including points associated with nerve block, and those muscles and tendons whose release from spasm was formerly associated with surgical intervention.

The mechanisms behind the relaxing effect of LLLT remain comparatively unclear, although some authors have investigated in detail the effects and possible mechanisms of LLLT in neural pathways. Kamikawa et al., however, postulated that low incident doses of laser radiation may cause local vascular dilatation through the sympathetic nervous system, and reduce tonic muscle spasm in muscles which had been in a hypoxicemic state. Harada et al. reported that the effect of laser radiation on the sympathetic nervous system can be indicated by changes in latency in evoked response potentials. We have previously reported the involvement of various feedback systems in the body including systemic effects mediated by the sympathetic nervous system and local effects at the irradiated sites. Recently, we observed an obvious spasm suppression effect following LLLT irradiation over the tibial nerve, using the evoked potential H-wave recovery curve as an indicator. It is clear that the action of laser therapy must depend on both the site irradiated and the conditions of laser irradiation.

Although there were no serious side effects in our series of patients, a very few complained of weakness and fatigue following LLLT of multiple points. From this we suggest that the number of irradiation points be reduced in children and malnourished patients.

Overstimulation of points which coincide with acupuncture points may also be a factor.

The use of LLLT in the treatment of CP is especially useful as an adjunctive therapy to improve the results of conventional functional physical therapy. The range of laser therapeutic applications may widen in the future. LLLT may well be used to activate brain function and to improve oral and respiratory functions by suppressing tonic spasm in appropriate muscle groups.

Conclusions

1: Laser therapy was performed in 150 patients with CP. With the exception of those with severe joint contracture, laser therapy effectively suppressed tonic muscle spasms.

2: Compared to other conventional therapeutic methods, LLLT is a simple, relatively reliable, painless and easy to apply method for the suppression of muscle spasm.

3: Laser therapy has many advantages, especially its ability to be easily repeated and its noninvasive characteristics. LLLT also allows almost unlimited selection of target points.

4: The effect of a single session of LLLT lasted from one hour to several hours in patients with severe CP. Although the duration of the LLLT effect was limited, it could be applied in conjunction with conventional functional therapies, thereby enhancing the effect of the latter.

5: The results of thermography and other objective tests indicate that the mechanisms of laser therapy may involve a systemic effect mediated by the sympathetic nervous system in addition to a local effect at the irradiation site. Additionally, an effect on spinal reflexes was suggested at particular irradiation sites.

References


