The Application of Low-Level Laser Therapy for the Treatment of Sensorineural Hearing Loss

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For most medical conditions there are a variety of therapeutic options available to the patient, but for those living with sensorineural hearing disorder, the choices are narrow. Nearly 10% of the US population suffers from some degree of hearing loss. The most prevalent hearing impairment is sensorineural hearing loss affecting approximately 50 million Americans. The etiology of this idiopathic otologic disorder is complex and multifactorial producing a difficult burden for hearing care practitioners to implement an effective evidence-based therapy. The inability to appropriately care for these patients is accurately reflected in the statistic that less than 5% of patients with sensorineural hearing loss can be medically helped.

The principle therapeutic approach for enhancing communication and reducing hearing handicaps in persons with sensorineural hearing loss includes the use of hearing aid amplification. Although today’s hearing aids have evolved into sophisticated and technologically advanced instruments improving the quality of hearing in a more discrete manner, the application of this technology does not address the pathogenesis of the otologic defect, it is simply designed to mask the symptoms. Sensorineural hearing loss involves damage to the cochlear hair cells or fibers of the eighth cranial nerve, and these physiologic impairments coupled with the electronic limitations of hearing aids, renders the restoration of "normal hearing" unattainable.

However, the development of a new therapeutic option utilizing low-level laser therapy (LLLT) may serve as an alternative option for patients with sensorineural hearing loss. In recent years LLLT has acquired interest from various medical disciplines to treat a myriad of dermatologic, ophthalmic, neurologic, and dental disorders and injuries. Numerous studies have revealed laser therapy’s ability to promote an assortment of cellular reactions within non-photosynthetic cells. Laser therapy has been shown to revitalize nutritionally starved cells, regenerate erythrocytes enhancing their ability to bind with oxygen, reduce chronic inflammation, and promote the increase of growth factors necessary for wound healing and increased blood flow. A continually growing body of evidence suggests that laser therapy can modulate a cells production of energy, consequentially influencing the biochemical reactions within that cell, generating an observable beneficial clinical outcome.

The application of LLLT for the treatment of sensorineural hearing loss may provide the first therapeutic approach able to resolve the underlining pathophysiology which could consist of a vascular event such as ischemia or lack blood and nutrient flow, mitochondrial impairment of the cochlear hair cells and the auditory nerve resulting impaired energy production, or acoustic neuroma. In order to assess the efficacy of LLLT for the treatment of sensorineural hearing loss a placebo-controlled, randomized, double-blind, multi-centered clinical study was conducted. The primary outcome tested was the improvement in unaided word recognition in ears with sensorineural hearing loss.
METHOD

The sensorineural study enrolled sixty four ears 18 years of age or older with a mean of 79 years. All sixty-four of the qualified ears satisfied the inclusion and exclusion criteria and completed study participation through to at least the study endpoint. Of the 64 participating ears, 32 were randomized to the active treatment group and 32 were randomized to the sham group. Patients were asked to abstain from participating in other treatments to improve speech detection and perception ability, with the exclusion of wearing hearing aids as they normally would. Further, patients were asked to avoid activities or work that involved exposure to excessive noise. Finally, patients had to maintain their pre-study medication regimen without change unless medically advised.

Subjects assigned to the test group were treated with a dual diode laser system composed of a pulsed laser emitting both 635nm and 532nm with an output intensity of 7.5 mW for each diode (HearingLaser, Developed by HearingMed and Erchonia Medical Inc.). Sham-treatment group participants were treated with a dual diode non-laser system composed of a constant wave light emitting diode (LED) emitting both 635nm and 532nm with an output intensity of 2.5 mW for each LED. Both the sham treatment light and real laser devices were designed to have the same physical appearance, including the appearance of any visible light output.

Patients were evaluated using the CID W-22 test list to evaluate their % correct word recognition scores, the Abbreviated Profile Hearing Aid Benefit (APHAB) questionnaire to sample patient behavior to accurately assess the impact of the disability across multiple dimensions, the Tinnitus Severity Index (TSI) questionnaire and air conduction and bone conduction pure tone averages (PTAs) were assessed as safety measures. The preceding variables were recorded at study baseline, prior to the administration of the first study procedure, and were again evaluated immediately following the first procedure administration, following the second and final procedure administration, and at weeks 2 and 4 and months 3 and 6 post-procedure.

The primary efficacy outcome measure was the statistically significant difference in proportion of ears that demonstrated both a significant and clinically meaningful increase in word recognition scores in quiet between test and control groups. The individual success criteria set for ears was defined as a statistically significant and clinically meaningful increase in word recognition score in quiet from baseline to study endpoint. The overall study success criteria was defined as at least a 30% difference between groups comparing the proportion of individual successes for each group.

Each study ear received two identical procedure administrations with the active or sham laser, each one week apart. Patients received treatment of their brain stem, temporomandibular joint and mandible, and external ear stimulation encompassing the outer ear canal, pinnal, and extending towards the mastoid process of the temporal bone. Each area received a total of 120 seconds of active or sham treatment.
Results

Of the 32 sham group ears, 6.25% (2 subjects), demonstrated a statistically significant and clinically meaningful increase in unaided word recognition scores in quiet from baseline to study endpoint, while 46.88% (15 subjects) of the 32 test group ears exhibited a significant and meaningful increase word recognition scores, a significant difference between groups (p<0.0005) (Table 1). Forty percent more test ears than sham treated ears revealed an improvement in unaided word recognition. This outcome exceeded the pre-established target of 30% difference between treatment groups by just over 10%. For sham group ears, 30 ears did not meet the individual success criteria compared to only 17 ears of the treated group.

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<tr>
<th>N</th>
<th>Test ears</th>
<th>Placebo ears</th>
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<tbody>
<tr>
<td>n meeting success criteria</td>
<td>15</td>
<td>2</td>
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<tr>
<td>% meeting success criteria</td>
<td>46.88%</td>
<td>6.25%</td>
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Comparison of the two independent group means for the continuous variable of mean change in word recognition % correct scores from study baseline to endpoint demonstrated a mean difference of 6.87%. At week 1 and 2 evaluation points, the test group ears demonstrated a greater improvement in word recognition % correct scores than sham treated ears compared to baseline (Figure 1). Moreover, test ears demonstrated a continual improvement in word recognition % correct scores from week 1 to week 2, while the sham treated ears demonstrated essentially no change in % correct scores. However, by the 2 weeks post-procedure evaluation point, test and placebo group ears revealed a comparable word recognition % correct scores.

The change in the unaided portion of the APHAB questionnaire scores at the 4 weeks post evaluation point when compared to baseline values revealed a 4.39% reduction for the ears receiving active treatment compared with the sham treated ears that exhibited a 1.17% reduction, a difference between the groups of 3.22%. At all other evaluation points the test group ears consistently revealed a lower global APHAB % scores when compared with the sham treated ears (Figure 2). Further, when assessing the average % scores for each of the APHAB subscales, the reverberation (RV) scale % mean score demonstrated a downwards trend for the test group ears across the 4 assessment points to end 6.34% lower at 4 weeks post-procedure compared with baseline. In contrast, the % scores on the RV scale increased slightly from baseline to 4 weeks post-procedure evaluation point for the sham group. The mean change in % scores on the RV scale revealed a difference 9.56% difference at the 4 week post evaluation point between test and sham treated ears (Figure 2).
Discussion

Based on the data collected following this clinical trial it can be concluded that low-level laser therapy of the appropriate wavelength applied twice in two weeks can significantly increase the % correct score in unaided word recognition. The statistically significant difference between the treatment and sham group effectively demonstrated that the greater treatment effect observed with the active laser treatment group can be directly attributed to the efficacy of the application of laser therapy. To fully appreciate these results however, further scientific exploration is required to gain a better understanding of the principle mechanism responsible for generating these observable clinical outcomes. Further, a study must be conducted to assess the long-term benefits and improvement in the quality of life post treatment. It is important to note that no adverse events were reported throughout the duration of this clinical investigation.

Low-energy laser does not employ a photothermal or photoacoustic mechanism but rather operates under the principle of photochemistry, which is the study of photonic energy or light energy influencing biochemical reactions within a cell. It has been firmly established within the literature that laser therapy is capable of targeting a photoreceptor molecule positioned within the inner membrane of the mitochondria. This photoreceptor is a terminal enzyme that is specifically positioned within the electron transport chain (ETC), a sequence of molecular structures that are responsible for producing the cell's energy. Often referred to as the power plant of the cell, the mitochondria manufactures Adenosine Triphosphate (ATP), a catalyst that drives several necessary biochemical reactions important for proper cell function and viability. The ETC requires oxygen and nutrients in order to function correctly, and when a patient suffers from a diseased state that can impair the flow of blood to a selection of tissue, limiting the amount of nutrients and oxygen, the ETC and ultimately the production of ATP can deteriorate. It is not understood at this moment, the exact pathophysiology of sensorineural hearing loss; however, it has been suggested that poor blood flow and mitochondrial impairment may contribute to the onset of the disorder.

The application of low-energy laser has been shown to stimulate the aforementioned photoreceptor molecule, causing it to enter into an excited state consequentially increasing the production of ATP. The stimulation of the photoreceptor can occur even within a nutritionally starved state; therefore, allowing an improperly functioning cell to once again return to a viable functioning state. The alteration of a cells metabolic performance following low-energy laser irradiation has been found to alter gene expression, cellular proliferation, and growth factor release, important processes necessary to resolve a diseased state. Studies have illustrated that laser therapy is a proven modality to upregulate oxygen and nutrient levels by stimulating the cell's power plant, and it is believed that laser therapy is capable of generating a similar clinical outcome within the middle ear; potentially increasing cellular metabolism of cochlear hair cells and auditory neural network, promoting proper cell function thus impacting unaided word recognition.
Extensive research is warranted to uncover the exact biological mechanism triggered by laser stimulation; however, what is lucid is that the application of LLLT can serve as a safe and clinically validated modality for the improvement of sensorineural hearing loss. Moreover, the utilization of laser therapy may function as a therapeutic option for other otologic disorders.