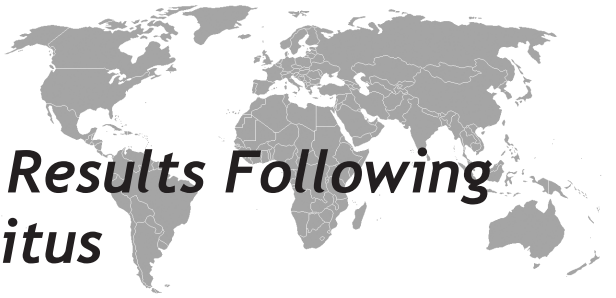

Changes in Audiometry Results Following Laser Therapy for Tinnitus

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ABSTRACT

***Aim**: To demonstrate the effect of laser therapy in the treatment of tinnitus with changes in audiometric results.*

***Method**: This current study included a total of 30 patients (15 females and 15 males). A laser with a 650 nm wave length at 5 mW was applied to the ear with tinnitus complaint on every consecutive week day for 20 minutes with a break on weekends. The process was continued for 8 weeks and a total of 40 sessions were performed. Pure tone audiometric evaluation between 250-20000 Hz frequency ranges was performed prior to the therapy and was repeated right after and two months after the treatment.Tinnitus scoring was performed before and two months after laser therapy. The results, obtained following therapy, were statistically evaluated.*

***Result**: 50% of the patients were female, and 50% were male. The patients' ages were between 20 and 74. In 7 of the patients, tinnitus was in the left ear, in 11 patients in the right ear and in 12 it was bilateral. The audiometric values of the patients were evaluated in 3 different conditions which included the values before therapy, values after therapy and values at 2 months following treatment. A greater difference was observed particularly in the frequencies above 8000 Hz. A significant difference was also detected in audiometry results after laser therapy (p<0,001). It was found that the difference between males and females was significant after laser therapy (p<0.001).*

***Conclusion**: The effect of laser therapy is still controversial. In our study, laser therapy seemed to be effective right after therapy. Although the audiometric values returned to pretreatment levels after 2 months, the tinnitus scores have remained lower compared to the pretreatment scores.*

***Key words**: Tinnitus, high frequency audiometry, laser therapy, ear, hearing*

Tinnitusta Lazer Tedavi Etkinliğinin Odyogram İle Değerlendirilmesi

Amaç: *Tinnitusta lazer tedavisinin etkinliğini ve odyogramda meydana getirdiği değişiklikleri incelemek.*
Metod: *Çalışmaya 30 hasta (15 kadın ve 15 erkek) dahil edildi. Tinnituslu kulaklara 650 nM dalga boyunda ve 5mW de lazer hafta içi her gün 20 dakika uygulandı. Hafta sonları ise ara verildi. Tedavi 8 hafta ve toplam 40 seans devam ettirildi. Saf ses odyometri 250-20000 Hz frekans aralığında tedaviye başlarken, hemen tedavi bitiminde ve 2 ay sonrasında yapıldı. Tinnitus skorlaması da tedaviye başlarken ve tedavi sonrası 2. ayda yapıldı. Elde edilen sonuçlar istatistik olrak karşılaştırıldı.*
Bulgular: *Çalışmaya katılan hastaların 50% si erkek ve 50% si kadındı. Hastaların yaşları 20 ile 74 arasında değişmekte idi. 7 hastada sol kulakta ve 11 hastada sağ kulakta tinnitus mevcuttu. 12 hastada ise bilateral tinnitus vardı. Tedaviye başlarken, tedavi bitiminde ve tedaviden sonra 2. ayda elde edilen değerler karşılaştırıldı. En büyük farklılıklar 8000 Hz üzerindeki frekanslarda gözlemlendi. Lazer tedavisi sonrası odyometre sonuçlarında anlamlı farklılıklar saptandı (p<0,001). Kadınlar ve erkekler arasında lazer tedavisini takiben anlamlı farklılık görüldü (p<0.001).*
Sonuç: *Lazer tedavisinin etkinliği halen tartışmalı br konudur. Yaptığımız çalışmada tedavi bitiminde odyogramda tedavi öncesine göre iyileşme olduğu ve subjektif olarak tinnitusun azaldığı saptanmışken, tedaviden sonraki ikinci ayda ise odyogram eski haline gelmekle beraber tinnitus şikayetinde eskiye dönüş olmadı.*

Anahtar kelimeler: *Çınlama,yüksek frekans odyometre, lazer tedavisi, kulak, duyma*

INTRODUCTION

Tinnitus is a sound felt in ears. These sounds are usually named as somatosounds. It can either be peripheral or have a more central auditory connection (1). The treatment of patients with chronic tinnitus is very troublesome and otologists are trying to find the most appropriate treatment (2). Management of tinnitus with sensorineural hearing loss is difficult. It can be treated by amplification (1). Biofeedback, cognitive therapy and tinnitus retraining therapy, physiotherapy and psychotherapy are other treatment modalities (1, 3).

Many methods have been tried in the treatment of tinnitus and the results are quite variable. In a retrospective study done by Hahn, many treatment methods have been evaluated. The most effective treatment was found vinpocetine combined with physiotherapy, whereas infusion of pure lidocaine was found to be ineffective (3).

In recent years, laser technologies have been used in the treatment of tinnitus. The main mechanism that causes the therapeutic effects of laser is the increase in blood flow in the inner ear (4). ATP increase in the cell has been established experimentally with low power laser therapy (LPLT) (5).

The mechanism of action of low power laser has been reported as biophysiologic, rather than thermal. The primary area that absorbs laser irradiation is the mitochondria inside the neurons. Laser irradiation causes the protons to be released from the mitochondria into the cytoplasm. It is suggested that these protons inhibit the permeability of Na+/K+ channels and this in turn leads to a decrease in the frequency of action potential of the nerves (6). The increase in blood flow with suppression of the nerve action potential in sympathetic nerve action potential is one of the mechanisms of its effect (7, 8). The improvement in the local microcirculation and the increase in oxygen flow to the hypoxic cells are considered to be due to the effect of LPLT (9). Laser therapy was performed with different wave lengths and intensities in literature. Some authors reported that low power laser was effective, and some other authors reported that no improvement was observed (6,10,11,12).

In our study, we evaluated 5 mW, 650 nm wave length laser application, not only by scoring, but also by audiometric evaluation in the 250-20000 Hz frequency range.

MATERIALS AND METHODS

30 patients, 15 males and 15 females, were included in this study following the approval of the institutional research ethics committee. Informed consents of all participants were obtained following a detailed explanation of all probable benefits and risks of the method. The patients were subdivided into 4 categories according to age groups (1st group: 20-30 years, 2nd. group: 31-40 years, 3rd group: 41-50 years, 4th group: 51 years and above). After ENT examination, laboratory tests, temporal CT and MRI studies were obtained. Patients with pathological laboratory or radiographic results were not included in the study. Laser therapy with 650 nm wave length laser at 5 mW was performed for all patients during 20 minutes per day for 8 weeks. Weekends

Table 1. *Distribution of the Least Square Analysis (LSA-General Linear Model Analysis) (LSM) and significance assessment findings for audio results before laser therapy over age, and frequency subgroups.*

Factor	LSM	SE
Age group	***	
1	51.273[c]	1.339
2	56.663[b]	1.101
3	49.116[c]	0.943
4	66.663[a]	1.179
Frequency	***	
250	25.140[gt]	2.039
500	20.090[g]	2.039
1000	17.161[gt]	2.039
2000	20.701[g]	2.039
4000	32.208[f]	2.039
8000	42.829[e]	2.039
9000	48.831[d]	2.039
10000	62.217[c]	2.039
11200	62.668[c]	2.039
12500	67.820[c]	2.039
14000	78.485[b]	2.039
16000	99.032[a]	2.039
18000	103.764[a]	2.039
20000	102.063[a]	2.039
Expected Mean	55.929	0.599
Frequency x Age Group	***	

*LSM: Least squares means; SE: Standard error; a, b, c, d, e, f, g, h, j, k, t: the difference between LSMs expressed with a different letter in the same column is significant (NS: Not significant; *** p < 0,001).*

Table 2. *Distribution of the Least Square Analysis (LSA-General Linear Model Analysis) (LSM) and significance assessment findings for audiological evaluation after laser therapy over age and frequency subgroups.*

Factor	LSM	SE
Age group	***	
1	42.816[c]	1.579
2	56.042[b]	1.291
3	47.614[c]	0.936
4	64.254[a]	1.186
Frequency	***	
250	21.523[gt]	2.014
500	17.722[g]	2.014
1000	15.173[gt]	2.015
2000	19.148[g]	2.015
4000	28.501[f]	2.015
8000	40.983[e]	2.015
9000	46.039[e]	2.015
10000	58.363[d]	2.015
11200	57.767[d]	2.015
12500	64.934[c]	2.015
14000	77.021[b]	2.015
16000	95.740[a]	2.015
18000	98.595[a]	2.015
20000	96.030[a]	2.015
Expected Mean	52.681	0.626
Frequency x Age Group	***	

*LSM: Least squares means; SE: Standard error; a, b, c, d, e, f, g, h, j, k, t: the difference between LSMs expressed with a different letter in the same column is significant (ns: Not significant; *** p < 0,001).*

were skipped and a total of 40 sessions were performed. The study was designed for using 650 nm of wave length which was used by Gungor et al (11). Pure tone audiometric evaluation in 250-20000 Hz frequency range was performed to all patients before therapy. Audiometric evaluation was repeated right and 2 months following therapy. In addition, tinnitus scoring was performed to patients before and 2 months after laser therapy.

Tinnitus visual analog scale was:

1-Tinnitus exists in silence.

2- Tinnitus is not constant, but remarkable in daily life.
3- Tinnitus is almost constant.

4- Tinnitus is constant and sometimes irritating.

5- Tinnitus is constant and usually irritating but not affective to daily activity or sleep.

6- Tinnitus effects my daily communication and sometimes going to sleep takes several minutes.

7- I have always-unpleasant sound. It affects sometimes my job. I can sleep only with medication.

8- Tinnitus is severe. Sometimes I wake up from tinnitus.

9- Tinnitus is very severe. I feel depressed. I can't realize some social activities.

10- Tinnitus is extreme. I can not work, I can not sleep and I always feel sick. In order to establish the effects of gender, age group, measurement results upon treatment, scores following this investigative laser therapy and the treatment results of different frequencies, SPSS 13.OV program was used by following GLM (General Linear Model) procedure.

RESULTS

50% of the patients included into the study were female, and 50% were male. The patients' ages ranged between 20 and 74 and the arithmetic mean was 42.93+

Table 3. *Distribution of the Least Square Analysis (LSA-General Linear Model Analysis) (LSM) and significance assessment findings for audiological evaluation at 2 months after laser therapy over gender, age, disease state, and frequency subgroups.*

Factor	LSM	SE
Age group	***	
1	49.171c	1.305
2	56.133b	1.073
3	48.987c	0.919
4	65.623a	1.149
Frequency	***	
250	23.605^{ht}	1.986
500	19.868^{h}	1.986
1000	16.961^{ht}	1.987
2000	20.339^{h}	1.987
4000	31.220^{g}	1.987
8000	42.627^{f}	1.987
9000	48.156^{e}	1.987
10000	60.035^{d}	1.987
11200	61.307^{d}	1.987
12500	67.124^{c}	1.987
14000	77.725^{b}	1.987
16000	98.122^{a}	1.987
18000	101.823^{a}	1.987
20000	100.787^{a}	1.987
Expected Mean	52.681	0.626
Frequency x Age Group	***	

*LSM: Least squares means; SE: Standard error; a, b, c, d, e, f, g, h, j, k, t: the difference between LSMs expressed with a different letter in the same column is significant (NS: Not significant; *** p < 0,001).*

Table 4. *Distribution of the Least Square Analysis (LSA-General Linear Model Analysis) (LSM) and significance assessment findings for tinnitus scoring results before laser therapy over gender, age, disease state and frequency subgroups.*

Factor	LSM	SE
Gender	***	
Male	2.605	0.057
Female	3.135	0.070
Age Group	***	
1	2.322c	0.107
2	2.713b	0.087
3	2.398c	0.066
4	4.046a	1.103
Disease State	**	
Normal	2.760	0.075
Diseased	2.980	0.048
Frequency	ns	
250	2.855	0.133
500	2.867	0.133
1000	2.871	0.133
2000	2.871	0.133
4000	2.871	0.133
8000	2.871	0.133
9000	2.871	0.133
10000	2.871	0.133
11200	2.871	0.133
12500	2.871	0.133
14000	2.871	0.133
16000	2.871	0.133
18000	2.871	0.133
20000	2.871	0.133
Expected Mean	2.870	0.046
Gender x Disease State	**	
Gender x Age	***	
Disease State x Age Group	***	

*LSM: Least squares means; SE: Standard error; a, b, c, d: the difference between LSMs expressed with a different letter in the same column is significant (NS: Not significant; *** p < 0,001; ** p < 0,01)*

12.814. In 7 of the patients, tinnitus was in the left ear, in 11 patients in the right ear and in 12 patients it was bilateral. The audiometric values of the patients were evaluated before therapy, after therapy and at 2 months following treatment (Table 1 and 2)(Figure 1). The tinnitus scores before and 2 months after therapy are given in Tables 1,2 and 3.

In the evaluation of audiometry results the difference between the results of females and males was not significant. A significant difference was also detected in audiometry results after laser therapy (p<0,001). It was found that the difference between males and females was significant after laser therapy (p<0.001). This situation was not observed before therapy and became evident following laser therapy. Lower scores were obtained after laser therapy compared to the scores before the intervention in statistical evaluation of tinnitus scores before and after laser therapy (Table 4 and 5)

DISCUSSION

Many studies have been performed upon the treatment of tinnitus. Many technological products have been tried along with many medical treatment modalities. Different treatment results have been reported. Furthermore, most of these reports have been evaluated subjectively, generally by different questions on the visual analog scale (VAS) (3, 11). In our study, we tried to establish the effect of laser therapy upon tinnitus with a more objective method.

Table 5. *Distribution of the Least Square Analysis (LSA-General Linear Model Analysis) (LSM) and significance assessment findings for tinnitus scoring results after laser therapy over gender, age, disease state and frequency subgroups.*

Factor	*LSM*	*SE*
Gender	*ns*	
Male	*1.567*	*0.050*
Female	*1.605*	*0.061*
Age Group	*****	
1	*1.158c*	*0.107*
2	*1.480b*	*0.087*
3	*1.379b*	*0.066*
4	*2.329a*	*1.103*
Disease State	*****	
Normal	*1.464*	*0.066*
Diseased	*1.709*	*0.043*
Frequency	*ns*	
250	*1.581*	*0.119*
500	*1.584*	*0.119*
1000	*1.587*	*0.119*
2000	*1.587*	*0.119*
4000	*1.587*	*0.119*
8000	*1.587*	*0.119*
9000	*1.587*	*0.119*
10000	*1.587*	*0.119*
11200	*1.587*	*0.119*
12500	*1.587*	*0.119*
14000	*1.587*	*0.119*
16000	*1.587*	*0.119*
18000	*1.587*	*0.119*
20000	*1.587*	*0.119*
Expected Mean	*1.586*	*0.041*
Gender x Age	*****	
Disease State x Age Group	*****	

*LSM: Least squares means; SE: Standard error; a, b, c, d: the difference between LSMs expressed with a different letter in the same column is significant (NS: Not significant; *** p < 0,001; ** p < 0,01)*

For this purpose, we performed pure tone audiometric evaluation in 250-20000 Hz frequency range. These evaluations were repeated after therapy and 2 months following therapy. Results were statistically analyzed. Several complications may be seen following laser application.

In one study, sudden hear loss was reported in 1 patient, while dizziness was reported to have increased in another patient (10). In our study, we didn't observe any complication during laser treatment.

In the Hahn's study the audiometric improvement in tinnitus was established as 20 dB. In one patient tinnitus had disappeared, whereas in 1 patient it had worsened by 10 dB. While there was an audiometric improvement in 50.8%, tinnitus stayed the same in 47.5% of the cases. In 18 patients there was an improvement by 10 dB, in 22 patients by 20 dB, in 10 patients by 30 dB, in 6 patients by 40 dB, and in 5 patients by 50 dB. In our study, we established the effect of laser therapy upon hearing in the 250-20000 Hz frequency range. A greater difference was observed particularly in the frequencies above 8000 Hz. The audiometric results obtained above this frequency displayed continuously increasing values.

Literature findings reveal that wave lengths, therapy duration, number of sessions and session intervals also differ in different studies.

Nakashima used 60 mW, 810 nm wave length laser transmeatally for 6 minutes for 1 day per week for a total duration of 4 weeks. Gungor used 5 mW, 650 nm wave length laser or placebo laser once a day 15 minutes for 1 week. Shiomi used 40 mW, 830 nm wave length laser for 9 minutes for 10 or more times once a week. Mirz, on the other hand, used 50 mW, 830 nm wave length laser in 10 minute sessions for 5 consecutive days, skipping the weekends and for 3 times reaching a total number of 15 sessions.

Hahn used 830 nm and 200 mW laser in 10 sessions for 3 weeks where each session lasted 10 minutes. It was reported that the higher improvement rate of tinnitus could be due to the use of higher intensity (200 mW) laser in comparison to other authors. Furthermore, every patient had been informed about the probable therapeutic effect of laser. This could have created a placebo effect on the patients. In conclusion, there was a 50.8% positive change in tinnitus (2,6,10-12).

In our study, we applied 5 mW, 650 nm wave length laser to the patients' ears with tinnitus, for 20 minutes every day on five consecutive week days, with a break at weekends, reaching with a total duration of 8 weeks and a total number of 40 sessions. Pure tone audiometry in the 250-20000 Hz frequency range was performed before therapy, at the end of the therapy and 2 months after therapy. In addition, tinnitus scoring was performed before laser therapy and scoring was repeated 2 months after laser therapy. Statistical analysis was performed in order to establish the effects of treatment.

The difference between the results of females and males was not significant. A significant difference was

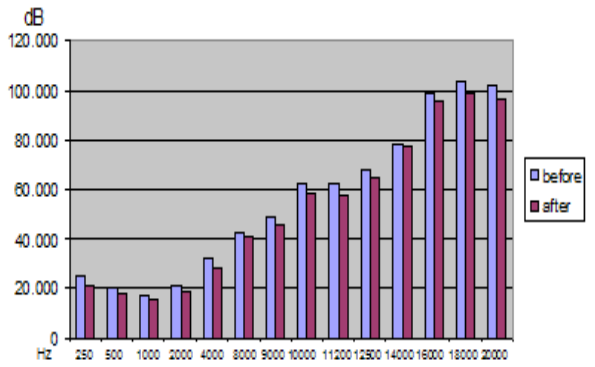

***Figure 1**. Odiometry results before and after laser therapy, dB: Decibel, Hz: Hertz*

also detected in audiometry results after laser therapy (p<0,001). It was found that the difference between males and females was significant after laser therapy (p<0.001). This situation was not observed before therapy and became evident following laser therapy. Concerning the effect of age upon audiometric values before and after laser, the significance of the difference between groups showed the same distribution. The audiometric results obtained in the diseased and normal ears following laser therapy showed a statistically significant difference, as also observed in the situation before laser therapy (p< 0,001). In the results obtained at frequency changes after laser therapy (Table 2), the difference in the results with different letters in the same column was found to be statistically important (p< 0.001). The audiometric results in women following laser therapy showed a greater change with age. This became obvious after the intervention and reveals the effect of laser therapy.

The effect of laser therapy is still controversial. The controversy in laser therapy arises from the variable applications in treatment, the availability of different wave lengths, variable intensities and different application times. In our study, laser therapy seemed to be effective right after therapy and although the audiometric values returned to the pretreatment levels after 2 months, the tinnitus scores have remained lower compared to the pretreatment scores. In this study, we have followed up a 2 months intervention on certain days and have tried to establish the audiometric values before and after laser therapy.

The audiometric values that appeared after treatment and returned to pretreatment levels in a short time suggest that treatment may need to be performed for a longer duration longer follow-up periods may be necessary. In our opinion, the statistical evaluations performed after studies with long term laser applications can make substantial contributions to the evaluation of the effect of this treatment modality. We think that particularly the change in the interactions between gender, age, frequency, disease state etc. during laser therapy can be enlightening for the evaluations regarding laser therapy.

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