A Clinical Study on the Therapeutic Effects of the Pulsed Nd:YAG Laser on Dentinal Hypersensitivity

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Ⅰ. Introduction

Dentinal hypersensitivity, shown to affect 18% of adults[1], is characterized by exposed dentin and demonstrated by an exaggerated response to various stimuli (tactile, chemical, thermal, osmotic)[2]. Response to stimuli can range from mild discomfort to extreme pain[3]. Dentinal hypersensitivity can affect eating, drinking and breathing [4]. Epidemiologically, it has been shown to peak in their 20s or 30s, particularly in periodontal patients[5,6].

The mechanism of dentinal pain is not well understood. According to Brännström's hydrodynamic theory, various stimuli displace the fluid in the dentinal tubules inwardly or outwardly[7-9]. Fluid movement activates the nerve endings at the pulp/dentin interface. Thus anything that decreases dentinal fluid movement or dentinal permeability should decrease sensitivity[10].

Scanning electron microscopy(SEM) has shown that hypersensitive teeth has highly siginificantly increased numbers of dentinal tubules per unit area (approximately 8×) compared with non-sensitive teeth[11], and diameters of dentinal tubules were siginificantly wider (approximately 2×) in hypersensitive teeth compared with non-sensitive teeth[11]. These results are very important since most of treatment modalities attempt to occlude the dentinal tubules[10-13].

Dentinal hypersensitivity can be treated with dentifrices, fluorides, oxalates, dentin bonding agents, lasers and restorations[14-16]. Clinicians are trying to achieve the ideals proposed by Grossman in 1935 : the ideal treatment should not irritate the pulp, nor cause pain, and should be easy to perform, and rapid and effective for long periods, and should not cause staining, and should be consistently effective[17].

The laser today has been harnessed for pratical use in a wide range of industries, dentistry among them. Its clinical application, many predict, will revolutionize dental care as increasing numbers of dentists adopt this emerging technology. The U. S. Food and Drugs Administration has approved use of dental lasers on hard tissue

in 1997. Many earlier studies reported an explatory study of the effect of laser radiation on teeth[18-20]. Prelasing dentin with a pulsed CO_2 laser increase dentin bonding by 300%[21]. Use of Argon and Nd:YAG lasers also have improved dentin bonding[22,23]. One of them is to treat dentinal hypersensitivity. The procedure is quick and simple. One treatment eliminates or drastically reduces sensitivity. Patient have remained asymptomatic for up to two years[24]. SEM reveals that the Nd:YAG, ArF-193nm Excimer, XeCl-308nm Excimer dental laser can cause melting of dentin and closure of dentinal tubules[22,25-27]. Lased dentin is harder than nonlased dentin[24]. Low level laser[28], He-Ne laser and Nd:YAG laser[29-31] treatments can be used to successfully reduce dentinal hypersensitivity [32]. The purpose of this study is to evaluate, clinically, the therapeutic effects of the pulsed Nd:YAG laser on dentinal hypersensitivity.

Ⅱ. Materials and Methods

1. Subjects

24 patients with dentinal hypersensitivity were selected for this study. Each patient has two or more hypersensitive teeth to cold and tactile stimuli on exposed cervical dentin. Of the dentinal hypersensitive teeth to regulated air flow from dental units air syringe and mechanical irritation from dental explorer, one tooth was chosen as a laser-treated group and another tooth was chosen as control which was not lased.

2. Laser system

A pulsed Nd:YAG laser, Sunlase Master® (Sunrise Technologies Inc., Fremont, U.S.A.) was used for treatment of dentinal hypersensitivity. This laser system has a wavelength of 1064 nm, a pulse duration of 120 μsec and a fiberoptic delivery system with a fiber dimeter of 320 μm.

3. Procedure

All dentinal hypersensitive teeth are examined clinically (tooth mobility, electrical pulp test) and radiographically to rule out the periodontal or the pulpal disease.

Baseline hyersensitivity assessment included cold sensitivity to air from dental unit air syringe, and tactile sensitivity to mechanical irritation from dental explorer on exposed dentin of the labial cervix.

Each patient rated his/her response in a Visual Analogue Scale(VAS) from chosen two teeth : one as a laser treated group and the other as control. No specific tooth (incisor or premolar or molar) was selected.

Laser treatment was delivered in beginning at 0.3 W and 10 Hz(30 mJ) for 10 seconds. Laser exposure was incrementally increased for 10 to 40 seconds, followed by a 5 to 10 seconds of rest period as the mJ setting was increased by increment of 10 mJ up to a maximum of 100 mJ, or until the patient complained discomfort. The laser energy was delivered by non-contact and contact modes to cervical exposed dentin surface. The fiberoptic tip was moved with a direction from mesial to distal direction, covering the exposed dentin. Laser treatment was again procedured for 10 seconds at 0.3 W and 10 Hz (30 mJ) followed by a 5 to 10 seconds rest period. If the patient reported no discomfort, the setting was increased 40 mJ to 100 mJ. Laser treatment continued at this parameter. The laser operator used the explorer intermittently during treatment to indentify the specific area of sensitivity. No attempt to establish the treatment goal was made by the operator exceeding up to two minutes. Laser treatment was delivered totally three times (the first visit, 1 day after the first visit, 3 days after the first visit). Subsequent evaluations of

VAS were made immediately after first laser treatment, and 1 day, 3 days, 7 days, 14 days after the first visit for total 24 patients, and up to 30 days after the first visit for 9 patients among the 24 patients.

4. Statistical analysis

Statistical analysis was performed using repeated measures of ANOVA and multiple range test of Ssheffẽe by SPSS/PC+(V.5.0).

Ⅲ. Results

At baseline, there was no significant difference in discomfort on VAS to cold and tactile stimuli between the laser treatment group and control group (Table 1, Table 2-1, Table 2-2, Table 3, Table 4-1, Table 4-2). The response, however, was higher on average to cold stimuli than to tactile stimuli at baseline and at all subsequent evaluation ; immediately after the first lasing and 1 day, 3 days, 7 days, 14 days, 30 days after the first visit(Table 2-1, Table 2-2, Table 4-1, Table 4-2).

In general the dentinal hypersensitivity decreased after laser treatment. Table 1 shows that comparative analysis of laser treatment effects to cold and tactile stimulation through 14 days follow-up check for total 24 patients. The level of discomfort (VAS scores) elicited by cold and tactile stimulation decreased from 6.16 (baseline) to 3.10 (immediatly after the first lasing) and to 2.93 (14days after the first visit) ($p<0.05$). But there was no significant difference among all subsequent evaluations from immediately after the first lasing to 14 days after the first visit ($p>0.05$).

Table 2-1 shows that comparative analysis of laser treatment effects to cold stimulation through 14 days follow-up check for total 24 patients. The level of discomfort (VAS scores) elicited by cold stimulation decreased from 6.45 (baseline) to 3.50 (immediately after the first lasing) and to 3.04 (14 days after the first visit) ($p<0.05$). But there was no significant difference among all subsequent evaluations from immediately after the first lasing to 14 days after the first visit ($p>0.05$).

Table 2-2 shows that comparative analysis of laser treatment effects to tactile stimulation through 14 days follow-up check for total 24 patients. The level of discomfort (VAS score) elicited by tactile stimulation decreased from 5.87 (baseline)

Table 1. Comparative analysis of laser treatment effects to cold and tactile stimulation (up to 14 days follow-up check after the first visit in total 24 patients)

VAS scores		lased teeth	control teeth
		mean±SD	mean±SD
baseline	→	6.16±2.64	5.54±2.26
immediately after the first lasing		3.10±2.80*	5.50±2.28
1 day after the first visit	→	3.95±2.49*	5.35±2.31
3 days after the first visit	→	3.41±2.49*	5.45±2.23
7 days after the first visit		2.95±2.33*	5.35±2.22
14 days after the first visit		2.93±2.35*	5.31±2.24

"*" denotes significant difference from the baseline data($p<0.05$).

"→" denotes lasing to hypersensitive tooth.

Table 2-1. Comparative analysis of laser treatment effects to cold stimulation (up to 14 days follow-up check after the first visit in total 24 patients)

VAS scores		lased teeth	control teeth
		mean±SD	mean±SD
baseline	→	6.45±2.53	5.70±2.27
immediately after the first lasing		3.50±2.68*	5.66±2.29
1 day after the first visit	→	4.00±2.35	5.58±2.37
3 days after the first visit	→	3.62±2.56*	5.58±2.20
7 days after the first visit		3.08±2.32*	5.50±2.28
14 days after the first visit		3.04±2.31*	5.41±2.32

"*" denotes significant difference from the baseline data($p<0.05$).
"→" denotes lasing to hypersensitive tooth.

Table 2-2. Comparative analysis of laser treatment effects to tactile stimulation (up to 14 days follow-up check after the first visit in total 24 patients)

VAS scores		lased teeth	control teeth
		mean±SD	mean±SD
baseline	→	5.87±2.77	5.37±2.29
immediately after the first lasing		2.70±2.91*	5.33±2.31
1 day after the first visit	→	3.91±2.66	5.12±2.27
3 days after the first visit	→	3.20±2.44	5.33±2.29
7 days after the first visit		2.83±2.38*	5.20±2.20
14 days after the first visit		2.83±2.44*	5.20±2.20

"*" denotes significant difference from the baseline data($p<0.05$).
"→" denotes lasing to hypersensitive tooth.

to 2.70 (immediatly after the first lasing) and to 2.83 (14 days after the first visit) ($p<0.05$). But there was no significant difference among all subsequent evaluations from immediately after the first lasing to 14 days after the first visit ($p>0.05$).

Table 3 shows that comparative analysis of laser treatment effects to cold and tactile stimulation through 30 days follow-up check for 9 patients of total 24 patients. The level of discomfort (VAS scores) elicited by cold and tactile stimulation decreased from 6.50 (baseline) to 2.94 (immediatly after the first lasing) and to 3.06 (30 days after the first visit) ($p<0.05$). But there was no significant difference among all subsequent evaluations from immediately after the first lasing to 30 days after the first visit ($p>0.05$).

Table 4-1 shows that comparative analysis of laser treatment effects to cold stimulation through 30 days follow-up check for 9 patients of total 24 patients. The level of discomfort (VAS scores) elicited by cold stimulation decreased from 7.44 (baseline) to 3.89 (immediatly after the first lasing) and to 3.56 (30 days after the first visit) ($p>0.05$). But there was no significant

Table 3. Comparative analysis of laser treatment effects to cold and tactile stimulation (up to 30 days follow-up check after the first visit in 9 patients)

VAS scores		laser tx.	control
		mean±SD	mean±SD
baseline	→	6.50±3.38	6.44±2.33
immediately after the first lasing		2.94±2.53*	6.44±2.33
1 day after the first visit	→	4.11±2.47	6.28±2.35
3 days after the first visit	→	3.44±2.48	6.39±2.25
7 days after the first visit		2.78±2.32*	6.28±2.22
14 days after the first visit		2.61±2.25*	6.28±2.22
30 days after the first visit		3.06±2.58*	6.11±2.05

"*" denotes significant difference from the baseline data($p<0.05$).
"→" denotes lasing to hypersensitive tooth.

Table 4-1. Comparative analysis of laser treatment effects to cold stimulation (up to 30 days follow-up check after the first visit in 9 patients)

VAS scores		laser tx.	control
		mean±SD	mean±SD
baseline	→	7.44±3.17	6.78±2.44
immediately after the first lasing		3.89±2.52	6.78±2.44
1 day after the first visit	→	4.44±2.60	6.67±2.55
3 days after the first visit	→	3.89±2.52	6.67±2.29
7 days after the first visit		3.22±2.39	6.56±2.40
14 days after the first visit		3.11±2.32	6.56±2.40
30 days after the first visit		3.56±2.74	6.22±2.17

"*" denotes significant difference from the baseline data($p<0.05$).
"→" denotes lasing to hypersensitive tooth.

Table 4-2. Comparative analysis of laser treatment effects to tactile stimulation (up to 30 days follow-up check after the first visit in 9 patients)

VAS scores		laser tx.	control
		mean±SD	mean±SD
baseline	→	5.56±3.50	6.11±2.32
immediately after the first lasing		2.00±2.29	6.11±2.32
1 day after the first visit	→	3.78±2.44	5.89±2.20
3 days after the first visit	→	3.00±2.50	6.11±2.32
7 days after the first visit		2.33±2.29	6.00±2.12
14 days after the first visit		2.11±2.20	6.00±2.12
30 days after the first visit		2.56±2.46	6.00±2.06

"*" denotes significant difference from the baseline data($p<0.05$).
"→" denotes lasing to hypersensitive tooth.

difference among all subsequent evaluations from immediately after the first lasing to 30 days after the first visit ($p>0.05$).

Table 4-2 shows that comparative analysis of laser treatment effects to tactile stimulation through 30 days follow-up check for 9 patients of total 24 patients. The level of discomfort (VAS scores) elicited by tactile stimulation decreased from 5.56 (baseline) to 2.00 (immediatly after the first lasing) and to 2.56 (30 days after the first visit) ($p>0.05$). But there was no significant difference among all subsequent evaluation from immediately after the first lasing to 30 days after the first visit ($p>0.05$). And there was no siginificant difference in the level of discomfort (VAS scores) between to cold and to tactile stimulation through 30 days follow-up check for 9 patients of total 24 patients (Table 4-1, Table 4-2).

Fig. 1 shows that comparative analysis of laser treatment effects to cold and tactile stimulation through 14 days follow-up check for total 24 patients versus 30 days follow up check for 9 patients of total 24 patients. Fig. 1 shows the similar decreasing tendency of the level of dicomfort (VAS scores) to cold and tactile stimulation up to 14 days after the first visit between total 24 patients group and 9 patients group. But the level of discomfort (VAS scores) in 9 patients group a little bit increased 30 days after the first visit.

There were no adverse effects and no complications during and after laser treatment in this study.

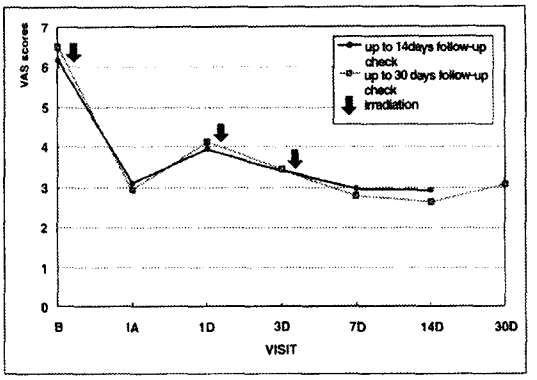

Fig. 1. Comparative analysis of laser treatment effects to cold and tactile stimulation (up to 14 days follow-up check in total 24 patients versus 30 days follow-up check in 9 patients)

B ; baseline, IA; immediately after the first lasing,
1D ;1 day after the first visit,
3D ;3 days after the first visit,
7D ;7 days after the first visit,
14D ;14 days after the first visit,
30D ;30 days after the first visit

Ⅳ. Discussion

The mechanism of dentinal hypersensitivity is not well understood and the symptoms of dentinal hypersensitivity are unspecific and subjective, so that an ideal compound does not exist[3,7].

According to Brännström's hydrodynamic theory, various stimuli displace the fluid in the dentinal tubules inwardly or outwardly[7-9]. Fluid movement activates the nerve endings at the pulp/dentin interface. Thus anything that decreases dentinal fluid movement or dentinal permeability should decrease sensitivity[10]. Numerous studies have reported that dentinal permeability and hydraulic conductance were related to dentinal surface area, thickness, tubular radius and surface character[33-35].

Research is now beginning to focus on the use of lasers to manage dentinal hypersensitivity. The Nd:YAG laser is capable of closing the tubular orifices of the intertubular dentin of bovine teeth[36]. Laser modified dentin surfaces observed by conventional SEM have demonstrated physical changes induced by laser treatment. It has been suggested that these changes include

a melted and resolidified dentin surface and partial closing of the tubules[22].

Dentin has been fused after short exposure to the Nd:YAG laser, and the fused dentin has been crystalized into a glazed, nonporous surface[25].

Upon above studies, therefore, this study was designed to evaluate, clinically, the therapeutic effects of the pulsed Nd:YAG laser on dentinal hypersensitivity.

The methods used in this study to evaluate hypersensitivity were based on previous studies, in which a blast of air from a dental syringe and mechanical stimulation of dentin with a dental explorer. The subjective evaluation of percieved pain by patients was based on the Visualized Analog Scale(VAS). The measurement was based on the patient's ability to rank pain on a scale from 0 to 10, where each increment is equal and 0 refers to no discomfort and 10 to intolerable pain. The patient's subjectivity and desire to avoid the discomfort caused by the stimuli may have played a role in the result of the study.

The methods used to assess the degree of sensitivity also vary greatly from trial to trial. Green[37] stated that trials relying only on subjective responses could only have minimal significance, whilst Lawson and Huff[38] concluded that subjective symptomatology would be the greatest value in demonstrating any positive results. The arguments for and against each method of assessment have been rehearsed elsewhere[39].

The laser parameters employed in this study were selected for their potential to promote seccessful desensitization without any untoward pulpal responses. It is generally accepted that 5℃ rise in pulpal temperature will cause pulpal necrosis in 15% of experimental group[40]. The Nd:YAG laser does not cause this rise in pulpal temperature even after two minutes of treatment at powers of 0.4 to 3.0W and frequencies of 10 to 30 Hz[41]- these parameters well beyond those used in this study.

This study demostrated that the pulsed Nd:YAG laser could be an effective method for the management of both thermal and tactile dentinal hypersensitivity. It produced an immediate effect (baseline versus immediatly after the first lasing) to a greater or lesser extent on almost all the sensitive teeth. But there was no significant difference among all subsequent evaluations from immediately after the first lasing to 14 or 30 days after the first visit. This means that laser desensitization effect was not proportionally increased by multplication of lasing.

The results in this study are similar to those in the recent controlled study of Gelsky, White and Pruthi who found that the laser treatment using He-Ne laser or/and Nd:YAG laser reduced thermal dentinal hypersensitivity by 58% and mechanical dentinal hypersensitivity by 61%[30].

And as shown in Fig. 1, the level of discomfort (VAS scores) in 9 patients group a little bit increased 30 days after the first visit. This means that the therapeutic effects of the pulsed Nd:YAG laser on dentinal hypersensitivity beyond 30 days may be diminished. So it is considered that more comprehensive study on this concerning point must be performed.

The therapeutic effects in this study was clinically measurable with checking the level of discomfort (VAS scores) elicited by regulated air flow from dental unit air syringe and mechanical irritation from dental explorer, and was found to be statistically significant.

From this study, it was suggested that pulsed Nd:YAG laser could be used to desensitize dentinal hypersensitivity.

V. Conclusion

In order to evaluate, clinically, the therapeutic effects of dental laser on dentinal hypersensiti-

vity, the author selected 24 dental patients with dentinal hypersensitive teeth divided into one experimental tooth (to be lased) and one control tooth (not to be lased) in each patient, and evaluated the severity of dentinal hypersensitivity using Visual Analogue Scale(VAS) to cold stimuli from dental unit air syringe and tactile stimuli from dental explorer. The author applied laser energy to cervical abraded dentin surface of experimental tooth under laser parameters of 0.3-1.0 W and 10Hz with combination of non-contact and contact modes within two minutes in lasing using the fiberoptic delivered, pulsed Nd:YAG laser (Sunlase Master®, Sunrise Technologies Inc., U.S.A., wavelength 1064 nm, pulse duration 120 μsec, fiber diameter 320 μm) at the first visit, 1 day and 3 days after the first visit, and analyzed the VAS scores obtained immediately after the first lasing, and 1 day, 3 days, 7 days, 14 days after the first visit.

The severity of dentinal hypersensitivity decreased about 50% immediately after the first lasing, and respectively about 36% (1 day), 45% (3 days), 53% (7 days), 53% (14 days) after the first visit ($p<0.05$), but there were not siginificant differences among all subsequent evaluations. And the severity of dentinal hypersensitivity in 9 patients of total 24 patients for evaluation of the therapeutic effects up to 30 days after the first visit decreased about 55% immediately after the first lasing, and respectively about 37% (1 day), 48% (3 days), 58% (7 days), 60% (14 days), 53% (30 days) after the first visit ($p>0.05$), and also there were not siginificant defferences among all subsequent evaluations. But the severity of dentinal hypersensitivity increased a little bit 30 days after the first visit compared with 14 days after the first visit. Therefore it is suggested that continuing studies on the possibility of recurrence of dentinal hypersensitivity after 30 or longer days laser treatment using the pulsed Nd:YAG laser.

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국문초록

상아질지각과민증에 대한 펄스형 Nd:YAG 레이저의 치료효과에 관한 임상적 연구

전북대학교 치과대학 구강진단학 · 구강내과학교실

최순정 · 신금백 · 김문현

저자는 치과용 레이저를 이용한 상아질지각과민증 치료효과를 임상적으로 평가하고자 상아질지각과민증환자 24명을 대상으로 각 환자마다 상아질지각과민치아중 레이저로 치료 할 치아1개(실험군)와 치료하지 않을 치아1개(대조군)를 선정하여, 치과용 air-syringe에 의한 냉자극과 치과용 탐침자에 의한 기계적 자극을 가한 후 Visual Analogue Scale(VAS)을 통해 지각과민증 정도를 평가하였으며, 이후 실험군 치아의 치경부마모면에 광섬유 레이저에너지 전달방식의 펄스형 Nd:YAG레이저의 일종인 Sunlase Master®(Sunrise Technologies Inc., U. S. A., 파장 1064 nm, 펄스지속시간 120 μsec, 광섬유직경 320 μm)를 사용하여, 0.3-1.0 W, 10 Hz 조건으로 환자의 반응에 따라 1회 2분을 초과하지 않는 범위내에서 비접촉식과 접촉식을 병행하여 3회에 걸쳐(초진 당일, 1일후, 3일후) 레이저를 조사한 후 처음조사 직후, 그리고 초진 1일후, 3일후, 7일후, 14일후 VAS를 채득하여 조사전과 비교, 분석, 평가하였던 바, 상아질지각과민증이 각각 약 50%, 약 36%, 약 45%, 약 53%, 약 53% 감소하였으나 ($p<0.05$) 경시적으로는 유의한 차이를 보이지 않았다. 그리고 24명중 9명에 대해서는 초진 30일후 까지 레이저조사치료효과를 평가하였던 바, 상아질지각과민증이 처음조사 직후, 그리고 초진 1일후, 3일후, 7일후, 14일후, 30일후 각각 약 55%, 약 37%, 약 48%, 약 58%, 약 60%, 약 53% 감소하였으며 ($p<0.05$) 역시 경시적으로는 유의한 차이를 보이지 않았다. 초진 30일후 상아질지각과민증이 초진 14일 후에 비해 약간 증가되는 경향을 보여, 레이저조사 치료효과가 약화되는 경향인지 여부에 대해 향후 추가적인 연구가 필요할 것으로 사료된다.