Efficacy Comparison of Nd:YAG laser, diode laser and dentine bonding agent in dentine hypersensitivity reduction: a clinical trial

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Purpose: Dentin hypersensitivity is characterized by short, sharp pain arising from exposed dentin in response to external stimuli. Several modalities have been suggested for treatment of this condition such as low-level laser therapy (LLLT) and application of dentin bonding agents. The aim of this study was to compare the clinical efficacy of diode laser, Nd:YAG laser and dentin bonding agent for treatment of dentin hypersensitivity.

Materials and Methods: In this study, 135 teeth of 22 patients diagnosed with dentin hypersensitivity were divided into three groups: In group 1, the teeth were irradiated by diode laser with 810 nm wavelength for 30 seconds and in group 2, the teeth were irradiated by Nd:YAG laser with 1064 nm wavelength for 40 seconds. CLEARFIL SE BOND was applied on teeth in group 3. LLLT was carried out in 3 sessions with 7-day intervals between sessions, during a period of 3 consecutive weeks. Hypersensitivity was assessed by cold test according to the criteria proposed by Uchida at baseline, immediately after treatment and at 1, 3 and 6 months, postoperatively.

Results: Reduction of dentin hypersensitivity was observed at 3 and 6 months following the use of Nd:YAG laser (p < 0.001). Reduction in dentin hypersensitivity was observed immediately after treatment in all groups. Statistically significant differences in level of dentin hypersensitivity were found between groups at 3 and at 6 months (p ≤ 0.001). The reduction in dentin hypersensitivity by Nd:YAG laser was significantly superior to that in other groups at this time.

Conclusion: The efficacy of Nd:YAG laser in reduction of dentin hypersensitivity was significantly superior to that of other modalities at 3 and 6 months.

Key words: Dentin hypersensitivity • Dentin bonding agent • Diode laser • Nd:YAG laser • Desensitizing agents

Introduction

Dentin hypersensitivity is among the most common problems causing discomfort and pain for patients. Pain mainly occurs following mechanical, thermal, chemical and osmotic stimulation of the cervical area of teeth with denuded dentin. Factors such as abrasion, attrition, erosion, traumatic toothbrushing and periodontal disease can cause dentin hypersensitivity 1). Dentin hypersensitivity pain cannot be attributed to any disease or pathological condition. Denuding of dentin mainly occurs due to two reasons: (I) removal of the enamel for any reason, (II) denuding of root surface following the loss of cementum and recession of the supporting periodontal tissues.

The buccal surface of teeth is more commonly involved and dentin hypersensitivity often occurs in the maxillary canine and premolar teeth followed by incisors and molars. In periodontal patients, the prevalence of dentin hypersensitivity varies from 72.5 to 98% 2).

The prevalence of dentin hypersensitivity is on the rise. By the advances in dental science and oral hygiene promotion, a higher number of the elderly retain their natural teeth and thus, the frequency of denuding of root
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surfaces following gingival recession and periodontal surgery is increasing.

Several theories have been suggested explaining the mechanism of dentin hypersensitivity. The hydrodynamic theory is the most widely accepted mechanism. Accordingly, hydrolytic changes in intra-tubular fluid of denuded dentinal tubules directly stimulate the mega-receptors of dental pulp or indirectly stimulate the odontoblasts. Therefore, factors decreasing the movement of fluid or permeability of dentin would decrease hypersensitivity and this is the basis of desensitizing treatments.

At present, several treatment modalities are available for desensitization including application of different desensitizing agents, bonding agents and laser. By advances in formulation of dentin bonding agents and introduction of newer generations of these adhesives, they are increasingly used for treatment of dentin hypersensitivity. It seems that the currently available modalities have failed to serve as an ideal desensitizer. Advances in laser science in dentistry have paved the way towards the possible application of laser for reduction of dentin hypersensitivity. For instance, Nd:YAG laser can serve as a desensitizing agent by sealing the dentinal tubules.

Ideally, the most efficient treatments for dentin hypersensitivity are those that have long-term effects, are resistant to oral environmental challenges, have immediate effects and result in patient comfort. However, despite the availability of a wide range of treatment modalities, no consensus has been reached on an ideal treatment strategy.

This clinical study aimed to compare the efficacy of Nd:YAG laser, diode laser and CLEARFIL SE BOND dentin bonding agent for treatment of dentin hypersensitivity to find a cost-effective and conservative treatment for this condition with long-term results.

Materials and Methods

This experimental clinical trial was conducted on patients presenting to the operative dentistry, periodontics and oral medicine departments of School of Dentistry, Tehran University of Medical sciences, irrespective of their age or gender. The study protocol was approved by the Ethics Committee of Tehran University of Medical Sciences. Patients had a minimum of two teeth with dentin hypersensitivity. The inclusion criteria were vitality of teeth, no carious lesion or restoration, absence of congenital enamel or dentin anomalies and absence of calculus in the respective teeth. The exclusion criteria were history of periodontal surgery in the past three months, use of desensitizing toothpastes and pregnancy. The treatment procedure was thoroughly explained to patients and those willing to participate in the study signed informed consent forms.

Patients with dentin hypersensitivity who met the inclusion criteria were clinically examined and the degree of dentin hypersensitivity was determined and recorded. Teeth with dentin hypersensitivity were radiographed to ensure absence of caries.

A total of 22 patients between 25 and 58 years of age with 135 teeth with dentin hypersensitivity were chosen. For testing of teeth, they were isolated using cotton rolls and dried with dental air spray. An ice cartridge was placed on the gingival third of the buccal surface of the teeth for 2 seconds and the degree of pain experienced was asked from patients using the classification suggested by Uchida as follows:

Score 0: No pain
Score 1: Slight pain or discomfort
Score 2: Sharp pain only upon stimulation
Score 3: Sharp pain when stimulated and continuous pain after removal of ice

In this study, all three therapeutic modalities were used for the same teeth with hypersensitivity in each patient. Since the number of similar teeth with dentin hypersensitivity was not enough in each patient, number of teeth in each group was determined such that the most similar status of teeth for all three methods was obtained. Accordingly, the teeth were divided into three groups and 37 were treated with dentin bonding agent, 45 were subjected to diode laser irradiation and 53 underwent Nd:YAG laser irradiation.

In this study, diode laser (Cheese, Gigaa, China) was irradiated using a handpiece of 300 µ diameter spot with 810 nm wavelength and 0.2 W power in continuous mode for 30 seconds. (Fluency = 89.4 J/cm²) Nd: YAG laser (Fidelis, Fotona, Ljubljana, Slovenia) with a handpiece of 320 µ diameter, with 1064 nm wavelength and 1 W power with pulse mode and 10 Hz frequency was also irradiated for 40 seconds. (Fluency = 49760.8 J/cm²)

For laser treatment, first the degree of dentin hypersensitivity was determined and then the respective tooth was isolated with cotton rolls and dried. Lasers were irradiated to the cervical area of the teeth for the designated time for each laser, with the sweeping motion of the tip of laser hand piece. This was repeated three times (once a week). The treated teeth were evaluated at the third treatment session and at one month, three months and six months postoperatively.

CLEARFIL SE BOND (Kuraray, Sakazu, Kurashiki, Okayama, Japan) dentin bonding agent was also used in this study. First, the degree of tooth hypersensitivity was determined. Next, the respective tooth was isolated with cotton rolls and dried, and primer was applied on the cervical area of the teeth using a microbrush. After 20 seconds, it was thinned with air spray with moderate pressure. Then, the bonding agent was applied and gently thinned with air spray. Next, it was cured for 20 seconds. The treated teeth were evaluated in the same treatment session (immediately after the intervention) and at
Data analysis

The mean and standard deviation of pain score were reported. Repeated measures ANOVA was applied to assess the effect of the three modalities on change in pain score. Since the interaction effect of the two variables was significant, one-way ANOVA was applied to compare the pain score among the three groups at each time point. Pairwise comparisons were made using the Tukey’s test.

Results

In this experimental clinical trial, a total of 135 teeth were evaluated; out of which, 37 were treated with dentin bonding agent, 11 were treated with diode laser and 13 were treated with Nd:YAG laser. Tables 1-3 show the mean score of pain in the three groups at different time points.

The results showed that in dentin bonding agent and diode laser groups, the pain score significantly decreased immediately after treatment compared to baseline ($P < 0.05$) but no significant difference was noted after 3 and 6 months. In the Nd:YAG laser group, level of pain at all time points was significantly lower than the baseline value ($P < 0.05$).

ANOVA showed no significant difference among the three groups at baseline, immediately after treatment and 1 month after treatment but this difference was significant at 3 and 6 months postoperatively.

Since the difference at 3 and 6 months post-treatment was significant, Tukey’s post hoc test was applied for pairwise comparisons of the groups at these time points. At 6 months, no significant difference was noted between dentin bonding agent and diode laser but the difference between these two groups and the Nd:YAG laser group was significant ($P < 0.05$).

The percentage of painless teeth at 3 and 6 months after treatment with dentin bonding agent and diode laser was 0% while this rate was 5% at 3 months and 2% at 6 months following treatment with Nd:YAG laser. Thus, it

| Pain score/Type of treatment | Number | Percentage |
|------------------------------|--------|------------|
| Bonding agent                | Diode laser | Nd:YAG laser |
| 0                            | 0      | 0          | 0 |
| 1                            | 3      | 12         | 27 | 2% | 9% | 20% |
| 2                            | 15     | 28         | 18 | 11% | 21% | 13% |
| 3                            | 19     | 5          | 3  | 14% | 4%  | 2%  |
| Total                        | 135    | 100        |

Table 1: Mean and standard deviation of pain score in treatment with different techniques

| Pain score/Type of treatment | Number | Percentage |
|------------------------------|--------|------------|
| Bonding agent                | Diode laser | Nd:YAG laser |
| 0                            | 0      | 0          | 0 |
| 1                            | 3      | 6          | 21 | 2% | 5% | 15.5% |
| 2                            | 11     | 27         | 27 | 8% | 20% | 20% |
| 3                            | 23     | 12         | 3  | 17% | 9%  | 2%  |
| Total                        | 135    | 100        |

Table 2: Frequency distribution of pain score at 3 months after treatment in the three groups

| Pain score/Type of treatment | Number | Percentage |
|------------------------------|--------|------------|
| Bonding agent                | Diode laser | Nd:YAG laser |
| 0                            | 0      | 0          | 2 |
| 1                            | 3      | 6          | 21 | 2% | 5% | 15.5% |
| 2                            | 11     | 27         | 27 | 8% | 20% | 20% |
| 3                            | 23     | 12         | 3  | 17% | 9%  | 2%  |
| Total                        | 135    | 100        |
may be concluded that the percentage of painless teeth increased at 3 months after treatment with Nd:YAG laser compared to baseline while at 6 months, the percentage of painless teeth decreased compared to 3 months.

Discussion

In the past 20 years, number of the elderly retaining their natural teeth has greatly increased due to improved life expectancy. As the result, the frequency of non-carious cervical lesions and consequently the prevalence of dentin hypersensitivity have greatly increased.

Dentin hypersensitivity is a chronic, multi-factorial condition. Dentin hypersensitivity pain often impedes oral hygiene and leads to plaque accumulation and subsequent periodontal problems. Thus, it is important to assess the efficacy of treatment modalities recommended for dentin hypersensitivity. However, the results of these treatment modalities may vary depending on the etiology of condition and duration of treatment. Kakaboura et al. stated that despite the availability of several modalities for treatment of dentin hypersensitivity, there is no modality to satisfactorily resolve this condition.

In our study, 72.7% of patients with dentin hypersensitivity were females and 27.3% were males, which indicates the higher prevalence of this condition in females. This finding is in agreement with that of Fischer et al. Moreover, the current results revealed that use of dentin bonding agent significantly decreased the severity of pain immediately after treatment compared to baseline but no significant difference was noted after 3 and 6 months.

Also, the percentage of painless teeth increased immediately and at 1 month after treatment while this rate decreased at 3 and 6 months, postoperatively.

Tengrungsun et al, in 2008 used Scotchbond for treatment of dentin hypersensitivity in 70 patients and reported a significant improvement in dentin hypersensitivity at 1 month after treatment. The percentage of painless teeth immediately after treatment and at 1 month later in their study was higher than that in our study. Aranha et al, in 2009 applied Gluma desensitizer on 20 teeth and reported a significant improvement at 5 minutes, 1 week, 1 month, 3 months and 6 months after treatment compared to baseline.

Evidence shows that dentin bonding agents result in protein deposition in deeper parts of dentin and formation of resin tags on the surface and consequently block the movement of intratubular fluid while laser irradiation blocks depolarization of C nerve fibers and decreases dentin hypersensitivity by production of dentin.

Our results showed that diode laser irradiation significantly decreased dentin hypersensitivity pain immediately after treatment compared to baseline but no significant change was noted at 3 or 6 months. Raichur et al, in 2013 used 940 nm diode laser, stannous fluoride gel and potassium nitrate gel and noticed improvement in all three groups. The greatest reduction in dentin hypersensitivity and immediate pain resolution were noted in diode laser group. The current results also confirmed their findings. Matsumoto et al. used 780 nm diode laser with 30 mW power for 30 seconds and reported 85% improvement in pain score when the tooth was directly irra-

![Figure 1: Degree of pain at different time points in use of the three modalities](image)
diated with laser 19. This study showed that application of Nd:YAG laser significantly decreased pain at all time points (immediately and at 1 month, 3 months and 6 months) compared to baseline. Farmakis et al., in 2013 evaluated the efficacy of Nd:YAG laser and bioglass for reduction of dentin hypersensitivity at the occlusal surface of teeth and concluded that Nd:YAG laser alone or in combination with bioglass yielded the best treatment results, which was in accord with our findings. In this study, the mean pain score in Nd:YAG laser group significantly decreased at all time points (immediately and at 1 month, 3 months and 6 months) 19. Olivera et al., in 2013 used Nd:YAG laser and desensitizing agent (Gluma) and showed immediate and long-term pain reduction following the use of laser alone or with Gluma. The reduction in pain was more significant in use of laser combined with Gluma 20. Junior described the mechanism of effect of laser for treatment of dentin hypersensitivity as follows: (I) primary or immediate effect by resolution of painful symptoms, (II) secondary or delayed effect with severe metabolic activity of cells, production of odontoblasts and production of reparative dentin and physiological obstruction of dentinal tubules. According to Junior, direct irradiation of dental pulp wall increases the production of odontoblasts and subsequently enhances the production of dentin 17. The analgesic effects of laser are also mediated by increased level of beta-endorphins, decreased release of histamine, decreased level of acetyl choline, decreased synthesis of bradykinin, increased blood circulation and angiogenesis, increased pain threshold and decreased activity of C fibers 18.

The Nd:YAG laser was more effective than the diode laser in reduction of dentin hypersensitivity over time. This is probably due to dentin fusion following Nd:YAG laser irradiation, probably as the result of occlusion or narrowing of dentinal tubules and subsequent blocking of fluid flow in dentinal tubules. Irradiation of diode laser blocks depolarization of C-fiber afferents and its effects are due to laser-induced changes in neural transmission within the pulp, rather than alterations in the exposed dentin surface, such as those seen with other types of treatments and this may also explain the different behavior of the irradiated tissues 19.

Somm er et al., in 1999 stated that laser light reaches the dental pulp with no reduction in its energy level. They clearly demonstrated that laser light was guided through the intertubular (not intratubular) dentin in a parallel fashion and reached the dental pulp 20. Patient response also plays a role in long-term effects of laser because patients often expect a miracle from laser and in the first phase of treatment, they often persuade themselves that they will no longer have hypersensitivity but after a while, they notice that the problem still exists and express their dissatisfaction with the result in the follow-up sessions; whereas, they might have required more treatment sessions in the first place 21.

West et al., in 1997 discussed that the placebo effect in studies for treatment of dentin hypersensitivity has been acknowledged as an interventional response, and its mechanism of action has not been well evaluated 22. This complex effect includes a combination of physiological and psychological interactions, that greatly depend on the patient-dentist communication and have two components of believing in the value of treatment and expecting improvement in pain symptoms. A positive communication between patients and dentists can activate the analgesic system and release of endorphins and decrease pain as such 23.

Thus, it may be stated that the short-term effect of laser is greater than its long-term effect at 3 months. It should also be stated that more than 3 months is required for production of reparative dentin and obstruction of dentinal tubules by laser irradiation. Laser irradiation and dentin bonding agents decrease dentin hypersensitivity by different mechanisms. Dentin bonding agents result in protein deposition in deeper areas, formation of resin tags on the surface and subsequent blocking of the flow of intratubular fluid; while, laser irradiation blocks depolarization of C nerve fibers and leads to formation of dentin and consequent reduction of dentin hypersensitivity.

Also, considering the course of treatment, the time required for laser irradiation (three 5-minute sessions) is longer than the time required for the application of dentin bonding agent (2-3 minutes). However, treatment with dentin bonding agent requires isolation of the area for the entire duration of the procedure.

Comparison of laser irradiation and dentin bonding agent revealed a significant difference in pain score only at 3 and 6 months; at these time points, Nd:YAG laser was found to be more efficient probably due to its mechanism of action i.e., coagulation of proteins in dentinal tubules and melting of dentinal walls, inhibiting signaling of pain and heat and cold stimuli and subsequent pain reduction.

**Conclusion**

Based on the findings of this study, it can be concluded that diode and Nd:YAG lasers and dentin bonding agent all seem to be suitable tools for immediate reduction of dentine hypersensitivity, but Nd:YAG laser seems to be more effective since its 6-month results were promising. Further studies are needed in order to evaluate the long-term stability of the obtained positive results.
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