Comparative evaluation of use of a diode laser and electrode application with and without two dentinal tubule occluding agents in the management of dentinal hypersensitivity – A clinical study

Chitra Laxmikant Patil, Dilip Ganpat Pol, Rajesh Prabhakar Gaikwad

Abstract:
Background: Dentinal hypersensitivity (DH) is common problem in dentistry. Traditional agents along with alternative therapies have been researched. Aim: To study the efficacy of a diode laser (DL) and electrode application with and without hydroxyapatite (HAP) and strontium chloride (SrCl2) powder. Materials and Methods: 60 Patients with mild cervical abrasion in at least two quadrant with two teeth per quadrant were selected and randomly divided into four groups: (i) Group 1 – DL versus DL with HAP (ii) Group 2 – electrode application versus electrode application with HAP (iii) Group 3 - DL versus DL with SrCl2 (iv) Group 4 - electrode application versus electrode application with SrCl2 and were subjected to tactile stimulus and air blast test and scores were recorded on verbal rating scale (VRS) and visual analogues scale (VAS) at different time for 3 months. The data was statistically evaluated by one way ANOVA and paired t test. Results: In group 1 and 3, DL alone had a short term reduction of hypersensitivity (P = 0.001). Synergistic effect of DL and HAP (group 1) showed a prolonged reduction on both scales (P < 0.001) whereas the additive effect of SrCl2 with DL (group 3) showed statistically significant reduction on both scales at all time (p<0.001). In group 2 there is insignificant difference on both scales at all time (P > 0.05) however group 4 showed significant reduction only in VAS score (p>0.05). Conclusion: DL alone had a short lived effect however with adjunctive sustained results were obtained whereas electrode application was neither beneficial nor did cause any adverse effect.

Key words: Dentinal hypersensitivity, diode laser, electrosurgical unit, hydroxyapatite, strontium chloride, verbal rating scale, visual analog scale

INTRODUCTION

Dentinal hypersensitivity (DH) is a relatively common condition of transient sharp tooth pain which occurs in response to nonnoxious stimuli. DH is one domain where human has not yet achieved the elusive “gold standards” for its management. One of the earliest citing of DH dates back to Blum in 1530. However, it was not until 1700 that this oral pain condition was more extensively investigated. DH is also called as dentinal sensitivity. Cervical DH is a condition characterized by sharp pain, associated with thermal, evaporative, tactile, osmotic, or chemical stimuli. The traditional methods used were calcium compounds, protein precipitates such as hydroxyapatite (HAP) and strontium chloride, fluorides or formalin, and in-office treatment procedures which include iontophoresis and application of resins and adhesives. Newer techniques include some dentin bonding agents which have been introduced with the purpose of treating DH such as Gluma Desensitizer (Heraeus Kulzer, Hanau, Germany) which contains hydroxyethyl methacrylate (HEMA), benzalkonium chloride, glutaraldehyde, and fluoride. It Glutaraldehyde...
causes coagulation of the proteins inside the dentinal tubules. It reacts with the serum albumin in the dentinal fluid, causing its precipitation. HEMA forms deep resinous tags and occludes the dentinal tubules.[3] Lasers such as neodymium-doped yttrium aluminum garnet and CO₂ and diode lasers have also been used. Electrosurgical units generate thermal energy which has been used in various dental applications. However, there is still a debate for the best clinical management of DH. In search of a better treatment, a comparative study was designed to study the effect of these alternative treatment modalities (diode laser and electrode application) individually and in combination with conventional agents such as HAP and strontium chloride.

MATERIALS AND METHODS

The research was approved by the local ethical committee. All the patients were motivated and explained about the treatment plan, and a written informed consent was acquired before the enrollment in the study which was going to be conducted as a 3-month study.

A flow diagram for complete methodology is presented in Figure 1. Sixty patients from both sexes between the age group of 25 and 60 years were selected. A special pro forma was designed for the systematic recording of the information. Inclusion criteria were: (a) patients with a history of tooth hypersensitivity to thermal, mechanical, sweet, or sour stimuli; (b) premolars with mild cervical abrasion cavities on the buccal aspect; (c) patients in the age group of 25–60 years; and (d) patients with at least two quadrants with two teeth per quadrant having hypersensitivity above 2 according to the Verbal Rating Scale (VRS) on air blast evaporative stimulus. Scaling and root planing was done preoperatively. Oral hygiene instructions were provided, and the participants were asked to perform brushing with the modified Bass technique twice daily (tooth paste was standardized after confirming the absence of any sensitivity agents and handed to them with strict instructions. Vitality test was assessed by an electric pulp tester (Parkell Pulp Vitality Tester D624 Gentle-Pulse Stimulus Electronics Division). All the selected teeth were vital. Envelopes containing identifications for treatment groups were enclosed, mixed, and then numbered. The patients were assigned equally but randomly to one of the following four groups (n = 15). In Group 1, an isolated operatory was set up and all the protocols for laser were followed. The selected teeth were treated with a diode laser ezlase940 (Biolase India private limited) with power adjusted to 0.1 W for 2 min in a noncontact continuous mode. A firing was initiated [Figure 2] with a fiberoptic tip using laser beam which was directed perpendicularly to the affected area for 40 s, while the other quadrants selected teeth were treated with diode laser along with prior burnishing of extra-fine HAP powder. In Group 2, the electrosurgical unit [Figure 3] was connected to a charger with a power of 0.1 W for 2 min. A ball-type electrode was applied in the selected teeth of a quadrant, while the other quadrant teeth were treated by burnishing of the adjunctive agents followed by touching the electrode. The electrode was moved with no pressure with contact time of <2 s and was cleaned with 3% hydrogen peroxide solution followed by subsequent wiping. Extra-fine, readymade HAP powder (63 µ) was topically burnished for 30 s with a ball burner. In Group 3, the same protocol and similar settings were done for diode laser firing as in the first group, however strontium chloride powder (Group 3) was burnished at the site. In Group 4, the same protocol and similar settings and procedure were done as in for electrosurgical unit as done in Group 2, however strontium chloride powder of 45 µ was topically burnished for 30 s with a ball burner. Direct application of the fine powder was suggested, as it enhanced direct penetration into the tubules. The examination site was isolated with cotton rolls and was subjected to the following tests.

Tactile test

The affected area was examined by a mechanical stimulus which was applied with a sharp dental explorer across the cervical area (17/23). The test was repeated thrice before both the scores were assigned.

Air blast test – A blast of air from a dental three-way syringe at a pressure between 45 and 60 lb/inch was placed perpendicular for 5 s at a distance of 2 mm from the affected tooth surface. The adjacent teeth were shielded by the operator’s fingers. Pain was assessed on a horizontal, 10-interval scale ranging from 0 to 10, with 10 representing the maximum pain. Tooth sensitivity was recorded at a time interval of 5 min by marking the degree of discomfort on VRS⁴ and visual analog scale (VAS).[5] Any dropouts were excluded. All patients were present during the follow-up and no adverse effects were observed during the recall periods. Follow-ups of all patients were done by the same examiner. The statistical analysis was performed for each parameter. The mean and standard deviation were calculated using the Statistical Package for Social Sciences (SPSS software version 19, IBM, India). One-way analysis of variance and paired t-test were performed to analyze the differences in the various groups at the respective interval. P < 0.05 was considered to be statistically significant.

RESULTS

The mean age was 38.2 ± 8.33, 41.4 ± 9.79, 38.53 ± 10.31, and 45.6 ± 9.17 years in Groups 1, 2, 3, and 4, respectively. The male-to-female ratio was 2:1, 3:1, 3:2, and 1:1, respectively. In Group 1, there was statistically significant reduction in DH at 20 min and 1 week interval as compared to baseline (P = 0.001 for all). Diode laser shows a significant reduction in hypersensitivity in all the time intervals. However, the mean posttreatment VAS score was significantly lower as compared to baseline (pretreatment) at all the time intervals (posttreatment VAS [P < 0.001 for all]), whereas the mean VRS and VAS scores [Table 1] were statistically significantly higher in the diode laser compared to the diode laser with HAP group (P < 0.001 for all), thus implying that HAP coupled with diode laser yields better results than diode alone. In Group 2, the use of electrode application showed an insignificant reduction in VRS and VAS scores. The mean VRS score for HAP powder along with electrode application showcased a statistically significant difference at 20 min, 1 week, and 1 month. However, at the end of 3 months, there was an insignificant difference as compared to baseline. The mean VAS scores were 6.20 ± 1.20, 4.60 ± 0.99, 4.60 ± 0.99, 4.60 ± 0.99, and 4.60 ± 0.99, showing a significant reduction at all the time intervals with P = 0.001. These findings of electrode application and HAP with electrode
DH caused due to exposed dentinal tubules is a common complaint in the adult population, with as many as one in seven (8%–57%) patients presenting for dental treatment.\textsuperscript{[5]} The transmission of pain stimuli across the dentin is by a hydrodynamic mechanism.\textsuperscript{[6]} It is reasonable to postulate that teeth exhibiting cervical sensitivity have open tubules which are patent to the pulp. Logically, one approach to treatment would be the occlusion of tubules or based on Poiseuille’s Law, at least a reduction in tubule diameter (Greenhill and Pashley, 1990).\textsuperscript{[7]} Several studies describe a synergistic action of lasers in association with desensitizing agents. In fact, the laser system along with an adjunctive showed an impressive efficacy in reducing DH.\textsuperscript{[8]} HAP had a definite potential as a desensitizer when used as an in-office agent, which was depicted in the study conducted by Shetty \textit{et al}.\textsuperscript{[9]} A recent study carried out with HAP-containing dentifrice shows similar effect in reducing DH. Lasers have a photo-biomodulating action on dental pulp, which was reported by Villa \textit{et al}.\textsuperscript{[10]} In the 1980s, the benefits of low-output delivery system as an anti-inflammatory tool and also the stimulation of nerve cells in a clinical environment were delineated. The age group of

\section*{DISCUSSION}
25–60 years was selected because many of the clinical surveys showed that DH mostly affects individuals at their fourth and fifth decades. Our results showed that males are more affected than females, which is contradictory to the study conducted by Addy, where women are more frequently affected and at a younger mean age; this may be due to population difference and small sample size. Keele described a 4-point VRS scale grading pain as slight, moderate, severe, and agonizing. A combined assessment using two different methods seemed appropriate to eliminate the discrepancies of either one method, which is why the VRS and VAS scales were used. In Group 1, there was a definite reduction in DH at all the time intervals, thus implying that the diode laser along with HAP powder was significantly better. The reduction VRS and VAS scores (which also partly reflect the inherent differences in the VRS and VAS scoring systems) the effectiveness of diode alone cannot be established without ambiguity. The results are

| Variable | Diode laser group (n=15) | Diode laser + hydroxyapatite group (n=15) | P |
|----------|--------------------------|------------------------------------------|---|
| VRS      |                          |                                          |   |
| Pre      | 2.40±0.51                | 2.47±0.52                               | 0.724 (NS) |
| 20 min   | 1.93±0.70                | 0.47±0.52                               | 0.001 (S) |
| 1 week   | 1.93±0.70                | 0.47±0.52                               | 0.001 (S) |
| 1 month  | 2.47±0.52                | 0.47±0.52                               | 0.001 (S) |
| 3 months | 2.40±0.51                | 1.07±0.80                               | 0.001 (S) |
| VAS      |                          |                                          |   |
| Pre      | 6.53±1.06                | 5.73±0.88                               | 0.999 (NS) |
| 20 min   | 5.40±1.18                | 5.26±0.59                               | 0.001 (S) |
| 1 week   | 5.40±1.18                | 5.33±0.48                               | 0.001 (S) |
| 1 month  | 4.60±0.91                | 5.46±0.63                               | 0.001 (S) |
| 3 months | 5.60±1.35                | 5.60±0.82                               | 0.001 (S) |

Values are mean±SD. P by independent sample t-test after confirming the underlying normality assumption. P<0.05 is considered to be statistically significant. S – Statistically significant; NS – Statistically nonsignificant; VRS – Verbal Rating Scale; VAS – Visual analog scale; SD – Standard deviation; P – P-value of significance

| Variable | Electrode application (n=15) | Hydroxyapatite + electrode application (n=15) | P |
|----------|------------------------------|-----------------------------------------------|---|
| VRS      |                              |                                               |   |
| Pre      | 3.00±0.00                    | 3.00±0.00                                   | *  |
| 20 min   | 2.80±0.41                    | 2.53±0.63                                   | 0.18 (NS) |
| 1 week   | 2.93±0.25                    | 2.66±0.48                                   | 0.07 (NS) |
| 1 month  | 2.93±0.25                    | 2.73±0.45                                   | 0.15 (NS) |
| 3 months | 3.00±0.00                    | 2.93±0.25                                   | 0.32 (NS) |
| VAS      |                              |                                               |   |
| Pre      | 5.80±0.77                    | 5.73±0.88                                   | 0.82 (NS) |
| 20 min   | 5.60±0.73                    | 5.26±0.59                                   | 0.18 (NS) |
| 1 week   | 5.73±0.70                    | 5.33±0.48                                   | 0.08 (NS) |
| 1 month  | 5.80±0.77                    | 5.46±0.63                                   | 0.20 (NS) |
| 3 months | 5.60±0.73                    | 5.60±0.82                                   | 1.00 (NS) |

*P value not applicable as the baseline values are similar, P<0.05 is considered to be statistically significant. S – Statistically significant; NS – Statistically nonsignificant; VRS – Verbal Rating Scale; VAS – Visual analog scale; SD – Standard deviation; P – P-value of significance

| Variable | Diode laser group (n=15) | Diode laser + strontium chloride group (n=15) | P |
|----------|--------------------------|-----------------------------------------------|---|
| VRS      |                          |                                               |   |
| Pre      | 2.40±0.51                | 3.00±0.00                                   | 0.001 (S) |
| 20 min   | 1.93±0.70                | 1.60±0.91                                   | 0.271 (NS) |
| 1 week   | 1.93±0.70                | 1.60±0.91                                   | 0.271 (NS) |
| 1 month  | 2.47±0.52                | 1.60±0.91                                   | 0.003 (S) |
| 3 months | 2.40±0.51                | 1.60±0.91                                   | 0.006 (S) |
| VAS      |                          |                                               |   |
| Pre      | 6.53±1.06                | 6.47±1.06                                   | 0.865 (NS) |
| 20 min   | 5.40±1.18                | 3.20±0.86                                   | 0.001 (S) |
| 1 week   | 5.40±1.18                | 3.20±0.86                                   | 0.001 (S) |
| 1 month  | 4.60±0.91                | 3.20±0.86                                   | 0.001 (S) |
| 3 months | 5.60±1.35                | 3.20±0.86                                   | 0.001 (S) |

Values are mean±SD. P values by independent sample t-test after confirming the underlying normality assumption. P<0.05 is considered to be statistically significant. S – Statistically significant; NS – Statistically nonsignificant; VRS – Verbal Rating Scale; VAS – Visual analog scale; SD – Standard deviation; P – P-value of significance

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similar to Liu and Lan who had studied diode laser however of different wavelength 40–100 mw, continuous wave for 15–60 s and showed that the effectiveness of the treatment to be 70%–88%. However, there was recurrence at 1- and 3-month intervals, which is in accordance to the results obtained by Matsumoto et al.[11] A recent systematic review proposed that laser has beneficial treatment effect of DH, however it may be due to the placebo effect. In this study, placebo control was not employed; hence, it is difficult to conclude whether the results obtained are due to any actual effect of laser. In Group 2, electrode application did not trend to provide any reduction in scores, whereas electrode application plus HAP showed an insignificant difference. Although beneficial effect was not obtained, it did not show any adverse effect too, as the pulp vitality test was positive at baseline and even after the treatment. This supports the finding of Nisha and Amil[12] that the electrode application severely damaged the pulp when the electrode tip contacted Class V amalgam restoration when electrosurgical current was delivered for not more than 1 s with a fully rectified unit. Where as there was no damage to the pulp of unrestored teeth when current was applied. In Group 3, diode laser definitely showed a reduction in DH at all the time intervals. The results are in accordance with those of several studies which focused on the effectiveness of the sole diode laser; Matsumoto et al.[11] showed an 85% improvement in teeth treated with laser and Yamaguchi et al.[13] noticed an effective improvement index of 60% in the group treated with laser compared to the 22.2% of the control non-lased group. The reduction in DH may be due to the effects of low-level lasers which have analgesic, bio-stimulant, and anti-inflammatory effects and regulate the cellular metabolism.[14] The benefit of strontium chloride powder and diode laser may be explained on the basis of the beneficial effect of strontium chloride as documented by Ross[15] and Kishore[16] who treated patients with 10% strontium chloride and observed that the desensitizing agents significantly reduced DH. In Group 4, the results could not be corroborated with any such similar study as the detailed perusal of the available literature failed to show any such similar study. Therefore, it is not possible to compare our findings with that of any other authors. The limitations of the study were (1) the study was not blinded as no placebo was used, so there may have been a bias patient response and evaluation by the operator; (2) its design is single masked and a larger sample size could have been used; (3) there is no control group, hence comparison is difficult to assess and obtain accurate results; (4) a longer follow-up period would have been better suited to evaluate the long-term effects; and (5) there was no exact measure of the amount of laser energy delivered to a particular area. A scanning electron microscope study conducted by Patil and Gaikwad[17] showed the highest tubular occlusion with HAP powder plus diode laser and least with electrode, which is further confirmed with clinical studies and will be definitely beneficial for the treatment of patients.

CONCLUSION

The study concludes that the combined use of HAP and 980-nm DL resulted in a significant reduction in the severity of DH. The therapeutic effect of this combination is better than the application of laser alone. Electrosurgery has neither beneficial nor any detrimental effect. The results obtained in the present study were favorable with regard to the efficacy and reliability of HAP powder and diode laser as a desensitizer. The in vitro study shows confirmatory results with synergistic use of HAP powder with diode laser. In addition, further comparative studies with various agents are required to prove the superiority, if any, of HAP, strontium chloride, and diode lasers over these agents.

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Conflicts of interest
There are no conflicts of interest.

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