

Assessing Post-treatment Pain: Comparing Traditional Caries Removal Versus Minimal Invasive Dentistry using Ozonated Water and Silver Diamine Fluoride

Rohini Dua, Geetika Agrawal*

Department of Pediatric and Preventive Dentistry, National Dental College and Hospital, S.A.S Nagar, Punjab, India.

Abstract

Background: For the management of dental caries, several treatment protocols are available. The study was conducted with the aim to assess post-treatment pain after the use of a traditional caries removal method followed by restoration, or after an ozonated water and silver diamine fluoride (SDF) application, the conservative method of caries removal. **Materials and Methods:** Three groups comprising a total of 36 molars with extensive carious lesions were selected. Group 1 involved using the conventional approach, Group 2 involved applying SDF, and Group 3 involved using ozonated water. The pre-treatment and post-treatment pain were measured using the Visual Analog Scale (VAS). A $P < 0.05$ was used for data analysis using the statistical software SPSS 22.0. **Results:** There was no statistically significant difference in the mean age and gender distributions between the three groups ($P > 0.05$). Using the ANOVA test, the three groups' mean VAS pre- and post-treatment scores revealed statistically insignificant differences between them ($P > 0.05$). The intergroup comparison of mean VAS post-treatment scores of the three groups revealed statistically insignificant differences between groups glass ionomer cement (GIC) and SDF, OZONE, and SDF ($P > 0.05$). Conversely, a statistically significant difference ($P < 0.05$) was observed between the GIC and OZONE groups. **Conclusion:** The study found that, when compared to conventional restorative procedures, ozone therapy may be a useful method for treating carious teeth in primary teeth.

Keywords: Minimal invasive dentistry, Ozone, Silver diamine fluoride, Stepwise caries excavation, Visual Analog Scale score.

INTRODUCTION

Dental caries is a dynamic, complex, non-communicable disease.^[1] A crucial component of deep caries management is preserving pulp vitality.^[2,3] There is growing interest in less invasive methods that involve incomplete removal of carious tissue instead of the traditional treatment of dentinal carious lesions, which involves complete removal of the carious tissue. These preservative techniques have a biological justification in that cariogenic bacteria either die or go dormant when they are sufficiently sealed off from nutrition, which causes caries arrest and carious dentin to remineralize. For the treatment of deep carious lesions, partial caries removal in one or two steps appears to be beneficial.^[4,5] To lower the risk of mechanical pulp exposure, evidence-based practice recommends selective caries removal and stepwise excavation.^[2,3] In addition to shielding the dental pulp, an intact dentin barrier releases growth factors that promote the reparative process.^[6] Unfortunately, the majority of direct restorative materials in the market today are unable to offer a strong enough seal or stop leaks for long enough. As a result, over time, residual

bacteria may multiply in the cavity's smear layer and dentinal tubules, resulting in pulp irritation, secondary caries, and restoration failure.^[7,8] It is advised to use cavity disinfectants such as sodium hypochlorite, dental bonding agents with antimicrobial activity, lasers, ozone, and antibiotics to resolve this problem.^[8,9] A simple, painless, ultra-conservative, and health-safe method called ozone therapy may help stop the progression of dental caries in children. Because of its strong oxidizing ability, ozone (O₃) can lyse the bacterial cell wall and convert the pyruvic acid the bacteria produce into carbon dioxide and acetic acid, which can stop or reverse the progression of dental caries.^[10] Silver diamine fluoride (SDF) is

Address for correspondence: Geetika Agrawal,
Department of Pediatric and Preventive Dentistry, National Dental College
and Hospital, S.A.S Nagar, Punjab, India.
Email: geetikamds@gmail.com

Received: Jul. 11, 2024; **Accepted:** Aug. 20, 2024; **Published:** Aug. 30, 2024

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

How to cite this article: Dua R, Agrawal G. Assessing Post-treatment Pain: Comparing Traditional Caries Removal Versus Minimal Invasive Dentistry using Ozonated Water and Silver Diamine Fluoride. J Res Adv Dent 2024;15(6):1-5.

Access this article online

Website:
www.jrad.co.in

DOI:
<https://doi.org/10.53064/jrad.2024.15.6.583>

a brush-on liquid that stops dental caries lesions. SDF received approval from the U.S. Food and Drug Administration (FDA) as a Class II medical device in August 2014. The formation of a hard, black, impermeable layer on the tooth surface that is resistant to decay is a sign of caries arrest and is how SDF stops the development of caries.^[11,12] The present study was conducted with the aim of assessing post-treatment pain after the use of a traditional caries removal method followed by restoration, or after an ozone and SDF application, the conservative method of caries removal.

MATERIALS AND METHODS

The prospective study was carried out at the National Dental College and Hospital's Post Graduate Department of Paediatric Dentistry in Dera Bassi, Punjab, India. The study included 36 molars in children aged 6–12 years who were in good general health, had extensive carious lesions in their molars that were asymptomatic and had never been treated before, were willing to follow the instructions, and could be followed up. The study excluded participants who had any of the following: teeth with pathological mobility, swelling or fistula, any discoloration other than carious lesions, any interradicular lesions, periapical radiolucency, pathological resorptions, pulpal calcifications, spontaneous pain or persistent pain against thermal and chemical stimuli, teeth sensitive to percussion or palpation, and children with chronic illnesses or special health-care needs.

The parents of the children involved in the study were fully informed of any potential risks and discomforts related to the study and the use of the materials before the procedure began, and their informed consent was obtained before the children were recruited for the study.

Enrolment in the study was limited to patients who met the inclusion, exclusion, and consent criteria as stated above. A total of 36 teeth were sampled.

The teeth were divided into three groups.

- Group 1 ($n = 12$): Conventional method
- Group 2 ($n = 12$): SDF
- Group 3 ($n = 12$): Ozonated water.

Operative procedure

Pre-treatment procedure

For every patient, a comprehensive case history comprising the medical and dental histories was documented. To assess the root status and rule out any pulpal or periapical lesion, a radiographic examination was conducted. The involved tooth underwent a pre-operative periapical digital radiograph to evaluate the periodontal and periapical health of the tooth and to look for signs of caries extension. The participants' tooth pain was then measured using a Visual Analog Scale (VAS), with a score ranging from 0 (no tooth pain at all) to 10 (the worst tooth pain imaginable).

Treatment procedure

The course of treatment was standardized. To restore the tooth, a step-by-step operating procedure was followed, depending

on the kind of technique being used in each group. A rubber dam was used to isolate the tooth in each group. Carbide burs were used to remove necrotic dentin, carious enamel, and the cavity's lateral walls. Dentin excavators and low-speed burs were used to remove the carious dentin, leaving some caries in the center. The affected dentin, which might be remineralized, was retained.

In Group 1, the carious dentin was removed using dentin excavators and low-speed burs. The affected dentin remained and was not removed. Following a portion of the carious dentin being removed, the residual carious dentin was covered with calcium hydroxide [$\text{Ca}(\text{OH})_2$] liner material without the use of cavity disinfectants.

In Group 2, about 1-mm thickness of the deep leathery caries was left on the pulpal floor depending on measurements from the pre-operative periapical digital radiograph. In addition, the residual caries had to be leathery, as shown by resistance to withdrawal when lightly probed with a sharp explorer. Use petroleum jelly to shield the mucous membrane and gingiva. Isolate the carious tooth. The carious lesion was dried and SDF was applied with microbrush. When treating proximal carious lesions, use super floss. Leave the SDF-treated lesion for 60–180 s.

In Group 3, about 1-mm thickness of the deep leathery caries was left on the pulpal floor depending on measurements from the pre-operative periapical digital radiograph. In addition, the residual caries had to be leathery, as shown by resistance to withdrawal when lightly probed with a sharp explorer. Next, 2 mL of ozonated water (concentration 1000 mg/h) was used for 5 min to disinfect the remaining damaged dentin. Following that, the cavity was cleaned for a minute using regular saline.

In all three groups, glass ionomer cement (GIC) was then used to seal the teeth. After that, petroleum jelly was applied to the restoration to keep it dry until the GIC set. The excess GIC was removed and the occlusion was checked by asking the patient to bite onto the articulating paper. If any high points were noted, they were reduced.

Post-treatment evaluation

The participants were told to return 24 h after restoration for a review and additional pain assessment. The same VAS score was used to evaluate each participant's tooth pain. The score was from 0 (no tooth pain at all) to 10 (tooth pain as bad as imaginable).

Statistical analysis

The statistical program SPSS 22.0 (SPSS Inc., Chicago, IL) was used to analyze the data. A significance threshold of $P < 0.05$ was applied. To evaluate the mean and standard deviation of each group, descriptive statistics were used. Both the ANOVA test and *post hoc* Tukey test were used in inferential statistics to determine the difference (between groups) and within groups.

RESULTS

Using the Chi-square test, the mean age distribution between the three groups was found to be statistically non-significant ($P > 0.05$).

The three groups' gender distribution and the outcomes were not statistically significant ($P > 0.05$) (Table 1).

Table 1 indicates that there was a statistically insignificant difference ($P > 0.05$) between the mean VAS pre-treatment scores of the three groups using the ANOVA test.

Table 2 indicates that there was a statistically insignificant difference ($P > 0.05$) between the mean VAS post-treatment scores of the three groups using the ANOVA test ($P > 0.05$).

Table 3, the *post hoc* Tukey test was used to compare the three groups' mean VAS pre-treatment scores, and the results indicated a statistically insignificant difference between them ($P > 0.05$).

In Table 4, the *post hoc* Tukey test was used to compare the three groups' mean VAS post-treatment scores, and the results indicated that there was a statistically insignificant difference between the groups GIC and SDF, OZONE, and SDF ($P > 0.05$).

Conversely, a statistically significant difference ($P < 0.05$) was observed between the GIC and OZONE groups.

DISCUSSION

Early childhood caries treatment presents a significant challenge since young children are unable to cooperate during traditional dental procedures.^[12] To avoid general anesthesia, researchers should create evidence-based strategies to find a less invasive, efficient management technique for controlling caries.^[13]

There was no statistically significant difference in the mean age and gender distributions between the three groups ($P > 0.05$). Using the ANOVA test, the three groups' mean VAS pre- and post-treatment scores reveal a statistically insignificant difference between them ($P > 0.05$). The mean VAS post-treatment scores of the three groups' intergroup comparisons reveal a statistically insignificant difference between groups GIC and SDF, OZONE, and SDF ($P > 0.05$). Conversely, a statistically significant difference ($P < 0.05$) was observed between the GIC and OZONE groups.

A decrease in the number and diameter of open dentinal tubules^[14,15] and collagen degradation^[16] may also be responsible for less tooth pain following ozone treatment. These factors have the ability to mechanically obstruct the dentinal tubules.

Compared to traditional treatment, ozone treatment of deep caries was linked to a lower requirement for RCT. This may also be explained by the fact that cariogenic microorganisms can be effectively eliminated by ozone.^[17,18]

To determine whether an ozone method of more conservatively managing deep caries and a restoration is preferable to a

Table 1: Mean values of VAS pre-treatment score of the three groups

Group	VAS pre-treatment score		P-value
	Mean	SD	
Group 1	4.83	0.57	0.109
Group 2	4.08	1.16	
Group 3	4.50	0.67	

SD=Standard deviation, VAS: Visual Analog Scale

Table 2: Mean values of VAS post-treatment score, of the three groups

Group	VAS post-treatment score		P-value
	Mean	SD	
Group 1	1.50	1.16	0.053
Group 2	1.00	0.73	
Group 3	0.58	0.66	

SD=Standard deviation, VAS: Visual Analog Scale

Table 3: Intergroup comparison of mean VAS pre-treatment scores for the three groups

Pain assessment scale	Group (I)	Group (J)	Mean difference (I-J)	P-value
VAS pre-treatment score	Group 1	Group 2	0.75	0.091
		Group 3	0.33	0.603
	Group 2	Group 1	-0.75	0.091
		Group 3	-0.41	0.457
	Group 3	Group 1	-0.33	0.603
		Group 2	0.416	0.457

VAS: Visual Analog Scale

Table 4: Intergroup comparison of mean VAS post-treatment scores for the three groups

Pain Assessment Scale	Group (I)	Group (J)	Mean difference (I-J)	P-value
VAS post-treatment score	Group 1	Group 2	0.50000	0.362
		Group 3	0.91667*	0.042*
	Group 2	Group 1	-0.50000	0.362
		Group 3	0.41667	0.490
	Group 3	Group 1	-0.91667*	0.042*
		Group 2	-0.41667	0.490

*The mean difference is significant at the 0.05 level. VAS: Visual Analog Scale

traditional caries removal method, Al-Omiri *et al.* conducted a controlled randomized crossover study to evaluate post-treatment pain and the need for root canal treatment. A significant reduction in pain scores was observed in both groups 24 h post-treatment ($P < 0.0001$). Compared to the conventional treatment, the ozone treatment resulted in less pain 24 h after treatment ($P < 0.0001$) and less need for root canal therapy ($P = 0.014$) after a 2-year follow-up. The study found that using ozone to treat symptomatic, deep carious lesions after partial caries removal resulted in reduced pain and a lower incidence of RCT after treatment.^[19]

In addition, ozone is good for pulp because it can counteract harmful endotoxins that irritate it and aid in its recovery. As was previously mentioned, ozone exhibits potent anti-inflammatory and anti-oxidant qualities that protect tissue damage caused by oxidative stress.^[20,21] In addition, ozone increases the activity of anti-inflammatory antioxidant enzymes such as catalase, superoxide dismutase, and glutathione peroxidase.^[20-22] In addition, it inhibits prostaglandin release and deactivates cyclooxygenase to regulate inflammatory pathways.^[23]

The aforementioned discussion supports the benefits of ozone for dental pulp tissues, including its anti-inflammatory, anti-oxidative, and analgesic properties.^[24] This helps to explain why ozone is effective in promoting healing and preventing damage to pulp tissues.

This is consistent with earlier research showing that applying ozone following partial caries removal from deep carious lesions in deciduous teeth could prevent the need for pulpotomy and have success rates comparable to those of pulpotomy.^[25]

Clinical research has shown that when traditional restorative treatment for caries is unavailable or too expensive, using 38% SDF can prevent and stop caries.^[26]

By forming fluorapatite, which is highly resistant to acid and is primarily responsible for remineralizing carious lesions, topical application of SDF solution has been shown to be effective in stopping active caries in primary teeth. Meanwhile, silver phosphate has antibacterial properties that act by inhibiting the enzymes on dextran-induced agglutination of cariogenic strains of *Streptococcus mutans*.^[27,28]

SDF is a non-invasive method that is also efficient, cost-effective, and can be used on deciduous teeth. However, the main drawback of SDF is the formation of dark stains on the tooth surface. The study conducted by Crystal *et al.* 2017 who concluded that staining on posterior teeth was more acceptable than staining on anterior teeth and most parents preferred this option to advanced behavioral techniques such as sedation or general anesthesia.^[29]

In a study conducted by Koul *et al.*, SDF, a more recent option for treating dental cavities with minimally invasive techniques, was found to be a viable treatment option when taking into account its affordability, ease of use, and non-invasiveness.^[30]

CONCLUSION

Ozone treatment of symptomatic teeth with deep, carious lesions almost reaching the pulp, shows promise for a more conservative approach to treat deep caries as well as being associated with less post-operative pain and less need for root canal treatment compared to a traditional method. As ozone therapy helps to slow down the progression of caries and improve patients' quality of life, the study concluded that it may be considered an effective technique for treating carious teeth in primary teeth when compared to traditional restorative treatments. Furthermore, because it is a simple and

non-invasive method, it might facilitate children's acclimation to dental procedures.

REFERENCES

1. World Dental Federation. The FDI World Dental Federation Policy Statement: Perinatal And Infant Oral Health (Adopted by the FDI General Assembly: New Delhi, India); 2014. Available from: <https://www.fdiworlddental.org/classification-caries-lesions-tooth-surfaces-and-caries-management-systems>
2. Banerjee A, Frencken JE, Schwendicke F, Innes NP. Contemporary operative caries management: Consensus recommendations on minimally invasive caries removal. *Br Dent J* 2017;223:215-22.
3. Innes NP, Frencken JE, Bjørndal L, Maltz M, Manton DJ, Ricketts D, *et al.* Managing carious lesions: Consensus recommendations on terminology. *Adv Dent Res* 2016;28:49-57.
4. Schwendicke F, Dörfer CE, Paris S. Incomplete caries removal: A systematic review and meta-analysis. *J Dent Res* 2013;92:306-14.
5. Casagrande L, Seminario AT, Correa MB, Werle SB, Maltz M, Demarco FF, *et al.* Longevity and associated risk factors in adhesive restorations of young permanent teeth after complete and selective caries removal: A retrospective study. *Clin Oral Investig* 2017;21:847-55.
6. Farges JC, Alliot-Licht B, Renard E, Ducret M, Gaudin A, Smith AJ, *et al.* Dental pulp defence and repair mechanisms in dental caries. *Mediators Inflamm* 2015;2015:230251.
7. Gu F, Bresciani E, Barata TJ, Fagundes TC, Navarro MF, Dickens SH, *et al.* *In vivo* acid etching effect on bacteria within caries-affected dentin. *Caries Res* 2010;44:472-7.
8. Geerts S, Bolette A, Seidel L, Guéders A. An *in vitro* evaluation of leakage of two etch and rinse and two self-etch adhesives after thermocycling. *Int J Dent* 2012;2012:852841.
9. Bin-Shuwaish MS. Effects and effectiveness of cavity disinfectants in operative dentistry: A literature review. *J Contemp Dent Pract* 2016;17:867-79.
10. Lupieri V, Manfra A, Ronfani L, Chermetz M, Cadenaro M. Ozone therapy for early childhood caries (ECC) treatment: An *in vivo* prospective study. *Appl Sci* 2022;12:1964.
11. Mei ML, Ito L, Cao Y, Li QL, Lo EC, Chu CH. Inhibitory effect of silver diamine fluoride on dentine demineralisation and collagen degradation. *J Dent* 2013;41:809-17.
12. World Health Organization. WHO expert consultation on public health intervention against early childhood caries: Report of a meeting, Bangkok, Thailand, 26-28 January 2016. Geneva: World Health Organization; 2017.
13. Schroth RJ, Quiñonez C, Shwart L, Wagar B. Treating early childhood caries under general anesthesia: A national review of Canadian data. *J Can Dent Assoc* 2016;82:g20.
14. Raafat Abdelaziz R, Mosallam RS, Yousry MM. Tubular occlusion of simulated hypersensitive dentin by the combined use of ozone and desensitizing agents. *Acta Odontol Scand* 2011;69:395-400.
15. Gürsoy H, Cakar G, Ipçi SD, Kuru B, Yılmaz S. *In vitro* evaluation of the effects of different treatment procedures on dentine tubules. *Photomed Laser Surg* 2012;30:695-8.
16. Atabek D, Bodur H, Yalçın G, Kalayci Ş. Effects of oxidative irrigants on root dentin structure: Attenuated total reflection Fourier transform infrared spectroscopy study. *Oral Health Dent Manag* 2014;13:753-6.
17. Safwat O, Elkateb M, Dowidar K, Salam HA, El Meligy O. Microbiological evaluation of ozone on dentinal lesions in young permanent molars using the stepwise excavation. *J Clin Pediatr Dent* 2018;42:11-20.
18. Libonati A, Di Taranto V, Mea A, Montemurro E, Gallusi G, Angotti V, *et al.* Clinical antibacterial effectiveness Healozone technology after incomplete caries removal. *Eur J Paediatr Dent* 2019;20:73-8.
19. Chu CH, Gao SS, Li SK, Wong MC, Lo EC. The effectiveness of the biannual application of silver nitrate solution followed by sodium fluoride varnish in arresting early childhood caries in preschool children: study protocol for a randomised controlled trial. *Trials* 2015;16:426.
20. Al-Omiri MK, Alqahtani NM, Alahmari NM, Hassan RA, Al Nazeah AA, Lynch E. Treatment of symptomatic, deep, almost cariously exposed

- lesions using ozone. *Sci Rep* 2021;11:11166.
21. Bocci VA, Zanardi I, Travagli V. Ozone acting on human blood yields a hormetic dose-response relationship. *J Trans Med* 2011;9:66.
22. Kucukgul A, Erdogan S, Gonenci R, Ozan G. Beneficial effects of nontoxic ozone on H₂O₂-induced stress and inflammation. *Biochem Cell Biol* 2016;94:577-83.
23. Bocci VA. Scientific and medical aspects of ozone therapy. State of the art. *Arch Med Res* 2006;37:425-35.
24. Alpert SE, Walenga RW, Jaspers I, Qu Q, Chen LC. Ozone inactivates cyclooxygenase in human tracheal epithelial cells without altering PGHS-2 mRNA or protein. *Am J Physiol* 1997;272: L879-87.
25. Azuma K, Mori T, Kawamoto K, Kuroda K, Tsuka T, Imagawa T, *et al.* Anti-inflammatory effects of ozonated water in an experimental mouse model. *Biomed Rep* 2014;2:671-4.
26. Beretta M, Federici Canova F. A new method for deep caries treatment in primary teeth using ozone: A retrospective study. *Eur J Paediatr Dent* 2017;18:111-5.
27. Suzuki S, Karube I. Bioelectrochemical sensors based on immobilized enzymes, whole cells, and proteins. *Appl Biochem Bioeng* 1981;3: 145-74.
28. Knight GM, McIntyre JM, Mulyani. The effect of silver fluoride and potassium iodide on the bond strength of auto cure glass ionomer cement to dentine. *Aust Dent J* 2006;51:42-5.
29. Crystal YO, Janal MN, Hamilton DS, Niederman R. Parental perceptions and acceptance of silver diammine fluoride staining. *J Am Dent Assoc* 2017;148:510-8.e4.
30. Singh RK, Datana CS. Assessment of parental perception and success of silver diamine fluoride as a treatment modality for early childhood caries in Indian Scenario. *J Pediatr* 2023;9(1).