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Clinical Evaluation of 38% Silver Diamine Fluoride for Dentin Hypersensitivity Following Full Coverage Vital Tooth Preparations

Mohammed Ziauddeen Mustafa[1*]
[1]Department of Restorative and Prosthetic Dental Sciences, College of Dentistry, Majmaah University, Al-Majmaah, 11952, Saudi Arabia

Author Designation: [1]Assistant Professor

*Corresponding author: Mohammed Ziauddeen Mustafa (e-mail: moh.z@mu.edu.sa).

Abstract: **Objectives**: To evaluate the clinical effectiveness of silver diamine fluoride (SDF) in the management of dentinal hypersensitivity following vital teeth preparation. **Methods**: A single-arm prospective interventional study was conducted among patients attending the Department of Prosthodontics, College of Dentistry, Majmaah University, who required a posterior fixed partial denture and met the criteria for vital tooth preparation. At baseline (before tooth preparation), the sensitivity of the selected tooth following exposure to air blast, tactile stimulation, thermal stimulation, and bite force was recorded using the Visual Analog Scale (VAS) prior to tooth preparation. All selected teeth were prepared for porcelain-fused-to-metal crowns under local anesthesia, and after completion of the procedure, a provisional crown was placed. At 24-hour follow-up, the provisional crown was gently removed, and the tooth was coated with 38% SDF solution using a micro-brush and allowed to dry for 10 minutes. The tooth's sensitivity was recorded as similar to baseline (immediate effect of SDF application), and the temporary crown was re-cemented. At the end of the first week of follow-up, the tooth's sensitivity was reassessed (delayed effect of SDF application) before cementing the final prosthesis. Intra-group comparison of sensitivity scores at baseline, 24 hours, and one week after the procedure was done using the Friedman test followed by the Wilcoxon signed rank test as post hoc analysis using SPSS (Version 24.0). **Results**: There was a significant reduction (p-value < 0.05) in the VAS score for sensitivity following air blast, tactile, thermal, and bite force tests, on both the buccal and lingual aspects of the tooth preparation, at the end of one week, compared with the baseline score. Similarly, the VAS score for sensitivity following bite force also decreased significantly at the end of one week compared with the baseline VAS score. **Conclusions**: Dentin hypersensitivity after full-coverage vital tooth preparation declined significantly between 24 hours and one week in teeth treated with 38% SDF. Since this is an uncontrolled, single-arm study design the findings are preliminary and warrant confirmation in a randomized controlled trial with longer follow-up period.

Key Words: Silver Diamine Fluoride, Dentin Hypersensitivity, Dental Crowns, Vital Tooth Preparation

INTRODUCTION

Tooth-supported crowns and bridges are a beneficial treatment option for patients who cannot receive dental implants due to compromised bone density and financial constraints [1]. Teeth preparation is an essential step for patients receiving bridges and crowns and involves the removal of the enamel and dentin layers of the selected abutment teeth. When vital teeth are prepared, a significant amount of dentin is removed, exposing dentinal tubules [2]. A vital teeth preparation exposes approximately [1-2] million dentinal tubules and provokes dentin hypersensitivity in patients immediately after the procedure [2]. The incidence of dentin hypersensitivity after tooth preparation was found to exceed 13%, with females showing greater sensitivity than males [3].

Dentin hypersensitivity may subsequently lead to pulpal irritation when the remaining dentin is exposed to the diamond burs that generate thin and excessive heat during tooth preparation [4].

Desensitizing agents are commonly used in the management of dentin hypersensitivity because they seal exposed dentinal surfaces by forming protein precipitates within dentinal tubules [5].

However, it should be noted that most studies reported the use of desensitizing agents to manage hypersensitivity due to carious or non-carious lesions [6]. SDF application results in the formation of mineral precipitates such as calcium phosphates and silver salts, on the applied tooth surface [7]. The fluorohydroxyapatite which is produced after SDF application can reduce the diameter of dentinal tubules, thereby reducing dentine hypersensitivity [8]. However, the commonly used desensitizing agents for the management of carious/non-carious lesions include potassium nitrates, glutaraldehyde, silver nitrate, sodium fluoride, strontium chloride, zinc chloride, and methyl methacrylate [9]. Scientific evidence on the effectiveness of desensitizing agents for managing dentin hypersensitivity following teeth preparation is sparse [10]. Silver Diamine Fluoride (SDF) at 38% concentration is used as a desensitizing agent in clinical practice [11]. The application of SDF could not only arrest the caries but also prevent the carious activity. Aldhuwayhi [12] also reported that SDF can be used as a desensitizing agent for vital crown preparations to reduce dentin sensitivity. A systematic review recommended SDF as an effective and safe tooth desensitizer for adults, based on a pooled analysis of three experimental studies [13]. Despite its use as a desensitizing agent, few clinical studies have examined the effectiveness of SDF in managing dentin hypersensitivity following vital tooth preparation. Hence, the primary objective of this research was to clinically evaluate the effectiveness of SDF in the management of immediate and delayed dentin hypersensitivity following teeth preparation. The hypothesis of the study was that topical application of SDF would not alleviate dentinal hypersensitivity.

METHODS

A single-arm prospective interventional with a before-and-after comparative design was conducted among patients aged 23-55 years who reported to the Dental Clinics at Al Zulfi, College of Dentistry, Majmaah University. The study proposal was approved by the Institutional Review Board bearing the reference number MUREC- Jun.19/COM-2023/23-9. The required permission to conduct the study was obtained from the Medical Director and the hospital's administrative head. Patients who met the eligibility criteria and reported to the Outpatient Department of Restorative Dentistry and Prosthodontics for crowns and bridges were consecutively selected for the study. The sample size (n= 25) was calculated using G*power software, with alpha set at 5%, beta at 10%, power at 90%, and an expected minimum difference of 1.5 units in the average sensitivity score before and after the intervention [14].

Eligibility Criteria

Subjects included in the study had at least one missing posterior tooth requiring a tooth-supported porcelain-fused-to-metal fixed dental prosthesis with vital abutment teeth, a normal periodontal ligament space, no hypersensitivity, and no previous restorations involving more than 50% of the tooth structure coronally. Exclusion criteria included patients taking anti-inflammatory drugs or analgesics, patients with neurological conditions affecting sensitivity perception, patients who had undergone periodontal surgery within the past 3 months, or patients using desensitizing agents in their oral hygiene regimen. Participants with multiple crown or root caries, or with gingival recession exposing the root surface, were also excluded, as these conditions can produce clinical symptoms similar to hypersensitivity following crown preparation. The baseline assessment (before tooth preparation) was intended to confirm that the abutment teeth were asymptomatic and to establish the magnitude of the sensitivity induced by preparation; the comparison used to assess change following application of 38% SDF was between 24 hours and one week (immediate versus delayed effect), at which timepoints all teeth were symptomatic.

Pre-operative Assessment

All patients underwent a comprehensive clinical oral examination prior to their inclusion in the study. Subjects were seated comfortably in a dental chair and examined under artificial illumination to assess their occlusal status, periodontal condition, and dentition. Bitewing radiograph and intra-oral periapical radiograph were made to rule out the presence of proximal caries/asymptomatic periapical pathology in the selected abutment teeth.

Prosthetic Procedure

Tooth preparation was performed according to standard prosthodontic principles after administration of local anaesthetic solution (Scandicaine 2%, Septodont, France), using a high-speed handpiece (NSK, Japan) and diamond burs (Shofu Inc., Japan) under copious air-water spray. All selected abutment teeth were prepared to receive a porcelain-fused-to-metal crown, and fabricated in a dental laboratory following standard laboratory protocols. For each participant, the selected abutment tooth was prepared with an axial reduction of 1.5mm, an occlusal reduction of about 2.0 mm and finally a shoulder finish line all around the tooth (Figure 1a). Braided retraction cord (SURE-CORD, Suredent, South Korea) was placed to expose the prepared finish line following which impression of the prepared tooth was made using addition silicone elastomeric impression material (3M Express, VPS, USA) using the two-step Putty reline technique. Provisional crowns (Protemp, 3M ESPE, USA) were fabricated and temporarily cemented using non-eugenol cement (RelyX TempNE, 3M ESPE, USA) during the same appointment. All dental materials used in the study, both in the clinical and laboratory settings, were manipulated according to the manufacturer's instructions.

Assessment of Dentin Hypersensitivity

Dentin sensitivity was assessed at multiple time points using the methodology previously described in the literature [15-17]. At baseline, the sensitivity of the selected abutment tooth following exposure to air blast, thermal stimulus, bite force,

and tactile stimuli was recorded prior to tooth preparation. An air-blast test was performed by directing a stream of air (approximately 40 psi) onto the smooth surface of the selected abutment tooth using a three-way syringe held 1 cm away, perpendicular to the tooth, as guided by the putty stent, custom fabricated with an access hole for this procedure (Figure 2a and 2b). The thermal stimulus was applied by irrigating the selected tooth with ice water (0-10˚C) from a plastic syringe. The abutment tooth was irrigated with 5 cubic centimeters (cc) of cold water through the hole in the stent for 5 seconds using a plastic syringe. The water was allowed to pool around the abutment tooth for 5 seconds, and the excess was then evacuated with a saliva ejector. Tactile stimulus was presented by running a sharp dental explorer at an acceptable probing force in the middle third of the crown height in a bucco-occlusal direction, followed by linguo-occlusal direction (Figure. 2c). All stimuli were applied on the buccal surface followed by the lingual surface of the selected abutment tooth at an interval of ten minutes [18].

Lastly, biting sensitivity was recorded by having participants bite a pre-formed cotton roll placed in the central fossa of the selected tooth (Figure. 2d). Sensitivity following each stimulus was recorded separately for the buccal and lingual surfaces using a visual analogue scale (VAS), ranging from 0 (no sensitivity) to 10 (the highest possible sensitivity).

Follow-Up Visit

All selected participants were invited to attend two follow-up visits: the first at 24 hours after temporary crown cementation and the second 1 week later. During the first follow-up visit, the temporary crown was removed gently, and the prepared tooth was cleaned with pumice slurry. The tooth was coated with 38% silver diamine fluoride solution (Advantage Arrest, Elevate Oral Care, USA) using a micro brush (Figure. 1a and 1c). After allowing the tooth to dry for 10 minutes, the patient's immediate postoperative sensitivity after SDF application to various stimuli was recorded as similar to baseline. Finally, the provisional crown was re-cemented (Figure. 1d). During the second follow-up visit, the delayed post-operative dentin sensitivity to various stimuli was re-assessed using the same procedure before cementing the final prosthesis using glass-ionomer cement (GC Fuji I, Japan). Thus, the time between crown preparation and delivery of the final prosthesis was 1 week.

Statistical Analysis

The data collected at baseline, 24 hours, and the end of one week were entered into a Microsoft Excel Spreadsheet and described using means and standard deviations. Normality was assessed with the Shapiro–Wilk test; as the data were not normally distributed, scores are presented as median and interquartile range (IQR) and non-parametric tests were used. The primary outcome was the VAS score for the air-blast stimulus on the buccal surface, as the sample-size calculation was based on this stimulus. The primary test of the null hypothesis was the comparison of this VAS score for the air-blast stimulus on the buccal surface, between 24 hour and one week, using the Wilcoxon signed-rank test, with $p < 0.05$ taken as evidence to reject the null hypothesis. The Friedman test was used first to check for an overall difference across baseline, 24 hours and one week, followed by the Wilcoxon signed-rank test for post hoc analysis. Pairwise comparisons (baseline vs 24 hours, 24 hours vs one week, baseline vs one week) were performed only when the Friedman test was significant. A p-value < 0.05 was considered statistically significant. All analyses were carried out using the Statistical Package for the Social Sciences (version 24.0, IBM SPSS Corp., Armonk, NY, USA).

RESULTS

The present study was conducted among 25 subjects, who included 13 males and 12 females, with a mean age of 39.76±10.01 years. Table 1 presents the descriptive VAS scores for dentin sensitivity in response to different stimuli on the buccal and lingual surfaces at baseline (before tooth preparation), 24 hours (after tooth preparation, SDF application to record immediate effect), and 1 week (after SDF application to record delayed effect). As all participants received 38% SDF and no concurrent control group was studied, the following results describe the temporal course of sensitivity in treated teeth only and are not comparative. The mean VAS score for sensitivity following air blast in the buccal surface of the selected teeth at baseline was 0.16±0.55, which increased to 4.92±3.67 at 24 hours and reduced to 2.8±2.77 at the end of one week of follow-up. The corresponding values for the lingual surface were 0.16±0.55, 5.24±3.56, and 3.04±2.73, respectively. The mean VAS score for sensitivity following tactile stimulation in the buccal surface at 24 hours was 1.48±2.12, and after one week, it was 1.48± 2.04, while on the lingual aspect, the scores were 1.56± 2.48 and 1.36± 1.93, respectively. The mean VAS score for sensitivity to cold stimulus at baseline on the buccal surface was 0.08±0.04, which increased to 4.84±3.7 at 24 hours and decreased to 3.4±3.35 after one week. On the lingual surface, the scores were 4.6±3.4 and 3.4±2.94 at 24 hours and after one week, respectively.

The mean VAS score for response to bite force was 1.12±1.51 at 24 hours and reduced to 0.76±2.09 after one week. The median VAS scores for sensitivity following air-blast at 24 hours and at the end of one week on the buccal surface were 5.00±7.00 and 2.00±5.00, respectively, and this difference was statistically significant compared with the baseline median score of 0.0±0.0 (Table 2). Similarly, on the lingual surface, the baseline median VAS score of 0.0±0.0 was significantly lower than the median VAS scores of 4.00±7.00 at 24 hours and 3.00±4.50 at the end of one week. The median VAS score for sensitivity in the buccal surface following tactile stimulus at 24 hours was 0.00±2.00, which was statistically significant when compared to the median VAS scores of 0.00±0.00 and 0.00±3.00 at baseline and at the end of one week, respectively (Table 2). On the lingual

Table 1: Descriptive VAS scores for Dentin Sensitivity in Response to Different Stimuli on the Bccal and lingual surfaces at baseline (before tooth preparation), 24 hours (Immediate Effect of SDF Application), and 1 week (Delayed Effect of SDF Application)

		Baseline		24 hours		One week	
Variable	N	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation
Air-Buccal	25	0.16	0.55	4.92	3.67	2.80	2.77
Air-Lingual	25	0.16	0.55	5.24	3.56	3.04	2.73
Tactile-Buccal	25	0.00	0.00	1.48	2.12	1.48	2.04
Tactile-Lingual	25	0.00	0.00	1.56	2.48	1.36	1.93
Cold water-Buccal	25	0.08	0.40	4.84	3.70	3.40	3.35
Cold water-Lingual	25	0.00	0.00	4.60	3.40	3.40	2.94
Bite force	25	0.00	0.00	1.12	1.51	0.76	2.09

Table 2: Intra-Group Comparison of VAS Score for Sensitivity following Various Stimulus at Baseline (before Tooth Preparation), 24 hours (Immediate Effect of SDF Application), and 1 Week (Delayed Effect of SDF Application)

		Baseline		24 hours		One week			post hoc analysis[b]		
Variable	N	Median	IQ R	Median	IQ R	Median	IQ R	p value[a]	24 hours - Pre-op	1 week- Pre- op	1 week -24 hours
Air-Buccal	25	0.00	0.00	5.00	7.00	2.00	5.00	<0.001*	<0.001*	<0.001*	0.003*
Air Lingual	25	0.00	0.00	4.00	7.00	3.00	4.50	<0.001*	<0.001*	<0.001*	0.003*
Tactile- Buccal	25	0.00	0.00	0.00	2.00	0.00	3.00	<0.001*	0.002*	0.937	0.002*
Tactile- Lingual	25	0.00	0.00	0.00	2.00	1.00	2.00	<0.001*	0.003*	0.001*	0.546
Cold water Buccal	25	0.00	0.00	4.00	7.50	2.00	7.00	<0.001*	<0.001*	<0.001*	0.007*
Cold water- Lingual	25	0.00	0.00	4.00	6.00	3.00	5.50	<0.001*	<0.001*	<0.001*	0.041*
Bite force	25	0.00	0.00	0.00	2.00	0.00	0.50	0.001*	0.003*	0.027*	0.13

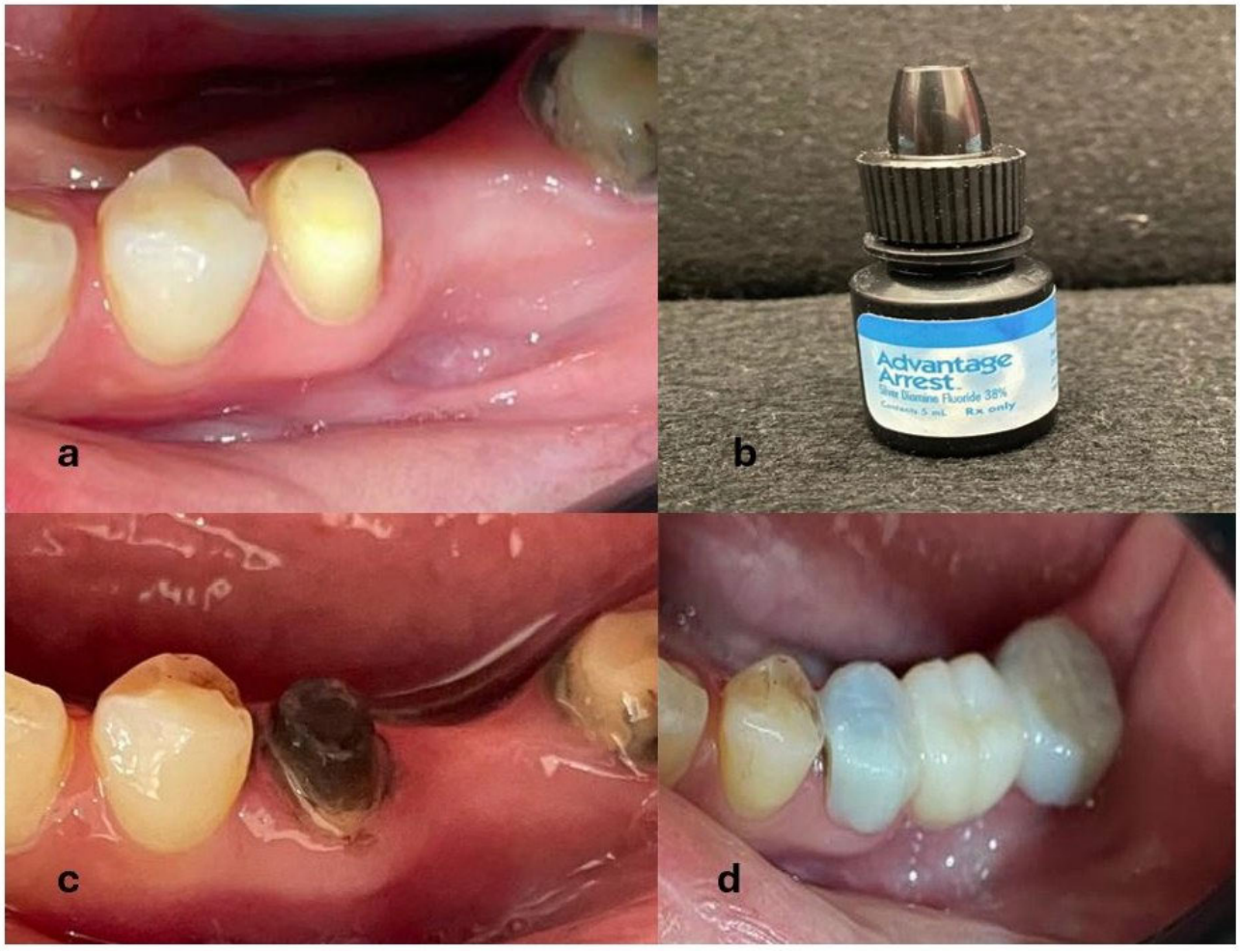

Figure 1: (a) Abutment Tooth Preparation for Porcelain-Fused-to-Metal Bridgework; (B) Premolar Abutment Tooth after Application of SDF Solution 24 Hours after Tooth Preparation; (c) 38% SDF Solution Used For Application; (d) Provisionalization of Bridgework Using Non-Eugenol Cement

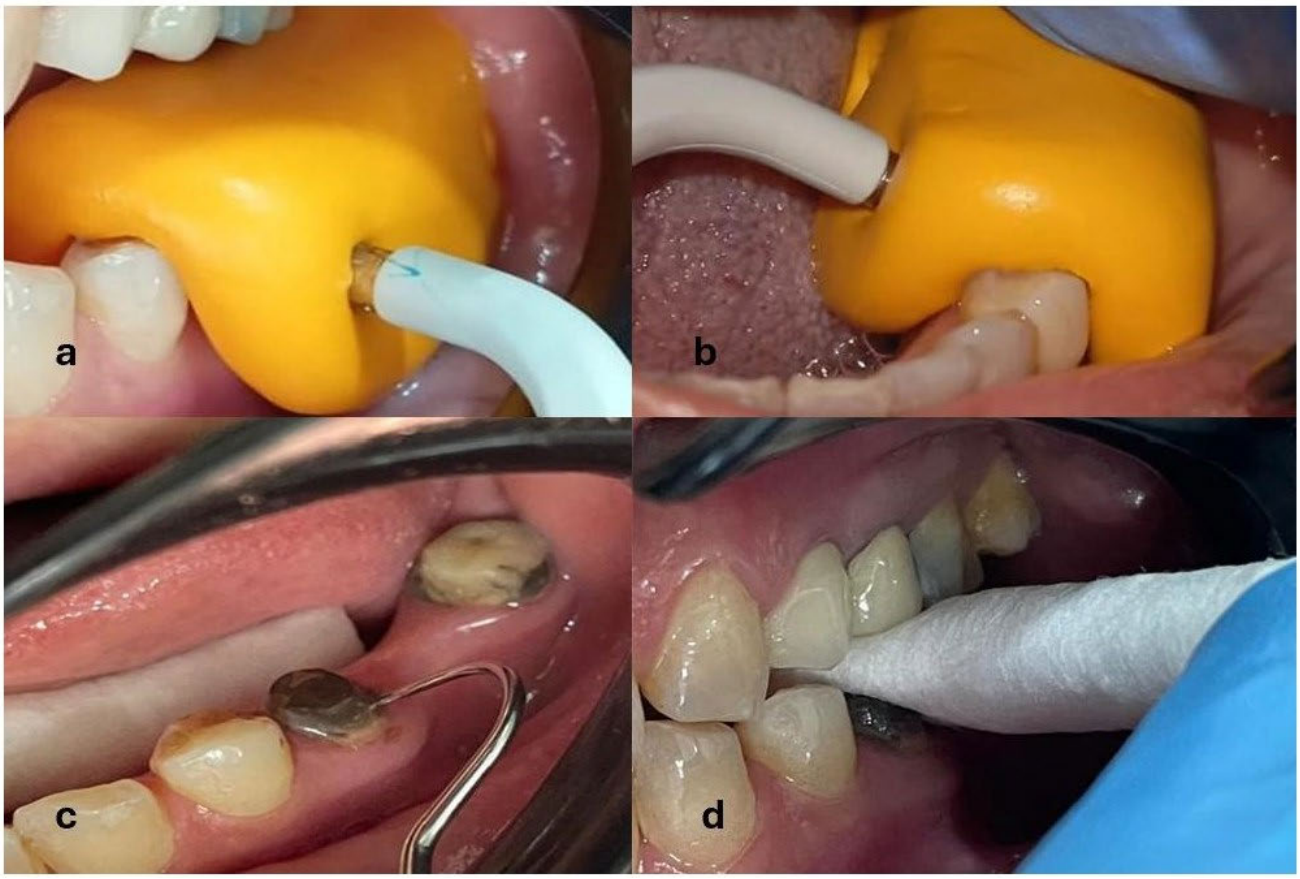

Figure 2: (a and b) Air Blast Evaluation on the Buccal And Lingual Surface of Prepared Abutment Tooth Respectively Using Custom Made Putty Guide; (c) Tactile Evaluation of the Abutment Tooth; (d) Bite Force Evaluation Using Cotton Roll

surface, the median VAS score at baseline was 0.00±0.00, which was significantly different from the median VAS scores of 0.00±2.00 at 24 hours and 1.00±2.00 at the end of one week. The median VAS score of 0.00±0.00 at baseline following cold stimulation on the buccal surface was statistically significant from the median VAS scores of 4.00±7.50 at 24 hours and 2.00±7.00 at the end of one week. Similarly, on the lingual surface, the median VAS score of 0.00±0.00 at baseline was statistically significant from the median VAS scores of 4.00±6.00 at 24 hours and 3.00±5.50 at the end of one week (Table 2). The median bite force score of 0.00±0.00 at baseline was statistically significant from the median bite force scores of 0.00±2.00 at 24 hours and 0.00±0.50 at the end of one week (Table 2).

DISCUSSION

The present study investigated the effect of SDF on dentinal hypersensitivity during tooth preparation. Following SDF treatment, prepared tooth surfaces became much less sensitive. Air blast, tactile stimulation, heat, and bite force were all used as sensitivity tests. Air blast, cold water, and tactile stimulation dramatically reduced postoperative dentin hypersensitivity. Due to dentinal tubule exposure, abutment tooth preparation frequently causes patient sensitivity. Crowns are typically cemented 3-4 days after tooth preparation to allow for trial prosthesis fitting, crown colour verification, and laboratory processing. Temporary crowns used to prepare abutment teeth may reduce external sensitivity [19]. Crown luting agents may irritate patients on the day of cementation. Approximately 65% of patients experience acute discomfort 24 hours after permanent prosthesis cementation [20]. Thus, replacing essential teeth with tooth-supported fixed partial dentures (FPDs) is a painful procedure [4,20]. Desensitising medications are used in this study to relieve discomfort following tooth preparation. Desensitising chemicals have been used in dentistry for many years to treat dentinal hypersensitivity. The usage of the following dental preparation has not been thoroughly investigated. There is minimal study on desensitising medications after tooth preparation. Potassium nitrate reduces sensitivity during essential tooth preparation, according to Jalalian *et al.* [21] Shetty *et al.* [22] demonstrated the effectiveness of calcium phosphate desensitising agents during tooth preparation. According to their findings, the calcium phosphate desensitising agent significantly lowered sensitivity before and after cementation. Sayed *et al.* discovered that all three commercial desensitizers reduced tooth preparation

hypersensitivity [23]. Despite proof, desensitising medicines remain controversial in clinical practice. According to Savitha *et al.* [24], dental practitioners have poor awareness, attitudes, and practices regarding the use of desensitising chemicals during tooth preparation, potentially contributing to the ongoing dispute over the use of desensitising medications in clinical practice. Since it is technique-independent, the SDF can be used on any patient, even the elderly and those with medical issues. Several investigations have shown that SDF lowers dentinal hypersensitivity [25]. They claim that the aqueous silver-fluoride solution clogs dentinal tubules, resulting in a squamous layer over exposed dentin. This decreases changes in dentinal tubule fluid and desensitises the tooth surface using chemical mechanisms. Several randomised controlled trials have demonstrated that SDF reduces carious lesion sensitivity. However, its role in sensitivity during essential tooth preparation remains unknown [26-27]. Recently, SDF outperformed potassium nitrate and glutaraldehyde in desensitising experiments [28]. In contrast to this study, the previous one did not assess post-operative sensitivity to a variety of stimuli. This is the first study to examine how SDF reduces dentinal hypersensitivity after essential tooth preparation using different types of stimuli. Pain is subjective, varying with age, gender, and other characteristics, making it difficult to quantify. Several studies used the Verbal Rating Scale to quantify crown cementation discomfort and sensitivity [29-30]. The Visual Analogue Scale (VAS) was used in this study for several reasons. First, the VAS is the most sensitive pain scale [31]. Patients can also select their pain degree more precisely with photos. Third, VAS is quantitative; conclusions are more reliable and generalisable. Several other studies, like this one, used VAS to quantify sensitivity [30,31]. External stimuli, including cold, mechanical, thermal, air, and tactile, can produce acute dentinal hypersensitivity. To boost dependability, this study included additional stimulus-specific assessments. Specific sensitivity tests, such as cold water, air blast, tactile feeling, and biting force, were administered. The current study did not follow up at 2 or 3 months, as previous research has shown that post- cementation sensitivity decreases within 1 month [22,28]. Cold-water, tactile, and air-blast tests revealed a significant decrease in postoperative dentin hypersensitivity following SDF treatment. SDF exerts pressure on the abutments via the retainers and has no effect on the temperature changes of the prepared teeth; it does not improve biting force sensitivity. SDF decreased cold, touch, and air-blast sensitivity. Clinical and epidemiological studies show that cold is the most common cause of dentinal hypersensitivity [32,33]. In practical practice, SDF may reduce cold- induced hypersensitivity, according to this study. Despite not employing ice, Castillo *et al.* [27] found significant pain reduction in response to air at 24 hours and 7 days following SDF treatment. They also discovered no gingival damage and merely transient discomfort following the procedure. Wolfart *et al.* [30] tested calcium hydroxide suspension and glutaraldehyde-based dentine primer for treating tooth hypersensitivity following full crown preparation. The study had a lengthy follow-up period (baseline, 7 days, 6 months, and 30 months) with a cold stimulus (20°C). Both materials decreased sensitivity without statistical significance. The present study did not include a long- term follow-up since the final prosthesis was permanently glued to the abutment teeth, making it impossible to apply all of the stimuli outlined in the technique. Since no control group was included in this experiment, the true effect of SDF on post-operative dentin hypersensitivity remained unknown. The study's limitations include a small sample size, a short follow-up period, and the absence of comparator groups. Future research, particularly randomised controlled trials, should examine how SDF reduces post-operative dentin hypersensitivity following dental preparation- induced sensitivity in large populations with long follow-up.

CONCLUSIONS

Within the limitations of this uncontrolled, single-arm study, a single application of 38% SDF to freshly prepared vital dentin was well tolerated, and sensitivity to air blast, cold water and bite force decreased significantly over the following week. Randomized controlled trials incorporating an untreated or placebo-treated control arm and longer follow-up are needed before 38% SDF can be recommended as a routine desensitizing step during fixed prosthodontic treatment.

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Institutional Review Board Statement

Ethical approval was acquired by the Deanship of Scientific Research at Majmaah University in Al-Majmaah, Saudi Arabia, with the Institutional Review Board (IRB) number MUREC- Jun.19/COM-2023/23-9. The study was conducted in complete conformity with the World Medical Association Declaration of Helsinki.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

Data will be available upon request to the corresponding author.

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Conflicts of Interest

The author declares no conflicts of interest.

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