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Effect of Interaction Between Lignocaine-Adrenaline and Sodium Hypochlorite on Coronal Seal of Post-Endodontic Restorations - An *in vitro* Study

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ABSTRACT

Intrapulpal injection is a commonly used supplemental anaesthetic technique in endodontics, and sodium hypochlorite (NaOCl) remains the gold-standard irrigant. The interaction between lignocaine–adrenaline and NaOCl produces a white precipitate that may reduce available chlorine and occlude dentinal tubules, potentially compromising the coronal seal of restorations. This in-vitro study evaluated the effect of this interaction on the coronal seal of endodontically treated teeth. Forty-five extracted single-rooted premolars were divided into three groups based on irrigant protocol: saline, 3 % NaOCl, and saline followed by 3 % NaOCl. After cleaning and shaping, obturation and composite restoration, specimens were immersed in 2 % methylene blue for seven days and dye penetration assessed under a stereomicroscope. Teeth irrigated with NaOCl exhibited significantly greater dye penetration compared with the other groups, indicating a compromised coronal seal.

Keywords: Coronal leakage; Intrapulpal injection; lignocaine hydrochloride; sodium hypochlorite.

INTRODUCTION

Fear and anxiety associated with endodontic treatment can be reduced significantly with effective pain management [1]. Pain-free treatment requires effective local anaesthesia. In root canal therapy, 2% lignocaine with 1:80,000 or 1:100,000 adrenaline is commonly used, with inferior alveolar nerve block for mandibular teeth and infiltration for maxillary teeth providing adequate pulpal anaesthesia. [2]. Many factors, such as the individual variations in response to the drug administered, operator differences, and anatomical variations, apart from decreased pH, altered membrane excitability of peripheral nociceptors, and increased tetrodotoxin-resistant sodium channels are responsible for the reduced anaesthetic effect [3,4]. Teeth with symptomatic irreversible pulpitis are difficult to anaesthetize, which subsequently require supplemental techniques such as intraligamentary, intraosseous or intrapulpal injection techniques to achieve complete pulpal anaesthesia [5]. When administered as intrapulpal injection (IPI), the local anaesthetic solution remains in the access cavity and may interact with the irrigating solutions. Following access cavity preparation, sodium hypochlorite (NaOCl) in various concentrations (0.5 % to 5.25%) is the commonly employed primary endodontic irrigant due to its excellent pulp tissue dissolution and dentine disinfecting capabilities.

Vidhya, et al. reported that a white precipitate was observed when NaOCl was loaded in a syringe which was used to load local anaesthetic solution [6]. Saravanakarthikeyan, et al reported, the precipitate formed on the interaction between 2% LA solution and 2.5% NaOCl tends to occlude the dentinal tubules at the coronal, middle, and apical root thirds. The chemo-mechanical rotary instrumentation procedure did not effectively remove the precipitate [7]. For successful endodontic outcome, after cleaning and shaping, coronal seal is more and equally important than apical seal [8,9,10]. To determine the possible effect of this precipitate on the sealing ability of post endodontic restoration, aim of the study is to evaluate the effect of interaction between lignocaine hydrochloride with Adrenaline and sodium hypochlorite solution on coronal seal of post endodontic restoration.

MATERIALS & METHODS

The Declaration of Helsinki and principles of good clinical practice were followed.

Sample size determination

The sample size was determined based on previously published in vitro studies assessing coronal microleakage using dye penetration methods, which demonstrated statistically significant differences with 12–15 specimens per group [19]. Assuming an effect size of 0.8, a power of 80%, and a significance level of 5%, the minimum required sample size was calculated to be 13 specimens per group. To allow for potential specimen loss during preparation and sectioning, 15 teeth were included in each group, resulting in a total sample size of 45 specimens.

Forty-five Human Mandibular Premolars extracted for Orthodontic and Periodontal reasons with inclusion criteria of mandibular premolars with straight single rooted mature apex with single root canal and teeth with extensive caries, curved roots, multiple canals, resorption, endodontically treated tooth were excluded. The specimens were washed to remove blood & saliva, tissue debris covering the tooth surface were removed using sickle scaler. The teeth were stored in 1% phosphate buffered saline in Humidor at 37^0C and 100% humidity until being used. To restrict dye penetration to the coronal aspect, the apical foramen was sealed with composite resin prior to dye immersion. Then specimens were placed in a transparent small plastic container into which a soft polyvinyl siloxane impression material has been embedded and excess material trimmed off.

Standardized conventional Access cavity preparation was done using Endo access bur (Dentsply Maillefer, Switzerland). 2% lignocaine with 1:80,000 adrenaline was administered as intra-pulpal anaesthesia. The initial patency was obtained using 10K file. The working length was established using 10K file until the tip of file seen from the apical foramen and by subtracting 1mm from length of the file. Size #15 and #20 hand file is passively inserted into the coronal two thirds of a root canal as path-finding files, which confirm the presence of smooth, reproducible glide path. Rotary instrumentation was done using X-Smart Endomotor (Dentsply Maillefer, Switzerland) and Protaper GOLD rotary file system. Final apical preparation was done till F_3(30/0.09) in a non-brushing motion at a speed of 300rpm and torque of 1.6 Ncm.

Based upon the irrigant used for cleaning, samples were divided into three groups. Group-I- 0.9% Saline was used to irrigate the canals between subsequent change of files during instrumentation. Group-II - 3% NaOCl (Prime Dental products Pvt Ltd.)

was used to irrigate the canals between subsequent change of files during instrumentation. Group-III- 0.9% Saline + 3% NaOCl was used to irrigate the canals. Irrigating solution was delivered using a 30-gauge side vented needle (Neo-endo, Orikam health care India, Gurugram, Haryana) to the working length. 2mL of the irrigant is used for canal irrigation after using each instrument and before proceeding to next. A total of 10mL of irrigant is used during the preparation of the canal. Following completion of canal preparation, a final rinse with 5 mL of 17% ethylenediaminetetraacetic acid (EDTA) was performed for 1 minute to remove the smear layer. The canals were then dried using sterile paper points prior to obturation. The prepared root canals were dried and obturated using single cone technique with guttapercha and AH plus sealer. Access cavities were restored using a nanohybrid resin composite (Tetric N-Ceram, Ivoclar Vivadent) placed incrementally following an etch-and-rinse adhesive protocol. Samples were immersed in 1% methylene blue dye for 7 days.

After 1week, the samples were longitudinally split in buccolingual direction using low speed diamond saw and examined under the stereomicroscope (×20 magnification) (Leica Microsystems, Wetzlar, Germany) to evaluate the dye penetration from the coronal end to root canal space. The dye penetration was measured in millimeter(mm) values starting from the coronal end of restorative surface to the point where dye penetration ends using a digital vernier caliper.

Statistical Analysis

The depth of dye penetration was calculated and values are tabulated. The statistical analysis was performed using SPSS 24.0 software (IBM SPSS, Chicago, IL, USA). The confidence interval was set to 95% and $p < 0.05$ was considered to be significant. Descriptive data (table-1) shows the mean values and standard deviation of group-I (1.79±0.03), group-II (4.0 ± 0.71), group-III (1.1 ±0.42). Mean comparison of micro leakage between groups was done using one way ANOVA as shown in (table-2). The highest dye penetration was noted in group-II(fig 2) , 3% NaOCl ($p<0.04$) followed by group-I(fig 1), 0.9%saline ($p<0.02$) and group-III, 0.9% Saline + 3% NaOCl ($p<0.01$) (fig 3) with the significant difference among the tested groups.

RESULT

Table 1: Mean values of micro leakage of groups

GROUPS	Mean ± SD
Group 1 (CONTROL)	1.79 ± 0.03
Group 2 (SODIUM HYPOCHLORITE)	4.0 ± 0.71
Group 3 (SALINE+SODIUM HYPOCHLORITE)	1.1 ± 0.42

Table 2: Mean comparison of micro leakage between groups using one way ANOVA test

GROUPS		Sum of squares	df	Mean square	F	p value
Group 1 (CONTROL)	Between Groups	0.015	12	0.001	50.144	0.02
	Within Groups	0.000	2	0.000		
	Total	0.015	14			
Group 2 (SODIUM HYPOCHLORITE)	Between Groups	6.386	9	0.710	5.250	0.04
	Within Groups	0.676	5	0.135		
	Total	7.062	14			
Group 3 (SALINE+SODIUM HYPOCHLORITE)	Between Groups	2.503	9	0.278	9.066	0.01
	Within Groups	0.153	5	0.031		
	Total	2.656	14			

Figure 1: 0.9%saline

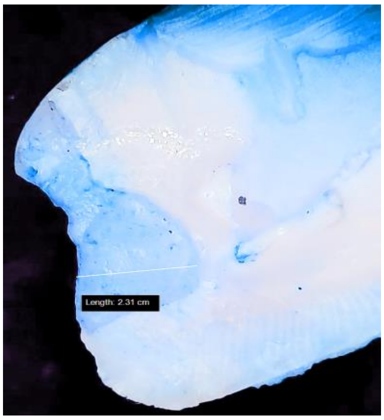

Figure 2: 3% NaOCl

Figure 3: 0.9% Saline + 3% NaOCl

DISCUSSION

In endodontic practice, effective pain management and thorough canal disinfection are critical for the success of root canal therapy. IPI is a common supplemental anaesthesia technique employed to achieve profound pulpal anaesthesia in cases where conventional methods are inadequate. Lignocaine hydrochloride with adrenaline is frequently used in IPI due to its potent anaesthetic properties and vasoconstrictive effects, which prolong the duration of anaesthesia and reduce bleeding [3].

Sodium hypochlorite (NaOCl) is widely regarded as the gold standard irrigating solution in endodontics due to its potent antimicrobial properties and ability to dissolve organic tissue. However, NaOCl is known to interact with various irrigants used during endodontic procedures, potentially affecting its efficacy and the overall outcome of the treatment [11].

Basrani et al., reported that the interaction between NaOCl and CHX resulted in the formation of para-chloro-aniline precipitate, which is a known carcinogen [12,13]. Rasimick et al., reported the formation of a highly insoluble pink powdery precipitate when 17% EDTA and 1% CHX were mixed, but this was found to be non-toxic [14].

Vidhya, et al. reported that a white precipitate was observed when NaOCl was loaded in a syringe which was used to load local anaesthetic solution. Interaction between lidocaine hydrochloride and NaOCl resulted in the formation of a toxic precipitate, 2,6-xylidine, a known carcinogen. The reason attributed to the formation of the 2,6-xylidine compound was due to the acid hydrolytic reaction between lidocaine hydrochloride and NaOCl. When NaOCl interacts with local anaesthetic solution (i.e., lidocaine hydrochloride with and without adrenaline), it liberates hypochlorous acid that combines with carbon atoms present in the lidocaine hydrochloride, resulting in the disruption of the molecule with subsequent cleavage of the double bond. On further hydrolysis, 2,6-xylidine precipitate was formed [6].

Gurucharan et al. reported reduction in free active chlorine content of NaOCl when admixed with lignocaine HCl even in small proportions [15]. Hence, adequate measures should be taken to remove the residual LA from the pulpal space, before the use of NaOCl after IPI administration. Rossi-Fedele et al., suggested intermediate flushing out of NaOCl with saline, water or alcohol prior to the use of chlorhexidine to prevent the toxic interactions. Hence, following the administration of intra-pulpal anaesthesia, flushing out the residual lidocaine hydrochloride with saline, prior to the use of NaOCl might prevent the formation of 2,6-xylidine precipitate [16].

Sneha et al., have reported that the precipitate formed on interaction between 2%LA solution and 3% NaOCl occluded the dentinal tubules at coronal, middle and apical thirds which was not removed even after chemo-mechanical rotary instrumentation procedure [17]. No irrigation protocol was successful in removing the precipitate formed; but when compared ultrasonic irrigation had the least precipitate seen at coronal, middle and apical thirds [18].

Previous studies have reported that any precipitate present can obstruct the creation of an impervious seal, which is crucial for supporting the healing of the affected tooth [19,20]. The presence of a precipitate in the pulp chamber could hinder the sealing of the restoration following endodontic treatment. According to a recent report by Chauhan et al., the carcinogenic precipitate 2,6-xylidine was found to cause significant microleakage, thus negatively impacting the impervious seal of the filling.

This study is important from a clinical perspective as the IPI technique is commonly used in teeth when traditional anaesthetic methods have been unsuccessful, offering the additional benefit of minimal systemic impact. It has been confirmed in various studies [6,7,11,20] that the precipitate formed would remain attached to root canal dentin and influence apical seal, blocks the dentinal tubules and prevents penetration of irrigants, intracanal medicaments and sealers. However, its influence on coronal seal of post endodontic restorations is not evaluated till date. Hence, the present study was conducted. Therefore, it is recommended to avoid using NaOCl immediately after IPI with LA solution to prevent these harmful effects.

The possible interaction of adrenaline–irrigant precipitate with chelating agents, sealers, obturating materials, and restorative materials was not evaluated and remains a limitation of the present study. This in vitro study focused on the chemical interaction between lignocaine–adrenaline and sodium hypochlorite and its effect on the coronal seal, rather than replicating in vivo conditions. The absence of thermocycling may limit direct extrapolation of the findings to clinical scenarios. Methylene blue dye was used due to its low molecular weight and proven sensitivity for detecting microleakage in in vitro studies. Although fluorescent dyes and advanced techniques such as fluid filtration and micro-computed tomography provide more precise evaluation, the dye penetration method remains a reliable and widely accepted screening tool for comparative assessment of coronal leakage.

CONCLUSION

Within the limitations of this in vitro study, interaction between lignocaine hydrochloride and sodium hypochlorite compromised the coronal seal of post-endodontic restorations; saline irrigation prior to sodium hypochlorite may minimize this effect.

Declaration by Authors

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