ORIGINAL RESEARCH

An *In Vitro* Evaluation of the Smear Layer Removal Efficacy of Three Different Chemical Decalcifying Agents on Periodontally Compromised Root Surfaces: A Scanning Electron Microscopy Study

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Abstract

Aim: Aim of the current research was to assess the smear layer removal efficacy of SofScale, Carisolv gel, and QMix chemical decalcifying substances on periodontally weakened radicular surfaces.

Materials and methods: The sample size constituted 60 recently extracted periodontally compromised teeth having a poor prognosis. The samples were allocated at random to one of the following three groups (20 in each): Group I: Scaling and root planing (SRP) with SofScale, Group II: SRP with Carisolv gel, and group III: SRP with QMix. The surfaces thus subjected to treatment were washed with 20 mL of saline and the crown portion was detached at the cementoenamel junction (CEJ). Following this, samples were horizontally and vertically segmented employing a diamond circular disk with 150–200 µm thickness. Every sample segment was subjected to rinsing in normal saline and positioned in 2.5% glutaraldehyde solution in 0.1 M phosphate buffer at a pH of 7.4 for at least 24 hours. Samples were evaluated in a scanning electron microscopy (SEM) at a magnification of 2000×, and photomicrographs were assessed to establish the degree of radicular biomodification by eliminating the smear layer.

Results: QMix group showed the highest smear layer elimination at 3.56 ± 0.13 in pursuit by Carisolv gel at 3.64 ± 0.11 and SofScale group with 4.68 ± 0.08. The differences amid the groups were statistically significant with $p < 0.001$. On multiple contrast assessments of smear layer elimination effectiveness of the dissimilar chemical decalcifying substances employing Tukey's HSD, statistically significant differences were noted between group I and group II, as well as group I and group III ($p < 0.001$). However, there were no significant differences between group II and group III ($p > 0.001$).

Conclusion: In conclusion, QMix was noted to have a superior smear layer elimination capacity in comparison with the radicular surfaces conditioned with Carisolv and SofScale.

Clinical significance: Modifying the surface of teeth by radicular conditioning causes the enhanced attachment of connective tissues coupled with progression in the final aim of reconstructive periodontal therapy. The utility of chemical substances along with physical management characterizes the probability of reduced trauma during treatment, avoiding the sacrifice of radicular portions of teeth.

Keywords: Periodontally compromised teeth, Scaling and root planing, Scanning electron microscopy, Smear layer.

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Introduction

Persistent chronic inflammation caused by microbial biofilm is pathognomonic of periodontal pathosis. The evolution of periodontitis is linked to an accumulation of bacteria in the subgingival, the toxins arising from which are wrapped permanently onto the cementum, serving as a blockade to periodontal tissue attachment. This subsequently enhances irritation, breakdown of collagen, and continued annihilation of alveolar bone, periodontal ligaments, and cementum.[1]

Conventional SRP techniques depend on the physical elimination of plaque, calculus plus toxins that are adherent to the radicular surface as well as the infected cementum. Though the efficiency of SRP is proven, the value of this management has been recently in question. In addition, the smear layer that is left over following the use of instruments can be detrimental to the healing of the periodontium.[2] Recently, there is an increasing inclination towards the utility of root detoxification that is chemically aided. These chemicals are hypothesized to promote the elimination of calculus, smear layer as well as endotoxins

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linked to the radicular portion. Also, they aid in decalcification of the planed radicular surface, exposure of the collagen matrix of dentin/cementum, thereby rendering a biologically suitable surface leading to regeneration of a fresh connective tissue connection.[3] As the radicular surface provides a wound border for the duration of regeneration, it is hypothesized that the same is essential to recuperate the radicular surface for cell attachment as well as fiber inclusion by means of chemical modifying substances.[4]

"Layer of grinding debris" refers to the smear layer made up of microcrystal fragments that is generated at the time of use of instruments. This practically blocks the opening of the dentin tubules. This layer which is approximately 2–15 µm thick is composed of organic/inorganic substances, with particle sizes ranging from <1 µm to >15 µm. This smear layer is closely linked to the surface of the tooth and can apparently be subject to removal only by the use of solutions that cause demineralization. SofScale is composed of chelating ingredients including disodium EDTA and detergent sodium lauryl sulfate that aid in dissolving calculus. QMix® is composed of a combination of bisbiguanide antibacterial, a polyaminocarboxylic acid calcium-chelating substance, saline, plus surfactant that are documented to be superiorly efficacious against microbial plaque. The key component of Carisolv was sodium hypochlorite which was coupled with three amino acids. The resultant gel showed the ability to eradicate the organic constituents of radicular cementum or calculus as it does with dental caries. In addition, this gel exhibited the capacity to lessen the smear layer creation.[5]

Among the highly competent implications of SofScale, Carisolv gel as well as QMix solution in the branch of Periodontology, is the ability for chemical dissolution of calculus along with the infected radicular cementum in order to promote their mechanical removal. Thus, the current research was performed to assess the smear layer removal efficacy of three different chemical decalcifying agents on periodontally compromised radicular surfaces.

Materials and Methods

Preparation of Samples

The current *in vitro* research was performed in the Department of Periodontics, Guru Gobind Singh Institute of Dental Sciences and Research Centre, Madhya Pradesh, India. A total of 60 teeth were included in the present study. Ethical approval and informed consent were obtained. Periodontally compromised teeth with a single root, supra/subgingival calculus but devoid of dental caries and having a poor prognosis were included. Exclusion criteria were teeth exhibiting wasting disorders, fracture, root canal treatment, and prosthetic restorations. Subsequent to extraction, the specimens were subjected to storage in normal saline.

Sample size was calculated by using $n = \frac{Z^2_{1-\alpha/2}}{d^2}$ formula. n was the total required sample, $z_{1-\alpha/2}$ was a constant, and d was an absolute precision 20%. Unhealthy root surfaces with attached calculus were selected as the therapy regions and were subjected to delimitation with a round bur. Following this, allotted 20 samples in each group are as follows:

Group I: SRP with SofScale™: This was coated to the delimited area on every root surface for 2 minutes. Radicular surfaces were subjected to instrumentation with Gracey curettes by means of 15 strokes in coronoapical direction, this was parallel to the long axis of the tooth.

Group II: SRP with Carisolv gel: This gel was subjected to burnishing onto the delimited regions for 30 seconds, with a non-reusable microbrush tip. Radicular surfaces were subjected to instrumentation using Gracey curettes, in a similar way as delineated in group I.

Group III: SRP with QMix®: This was applied for 2 minutes, and the radicular surfaces were subjected to instrumentation using Gracey curettes, in a similar way as delineated in group I.

The surfaces thus subjected to treatment were washed with 20 mL of saline and the crown portion was detached at the CEJ. Following this, samples were horizontally and vertically segmented employing a diamond circular disk with 150–200 µm thickness. Every sample segment was subjected to rinsing in normal saline and positioned in 2.5% glutaraldehyde solution in 0.1 M phosphate buffer at a pH of 7.4 for at least 24 hours.

Preparation of Samples for SEM Examination

Following chemical management, the specimens were subjected to dehydration in graded series of ethanol (10–90%) and ultimately in 100% acetone for 30 minutes. Sample teeth were dried beneath a lamp, positioned on aluminum stubs, and subjected to insertion in an SC7640 sputter coater machine to facilitate gold/palladium coating on the specimens (Fig. 1).

Evaluation of Photomicrographs

Photomicrographs were disseminated to standardized trained single-blinded observer (kappa score was 0.80) for evaluating the degree of smear layer elimination as per the radicular surface alteration index (Sampaio's index). The scoring is as follows:

Score 1: Radicular surface devoid of smear layer, dentinal tubules entirely open; no evidence of smear layer within dentinal tubular breaches.
Score 2: Radicular surface devoid of smear layer, dentinal tubules entirely open; evidence of smear layer within dentinal tubular breaches.
Score 3: Radicular surface devoid of smear layer, dentinal tubules partly open.
Score 4: Radicular surface coated with smear layer, having uniform characteristics; evident dentinal tubular gaps.
Score 5: Radicular surface coated with smear layer, having uniform characteristics; no evident dentinal tubular gaps.
Score 6: Radicular surface coated with smear layer, with unequal characteristics and existence of grooves and/or sprinkled debris.

Statistical Analysis

The data thus collected were subjected to statistical analysis using Statistical Package for the Social Sciences software version 19 for Windows (SPSS Inc., Chicago, IL, USA). Results were expressed in standard deviation and mean. ANOVA and Tukey's *post hoc* statistical tests were utilized next to determine the statistically

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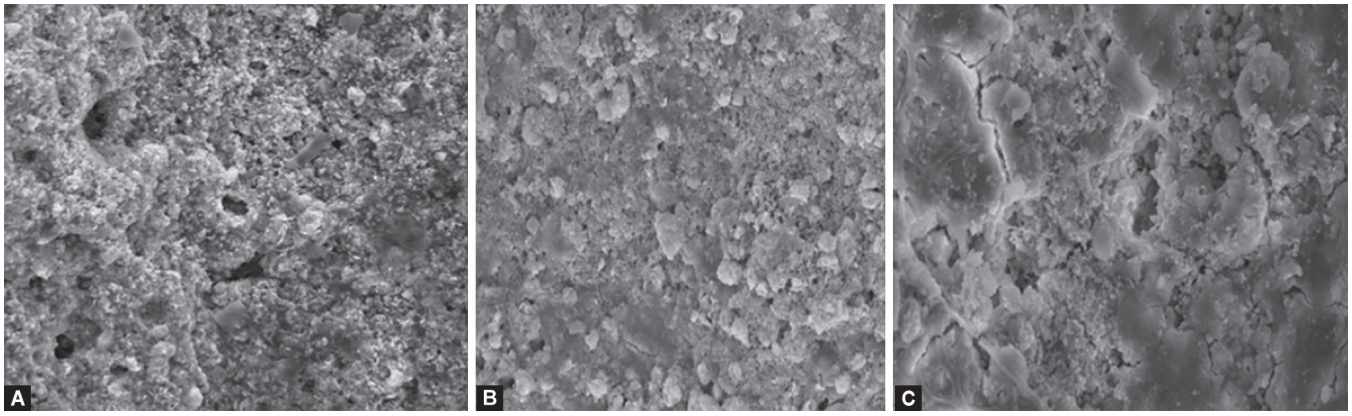

Figs 1A to C: SEM images of (A) SofScale; (B) Carisolv gel; and (C) QMix chemical decalcifying agents

Table 1: Evaluation of mean smear layer removal efficacy of three different chemical decalcifying agents

Chemical decalcifying agent groups	*Mean ± SD*
Group I: SofScale	4.68 ± 0.08
Group II: Carisolv gel	3.64 ± 0.11
Group III: QMix	3.56 ± 0.13

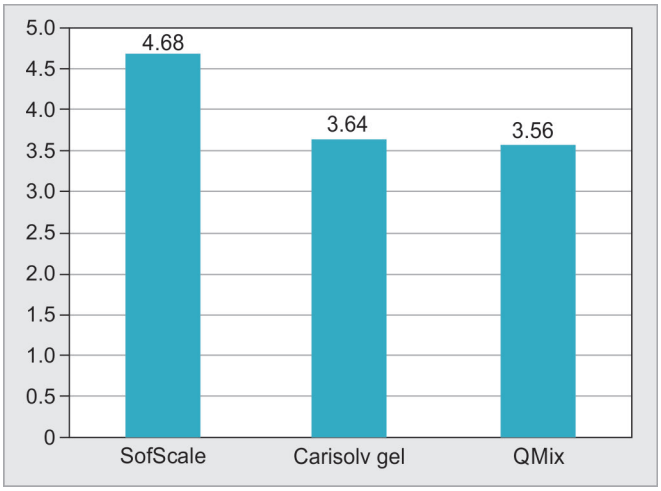

Fig. 2: Mean smear layer removal efficacy of three different chemical decalcifying agents

Table 2: Comparison of mean smear layer removal efficacy of three different chemical decalcifying agents

Chemical decalcifying agent groups	*Mean ± SD*	*F value*	*p value*	*Significance*
Group I: SofScale	4.68 ± 0.08	28.316	0.001	HS
Group II: Carisolv gel	3.64 ± 0.11			
Group III: QMix	3.56 ± 0.13			

p <0.05; HS, highly significant

significant differences among every group. A *p*-value of <0.05 signified statistical significance.

Results

Table 1 depicts the mean smear layer elimination efficiency of three different chemical decalcifying substances. SofScale substance cohort exhibited a mean smear layer elimination efficiency of 4.68 ± 0.08, Carisolv gel showed 3.64 ± 0.11, while QMix delineated effectiveness of 3.56 ± 0.13 (Fig. 2).

Table 2 shows the comparison of mean smear layer elimination efficiency of 3 dissimilar chemical decalcifying substances. QMix cohort showed the highest smear layer elimination at 3.56 ± 0.13 in pursuit by Carisolv gel at 3.64 ± 0.11 and SofScale group with 4.68 ± 0.08. The differences amid the groups were statistically significant with *p* <0.001.

Table 3 delineates the multiple contrast assessment of smear layer elimination effectiveness of the dissimilar chemical decalcifying substances employing Tukey's HSD. Statistically significant differences were noted between group I and group II with a mean difference of 1.04, as well as group I and group III with a mean difference of 1.12 (*p* <0.001). However, there were no significant differences among group II and group III (mean difference was 0.08) (*p* >0.001).

Table 3: Multiple comparisons of smear layer removal efficacy of three different chemical decalcifying agents groups using Tukey's HSD

Group	*Compared with*	*Mean difference (I–J)*	*Sig.*
Group I	Group II	1.04	**0.001**
	Group III	1.12	**0.001**
Group II	Group I	–1.04	**0.001**
	Group III	0.08	0.064
Group III	Group I	–1.12	**0.001**
	Group II	–0.08	0.064

Bold values represents statistically significant; Sig., significant, *p* <0.05

Discussion

The chief goal of regenerative periodontal regenerative management is a modification of the radicular surface afflicted with periodontal inflammation, rendering it a generous medium to promote and assist movement, growth, attachment as well as an appropriate phenotype of periodontal connective tissue stem cells. Nevertheless, the radicular surfaces afflicted by periodontal pathosis are hyper-mineralized, infected with cytotoxic and certain materials that are energetic biologically. Such a surface is not biologically suited to adjoining periodontal cells, whose growth and multiplication are critical for the cure of periodontal wounds. Owing to such complexity, it is not feasible to attain decontamination of radicular surfaces afflicted by periodontal disorders using physical methods as the sole treatment technique.[6]

With time, SRP has been documented as an aid for developing a biologically friendly radicular surface for surrounding periodontal cells and tissue structures. Nevertheless, such traditional therapeutic strategies lead to the formation of a thin smear layer on the surface of tooth roots which is detrimental to wound healing. Thus, chemical as well as physical therapies coupled together are best suited to aid in decontamination plus the elimination of smear layer, decalcification of radicular surface, and exposure of dentinal collagen matrix, that promote the production of a novel periodontal fiber connection.[7]

Multiple research have demonstrated that following the use of ultrasonic/specialized burs employed manually, a smear layer is produced that lies on the radicular surface that is apparently spotless. Such layers present an unsuitable parameter for healing of the periodontium and are detrimental to therapeutic aids applied for cervical hypersensitivity following the use of instruments with particular agents on the radicular surfaces. On the contrary, the dentin tubular exposure may represent an auxiliary parameter in clot stability in the initial phases of periodontal healing by escalating the adhesion ability of vascular cells plus fibrin on the radicular surface, or also enhancing the preservation and contact of certain substances like enamel matrix, that serves as a growth factor. Numerous agents have been implicated for radicular surface conditioning following SRP with certain having higher cytotoxic capacity than others.[8]

This current research utilized SofScale, Carisolv gel, and QMix and showed that these have constituents that promote highly efficient removal of the smear layer. SofScale is composed of chelating ingredients including disodium EDTA and detergent sodium lauryl sulfate that aid in dissolving calculus. QMix® is composed of a combination of bisbiguanide antibacterial, a polyaminocarboxylic acid calcium-chelating substance, saline, plus surfactant that are documented to be superiorly efficacious against microbial plaque. Sodium hypochlorite was the main element in Carisolv that was coupled with three amino acids. The resultant gel showed the ability to eradicate the organic constituents of radicular calculus or cementum, like it does with dental caries. In addition, this gel exhibited the capacity to lessen the smear layer creation, since it was frequently employed alongside mechanical instrumentation, hence performing also as a lubricant.[5] This research assessed the efficacy of radicular decalcifying substances with the aid of an SEM. This has enhanced resolution, better magnification at the interface, as well as superior field depth.

According to this research, noteworthy efficiency of eliminating smear layer was established with the use of QMix vs SofScale and Carisolv gel. This is in accordance with the research of Shewale et al.[6] The benefits of QMix stem from its various constituents like CHX, EDTA, plus a detergent that serves as a surface active substance. Dai et al.[9] found QMix to be equal in efficiency as 17% EDTA in smear layer elimination. Stojicic et al.[10] assessed the effectiveness of QMix and the capability for smear layer elimination by means of SEM, and they suggested that QMix was better than other substances under lab circumstances.

An efficient active application of Carisolv gel was significantly superior in taking off the smear layer from the radicular surface vs with the use of SofScale. This is in accordance with the findings of prior research by Sterrett et al.[11] and Gohil et al.[12] who noted the absence of the smear layer following several applications of the Carisolv gel. When numerous applications of Carisolv with SRP were done, there was a reduction in smear layer vs passive plus active applications. This Carisolv gel was also capable of removing the infected layer of cementum while exposing healthy underlying tissues. These outcomes are in harmony with that of prior research by Banerjee et al.[13]

Yazici et al.[14] and Cederlund et al.[15] noted that Carisolv was unsuccessful in removing the dentinal smear layer. This is not astounding as the utility of Carisolv gel was suggested as a supportive treatment measure to SRP for the elimination of calculus as well as contaminated cementum. Therefore, it should be applied prior to radicular scaling and not following the same. This can demonstrate the restricted efficiency of a solitary application of Carisolv gel on smear layer elimination. Numerous research studies have demonstrated that a single session of closed radicular instrumentation does not attain the objective of entire removal of calculus deposits.[16]

In the present study, root surfaces treated with the Qmix agent group showed lesser smear layer presence as compared to root surfaces treated with the Carisolv gel group and SofScale group. Thus, QMix has a better smear layer removal ability as compared to other chemical agents.

The limitations of this research are that it was performed in *in vitro* situations. In a clinical setting, reflecting flap to gain contact and visualization for performing SRP is challenging to get rid of the calculus totally from the radicular surfaces. Additional research is warranted to examine if these substances can enhance the elimination of the smear layer and ascertain whether the morphological changes of radicular surfaces caused by chemo-mechanical treatment may provide a biologically suitable situation for periodontal healing.

Conclusion

The current research arrived at a conclusion that chemical and mechanical management led to noteworthy alterations in radicular surface morphological traits of periodontally deteriorated teeth. Radicular surfaces that were subjected to treatment with QMix exhibited lower smear layer existence vs radicular surfaces conditioned with Carisolv gel and SofScale. QMix was noted to have a superior smear layer elimination capacity in comparison with the other chemical agents.

References

1. Houshmand B, Ghandi M, Nekoofar MH, et al. SEM analysis of MTAD efficacy for smear layer removal from periodontally affected root surfaces. J Dent (Tehran) 2011;8(4):157–164. PMID: 22509454.
2. Avirdsson A, Liedberg B, Möller K, et al. Chemical and topographical analyses of dentin surfaces after CarisolvTM treatment. J Dent 2002,30(2–3):67–75. DOI: 10.1016/s0300-5712(01)00051-3.
3. Grisi DG, Theodoro LH, Sampaio JEC, et al. Scanning electron microscopic analysis of the effect of CarisolvTM gel on periodontally compromised human root surfaces. Braz Dent J 2006;17(2):110–116. DOI: 10.1590/s0103-64402006000200005.
4. Mariotti A. Efficacy of chemical root surface modifiers in the treatment of periodontal disease. A systematic review. Ann Periodontol 2003;8(1):205–226. DOI: 10.1902/annals.2003.8.1.205.
5. Nawathe AA, Deshpande NC, Dandekar SA. A comparative scanning electron microscopic analysis of the effect of QMix® and SofScale™ as an adjunct to scaling and root planing on periodontally compromised root surfaces: an *in vitro* study. Contemp Clin Dent 2017;8(3):427–432. DOI: 10.4103/ccd.ccd_539_17.
6. Shewale A, Gattani D. A novel root biomodifier containing chlorhexidine and EDTA–an ESEM analysis. Int J Curr Res 2015;

7(8):19143–19146. https://www.journalcra.com/sites/default/files/issue-pdf/10069.pdf.
7. Vandana KL, Sadanand K, Cobb CM, et al. Effects of tetracycline, EDTA and citric acid application on fluorosed dentin and cementum surfaces: an in vitro study. Open Corrosion J 2009;(2):88–95.https://benthamopen.com › TOCORRJ-2-88.
8. Froum S, Lemler J, Horowitz R, et al. The use of enamel matrix derivative in the treatment of periodontal osseous defects: a clinical decision tree based on biologic principles of regeneration. Int J Periodontics Restorative Dent 2001;21(5):437–449. PMID: 11693237.
9. Dai L, Khenchen K, Khan S, et al. The effect of QMix, an experimental antibacterial root canal irrigant, on removal of canal wall smear layer and debris. J Endod 2011;37:80–84. DOI: 10.1016/j.joen.2010.10.004.
10. Stojicic S, Shen Y, Qian W, et al. Antibacterial and smear layer removal ability of a novel irrigant, QMix. Int Endod J 2012;45(4):363–371. DOI: 10.1111/j.1365-2591.2011.01985.x.
11. Sterrett JD, Murphy HJ. Citric acid demineralization of cementum and dentin: the effect of application pressure. J Clin Periodontol 1995;22(6):434–441. DOI: 10.1111/j.1600-051x.1995.tb00174.x.
12. Verma SJ, Gohil MH. Scanning electron microscopy study to analyze the morphological characteristics of root surfaces after application of Carisolv gel in association with scaling and root planing: in vitro study. J Indian Soc Periodontol 2012;16(3):329–332. DOI: 10.4103/0972-124X.100906.
13. Banerjee A, Kidd EA, Watson TF. Scanning electron microscopic observations of human dentin after mechanical caries excavation. J Dent 2000;28(3):179–186. DOI: 10.1016/s0300-5712(99)00064-0.
14. Yazici AR, Özgünaltay G, Dayangaç B. A scanning electron microscopic study of different caries removal techniques on human dentin. Oper Dent 2002;27(4):360–366. PMID: 12120773.
15. Cederlund A, Lindskog S, Blömlof J. Effect of chemo-mechanical caries removal system (CarisolvTM) on dentin topography of non-carious dentin. Acta Odontol Scand 1999;57(4):185–189. DOI: 10.1080/000163599428751.
16. Singh S, Uppoor A, Nayak D. A comparative evaluation of the efficacy of manual, magnetostrictive and piezoelectric ultrasonic instruments–an *in vitro* profilometric and SEM study. J Appl Oral Sci 2012;20(1):21–26. DOI: 10.1590/s1678-77572012000100005.