Original Article

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

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Abstract

Aim: This study aimed to comparatively analyze, under scanning electron microscope (SEM), the effect of the use of QMix® and SofScale™ as an adjunct to scaling and root planing (SRP) on periodontally compromised root surfaces. **Settings and Design:** This study was carried out in K. M. Shah Dental College and Hospital, Vadodara. **Methodology:** This was a single-blinded *in vitro* study which compared QMix® and SofScale™ as an adjunct to SRP on periodontally compromised root surfaces under SEM. **Statistical Analysis Used:** Statistical analysis was done using a nonparametric Mann–Whitney U-test to test the null hypothesis that there is no difference between the test and control groups. **Results:** The sum of ranks for QMix® was 306.50 and the sum of ranks for SofScale™ was 513.50. The group which was treated with QMix® showed statistically significant results ($P = 0.004$) as compared to group which was treated with SofScale™. **Conclusion:** Comparative analysis showed that QMix® had significantly better smear layer removal ability as compared to SofScale™. However, uniform root surface was achieved with both QMix® and SofScale™.

Keywords: *Periodontally compromised teeth, QMix®, scanning electron microscope, SofScale™*

Introduction

The development and manipulation of molecules, cells, or tissues to replace the function of defective, diseased, or injured portions of the periodontium has been a relentless goal of the periodontist. The types of periodontal tissue engineering that have been attempted over the past century have included: (1) regeneration of periodontal defects with bone or bone substitutes; (2) stimulation of bone with growth factors, hormones, or extracellular matrix proteins; (3) manipulation of cell growth and proliferation; (4) immobilization of tissue adjacent to the site of regeneration; and (5) modification of the tooth surface.

Perhaps, the oldest and most frequently attempted type of periodontal regeneration has involved chemical modification of the root surface. Since the late 19th century, when Marshall introduced aromatic sulfuric acid into periodontal pockets, modification of the root surface through decalcification has been directed to create an area that is compatible for connective tissue attachment.

The rationale for chemically developing a biologically compatible root surface has emerged as a result of the structural and biochemical damage following exposure of the root surface to the oral cavity as a consequence of periodontal disease. These undesirable disease-induced alterations in and on the root surface include reduced collagen fiber insertion, alterations in mineral density and surface composition,[1] and root surface contamination by bacteria and their endotoxins.[2,3] Since the root surface serves as a wound margin during regeneration, it has been postulated that it is necessary to rehabilitate the root surface for cell attachment and fiber insertion using chemical-modifying agents. The mechanism by which these chemicals operate on the root surface is not well understood, but it has been hypothesized that demineralizing agents act by exposing collagen fibers within the root matrix, thereby facilitating attachment by other fibers in the periodontium, and/or by decontaminating the root surface through elimination of endotoxin and bacteria, and/or by removal of the root debris allowing

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for the un-obstructive attachment of regenerative cells to the root surface.[4]

In periodontal disease, root surface is exposed to the subgingival environment and bacterial plaque. Exposure to crevicular fluid, as well as to enzymes and metabolites produced by subgingival plaque bacteria, induces physical and chemical alterations on root cementum.[5]

Calculus deposits on root surfaces, as well as alterations in the root surfaces exposed to bacterial plaque, usually occur as a result of periodontal disease. Due to this, pathologically exposed root surfaces are not suitable for cell attachment and fiber formation. Scaling and root planing (SRP) is a common procedure undertaken during periodontal therapy. However, SRP does not completely eliminate calculus[6] and bacterial contaminants.[7]

A smear layer of microcrystalline debris has also been referred to as the layer of grinding debris produced during instrumentations and virtually occludes the dentinal tubule apertures. The layer (2–15 μ in thickness) consists of organic and inorganic materials, with particles varying in size from <1 μ to more than 15 μ. The smear layer is intimately associated with the tooth surface and is virtually only removed by demineralizing solutions.[8]

Whatever the mineral composition is, the surface of dental calculus always remains covered with dental plaque; endotoxin and proteins derived from gingival crevicular fluid and inflammatory exudates.[9]

Due to the limitations of conventional SRP procedures, several instruments have been developed to improve the access to root surfaces. In addition, there has been considerable interest in the use of chemical agents to assist root detoxification.[10]

Chemical agents have been proposed to facilitate calculus detachment,[11,12] smear layer removal,[13] decalcification of planed root surfaces, and exposure of dentinal or cemented collagen matrix. These procedures are aimed at providing a biologically acceptable surface for new connective tissue attachment.[14]

Rationale

Since critical events in periodontal regeneration involve cementogenesis and the attachment of new connective tissue to the root surface, a considerable amount of research has been aimed at evaluating whether chemical agents can transform the root surface to a biologically suitable one. The most commonly used chemical decalcifying agent for root surfaces has been citric acid; an acidic antibiotic (tetracycline HCl) and a chelating agent, ethylenediaminetetraacetic acid (EDTA), have also been used to alter root surfaces.

The use of chemical agents in association with mechanical treatment represents a possibility of a less traumatic procedure, preventing the excessive loss of root substance. In the field of periodontics, the possibility of chemically dissolving calculus and contaminated root cementum to facilitate their mechanical removal is one of the most promising applications of QMix® solution (Dentsply Ltd.) containing EDTA (17%) and chlorhexidine (2%) and SofScale™ (Dentsply Ltd.) containing chelating agents such as disodium EDTA and detergent sodium lauryl sulfate.

Therefore, the purpose of this study was to comparatively investigate, under SEM, the morphologic characteristics of periodontally compromised human root surfaces after application of QMix® solution (Dentsply Ltd.) containing EDTA (17%) and chlorhexidine (2%) and SofScale™ (Dentsply Ltd.) containing chelating agents such as disodium EDTA and detergent sodium lauryl sulfate as an adjunct to SRP.

Methodology

This was a single-blinded *in vitro* study.

Source of specimens

Periodontally compromised extracted human teeth with supra- and sub-gingival calculus were used for this study. The teeth extracted for periodontal reasons were stored in saline for a maximum of 3 h.

Inclusion criteria

- Maxillary and mandibular single-rooted teeth
- Teeth which were periodontally compromised
- Teeth with supra- and sub-gingival calculus.

Exclusion criteria

- Nonvital teeth
- Teeth with cervical abrasion that needs restoration
- Teeth with root surface restoration
- Teeth with root surface caries.

Protocol

Forty periodontally compromised human teeth with supra- and sub-gingival calculus, which were extracted for periodontal reasons, were used. Diseased tooth surfaces with adhered calculus were chosen as the treatment areas and delimited with a round bur, and the teeth were randomly assigned to two groups (n = 40), as follows:

- Group 1: SRP with QMix® A for 2 min. The root surfaces were instrumented with Gracey curettes (Hu-Friedy, Chicago, IL, USA), using 15 strokes in an apical-coronal direction, parallel to the axis of the tooth
- Group 2: SRP with SofScale™ applied to the delimited area in each root for 2 min. Root surfaces were instrumented with Gracey curettes in the same way as described in Group 1.

The treated surfaces were rinsed in 20 mL saline and the crowns were removed at the cementoenamel junction. The teeth were then horizontally and vertically sectioned with a diamond circular saw, using the treated area as a reference.

Each tooth section was rinsed in saline and placed in 2.5% glutaraldehyde in 0.1 M phosphate buffer (pH 7.4) for a minimum of 24 h. The specimens were washed and dehydrated in a series of graded alcohol solutions (50, 70, 80, 95, and 100%) for 10 min each. After two additional 10-min washings in absolute alcohol, the specimens were dried overnight in a desiccator jar, mounted on the SEM.

Specimens were examined using a scanning electron microscope (SEM). Photographs of the central portion of each specimen were taken at ×1000 magnification.

The principal investigator did the sample preparation and collected the SEM images at ×1000 magnification, and dummy numbering of the images was done. The second investigator who was blinded to the two groups evaluated the images and scored according to the Sampaio index which is as follows.

Score interpretation

1. Root surface without smear layer, with the dentinal tubules completely opened without evidence of smear layer in the dentinal tubules
2. Root surface without smear layer, with the dentinal tubules completely opened, but with some evidence of smear layer in the dentinal tubules' entrance
3. Root surface without smear layer with the dentinal tubules partially opened
4. Root surface covered by a uniform smear layer with evidence of dentinal tubule opening
5. Root surface covered by a uniform smear layer without evidence of opening of the dentinal tubules
6. Root surface covered by an irregular smear layer, with the presence of grooves and/or scattered debris.

Statistical analysis

Statistical analysis was done using a nonparametric Mann–Whitney U-test to test the null hypothesis that there is no difference between the test and control groups.

Observation and Results

The study was carried out on forty periodontally compromised teeth.

SEM analysis was carried out and the following observations were made.

The teeth treated with QMix® [Figure 1].
- Little amount of smear layer
- More patent dentinal tubules
- Uniform root surface.

The teeth treated with SofScale™ [Figure 2].
- Significant amount of smear layer
- Less patent dentinal tubules
- Uniform root surface.

The individual results for Qmix presented valid scores of all the samples analysed [Table 1].

The individual results for SofScale presented valid scores of all the samples analysed [Table 2].

Mann–Whitney U-test was used to carry out the statistical analysis. The sum of ranks for QMix® was 306.50 and the sum of ranks for SofScale™ was 513.50 [Table 3].

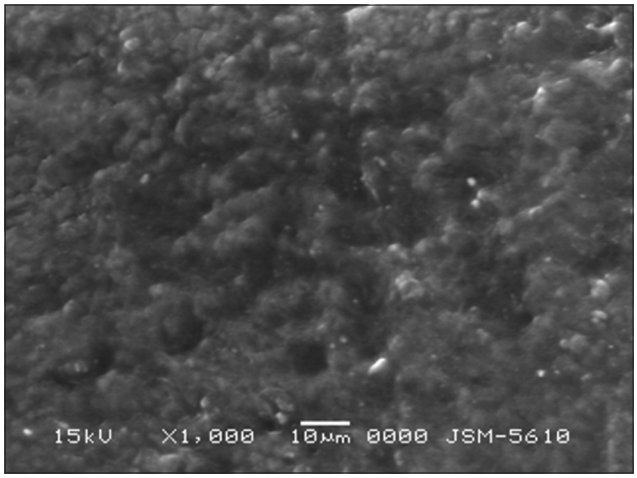

Figure 1: QMix®

Table 1: The individual results for QMix®

Test	Score
n	
Valid	20
Missing	0
Mean	3.2500
Median	3.0000
Mode	1.00
SD	1.77334
Minimum	1.00
Maximum	6.00
Percentiles	
25	1.2500
50	3.0000
75	4.7500

SD: Standard deviation

Table 2: The individual results for SofScale™

Test	Score
n	
Valid	20
Missing	0
Mean	4.8000
Median	5.0000
Mode	5.00
SD	0.95145
Minimum	3.00
Maximum	6.00
Percentiles	
25	4.0000
50	5.0000
75	5.7500

SD: Standard deviation

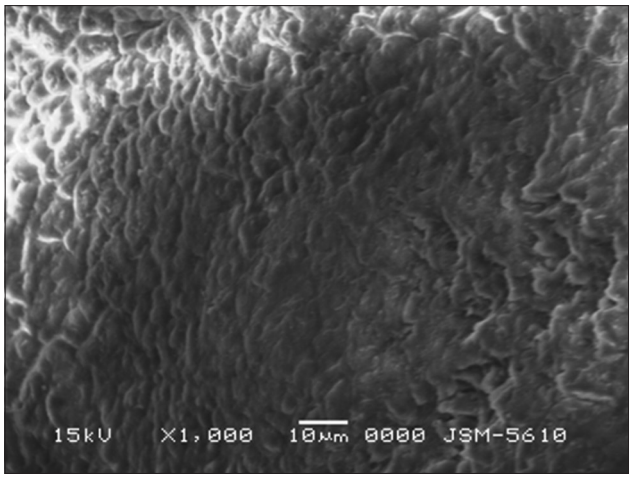

Figure 2: SofScale™

The group which was treated with QMix® showed statistically significant results (P = 0.004) as compared to the group which was treated with SofScale™ [Table 4].

Table 3: Mann-Whitney test

Group	Ranks		
	n	Mean rank	Sum of ranks
Score			
QMix®	20	15.32	306.50
SofScale™	20	25.68	513.50
Total	40		

Table 4: Test statistics

	Score
Mann-Whitney U	96.500
Wilcoxon-W	306.500
Z	−2.857
P	0.004

Discussion

The use of chemical agents in association with mechanical treatment represents a possibility of a less traumatic procedure, preventing the excessive loss of root substance. In the field of periodontics, the possibility of chemically dissolving calculus and contaminated root cementum to facilitate their mechanical removal is one of the most promising applications of SofScale™ gel and QMix® solution.

Several studies demonstrate that, after manual instrumentation with ultrasonic or even special burs, a smear layer forms, overlapping the presumed clean root surface.[15-17] The smear layer may represent an unfavorable factor for periodontal healing processes and hamper cervical hypersensitivity treatment after instrumentation of the root surfaces with specific products.[18,19] On the other hand, the dentinal tubules' exposition may be an ancillary factor in clot stabilization in the earliest stages of periodontal healing by increasing the adhesion capacity of the blood cells and fibrin on the root surface, or even increasing the retention and contact of some substances such as enamel matrix, which would act as a growth factor.[20] Many substances have been proposed for root surface treatment after SRP, some with greater cytotoxic potential than others. In the present study, QMix® solution and SofScale™ gel had been used which contain ingredients which have been able to remove the smear layer very effectively.

Several previous studies that have assessed the effects of EDTA gel as a coadjuvant in periodontal treatment focused on the root surface of human teeth extracted due to severe periodontitis. The purpose of these studies was to analyze the surface with different combinations of treatments.[17,21-28] The authors concluded that root surfaces treated with EDTA appeared to be more suitable for cellular colonization and subsequent connective tissue formation[21,22] and exhibited numerous dentinal tubules exposed by removal of the smear layer,[17,23-27] and an intact collagenous matrix.[17,28] In view of these promising results, it seems important to study the effect of EDTA gel on soft periodontal tissue.

After root surface instrumentation, areas of contaminated cementum,[29] as well as a smear layer produced during mechanical debridement, may still remain on instrumented surfaces, interfering with periodontal repair.[17,30] Therefore, chemical treatment of the root surface after SRP has been introduced as a promising procedure for removing the smear layer[24,25,30] and hypermineralized areas of the root surface, to expose collagen fibers and render the root surface biocompatible with periodontal cells. Furthermore, acid etching may also facilitate the attachment of connective tissue.[7,31]

However, etching of root surfaces at low pH has been shown to impair periodontal healing[31] in comparison with etching at neutral pH, since the use of low-pH biomodification agents may have necrotizing effects.[31] Thus, the beneficial smear-removing capacity of citric acid is diminished by its low pH, which necrotizes the surrounding periodontal tissue cells and jeopardizes its healing potential.[32] Furthermore, etching at low pH with phosphoric acid appears to erode the surface rather than selectively exposing collagen fibers, as evidenced by the resulting surface granulation.[26]

The use of NaOCl and EDTA has been reported to be effective in removing pulpal tissue remnants and the organic and inorganic components of the smear layer.[33,34] BioPure™ MTAD™ (Dentsply Tulsa Dental Specialties, Tulsa, OK) has shown to be a promising smear layer removal agent after the use of 1.3% NaOCl as the initial rinse.[35-37] However, the antimicrobial efficacy and substantivity of this irrigant combination has been challenged.[34,36,37] It is effective in removing canal wall smear layers but demineralizes intraradicular dentin.[38]

Another study found increased attachment with conditioning of surfaces with tetracycline hydrochloride and EDTA.[39] However, an antimicrobial root canal irrigant (QMix®) and its modifications containing a mixture of a bisbiguanide antimicrobial agent, a polyaminocarboxylic acid calcium-chelating agent, saline, and a surfactant have been found to be more effective than BioPure™ MTAD™ against bacterial biofilms.[39]

A number of studies have shown that one session of closed root instrumentation does not achieve the goal of total elimination of all calculus deposits.[40] Other investigations in which flaps have been reflected to secure access and visibility before SRP have failed to secure calculus-free root surfaces. It is worth mentioning at this juncture that, even under optimal conditions *in vitro,* it is not always possible to remove the entire calculus from all the root surfaces.

There are two methods of determining tooth damage *in vitro*. The first is to apply instruments until the tooth surface is clean and clear of calculus as deemed by the operator. The second is to instrument for a controlled length of time or number of strokes.[41] The latter is often more controlled in so far as operating parameters such as load and contact angle are concerned, clinically it is less appropriate. Employing the latter method in the present study, teeth samples were instrumented with Gracey curettes for 15 strokes, however it can be justified as uniform instrumentation was required to establish equal strokes for both test and controls.

One of the highlights of this study is that periodontally diseased teeth were selected. Results from such a work are more meaningful because that the sample mimics actual conditions in patients unlike studies that are carried out on periodontally healthy extracted teeth originally for orthodontic reasons.[42]

Conclusion

The following conclusions can be drawn from this study. Comparative scanning electron microscopic analysis of the tooth surface with Qmix and Sofscale showed that both produced uniform root surface. Tooth surfaces treated with Qmix showed lesser smear layer presence as compared to tooth surfaces treated with Sofscale. Thus it can be concluded that Qmix has a better smear layer removal ability as compared to Sofscale.

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Conflicts of interest

There are no conflicts of interest.

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