

## Coronal microleakage of root canal filled teeth pretreated with ferric-oxalate or dental bonding agent

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### ABSTRACT

An in vitro study was carried out to compare the effects of the smear layer and the pretreatment of the root canal wall with tubular occluding desensitizing agent (6% ferric-oxalate) or a bonding agent on the coronal seal of endodontically treated teeth.

Seventy freshly extracted human teeth with single and straight canals were used in this study. The teeth were divided into five experimental groups; twelve teeth each, with one positive and one negative control for each. Group I: With intact smear layer. Group II: Without smear layer. Group III: With intact smear layer and with ferric-oxalate painting of the canal walls. Group IV: Without smear layer and with ferric-oxalate painting of the canal walls. Group V: Without smear layer and with bonding agent.

After canal obturation the access cavities were exposed to natural saliva then Pelikan ink. Teeth were cleared and linear dye penetration measured. The results showed that the removal of the smear layer significantly increased the tightness of the coronal seal, and pretreatment of the canal walls with ferric-oxalate significantly decreased the coronal microleakage more than with or without smear layer. Using the bonding agent with a hydrophilic primer, after removing the smear layer, showed significantly less microleakage than all other groups.

**Key Words:** Microleakage, ferric-oxalate, bonding agent.

### الخلاصة

أجريت هذه الدراسة لمقارنة تأثير وجود المسحة (smear layer)، طلاء سطح القناة الداخلي بمحلول أوكزالات الحديد مع تأثير وجود المسحة معه وتأثير طلاء سطح القناة الداخلي بمادة الربط السني (dentin bonding) على التسرب التاجي.

النموذج المستخدم لهذه الدراسة يتكون من (70) سن بشري مخلوع حديثاً ذو قناة جذرية واحدة مستقيمة، وقد تم قطع الجزء التاجي من الأسنان وبعدها تم تنظيف وتوسيع القنوات مع غسلها بمادة هايبيوكلورايد الصوديوم. وبعد ذلك قُسمت الأسنان إلى خمس مجاميع، في كل مجموعة (12) سن مع مسطر إيجابي ومسيطر سلبي لكل مجموعة: (1) ترك مادة المسحة على الجدران الداخلية للقناة؛ (2) إزالة مادة المسحة من على الجدران الداخلية للقناة للقناة بمادة المحلول الكلابي ثم هايبيوكلورايد الصوديوم؛ (3) ترك مادة المسحة ومعالجة الجدران الداخلية للقناة بمادة أوكزالات الحديد بعد إزالة المسحة بالمحلول الكلابي ثم هايبيوكلورايد الصوديوم؛ و (4) معالجة الجدران الداخلية للقناة بمادة الربط السني بعد إزالة المسحة بحامض الفوسفوريك بتركيز (10%) حسب تعليمات المصنّع.

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وبعد الانتهاء من معالجة وطلاء السطوح الداخلية للقنوات تم حشوها بأقماع الكوتابيريكا والسمنت اللاصق (AH-26) بتقنية الضغط الجانبي. ثم تمت تغطية السطح الخارجي لكل سن عدا فتحة القناة الخارجية والمسيطر الإيجابي، أما المسيطر السلبي فقد تمت تغطيته كلياً. ثم تم حفظ الأسنان في اللعاب الطبيعي لمدة عشرة أيام مع تغيير اللعاب يومياً، وتم حفظها في الحبر لمدة عشرة أيام أخرى وبدرجة (37) مئوية. أظهرت النتائج أن وجود المسحة يساعد على نفاذ الحبر لمسافة أبعد من باقي المجاميع وأن إزالتها يقلل من مسافة نفوذ الحبر. إن استخدام أوكزالات الحديد يقلل من نفوذية الحبر وعمل أوكزالات الحديد أفضل بعد إزالة المسحة. إن مجموعة الرابط السني هي الأفضل بين كل المجاميع.

## INTRODUCTION

Microleakage, as related to endodontics, refers to the seepage of fluids, bacteria, and toxic materials into the periapical area, which in most of the situations can elicit many clinical problems and being a major cause of endodontic treatment failures<sup>(1)</sup>.

Microleakage at the apical seal has been considered to be the primary concern. More recently, the degree of coronal microleakage, has been brought to light, as one of the most important cause of failure over time of endodontic treatment<sup>(2,3)</sup>.

The coronal root canal has a number of susceptible interfaces where microleakage may occur, between sealer and root canal wall and between sealer and gutta-percha. Microleakage has been shown to occur most frequently at these interfaces<sup>(4)</sup>.

Hovland and Dumsha<sup>(5)</sup> observed that most leakage occurred between the wall of the root canal and sealer when using the gutta-percha and sealer combination. The influence of the smear layer created during endodontic instrumentation is of uncertain significance in relation to the development of an effective seal of the root canal system. This layer constitutes a natural cavity liner that reduces the dentin permeability better than any of the varnishes. However, on the negative side, it has a potential to provide a media for bacteria and its presence interferes with the adhesion of the obturation materials<sup>(6)</sup>.

The introduction of oxalate salts have been reported to show promise in reducing dentin permeability and microleakage due to the replacement of the soluble loosely attached smear layer<sup>(7)</sup> by sterile, non-toxic, and insoluble artificial smear layer of calcium oxalate crystals which precipitate on the calcific surface and inside the dentinal tubules to occlude them<sup>(8)</sup>. The formation of insoluble calcium oxalate salts due to the application of ferric-oxalate solution prior to placing a "Walking Bleach" paste in endodontically obturated teeth have been shown to prevent seepage of caustic bleaching agents by blocking the dentinal tubules and other gaps in the cemento-enamel junction<sup>(9)</sup>.

Latest generations of dentin bonding agents have shown increasingly greater bond strengths, the ability to penetrate dentinal tubules through hydrophilic wetting and a greater tendency to resist microleakage, thereby justifying research efforts in the ability to incorporate this modality into root canal filling materials<sup>(1)</sup>.

The purpose of this study was to compare the effects of smear layer, ferric-oxalate and dentin bonding agent pretreatment of the canal wall on the coronal microleakage of endodontically treated teeth.

## MATERIALS AND METHODS

Seventy single rooted freshly extracted human teeth with straight root canals and mature apices were used in this study. After extraction all the teeth were stored in normal saline solution. External soft tissues and debris were removed from the teeth using a cumine.

In order to get flat reference point for measurements and to eliminate variables in access preparations; the crown portion of each tooth was removed to the level of the cervical line using a diamond disk with a straight hand piece. Circular access opening for each tooth was prepared using carbide round bur No. 023 with conventional hand piece.

The pulpal tissue was removed by barbed broaches, patency of each canal was established by passing a No. 10 K-type file through the apical foramen, then the working length was determined by subtracting one mm from the length at which the tip of the file just appeared at the apical foramen.

The canals were instrumented using a conventional hand instrumentation technique with circumferential filing action to master apical file No. 50 K-type files. Each canal was irrigated after each instrument size with 1 ml of 1% NaOCl.

A No. 55 Hedstrom file was then used to circumferentially file the canal walls to produce dentin chips that could subsequently be packed into the apical region. A plug of dentin filing approximately 1 mm thick was placed.

The instrumentation was continued with No. 2 to 3 Gates-Glidden drills with 1% NaOCl irrigation, the coronal 5 mm was enlarged with No. 5 Gates-Glidden drills. Finally, an irrigation with 5ml of a 1% NaOCl solution followed by 5 ml of deionized water, then the root canals were dried with absorbent paper points.

The teeth were randomly divided into five groups, twelve teeth with one positive and one negative controls for each. Group I: With intact smear layer. Group II: Without smear layer. Group III: With intact smear layer and with ferric oxalate treatment. Group IV: Without smear layer and with ferric oxalate treatment. Group V: Without smear layer and with bonding agent. (Bondit-Jeneric/Pentron Inc., USA)

The smear layer was removed with 5 ml of 17% EDTA (pH 7) irrigation then 5 ml of NaOCl, and the final flush with 5 ml of deionized water and were dried with paper points. The smear layer was removed from the canal walls in group V by etching the inner canal walls with 10% phosphoric acid gel (Bond it - Jeneric/ Pentrom Incorp, USA).

Application of 6% ferric oxalate solution to the canal walls was done with a piece of cotton rolled on a barbed broach and soaked in the solution, then painting the canal walls, waiting for 5 minutes, drying with paper points, and then repeating the procedure for the second layer. Application of the bonding agent was done according to the manufacturer's instructions, by painting the canal walls with same method of application of ferric oxalate.

All the canals except the positive controls, were obturated with gutta-percha and AH26 sealer (De-Tray Dentsply, USA), which was mixed according to the manufacturer's instructions, using lateral condensation technique of canal obturation.

The access gutta-percha was removed to the cemento-enamel junction. The access opening of the teeth in groups III and IV were lined with one layer of 6% ferric oxalate solution, and in group V with one layer of bonding agent. After that, access openings were sealed with sticky wax. The teeth were kept in 100% humidity and 37C incubator

for 48 hours. Then the sticky wax was removed, and all teeth except the positive controls were coated with two layers of nail varnish and two layers of sticky wax except for the access openings. The negative controls were entirely coated. The teeth stored in natural saliva for 10 days then stored in ink for 10 days at 37C to demonstrate microleakage, following that the teeth were cleared and linear dye penetration was measured using a 0.01 mm vernier microscope.

## RESULTS

Group I (with intact smear layer) showed the highest mean of dye penetration, followed by group II (without smear layer), followed by group III (intact smear layer with ferric oxalate), then group IV (without smear layer and with ferric oxalate). The lowest mean was found to be in the group V (bonding agent) as shown in table (1).

Table (1): Comparison of coronal microleakage (in mm) in experimental groups

Group	No. of Teeth	Mean	SD	Max. Leakage	Min. Leakage
I	12	5.417	1.036	8.7	2.2
II	12	3.075	1.610	5.9	1.5
III	12	1.917	0.319	2.5	1.5
IV	12	1.542	0.124	1.8	1.4
V	12	0.725	0.548	1.5	0

Analysis of variance ANOVA test was performed to test comparison between and within the mean of leakage among the five experimental groups at ( $F=27.765$ ) ( $p<0.01$ ). A highly statistical significant difference was found among the five experimental groups.

Student t-test was also used to compare the mean leakage between each pair of groups. A highly statistical significant difference was found between the groups at  $p<0.01$  except for the comparison between group II and group III where there was a significant difference at  $p<0.05$ .

## DISCUSSION

Coronal microleakage has received increasing attention as a major cause of root canal treatment failure<sup>(3,5)</sup>. Exposure of obturation materials to oral fluids, even for brief periods, through loss of temporary seal, marginal discrepancy or recurrent caries leads eventually to sealer dissolution. Salivary and bacterial contamination of the canal system then occurs, reestablishing a pathway to the periapical tissues<sup>(10)</sup>.

During the instrumentation, a smear layer is created on the dentin surface, imposing an additional interface which affects the tightness of the coronal seal<sup>(10,11,12)</sup>.

The oxalate salts (desensitizing agents) have a promising effect on reduction of the microleakage under the amalgam and glass ionomer final restoration by replacing the soluble loosely attached smear layer by hardly attached, insoluble, acid resistance and non toxic crystalline artificial smear layer of calcium oxalate crystals on the calcific surface and inside the dentinal tubules which occlude them<sup>(13)</sup>. No previous research was found in literature that have tested 6% ferric-oxalate solution in coronal microleakage of root-canal filled teeth. Ferric-oxalate has been reported to reverse the pH values post

“Walking Bleach” technique more than did the calcium hydroxide liner by preventing the seepage of caustic bleaching agent through dentinal tubules and cemento-enamel junction<sup>(9)</sup>.

Concerning the use of the bonding agents, there are few studies that evaluated the potential of using dentin bonding agents and resins as obturating materials in non-surgical root canal treatment. Reasons for not using resins have centered around questionable results, difficult and unpredictable methods for delivery into the root canal system, and the inability to retreat the canal if necessary<sup>(14)</sup>.

It appears from the experimental results and analysis of data that the group I (intact smear layer) showed higher mean of dye penetration than group II (without smear layer) with significant difference ( $p < 0.01$ ).

These findings were comparable with those found by Taylor *et al.*<sup>(11)</sup> when they used AH-26 epoxy resin sealer. At the same time it coincided with that of Saunders *et al.*<sup>(15)</sup>, when they used glass ionomer and Tubliseal sealer ( $p < 0.001$ ). Also the results of the present study agreed with the findings of Vassiliadis *et al.*<sup>(12)</sup> in that the removal of the smear layer with the use of Roth's 811 sealer significantly improved the tightness of the seal in the coronal area.

The smear layer consists of two separated layers, one superficial and adhering loosely to the underlying dentin, and the other consisting of debris plugs in the dentinal tubule openings. This layer may permit fluid to pass around its particles, in addition its quite soluble and the smear layer is subjected early to dissolution, so the space created by the loss of the smear layer serves as an open site for microleakage<sup>(7)</sup>.

Regarding the interference of the smear layer with the adaptation and adherence of the sealer and the filling materials, McComb and Smith<sup>(16)</sup>, noted its poor adhesion to the canal wall and concluded that it was an unsatisfactory surface for mechanical or chemical bond.

The results of this study which were obtained from the comparison of groups I and II with groups III, and IV, indicated that the pretreatment of the canal wall with ferric oxalate significantly decreased the coronal microleakage. These findings can be explained as that the reaction of 6% ferric oxalate with ionized calcium of the tubules, causes formation of crystals of insoluble calcium oxalate which are small enough to enter and precipitate inside the dentinal tubules and on the calcific surface<sup>(13)</sup>, resulting in replacement of soluble loosely attached smear layer with insoluble and hardly attached calcium oxalate layers.

Group III (intact smear layer + ferric oxalate) showed higher mean of dye penetration than group IV (without smear layer + ferric oxalate) ( $p < 0.01$ ). These findings could be explained by interfering of the smear layer with the reaction of the ferric oxalate with the calcium of the underlying dentin and that the 6% ferric oxalate reacts preferably with the calcium of the smear layer which adheres loosely to the underlying dentin rather than the calcium of the firm dentin and allows the fluid to seep around its crystals. At the same time the organic constituents of the smear layer may interfere with the reaction of the ferric oxalate and the dentinal calcium.

Group V (without smear layer and with bonding agent) showed significantly less microleakage than all other groups, this finding agreed with the results reported by Dobo *et al.*<sup>(17)</sup>. It could be explained by the great bond strength of the bonding agent to the dentin, the great tendency to resist microleakage, and the ability of the bonding agent to



penetrate dentinal tubules of cleaned root canal system through hydrophilic wetting of the primer. This penetration creates a mechanical interlocking that resist the penetration of the dye. Penetration of the resin into the dentinal tubules was in contrast to the results obtained by Rawlinson<sup>(14)</sup> where very limited resin penetration was noted. It was found that certain agents will not adhere to moist dentin as Scotch bond II, Clearfil, Photobond and Tenure, since it is almost impossible to totally dry a root canal. Therefore, an adhesive must be selected that bonds to both wet and dry dentin. So by using the bonding agent with a hydrophilic primer, the resin was drawn into the tubules creating intimate hybrid layer and resin tags.

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