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Microleakage of Human Saliva through Dentinal Tubules Exposed at the Cervical Level in Teeth Treated Endodontically

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This study investigated the possibility of saliva recontamination occurring between the root canal wall and sealer through dentinal tubules exposed after the cementum was removed at the cervical level by root planing and treatment with citric acid. Thirty-four extracted human maxillary anterior teeth were randomly placed into five groups after chemomechanical preparation and obturation with gutta-percha and sealer; the sealer was allowed to set for 48 h. A ring 3 mm high, at the cervical level, was subjected to root planing, with complete removal of the cementum. All specimens were coated with two layers of nail polish and two layers of sticky wax, except for the ring subjected to root planing that was treated with citric acid for 30 s. The specimens were exposed to human whole saliva for 20 to 80 days and then immersed in dye to determine microleakage. Specimens were cleared and measurements made to the maximum point of dye penetration. All of the specimens exposed to saliva showed leakage except for the negative control, wherein no dye penetration was seen. Where leakage was found, the dye penetrated between the canal walls and the sealer to increasing depths, proportional to the time of exposure to the saliva. Statistical analysis confirmed these data, evidencing a difference between the means, which was highly significant for all pairs.

The success of endodontic treatment is determined by the dentist's ability to remove the contents of the canal system completely and to obturate this space three-dimensionally (1, 2). The permanence of success over time is ensured by the seal's preserving the endodontic space from any bacterial recontamination (3). Obturated root canals may be recontaminated in a number of ways (4): delay in placing a coronal restoration after root canal therapy, which allows the temporary restoration (Cavit) to dissolve and the seal to be broken; fracture of the coronal restoration and/or tooth; and preparation of post space for the provision of a post-retained restoration when the remaining apical seal is found to be inadequate.

Coronal leakage has been shown to be one of the more important causes of failure over time of endodontic treatment (5–7). Torabinejad et al. (8) found that 50% of single-rooted teeth obturated by lateral condensation of gutta-percha and sealed with cement were contaminated with bacteria along the whole length of the root after 19 or 42 days, depending on the contaminating bacteria. Magura et al. (9) showed that endodontically treated teeth contaminated coronally by saliva for 3 months must be considered as needing retreating before any definitive coronal restoration. The most recent studies by Khayat et al. (10) showed that root canals obturated with gutta-percha and root canal sealer using either lateral or vertical condensation techniques were recontaminated in <30 days when placed in contact with human saliva. A nonsignificant difference was found between the two obturation techniques (10).

This study investigated the probability of recontamination by saliva between the wall of the root canal and the sealer through dentinal tubules exposed by removal of cementum consequent on root planing and treatment with citric acid.

MATERIALS AND METHODS

Thirty-four extracted human maxillary anterior teeth were used. The teeth were stored in 10% formalin. All traces of organic debris or calculus were removed from the teeth by ultrasound. To obtain specimens sufficiently uniform in length, the crown of each tooth was cut to obtain roots between 13 and 16 mm long. An access opening was made (~2 mm in depth and 2 mm in diameter), and the root canal contents were removed with a barbed broach.

Canals were instrumented using the "Orly coronal enlargement" technique described by Ruddle (11) and Castellucci (12). K-type files #10 to #60 (Brasseler USA, Savannah, GA) and Gates Glidden burs from #1 to #4 (Maillefer, Ballaigues, Switzerland) were used. The working length was established when the endodontic instrument exited the apical foramen. All specimens were instrumented apically to a #30 file. Irrigation was with 5% NaOCl; a total of 34 ml of NaOCl was used for each canal. NaOCl solution

was present in the root canal system for a total time of exactly 11 min for each specimen. Canals were dried with sterile paper points. Thirty-two root canals were obturated by vertical condensation of gutta-percha and EWT pulp canal sealer (Kerr/Sybron, Romulus, MI) to within 2 mm of the coronal end; the remaining portion of the canal was obturated with Cavit (Premier Dental Co., Seefeld, Germany). The specimens were then placed in 100% humidity at 37°C for 48 h to allow the sealer time to set.

A 3-mm high ring of tooth surface, 2 mm below the coronal rim of each specimen, was subjected to root planing with Gracey curettes, until the root cementum was completely removed. The specimens were then randomly assigned to five groups: groups A to C had 10 specimens each; two obturated roots were used as negative controls; and two roots were not obturated and were used as positive controls.

The external surfaces of each specimen in groups A to C and the positive controls were coated with two layers of nail polish and two layers of sticky wax, except for the ring that had undergone root planing. The external surfaces of the specimens in the negative control group were entirely covered with two layers of nail polish and two layers of sticky wax. The ring subjected to root planing in groups A to C and in the positive controls was then treated with a saturated solution of citric acid (pH 1) for 30 s and washed in water for 5 min.

Fifty ml of whole human saliva was collected in a 200-ml brown glass screw-top container, and the specimens were immersed in it. Exposure times to saliva in the various groups were as follows: group A = 20 days; group B = 40 days; group C = 80 days; and positive and negative controls = 20 days.

All specimens were then immersed in Pelikan ink for 48 h to demonstrate any microleakage. After dye exposure and removal of sticky wax and nail varnish, the specimens were decalcified in 5% nitric acid for 3 days, renewing the acid daily. Specimens were then washed for 4 h under running water and dehydrated in increasing concentrations of ethyl alcohol.

Specimens were made transparent by immersion in methyl salicylate for 24 h. Cleared specimens were examined under ×16 magnification with a stereomicroscope (SR with photographic system MC 63 A; Carl Zeiss, Oberkochen, Germany). Microleakage was measured from the cervical end of the canal obturation to the maximum apical extent of dye penetration. Data were analyzed using variance analysis.

RESULTS

Positive controls exposed to saliva showed complete dye penetration, whereas negative controls showed no dye penetration. All specimens in groups A to C exposed to saliva showed some dye penetration. The dye was abundantly present inside the dentinal tubules at the level of the ring that had undergone root planing. From there, the dye extended through the canal walls and the obturation material to a depth proportional to the time of exposure to saliva (Figs. 1 to 3). Within this leakage zone, the dye also penetrated the dentinal tubules. Table 1 sums up the results.

Variance analysis produced an F value of 164.1 ($p < 0.0001$); thus, the means between groups are significantly different one from another. The comparison between the pairs of groups by the t test showed a difference between means that was highly significant for all pairs ($p < 0.0001$).

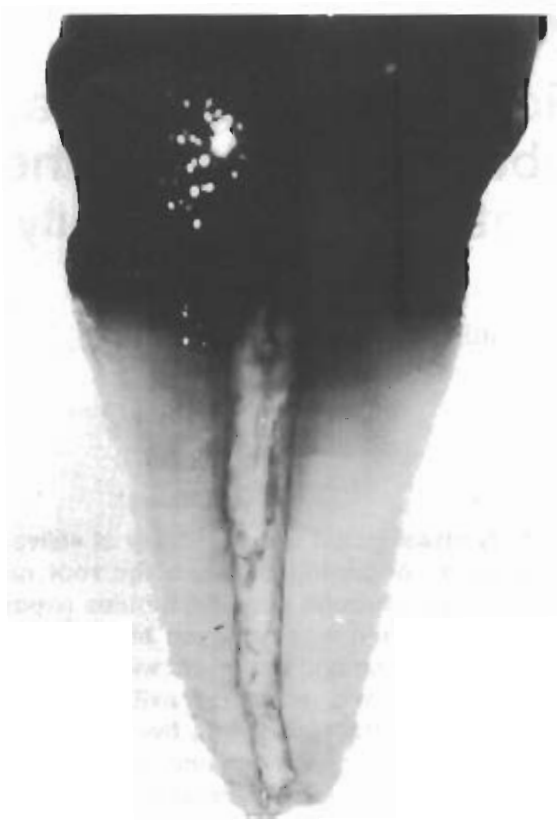

FIG 1. Cleared specimen, group A, demonstrating the extent of dye penetration after 20 days. The dye has reached the canal.

DISCUSSION

Microleakage may be presumed to occur after exposure of the dentinal tubules to oral cavity fluids. Determinant factors are undoubtedly maintenance of patency of the dentinal tubules, number of dentinal tubules exposed, and the exposure time. When dentin is exposed after abrasion, grinding, scaling, caries, or cementing of crowns, a mat of mineralized material may form in ~2 wk, occluding the dentinal tubules (13).

For numerous reasons (such as excessively acid food, alteration of the composition of the saliva, and in certain patients excessive tooth brushing with unsuitable toothpastes), the external opening of the dentinal tubules may become uncovered (13). Davis and Winter (14) examined the effect on enamel and dentin of the acid erosion with a grapefruit/whole saliva mixture on enamel and dentin. About 0.3 μm of enamel was completely removed in 45 s at 25°C and 1.3 μm of dentin was removed in 3 min at 25°C. If this remaining demineralized tissue was brushed, even with only a brush and water, accelerated abrasion occurred until the demineralized layers were removed (14). An acidic diet undoubtedly stops the mat of mineralized material from forming over the exposed dentin, helping to maintain patency of the dentinal tubules.

Periodontal disease and its therapy are undoubtedly the most frequent cause of exposure of cervical dentin. After root planing, most of the root cementum is generally removed.

On observation under the stereomicroscope, enretted surfaces had an amorphous granular appearance consistent with the presence of a surface smear layer produced by instrumentation. The orifices of the dentinal tubules were not visible. Subsequent treatment of these cervical root surfaces with acids would facilitate new

FIG 2. Cleared specimen, group B, demonstrating the extent of dye penetration after 40 days. The dye has reached the coronal third of the canal.

FIG 3. Cleared specimen, group C, demonstrating the extent of dye penetration after 80 days. The dye has reached the median third of the canal.

attachment, perhaps caused by the removal of the smear layer, denaturing of the organic matrix, and exposure of the collagen fibers.

Hanes et al. (15) showed under the scanning electronic microscope that root planing and treatment with citric acid (pH 1) not only removed the smear layer, but also opened and enlarged the apertures of the dentinal tubules. In 1976, Garberoglio and Brännström (16) had already shown that saturated citric acid (pH 1) enlarged or widened the tubule orifices caused by preferential demineralization of the peritubular dentin.

This study demonstrates experimentally in vitro that it is possible that the space between the canal wall and the obturation become recontaminated because of microleakage through patent dentinal tubules in the cervical surface of roots exposed to saliva. It can be hypothesized that, in the experimental conditions at least, the dye that penetrated through the dentinal tubules and then through the canal walls and sealer represents previous leakage of saliva. If ideal conditions continue (patent dentinal tubules), this leakage can continue in the apical direction, in time recontaminating the root canal.

This study does not pretend to show what precisely occurs in vivo, but rather to provide an experimental working model that should be cause for reflection on its possible endodontic and periodontic implications.

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TABLE 1. Dye penetration

	Mean (mm)	SD	SE	Minimum (mm)	Maximum (mm)
Group A					
20 days	4.43	0.514	0.163	3.6	4.9
Group B					
40 days	6.08	0.437	0.138	5.2	6.55
Group C					
80 days	8.185	0.438	0.138	7.5	8.9

References

1. Schilder H. Cleaning and shaping the root canal. Dent Clin North Am 1974;18:269–296.
2. Schilder H. Filling root canals in three dimensions. Dent Clin North Am 1967;11:723–744.
3. Strindberg LZ. The dependence of the results of pulp therapy on certain factors. Acta Odontol Scand 1956;14(suppl 21):175–180.
4. Saunders WP, Saunders EM. Coronal leakage as a cause of failure in root-canal therapy: a review. Endod Dent Traumatol 1994;10:105–8.
5. Allison D, Weber C, Walton R. The influence of the method of canal preparation on the quality of apical and coronal obturation. J Endodon 1979; 5:298–304.
6. Swanson D, Madison S. An evaluation of coronal microleakage in endodontically treated teeth. Part 1. Time periods. J Endodon 1987;13:56–9.
7. Madison S, Wilcox LR. An evaluation of coronal microleakage in endodontically treated teeth. Part 3. In vivo study. J Endodon 1988;14:455–8.
8. Torabinejad M, Ung B, Kettering JD. In vitro bacterial penetration of coronally unsealed endodontically treated teeth. J Endodon 1990;16:566–9.
9. Magura ME, Kafrawy AH, Brown CE, Newton CW. Human saliva coronal microleakage in obturated root canals: an in vivo study. J Endodon 1991;17: 324–31.
10. Khayat A, Lee SJ, Torabinejad M. Human saliva penetration of coronally unsealed obturated root canals. J Endodon 1993;19:458–61.
11. Ruddle CJ. Endodontic canal preparation: breakthrough cleaning and shaping strategies. Dentistry Today February 1994;13:44–49.

12. Castellucci A. Endodonzia. Prato, Italy: Edizioni Odontoiatriche Il Tridente, 1993:374–403.
13. Brännström M. Dentin and pulp in restorative dentistry. Dent Ther AB 1981;24–27.
14. Davis WB, Winter PJ. The effect of abrasion on enamel and dentine after exposure to dietary acid. Br Dent J 1980;148:253–6.
15. Hanes PJ, O'Brien NJ, Garnick JJ. A morphological comparison of radicular dentin following root planing and treatment with citric acid or tetracycline HCl. J Clin Periodontol 1991;18:660–8.
16. Garberoglio R, Brännström M. Scanning electron microscopic investigation of human dentinal tubules. Arch Oral Biol 1976;21:355–62.