

Effect of a Separated Instrument on Bacterial Penetration of Obturated Root Canals

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The aim of this study was to determine the effect a separated instrument has on the time required for bacterial penetration of obturated root canals. Twenty-six extracted human mandibular premolars with single canals were used in the study. Group 1 consisted of teeth that contained a separated size 40 Profile rotary file and were obturated with gutta-percha and zinc oxide eugenol sealer to the level of the separated file. Group 2 consisted of teeth that were similarly obturated, but without a separated file. The negative control canals were obturated and had the entire root surface sealed with nail polish. The positive controls were obturated without sealer. *Streptococcus sanguis* was placed in the access chamber daily, and penetration was determined when turbidity was noted in the culture broth. The results showed no significant difference between the two experimental groups.

Instrument separation is an unfortunate sequela of endodontic instrumentation. Reasons include overuse of the instrument, improper use of the instrument, microcracks inherent in the new instrument, and calcified or curved canals. When instrument separation occurs, the clinician has the choice of leaving the instrument in the canal or attempting to remove it either surgically or nonsurgically. Several factors need to be weighed when determining whether an attempt should be made to retrieve the separated instrument. Such factors include the position in the canal at which separation occurred, the amount of potential irritant remaining in the canal, and the amount of damage that would be caused to the remaining tooth structure if instrument removal were attempted. Crump and Natkin (1) used statistical methods to show that separated instruments did not adversely affect the success rate of endodontic cases.

Many experiments have been performed investigating penetration of root canal fillings using various dyes and isotopes (2–7). Torabinejad et al. (8) and Khayat et al. (9) have stated that bacterial penetration may be more meaningful and clinically relevant in leakage studies. Torabinejad et al. (8) found complete penetration

of bacteria in more than 50% of the root canals in their study within 19 days and 42 days when using *Streptococcus epidermidis* and *Proteus vulgaris*, respectively. Khayat et al. (9) found complete bacterial penetration in an average of 28.8 days and 25.4 days for root canals filled using lateral condensation and vertical condensation, respectively, when human saliva was introduced into the access cavities. No study has been performed investigating the effect of bacterial penetration of root canals with broken files plus gutta-percha and zinc oxide eugenol (ZOE) sealer.

Because separation of instruments is a sequela of endodontic treatment, it would be useful to know how such occurrences affect the sealing ability of the obturation material. Knowing the answer may affect a clinician's decision whether to attempt separated instrument retrieval. Through the endodontic literature, it is unclear whether a fluted instrument separated in a root canal would allow quicker penetration of bacteria than the same length of gutta percha and ZOE sealer. The purpose of this investigation was to determine the effect a separated instrument has on the time of bacterial penetration of canals obturated with gutta-percha and ZOE sealer.

MATERIALS AND METHODS

Twenty-six extracted mandibular premolars were used in this study. All of the teeth were caries-free and contained either minimal or no coronal restoration. The teeth all possessed fully formed apexes. The teeth had been stored in 10% formalin and were kept moist throughout the experiment. The teeth were radiographed both from the buccal and proximal direction to ensure one straight canal. Standard endodontic access was achieved using a #2 round bur and an Endo-Z bur. Canal length was determined by placing a #10 k-file through the canal space until it could be visualized exiting the apical foramen. Working length was determined by subtracting 1 mm from the canal length. All of the canals were flared coronally with size #2 to #4 Gates Glidden drills, and the apical canal was instrumented to size 30 using hand files. The canal was flushed with sodium hypochlorite between every instrument, and apical patency was maintained with a size 15 file throughout the instrumentation. The teeth were divided into four groups by random draw. The four groups consisted of a positive control; a negative control; experimental group 1, with a broken file; and experimental group 2, with no broken file.

After hand filing, 16 teeth were sequentially instrumented using .04 Profile rotary instruments starting at a size 25 until a size 40

would reach working length. Ten of these teeth were assigned to experimental group 2. The remaining six teeth were divided into two control groups containing three teeth each. None of these teeth contained a broken file.

For experimental group 1, 10 size 40 .04 Profile rotary instruments were nicked with a #2 round bur 3 mm from the tip to facilitate file separation at this point. The size 40 Profile rotating at 300 rpm was then introduced with apical pressure into each canal until separation occurred. After instrument separation, each of the 10 teeth in this group was again radiographed to ensure that the separation occurred in the apical third of the canal.

After instrumentation, the roots of all 26 teeth were coated with two applications of fingernail polish. The apical 2 mm of the roots were not covered with polish, except for the three teeth in the negative control group, which had their entire root coated. All 26 teeth were then autoclaved.

All teeth in the negative control group and experimental group 2 were obturated to the working length with gutta-percha and Roth 811 sealer (Roth International, Chicago, IL) using the lateral condensation technique. A sterile technique was used for obturation of all teeth. A heated plugger was used to remove coronal gutta-percha until a standardized length of 10 mm of filling was left in each canal. The same filling procedure was used in experimental group 1 except that the canal was obturated to the separated instrument and only 7 mm of gutta-percha was left in the canal, so that the total obturation length was 10 mm, including the 3 mm of separated instrument. The three teeth in the positive control group were obturated using the same lateral condensation technique, although without sealer.

Culture medium, 5 ml, was placed in 26 individual test tubes. Each of the 26 teeth was suspended using orthodontic ligature wire into the test tube so that at least 2 mm of each tooth's apex was within the broth. The chamber of each tooth was filled with a suspension of *Streptococcus sanguis* on day 0.

A fresh bacterial suspension of *S. sanguis*, which was prepared daily, was added to the access opening of each tooth until the chamber was nearly full. This procedure was performed every day throughout the experiment. Penetration of the root canal was recorded when turbidity was noted in the broth. Cultures were checked daily until the final test system became positive at day 90.

TABLE 1. Effect of a 3-mm separated file on the bacterial penetration in obturated single-rooted teeth*

Group 1 (separated file)		Group 2 (no separated file)	
Sample	No. of days for turbidity	Sample	No. of days for turbidity
1	30	1	42
2	47	2	5
3	62	3	49
4	90	4	41
5	21	5	71
6	5	6	—
7	33	7	31
8	52	8	—
9	14	9	64
10	76	10	49
Mean: 43 days		Mean: 44 days	
Range: 5–90 days		Range: 5–71 days	

* Rate of total bacterial penetration by *S. sanguis* in experimental group 1 (teeth containing a separated instrument) and group 2 (no separated instrument). No statistically significant difference ($p = 0.933$) between group 1 and 2.

—, indicates sample lost due to contamination during initial setup.

RESULTS

Turbidity was noted on day 1 for all three of the positive control teeth. The culture medium of the three negative control teeth showed no turbidity over the 90-day course of the experiment.

In experimental group 1, containing the separated files, all of the samples showed turbidity by day 90. The amount of time it took for the samples to show turbidity varied from 5 to 90 days, with an average of 43 days. (see Table 1).

In experimental group 2, two of the samples were contaminated during the initial setup. Teeth 6 and 8 of group 2 were fully submerged into the culture broth and were excluded from analysis. The amount of time it took for turbidity to occur in the group 2 samples varied from 5 to 71 days, with an average of 44 days.

A statistical analysis using a *t* test showed that the difference in the two experimental groups was not statistically significant ($t = -0.0857$, with $p = 0.933$).

DISCUSSION

In this study, the presence of turbidity indicated full bacterial penetration through the root canals of the teeth. The results of the three teeth in the positive control group showing turbidity by day 1 confirm the results by Marshall and Massler (10), who found that sealer is necessary to improve the apical sealing ability of obturation material. Because none of the three negative control teeth showed turbidity after 90 days, it is apparent that the experimental setup provided a contamination-free environment.

Although the average numbers of days for total bacterial penetration (43 days for group 1 and 44 days for group 2) were very similar, there was a very large range for both groups. Other authors have also reported large ranges for leakage of obturated root canals. Torabinejad et al. (8) and Khayat et al. (9) reported large ranges when examining bacterial penetration through root canal fillings. Swanson and Madison (4) also found a significant variability when they examined the penetration of a dye through obturated root canals.

The large range of time for penetration of the experimental groups can possibly be attributed to variable root canal anatomy, shape of canal preparation, and sealer type.

The presence of 3 mm of separated instrument did not speed up or slow down penetration of bacteria when compared with the normally obturated experimental group. This result implies that the separated file did not compromise obturation of the root canal space. This fact is surprising, because root canal anatomy is quite variable and is not perfectly round like the separated instrument. Also, the separated instrument has flutes, so it would be unlikely to completely obturate the root canal space by itself. With sealer extruded into the flutes, the separated file may become the equivalent of any other obturation material.

The results of this study indicate that the separated instrument itself does not play a large role in the sealing ability of the obturation material. Perhaps more important to the success of the root canal therapy is the coronal seal and absence of any residual irritant beyond the level of the separated instrument.

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References

1. Crump MC, Natkin E. Relationship of broken root canal instruments to endodontic case prognosis: a clinical investigation. *J Am Dent Assoc* 1970;80:1341-7.
2. Matloff IR, Jensen JR, Singer L, Tabibi A. A comparison of methods used in root canal sealability studies. *Oral Surg* 1982;53:203-8.
3. Rhome BH, Solomon EA, Rabinowitz JL. Isotopic evaluation of the sealing properties of lateral condensation, vertical condensation, and Hydron. *J Endodon* 1981;10:458-61.
4. Swanson KS, Madison S. An evaluation of coronal microleakage in endodontically treated teeth, part I: time periods. *J Endodon* 1987;13:56-9.
5. Madison S, Swanson K, Chiles SA. An evaluation of coronal microleakage in endodontically treated teeth, part II: sealer types. *J Endodon* 1987;13:109-12.
6. Madison S, Wilcox LR. An evaluation of coronal microleakage in endodontically treated teeth, part III: in vivo study. *J Endodon* 1988;14:455-8.
7. Higginbotham TL. A comparative study of the physical properties of five commonly used root canal sealers. *Oral Surg Oral Med Oral Pathol* 1967;24:89-101.
8. Torabinejad M, Ung B, Kettering JD. In vitro bacterial penetration of coronally unsealed endodontically treated teeth. *J Endodon* 1990;16:566-9.
9. Khayat A, Lee S, Torabinejad M. Human saliva penetration of coronally unsealed obturated root canals. *J Endodon* 1993;19:458-61.
10. Marshall FJ, Massler M. The sealing of pulpless teeth evaluated with radio-isotopes. *J Dent Med* 1961;16:172-84.