The effectiveness of four clinical irrigation methods on the removal of root canal debris

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Residual pulpal tissue, bacteria, and dentin debris may persist in the irregularities of root canal walls, even after careful mechanical preparation.[1-3] A number of irrigants are used in conjunction with canal instrumentation. In comparing these irrigants in terms of their disinfecting and cleaning qualities, there are two schools of thought. In one a great emphasis is placed on the chemical properties of an irrigant such as sodium hypochlorite, whereas in the other the overriding consideration is the mechanical action of the solution as a flushing agent. Some studies, in fact, have concluded that the flushing action is more important than the type of irrigant and that cleansing is a function of the quantity rather than the type of irrigant.[4-6]

Ram[6] found that the canal must be enlarged to a size 40 at the apex in order for the irrigant to be effective. Likewise, Senia and others[7,8] doubted the effectiveness of irrigation in narrow canals.

There is little information in the literature regarding the efficiency of different methods of delivering an irrigant into the root canal and their effectiveness in debris removal.

A review of the related literature on irrigation of the root canal indicates the following conclusions:

1. Irrigation of the canal is essential during root canal preparation.[4,9,10]

2. There are many clinical opinions as to the ideal method of delivering the irrigant. Some clinicians use a plastic syringe to deposit the irrigant into the pulp chamber and carry the irrigants into the deeper part of the canal with a file. Others employ anesthetic needles of 25 gauge in a 3 c.c. syringe, using either anesthetic solution or other irrigants. Still others advocate the use of perforated needles.[11]

3. There is some evidence that the removal of canal debris is dependent on canal size, diameter of the irrigating needle, and its depth of penetration into the root canal.[6,7,12]

PURPOSE

The purpose of this study is to investigate the effect of four methods of irrigation of the root canal on removal of dentinal debris.

Specifically, this study was made to determine which of the four following methods is most effective in removing canal debris:

1. Irrigation by flooding the pulp chamber and carrying the irrigant into the canal with a No. 15 file.
2. Irrigation and flushing with a 23-gauge Endo Lock irrigating needle.*
3. Irrigation and flushing with a 30-gauge anesthetic needle.†
4. Effervescent action by the chemical interaction of hydrogen peroxide and sodium hypochlorite.

METHODS

Sample selection

Extracted mandibular molars were screened by radiographic and clinical exploration of the canal in order to select only narrow and curved roots (No. 15 file fit snugly within 1 mm. short of the apex). Forty-eight teeth were selected, and only the mesial roots were used in the study.

Tooth preparation

Group I consisted of twenty-four teeth (forty-eight canals) prepared by the step-back technique with an apical stop to a size 25 file.[1,13] In Group II, twenty-

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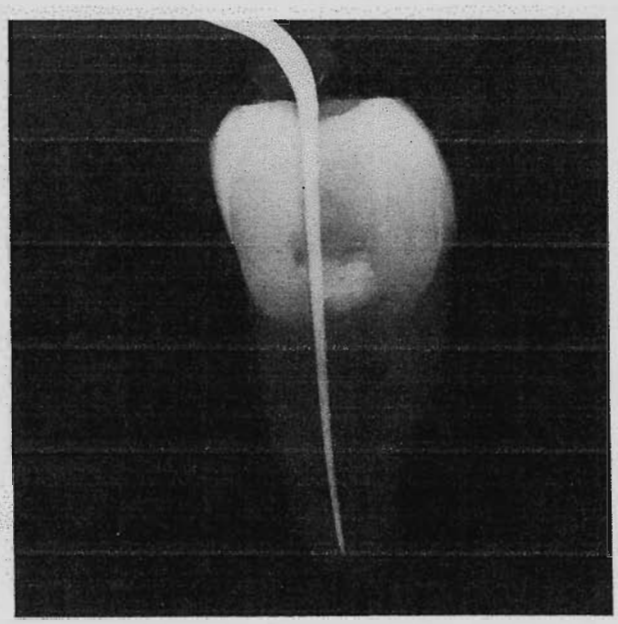

Fig. 1. An example of the prepared root canal with a "flare" that permits a No. D-11 to reach within 1 mm. short of the apex.

four teeth (Forty-six canals) were prepared to a size 40 file at the apex. All teeth had a flared cervical third to a degree of taper that would permit a D11 spreader to be placed loosely within 1 mm. short of the apical stop[14] (Fig. 1). Throughout the canal preparation, the canals were irrigated repeatedly with a 2.5 percent solution of sodium hypochlorite and frequent applications of RC Prep.* The foramen was kept patent with a No. 15 file. Dentin shavings were collected by grinding extracted teeth in order to simulate dentinal debris in the root canal. The dentin shavings were then mixed with 5 ml. of radiopaque contrast medium Renografin—60† and the mixture was shaken vigorously until the shavings could be seen floating loosely in the solution. The prepared canals were filled with the radiopaque medium by placing the solution into the pulp chamber and drawing it through the apex with the aid of a high-speed suction tip. The apex was sealed with wax to prevent leakage of the contrast medium and irrigants. The teeth were then radiographed to ensure that the canals were completely filled and no voids were present (Fig. 2). The same forty-eight teeth were used with each of the four irrigation methods in order to control the effect of canal diameter on the results.

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Fig. 2. Molar tooth filled with the Renografin-60 and dentin chips.

The four irrigation methods studied were as follows:

Method I. Tap water 3 ml., was placed in a 3 ml. syringe with a 23-gauge endodontic needle. Next 1.5 ml. of the solution was placed in the pulp chamber and then stirred in each canal with a No. 15 file. The irrigation was repeated with the remaining 1.5 ml. of solution.

Method II. The canals were irrigated with 3 ml. of tap water (in 0.75 ml. increments) from a 3 ml. syringe and a 23-gauge endodontic needle placed into the canal as far as possible without binding.

Method III. The canals were irrigated with 1.8 ml. (in 0.5 ml. increments) of anesthetic solution from a 30-gauge needle and a standard anesthetic syringe. The anesthetic needle was placed into the canal as far as possible without binding.

Method IV. The canals were irrigated with 0.75 ml. of 3 percent hydrogen peroxide followed by 0.75 ml. of 2.5 percent sodium hypochlorite via a 23-gauge needle placed into the canal as far as possible without binding. This was then repeated to ensure flow of the solution in the canal.

Once the teeth were irrigated by each of the four methods, radiographs were taken to check the com-

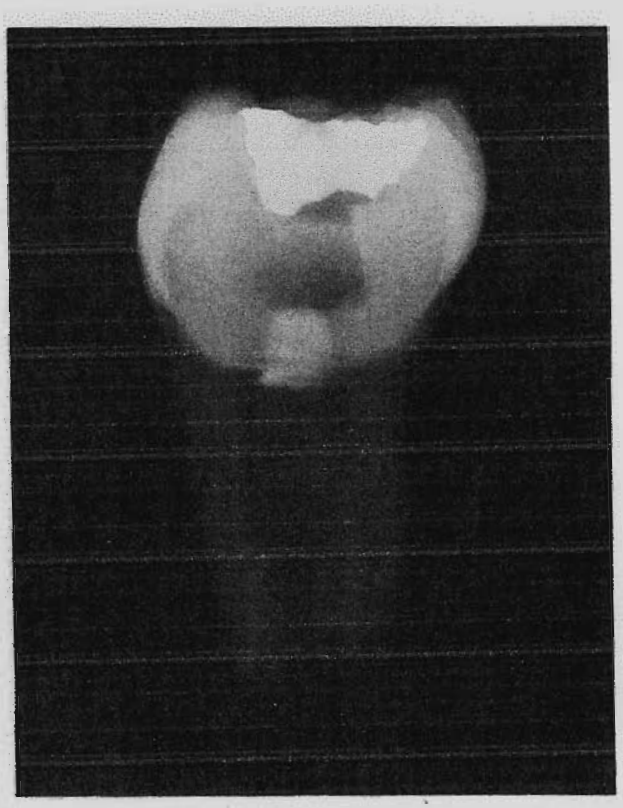

Fig. 3. An example of 1/3 score where the cervical third is cleared from the opaquer and dentin chips.

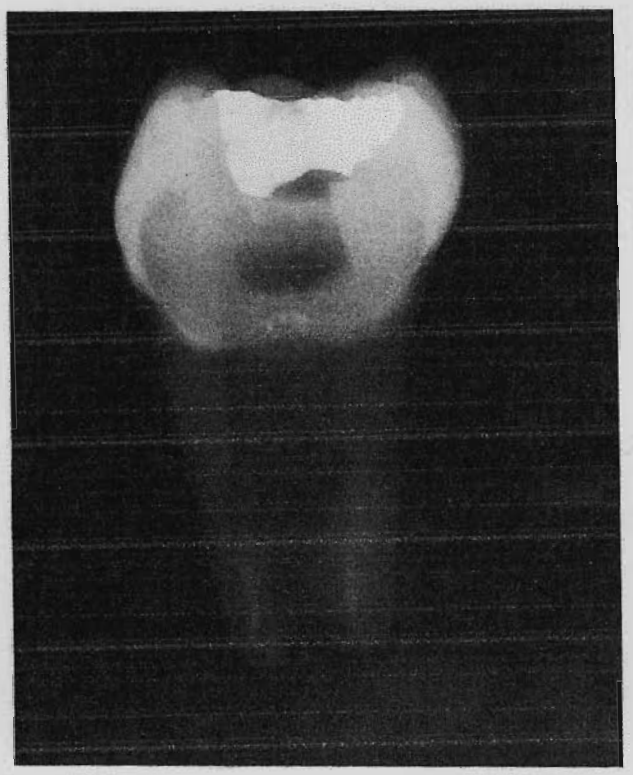

Fig. 4. An example of 2/3 score where the cervical and middle root thirds are cleared from the opaquer solution and dentin chips.

pleteness of the irrigation and flushing action. The radiographs were examined with a magnifying lens and scored according to the level of contrast medium remaining in the canal after flushing. Radiographically, the root canal was divided into thirds as follows:

1. A 1/3 score indicated flushing of the cervical third only. This was considered a poor score (Fig. 3).
2. A 2/3 score indicated flushing of the cervical and middle thirds of the root. This was considered an average score (Fig. 4).
3. A 3/3 score indicated complete flushing of the contrast medium from all portions of the root canal, including the apical, middle, and cervical thirds. This was considered a complete and desired score (Fig. 5).

Following collection of data for each irrigation method studied, the wax was removed from the root apex and each tooth was flushed thoroughly with water and suction to ensure that all the Renografin-60—dentin shavings mixture was removed. All teeth were radiographed again as a final check before the next experimental method was tested.

The length of each tooth and canal was tabulated along with the depth of needle insertion for methods II, III, and IV.

Statistical analysis

The data were analyzed statistically by the chi-square goodness of fit test. A P value equal to or less than 0.05 ($P < 0.05$) was considered statistically significant and a P value equal to or less than 0.0001 ($P < 0.0001$) was considered to be statistically highly significant.

RESULTS

Group II

Canals were prepared to a size 40 at the apex. The average length of teeth in this group was 20.3 mm.

1. The results are summarized in Table I. When the irrigant was placed in the pulp chamber and stirred with a No. 15 file, twenty-four of the forty-six canals were completely cleared of debris.
2. When the 23-gauge needle was inserted as far as possible without binding, thirty-two of the forty-six canals were completely cleared of debris. The needle reached an average depth of 14.0 mm; which

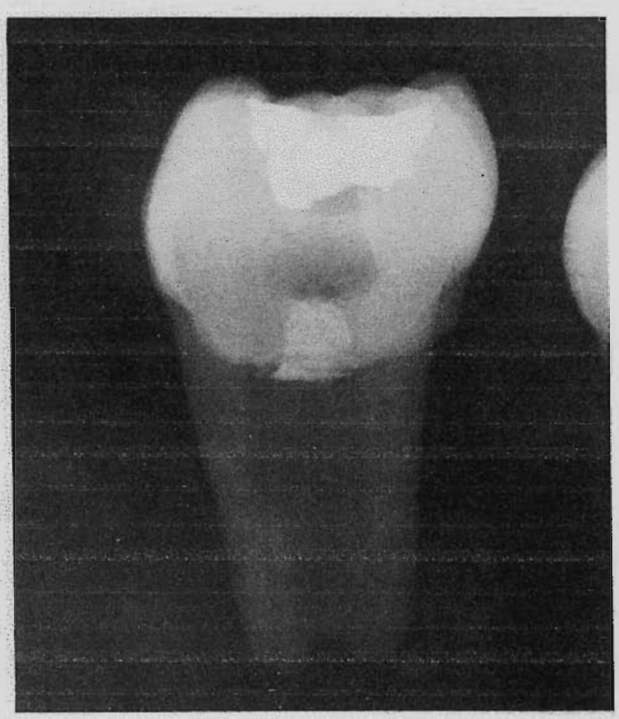

Fig. 5. An example of 3/3 score where the total root canals are cleared from the opaquer solution and dentin chips.

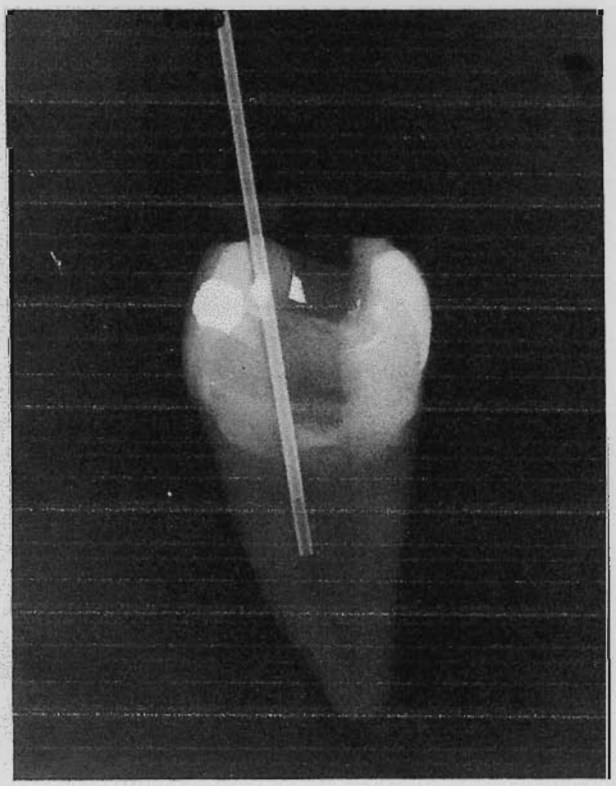

Fig. 6. The level of penetration of 23-gauge needle an average of 14.0 mm. in teeth with 20 mm. length.

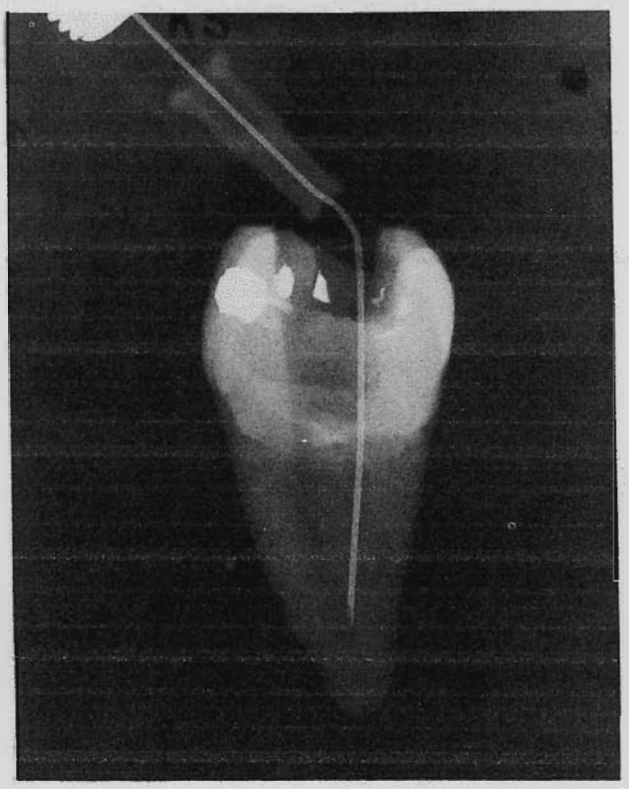

Fig. 7. The level of penetration depth of 30-gauge needle an average of 17.4 mm. in a 20.3 mm. tooth length.

placed the needle tip in the middle third of the root (Fig. 6).

3. When the 30-gauge needle was inserted as far as possible without binding, forty-five of the forty-six canals were completely cleared of debris. The average depth of insertion was 17.4 mm; and the needle tip reached the apical third of the canal in all cases (Fig. 7).

4. In the effervescence method, twenty-two of the forty-six canals were cleared.

Comparison of Method I (irrigant in chamber and stir) with Method II (23-gauge Endo needle to midroot level) and Method IV (effervescence with needle to mid-root) reveals that there was no statistical significance in the effectiveness of the irrigation methods. Method II was more effective when compared to Method IV. When Method III (30-gauge needle to apical third) was compared to Methods I, II, and IV, the results indicated that Method III was more effective in each case, and this was statistically significant ($P < 0.05$ level).

Group I

The canals were prepared to a size 25 at the apex. The average length of the teeth in this group was 20.75 mm.

Table I. Number of canals irrigated by four different methods and degree of debris removal

Method	*Size 25 file at apex with flare*			*Size 40 file at apex with flare*		
	*3/3**	*2/3†*	*1/3‡*	*3/3**	*2/3†*	*1/3‡*
Irrigants stired in the canal with No. 15 file	26	19	3	24	22	0
23-gauge Endo needle to midroot	29	16	3	32	14	0
30-gauge anesthetic needle to apical third	43	4	1	45	1	0
Effervescent action of H_2O_2 + NaOCl.	25	17	6	22	20	4

*Complete score. Cervical, middle, and apical thirds were cleared.
†Average score. Cervical and middle thirds only were cleared.
‡Poor score. Cervical third only was cleared.

The results are summarized in Table I. The canals irrigated by Method I were completely flushed in twenty-six of the 48 canals. The canals irrigated by Method II were completely flushed in twenty-nine canals. Method III resulted in complete flushing in forty-three canals and Method IV in twenty-five of the forty-eight canals.

When Methods I, II, and IV were compared, statistical analyses showed no significant difference. However, when Method III was compared to Methods, I, II, and IV, the differences were significant (P value < 0.05).

DISCUSSION

The results of this study suggest that the proximity of the irrigation needle to the apex plays an important role in removing root canal debris. The needle delivering the solution apparently must come in close contact with the material to be removed in order to be most effective.

Clinically, a common problem encountered during enlargement of narrow and curved canals, is ledging and the build-up of dentin shavings. Ram[6] found that when the canal was enlarged to a No. 25 file, debris was left unflushed. Our study showed more positive results than those reported by Ram perhaps because of the difference in canal preparation design. The results of this study clearly show that canals prepared to a minimum diameter (size 25 at the apex) can be consistently flushed if the preparation provides sufficient cervical and midroot taper to allow for placement of the irrigation needle tip in the apical third of the canal.

The practice of alternating a peroxide with sodium hypochlorite has been recommended for mechanically elevating debris from the canal by the release of nascent oxygen.[12] The results of this study suggest that such a method is no more effective than the use of water or anesthetic solutions. This finding substantiates the opinion of Senia and colleagues[7] that the release of air bubbles by the interaction of the proxide with the hypochlorite may be a barrier to the exchange of fresh solution in the deeper parts of the canal.

Recent studies have shown that a plug of dentin chips may serve to prevent overfilling and at the same time promote formation of new cementum. However, a lack of periapical tissue response has been demonstrated only in vital cases.[15,16] In contaminated canals, the apical plugging of root canals with infected dentin chips may produce unfavorable results, such as irritation of the periapical tissues and delay in the healing process.[17] Regardless of the value of dentin chips or shavings as an apical seal, this study demonstrates that the suspension of liquid and dentin chips can be cleared from the root canal when the needle is placed in the apical third. This more efficient irrigation would permit the elimination of infected chips produced during instrumentation if an intentional apical plug of dentin chips is desired.

Clinical Implications

We recommend that, upon completion of canal preparation, the canal contents consisting of dentin debris should be flushed by means of a small-diameter (27- or 30-gauge) irrigation needle placed in the apical third of the canal. Such irrigation can be effectively performed with the same anesthetic needle that is used for anesthetizing the patient and with anesthetic solution as an irrigant.

SUMMARY

Forty-nine extracted teeth with narrow canals were prepared to a size 40 and standard taper (forty-six canals) and to a size 25 with a step-back taper (48 canals). The canals were filled with a radiopaque contrast medium and dentin chips mixture and irrigated by each of four different methods commonly used clinically.

The findings of this study indicate that the needle delivering the irrigant must come in close proximity to the material being removed, in order to be most effective. Narrow canals prepared to a minimum diameter (size 25) can be effectively flushed of debris if prepared with sufficient taper to allow a small needle to be placed in the apical third of the canal. The use of alternating solutions of peroxide and sodium hypochlorite was no more effective than the use of tap water or anesthetic solution.

CONCLUSIONS

1. The proximity of the needle delivering the irrigant to the apex plays an important role in irrigation. In order to be effective, the needle delivering the solution must come in close proximity to the material to be removed.

2. Narrow canals prepared to a minimum diameter of size 25 can be effectively flushed of debris when the cervical and middle thirds are tapered to allow for placement of the irrigation needle in the apical third of the canal.

3. The use of a 30-gauge anesthetic needle is more effective than the use of a 23-gauge Endo needle or stirring the irrigant in the root canal with a file.

4. The use of alternating solutions of peroxide and sodium hypochlorite was no more effective than the other methods tested.

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