

# Effectiveness of Halothane Used with Ultrasonic or Hand Instrumentation to Remove Gutta-percha from the Root Canal

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**This study compared halothane and chloroform used with hand or ultrasonic instrumentation to remove gutta-percha and sealer from root canals. Apically extruded debris, residual debris, time for filling removal, and amount of solvent used were determined. The differences in extruded apical debris and radiographically visible residual debris were not significant ( $p > 0.05$ ). Ultrasonic instrumentation required significantly less time to remove the root canal filling than did hand instrumentation ( $p = 0.02$ ). The only significant difference in the amount of solvent used occurred when the ultrasonic-chloroform group was compared with the hand instrumentation-chloroform group ( $p = 0.05$ ). Halothane was found to be an acceptable alternative to chloroform for removing gutta-percha and sealer from the obturated root canal.**

Removing gutta-percha from inadequately prepared and obturated root canal systems is a major part of most root canal retreatments. In canals where the gutta-percha is well condensed or aged, removal is usually accomplished with hand instrumentation and a solvent to soften the gutta-percha.

Because chloroform has been identified as a potential carcinogen (1), emphasis has been directed toward identifying alternative solvents. Halothane, a commonly used inhalation anesthetic, recently was described as being nearly as effective as chloroform in dissolving gutta-percha (2). Halothane is not irritating, flammable, or explosive.

Removing obturation materials from the root canal can be time consuming and frustrating. Operator fatigue and hurried procedures may lead to extrusion of debris through the apical foramen. Debris expressed into the periradicular tissues may cause acute exacerbations of chronic inflammatory conditions (3). Extrusion of debris appears to occur with all instrumentation techniques. However, Fairbourn et al. (4) reported less extrusion with ultrasonic instrumentation than with hand instrumentation after comparing conventional filing, cervical filing, and ultrasonic and sonic instrumentation techniques. Ultrasonic instrumentation has been used successfully to remove obturation materials from root canals (5-7), and Martin

and Cunningham (8) recommend ultrasonic instrumentation alone or with a solvent to remove gutta-percha.

To date, no study has been published in which halothane was used with ultrasonic or hand instrumentation to remove gutta-percha from the root canal. If halothane and ultrasonic instrumentation were effective for this purpose, the removal procedure would require less time and effort. Also, the amount of debris expressed from the apical foramen during removal of gutta-percha has not been previously addressed. The amount of debris expressed could affect the outcome of retreatment and the incidence of postoperative pain and swelling.

The purpose of this study was to evaluate the efficacy of halothane used with hand or ultrasonic instrumentation for removing gutta-percha from obturated root canals.

## MATERIALS AND METHODS

One-hundred four extracted human maxillary anterior teeth with straight canals were used. After bony fragments were removed with a periodontal curette, the teeth were placed in 5.25% NaOCl for 24 h to remove organic debris, rinsed in sterile saline, and stored in 0.2% sodium azide.

All teeth were instrumented with a modified step-back technique and obturated with a modified lateral condensation technique. After the teeth were obturated, they were radiographed with Ultraspeed film (Kodak, Rochester, NY) from the proximal and facial directions to verify adequacy of the root canal filling. The filling was deemed adequate when it appeared to be dense and filled all portions of the prepared canal. Then, the teeth were stored in a humidior at 37°C and 100% humidity for 1 month (24 samples) or 4 months (80 samples).

## Gutta-percha Removal

To standardize the length of the filled canals, the clinical crown and part of the coronal root of the prepared teeth were removed with a #769 tapered diamond bur (Star Dental Co., Valley Forge, PA) under water spray in a high-speed hand-piece. The bur was directed in a horizontal plane perpendicular to the long axis of the root at a point 17 mm from the apical foramen. All roots had 1 mm of gutta-percha removed

from the coronal end of the canal with a heated, premeasured 5/7 plugger to create a reservoir for the solvent. The teeth were then secured for instrumentation and debris collection using a modification of the technique described by Fairbourn et al. (4).

Each root was forced through a hole in a #1 rubber stopper. An aluminum crown (Ion Iso-Form #5; 3M, St. Paul, MN) served as the collection assembly. It was suspended around the protruding root by two wires that were inserted into the rubber stopper and through holes drilled near the margin of the aluminum crown (Fig. 1). The aluminum crown was weighed before assembly. To allow for venting, the rubber stopper, tooth, and collection assembly were loosely fitted into the mouth of a 20-ml vial. The aluminum crown collection assembly prevented the viewing of debris expressed from each tooth apex (Fig. 2).

Using a table of random numbers, the teeth were assigned to one of four retreatment groups. In group 1 (control), hand instrumentation with K-type files was used in conjunction with chloroform (MCB Chemists Inc., Cincinnati, OH). In group 2, halothane (Fluothane; Ayerst, New York, NY) was used as the solvent. Dry ultrasonic instrumentation (Cavi-Endo; Caulk/Dentsply, Milford, DE) was used with chloroform for group 3 and with halothane for group 4. The retreatment techniques were used until the apical seat was reached, clean filings were present, no gutta-percha or sealer could be seen on the files, and the canal walls were smooth to tactile examination (1).

The hand instrumentation of roots in groups 1 and 2 included the removal of coronal gutta-percha with a push-pull filing method and then the removal of the apical 1 to 2 mm of gutta-percha with a quarter-turn push-pull method to minimize apically extruded debris. Small files were used for the ultrasonic instrumentation of roots in groups 3 and 4. The coronal gutta-percha was removed with #25 ultrasonic files, followed by the removal of the apical 1 to 2 mm of gutta-percha with #15 ultrasonic files (10). The solvent was the only irrigant used with the ultrasonic files (11).

All solvents were delivered to the prepared reservoir by a 1.0-ml tuberculin syringe. The amount of solvent used and the time required to achieve the retreatment criteria for satisfactory gutta-percha removal were recorded for each technique.

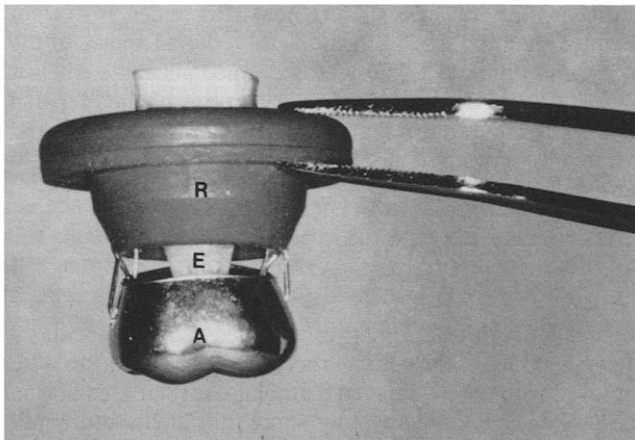


FIG 1. Debris collection assembly. E, extracted tooth; R, rubber stopper; and A, aluminum crown.



FIG 2. Debris collection assembly mounted on a 20-ml scintillation vial.

### Weighing Apically Extruded Debris

After gutta-percha removal, the aluminum crown was detached from the suspension wires, and the debris adhering to the root apex was collected by scraping with the edge of the aluminum crown. The debris and the aluminum crown were weighed with a microbalance (M3; Mettler Instrument Corp., Highstown, NJ). The weight of the debris was calculated by subtracting the weight of the aluminum crown from the combined weight of the aluminum crown and debris.

### Calculating Residual Debris

Final facial and proximal radiographs were obtained after removal of the teeth from the rubber stoppers. Effectiveness of gutta-percha removal was calculated using an image analyzer (Zidas; Carl Zeiss Inc., Thornwood, NY) (Fig. 3). Radiographs were projected onto the surface of the system's magnetized digitizer tablet, and one observer with an activated stylus outlined the root canal and residual debris areas. Using a scale relative to the enlargement of each radiograph, the system's computer calculated the mean and standard deviations from three separate debris area readings and three separate total canal space area readings. From these mean values, the percentage of residual debris was calculated. The resultant mean percentages from the proximal and facial

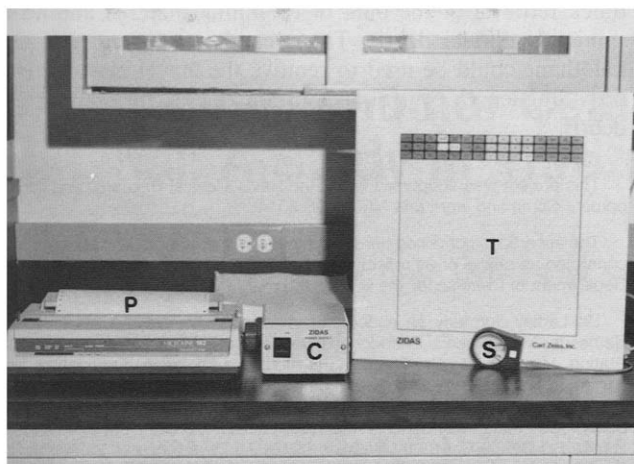


FIG 3. Zidas Image Analyzer. Radiographs were projected on the magnitized digitizer tablet (T), and the area readings were outlined by the stylus (S). The system's computer (C) calculated means and standard deviations. The printer (P) was an additional peripheral device.

radiographs were then averaged to produce a single mean percentage.

### Statistical Analysis

The mean and standard deviation for the weight of extruded debris, the percentage of residual debris, the time required for removal of the root canal filing, and the volume of solvent used were statistically evaluated for all retreatment groups (dependent variables). A two-way analysis of variance (ANOVA) was used to identify any significant main effect differences and/or interactions between the independent variables (method of instrumentation and solvents). If significant interactions between the independent variables were identified, then a one-way ANOVA and a Scheffe's multiple comparison test were used to determine which groups were significantly different from each other. The probability level for significance in all tests was set at  $p = 0.05$ .

### RESULTS

Of the original 104 teeth, 102 remained for analysis. Two samples were lost because of instrument fracture. In no teeth did the root canal filling come out in one piece.

All retreatment techniques caused extrusion of apical debris. To evaluate the amount of apically extruded debris, a  $2 \times 2$  factorial design was used, with instrumentation method (ultrasonic and hand instrumentation) as one independent variable and solvents (halothane and chloroform) as the other. The results of the analysis of variance disclosed that there were no significant differences in amounts of extruded debris between the ultrasonic and hand instrumentation methods ( $F = 1.22$ ,  $df = 1/98$ ,  $p = 0.27$ ) and no significant differences between the halothane and chloroform ( $F = 1.59$ ,  $df = 1/98$ ,  $p = 0.21$ ). Also, there was no significant interaction between the independent variables, instrumentation methods and solvents ( $F = 0.88$ ,  $df = 1/98$ ,  $p > 0.05$ ).

All retreatment techniques caused an accumulation of re-

sidual debris. Two-way ANOVA showed there was a significant interaction between the instrumentation group and the solvents ( $p = 0.01$ ). One-way analysis of variance indicated that the differences among the four groups for the amount of residual debris left in the canal was not significant ( $p = 0.06$ ).

The  $2 \times 3$  ANOVA revealed significant differences in the amount of time required to remove old root canal fillings depending on the method of instrumentation. Hand instrumentation required significantly more time than ultrasonic instrumentation for removal of old root canal fillings ( $F = 5.76$ ,  $df = 1,98$ ,  $p = 0.02$ ). There was no significant difference between chloroform and halothane in the time required to remove root canal fillings ( $F = 2.77$ ,  $df = 2,98$ ,  $p > 0.05$ ), nor was there a significant interaction between the method of instrumentation and the solvent used ( $F = 0.51$ ,  $df = 2,98$ ,  $p > 0.05$ ).

When evaluating the amount of solvent used, the two-way analysis of variance revealed significant interaction between instrumentation groups and solvent groups ( $F = 7.37$ ,  $df = 1,98$ ,  $p = 0.01$ ). Because of this interaction, the four retreatment groups were compared using a one-way ANOVA. The one-way ANOVA indicated that there was a significant difference among the four groups in the amount of solvent used ( $p = 0.001$ ). Scheffe's multiple comparison test showed that the hand instrumentation-chloroform group used significantly less solvent than the ultrasonic-chloroform group ( $p < 0.05$ ). The amount of solvent used in the halothane groups, regardless of instrumentation, was not significantly different from that used in the chloroform groups.

### DISCUSSION

According to our findings, halothane is as effective as chloroform when used as a gutta-percha solvent in conjunction with hand or ultrasonic instrumentation. In addition, ultrasonic instrumentation is as effective as hand instrumentation in removing gutta-percha from the root canal.

To reduce extrusion of apical debris, a quarter-turn push-pull method was used for hand instrumentation and a push-pull method with small files for ultrasonic instrumentation. Despite these precautions, all retreatment groups exhibited apically extruded debris. The apically directed pressure used to facilitate file and solvent penetration may have contributed to the amount of debris extruded. Also, Martin and Cunningham (10) found that greater extrusion of debris occurs if instrumentation is performed when the file is at the apical foramen rather than 1 mm short of it. Because length control with ultrasonic files is more difficult than with hand files, there is the potential for a higher incidence of the ultrasonic files passing through the apical foramen and contributing to the extrusion of apical debris.

An in vivo model could show less extrusion because the periradicular tissues may serve as a natural barrier. Also, periradicular tissue pressure that exceeds intracanal pressure could limit the amount of extruded debris (4).

The ultrasonic-chloroform technique may produce residual debris because the rapid attainment of working length to the apical seat may preclude the complete removal of the obturating material in the coronal area of the canal. Attainment of working length could be confused with the completion of the retreatment procedure. This technique also seemed to create

a slurry that coated the canal wall. In contrast, when halothane was used, the gutta-percha was not as soft and could be removed in bits rather than as a slurry.

Image analysis of debris within the canal system was based on the subjective interpretation of the projected radiograph. To overcome this potential variable, all of the area data were collected by the same investigator, and each value used in the percentage calculations was a mean of three separate values. Although comparison of the debris could not be determined radiographically, the amount remaining in the root canal may be more important than its components. Residual gutta-percha and sealer in the canal can cover remnants of necrotic tissue or bacteria that could cause endodontic failure.

As expected, the ultrasonic technique with chloroform or halothane used significantly more solvent than the hand instrumentation group with either solvent because the solvent not only acted as an irrigant, but also was volatilized.

Ultrasonic instrumentation required less time to attain the working length than hand instrumentation. The frictional heat generated by the ultrasonic files may enhance the solvent action, thus reducing the time required for gutta-percha removal.

As with any investigation using extracted teeth, there are inherent problems with the experimental model; however, variables were minimized by selecting teeth with straight canals that were subsequently instrumented to a #35 master apical file. Although all canal lengths were 17 mm with 16 mm of obturated space, elimination of differences in canal width and anatomy was impossible. Random selection was used to minimize these variables.

In none of the groups did the root canal filling come out in one piece. This was probably due to the time that elapsed between obturation and retreatment. Wilcox (12) demonstrated that a 3-month setting time, as opposed to a 2-week setting time, prevented root canal fillings from being removed in one piece. The current study showed that a 1- or 4-month setting time created the same conditions as the 3-month setting time.

The findings of this study suggest a new and perhaps better approach to retreatment of teeth obturated with gutta-percha. Ultrasonic instrumentation and halothane would provide

quick retrieval of the bulk of the filling material and leave minimal residual debris. Then, hand instrumentation and halothane could be used to remove the apical plug, thereby providing length control and minimizing extrusion of apical debris.

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