REPORT DOCUMENTATION PAGE

OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE: June 1995

3. REPORT TYPE AND DATES COVERED

4. TITLE AND SUBTITLE: A Comparison of Sealer Placement Techniques In Curved Canals.

5. FUNDING NUMBERS

6. AUTHOR(S): Michael C. Hall, David J. Clement, S. Brend Dove, William A. Walker

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

AFIT Students Attending: The University of Texas, HSC

8. PERFORMING ORGANIZATION REPORT NUMBER: AFIT/CI/CIA 95-044

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

DEPARTNEMT OF THE AIR FORCE
AFIT/CI
2950 P STREET, BDLG 125
WRIGHT-PATTERSON AFB OH 45433-7765

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for Public Release IAW AFR 190-1
Distribution Unlimited
BRIAN D. GAUTHIER, MSgt, USAF
Chief Administration

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

14. SUBJECT TERMS

15. NUMBER OF PAGES: 23

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT

A COMPARISON OF SEALER PLACEMENT TECHNIQUES IN CURVED CANALS

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Sealer placement technique comparison

ABSTRACT

Sealer placement techniques have not been examined in teeth with curved canals prepared with Lightspeed instruments. Three traditional methods of placing sealer were studied, using 45 extracted human single-rooted teeth, divided into 3 groups of 15. Root canal preparations were made with Lightspeed nickel titanium engine-driven instruments. AH26 sealer was applied with either K-file, lentulo spiral, or master gutta-percha cone. Radiographs were taken after sealer placement and analyzed for amount of canal sealer fill. The teeth were then obturated with laterally condensed gutta-percha, chemically cleared, photographed, and analyzed for total canal wall sealer coverage. The results showed a statistically significant difference in canal sealer fill among the 3 groups before obturation, but there was no statistical difference in canal wall coverage among the 3 groups after obturation. None of the examined methods exceeded an average of 62.5% wall coverage of sealer after obturation. This suggests that complete wall coverage after obturation may not be possible.

A COMPARISON OF SEALER PLACEMENT TECHNIQUES IN CURVED CANALS

INTRODUCTION

Three-dimensional obturation of the root canal system is the final objective of non-surgical root canal therapy (1). Gutta-percha is the preferred core filling material, but it has the disadvantage of being non-adherent to canal walls. In order to prevent leakage of contaminants from the periapical tissue or the oral cavity, a root canal sealer should be placed into the canal prior to obturation with gutta-percha (2). Ideally, sealer coverage of the canal walls should be complete. Sealers also function to fill voids between the core filling material and the canal walls, to serve as lubricants to aid in gutta-percha cone placement, and to fill dentinal irregularities, accessory canals, and multiple apical foramina (2).

Sealer is important to the integrity of the obturation of the canal space. Accepted methods of sealer placement include endodontic files or reamers, lentulo spirals, gutta-percha cones, paper points, and, recently, ultrasonic files. Many questions concerning sealer placement and eventual dispersal during the condensation of gutta percha have not been completely resolved in the literature.

There have been few studies to evaluate sealer placement technique. None have specifically evaluated teeth with curved canals, and the question of sealer dispersal following obturation has rarely been addressed. In an unpublished abstract, Amato et al. (3) placed sealer in 30 anterior teeth with straight and curved (curvature undefined) canals with lentulo spirals, files, and gutta-percha points, and concluded that the method used to place sealer was unimportant. Jeffrey et al. (4), using transparent tooth models with straight canals to evaluate sealer placement with master gutta-percha cones and lentulo spirals, also concluded that the placement

technique did not affect the coating of the sealer. Hoen, LaBounty, and Keller (5) examined sealer placement in the mesial roots of 50 mandibular molars (curvature undefined) using hand reamers or ultrasonic files and concluded that ultrasonic files were significantly better than hand reamers. West, LaBounty, and Keller (6), in a similar study also concluded that ultrasonic file placement was superior. Wiemann and Wilcox (7) examined 40 mandibular incisors with straight canals with sealer applied by files, lentulo spirals, gutta-percha cones, and ultrasonic files and concluded that no statistically significant differences existed. In a recent companion study, Wilcox and Wiemann (8) examined 40 single-rooted teeth with canal curvatures < 30 degrees. They applied sealer with a lentulo or a #35 file, used alcohol or NaOCl as a final irrigant, and obturated with laterally-condensed gutta-percha. They concluded that the best sealer coverage was in the coronal third, and that drying canals with alcohol did not significantly improve sealer coverage.

The nickel-titanium Lightspeed instrumentation technique was developed to address the problem of preparing curved canals (9-12). Lightspeed instruments stay centered in the canal, minimize apical transportation, and do not remove excessive amounts of tooth structure (12). However, the ability to properly prepare curved canals without removing excessive amounts of tooth structure, as well as the production of a less-tapered preparation, may increase the difficulty of delivering an adequate amount of sealer to the apical half of the curved canal. This could result in poor sealer distribution in the canal and inadequate wall coverage, ultimately leading to compromised obturation.

Sealer placement techniques and sealer distribution have not been examined in curved canals prepared with Lightspeed instruments. Therefore, the purpose of this study was to compare three traditional methods of sealer placement in canals with slight-to-moderate canal curvatures (15° to 36°) prepared with Lightspeed nickel-

titanium, engine-driven instruments, and to examine dispersal of sealer following obturation with laterally condensed gutta-percha.

MATERIALS AND METHODS

Tooth Selection

Forty-five extracted human single-rooted incisors, canines, and premolars with one canal, and curvatures ranging from 15 degrees to 36 degrees, were stored in 10% formalin. Canal curvature was measured from buccal and proximal radiographic views using the technique described by Schneider (13). The teeth were randomly divided into three groups of 15. Canal size permitted standardization of the preparation in the apical 5 mm.

Root Canal Preparation

Standard access preparations were made, and working lengths were determined by placing a #10 Flex-R file (Union Broach, York, PA) into the canal until it was visible at the apical foramen, and then subtracting 0.5 mm. Circumferential filing with #10 and #15 Flex-R files was performed at working length until the #15 fit passively. Canals were prepared utilizing Canal Master rotary files (Brasseler USA, Savannah, GA) for pre-flaring, and Lightspeed engine-driven instruments (Lightspeed Technology Inc., San Antonio, TX) according to techniques developed by the endodontic department at the University of Texas Health Science Center at San Antonio (14), for apical preparation. Canal Master rotaries sizes #50 - 100 were used to prepare the middle and cervical thirds of the canal to the level of the curvature, but no closer than 5 mm from working length. Lightspeed instruments

were then used to prepare the apical portion of the canal to a minimum size #40 at working length. Apical preparations ranged from a #40 MAR (master apical rotary) to a #60 MAR. Of the 45 teeth prepared, 24, or 53.3%, were prepared to a size #50 MAR. A step-back flare was accomplished in half-size Lightspeed instruments (#42.5, 45, 47.5, 50, etc.) in 0.5 mm increments. Apical patency was maintained with a #10 Flex-R file, and copious irrigation was provided throughout the procedure with 2.6% sodium hypochlorite. Canals were dried with paper points. Suitable master gutta-percha cones were selected for each canal, and a final flush of 100% ethyl alcohol was used for further drying of the canal walls.

Sealer Placement

Each group of 15 teeth had sealer applied by one of three methods: K-type file (Kerr, Romulus, MI), lentulo spiral (Caulk/Maillefer, Milford, DE), or gutta-percha master cone. AH26 sealer (DeTrey/Dentsply, Zurich, Switzerland) was used for all study groups. It was mixed according to the recommendations of Barthel, et al. (15) with the following alteration. A small amount of Han-See Pounce Powder (Hancy Manuf. Co., Eugene, OR), a carbon black powder, was added to the sealer to darken it for visibility following the clearing of the specimens. No alteration in consistency of the sealer was noted by the addition of the Pounce Powder. Following mixing on a glass slab to a consistency that allowed it to string out one inch and remain for 5 seconds, a standard amount of 0.05 ml of sealer was delivered to each canal via a 1 ml tuberculin syringe.

All groups consisted of 15 teeth prepared by the method described. Teeth in Group A had sealer placed via a #20 K-type file that was slowly placed into the canal in a counterclockwise motion to within 1 mm of working length; the file was gently pumped up and down within the canal at least 5 times. Teeth in Group B

had sealer placed with a 25 mm, #2, engine-driven lentulo spiral, which was gently rotated to working length and worked gently up and down within the canal at least 5 times. Group C teeth had sealer applied with the master gutta-percha cone, which was placed to working length and gently pumped up and down at least 5 times. Excess sealer which extruded apically or coronally was cleaned from the tooth surface with cotton gauze. Radiographs of the teeth in the clinical (buccal) and proximal views were taken following sealer placement.

Canal Obturation

Following sealer placement and radiographs of the teeth, all teeth were obturated with laterally-condensed gutta-percha (Union Broach, Emigsville, PA). No additional sealer was applied before gutta-percha cone insertion. The master gutta-percha cone was gently inserted into the canal, allowing excess sealer to escape (2). Lateral condensation was accomplished using pre-curved 25 mm fine finger spreaders (Union Broach, York, PA). Following obturation, a heated #1 Glick plastic instrument (Union Broach, York, PA) was used to remove excess gutta-percha and sealer to the canal orifice. The root access was sealed with Cavit temporary restorative material (Espe, W. Germany). Teeth were randomly and blindly coded and stored in 100% humidity at 37 degrees C for seven days to allow the sealer to set.

Radiographic Analysis of Sealer Placement

Clinical and proximal view radiographs taken following sealer placement and before lateral condensation of gutta-percha provided 2 views of each tooth (Fig. 1). The apical 10 mm on each view was measured, the radiographs were placed in slide

mounts, and the slides were projected on Kodak Ektagraphic AudioViewers (Eastman Kodak, Rochester, NY). The root canals in each view were traced onto plastic transparencies, and the total canal area, the area occupied by sealer, and the area void of sealer were calculated using Sigma Scan software (Jandel Scientific, Corte Madera, CA). Analysis of variance and a post hoc comparison by the Newman-Keuls test was performed to statistically compare canal sealer fill in the clinical and proximal views within and between groups ($p < 0.05$).

Analysis of Obturation Dispersal of Sealer

Teeth were decalcified in 5% nitric acid, dehydrated in graded ethyl alcohol rinses, and cleared in methyl salicylate according to the technique proposed by Robertson, et al (16). Both proximal surfaces of each tooth were examined under stereomicroscope (Zeiss, Germany) at a power of 1.2X. The apical 10mm of each proximal view was photographed in color. This produced a total of 90 images. The gutta-percha appeared as a uniform pink color, and sealer appeared grey-black. Buccal and lingual views of the cleared specimens were not photographed. During pilot studies, these views demonstrated too much distortion to be accurately evaluated. Black and white images produced from the color slides clearly show the difference between sealer and gutta-percha (Fig. 2). All images were coded according to group. Percentage of total sealer coverage for each proximal surface was calculated utilizing the Macintosh Quadra 800 computer (Apple Computers, Inc., Cupertino, CA), Adobe Photoshop Vers. 3.0 (Adobe Systems, Inc.) digitizing software, and NIH Image Vers. 1.55 (National Institutes of Health, Bethesda, MD) imaging software. Analysis of variance was used to determine the significance of between-group differences.

RESULTS

Statistical analysis of radiographs of sealer placement before obturation with gutta-percha showed a significant difference in canal sealer fill of the apical 10 mm between all three groups. Group A (K-file placement) had a mean canal sealer fill of 76.4%, Group B (lentulo spiral) had a mean canal fill of 90.2%, and Group C (master gutta-percha cone) had a mean of 56.4% canal fill (Fig. 3). Analysis of the apical 10 mm of the cleared specimens from the color slides showed no statistically significant difference in sealer wall coverage among the three groups after obturation: Group A had a mean of 57.7% sealer wall coverage, Group B had 62.5% coverage, and Group C had 55.5% coverage (Fig. 4). There was a statistically significant difference in canal sealer fill before obturation and in sealer wall coverage after obturation.

DISCUSSION

Numerous studies have demonstrated the importance of root canal sealer to fill irregularities and voids between non-adherent gutta-percha and canal walls during obturation. Most leakage studies have shown that the use of sealer causes significantly less leakage than when it is not used (17-19).

Are traditional placement techniques satisfactory in placing sealer throughout the apical to coronal extent of the canal? How is sealer displaced within the canal system during obturation? Is sealer coverage less predictable in curved than in straight canals? If so, what impact does incomplete sealer coverage in curved canals have on the success or failure rate in those teeth? These questions are not easily answered, but important knowledge may be gained by examining sealer placement before obturation and sealer displacement after obturation in teeth with curved

canals. The studies (3-8) which have examined sealer placement techniques have been unable to definitively determine if one method is preferable to another. Differences in methods of canal preparation, different placement evaluation methods, and failure to compare straight and curved canals all can affect study results. In the study by Amato et al. (3), after the sealer was placed, radiographs were taken from the buccal and from the mesial, the canals were laterally condensed with gutta-percha, and two cross-sections, at 1 mm and 4 mm from the apex, were examined. They concluded the sealer placement method was unimportant, but it is not known how much sealer was applied, whether it was a standard amount for each tooth, how the cross-sections were evaluated, or what percentage of the canals before and after obturation were covered with sealer. In addition, neither total canal coverage nor sealer displacement characteristics were examined, and methods of evaluating radiographs were not mentioned.

The focus of the study by Jeffrey et al. (4), which used transparent tooth models with straight canals to evaluate sealer placement with master cones and lentulo spirals, was on the amount of sealer extruded from the apex and a subjective evaluation of voids left on the plastic canal walls after sealer placement. They concluded that the application method did not make a difference on overall sealer coating and that the lentulo caused greater apical extrusion of sealer. Sealer amount was not standardized, percentages of total wall coverage were not determined, and sealer coverage after obturation was not examined.

Hoen, LaBounty, and Keller (5) used mesial roots of 50 mandibular molars to evaluate sealer placement by hand reamers or ultrasonic files by horizontally sectioning prepared roots after sealer was placed. Sections from 1 mm to 7 mm from the apex, in one mm increments, were evaluated for complete or incomplete coverage of wall surfaces. Only 27% of the sections with sealer applied by hand instrument demonstrated total peripheral sealer coverage, while 76% of the sections

applied with the ultrasonic files showed total coverage. They concluded that ultrasonic files were significantly better than reamers in placing sealer; however, canals were not obturated, so sealer displacement was not examined. In the follow-up study by West, LaBounty, and Keller (6), similar materials and methods were used, but sealer placement by hand instrument or ultrasonic file was followed by lateral condensation of gutta-percha. This time the authors showed 69% of the sections were completely covered with sealer following hand instrument application and obturation, and 84% of the sections with sealer applied by ultrasonic file were totally covered, again concluding that ultrasonics was more effective than reamers in achieving dentinal wall coverage. In neither study was a standard sealer amount used, canal curvature was not defined, and total canal wall coverage was not evaluated.

Wiemann and Wilcox (7), using four sealer placement techniques, examined mandibular incisors with straight canals. After obturation with laterally condensed gutta-percha, the teeth were cleared and examined subjectively. No significant difference among the techniques could be determined. Complete and consistent coverage of canal walls by sealer was not accomplished by any of the methods tested. This study was noteworthy for the attempt to standardize some of the variables involved in evaluating sealer placement by using a standard amount of sealer and evaluating total canal wall coverage. The authors found less sealer in apical areas than in coronal areas, and hypothesized that dentinal wall moisture may prevent sealer flow in those areas. In a recent study (8) they examined this variable by applying sealer after drying the canals with alcohol and concluded that sealer coverage was not affected.

The present study attempted to standardize sealer placement technique evaluation in single-rooted teeth with curved canals: (1) by defining the canal curvature; (2) by controlling the amount of sealer; and (3) by using computer

analysis to objectively evaluate total root canal sealer fill prior to obturation with laterally condensed gutta-percha (on radiographs), and total canal wall coverage after obturation (on color slides of cleared specimens). Canal images from the radiographs had to be traced onto plastic transparencies before computer evaluation. These were analyzed with different computer software than the color photographs because the NIH Image software could not evaluate the black and white radiographic images sufficiently to discern sealer coverage from voids. An attempt to analyze the groups according to canal curvature was not possible. Since the specimens were randomly distributed, each group did not contain an equal number of teeth with similar curvatures. The results showed that prior to obturation, placement of sealer with lentulo spirals resulted in significantly better wall coverage than K-files or master gutta-percha cones. However, following obturation, there was no statistically significant difference in total wall coverage among the groups. Although the group obturated following lentulo spiral sealer application was slightly better than the other two groups, none showed much greater coverage than 50%.

The findings demonstrated that there was a difference in the abilities of these techniques to place sealer into the canal, which had not been shown previously when comparing K-file, lentulo spiral, or master cone sealer application methods. However, the results generally agreed with those by Wiemann and Wilcox (7) that traditional methods of sealer placement following lateral condensation of gutta-percha may not completely and adequately produce total canal wall coverage. Regardless of technique, only about half of the observed canal walls were seen to be covered by sealer following obturation. This indicates that displacement of sealer during obturation of gutta-percha is considerable. No observable trends regarding sealer placement in the apical few millimeters could be reported: some specimens showed coverage, while others did not. The viscosity of AH26 recommended by

Barthel et al. (15) resulted in a free-flowing mix, and canal moisture was controlled by flushing the canals with concentrated alcohol before sealer application. AH26 is easily-stainable with carbon black powder without altering its viscosity, it maintains its consistency during clearing procedures, and it is similar in consistency to ZOE sealers (15). The liberal amount of sealer applied was carefully controlled and standardized for each canal. It is unlikely that lateral condensation of gutta-percha could displace sealer so thinly along canal walls that it would be unobservable under stereomicroscope. Some teeth were observed to have 100% wall coverage, while others had less than 40% coverage.

Other than the slightly better coverage shown by lentulo spiral application, which was not statistically significant, no method resulted in complete, predictable canal coverage following obturation. The possibility that canal preparation with the newer nickel-titanium Lightspeed instruments may be a factor in the prevention of total wall coverage is more plausible. Lightspeed instrumentation results in preparations that remain centered, but it also results in less-tapered canal preparations with less dentin removed. In many instances, pockets which were void of sealer could be seen throughout the obturated and unobturated canals, indicating that trapped air in the smaller canal preparations may prevent sealer expression to all parts of the canal. In the final analysis, the results suggest that 100% canal wall coverage with sealer may not be achievable, particularly following obturation. It is beyond the scope of this study to determine what effect sealer displacement may have on the quality of obturation. Studies to evaluate the effect of this displacement on leakage are needed.

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FIGURE LEGENDS

FIG 1. From top to bottom, each radiograph represents a specimen from Group A (K-file), Group B (lentulo), and Group C (gutta-percha cone), respectively. Analysis of canal sealer fill was made from the apex to the inferior aspect of the solid black line, a distance of 10 mm.

FIG 2. The same teeth shown in Fig. 1; from top to bottom, Group A, Group B, and Group C. Gutta-percha appears white in the canal; sealer appears black.

FIG 3. Pre-obturation (radiographs). Sealer canal fill was significantly greater in Group B (lentulo spiral) than in Group A (K-file) or Group C (gutta-percha cone). Group A sealer fill was significantly greater than Group C ($p < 0.05$).

FIG 4. Post-obturation (slides). There was no statistically significant difference in sealer wall coverage among the 3 groups after obturation of laterally condensed gutta-percha.

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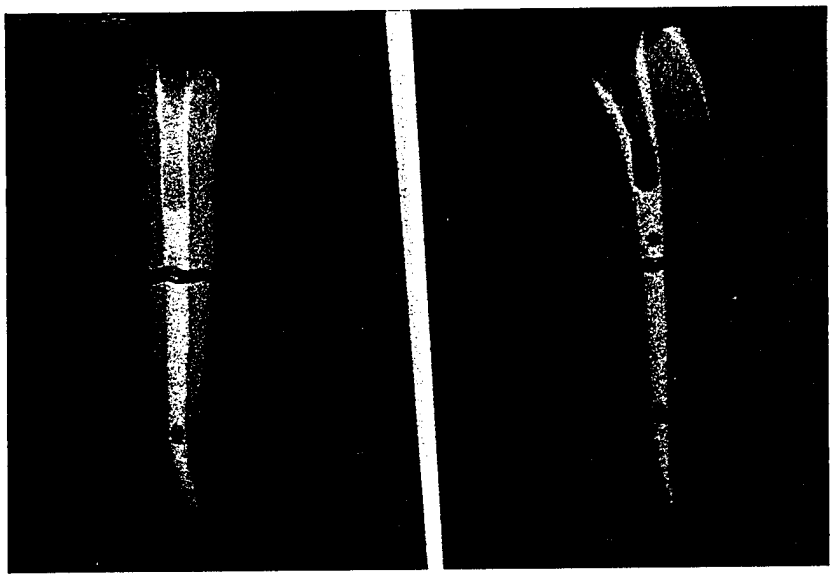
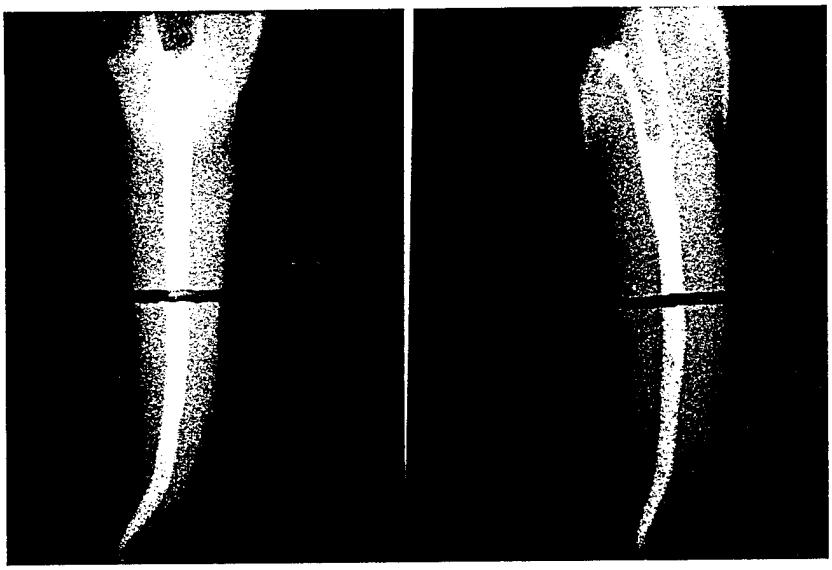




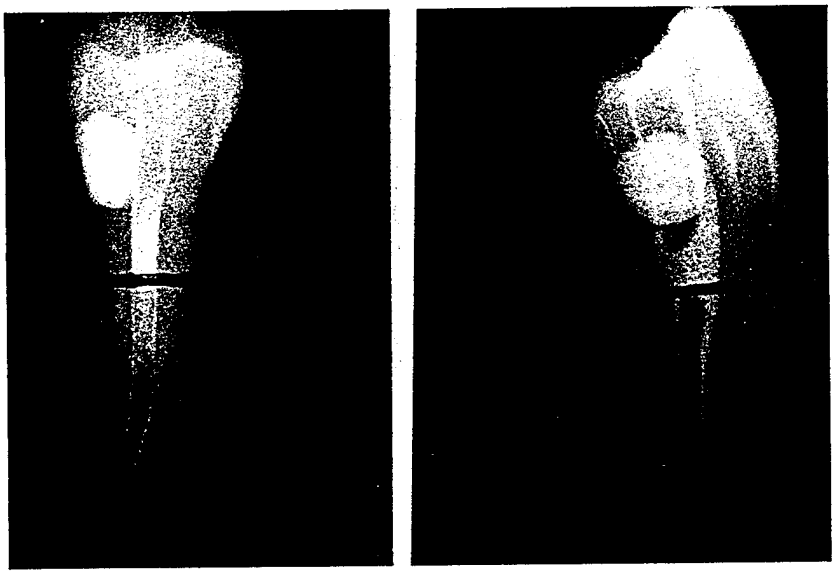


FIG 1

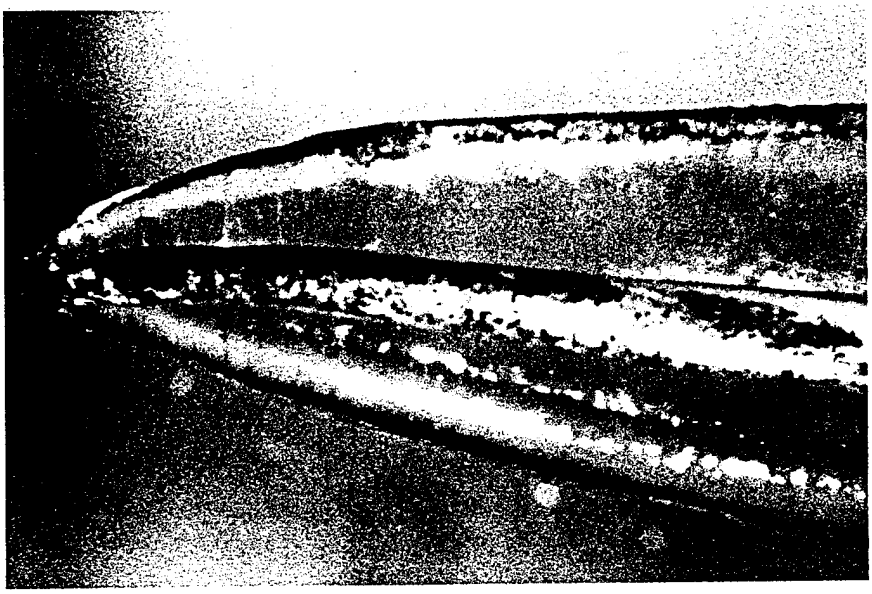
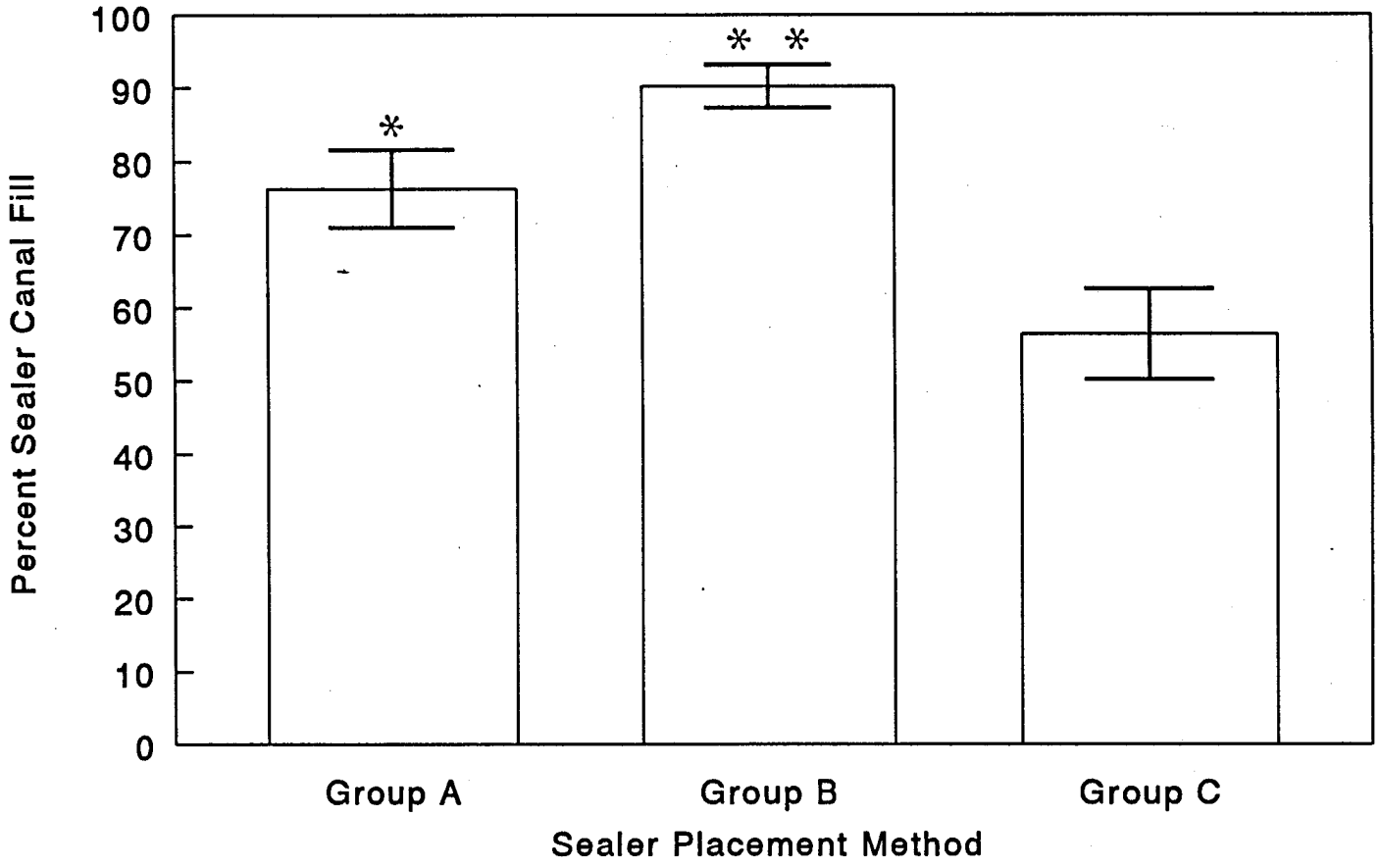


FIG 2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Percent Sealer Canal Fill
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Group A
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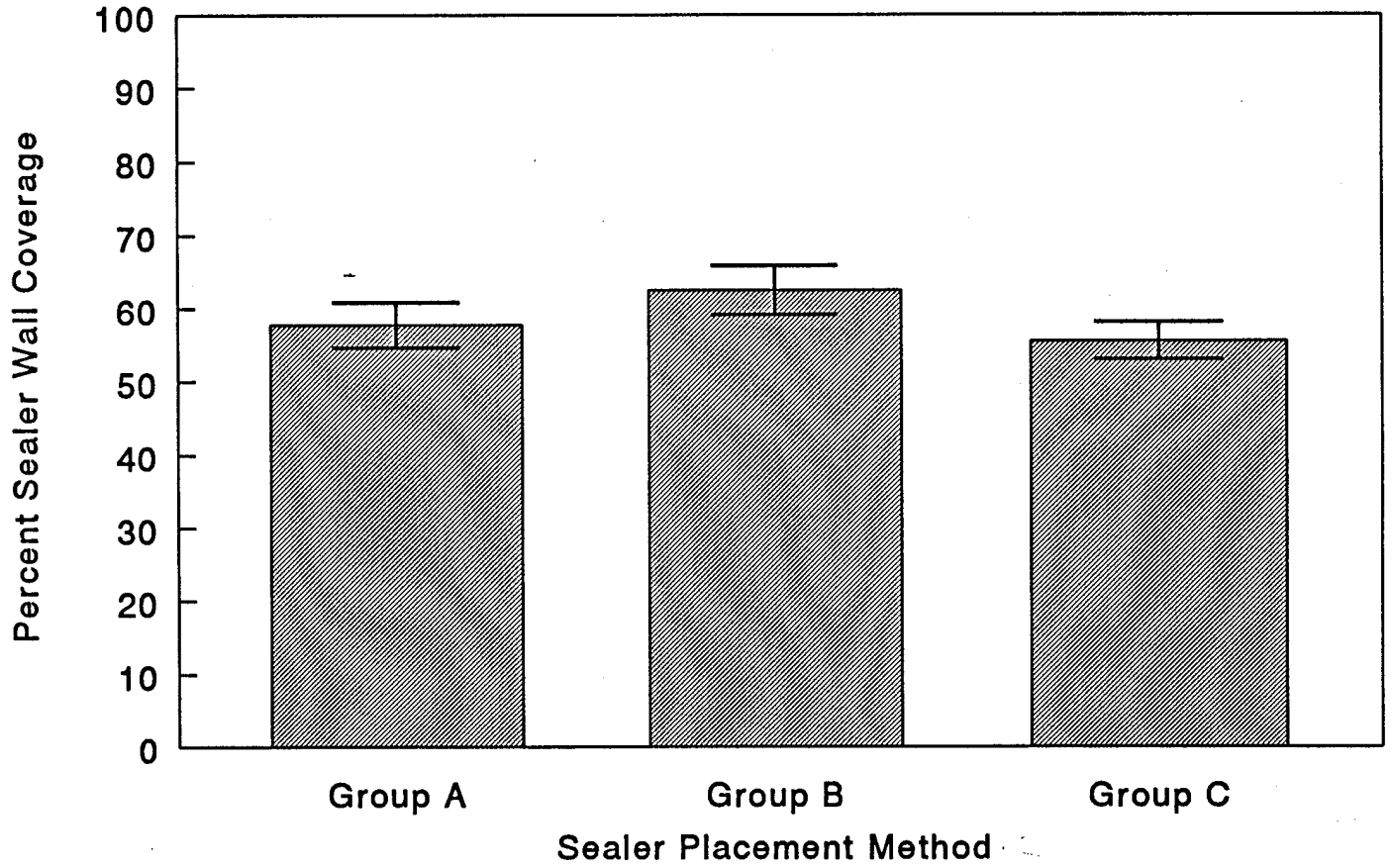
Group C
Sealer Placement Method

FIG 3.


100
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10
0
Percent Sealer Wall Coverage
Group A
Group B
Group C
Sealer Placement Method

FIG 4.