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Effects of Ultrasonic Scaling and Hand Scaling on Root Typography

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EFFECTS OF ULTRASONIC SCALING AND

HAND SCALING ON ROOT TOPOGRAPHY

by

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ABSTRACT

EFFECTS OF ULTRASONIC SCALING AND HAND SCALING ON ROOT TOPOGRAPHY

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The purpose of this study was to determine the effects of scaling and root planing with the modified P-10 Cavitron^{R} tip and curet instruments on root surface topography. Sample specimens included 20 periodontally involved extracted human teeth. Specimens were carved into a three split root design, each sample specimen acting as its own control. Control and experimental surfaces were randomly assigned to each specimen. Scaling techniques were applied on the assigned experimental surfaces for 2 minutes and 14 seconds. A scanning electron microscope was used to examine and micrograph root surface topography of experimental surfaces. Photomicrographs were evaluated using categories of root smoothness and scored by an examiner blind to the assigned specimen groups. Surface measurements from the modified ultrasonic P-10 tip were compared to surfaces hand scaled with curets. Data were analyzed at the 0.05 level of significance using a one-way analysis of variance and Newman-Kuels multiple comparison tests. Findings concluded

that scaling and root planing with the modified P-10 resulted in smoother root surfaces than curets. However, both methods of instrumentation produced a significantly smoother root surface than the control group.

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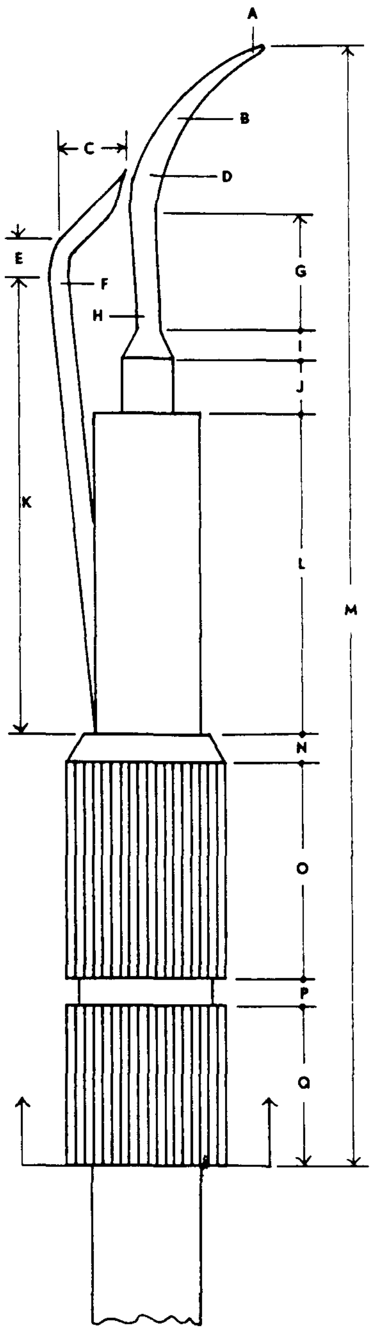
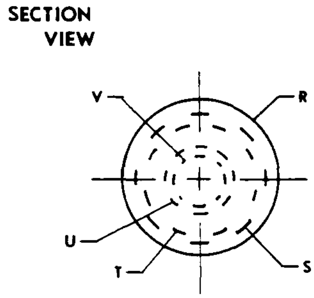
CHAPTER 1

Introduction

Scaling and root planing are used widely in periodontal therapy to remove irritants from the surfaces of teeth and to reduce tooth surface roughness which may facilitate the accumulation of irritants. The purpose of scaling and root planing includes smoothing root surfaces to inhibit reformation of bacterial plaque and calculus deposits, and produce a root surface that is biologically acceptable for new attachment. Common armamentarium for scaling and root planing are hand and ultrasonic instruments. Numerous investigations have been conducted to compare hand and ultrasonic instrumentation with varying results of effectiveness (Clark 1968; D'Silva et al. 1979; Ewen and Sorrin 1964; Garnick and Dent 1989; Green 1966; Hunter, O'Leary and Kafrawy 1984; Jones, Lozdan and Boyde 1972; Kerry 1967; Moskow and Bressman 1964; Pameijer, Stallard and Hiep 1972; Stende and Schaffer 1961; Wilkenson and Maybury 1973). Some investigators report unaltered or smoother root surfaces after ultrasonic instrumentation versus hand scaling (Jones, Lozdan and Boyde 1972; Moskow and Bressman 1964).

Others report that hand instruments are superior in producing smoother root surfaces (Green 1966; Hunter, O'Leary and Kafrawy 1984; Kerry 1967; Wilkenson and Maybury 1973; Stende and Schaffer 1961). Additional research suggests that root surface damage will occur regardless of the choice of instrumentation (D'Silva et al. 1979; Pameijer, Stallard and Hiep 1972). Neither instruments' superiority has been proven. While some researchers have reported the changes of the root surfaces caused by instrumentation, none have measured the effects of instrumentation from the modified P-10 tip in a manually tuned ultrasonic unit on root surface topography (See Figure 1 for illustration of the modified P-10). This scaling technique was developed by Thomas E. Holbrook, D.D.S., in reaction to the limitations of curets and other commercially available ultrasonics tips in the subgingival arena. Considering the relatively large diameter of a standard Cavitron[R] P-10 tip and the distance between the tip and shank of any given curet, the ability to negotiate a narrow periodontal pocket with either instrument is limited. Holbrook (1989) found that modifying a standard P-10 tip into the shape of a narrow periodontal probe can provide greater access into periodontal pockets. Modification of a P-10 Cavitron[R] tip requires using a slow speed handpiece with a fastcut acrylic stone, a medium grit sharpening stone and a fine grit rubber cylinder to taper and





DENTSPLY / CAVITRON MODIFIED P-10 TYPE INSERT

A - .021	L - .75
B - .051	M - 2.5625
C - .25	N - .0625
D - .058	O - .5
E - .0625	P - .0625
F - .046	Q .3125
G - .3125	R - .382 Ø
H - .066	S - .280 Ø
I - .0625	T - .275 Ø
J - .125	U - .247 Ø
K - 1.0625	V - .120 Ø

MEASURED IN INCHES

ALBERT M. CIAROCHI, III

Figure 1

Illustration of the Modified P-10

refine the shank of a P-10 tip (Holbrook, 1989). Holbrook's (1989) scaling technique includes using the lowest power setting on a manually tuning ultrasonic unit and a gentle pen grasp with a soft tissue rest for orientation and limitation of movement. Holbrook (1989) recommends starting at the apical extent of a pocket using a continious, overlapping stroke to maximize coverage of the subgingival surface area. After 20 years of clinical practice with the modified P-10, Holbrook (1989) found the modified P-10 advantageous over hand instruments for the following reasons: increased tactile sense of pocket topography, less soft tissue distention and trauma, greater patient comfort and acceptance, washed field of visibility and pocket irrigation, faster wound healing after removal of sulcular epithelium, applicable to all surfaces in active and static positions and less tiring for the clinician. Contrary to current theories of instrumentation, the modified P-10 ultrasonic tip is used in place of curets and not as an adjunct for scaling with curets. This study will examine the effects of both curets and the modified P-10 ultrasonic tip on root surface topography.

Statement of the Problem

This investigation was conducted to determine the following:

1. Is there a difference in root surface topography after scaling and root planing on exposed cemental surfaces with the modified P-10 Cavitron^R tip as compared to exposed cemental surfaces scaled with curets?

Significance of the Problem

Scaling and root planing in deep periodontal pockets is one of the most difficult procedures in dental hygiene care. The rationale for producing a smooth root surface through scaling and root planing is to minimize surface irregularities. Clinically, a smooth root surface is used to determine the end point of instrumentation. The size and shape of commercially available hand and ultrasonic scalers are inadequate for the task of scaling and root planing. The distance between the shank and tip (over 4 millimeters in length) and the relatively large blade width of a curet limits access to negotiate a narrow periodontal pocket. In comparison, a modified P-10's diameter is less than 0.5 millimeters. To debride and smooth a root surface, the dental hygienist must have access to the subgingival area. Therefore, considering the superior design for subgingival access, the modified P-10 would be the instrument of choice.

Various root morphology and periodontal pocket topography decrease the likelihood of thorough periodontal instrumentation of root surfaces. Thorough subgingival plaque removal was found by Waerhaug (1975) to be the single most important factor in the success or failure of periodontal treatment. Studies have been conducted to determine if the removal of cementum in conjunction with root debridement during subgingival instrumentation was necessary to obtain periodontal health (Nyman, 1986). Nyman (1986) concluded that healing following flap surgery was the same whether exposed root cementum had been removed or retained. Therefore, it is not the amount of cementum removed but the thorough removal or disruption of subgingival plaque that controls periodontal health (Nyman 1986; Ramfjord 1982; Waerhaug 1978).

If clinicians are to achieve a clinically smooth root surface during subgingival scaling and root planing, the effects of instrumentation on root surface topography should be examined. Although the ability of ultrasonic and hand scaling for the removal of subgingival plaque and calculus is well documented, (Clark 1968; D'Silva et al. 1979; Ewen and Sorrin 1964; Garnick and Dent 1989; Green 1966; Hunter, O'Leary and Kafrawy 1984; Jones, Lozdan and Boyde 1972; Kerry 1967; Moskow and Bressman 1964; Pameijer, Stallard and Hiep 1972; Stende and Schaffer 1961; Wilkenson and Maybury 1973) the methods of instrumentation used to produce smooth root surfaces is largely controversial.

To produce a smooth root surface, the dental hygienist must have access to the diseased root surface. A clinical interest in accessibility of periodontal pockets led Holbrook (1989) to modify existing commercially available standard P-10 Cavitron^{R} tips and create his own ultrasonic technique. Holbrook's (1989) technique requires modification of a standard P-10 Cavitron^{R} tip. He recommends using a low power setting and a manual tuning ultrasonic unit to control the level of frequency (number of vibrations) supplied to the tip. His technique includes using a soft pen grasp versus a modified pen grasp required for hand instrumentation. A soft tissue rest is recommended for the modified P-10 rather than a hard tissue fulcrum required for hand instruments. To negotiate the modified P-10 subgingivally, the dental hygienist must first activate the tip and enter the convex (or back) surface of the instrument to avoid traumatizing the soft tissue. The modified P-10 tip should be kept parallel to the root to minimize tissue distention and to avoid gouging the root surface. Unlike hand instruments, the modified P-10 tip is effective in a static position and does not require precise angulation for debridement. However, this does not imply that any stroke with the modified P-10 is used for scaling. Holbrook (1989) specifically defines using an overlapping, brush-like stroke with very light pressure to cover the entire subgingival area. Although the objectives of both hand and ultrasonic procedures are similar, the scaling techniques bear little resemblance to one another. The modified P-10 tip is technique sensitive and its application requires advanced skills in instrumentation (see Appendix A for Holbrook's specific technique for instrumentation of the modified P-10). Holbrook's (1989) technique has generated an increase interest among the dental community for ultrasonic instrumentation in perio-dontal therapy. Considering the importance of access and maintenance of a smooth root surface, further investigation is important to determine if root surface topography will be altered to a greater extent by a modified P-10 Cavitron[R] tip as compared to hand scaling with curets. Studies such as this could provide information not yet revealed in the literature.

Definition of Terms

For the purpose of this study, the following terms were defined:

1. **Exposed cemental surface.** The calcified tissue that forms the outer covering of the root which is coronal to the sulcular epitheilial attachment. Characteristics of exposed cemental surfaces were evaluated from photomicrographs.

2. **Hand instrumentation.** Scaling and root planing with new double-ended Hu-Friedy[R] gracey periodontal finishing curets, #'s 1/2, 11/12, 13/14 were the second independent variable

used in this study.

3. **Micrograph.** A photograph produced by the scanning electron microscope. Micrographs were enlarged to 8" X 10" photomicrographs with a nine section grid superimposed over them for evaluation by the examiner using Krupa Lavigne's (1988) categories of root smoothness.

4. **Modified P-10 ultrasonic tip.** A Dentsply^{R} standard P-10 ultrasonic tip reduced to the size and shape of a Michigan "O" probe. One of the independent variables, the modified P-10, was narrow, smooth (no cutting edges), and straight with a tip round in cross section (See Figure 1).

5. **Root topography.** The cemental surface characteristics, to include fractures, fissures, grooves, pitting, nicking, markings or lack thereof. Root topography, the dependent variable, was measured using Krupa Lavigne (1988) categories of root smoothness.

6. **Scanning electron microscope (SEM).** A focused electron beam of the smallest possible diameter, using electromagnets as condensing lens, is scanned across the specimen surface in a vacuum chamber. These primary electrons interact with the host atoms so that as a result of collisions, a cascade of secondary electrons are formed and escape from the specimen surface. Using these surface emitted electrons, amplified surface images revealing three dimensional quality can be obtained. These images are constructed using

an electron collector and photomultiplier. The final magnified image in the SEM is formed on a cathode-ray tube. A separate channel is used for photographic recording. A magnification of 3000X was selected to examine sample specimens.

Assumptions

For the purpose of this study, the following assumptions were made:

1. Specimen surfaces were assigned randomly to one of three groups - modified P-10, curets or control - for treatment.
2. Specimens possessed similar root anomalies and roughness prior to instrumentation.
3. The scanning electron microscope accurately examined and micrographed root surfaces.
4. The examiner for the SEM micrographs was proficient in reading micrographs.
5. Differences in root surface topography between the two experimental surfaces were the result of the scaling technique, modified P-10 or curet, rather than natural root anomalies as observed on the control surfaces.
6. Clinicians were proficient in scaling and root planing with the assigned instrument.
7. Clinicians used the same scaling and root planing tech-

nique on all specimens.

Limitations

The validity of this study might have been affected by the following:

1. Handling and storage of the teeth prior to instrumentation might have altered root surfaces. This problem was minimized by following D'Silva et al.'s (1979) recommendations for handling and storage.
2. Specimen samples were in vitro; therefore, results cannot be generalized to teeth specimens in vivo.
3. Pressure of scaling methods applied to experimental surfaces were not controlled or measured in this study.
4. Scope of study was limited to one brand of ultrasonic unit; therefore, results cannot be generalized to other ultrasonic units.
5. No specific scaling technique was given to the clinician (dental hygienist) who used the hand instruments. The clinician determined a clinically smooth root surface through visualization and tactile sensitivity with the instrument employed.
6. The possiblity that instruments had previously been used on the tooth specimens prior to conducting this study cannot be excluded.

Hypothesis

The following null hypothesis was tested:

1. There is no statistically significant difference at the 0.05 level in root surface topography of exposed cemental surfaces scaled with a modified ultrasonic tip as compared to exposed cemental surfaces scaled with curets, as measured by Krupa Lavigne categories of root smoothness.

Methodology

Twenty periodontally involved extracted human teeth including maxillary and mandibular, posterior and anterior, were donated as specimens from oral surgeons from Tampa Bay, Florida. Prior to instrumentation, the teeth were immersed in a 10 percent formalin solution and washed in distilled water as recommended by D'Silva et al. (1979). Each specimen was divided into a three split root surface design. Control and experimental treatments were randomly assigned to each surface. Each surface received one of three possible treatments: modified P-10, curets or no scaling and root planing. Reference notches were placed on the crown to delineate control and experimental surfaces. A Dentsply 660 Cavitron^{R} (a manually tuned ultrasonic unit) inserted with a modified P-10 tip (See Appendix B) and hand instruments, Hu-Friedy^{R} curets 1/2, 11/14 and 12/13, were employed during this investigation (See Appendix C). All scaling and root planing procedures were performed by two different clinicians on specimens mounted in dental stone for two minutes and 14 seconds. The length of instrumentation was determined to simulate the average clinical time allowed for scaling and root planing per root surface (See Appendix D for mathematical computation of scaling methods). After instrumentation, the specimens were stored in 70 percent ethanol until further processing. Prior to SEM examination, specimens were allowed to air dry for several days. The specimens were mounted, numbered and sputter coated with approximately 100-120 angstroms of gold palladium. The specimens were examined by a scanning electron microscopy technician at approxiamately 3000X magnification. The range of magnification was selected by the SEM technician and researcher upon viewing specimens for the largest scope of field that would provide greatest detail of surface characteristics. Specimen micrographs were taken of each specimen's control and experimental surfaces. Eight by ten inch photomicrographs were generated from each micrograph and placed on a nine section grid. Sections of the specimen photomicrographs were calibrated utilizing the following categories for scoring root surface characteristics:

1 = Smooth surface, no nicking or markings due to instrumentation

2 = Relatively smooth appearance with minimal

nicking and markings

3 = Moderately smooth but uneven grooves, pitting or markings

4 = Moderately rough with uneven grooves, pitting or markings and some isolated fissures or fractures

5 = Rough surface, with multiple irregular markings and/or abrupt fractures

A final score was generated by summarizing each photomicrograph and dividing by nine (See data collection sheet in Appendix E). Specimen photomicrographs were evaluated by one examiner blind to the treatment applied to each root surface. Even though validity was not available on this scale of measurement, variations of this scale have been used in previous studies by Krupa Lavigne et al. (1988), Toevs (1985) and Rabbani, Ash and Caffesse (1981). To ensure standardization of the scoring methods, a preliminary calibration was conducted prior to the investigation to demonstrate a high degree of reproducibility (See Appendix F). A confidence interval of 0.50 was achieved amongst mean scores from the same specimens selected during the three day calibration study (See Appendix G).

CHAPTER 2

Review of the Literature

The literature review addresses characteristics of root surfaces following ultrasonic and hand instrumentation. The review consists of three sections: (1) comparison of ultrasonic and hand instruments in periodontal therapy, (2) comparison of ultrasonic and hand instruments on root surface topography and (3) ultrasonic instrument design.

Comparison of Ultrasonic and Hand Instruments in Periodontal Therapy

In the early 1950s, ultrasonic units were first used in dentistry for cavity preparations (Balamuth 1955); however, early ultrasonic units did not gain popularity with the profession. Clark (1968) believed the lack of acceptance was probably due to the high cost, poor visibility, inefficiency and competition from the high-speed rotary turbine. Later, an increasing number of favorable investigations on the use of ultrasonic units in periodontal therapy was reported (Breininger, O'Leary and Blumenshine, 1987; Jones, Lozdan and Boyde, 1972; Clark, Grupe and Mahler, 1968;

Garnick and Dent, 1989; Leon and Vogel, 1987; Oosterwaal et al., 1987 and Pameijer, Stallard and Heip 1972).

The effectiveness of calculus removal by ultrasonic scalers has been reported by various investigators (Breininger, O'Leary and Blumenshine 1986; Ewen and Sorrin 1964; Hunter, O`Leary and Kafrawy 1984; Jones, Lozdan and Boyde 1972; Moskow and Bressman 1964; Pameijer, Stallard and Hiep 1972; Stende and Schaffer 1961). When ultrasonic scalers were compared to curets for their effectiveness in calculus removal, it was concluded that ultrasonic instruments were equally effective. However, Breinenger, O'Leary and Kafrawy (1984) reported that neither method was capable of removing all the calculus at the light microscopic level.

Ultrasonic instruments are commonly known for removing gross amounts of supragingival calculus and stain, and debriding shallow pockets. Recent research has examined the effects of ultrasonics in the subgingival arena. Oosterwaal et al. (1987) conducted a clinical and microscopic evaluation to determine the effects of hand and ultrasonic instruments on the subgingival flora using a split mouth pretest-posttest design. Twelve subjects were selected to participate in the study. Each subject had at least six periodontal pockets, 6-9 millimeters deep, with bleeding after probing and apparent alveolar bone loss. Subjects had no history of receiving antiobitics within the last six months nor any history of a systemic disease. Six sites from each subject were selected for examination; two for hand instrumentation, two for ultrasonic instrumentation and two for controls. Prior to treatment, subjects were given oral hygiene instructions. Treatment was applied by one clinician until determined clinically smooth with an explorer. Clinical and microbiological examinations were conducted at 7, 21, and 49 days after treatment, as well as, additional oral hygiene instructions. Clinical evaluations including bleeding after probing, pocket depths and supragingival plaque were carried out by one examiner. Microbiological evaluations including microscopic and culture studies of subgingival plaque samples were carried out by another examiner. Both examiners were blind to the treatment applied to the sites. Oosterwaal et al. (1987) concluded that hand and ultrasonic treatments were equally effective in reducing probing pocket depths and bleeding scores. Microscopic and cultural analysis confirmed no statistical difference between hand and ultrasonic debridement. In addition, Oosterwaal et al. (1987) found that both treatments reduced the microbial count and decreased bleeding and pocket depths, which is condusive to periodontal health.

Histological studies after ultrasonic curettage have reported tissue fragmentation and removal of sulcular epithelium and connective tissue (Frisch 1967; Ewen and Sorrin 1964). The effects of ultrasonic and hand instrumentation on wound healing have been investigated by many authors, including Schaffer, Stende and King (1974); Bhaskar (1982); Goldman (1964); and Zach (1970). They reported that specimens instrumentated with ultrasonics demonstrated faster gingival healing as compared to curets.

A number of factors will determine the effectiveness of ultrasonics in periodontal therapy, to include the amount of power (amplitude) of the unit, force applied by clinician, tuning (frequency), stroke, relative sharpness of the tip, length of time and tip surface applied to the tooth (Clark, 1969 and Holbrook, 1989). The clinician must select the correct power, frequency, tip and technique depending on the tenacity of the calculus or roughness engaged during scaling. With a manual tuning ultrasonic unit, the clinician must tune each tip individually (See Appendix H for steps in manual tuning). Contrary to manufacturer's literature, an automatic tuning ultrasonic unit does not automatically tune to the size and shape of individual tips. A clinician must be able to control the number of vibrations provided to the tip through the tuning (frequency) mechanism provided on a munual tuning ultrasonic unit. Movement of the tip should be smooth and quick to avoid burnishing the root surface. The primary objective during periodontal therapy is to provide thorough debridement of bacterial plaque and calculus. In theory, the ultrasonic tip should contact the entire subgingival area, using a continious, overlapping stroke (Holbrook 1989). However, other than what is recommended by the manufacturer, no previous studies promote a particular ultrasonic technique. Currently, a study is being conducted by Dragoo (1991) on the effectiveness of subgingival root debridement by hand and ultrasonic instruments (modified and unmodified). Dragoo (1991) addresses using a particular ultrasonic technique but does not define its origin. Results from his study will be published in the near future.

Comparison of Ultrasonic and Hand Instruments on Root Surface Topography

With regard to ultrasonic instrumentation on the root surface, a great difference in viewpoint has existed among researchers. The depth of root structure removed during scaling and the importance of smooth root surface topography is controversial as reported by O'Leary (1986) and Khatiblou and Ghodssi (1983).

The rationale for producing a smooth root surface through scaling and root planing is to minimize surface irregularities and prepare a biologically acceptable surface for reattachment and new attachment of connective tissue.

The significance of a smooth root surface was questioned by Khatiblou and Ghodssi (1983). They investigated the effects of root surface roughness on healing of periodontal pockets after flap surgery. Twelve subjects with localized advanced periodontitis comprised the sample. Experimental and control groups were divided among 18 teeth. Prior to treatment, a periodontal charting was prepared for each patient. A modified Widman flap procedure was performed and roots in both groups were planed until smooth. The experimental group received a number of shallow horizontal grooves on the root surface to roughen the surface while the control surfaces were left smooth. Periodontal attachments were measured four months after treatment. Statistical analysis concluded that no significant difference existed between the experimental (intentional horizontal grooves on the root surfaces) and the control (root surfaces planed until hard and smooth) groups in pocket reduction and gain of periodontal ligament attachment. The roots in both groups demonstrated a significant gain of attachment but the difference between the two groups was not significant. Results from Khatiblou and Ghodssi's (1983) study failed to conclude an advantage for root smoothness versus root roughness in periodontal therapy. Further histological studies are needed before definitive statements can be presented.

Conflicting reports have been found when assessing the effects of ultrasonic instrumentation on root surfaces. Various studies have reported no significant difference in root surface abrasion with ultrasonic instrumentation as compared to hand instrumentation (D'Silva et al. 1979; Pameijer, Stallard and Hiep 1972). Pameijer, Stallard and Hiep (1972) reported that ultrasonic scaling left the root surfaces clean and practically unaltered. These results occurred after 25 sample specimens were exposed to scaling and root planing with either a new P-10 tip or new Hu-Friedy[R] curets (nos. 1,2,9,10,13 and 14). Instrumentation on specimens were conducted until root surfaces felt clean and smooth upon probing. They concluded, with a SEM magnification of 175X, that the topography of root surfaces after ultrasonic instrumentation appeared similiar to those produced by hand instruments. Ultrasonically treated root surfaces did not reveal gouging or scratches. The sample specimens treated with curets showed a smooth surface and differed from the ultrasonically treated teeth only in that there was absence of undulation in the topography of the root. However, when higher magnifications were used to observe the undulating topography, it was not considered to be rough. D'Silva et al. (1979) conducted an in-vivo SEM study to examine the topography of root surfaces after instrumentation with ultrasonics as compared to hand instruments. They reported that ultrasonics were superior to hand instrumentation in cleaning root surfaces on incisor teeth; however, where accessibility was more difficult, ultrasonics were no better than hand instruments in cleaning the root surfaces.

Zinner (1955) and Jones et al. (1972) expressed their views that ultrasonic instruments were likely to leave root surfaces unaltered. On the contrary, Kerry (1967), Hunter, O'Leary and Kafrawy (1984), Wilkenson and Maybury (1973) and Green (1966) reported that ultrasonic instruments produced a significantly rougher root surfaces than hand instruments. Kerry (1967) and Green (1966) both used a profilometer, an electronic mechanical instrument, to measure root roughness. Kerry concluded that an ultrasonic device produces a significantly rougher root surface as compared to hand instruments. These results occurred after 180 teeth were exposed to scaling and root planing with either Dentsply® Cavitron tips, (no.'s EW.PP and EWP-10R/L) or S.S. White® curets (Bunting no.'s 5 and 6). Scaling and root planing were conducted until root surface felt smooth with a explorer. Kerry's findings suggest that ultrasonic instruments are incapable of root planing or producing a smooth root surface. However, it must be noted that these results were scored by a profilometer (a mechanical device which traces surface deviations). The exposed natural undulations of root surfaces after ultrasonic instrumentation might have been scored as roughness by the profilometer. Higher microscopic magnification is needed to reveal the actual surface characteristics of instrumentation.

Hunter, O'Leary and Kafrawy (1984) studied the effectiveness of hand versus ultrasonic instrumentation in open flap root planing. Fifty periodontally involved teeth, scheduled for extraction, were selected as sample specimens. Envelope-type flaps were performed to provide access to root surfaces for scaling and root planing with hand or ultrasonic instruments. Scaling and root planing were conducted until root surfaces felt smooth to an explorer. At magnification 4.6X with a stereomicoscope, Hunter, O'Leary and Kafrawy (1984) revealed statistically significant differences in root abrasion among the hand scaled as compared ultrasonically scaled root surfaces. Hand scaled teeth were considered 41 percent smoother than ultrasonically scaled teeth. Using a scanning electron microscope at 20 KV (specimen samples coated with a flash of carbon and 200-400 angstroms of aluminum), Wilkenson and Maybury (1973) found that root abrasion was significantly rougher with a P11L and P11R Cavitron[R] tip (used at medium power setting) as compared to hand instruments. Whereas, research lead by Moskow and Bressman (1964) reported that although root surface etching and gouging will occur regardless of the choice of instrumentation, root surface defects were found more frequently on specimens scaled by hand instruments. Moskow and Bressman (1964) conducted a microscopic and histological study on the cemental response to ultrasonic and hand instrumentation. Ninety-five human teeth representing all areas of the oral cavity comprised the sample. Generally, half the number of teeth to be extracted on any patient were scaled with ultrasonic instruments (nos. P-7, P-41, P-4r, P-9) set at the highest power level. The remaining teeth were scaled with hand curets (Columbia 4R and 4L, McCall 17S and 18S). Treatment was applied until the operator determined it clinically smooth with an explorer. No specific time was set to complete this objective. Specimens were examined under a dissecting microscope for the presence of calcareous deposits and the evidence of root planing or root gouging. Results concluded that calculus removal by the ultrasonic instrument was effective. However, in inaccessible regions, such as deep tortuous pockets and interradicular regions, the ultrasonic was less effective in the removal of deposits. The author stated that the design of the standard tip may account for the limitations of the ultrasonic. Histological analysis confirmed that both treatments created root surface gouging and etching as a result of instrumentation. However, these defects were more common in specimens scaled by hand instruments.

Ultrasonic Instrument Design

The limitations of ultrasonic tip design, in terms of shape and size, must be considered when selecting an ultrasonic instrument. For example, large, bulky ultrasonic tips will decrease access into deep, narrow periodontal pockets as reported by Moskow and Bressman (1964). There are few constraints for designing ultrasonic tips as compared to hand instruments. Ultrasonic tips do not need bulk for strength nor a cutting edge placed at a specific angle to remove deposits. Ewen and Sorrin (1964) concluded that cavitation alone was not sufficient to remove calculus deposits. Mechanical contact of the tip is necessary to remove accretions from the tooth surface (Ewen and Sorrin, 1964). Ewen and Sorrin (1964) conducted an in-vivo study with eighteen subjects selected for the sample population. Specimens treated with ultrasonic scaling instruments were extracted and microscopically examined. They concluded that holding the ultrasonic tip close to the calculus was not sufficient for removal. The ultrasonic tip must be in physical contact with the tooth surface to remove bacterial plaque and calculus deposits. Ultrasonic tips must be contoured to come into direct contact with the tooth surface. One of the most common instruments for assessing periodontal disease is a periodontal probe, specifically designed for access into deep, narrow periodontal pockets

(Glickman 1972). The ultrasonic tip which most resembles the size and shape of a periodontal probe is the modified P-10 Cavitron[R] tip. The modified P-10 is a thin, blunt ended tip (round in cross section) with no cutting edges. The modified P-10 is a standard Dentsply[R] P-10 Cavitron[R] tip reduced in size and shape for increased access into narrow, deep periodontal pockets. Standard P-10 tips are reduced using various grades of dental stones to aquire a smooth tapered instrument from shank to tip (Holbrook, 1989). Reduction of standard P-10 Cavitron[R] tips are necessary because commerically manufactured modified P-10's are limited. Holbrook and Low (1989) discuss the lack of commercially available ultrasonic tips of this design and the procedure necessary to modify a Dentsply, standard P-10 Cavitron[R] tip. However, a new ultrasonic tip similiar to the modified P-10 has recently been made available from Rizzo, Incorporated (1991).

Conclusions drawn by previous investigators might be dependent on the various designs and scaling techniques used with the ultrasonic scaling tips examined. Garnick and Dent (1989) claimed that the inconsistent variables involved in much of the research on ultrasonics, such as choice of ultrasonic instrument, methods of evaluation and number of strokes, make comparisons of research findings impossible. Other inconsistent variables affecting ultrasonic energy include pressure applied by the clinician, frequency of ultrasonic vibrations, power setting on the unit, angulation of application and relative sharpness of the ultrasonic tip. Ewen and Sorrin (1964) found that the amount of applied pressure from the clinician directly affects the root surface. They recommend a force of 50 gms or less for ultrasonic instrumentation on the root surface. D'Silva et al. (1979) also reported that differing conclusions from previous investigators may be dependent on the variability of the ultrasonic instruments sharpness, type of stroke and working time employed by the clinicians.

Most researchers investigating the effects of ultrasonic instrumentation on the root surface have used standard, commercially available P-10 Cavitron^R tips (D'Silva et al. 1979; Garnick and Dent 1989; Green 1966; Hunter, O'Leary and Kafrawy 1984; Jones, Lozdan and Boyde 1972; Stende and Schaffer 1961). Unfortunately, the size and shape of the standard P-10 tip limited accessibility of the ultrasonic tip into the subgingival arena. Therefore, limited accessibility of ultrasonic tips may not reflect the effectiveness of ultrasonic instrumentation on the root surface but rather its size.

Summary

Review of the literature has encompassed various studies of ultrasonic instrumentation in periodontal therapy, effects of ultrasonic instrumentation on the root surface and ultrasonic instrument design. A number of studies reported that both hand and ultrasonic instrumentation are effective in debridement, as well as alters root structures during instrumentation. It is probable that varying conclusions drawn by different investigators depended on the ultrasonic tips size and shape, amount of applied pressure and sharpness of the instrument and the ultrasonics amplitude (power setting) and frequency of vibrations (tuning) used in the various investigations. These factors were not standardized, thus, comparisons are difficult if not impossible. The clinical significance of rough root surfaces versus smooth root surfaces remain unanswered. This investigation will examine root surface topography after instrumentation with the modified P-10 Cavitron^{R} tip and curets.

CHAPTER 3

Methods and Materials

An experimental research design was used to determine the effects of scaling and root planing techniques using the modified P-10 and hand curets on root surface topography. Twenty periodontally involved extracted teeth, each divided into two experimental and one control surface, were used as specimen samples. Experimental and control surfaces were delineated by carving grooves on exposed root surfaces with a diamond bur.

Sample Description

The sample size included 20 periodontally involved, extracted human teeth (See Table 1 for tooth classification of sample specimens). Each specimen was divided into three sections per tooth (modified P-10 group (N=20), hand instrument group (N=20) and control (N=20). Experimental and control treatments were randomly assigned to the tooth surfaces using a table of random numbers. The sample specimens met the following criteria:

Table 1

Tooth Classification of Sample Specimens

Tooth Classification	Number of Specimens
Maxillary Central Incisor	1
Maxillary Cuspid	1
Maxillary First and Second Premolars	4
Maxillary First Molars	1
Maxillary Second Molars	1
Mandibular First and Second Premolars	2
Mandibular First Molars	4
Mandibular Second Molars	5
TOTAL =	20

1. Neither dental caries nor macroscopic defects on root surfaces.
2. Three millimeters or greater loss of periodontal attachment.
3. Either maxillary or mandibular, posterior or anterior permanent teeth.
4. Obvious cemento-enamel junction.
5. Normal root length with no fused roots.
6. Calculus as determined by visual inspection.
7. No furcation root surfaces.

Research Design

A three group posttest only design was the experimental approach for this research. The groups were derived from a split root design with each sample specimen acting as its own control. Randomization of treatments to one of three surfaces on the same tooth equalizes cemental surface characteristics. The researcher was blind to specimen assignment controlling for researcher bias. This design allowed for the observation and measurement of the effects of the independent variables - curets and modified P-10 - on the dependent variable - root surface topography - under controlled conditions (See Table 2).

Table 2

Reseach Design for the Randomized
Subjects Posttest Only Design

Group	Dependent Variables	Independent Variables	Post-Test
E1	Root Topography	Curets	Krupa Lavigne Categories of Root Smoothness as Applied to SEM Photomicro-graphs
E2	Root Topography	Modified P-10	Krupa Lavigne Categories of Root Smoothness as Applied to SEM Photomicro-graphs
C1	Root Topography	--------	Krupa Lavigne Categories of Root Smoothness as Applied to SEM Photmicro-graphs

Methodology

A total of 20 periodontally involved, extracted, permanent teeth were obtained as specimens. All specimens were stored in a 10 percent formalin solution, at room temperature, prior to instrumentation. To reduce root surface distortion, storage and handling of specimens were completed by following similar procedures implemented by D'Silva et al. (1979). Control and experimental surfaces were created by carving vertical lines on the periodontally involved root surface with a high speed, diamond bur. The experimental surfaces were bound by the following landmarks: the apical, proximal and coronal bur grooves. The cementoenamel junction was substituted as a coronal landmark when no apparent bur groove was defined as suggested by Breininger, O'Leary and Blumenshine (1986). Experimental surfaces were notched to differentiate experimental surfaces from control surfaces. Specimens were mounted in approximately the same depth of dental stone for instrumentation by the two scaling methods.

Ultrasonic scaling procedures were conducted by a clinician (dental hygienist) versed in Holbrook's (1989) ultrasonic technique. Hand scaling was conducted by a second clinician (dental hygienist). (For specific scaling instructions, see Appendix B and C). Both clinicians possessed a minimum of three years of experience with the assigned scaling technique. Each specimen was scaled for two minutes and 14 seconds excluding time for resharpening of the hand instruments or retuning of the ultrasonic unit. Experimental surfaces were subjected to the randomly assigned scaling technique to approximate the clinical length of time spent scaling and root planing a periodontally involved tooth (See Appendix D for mathematical computations of scaling methods). Each specimen was sectioned with a diamond separating disc before mounting it on a SEM stub. Specimens were cut horizontally from the long axis of the tooth at either the cementoenamel junction or root (apical to experimental and control surfaces) to remove excess bulk of the tooth. Specimens were rinsed with distilled water and stored in 70 percent ethyl alcohol. Prior to SEM prep-eration, the specimens were air dried for seven days to avoid the need of critical point drying. The specimens were mounted, numbered and sputter coated with approximately 100-120 angstroms of gold pallidium. Upon viewing sample specimens for definite root surface characteristics, the range of magnification was determined by the researcher and SEM technician. A magnification range of 3000X was selected for the largest scope of field that would provide the greatest detail of surface characteristics. The SEM technician, blind to specimen assignment, examined and micrographed each specimens control and experimental surfaces at 3000X magnification. Each specimen's micrograph was used to generate an eight inch by ten inch photomicrograph. The photomicrographs were placed onto a nine section grid to quantify the amount of total root surface topography as recommended by Krupa Lavigne et al. (1988). Each section of a photomicrograph was evaluated and scored by one examiner blind to the treatment applied to each root surface. Scores of root smoothness ranged from 1 to 5. A mean value was calculated for each photomicrograph (See Appendix I for mean values scored from photomicrographs). To ensure standardization of the examiner's scoring methods, a preliminary calibration study was conducted to demonstrate a high degree of reproducibility (See Appendix G for photomicrograph scores from the preliminary calibration study). Eight randomly distributed photomicrographs were distributed to the examiner for three consecutive days to score root surface topography according to Krupa Lavigne's et al. (1989) root surface smoothness. The examiner achieved at least a confidence interval of 0.50 (plus or minus) among sample means scored from the three day calibration study. The method for calibration was adopted as a reproducible means of scoring root smoothness.

Instrumentation

Root surface topography was examined by the scanning electron microscope, which provides greater depth of focus as compared to light microscopy, can resolve to about 150 angstroms and the bulk surface of a specimen can be viewed directly. Jones, Lozdan and Boyde (1972), Pameijer, Stallard and Hiep (1981), Toevs (1985) and Wilkenson and Maybury (1973) used this examination technique successfully to study root surface characteristics of teeth following periodontal instrumentation. Five categories for root surface smoothness were used, as defined by Krupa Lavigne et al. (1988), to describe quantitatively root surface characteristics. Specimen photomicrographs were placed on a nine section grid and rated from 1 to 5 in each section using the following categories:

1 = Smooth surface, no nicking or markings due to instrumentation

2 = Relatively smooth appearance with nicking and markings

3 = Moderately smooth but uneven grooves, pitting or markings

4 = Moderately rough with uneven grooves, pitting or markings and some isolated fissures or fractures

5 = rough surface, with multiple markings and/or

abrupt fractures

Scores obtained from the photomicrographs were recorded on data collection sheets and used for statistical analysis (See Appendix E for a sample of the data collection sheet used for scoring photomicrographs).

Statistical Treatment

The data from this investigation were continuous and interval scaled. This investigation analyzed the effects of two independent variables simultaneously (modified P-10 and curets) on the dependent variable (root topography) in the same research design.

A one-way analysis of variance (ANOVA) was applied with the underlying assumptions:

1. Observations within the experimental groups were mutually independent.
2. Variances within experimental groups were approximately equal.
3. Variations within experimental groups were from normally distributed populations.

Analysis of variance is the statistical technique used most often to determine a significant difference among experimental group means. The F-test is a technique used in analysis of variance to compare the between group variance to the within group variance. Multiple comparison tests are used to specify where the statistically significant differences between groups existed.

A one-way analysis of variance (p=0.05) was used to analyze photomicrograph scores from each group to determine if statistically significant differences occurred among root surfaces scaled with a modified P-10 as compared to those scaled with curets and control surfaces. To implement the statistical analysis for this investigation, an ANOVA software package on the Statistical Analysis System (SAS) was used to analyze root surface scores. To determine where statistical differences occurred among the three groups the Newman-Kuels multiple comparison technique was performed.

Chapter 4

Results and Discussion

The purpose of this study was to determine the effects of scaling and root planing with the modified P-10 ultrasonic instrument as compared to curet instruments on root surface topography. Twenty periodontally involved, extracted teeth were included in the sample population. Specimens were carved into a three split root design, each sample specimen acting as its own control. Experimental specimens were treated by the assigned scaling technique, curets or modified P-10, for two minutes and 14 seconds. Experimental surfaces were photomicrographed and scored from a nine section grid to quantify the total amount of root smoothness. Data collected from this investigation were analyzed using the computerized Statistical Analysis System (SAS). This investigation used ANOVA and multiple comparison tests for statistical treatment.

Results

The results of the analysis rejected the null hypothesis that there is no statistically significant difference at the 0.05 level in root surface topography of exposed cemental surfaces scaled with a modified P-10 ultrasonic tip as compared to exposed cemental surfaces scaled with curets, as measured by Krupa Lavigne's categories of root smoothness. Data gathered from this investigation demonstrated that the modified P-10 ultrasonic tip resulted in the smoothest root topogaphy rating as compared to curet and control surfaces. The mean score derived from Krupa Lavigne's categories of root topography was 1.45 with a standard deviation of 0.17 for the modified P-10 group (See Table 3 for mean and standard deviation of topography ratings assigned to photomicrographs). Among the 20 surfaces scored from the modified P-10 group, 90 percent were scored within category 1 (Smooth surface, no nicking or markings due to instrumentation) and 10 percent were scored within category 2 (Relatively smooth appearance with minimal nicking and markings) (See Table 4 for distribution of photomicrograph ratings).

The mean score derived from Krupa Lavigne's categories of root topography was 2.99 with a standard deviation of 0.64 for specimens treated by curets (See Table 3). Among the 20 surfaces scored from the curet group, 50 percent were scored within category 2 (Relatively smooth appearance with nicking and markings), 45 percent scored within category 3 (Moderately smooth but uneven grooves, pitting or markings)

Table 3

Mean and Standard Deviation of Topography Ratings Assigned to the Photomicrographs

Type of Instrumentation	N	Mean	Standard Deviation
Curets	20	2.99	0.64
Modified P-10	20	1.45	0.17
Control	20	4.94	0.32

Table 4

Distribution of Photomicrograph Ratings of Twenty Specimens (3 Surfaces Each)

Categories of Root Topography	1	2	3	4	5
Curets	0	10(50%)	9(45%)	0	1(5%)
Modified P-10	18(90%)	2(10%)	0	0	0
Control	0	0	0	3(15%)	17(85%)

Category 1 = Smooth surface, no nicking or markings due to instrumentation
Category 2 = Relatively smooth appearance with minimal nicking and markings
Category 3 = Moderately smooth but uneven grooves, pitting and markings
Category 4 = Moderately rough with uneven grooves, pitting or markings and some isolated fissures or fractures
Category 5 = Rough surface with multiple irregular markings and/or abrupt fractures

and 5 percent fell into category 5 (Rough surface with multiple irregular and abrupt fractures). In contrast, 100% of the specimen teeth scaled with the modified P-10 fell into cateories 1 or 2, smooth or relatively smooth (See Table 4 for distribution of photomicrograph ratings). The mean score derived from Krupa Lavigne's categories of root surface topography for control surfaces was 4.94 with a standard deviation of 0.32 (See Table 3). Eighty-five percent from the 20 control specimens scored fell within category 5 (Rough surface, with multiple irregular markings and/or abrupt fractures). The remaining 15 percent fell within category 4 (Moderately rough with uneven grooves, pittings or markings and some isolated fissures or fractures (See Table 4 for distribution of photomicrograph ratings).

Analysis of variance revealed a statistically significant difference at the 0.05 level among treatment means. Results showed that a statistically significant difference existed among the three group means as measured by the Krupa Lavigne criteria (F=344.20, df=2/57, P=0.05) (Table 5 demonstrates this analysis).

Multiple comparisons between treatment means were performed using Newman-Keuls multiple range test to determine if statistically significant differences existed among groups at the 0.05 level. Newman-Keuls multiple comparison test revealed a statistically significant difference

Table 5

Analysis of Variance for Topography Ratings
Assigned to Photomicrographs

Source of Variance	SS	df	MS	F	P
Model	122.74	2	61.37	344.20	<0.0001
Error	10.47	57	0.18		
Total	133.20	59			

($p < 0.05$) among surface means scaled and root planed by curets, modified P-10 and controls. Data are presented in Table 6. Statistically significant differences were found in root topography scores of the control group when compared to the modified P-10 and curet group. Root topography scores for control surfaces were more rough than either curet or modified P-10 treatment surfaces. The curet group resulted in a smoother root surface topography score then the control (no treatment) group. Surfaces scaled and root planed by the modified P-10 resulted in the smoothest root surface topography score. All experimental surfaces were smoother then the control (or no treatment) group.

From the micrographs obtained during this investigation (N=20), five micrographs (representing 25 percent of the sample population) were selected for presentation. Micrographs, at the SEM's 3000X magnification level, are displayed in plate format. Each plate illustrates the three experimental surfaces, modified P-10, curets and the control, from one specimen. Modified P-10 surfaces illustrated in the plates are labeled with an A. Curet surfaces illustrated in the plates are labeled with a B. Control surfaces illustrated in the plates are labeled with a C. Plate I-A depicts a smooth surface with minute pitting and markings due to instrumentation with the modified P-10. Plate I-B depicts prominent striations and/or grooves from instrumen-

Table 6

Newman-Kuels Multiple Comparisons Between Root Topography Rating Means

Groupings	N	Type of Instrumentation	Means
A	20	Modified P-10	1.45*
B	20	Curet	2.99*
C	20	Control	4.94*

*Means with the same letter are not significantly different
P = 0.05

tation with curets. Plate I-C illustrates gross projections or amphorous foreign bodies on the control surface (See Plate I). Plate II-A demonstrates a smooth surface created from instrumentation with the modified P-10. Plate II-B illustrates prominent striations in a cross-hatched pattern from instrumentation with curets. Plate II-C depicts moderate sized projections and foreign matter on the control surface (See Plate II). Plate III-A depicts a relatively smooth but undulated (wavy) surface from instrumentation with the modified P-10. Plate III-B illustrates prominent vertical ridges and striations created from instrumentation with curets. Plate III-C demonstrates gross adhesions of foreign matter on the control surface (See Plate III). Plate IV-A demonstrates a smooth surface with no striations or grooves from instrumentation with a modified P-10. Plate IV-B illustrates uneven grooves and striations caused from instrumentation with curets. Plate IV-C depicts gross adhesions of foreign matter on the control surface (See Plate IV). Plate V-A depicts a relatively smooth surface with minute pitting and undulating topography created from instrumentation with the modified P-10. Plate V-B demonstrates a relatively smooth surface with minimal markings and striations from instrumentation with curets. Plate V-C illustrates gross projections of foreign matter on the control surface (See Plate V).

PLATE I

A. MODIFIED P-10 ROOT TOPOGRAPHY

B. CURET ROOT TOPOGRAPHY

C. CONTROL ROOT TOPOGRAPHY

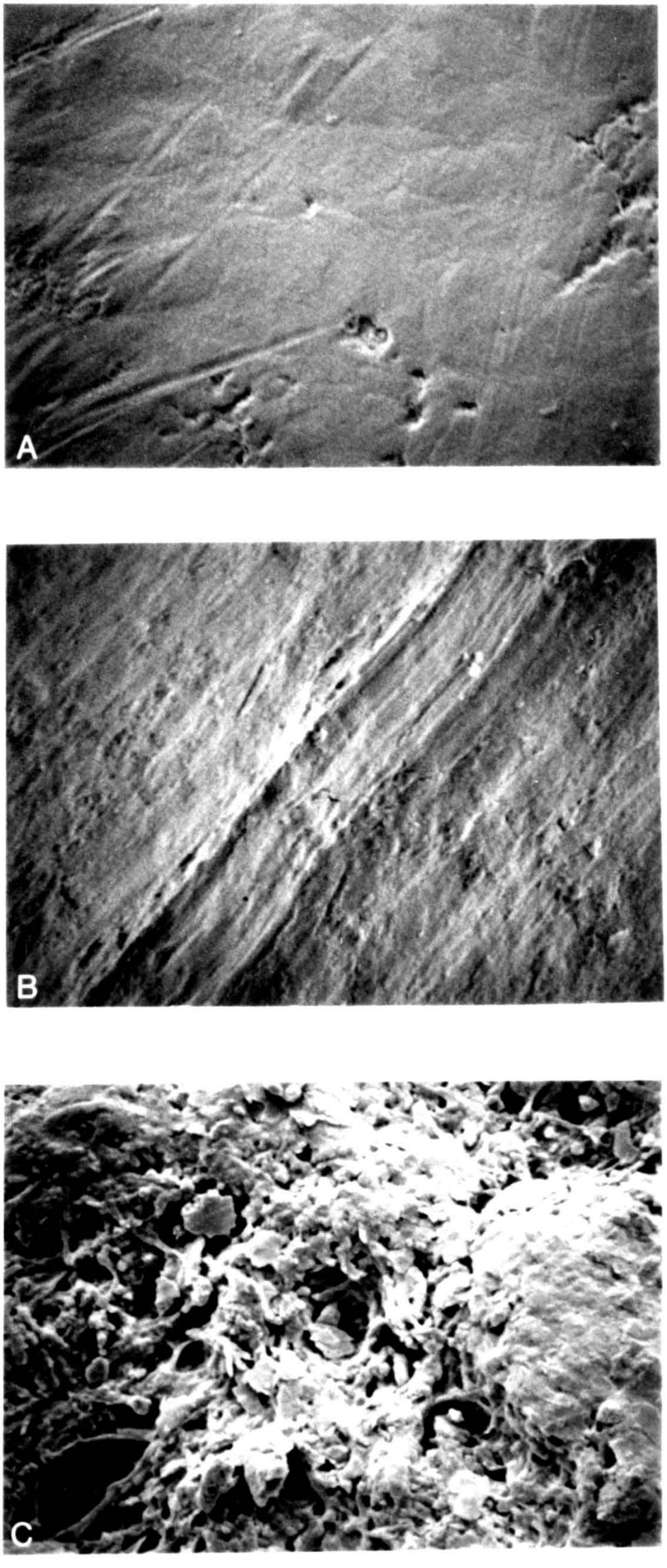

A
B
C

PLATE II

A. MODIFIED P-10 ROOT TOPOGRAPHY

B. CURET ROOT TOPOGRAPHY

C. CONTROL ROOT TOPOGRAPHY

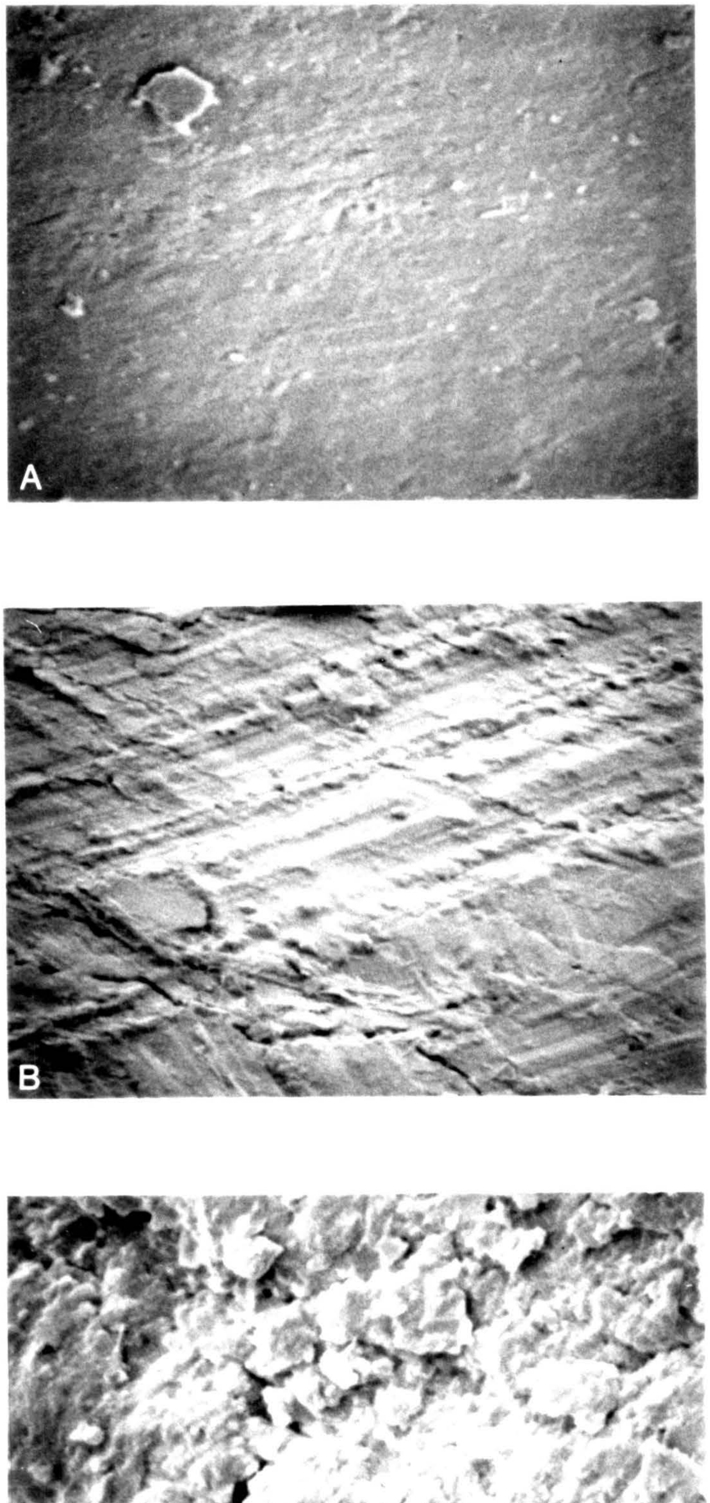

A
B
C

PLATE III

A. MODIFIED P-10 ROOT TOPOGRAPHY

B. CURET ROOT TOPOGRAPHY

C. CONTROL ROOT TOPOGRAPHY

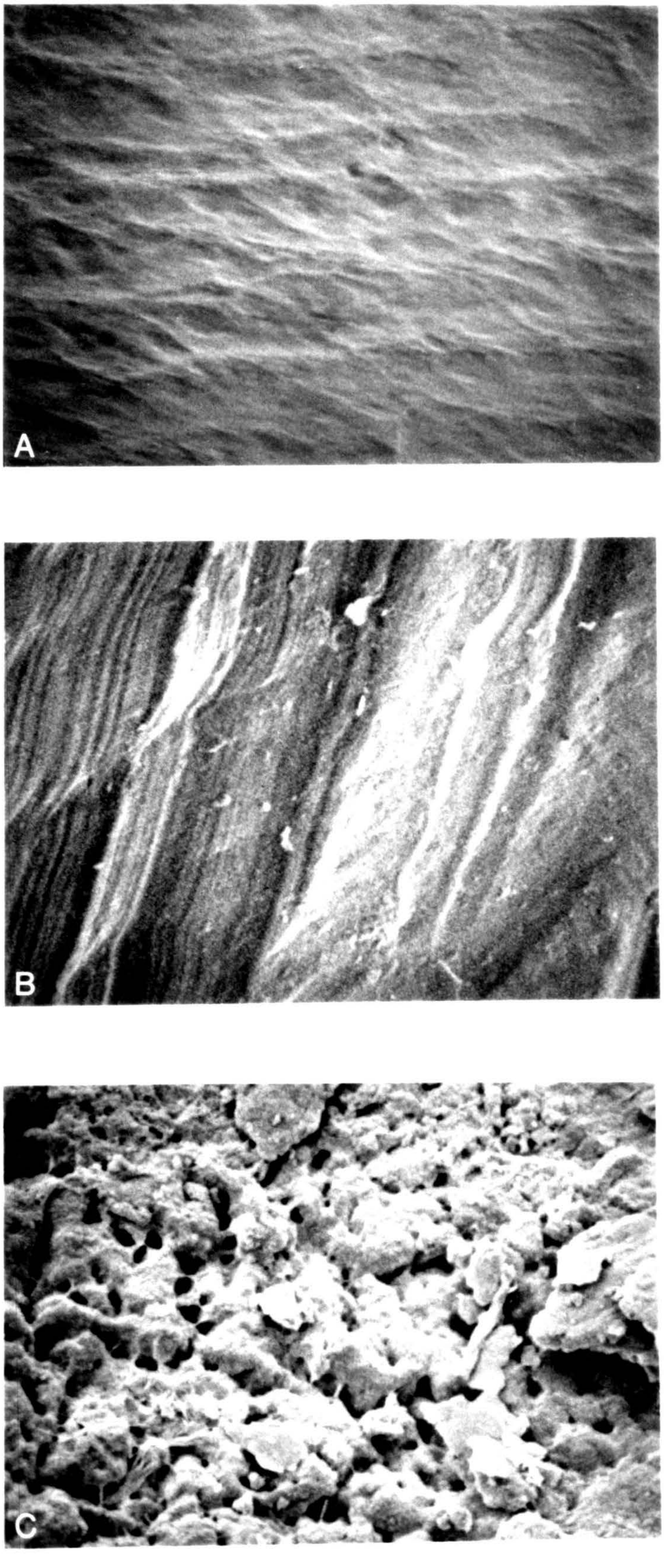

A
B
C

PLATE IV

A. MODIFIED P-10 ROOT TOPOGRAPHY

B. CURET ROOT TOPOGRAPHY

C. CONTROL ROOT TOPOGRAPHY

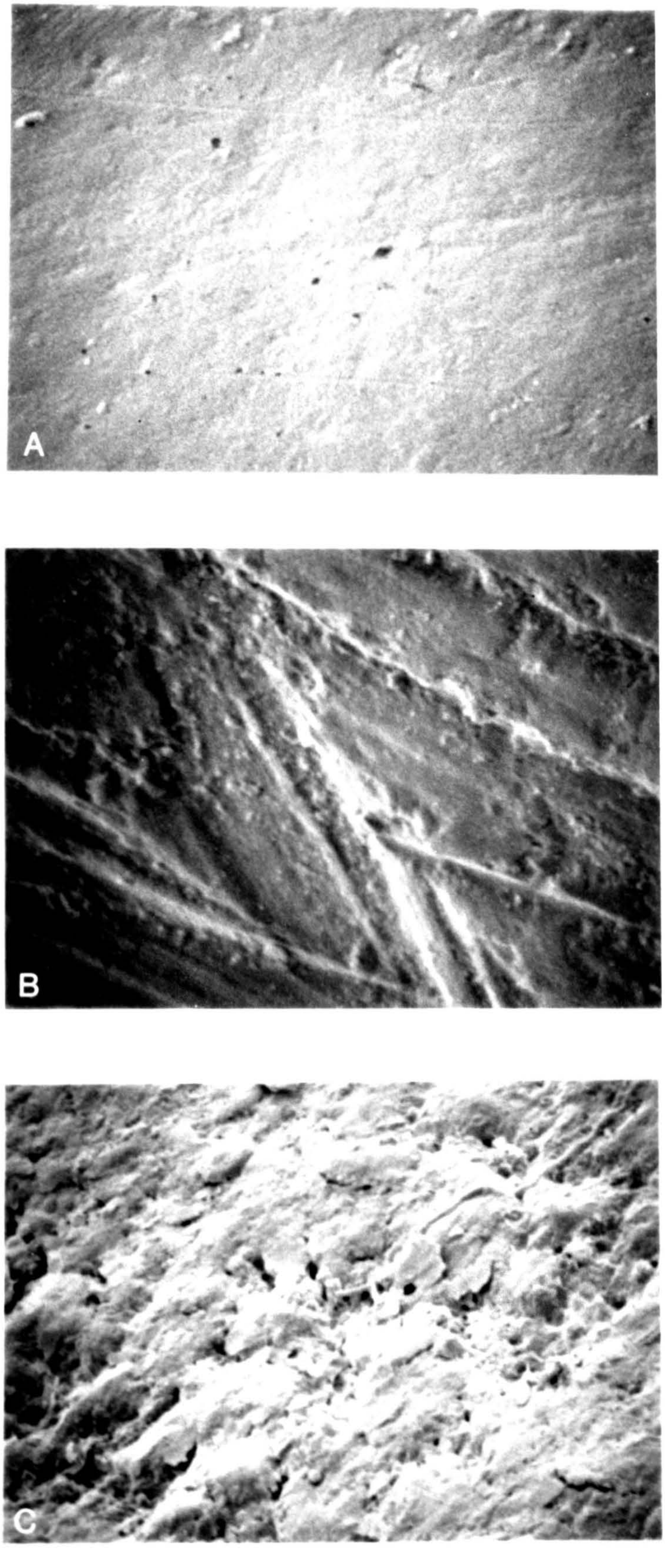
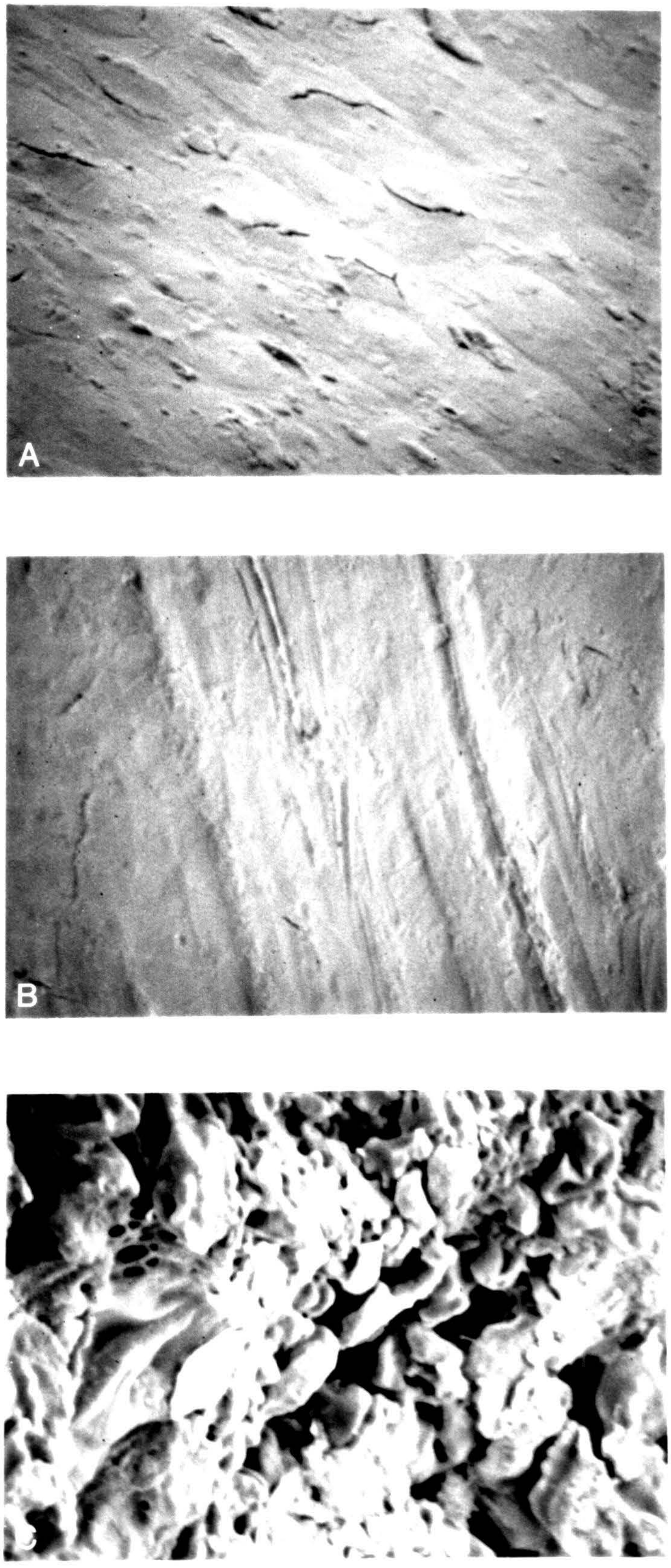

A
B
C

PLATE V

A. MODIFIED P-10 ROOT TOPOGRAPHY

B. CURET ROOT TOPOGRAPHY

C. CONTROL ROOT TOPOGRAPHY



Discussion

Results determined that statistically significant differences existed at the 0.05 level among root topography scores obtained from surfaces scaled and root planed with a modified P-10 ultrasonic tip as compared to those scaled and root planed with curet instruments, as measured by Krupa Lavigne's categories of root smoothness. At the 3000X level of magnification, root surfaces treated by the modified P-10 demonstrated a fine surface texture with minute undulating depressions. Results demonstrated that the modified P-10 left the root surface generally intact without causing significant alterations to the root structure. This finding is in agreement with Jones, Lozdan and Boyde (1972) who also concluded that the ultrasonic scaling instrument caused the least roughness on root surface as compared to curets (Jones, Lozdan and Boyde 1972). Although specific ultrasonic instrumentation was not addressed by Jones, Lozdan and Boyde (1972), conclusions drawn from their study support ultrasonic instrumentation for smoothing root surfaces. Studies by Pameijer, Stallard and Hiep (1972) reported root surfaces treated by ultrasonic instrumentation showed an undulating surface with a texture which appeared smooth but irregular. Conclusions from their investigation are in agreement with surface characteristics from ultrasonic instrumentation found in this study.

Root surfaces scaled and root planed with curets differed from the modified P-10 in that regular prominent ridges and striations were visible. These results support those of Jones, Lozdan and Boyde (1972) who found root surfaces treated with curets to have a grooved or striated appearance.

Results from this investigation contradict Hunter, O'Leary and Kafrawy (1984) who concluded that hand instruments produced a higher percentage of smooth root surfaces (56.6 percent vs 18.8 percent) as compared to ultrasonic instruments. In contrast, results obtained during this investigation concluded that the modified P-10 ultrasonic tip produced a higher percentage of smooth root surfaces as compared to curets. Hunter, O'Leary and Kafrawy findings occurred after sampling 25 in-vivo specimens to hand or ultrasonic instruments until root surfaces felt smooth to an explorer. Indiana University model curets (nos. 13, 14, 17 and 18) were used for hand instrumentation. A Cavitron[R] 1010 with a PF10 flow-through tip was utilized for ultrasonic instrumentation. A stereomicroscope at 40X magnification with an eyepiece grid of 100 squares was used to examine and quantify percentages for specimen root surfaces. One investigator, blind to specimen treatment, completed all stereomicroscopic evaluations. Intrarater reliability of the examiner was not established prior to evaluations. Therefore, chances of varying interpretations may have influenced these results. No specific instrumentation techniques for scaling and root planing was described by the investigators. Studies by Pameijer, Stallard and Hiep (1972) reported either instrument may result in undesirable root surface characteristics if improper technique is utilized.

Control surfaces showed numerous large projections in irregular patterns across the root specimen surfaces. Photomicrographs of control surfaces were compared to previous investigations. Control surfaces exhibited similar root surface characteristics to those illustrated by Wilkenson and Maybury (1973). Wilkenson and Maybury (1973) found that the foreign particles on their control specimens were deposits of calculus and bacterial plaque. The numerous projections found on control surfaces from this investigation are thought to be either bacterial plaque or calculus.

Results from this investigation were unexpected. Both methods of instrumentation produced a significantly smoother root surface than the control but the modified P-10 surfaces resulted in the smoothest root surface topography rating. Although the ability of ultrasonic instruments for scaling and root planing is well documented, no published research on the effects of a modified P-10 Cavitron^{R} tip on root surface topography has been available prior to this study.

As reported in the literature review, previous studies conducted to compare curets and ultrasonic instruments have yielded varying results. Differences in root surface topography following instrumentation may be attributed to various factors such as, length of time allowed for instrumentation, design and size of the instrument and the amount of pressure applied during instrumentation. Pameijer, Stallard and Hiep (1972) concluded that excessive force applied with hand instruments will produce irregular strokes and gouged root surfaces, and incorrect ultrasonic technique will result in irregular root surfaces. The ultrasonic technique applied in this investigation, as described by Holbrook (1989), recommends using a low power setting for instrumentation and manually tuning the modified P-10 to control the number of vibrations supplied to the tip. Previous studies that followed manufacturer's recommendations for ultrasonic instrumentation most often used high or medium power settings (Breininger, O'Leary and Blumenshine 1987; Moskow and Bressman 1964; Wilkenson and Maybury 1973; D'Silva et al. 1979; Garnick and Dent 1989). Based on this investigations results, dental hygienists should select the modified P-10 and utilize Holbrook's (1989) ultrasonic technique to obtain maximum smooth root surfaces during scaling and root planing. According to Clark (1969) the depth and degree of tooth surface effects are governed by the quantity of energy applied by the ultrasonic unit power settings (amplitude), tuning (resonance), time of exposure, applied pressure and relative sharpness of the tip. As stated by Breininger, O'Leary and Blumenshine (1987), the extent of root surface damage from the use of an ultrasonic unit at a high power setting was disturbing as viewed under the SEM. While little information for ultrasonic technique is available, it seems wise to limit such potential harmful affects by reducing the power setting and using the least of amount of amplitude consistent with effectiveness.

An essential part of periodontal therapy is to remove debris from tooth surfaces and to reduce tooth surface roughness which may facilitate the accumulation of irritants. Clinically, a smooth root surface denotes the end point of instrumentation. The biological relationship between a smooth root surface, pocket reduction and gain of attachment is still under debate (Khatiblou and Ghodssi 1983). However, a smooth root surface still remains important due to the belief that a roughened root surface could facilitate reaccumulation and enhance disease (Green and Ramjord 1966; Clark, Group and Mahler 1968). Therefore, dental hygienists must still strive to obtain a smooth root surface during scaling and root planing. Data suggest that a modified P-10 is more effective than curets in achieving root smoothness. This result implies dental hygienists should choose a modified P-10 for scaling and root planing for optimal root smoothness. However, based on results of this study, dental hygienists may choose either method of instrumentation for scaling and root planing to acquire a smooth root surface. Although this study does not investigate the limitations of scaling and root planing subgingivally, the design of the modified P-10 is superior to curets for access into narrow periodontal pockets. As concluded by D'Silva et al. (1979), ultrasonics were superior in cleaning root surfaces with lesser damage to incisor teeth but had no particular advantage over hand instruments with respect to the treatment of molars. This could suggest that where accessiblity is more difficult, as in the case of molars, size of the tip may impede the efficiency of the standard ultrasonic instrument. Therefore, with respect to increased root smoothness and greater access subgingivally, the modified P-10 should be recommended in dental hygiene practice.

Limitations from this investigation should be discussed when interpreting results. Handling, storage and preparation of sample specimens prior to instrumentation may have altered specimens causing the root topography to appear more rough than in vital teeth. Pressure of scaling methods were not controlled or measured in this study. The utilization of one brand of ultrasonic unit limits generalization to other ultrasonic units used in similar studies. Sample specimens may have been exposed to instrumentation prior to conducting this study. Therefore, results obtained from this investigation can only be compared to other similar studies.

CHAPTER 5

Summary and Conclusions

Scaling and root planing are widely accepted methods used in periodontal therapy to remove plaque and calculus from the surfaces of teeth and to reduce tooth surface roughness which may facilitate accumulation of irritants. The most commonly recognized armaments for scaling and root planing are hand and ultrasonic instruments. Previous research demonstrates a great difference in viewpoints among those who have studied the effects of hand and ultrasonic instruments on the root surface (Clark, Grupe and Mahler 1968; Breininger, O'Leary and Blumenshine 1987; D'Silva et al. 1979; Ewen and Sorrin 1964; Garnick and Dent 1986; Green 1966; Hunter, O'Leary and Kafrawy 1984; Jones, Lozdan and Boyde 1972; Kerry 1967; Moskow and Bressman 1964; Pameijer, Stallard and Hiep 1972; Stende and Schaffer 1961; Wilkenson and Maybury 1973). Limited studies have been conducted to determine the effects of instrumentation from the modified P-10 on root surface topography. The purpose of this investigation was to examine the effects of both curets and the modified P-10 on root surface topography.

Twenty specimens comprised of maxillary and mandibular and posterior and anterior teeth were carved into a three split root design and randomly assigned to a treatment group, curets or modified P-10. Each scaling technique was applied for 2 minutes and 14 seconds. Specimens were mounted, numbered and sputter coated with approximately 100-120 angstroms of gold palladium prior to SEM examination. Experimental surfaces were micrographed at 3000X magnification. Photomicrographs were generated from each micrograph and placed on a nine section grid to quantify total root smoothness. A mean value was calculated from each experimental group. A one-way analysis of variance (ANOVA) was used to determine the effects of the independent variables, curets, modified P-10 and control (no treatment) on the dependent variable (root topography). Multiple comparisons were performed using Newman-Kuels multiple range test to determine where the statistically significant differences existed among groups.

Results from the statistical analyses revealed a statistically significant difference, at the 0.05 level, among experimental groups, curets and modified P-10. Based on results, the investigation found a statistically significant difference at the 0.05 level in root surface topography of exposed cemental surfaces scaled with a modified P-10 ultrasonic tip as compared to exposed cemental surfaces scaled with curets, as measured by Krupa Lavigne's categories of root smoothness. Data suggest that a modified P-10 is more effective than hand curets in achieving root smoothness.

Based on the discussion of this investigation, the following conclusions were made:

1. Scaling and root planing with the modified P-10 created a significantly smoother root surface than did the curets.
2. Both methods of instrumentation produced a significantly smoother root surface than the control (no treatment) group but the modified P-10 resulted in the smoothest root surface topography rating.

The present study has shown that the modified P-10 can produce a smooth surface, however, more research is required to determine the factors necessary to produce such a surface using this method.

Recommendations for future research are made:

1. An investigation should be developed to compare various ultrasonic instrument tip designs and their effects on root surfaces.
2. A study should be designed to determine the effects of amplitude, tuning, pressure, time of exposure and relative sharpness of the tip on root surfaces during ultrasonic instrumentation.
3. An investigation should be conducted to determine the

effects of Holbrook's (1989) ultrasonic technique as compared to manufacturerer's recommendations for ultrasonic instrumentation on root surfaces.

4. A replication of this study should be conducted with a larger sample size to verify results.

5. This investigation should be conducted using various levels of microscopic magnification to determine if magnification levels effect interpretation of root surface smoothness.

6. A replication of this investigation should be conducted with specific hand scaling techniques identified to ensure standardization of the clinician.

7. A replication of this investigation should be conducted to compare the effects of the modified P-10 and curets on root surface cleanliness.

Within limits of this study, findings suggest that root surfaces treated with the modified P-10 are significantly smoother as compared to curets. Both methods of instrumentation are significantly smoother as compared to the control (no treatment) root surfaces. Based on results of this investigation, dental hygienists may select either method of instrumentation for scaling and root planing to obtain a smooth root surface. However, for optimal root surface smoothness the modified P-10 would be the instrument of choice.

BIBLIOGRAPHY

Balamuth, L. "Technical Background on Cavitron Ultrasonic Dental Unit." Annex of Dentistry 14 (1955): 49-52.

Breininger, D.R., T.J. O'Leary and V.H. Blumenshine. "Comparative Effectiveness of Ultrasonic and Hand Scaling for the Removal of Subgingival Plaque and Calculus." Journal of Periodontology 58 (1987): 9-18.

Clark, S.M., H.E. Grupe and D.B. Mahler. "Effects of Ultrasonic Instrumentation on Root Surfaces." Journal of Periodontology 39 (1968): 135.

Dragoo, M.R. "The Limitations of Hand and Ultrasonic Instruments on Subgingival Debridement." 1991.

D'Silva, I.V., et al. "An Evaluation of the Root Topography Following a Scanning Electron Microscopic Study." Journal of Periodontology 50 (1979): 283-90.

Ewen, S.J., and S. Sorrin. "Ultrasonics and Periodontal Therapy." Dental Clinicians of North America 8 (1964): 145.

Garnick, J.J. and J. Dent. "A Scanning Electron Micrographical Study of Root Surfaces and Subgingival Bacteria After Hand and Ultrasonic Instrumentation." Journal of Periodontology 60 (1989): 441-47.

Glickman, I. Clinical Periodontology 4th ed. Philadelphia: W.B. Saunders Company, 1972.

Green, E. and S.P. Ramfjord. "Tooth Roughness After Subgingival Root Planing." Journal of Periodontology 37 (1966): 396-99.

Frisch, J. "Effect of Ultrasonic Instrumentation on Human Gingival Connective Tissue." Periodontics 5 (1967): 123.

Holbrook, T.E., and S.B. Low. "Power-Driven Scaling and Polishing Instruments." Clark's Clinical Dentistry. 3 (1989): 1-24.

Hunter, R.K., T.J. O'Leary and A.H. Kafrawy. "The Effectiveness of Hand Versus Ultrasonic Instrumentation in Open Flap Root Planing." Journal of Periodontology 55 (1984): 697-703.

Jones, S., J. Lozdan and A. Boyde. "Tooth Surfaces Treated in Situ With Periodontal Instruments." British Dental Journal 132 (1972): 57-64.

Kerry, G.J. "Roughness of Root Surfaces After Use of Ultrasonic Instruments and Hand Curettes." Journal of Periodontology 38 (1967): 340-46.

Khatiblou, F.A. and A. Ghodssi. "Root Surface Smoothness or Roughness in Periodontal Treatment." Journal of Periodontology 54 (1983): 365-67.

Krupa Lavigne, C., et al. "In Vitro Evaluation of Air-Powder Polishing as an Adjunct to Ultrasonic Scaling on Periodontally Involved Root Surfaces." Journal of Dental Hygiene (Nov./Dec. 1988): 504-09.

Leon, L.E., and R.I. Vogel. "A Comparison of the Effectiveness of Hand Scaling and Ultrasonic Debridement in Furcations as Evaluated by Differential Dark-Field Microscopy." Journal of Periodontology 58 (1987): 86-94.

Moskow, B.S., and E. Bressman. "Cemental Response to Ultrasonic and Hand Instrumentation." Journal of the American Dental Association 68 (1964): 698-703.

Nyman, S., et al. "The Effects of 'Diseased' Root Cementum in Healing Following Treatment of Periodontal Disease. An Experimental Study in the Dog." Journal of Clinical Periodontology 21 (1986): 496.

Oda, S., and I. Ishikawa. "In Vitro, Effectiveness of a Newly-Designed Ultrasonic Scaler Tip for Furcation Areas." Journal of Periodontology 60 (1989): 634-38.

O'Leary, T.J. "The Impact of Research on Scaling and Root Planing." Journal of Periodontology 57 (1986): 69-73.

Oosterwaal, P.M., et al. "The Effect of Subgingival Debridement With Hand and Ultrasonic Instruments on the Subgingival Microflora." Journal of Clinical Periodontology 14 (1987): 528-33.

Pameijer, C.H., and R.E. Stallard. "Application of Replica Techniques for Use with Scanning Electron Microscopes in Dental Research." Journal of Dental Research 51 (1972): 672.

Pameijer, C.H., R.E. Stallard and N. Hiep. "Surface Characteristics of Teeth Following Periodontal Instrumentation: A Scanning Electron Microscope Study." Journal of Periodontology 43 (1972): 628-33.

Rabbini, G.M., M.A. Major and R.G. Caffesse. "The Effectiveness of Subgingival Scaling and Root Planing in Calculus Removal." Journal of Periodontology 52 (1981): 119-23.

Ramfjord, S.P., et al. "Oral Hygiene and Maintenance of Periodontal Support." Journal of Periodontology 53 (1982): 26-30.

Rizzo, Anthony. Telephone interview. 12 March 1991.

Stende, G.W., and E.M. Schaffer. "A Comparison of Ultrasonic and Hand Scaling." Journal of Periodontology 32 (1961): 312-14.

Toevs, Sarah E. "Root Topography Following Instrumentation." Dental Hygiene 8 (1985): 350-54.

Waerhaug, J. "A Method for Evaluation of Periodontal Problems on Extracted Teeth." Journal of Clinical Periodontology 2 (1975): 160-68.

Waerhaug, J. "Healing of the Dento-Epithelial Junction Following Subgingival Plaque Control." Journal of Periodontology 49 (1978): 119-34.

Westfelt, W., et al. "Significance of Frequency of Professional Tooth Cleaning for Healing Following Periodontal Surgery." Journal of Clinical Periodontology 10 (1983): 148-56.

Wilkenson, R.F., and J.E. Maybury. "Scanning Electron Microscopy of the Root Surface Following Instrumentation." Journal of Periodontology 44 (1973): 559-63.

Zander, H.A. "The Attachment of Calculus to Root Surfaces." Journal of Periodontology 24 (1953): 16-19.

Zinner, D.D. "Recent Ultrasonic Studies Including Periodontia Without the Use of An Abrasive." Journal of Dental Research 34 (1955): 748-49.

APPENDIX A

Holbrook's Technique for Instrumentation of the Modified P-10 Tip

Holbrook's Technique for Instrumentation of the Modified P-10

1. Hold handpiece with a gentle pen grasp versus a firm modified pen grasp.
2. Balance handpiece to eliminate torque of cord.
3. Use a soft tissue rest for orientation and limitation of movement versus a hard tissue fulcrum.
4. Activate tip before applying to the tooth or root surface.
5. Adapt tip parallel to the tooth or root surface.
6. Insert tip subgingivally using the back (or convex) surface of the modified P-10.
7. Use a brush-like or erasing type stroke with the lightest possible pressure allowing the instrument to do the work for you.
8. Start at the greatest depth of the pocket and use multiple overlapping strokes out of the pocket to fully negotiate complete root coverage.
9. Keep tip moving at all times.

APPENDIX B

Modified P-10 Instructions
for the Clinician

Modified P-10 Instructions: for the Clinician

1. Utilize a Dentsply 660 (a manually tuning ultrasonic unit) to complete the procedure.
2. Tune the modified P-10 tip and implement scaling accord ing to Holbrook's (1989) scaling technique (See Appendix A for Holbrook's scaling technique and Appendix G for steps in manual tuning).
3. Scale and root plane the designated experimental surfaces of the specimens for two minutes and 14 seconds.
4. Pause to adjust the tuning as necessary.
5. The clinician will be instructed to proceed to the next tooth after completing the two minutes and 14 seconds per specimen; simulating a clinical routine periodontal scaling.
6. The assistant will instruct the clinician when to "begin scaling" and when to "stop scaling." A stop watch will be used to record time.

APPENDIX C

Hand Instrumentation Instructions for the Clinician

Hand Instrument Instructions for the Clinician

1. Utilize new Gracey curets #'s 1/2, 11/12, 13/14 to complete the procedure.
2. Implement scaling and root planing to debride and smooth the root surfaces.
3. Scale and root plane the designated experimental surfaces of each specimen for 2 minutes and 14 seconds.
4. Pause to sharpen the instrument as necessary.
5. The clinician will be instructed by the principal investigator to proceed to the next tooth after completing the 2 minutes and 14 seconds per specimen; simulating routine periodontal scaling procedure.
6. The principal investigator will give instructions when to "begin scaling" and when to "stop scaling." A stop watch will be used to record time.

APPENDIX D

Mathematical Computation for Scaling Methods

Mathematical Computation for Scaling Method

The length of instrumentation was determined by dividing the average clinical time allowed for scaling and root planing (60 minutes) by seven (the average number of teeth present in an adult quadrant). Eight minutes and 57 seconds was determined the average length of time of scaling and root planing per tooth. To determine the average length of scaling and root planing per root surface, the 8 minutes and 57 seconds were divided by the four root surfaces (buccal, lingual, mesial and distal). Therefore, 2 minutes and 14 seconds was computed for scaling and root planing with either scaling instrument (modified P-10 or curets) on the randomly assigned experimental surfaces. The following demonstrates the mathematical computations for scaling and root planing on experimental surfaces:

Sixty minutes divided by seven teeth = Eight minutes and 57 seconds per tooth.

Eight minutes and 57 seconds/tooth divided by four root surfaces = Two minutes and 14 seconds/root surface.

APPENDIX E

Data Collection Sheet for Photomicrographs

<u>Data Collection for Photomicrographs</u> _

Photomicrograph # ______

Surface # ______:

L	T	R
L	B	R

Total = ______

÷ 9 = ______

Surface # ______:

L	T	R
L	B	R

Total = ______

÷ 9 = ______

Surface # ______:

L	T	R
L	B	R

Total = ______

÷ 9 = ______

Photomicrograph # ______

Surface # ______:

L	T	R
L	B	R

Total = ______

÷ 9 = ______

Surface # ______:

L	T	R
L	B	R

Total = ______

÷ 9 = ______

Surface # ______:

L	T	R
L	B	R

Total = ______

÷ 9 = ______

Preliminary Calibration Study

The examiner was given eight randomly selected photomicrographs for three consecutive days to score root surface topography according to Krupa Lavigne's root surface characteristics for smoothness. The examiner was instructed to evaluate and score each section separately on the nine grid photomicrograph. Mean scores were calculated for each specimen. Data were analyzed using a confidence interval of 0.50 (+ or -) among mean scores from the same specimen. The examiner achieved at least a confidence interval of 0.50 (+ or -) among sample specimen means during the three day calibration study.

APPENDIX G

Raw Data from Preliminary Calibration Study

Preliminary Calibration Study
Raw Data from Photomicrograhs

Day 1

Specimen No.	Curets	Control	Modified
1.	2.78	5.0	1.0
2.	3.0	5.0	1.67
3.	2.67	5.0	1.33
4.	3.0	5.0	2.55
5.	3.89	5.0	1.55
6.	4.0	5.0	1.11
7.	1.8	5.0	1.67
8.	2.78	5.0	1.33

Preliminary Calibration Study
Raw Data from Photomicrograhs

Day 2

Specimen No.	Curets	Control	Modified P-10
1.	3.0	5.0	1.0
2.	3.0	4.89	1.55
3.	2.55	4.78	1.44
4.	3.34	5.0	2.45
5.	3.44	5.0	1.34
6.	3.84	5.0	1.12
7.	1.89	5.0	1.89
8.	2.56	5.0	1.23

Preliminary Calibration Study
Raw Data from Photomicrograhs

Day 3

Specimen No.	Curets	Control	Modified P-10
1.	2.78	5.0	1.0
2.	3.0	4.89	1.89
3.	2.67	4.89	1.22
4.	3.0	5.0	2.45
5.	3.78	5.0	1.55
6.	3.66	5.0	1.11
7.	2.0	5.0	1.67
8.	2.33	5.0	1.33

Preliminary Calibration Study
Raw Data from Photomicrograhs

Specimen No.		Day 1	Day 2	Day 3	Mean
1.	Curets	2.78	3.0	2.78	2.85
	Control	5.0	5.0	5.0	5.0
	Modified P-10	1.0	1.0	1.0	1.0
2.	Curets	3.0	3.0	3.0	3.0
	Control	5.0	4.89	4.89	4.93
	Modified P-10	1.67	1.55	1.89	1.70
3.	Curets	2.67	2.55	2.67	2.63
	Control	5.0	4.78	4.89	4.89
	Modified P-10	1.33	1.44	1.22	1.33
4.	Curets	3.0	3.34	3.0	3.12
	Control	5.0	5.0	5.0	5.0
	Modified P-10	2.55	2.45	2.45	2.48
5.	Curets	3.89	3.44	3.78	3.70
	Control	5.0	5.0	5.0	5.0
	Modified P-10	1.55	1.34	1.55	1.48

Preliminary Calibration Study
Raw Data from Photomicrograhs

Specimen No.		Day 1	Day 2	Day 3	Mean
6.	Curets	4.0	3.84	3.66	3.83
	Control	5.0	5.0	5.0	5.0
	Modified P-10	1.11	1.12	1.11	1.11
7.	Curets	1.8	1.89	2.0	1.89
	Control	5.0	5.0	5.0	5.0
	Modified P-10	1.67	1.89	1.67	1.74
8.	Curets	2.78	2.56	2.33	2.56
	Control	5.0	5.0	5.0	5.0
	Modified P-10	1.33	1.23	1.33	1.30

APPENDIX H

Steps in Manual Tuning the Modified P-10 Tip

Steps in Manual Tuning the Modified P-10 Tip

1. Use the lowest power setting and ensure water flow is adequately opened.
2. Clean air from handpiece by running the unit briefly, then insert tip holding the handpiece vertically.
3. Hold handpiece in a horizontal position to adjust the water flow. (The correct amount of water will gently flow up and over the end of the upward pointed tip).
4. With the handpiece in a horizontal position and the tip pointed downward, tune the resonance of the tip until a rapid drip of water and a light spray of aerosol is emitted from the tip.

Raw Data from Photomicrograph Ratings

(n=20)

Specimen No.	Curets	Control	Modified P-10
1.	3.55	5.0	1.0
2.	2.55	5.0	1.55
3.	2.33	5.0	1.11
4.	2.44	5.0	1.77
5.	2.55	5.0	1.67
6.	3.0	5.0	1.33
7.	2.44	5.0	1.33
8.	2.67	5.0	1.78
9.	5.0	5.0	1.56
10.	3.22	5.0	1.22
11.	3.67	5.0	1.22
12.	3.0	4.89	2.0
13.	2.44	5.0	2.11
14.	3.0	5.0	1.11
15.	2.78	5.0	1.22
16.	2.44	4.89	1.67
17.	3.0	5.0	1.22
18.	2.67	5.0	1.67
19.	3.33	4.22	1.0
20.	3.78	4.89	1.44