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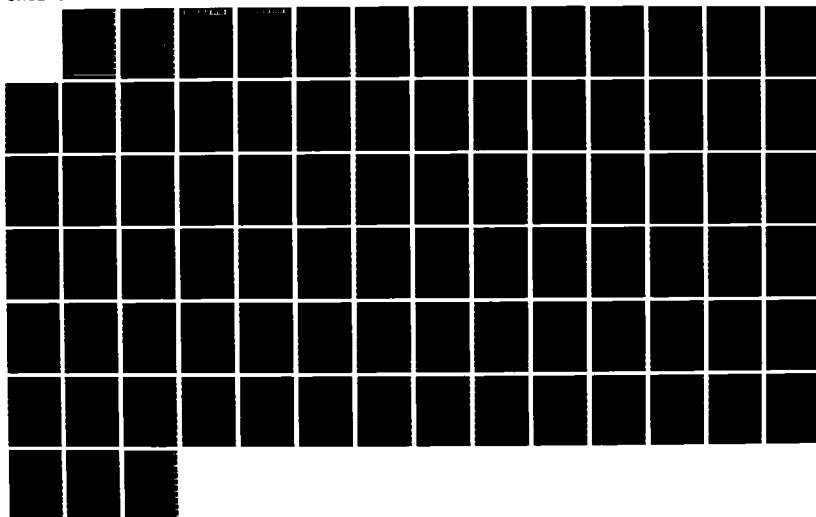
PROPHY-JET: EFFECT ON SURFACE ROUGHNESS AND PLAQUE
ACCUMULATION ON RESTORATIVE MATERIALS(U) AIR FORCE INST
OF TECH WRIGHT-PATTERSON AFB OH K W STOFFERS 1986
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1. REPORT NUMBER AFIT/CI/NR 86-161T		2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Prophy-Jet: Effect On Surface Roughness And Plaque Accumulation On Restorative Materials		5. TYPE OF REPORT & PERIOD COVERED THESIS/DISSERTATION	
		6. PERFORMING ORG. REPORT NUMBER	
7. AUTHOR(s) Kenneth W. Stoffers		8. CONTRACT OR GRANT NUMBER(s)	
9. PERFORMING ORGANIZATION NAME AND ADDRESS AFIT STUDENT AT: University of Michigan		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS	
CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE 1986	
		13. NUMBER OF PAGES 77	
MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASS	
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE	
DISTRIBUTION STATEMENT (of this Report) APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED			
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)			
18. SUPPLEMENTARY NOTES APPROVED FOR PUBLIC RELEASE: IAW AFR 190-1		 LYNN E. WOLAVER 9 Sept 86 Dean for Research and Professional Development AFIT/NR	
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)			
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INTRODUCTION

The introduction of the Prophy-Jet dental prophylaxis unit by Dentsply/Cavitron offers a new method for easily and quickly removing plaque and stubborn stain from the teeth. Many studies have already been done demonstrating the efficiency and effectiveness of this technique and establishing its relative safety to the dentition. The effect upon the diverse restorative materials present in the oral environment has not been adequately addressed.

This study will compare the air polishing technique with prophylaxis using a rubber cup in order to evaluate their effect upon surface roughness produced on representative restorative materials. It will also compare differences in plaque collection upon these materials as a result of the two methods.

The specific aims are:

1. Measure and compare changes produced in the surface roughness of some commonly used restorative materials when exposed to conventional rubber cup polishing and application of the Prophy-Jet, and

2. Measure and compare plaque accumulation on the surfaces of restorative materials which have been polished with a rubber cup and with a Prophy-Jet.

Although other studies have already shown the Prophy-Jet system to be no more abrasive to enamel nor traumatic to soft tissue than conventional oral prophylaxis techniques, it is important to establish the relationship of the Prophy-Jet treatment to gingival health as effected by plaque. Since many patients have dental restorations in their mouths, this research is important to establish the effect of the device on restorative materials and subsequent plaque accumulation.



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PROPHY-JET: EFFECT ON SURFACE ROUGHNESS AND PLAQUE
ACCUMULATION ON RESTORATIVE MATERIALS

by
Kenneth W. Stoffers

Presented to the faculty of the Horace A. Rackham School of
Graduate Studies, University of Michigan, in partial
fulfillment of the requirements for the degree of Master of
Science in Dental Materials and Restorative (Operative)
Dentistry

Ann Arbor, Michigan
1986

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ACKNOWLEDGEMENTS

The author extends special thanks to:

My family, for their patience and support during a three year hiatus in our normal lives

The U. S. Air Force, for making my graduate training possible

My thesis committee members, who proved to be both friends and mentors, for their guidance, inspiration and help

Dr. Gloria J. Kerry who served as a special advisor

Dr. Charles J. Kowalski, for his guidance and encouragement in preparation of the statistical analyses

The faculty and staff of the Dental Materials and Graduate Operative Departments for their encouragement and help.

TABLE OF CONTENTS

LIST OF TABLES.....	iv
INTRODUCTION.....	1
REVIEW OF LITERATURE.....	3
History of Air Abrasives in Dentistry.....	3
Effectiveness of Air Polishing.....	5
Effects on Enamel.....	5
Effects on Dentin.....	9
Effects on Cementum.....	11
Effects on Restorative Materials.....	12
Effects on Gingival Tissues.....	14
Abrasive-ness of Powder.....	18
Toxicity of Air Abrasive Agents.....	19
Prophy-Jet vs Rubber Cup Prophylaxis.....	24
Effect of Surface Roughness on Plaque Accumulation.....	28
Methods for Measuring Smoothness.....	29
Models for Evaluation of Plaque Formation.....	30
METHODS AND MATERIALS.....	33
Sample Preparation.....	33
Experimental Treatment.....	37
Measurement of Surface Roughness.....	39
Plaque Accumulation.....	40
Plaque Evaluation.....	42
Statistical Methods.....	45
RESULTS.....	47
Surface Roughness.....	47
Plaque Accumulation.....	52
Evaluator Agreement.....	54
DISCUSSION.....	57
Roughness.....	57
Plaque Accumulation.....	61
Evaluator Agreement.....	63
Toxicity of Abrasive Agent.....	64
Investigations Needed.....	66
SUMMARY.....	70
CONCLUSIONS.....	72
BIBLIOGRAPHY.....	73

LIST OF TABLES

Table 1:	Materials.....	34
Table 2:	Arithmetic Average Roughness.....	48
Table 3:	Average Maximum Peak Height Roughness.....	48
Table 4:	Roughness Differences Between Treatments.....	49
Table 5:	Roughness Differences Between Materials.....	51
Table 6:	Difference in Plaque Accumulation Among Treatment Areas and Control.....	53
Table 7:	Difference in Plaque Accumulation Among Materials.....	53
Table 8:	Difference of Plaque Accumulation Among Materials.....	54
Table 9:	Evaluator Agreement: Initial Rating of Difference in Accumulation on Treatment Areas.....	56
Table 10:	Evaluator Agreement: Initial Rating of Comparison to Standards.....	56

INTRODUCTION

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REVIEW OF LITERATURE

History of Air Abrasives in Dentistry

Black(1), in 1945, initiated the use of air abrasives in dentistry when he described his development of an apparatus which used air propelled abrasive powder for cavity preparation. He used aluminum oxide particles as his abrasive and coined the name "Airbrasive" to describe the procedure. He suggested that with a less abrasive powder and with decreased air pressure, the system could be used to perform dental prophylaxis. This study generated an interest which was explored by others. In 1950, Bailey and Phillips(2) reported using dolomite as an abrasive in Black's apparatus, which by that time had come to be known as the Airdent, to perform oral prophylaxis.

Epstein(3) also reported using the device for oral prophylaxes and cited an improved receptiveness on the part of the patients. He noted, however, that there were problems with the device which included a lack of tactile sensation for the operator and general messiness of the machine in that it spread the abrasive powder all around the operatory. Norton(4) likewise spoke of the use of the

Airdent for cavity preparation and reported that patients liked the lack of noise and vibration normally associated with the dental handpiece.

In 1954, White and Peyton(5) suggested that dolomite prophylaxis using the Airdent might cause unacceptable loss of tooth structure. They arrived at this conclusion after their study showed loss of tooth structure and opening of margins of restorations using this technique. Boyde(6) claimed that the use of the technique was soon abandoned because of its disadvantages, mainly the spreading of dust everywhere, including the dentist's and patient's eyes and respiratory systems.

With the development of the Prophy-Jet by Dentsply/Cavitron, a new approach to the use of air abrasives was introduced. Willmann, Norling, and Johnson(7) described this device and some of its effects as early as 1980. The instrument uses air inlet pressure of 50 to 100 psi and water inlet pressure of 10 to 50 psi. An air jet operating at 50 to 60 psi propels particles of sodium bicarbonate from the tip of the handpiece. These are immediately trapped by small streams of water, creating a slurry out of the powder. Boyde(6) noted as an advantage over the Airdent, that the Prophy-Jet abrasive was highly soluble and that dissolution

was almost ensured by the shrouding circumferential water jet.

Effectiveness of Air Polishing

Bailey and Phillips(2) found that the Airdent removed both stain and calculus rapidly. Willmann, Norling, and Johnson(7) reported that the Prophy-Jet removed most extrinsic stain except in the deepest pits and fissures. Other investigators(6,8,9,10,11,12) reported that the device was effective in removing plaque, stain, or residual calculus and some(8,9,12) claimed that it was highly effective on pits and fissures.

Effects on Enamel

Almost as soon as such techniques became available, investigators became interested in the effect that air polishing would have on the surface of the tooth. Bailey and Phillips(2) reported enamel loss varying from 3 to 106 micrometers (um.) when performing prophylaxes using dolomite in the Airdent. They noted that the effect on enamel was influenced by the length of time of the exposure and the distance of the instrument tip from the tooth surface. In evaluating the quality of the surface left on the enamel,

they ground a flat spot on the enamel and then polished it smooth. After this, they exposed some of the surfaces to rubber cup prophylaxis and others to Airdent prophylaxis. They observed that the rubber cup produced scratches on the enamel and that the Airdent produced a pitting effect.

Epstein(3) reported a dull satin-like appearance of teeth after cleaning with air abrasives, but noted that the original luster could be restored by polishing with a rubber cup. He also reported that the natural luster would return in approximately three days even if the enamel were not polished after Airdent prophylaxis.

White and Peyton(5) also evaluated the effect of the Airdent on polished enamel surfaces. They agreed that time of exposure and distance of the tip from the tooth surface were very important factors in the effect produced. They found that the Airdent caused a loss of luster of the enamel surface but that this could be restored with rubber cup polishing. Their study concluded that both of these procedures caused loss of enamel from the surface and suggested that this loss could be as much as 30 um. They expressed concern that enamel loss could eventually become so great that no protection would be afforded the dentin.

Newman, Silverwood and Dolby(13) conducted a study in which teeth were exposed to the Prophy-Jet spray for times varying from ten seconds to five minutes. They used both stationary and moving tips. They reported that changes in the enamel appeared minimal but that the lamellae became more prominent.

Some studies have shown that the effect of air polishing is not the same when applied to the natural surface of enamel as it is when applied to ground and polished enamel surfaces. The ground and polished surfaces are created as a convenience to facilitate the use of instrumentation available for evaluation of roughness.

Willmann, Norling, and Johnson(7) found that the Prophy-Jet produced a non-uniform roughening or pitting of enamel when applied to polished enamel surfaces. They reported, however, that this was not so apparent on natural enamel.

Gwinnett(8) reported a similar appearance of enamel surfaces cleaned with the Prophy-Jet and with a rubber cup. Clinical Research Associates(12) reported "little alteration" of the surface of enamel or dentin after prophylaxis with the Prophy-Jet. They obtained their measurements using a scanning electron microscope (SEM),

light microscopy, and visual examination. Garnick(10) believed that the Prophy-Jet left "a clinically more acceptable enamel surface," but did not describe on what basis.

Boyde(6) noted that sound surface enamel was not abraded by the Prophy-Jet but that all cut, fractured, chiseled, abraded or polished enamel surfaces were eroded by the procedure. He noted, however, that on polished surfaces, the enamel nearest the dentinoenamel junction was more resistant to abrasion. His explanation for this observation was that since sodium bicarbonate is a soft material, it was not true abrasion that resulted in the removal of enamel but rather the high velocity particles that imparted kinetic energy to the enamel. Thus, enamel on the edge of any defect could be dislodged in microscopic amounts. This being the case, enamel exposed to the oral environment could have such defects or discontinuities occluded by a natural maturation-mineralization phenomenon such that removal of tissue fragments at the discontinuity would no longer occur. This observation caused him concern that the use of the Prophy-Jet following hand scaling could cause more enamel removal since the scaling could remove some of the prism-free enamel and induce small fractures

parallel with the perikymata. These fractures would result in weaknesses where the enamel could be removed.

Effects on Dentin

Since the Prophy-Jet is designed primarily for use on enamel surfaces, much less work has been done to evaluate the effect it may produce upon dentin or cementum. Some information, however, is available and is of great interest since a patient may have experienced gingival recession or abrasion, exposing either of these tissues to the oral environment.

Clinical Research Associates(12) reported little alteration of dentin surfaces by the Prophy-Jet. Boyde(6), on the other hand, found dentin to be subject to rapid erosion by air polishing. He reported that the Prophy-Jet also removed the smear layer and that carious dentin was removed more rapidly than sound dentin. He suggested that this result indicated a possibility of using the technique in the caries removal step of cavity preparation. The Instruction Manual(14) supplied with the Prophy-Jet recommends that it not be used for prolonged periods on dentin.

Atkinson, Cobb, and Killoy(15) and Atkinson(16) reported a study in which they intentionally exposed root surfaces to Prophy-Jet treatment for 30 seconds at an angle of 90 degrees to the tooth surface and a distance of 4 mm. They suggested that this exposure was similar to that which would be experienced by a patient receiving a Prophy-Jet treatment every three months for 15 years. They found that the average depth of penetration of the surface was 0.6366 mm. They acknowledged, however, that exposed root surfaces became hypermineralized and that in the time between appointments they might become more resistant to this form of abrasion. They noted that the exposed dentin exhibited a lack of open tubules and speculated that this might be caused by occlusion or obliteration of the tubules by the slurry. They suggested that this effect might be the reason for decreased sensitivity of root surfaces noted in teeth treated by this technique.

In a study using a similar type of exposure, Newman, Silverwood and Dolby(13) reported apparent loss of dentin as seen in SEM photographs.

Effects on Cementum

The Instruction Manual(14) supplied with the Prophy-Jet suggests not using the instrument on cementum for prolonged periods. Boyde(6) noted rapid removal of cementum using the Prophy-Jet. He reported that the removal approached 160 um. per minute when the tip was moved continuously. He found that one could easily remove cementum to expose the underlying dentin which was identifiable by the presence of exposed tubules. He recommended extreme caution in using the instrument near the cervical area of the tooth.

Newman, Silverwood and Dolby(13) likewise noted significant loss of cementum following Prophy-Jet treatment. They suggested that use of this technique, rather than scaling, for removing diseased cementum would be difficult to support.

Petersson et al.(17) reported an experiment done on the roots of extracted teeth in which they masked out some areas and exposed other areas to the spray for 30 seconds. They found an abrasive removal of root surface reaching 25 um.

Atkinson, Cobb, and Killoy(15) and Atkinson(16) reported that root surfaces carefully prepared with the Prophy-Jet were shiny and uniformly smooth. They used a

brush stroke and obtained a surface which they described as smooth and devoid of residue and soft tissue debris. Atkinson(16) thought the surface was too smooth to expect reattachment of soft tissue under a surgical wound but suggested that an application of citric acid could perhaps remedy this situation.

Effects on Restorative Materials

Since it is impossible to perform a prophylaxis without bringing the polishing agent into contact with dental restorations, it is certainly of interest to discover what effect a polishing agent may have upon these materials. Epstein(3) studied the effect of the Airdent upon materials and reported that metal restorations were abraded only slowly by the aluminum oxide abrasive powder.

The Instruction Manual(14) supplied with the Prophy-Jet indicates that the instrument will leave a mat finish on polished metal restorations. Boyde(6) reported this finding to be correct.

Clinical Research Associates(12) observed SEM photographs and suggested that the Prophy-Jet roughened surfaces of some restorative materials. They also reported finding the mat finish on polished metal restorations. They

suggested that severe damage can occur on resins, gold foil, and cast gold restorations and recommended that the instrument be confined to use on tooth surfaces only. They do not offer the evidence upon which they based this recommendation.

Gwinnett(19) compared the effects of the Prophy-Jet with a prophylaxis performed with a rubber cup and a slurry of pumice upon restorations of both microfilled composite and a conventional composite restorative materials. The teeth and restorations were stained with tea and then cleaned using the two methods on contralateral segments. He concluded that both the Prophy-Jet and the rubber cup selectively removed some of the resin matrix of the restorations. He stated that the loss of material was not measurable but believed that it appeared comparable for both methods. Both methods caused a loss of luster of the restoration but this was easily restored by refinishing with disks. Prophy-Jet action produced numerous micro-pits in the surfaces and exposed porosities in the material. Polishing with pumice resulted in numerous surface scratches and also exposed porosities in the material. He concluded that the loss of material was minimal since SEM examination after the prophylaxis revealed many of the original surface

particles remaining. They were identifiable by the flattened sides of the particles where they had been finished originally. He stated that, in his opinion, it was not necessary to add any additional material to these restorations following prophylaxis with either method.

Cooley, Lubow and Young(20) reported a study on the effects of the Prophy-Jet on ten different materials. They found a statistically significant increase in roughness in seven of the ten materials after treatment. Only porcelain materials and unpolished amalgam did not follow this pattern. They concluded that the composites showed, by far, the greatest change in roughness and suggested that repolishing of these materials after Prophy-Jet prophylaxis might be indicated.

Effects on Gingival Tissue

It is difficult to imagine that an operator could use an air abrasive on the teeth without some of the material contacting gingival tissues. It is, therefore, of great interest to review what effect these abrasives may have on these soft tissues.

Norton(4), in describing the Airdent, reported that since the soft tissues of the mouth are more resilient than

the teeth, they suffer little or no damage from the procedure. Epstein(3) noted that the Airdent produced a "stippling" effect on the gingiva.

Barnes and Holroyd(11) found no significant difference in soft tissue trauma produced by the Prophy-Jet when compared to rubber cup prophylaxis. They reported that the evidence of trauma after Prophy-Jet treatment consisted of small clots at the margin whereas the rubber cup produced small areas of gingival abrasion. They noted that increasing the time spent to perform the prophylaxis with the Prophy-Jet decreased the resulting trauma. No such correlation was found with the rubber cup. Garnick, Flinn and Hardin(10) found no difference in soft tissue trauma between the Prophy-Jet and the rubber cup.

Clinical Research Associates(12) reported no significant histological changes in soft tissues on a dog model when the Prophy-Jet was used according to manufacturer's instructions. They did find, however, that improper use could damage the oral tissues.

In the study by Newman, Silverwood, and Dolby(13), the skin of a rabbit was exposed to the Prophy-Jet spray and, following sacrifice of the animal, the oral mucosa was also exposed. They found that a 60 second exposure could

perforate the skin and that a ten second exposure of the oral mucosa could abrade the outer epithelial layers.

Offenbacher, Schweinebratin, and Armstrong(18) used a split mouth method of prophylaxes on 24 patients and evaluated gingival response immediately before, immediately following, and six days following treatment. They found gingival abrasion on two percent of the sites treated with rubber cup prophylaxis and on ten percent of the sites treated with the Prophy-Jet. They reported that no gingival site received severe abrasion from either method. All sites returned to normal by the sixth day following prophylaxis. Both methods resulted in an immediate increase in the number of sites which bled upon probing and an increase in pocket depth. No significant difference was found between the two methods. They also noted that the Prophy-Jet produced a significant decrease in subgingival bacterial counts whereas a rubber cup prophylaxis did not. They concluded that the Prophy-Jet was significantly better at removing subgingival plaque.

Baer(21) treated 20 patients with the Prophy-Jet on one side of the mouth and with rubber cup prophylaxis on the other side. His study showed that the Prophy-Jet was slightly more traumatic initially and resulted in slight

gingival bleeding following its use. This bleeding, however, stopped within one minute. The gingiva returned to its prior state of health within one week. Neither method resulted in patient complaints of soreness, pain, or tooth sensitivity.

Gwinnett(9) believed that the Prophy-Jet was more traumatic to the gingiva than a rubber cup and paste. He noted, however, that proper use of the Prophy-Jet could minimize trauma and that the Prophy-Jet produced no clinical symptoms or long term adverse effects. He recommended that the tip be angled away from the gingiva during its use.

Weeks-Dyvbigh(22) studied the effects of the Prophy-Jet compared to the rubber cup and evaluated the amount of trauma produced. She reported that the Prophy-Jet produced more gingival trauma but that it had healed six days after treatment. She felt that, considering the advantages, the Prophy-Jet might be the preferred treatment, especially for orthodontic patients.

Mishkin et al.(23) compared the gingival effects of the Prophy-Jet with those of rubber cup prophylaxis and found no statistical difference between the two in the amount of trauma produced except on facial surfaces evaluated immediately following treatment. In these locations, they

found that the Prophy-Jet caused slightly greater trauma but noted that at seven days following treatment, the difference no longer existed. They showed that neither method caused much tissue damage.

The Instruction Manual(14) supplied with the Prophy-Jet recommends that prolonged use on the soft tissue be avoided. They also advise against directing the tip into the sulcus.

Abrasiveness of Powder

Evaluation of the effect of air abrasives on tooth structure mandates a consideration of the qualities of the abrasive agent. The abrasive powder used in the Airdent was mainly aluminum oxide. Epstein(3) reported that this powder would scratch mirrors rapidly and would also scratch eyeglasses if they were not properly cleaned by rinsing before wiping. In a search for a less abrasive but still effective agent, Stoll and Werner(24) suggested the use of recrystallized kaolinite as a prophylaxis paste. They postulated that because of its fine particle size, 0.1 um. as opposed to 3 um. for pumice, it would produce less scratching of enamel than pumice.

Lehne and Winston(25) compared several commercial dentifrices to sodium bicarbonate and found the bicarbonate

to be the least abrasive of any available. According to Atkinson, Cobb and Killoy(15), the abrasive agent used in the Prophy-Jet is sodium bicarbonate treated with tribasic calcium phosphate. They reported that the powder is specially sifted to eliminate large particles. They described them as "crystal shaped" with sharply pointed edges. Barnes and Holroyd(11) further described the sifting, stating that the powder is passed through a 200 mesh screen, eliminating all particles over 74 um. in size.

Boyde(6) noted that sodium bicarbonate is neither hard, nor sharp, and suggested that abrasion of enamel by the Prophy-Jet occurred as the particles impart energy to the enamel as previously described. Ginzler(26) reported that Prophy-Jet Powder-1 (Dentsply/Cavitron) had a higher cleaning factor when used in the Prophy-Jet than did pumice in a rubber cup. Its abrasiveness on dentin was approximately equal to that of pumice but was much lower than pumice on enamel.

Toxicity of Air Abrasive Agents

The concern over the possible toxicity of air abrasives is of interest from two aspects. One is the possible effect the agent might have on the patient and the other is the

potential effect on the dental care delivery team. An additional concern is the general deposition of the dust throughout the operatory and onto work surfaces and other instruments. This latter concern is not within the objectives of this review.

Investigators became interested in the use of the aluminum oxide in the Airdent. Van Leeuwen and Rossano(27) performed dust counts in the dental operatory where an Airdent was in use. They found that dust counts of the aluminum oxide abrasive were below the then recommended industrial maximum of 50 million particles per cubic foot (MPPCF) in both the dentist's breathing zone and in the operatory in general. By making some modifications in the apparatus of the Airdent and by modifying the method of rubber dam application, they were able to decrease average concentration in the breathing zone from 20 to 6.4 MPPCF.

Kerr, Ramfjord, and Grape-Ramfjord(28) studied the toxicity of the abrasive used in the Airdent by injecting samples into the peritoneum of guinea pigs. They found a mildly proliferative response resulted. They also noted that powdered enamel and dentin, which could possibly be a problem, since aerosols of these two substances were created by the abrasive action, initiated a resorptive response with

an associated slight fibrosis. Based on this study, they concluded that it was probably unwise to inhale these agents. They suggested that the dental team wear protective masks.

In another study on the Airdent abrasive, Kerr, Ramfjord, and Grape-Ramfjord(29) exposed animals to the inhalation of the agent in a dusting chamber which they had devised. Necropsies on the animals revealed that inhaling large quantities of the dust could reduce vital capacity considerably. The microscopic changes found were not characterized by fibrosis, indicating that the powder had a low degree of toxicity. They concluded that because of the periodic and slight nature of their exposure, the powder did not pose a health hazard to dentists or patients. They did, however, recommend making the powder silica-free and suggested removal of any particles smaller than three to five um.

As noted in the section of this report entitled "Abrasive of Powder," the agent used in the Prophy-Jet consisted mainly of sodium bicarbonate. The warning in the Instruction Manual(14) supplied with the Prophy-Jet suggested that the instrument not be used on patients wearing contact lenses, patients with severe respiratory

illness, or patients on a sodium restricted diet. The implication was that these conditions could be aggravated by exposure to the dust.

Gwinnett(9) reported that the Prophy-Jet created a clean-up problem on the patient's face and surrounding equipment. He felt this became less of a problem as operators gained experience and as they followed the manufacturer's instructions more closely. He suggested that patients on sodium restricted diets should not be treated with the Prophy-Jet because inadvertent ingestion of the powder might result in elevated sodium levels. He recommended the use of a protective mask and glasses for the operator.

Clinical Research Associates(12) reported that the Prophy-Jet generated an airborne sodium bicarbonate aerosol which resulted in widespread deposition of gritty debris on patients, operator, and throughout the operatory. They also suggested the use of a protective mask and glasses.

The use of masks and protective eyewear was also advocated by Glenwright, Knibbs and Burdon(30). Their study reported that the Prophy-Jet created a bacteria and powder laden aerosol. In addition to the use of masks and eyewear, they recommended using more efficient suction equipment,

gloves or finger cots for the operator and a reduced water volume in the spray.

Studies presently reported suggest that the Prophy-Jet powder is not toxic. Barnes and Holroyd(11) measured the blood pressure of patients before and after prophylaxis using the Prophy-Jet and found no increase in blood pressure following the procedure. Casey(31) tube-fed 15 grams of a mixture containing 30 percent by weight of the Prophy-Jet abrasive to experimental animals and found no significant resulting pathology. In another study(32) Casey found no mucosal irritation or histologic abnormality resulting from exposure of the cheek pouches of hamsters to the Prophy-Jet powder.

Rawson, et al.(33) reported a study done on one healthy subject in which blood samples taken before and after a Prophy-Jet prophylaxis showed an increase in pH to a marginal alkalotic state. They did not suggest the conclusion that the sodium bicarbonate in the Prophy-Jet powder was the cause but suggested that further study is warranted before the instrument is used on patients in whom this would represent a hazard.

Prophy-Jet vs Rubber Cup Prophylaxis

Since the majority of prophylaxes are performed by the traditional method of a rubber cup with some sort of mild abrasive, a comparison of the air abrasive procedure with the traditional method is of considerable interest.

Bailey and Phillips(2) found that they could remove 3 to 106 um. of enamel with the Airdent but only 4 um. with the rubber cup and pumice. They discovered that the air abrasive caused a rather even removal over the surface whereas the rubber cup produced scratches, rather than a general leveling of the surface. Using reflected light measured by a photometer, they found that the Airdent treatment caused four times as much loss of luster on enamel as did the rubber cup. They also found that ten seconds of polishing with levigated alumina could restore either surface to its original luster. The rubber cup produced a scratched surface whereas the Airdent produced general removal of enamel and left a pitted surface.

Epstein(3) reported that a hygienist could perform scaling and polishing as rapidly using conventional methods as could an operator using air abrasive techniques.

Willmann, Norling, and Johnson(7) reported that the Prophy-Jet more effectively removed extrinsic stain. They compared rubber cup methods with air polishing and ultrasonic cleaning. They found shallow curved scratches from the rubber cup but a non-uniformly roughened (or pitted) surface from the Prophy-Jet. Using a profilometer, they found that the Prophy-Jet produced the greatest variation in surface roughness. It produced both the smoothest and the roughest specimen in their study.

Gwinnett(9) stated that the Prophy-Jet and the rubber cup prophylaxis were equivalent in effectiveness on smooth enamel surfaces but he concluded that the Prophy-Jet was better for pits and fissures and also for interproximal areas. He used a questionnaire to determine patient opinion of the two methods of treatment and discovered that some preferred one method and some the other. The main complaints against the Prophy-Jet were taste, lack of neatness, and cold sensation on the teeth.

In another study, Gwinnett(8) reported that the Prophy-Jet and the rubber cup prophylaxis were equally effective on smooth enamel surfaces but that the Prophy-Jet was better for pits and fissures. He section a tooth upon which both methods had been used and found much less

remaining debris in the area cleaned with the Prophy-Jet. He noted that the enamel surfaces appeared similar following prophylaxis with either method.

Barnes and Holroyd(11) performed prophylaxes on 30 patients and compared the efficiency of the rubber cup with the Prophy-Jet. They found that the time needed to reduce plaque to zero level with the Prophy-Jet (mean 5.4 minutes) was less than half that (mean 13.4 minutes) needed with a rubber cup. They determined that for comfort, 53 percent of the patients preferred the Prophy-Jet, 26 percent had no preference, and 21 percent preferred the rubber cup. For taste, however, 21 percent preferred the Prophy-Jet, 33 percent had no preference, and 46 percent preferred the rubber cup. When asked which technique they felt was the neater, 13 percent rated the Prophy-Jet neater, 46 percent saw no difference, and 41 percent stated that they thought the rubber cup was neater.

After treating 140 patients with stain, Clinical Research Associates(12) reported that 94 percent preferred the Prophy-Jet over hand or ultrasonic cleaning. They stated that patients thought the stain removal was more thorough with the Prophy-Jet. Their findings also suggested that the Prophy-Jet cleaned sensitive areas with less

discomfort to the patient. They stated that the Prophy Jet was far better for prophylaxis on orthodontic patients and caused no significant damage to wires or brackets. They recommended the Prophy-Jet for cleaning of occlusal pits and fissures prior to placement of a sealant, however, they acknowledged that the effect of the abrasive agent on the sealant was unknown. They believed that the lack of tactile sensation to the operator was a disadvantage of the Prophy-Jet and noted that several weeks of training were required to acquire proficiency. They said that patients reported not caring for the taste experienced with the Prophy-Jet and reported mild discomfort or a "prickly" sensation when the spray was directed against soft tissue.

The Instruction Manual(14) provided with the Prophy-Jet recommends cupping of the lips, rather than retracting, to control the spread of the abrasive outside the oral cavity. Because of the deliterious effect upon the surface of mouth mirrors, they recommend the use of direct vision. They instruct that the spray should be directed at the middle third of the tooth and that the edge of the spray will clean near the gingiva. The operator is instructed to direct the spray at 80 degrees to the gingiva on posterior teeth and at 60 degrees to the gingiva on the anterior teeth. A quick,

sweeping motion in areas of soft tissue is suggested. They counsel that the operator should wear a protective mask.

Effect of Surface Roughness on Plaque Accumulation

Since prophylaxis can alter the surface roughness of teeth and restorative materials, it is of interest to examine what effect, if any, these alterations may have on the ability of the surface to accumulate dental plaque.

Mathis, Hylin, and Henry(34) reported that polished occlusal amalgam restorations on mandibular permanent first molars were not statistically less plaque retentive than were unpolished ones. The implication was that smooth surfaces were no less plaque retentive than rough surfaces. Their measurements were made approximately 48 hours after placement of the restorations.

Other investigators, however, have found contrasting results. Waerhaug(35) stated that a rough tooth surface facilitates the retention of bacterial plaque. Schwartz and Phillips(36) found that bacteria accumulated to a greater degree per unit of time on a rough, abraded enamel surface than on a highly polished one. They also found that bacteria were retained in greater numbers on the roughened surfaces even after vigorous brushing.

Similar results were found by Gildenhuis and Staller(37) and Keenan et al.(38) who reported that significantly more plaque accumulated on roughened surfaces of dental restorations than on smooth surfaces. They both suggested that through maintenance procedures, such as routine prophylaxis or diligent brushing, the surfaces of polished restorations could become rougher and could, therefore, become more plaque retentive.

Methods for Measuring Smoothness

Since many investigators include in their studies reports on the smoothness of tooth surfaces or restored surfaces, a consideration of the different methods used to arrive at a determination of smoothness is in order.

Bailey and Phillips(2) used reflected light and microscope focusing to determine the amount of enamel lost from specimens.

Reinhardt et al.(39) reported using three different methods for determining smoothness of restorations fabricated from composite resins. These were surface profile measurements with a profilometer, viewing with a SEM, and using a video analyzer to measure the brightness of light reflected from the surface of the restoration.

Charbeneau(40) used a Profilometer to measure surface roughness of amalgams which had received different degrees of polishing.

Walker and Ash(41), Boyde(6), Petersson et al.(17), Newman, Silverwood and Dolby(13), and Gwinnett(19) all reported using SEM photographs to make evaluations of smoothness.

Creaven, Dennison and Charbeneau(42) used a surfanalyzer to obtain surface profile tracings of restorations. The arithmetic average roughness (in um.) was recorded and an average maximum peak height roughness was calculated from the tracings. They found a high correlation between these two indicators of roughness.

Petersson et al.(17) also used roughness tracings on ground and polished root surfaces to determine the amount of tooth structure lost during Prophy-Jet treatment.

Models for Evaluation of Plaque Formation

In order to study the effects of the type of prophylaxis treatment on retention of plaque on a surface, a model is needed. Various methods have been suggested which could be considered for models.

Schwartz and Phillips(36) used a system of immersing plaque contaminated teeth in a culture medium and subsequently plating to evaluate the amount of plaque on the enamel surfaces. Mathis, Hylin, and Henry(34) studied plaque retention using a method of making an impression of the teeth and then pouring this impression with culture medium. They were then able to incubate the model and observe where the bacterial colonies were most numerous. Gildenhuys and Stallar(37) used SEM photographs to evaluate the extent of plaque formation.

Keenan et al.(38) described a quantitative system of evaluating plaque accumulation on surfaces of teeth. They embedded samples to be studied in acrylic lingual appliances and exposed them to plaque formation in the mouth. They then dyed each sample to be studied using a disclosing dye having no antimicrobial activity. Following this staining, they took color transparency photographs of each surface. These transparencies were then projected onto paper and tracings made of the area covered with plaque. A compensating polar planimeter was then used to measure the stained surface area and the total surface area of the sample. Using such a process, they were able to determine actual percentages of the surfaces covered with plaque.

Lang et al.(43) used a removable carrier which could be placed in the lingual flanges of lower dentures. These carriers held samples which were being tested for plaque accumulation.

METHODS AND MATERIALS

Sample Preparation

Ten samples were prepared from each of six different materials (Table 1) which were chosen as representative of restorative materials commonly found in the mouth. Samples were prepared approximately 15 mm long, 5 mm wide and 1 to 2 mm thick.

A mold was made from Plexiglas for preparation of the samples of materials 1 through 4. A tapered cavity with a face of 5 X 15 mm was cut through one sheet of 3/16 inch Plexiglas. This was then clamped against a second sheet with "C" clamps. The materials were condensed or compressed into the cavity. When set, the sheets were separated and the sample was removed. The surface to be tested was thereby prepared against a smooth surface of Plexiglas. All materials were prepared according to manufacturer's instructions.

The Tytin (TY) was triturated for seven seconds in a Vari-Mix III amalgamator (L. D. Caulk Co., Div. of Dentsply Int'l. Inc.) at the "M" setting. It was then hand-condensed into the mold, carved level with the mold surface, and allowed to set for ten minutes before removal. After 24

Table 1: Materials

Material	Manufacturer	Batch
1. Tytin Fast Set, 600 mg Whitecaps	S. S. White Co.	3608206
2. Prisma Fil shade-light	Caulk/Dentsply	mfg. date 012182
3. Silux no. 5502 YB	3M Corp.	2A12
4. G C Fuji Ionomer Type II (Aset) shades 21,22 & 23	G. C. Dental Industrial Corp.	290351 shade 21 050451 shade 22 060451 shade 23 220451 liquid 120451 varnish
5. Micro Fine 820 Type II, medium hard gold	Pennwalt- Jelenko	1018349
6. Vita VMK 68, #558 (incisal)	Degudent	414

hours, the samples were ground flat on a standard metallographic wheel to 600 grit silicon carbide abrasive so as to obtain as flat a surface as possible for profile tracing. Following the grinding, the samples were polished to a clinical polish using XXX silex and tin oxide in a webbed rubber prophylaxis cup.

The Prisma Fil (PF) was pressed into the lubricated mold, covered with a transparent plastic matrix strip, and cured with a Command visible light curing light, (Sybron/Kerr) with the large (9 mm.) tip wand. The exposure time used was 20 seconds. The wand was placed directly on the matrix strip or the Plexiglas and the samples were cured from both sides. The wand was stepped from one area to another to cover the entire sample. Three exposures were needed to cover each side. After removal from the mold, the surface of the samples was ground flat on a metallographic polishing wheel in successively finer grits up to 600 grit silicon carbide paper. The resulting surface has been shown by Dennison and Craig(44) to give an equivalent finish to the fine polishing discs normally used clinically.

The Silux (SI) was prepared in the same manner as the Prisma Fil.

The glass ionomer (GI) was prepared by mixing six scoops of powder with six drops of liquid and pressing the mix into the lubricated mold under a transparent plastic matrix strip. At the time specified in the directions (90 seconds from start of mix) the matrix strip was removed and the varnish applied. The material was then allowed to set 15 minutes from the start of the mix, whereupon, it was removed from the mold and all surfaces were covered with the varnish.

The gold samples (Au) were prepared by fabricating and casting wax patterns. Pink baseplate wax was cut into 5 X 15 mm. pieces. These were sprued with #12 wax sprues and vacuum invested in Luster Cast Investment (Sybron/Kerr) using a water/powder ratio of 16 ml. distilled water to 50 gm. powder. The investment was burned out at 900 F for 60 minutes and castings were made using a Kerr broken arm casting machine and a natural gas/air blowpipe flame. The samples were bench-cooled for five minutes and then quenched in water. They were then deflasked, sprues cut off, and finished flat to 600 grit silicon carbide paper on a metallographic wheel as previously described. Following the flattening, the samples were given a clinical polish using Tripoli (William Dixon Co.) and rouge on a ragwheel.

The porcelain (PC) was condensed as a water/powder slurry into a mold approximately 5 X 15 X 1.5 mm. in dimensions. The samples were then extruded from the mold, dried and fired from 1000 to 1760 F under a vacuum of 24 in. Hg. After cooling, the samples were flattened on the metallographic polishing wheel to 600 grit silicon carbide and were then reglazed to a natural glaze at 1760 F.

All samples were stored until needed in room temperature distilled water which was changed three times weekly. They were kept in the distilled water both before and after testing.

Experimental Treatment

In preparation for performing the experimental treatments to the materials, the middle one-third of each sample was masked out with cellophane tape. A five-second treatment with prophylaxis paste in a rubber cup was done on one end of the sample and a five-second treatment with the Prophy-Jet was done on the other end. Both treatments were done with hand-held handpieces to simulate actual clinical procedures. The center of the sample was left untreated in its clinically polished condition as a control.

The rubber cup prophylaxis treatment was done using a webbed rubber cup and NuPro Prophylaxis Paste, medium grit (Junar Co., Inc. a Johnson & Johnson company) lot 4C3656, in an air driven low speed prophylaxis handpiece. This material is the one used in the Dental Hygiene Clinics of the School of Dentistry of The University of Michigan.

The Prophy-Jet treatment was done with the Prophy-Jet C-300 (Dentsply/Cavitron). Input water pressure was 30 psi and input air pressure was 62 psi. Prophy-Jet Powder 1 (Dentsply/Cavitron) was the abrasive used. The water and the powder controls were set midway between the high and the low settings. The instrument tip was held approximately 5 mm from the surface of the samples and at an angle of approximately 80 degrees to the surface as recommended by the manufacturer. During the treatment, the tip was kept constantly in motion.

Treatments were timed using a stop watch. All treatments were performed by the same operator for standarization. Immediately following the treatments, the tape was removed from the middle section and the samples were returned to storage in distilled water.

Measurement of Surface Roughness

The roughness of each area of the samples was obtained from a surface profile tracing which was performed on each sample using the Gould Surfanalyzer 150 (Clevite Corp.). The tracings obtained permitted the comparison of the change in roughness produced by each of the experimental treatments. The cutoff was set at 2.5 mm. for 0.254 mm./sec., the rate of stylus travel at 0.01 mm. per second, and chart speed at 1 mm. per second, which resulted in chart travel of 10 um./division. Magnification was set as high as possible while still keeping the tracing within the space on the paper. The magnification setting was 0.1 um. per division for profile and 0.02 um. per division for arithmetic average roughness whenever possible. Some of the samples were too rough to use this setting so controls were set at a lower magnification as required. When possible, a single tracing was done over the entire length of the sample, obtaining measurements for both treatments and the control in one pass. Frequently, however, the treatments had altered the flatness of the sample sufficiently that this could not be done at the desired magnification. In

these instances, the sample was leveled individually for each of the three areas.

The tracings were analyzed for two different values in a manner similar to that used by Creaven, Dennison and Charbeneau(42). The arithmetic average roughness is a reading produced electronically by the machine and is continuously recorded on the chart. To obtain the most representative figure, a reading was taken every 10 cm. along the magnified paper tracing and the values averaged. This average value was recorded as the value for the entire area of the sample being scanned (such as one of the treatment areas or the control). The average maximum peak height roughness was determined by measuring the highest peak on the profile tracing within a two centimeter length immediately preceding the point at which each arithmetic average reading was taken. These values were also averaged and the average recorded as the value for the entire area.

Plaque Accumulation

In order to evaluate their plaque accumulation potential, the samples were attached to an appliance which was worn in the mouth and plaque was allowed to form. Two samples were worn at a time, one on each lingual flange of

the appliance. All samples were worn by the same individual in order to standardize conditions.

The lingual appliance was fabricated of clear, self-curing acrylic (Perm Rebase Repair Acrylic - Clear, The Hygienic Dental Mfg. Co.). It covered the lingual aspect of the mandibular teeth and extended into the lingual sulcus, much like a denture flange. The samples were attached to the lingual flanges using sticky wax and the appliance was then worn in the mouth for 48 hours. No dietary restrictions were observed by the investigator wearing the appliance. The appliance was removed to perform personal oral hygiene and the mouth was then rinsed thoroughly with water so as to remove as much of the oral care materials as possible before reinsertion. The aspect of the appliance which was against the teeth and tissues was brushed with plain water twice daily but the side bearing the samples was left uncleansed. Care was exercised to avoid touching surfaces of the sample with the fingers during insertion or removal of the appliance.

The positioning of samples for each material was alternated from the right to the left side so an equal number were worn on each side. The orientation was also alternated so that half the samples had the Prophy-Jet

treated end placed anterior and half had the rubber cup treated end anterior. This was done to minimize the influence of position of wear on the accumulation of plaque. The material of the samples was also varied so that no one material was always worn with the same other material. Each of the samples was worn with samples of all the other materials.

After the 48 hour wear period, the samples were stained with Trace 28 Dental Disclosing Agent (Lorvic Corp.), lot T001. The solution was placed on the samples and allowed to remain approximately five seconds. They were then rinsed in cold running tap water for another five seconds and dried under a gentle stream of air. Color transparencies were then exposed with an intraoral camera using a macro lens at a 1:1 magnification. Two or more exposures were made of each sample and the two best slides selected for the data set.

Plaque Evaluation

A panel of three individuals from the thesis committee was selected to perform the evaluation of the amount of plaque accumulated on the different areas of the samples. The color slides were projected and the evaluators ranked

the areas of the sample giving them the ranks of 1, 2, or 3 with 1 being the most plaque and 3 the least. In order to prevent a bias in their decisions, the evaluators were not advised of the material nor of the location of the different experimental treatments. The evaluators calibrated and standardized their grading on a random series of pictures taken from the data set. During the evaluation, each evaluator would mark his own score independently then all would compare their choices. If they were not unanimous in their choice, they would discuss the sample, reaching a consensus. This evaluation resulted in a list of data which compared the relative plaque accumulation on the control and experimental areas of the individual samples. On some samples, no difference could be discerned between the plaque accumulations of the different treatment areas. In these instances, a rating of "U" was given indicating "undecided." In the event that no distinction could be made among any of the three areas, three U's were given. In some instances, however, no difference could be discerned between two of the areas but the two were noticeably different from the third. On these samples, the two like areas were rated U but were differentiated from the third. For example, a rating of U,U,1 indicated no difference could be detected between the

two but that they both had less plaque than the area marked 1. Likewise, a rating of U,U,3 indicated that the undecided areas had more plaque than the area rated 3. A rating of U,U,2 was not possible with this evaluation system.

A second series of evaluations were then performed in which four samples varying in plaque accumulation from heavy to very light were used as standards. The evaluators then compared the two experimental ends of the samples to these standards and rated them. Since a sample might not match one of the standards, evaluators were allowed to mark each as falling between two of the standards or outside the high and low. With four standards, this resulted in nine possible ratings. The standards were listed as values 1, 2, 3, and 4, with 1 having the heaviest and 4 the lightest accumulation of plaque. In order to indicate the intermediate values, the raters used the values of 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, and 4.5. As an example, a rating of 2.5 indicated a sample judged to have less plaque than standard 2 but more than standard 3. As before, the evaluators made independent decisions. Differences among the three evaluators were discussed to reach a consensus. Since these evaluations were ratings against a standard, there were no "undecided" values.

Statistical Methods

The paired t test using Scheffe's method for multiple comparison was selected to evaluate the roughness values for the experimental treatment areas on the samples since they were basically a before and after treatment of each sample. Since the different materials represent different treatment groups of materials, analysis of variance was used to compare the roughness.

The ranks in the plaque evaluation represented ordinal values, therefore, non-parametric statistical methods were used to analyze this data. The Wilcoxin signed-rank test with the Bonferroni correction was used to compare the different treatments of the samples. The Kruskal-Wallis test and the median test were used to compare the different materials. The rankings of 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, and 4.5 were converted to whole numbers 1 through 9 respectively to simplify the statistical treatment.

In order to determine the agreement of the evaluators, their initial rankings, those recorded before discussion and reaching a consensus, were subjected to two-way cross tabulation. Such tabulation revealed the percent agreement on the individual samples. In addition, their initial

observations were also tabulated to demonstrate their agreement with each other, stratified by material. This analysis gave some indication of the ease of rating each material.

RESULTS

Surface Roughness

Values for surface roughness obtained from arithmetic average readings of the control and the treatment surfaces are reported in Table 2. Those obtained from average maximum peak height roughness calculations are reported in Table 3. Values reported are averages for all the readings from each material. Sample sizes less than ten are reported because a malfunction of the Surfanalyzer went unnoticed during tracing of 11 of the samples. By the time the error was discovered, the samples in question had already been worn in the mouth for the plaque accumulation phase and it was thought that to repeat the tracings following that step would yield unreliable data.

Table 4 shows the significant differences among the treatment areas and the controls. One of the aims of this study was to compare the surfaces produced by the rubber cup to those left by the Prophy-Jet. While both parts of the table show instances where one treatment or the other differed from the control, the key information was those situations in which the experimental treatments differed.

Table 2: Arithmetic Average Roughness

TY = Tytin, PF = Prisma Fil, SI = Silux, GI = glass ionomer,
Au = gold, PC = porcelain

Mat.	N	Rubber Cup		Control		Prophy-Jet	
		Mean(um.)	S.D.	Mean(um.)	S.D.	Mean(um.)	S.D.
TY	9	0.19	0.09	0.15	0.07	0.19	0.07
PF	8	0.18	0.05	0.14	0.06	0.28	0.04
SI	8	0.16	0.11	0.11	0.07	0.28	0.14
GI	7	0.95	1.18	0.39	0.09	1.66	1.37
Au	8	0.05	0.01	0.04	0.02	0.06	0.02
PC	9	0.12	0.07	0.07	0.02	0.17	0.20

Table 3: Average Maximum Peak Height Roughness

TY = Tytin, PF = Prisma Fil, SI = Silux, GI = glass ionomer,
Au = gold, PC = porcelain

Mat.	N	Rubber Cup		Control		Prophy-Jet	
		Mean(um.)	S.D.	Mean(um.)	S.D.	Mean(um.)	S.D.
TY	9	0.91	0.27	0.65	0.29	1.32	0.74
PF	8	0.95	0.22	0.66	0.29	1.80	0.34
SI	8	0.79	0.34	0.50	0.32	2.05	0.85
GI	7	5.83	6.26	2.71	1.09	6.99	4.39
Au	8	0.43	0.13	0.24	0.13	0.60	0.14
PC	9	0.56	0.36	0.40	0.35	0.46	0.16

Table 4: Roughness Differences Between Treatments

From paired t test using Scheffe's method for multiple comparisons; S = significant difference; P values listed under "S;" TY = Tytin, PF = Prisma Fil, SI = Silux, GI = glass ionomer, Au = gold, PC = porcelain

Arithmetic Average Roughness

	TY	PF	SI	GI	Au	PC	all
RC vs C	S .046						
RC vs PJ		S .0001					
PJ vs C		S .001	S .002	S .04			S .01

Average Maximum Peak Height Roughness

	TY	PF	SI	GI	Au	PC	all
RC vs C					S .01		
RC vs PJ		S <.0001	S .002		S .0002		
PJ vs C	S .04	S .001	S .001	S .03	S .0002		S .0001

When the materials were considered individually, this difference was evident for Prisma Fil under arithmetic average roughness and for Prisma Fil, Silux and gold under average maximum peak height roughness with $P < 0.05$ using the paired t test. If, however, the materials were all considered together, the experimental treatments were not significantly different.

The difference in roughness of the materials is indicated by Table 5. The glass ionomer was shown by analysis of variance for both arithmetic average roughness and for average maximum peak height roughness to be significantly rougher, $P < 0.05$, than all other materials when prepared as a control or treated with the Proply-Jet. With the rubber cup treatment, the roughness of the glass ionomer was significantly greater than all other materials when analyzed by average maximum peak height roughness, but only greater than gold and porcelain when analyzed by arithmetic average values. In evaluating surfaces treated with the rubber cup using arithmetic average roughness, there was no significant difference in roughness between glass ionomer and either amalgam, Silux or Prisma Fil. The only other significant roughness was that among the control areas of Tytin, gold and porcelain. Reviewing the roughness

Table 5: Roughness Differences Between Materials

From analysis of variance; S = significant difference; P values listed under "S;" TY = Tytin, PF = Prisma Fil, SI = Silux, GI = glass ionomer, Au = gold, PC = porcelain

	Arithmetic Average * Roughness			*	Average Maximum Peak Height Roughness		
	RC	C	PJ		RC	C	PJ
TY vs PF				*			
TY vs SI				*			
TY vs GI		S <.0001	S <.0001	* *	S .0002	S <.0001	S <.0001
TY vs Au		S .001		* *			
TY vs PC		S .01		* *			
PF vs SI				*			
PF vs GI		S <.0001	S <.0001	* *	S .0002	S <.0001	S <.0001
PF vs Au				*			
PF vs PC				*			
SI vs GI		S <.0001	S <.0001	* *	S .0002	S <.0001	S <.0001
SI vs Au				*			
SI vs PC				*			
GI vs Au	S .0003	S <.0001	S <.0001	* *	S .0001	S <.0001	S <.0001
GI vs PC	S .001	S <.0001	S <.0001	* *	S .0001	S <.0001	S <.0001
Au vs PC				*			

data in Tables 2 and 3 shows that both treatments increased the roughness of the experimental areas over the control but that this increase sometimes did not always achieve statistical significance. The porcelain was altered the least (no significant change in roughness) by either procedure. The glass ionomer was the roughest at the start and was also altered the most by both procedures.

Plaque Accumulation

The difference in plaque accumulation among the experimental surfaces and the control are indicated in Table 6. The two experimental treatments produced no significantly different plaque accumulations. The only significant difference found was between the control surfaces and the Prophy-Jet treated surfaces of Silux and the glass ionomer.

The evaluation of data on differences in plaque accumulation among materials (Table 7) was done using the Kruskal-Wallis test and the median test. The median test showed that the medians of the materials identified as significantly different (PF, GI, Au & PC) were unevenly distributed around the overall median with Prisma Fil and the glass ionomer skewed to the lower values (greater

Table 6: Difference in Plaque Accumulation Among Treatment Areas and Control

Results from Wilcoxin signed-rank test with Bonferroni correction; line indicates no difference; $P < 0.05$; RC = rubber cup, C = control, PJ = Prophy-Jet; TY = Tytin, PF = Prisma Fil, SI = Silux, GI = glass ionomer, Au = gold, PC = porcelain

Material	TY	PF	SI	GI	Au	PC
C						
RC						
PJ						

Table 7: Difference in Plaque Accumulation Among Materials

Results from Kruskal-Wallis test; * = outliers; TY = Tytin, PF = Prisma Fil, SI = Silux, GI = Glass ionomer, Au = gold, PC = Porcelain

Rubber Cup $P = 0.0492$			Prophy-Jet $P < 0.0001$		
Mat.	Ave. Rank	N	Ave. Rank		
TY	31.900	10	36.250		
PF	32.300	10	23.800 *		
SI	34.350	10	29.100		
GI	14.850 *	10	9.900 *		
Au	39.100 *	10	47.750 *		
PC	30.500	10	36.200		

Results from median test; * = uneven distribution; TY = Tytin, PF = Prisma Fil, SI = Silux, GI = glass ionomer, Au = gold, PC = porcelain

Rubber Cup median=8.00 $P = 0.0483$				Prophy-Jet median=7.00 $P = 0.0022$			
Mat.	N<	N=	N>	N	N<	N=	N>
TY	4	2	4	10	4	1	5
PF	4	1	5	10	6	1	3 *
SI	3	3	4	10	4	2	4
GI	8	1	1 *	10	10	0	0 *
Au	1	4	5 *	10	1	0	9 *
PC	3	4	3	10	3	0	7 *

plaque) and the gold and porcelain skewed to the higher values (less plaque). The Kruskal-Wallis results showed that the average ranks of most of these same materials were "outliers" in the distribution of all the averages. Table 8 displays this information according to significance. It shows that at $P < 0.05$, only the glass ionomer and the gold were significantly different for the rubber cup treatment. Likewise, Prisma Fil, the glass ionomer, the gold and the porcelain differed significantly for the Prophy-Jet surfaces. In that instance, the Prisma Fil and the glass ionomer had higher accumulations of plaque and the gold and porcelain had lower accumulations.

Evaluator Agreement

In order to examine the agreement of the evaluators in ranking plaque accumulation, their initial ratings,

Table 8: Difference of Plaque Accumulation Among Materials

line indicates no difference; $P < 0.05$; RC = rubber cup treatment, PJ = Prophy-Jet treatment; TY = Tytin, PF = Prisma Fil, SI = Silux, GI = glass ionomer, Au = gold, PC = porcelain

Material	GI	PF	SI	TY	PC	Au
RC						
PJ						

recorded before discussing the samples to reach a consensus, were tabulated and subjected to two-way cross tabulation. Table 9 demonstrates their agreement on the initial ranking of plaque accumulation, comparing each treatment group and the control on a given sample. The initial evaluations of the three evaluators agreed an average of 62 percent of the time. At least two of the evaluators agreed 66 percent of the time.

The initial ratings comparing the amount of plaque retained for each treatment group with a ranked set of standards were also tabulated to determine initial agreement of the three evaluators. The results are listed in Table 10 which shows that all agreed 25 percent of the time and at least two agreed 41 percent of the time.

Table 9: Evaluator Agreement: Initial Rating of Difference
in Accumulation on Treatment Areas

RC(%) = agreement on rubber cup treatment surfaces
PJ(%) = agreement on Prophy-Jet treatment surfaces

Evaluators	RC(%)	PJ(%)	All(%)
All agree	52	73	62
1 & 2 agree	67	68	68
1 & 3 agree	60	62	61
2 & 3 agree	75	62	68
Average of pairs	67	64	66
All disagree	3	0	2

Table 10: Evaluator Agreement: Initial Rating of
Comparison to Standards

TY = Tytin, PF = Prisma Fil, SI = Silux, GI = glass ionomer,
Au = gold, PC = porcelain

Evaluators	Materials (%)						
	TY	PF	SI	GI	Au	PC	All
All agree	30	20	10	10	50	30	25
1 & 2 agree	50	30	30	30	70	60	45
1 & 3 agree	50	50	10	20	50	70	37
2 & 3 agree	30	30	50	30	70	30	40
Average of pairs	43	37	30	27	63	53	41
All disagree	30	30	30	40	10	30	28

DISCUSSION

Roughness

The data obtained from the roughness tracings indicated that in all materials, both the rubber cup treatment and the Prophy-Jet treatment left a rougher surface than the control. This increase in surface roughness, while evident in the values presented, did not always reach statistical significance. Wide variation was seen between materials with the porcelain and gold being affected the least and the glass ionomer the most.

The range of increase in roughness varied from as little as 25 per cent for the rubber cup treatment of the gold to as high as 325 per cent increase for the Prophy-Jet treatment of the glass ionomer. The general pattern apparent in the data suggests that the Prophy-Jet increased roughness more than the rubber cup. This increase was statistically significant for Prisma Fil, Silux and the glass ionomer using arithmetic average roughness and for all materials except the porcelain using average maximum peak height roughness. The exception to this pattern of the Prophy-Jet giving a rougher surface was Tytin, in which the

rubber cup produced a surface significantly rougher than the control, but the Prophy-Jet did not.

The primary aim of this study, the comparison of the two treatment modalities, is partially answered, with roughness data, in Table 4. Both arithmetic average roughness and average maximum peak height roughness data indicated that the Prophy-Jet induced increase was significantly greater than that of the rubber cup for the Prisma Fil. Average maximum peak height roughness data also suggests that the difference was significant for Silux and the gold. Neither method indicated significance for amalgam, glass ionomer or porcelain.

The only other reported study which compared the effect of the Prophy-Jet to that of the rubber cup was that done by Gwinnett(19). His study, however, used SEM photographs for the evaluation and was unable to provide quantitative data. He reported that on composite resins, both methods removed matrix material but left behind the filler particles. This information agrees with the arithmetic average roughness data of this study, which showed average roughness increases ranging from 0.04 to 0.17 μm ., for Prisma Fil and Silux. Such loss is consistent with removal of matrix but leaving the protruding filler

particles. The study by Cooley, Lubow and Young(20), did not compare the Prophy-Jet to the rubber cup but did show that a Prophy-Jet treatment of five seconds on composite materials resulted in average material losses of 56.6 to 75.0 microinches (uin.) which is 1.4 to 1.9 μm . Their increase in roughness was much more than that reported in this study but their methods were not clearly defined so it is difficult to make a comparison. They simply stated that one operator applied the treatments but did not specify tip-to-surface distance for the Prophy-Jet instrument nor whether or not the tip was stationary or in motion. A possible explanation is found in the method by which they produced their composite samples without polishing the surface. They filled the holes in an amalgam capsule holder and allowed the surface cure to occur untouched by matrix band or glass plate. This would leave a surface rich in the matrix material which would be abraded more rapidly. Their initial roughness values for polished amalgam and gold were near those of this study.

Table 5 indicates a significant difference in the effect the treatments had on different materials. It shows that the glass ionomer was statistically rougher than all other materials under all conditions except for the rubber

cup treatment of Silux, Prisma Fil and Tytin. Although not shown to be statistically significant, the roughness data for the composite resins approached that of the glass ionomer. These findings reveal cause for concern over the increase in surface roughness with either prophylaxis technique on composite resin or glass ionomer restorative materials.

It is important to note the methodology of experiments when comparing studies of the surface effect of the Prophy-Jet. Many of the unfavorable studies cited in the review of literature used the instrument in a manner out of compliance with the manufacturer's instructions. The manufacturer recommends(14) that the tip be kept constantly in motion, that the angle to the gingiva be 60 degrees in the anterior and 80 degrees in the posterior areas, and that prolonged contact with cementum, dentin or soft tissue be avoided. In the cited studies(6,13,15,16), the handpiece was often fixed at 90 degrees to the surface and operated for many seconds while stationary. Similarly, the studies reporting the loss of cementum or dentin(6,13,15,16,17) did not compare the loss from Prophy-Jet treatment with that caused by root planing. Since the loss of cementum and dentin is expected with root planing, a similar result with

the Prophy-Jet should not necessarily be a contraindication for its use.

To keep roughness of restorative materials in perspective, it is worthwhile to remember that many practitioners place amalgam restorations which are left in the "as-carved" condition and are never polished. The data of Creaven, Dennison and Charbeneau(42) suggested that these surfaces are many times rougher than any reported in this study following either prophylaxis technique. Thus, any concern over this amount of roughness would seem odd if it were not a custom to carefully polish all restorations placed.

Plaque Accumulation

The information derived from evaluating plaque accumulation is especially important, since plaque might be more likely to impose a hazard to longevity of the restoration than would the roughness per se. Although Mathis, Hylin and Henry(34) suggest that rough surfaces are no more plaque retentive than are smooth surfaces, their work was done on occlusal restorations. Occlusal surfaces, however, are not the areas normally of greatest concern in

plaque accumulation. In addition, the chewing of food tends to remove plaque in these areas.

Table 6 indicates that there was no significant difference in plaque accumulation between samples treated with the rubber cup and the Prophy-Jet. The rubber cup did not cause a significant increase in plaque accumulation over the control for any material but the Prophy-Jet did so for Silux and the glass ionomer. This would seem to give the operator cause for concern for restorations of both microfilled composite resins and glass ionomers following Prophy-Jet prophylaxis if the patient did not have good oral hygiene habits. The suggestion of Cooley, Lubow and Young(20) favoring the repolishing of composite materials, and from this study the glass ionomers also, following prophylaxis could well be heeded. Since dental hygienists are already trained to polish restorations, it would be a simple task for them to repolish such restorations with an appropriate disk or strip as a final step in oral prophylaxis. Another possibility might be to place a glaze of unfilled resin over the restorations following prophylaxis.

Tables 7 and 8 indicate that there is a difference among materials in plaque accumulation as well. These data reveal that Prisma Fil and the glass ionomer collected

significantly more plaque than gold or porcelain when treated with the Prophy-Jet. It also shows that following treatment with a rubber cup, the glass ionomer collected significantly more plaque than the gold. These findings suggest that the porcelain and gold accumulated the least plaque of all materials tested following Prophy-Jet prophylaxis and gold collected the least after rubber cup treatment.

Evaluator Agreement

Tables 9 and 10 indicate the level of agreement of the evaluators on their first rating of the plaque accumulation. As mentioned before, this tabulation was done on their ratings recorded prior to discussion and arrival at a consensus value.

Table 9 shows that when comparing the plaque accumulations on the different experimental areas of the samples the three evaluators were in agreement with one another in approximately two out of three cases prior to discussing the values. That such a high level of agreement could be achieved at first impression indicates that the ratings were not strongly contested.

Table 10 shows their agreement with one another when comparing the samples to the standards. One may note that it seemed to be easier to reach agreement on some materials than on others. In general, the initial agreement was higher than the mean for amalgam, gold and porcelain but lower for Prisma Fil, Silux and the glass ionomer. The materials with the greatest roughnesses appeared to give the widest range of ratings on first impression.

Toxicity of Abrasive Agent

Although three of the studies included in the review of literature on this subject indicated that the Prophy-Jet Powder 1 was not toxic(11,31,32), two which raised cautions should be considered in this discussion.

Glenwright, Knibbs and Burdon(30) reported the creation of a bacteria and powder laden aerosol being generated by the Prophy-Jet. While this is true, the implication, stated or not, was that this is a unique hazard. It is the opinion of this author that such a discussion should have included any available information on the bacterial counts present in the aerosol generated by the air turbine handpiece. Since this handpiece receives significant use, the aerosol it

generates may be no less hazardous than that of the Prophyl-Jet.

The other study of concern is that by Rawson, et al.(33). Although identified as a pilot study, the implication is clear, that alkalosis may result from receiving Prophyl-Jet treatment. It should be pointed out that the sample was a single, healthy individual and that there were no controls, notwithstanding the fact that they considered the pretreatment blood sample to be a control. This is, in reality, nothing more than a pretreatment sample and should not be confused with a control. A true control should be another individual on which all activities were duplicated except the variable under consideration. Their data was all derived from seven blood samples, one of which they called the control. In their own text, however, they acknowledge inadvertent hemolysis of two of the samples, yet they persisted in reporting data obtained from these samples. In their text, they also acknowledge that the subject hyperventilated during the procedure. It would seem that the alkalosis could be the result of the hyperventilation and that to blame the abrasive powder is not warranted. It is the opinion of this author that this article presents an undeserved warning about the powder. It

might better have been offered as a report of a case and not as a study.

Investigations Needed

If this study were to be repeated, it is the opinion of the author that the following changes should be considered.

Since many of the roughness values not actually shown to be significant by statistical methods were very close to being so, a larger sample size would be appropriate to determine whether or not they actually are significant.

An in vivo evaluation of the plaque would be preferred over the photographic evaluation. The quality of the photographs including the angle of exposure, reflection of light off the samples, exposure setting, and reflection of surroundings in the samples all combined to make true evaluation of the amount of plaque difficult. To have the evaluators see the stained plaque on the samples would have been preferable.

To accomplish the in vivo evaluation, it would be simpler to have several subjects wear the samples at the same time so the evaluators could be brought together only once to see all the samples.

A model for evaluating roughness of the surface of materials by some method such as tactile evaluation with an explorer would be desirable. Such a model would provide a method for monitoring intraoral restorations for roughness.

It is not within the scope of this thesis to answer all the questions pertaining to the safety and effectiveness of the Prophy-Jet. The investigation has, however, raised certain questions. These concerns follow.

Since some of the authors have suggested repolishing of restorations as a possible benefit following prophylaxis with the Prophy-Jet, a study to determine the effect such repolishing would have on both surface roughness and plaque accumulation would seem to be in order. If it were found that simply "touching up" a restoration with a fine disk would resolve the roughness created, it would be a worthy recommendation. It is possible, however, that repolishing of the restorations could lead to substantial loss of material over time and might decrease the lifespan of the restorations.

Another question raised is that of the possible effect of both types of prophylaxis upon the margins of restorations. In vivo, this is the area of greatest concern since plaque accumulation is really only likely to cause

failure of a restoration at the margin. A valuable study would be one which would examine whether either prophylaxis procedure causes loss of material or increase of plaque accumulation at that location.

It would also seem appropriate to conduct a study of individuals who have demonstrated differences in oral hygiene practices to see if roughness of a restoration effects plaque accumulation under such conditions. It is possible that the results would show that proper home care can sufficiently remove plaque from even the rougher surfaces. This would remove some of the concern over using the Prophy-Jet on patients who are conscientious in their personal oral care.

Inasmuch as two of the articles suggested that the Prophy-Jet is quite effective on orthodontic patients(12, 22), a split arch study comparing the gingival health of orthodontic patients using conventional techniques on one side and the Prophy-Jet on the other side could provide meaningful data.

Offenbacher, Schweinebratin and Armstrong(18) found that the Prophy-Jet reduced bacterial counts in the gingival sulcus while the rubber cup did not. This finding suggests

the need for longitudinal studies which compare gingival health over a long period in a split mouth model.

SUMMARY

➤ The aims of this study were; to compare surface roughness changes following treatment with a rubber cup using a medium grit prophylaxis paste and a Prophy-Jet on six different restorative materials, and (to also) compare differences in plaque accumulation produced by these treatments.

Samples made from six different materials had one end treated with a rubber cup and the other end with a Prophy-Jet with the center third acting as a control. Surface profile tracings were done on the two treatment areas and on the control surface and roughness data recorded for arithmetic average roughness and average maximum peak height roughness.

The samples were then attached to the lingual surfaces of a mandibular appliance and worn in the mouth for 48 hours. Disclosing stain was applied and the samples photographed to record the accumulation of plaque. A panel of evaluators viewed color slides of these samples and rated the differences in plaque found on each sample.

Surface profile tracing analysis showed that increases in roughness produced by the experimental procedures ranged from 25 to over 300 per cent. Both the rubber cup and the

Prophy-Jet caused an increase in roughness but the difference between the two treatments was significant only for Prisma Fil, Silux and the gold material. No significant difference was found between the treatments for the Tytin, the glass ionomer and the porcelain materials.

The glass ionomer showed the greatest roughness of all the materials tested. The roughness was significant under most of the conditions considered.

The information from this study seems to suggest that operators should consider repolishing restorations of microfilled and hybrid composite resins and glass ionomer restorative materials following prophylaxis of any type. When considered in light of the potential convenience and ease of use of the Prophy-Jet, these findings do not seem to provide justification for condemning its general usage based on its effect upon restorative materials and subsequent plaque accumulation. Caution in its use upon selected materials as mentioned above would seem to be in order.

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CONCLUSIONS

1. Both the rubber cup with a medium grit prophylaxis paste and the Prophy-Jet prophylaxis techniques left polished restorative materials rougher than they were before treatment. The rubber cup caused a significant increase in roughness for Tytin and the gold. The Prophy-Jet caused a significant increase for all materials except the porcelain.
2. The Prophy-Jet procedure caused a significantly greater increase in the roughness of the glass ionomer than in any of the other materials. The rubber cup procedure caused a significantly greater increase in the roughness of the glass ionomer than it did in the gold or porcelain.
3. There were no significant differences in plaque accumulation between surfaces treated with the Prophy-Jet and the rubber cup procedures.
4. Among materials treated with a rubber cup procedure, the glass ionomer accumulated significantly more plaque than gold. Among those treated with the Prophy-Jet, Prisma Fil and the glass ionomer accumulated significantly more plaque than the gold or porcelain.

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