Summer 1994

Effects of a Commercial Sodium Bicarbonate Toothpaste on Composite Restorative Material

Maggie Jackson
Old Dominion University

EFFECTS OF A COMMERCIAL

SODIUM BICARBONATE TOOTHPASTE

ON

COMPOSITE RESTORATIVE MATERIAL

by

Maggie Jackson
B.S. May 1991, Old Dominion University

A Thesis Submitted to the Faculty
of Old Dominion University
in Partial Fulfillment of the Requirements
for the Degree of

MASTER OF SCIENCE

IN

DENTAL HYGIENE

OLD DOMINION UNIVERSITY
August, 1994

Approved by:

Deanne Shuman, Director

Michele Darby

Christine Nathe

ABSTRACT

EFFECTS OF A COMMERCIAL SODIUM BICARBONATE TOOTHPASTE ON COMPOSITE RESTORATIVE MATERIAL

Maggie Jackson
Old Dominion University, 1994
Director: Deanne Shuman

Commercial sodium bicarbonate toothpaste is a relatively new product on the market and limited research has tested its effects on composite material. The purpose of this investigation was to determine and compare, <u>in-vitro</u>, the effects of a commercially available sodium bicarbonate toothpaste versus a leading brand of fluoridated toothpaste on composite restorative material simulated in daily toothbrushing for a six month time period. Deionized water was used as the control treatment. A three-group, post-test only design was used to test the abrasive effects of the paste on 48 filled composite resin shade guide teeth. The digital microprocessor scanning device, a measurement component of the scanning electron microscope, was employed to examine surface changes in the composite material. A root surface smoothness test, was utilized by a calibrated examiner to categorize the scanning electron microscope photomicrographs. Data on the amount of abrasion in micron measurements was analyzed using analysis of variance; Duncan's multiple range test was employed to determine significant differences. An alpha level of 0.05 was selected for testing of hypotheses. Results indicated that

specimens brushed with water exhibited some surface roughness as compared to the dentifrices; however, there were no statistically significant differences between the dentifrices. It was concluded that sodium bicarbonate dentifrice and fluoridated dentifrice were no more abrasive than water on composite material and created a smoother surface than water with minimal nicking and marking.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

I would like to express my thanks and gratitude to everyone who helped to make the completion of this thesis project possible. I would also like to extend a personal thank you to the following:

Church & Dwight Co., Inc. and Mr. Todd Domke, Technical Manager, Research & Development, Funding Contributors--Your decision to fund this project as well as your donation in the form of toothbrushes and toothpaste is greatly appreciated.

Mrs. Deanne Shuman, BSDH, MS, Professor and Chairperson, Thesis Director--Your time, patience, support, editing, ideas, and review of statistical information requires an extra special thank you. Your efforts made the completion of this thesis feasible.

Mrs. Christine Nathe, BSDH, MS, Thesis Committee Member--Your assistance, editing, and idea for this thesis topic is commendable. The time you spent to aid in the completion of this project requires a special thank you.

Mrs. Michele Darby, BSDH, MS, Graduate Program Director and Thesis Committee Member--Your editing, ideas, and review of this thesis project is greatly appreciated and warrants a special thank you.

Mr. Bruce Schemehorn, Assistant Director, Oral Health Research Institute, Indiana University, Indiana--Your time, patience, advice, and assistance in preparation of specimens and methodology is greatly appreciated and requires a special thank you.

Mrs. Glynis Henry, V-8 Cross-brushing Machine Expert--Your advice, time, and assistance with the use of the V-8 Cross-brushing machine is greatly appreciated and warrants special thank you.

Mr. Michael Adams, SEM Expert--Your time, patience, and efforts spent on SEM preparation and photomicrographs is greatly appreciated and warrants a special thank you.

Mrs. Kim Herremans, BSDH, MS, Consultant--Your time and efforts spent rating the SEM photomicrographs warrants a special thank you.

Ms. Maria Kronenberg, Statistical Consultant--Your analysis of the data is greatly appreciated.

Fred and Charlie Dantonio, Dantonio's Dental Lab Technicians--Your assistance in the location of composite specimens and the donation of those specimens is greatly appreciated.

Mr. Richard Best, Manager of Education, Ivoclar® Representative--Your assistance in the collection of composite background information is greatly appreciated.

Mrs. Evelyn Thomson-Lakey, BSDH, MS, Instructor--Your photography skills are excellent. Thank you for the slides.

Dr. Douglas Hughes, D.D.S.--Your advice, ideas, and support made the completion of this thesis possible. Thank you.

Old Dominion University Staff and Instructors (Past and Present): Mrs. Deborah Bauman, Mrs. Pamela Brangan, Mrs. Debbie Baldwin, Mrs. Macie Horton, Mrs. Patricia Damon-Johnson, Dr. Cameron Lowe, Dr. James Luton, Mrs. Lynn Tolle-Watts, and Ms. Nancy Webb--Your guidance and teachings over the years has made the completion of this thesis possible.

Ms. Deborah Hardy, Assistant Professor, Caruth School of Dental Hygiene, Baylor--Your support and guidance is greatly appreciated.

My Family and Friends--Your support throughout this project has been immeasurable. An extra special thanks and warmest wishes is extended to all of you.

My spiritual guide, Jesus--Faith in you makes all things possible.

Mrs. Bettie Grizzard, Typist--Your typing and editing skills greatly improves the paper. Thank you.

Atlantis Photo Processing--Your time and care with the photographs and slides deserves a special thank you.

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

Introduction

An abrasive agent is an inert ingredient found in commercial dentifrices (toothpaste) to clean teeth (Hefferren, 1984). The abrasive agent aids in the removal of stained pellicle, bacterial plaque, and debris in the oral cavity. The purpose of a dentifrice is to assist the toothbrush in the cleansing of tooth surfaces (Kitchin & Robinson, 1948; Kluppel, et al., & Svinnseth, et al., 1987). A dentifrice therefore, should be abrasive enough to remove stained pellicles, bacterial plaque, and debris without removing enamel, cementum, or dentin from the tooth surface or causing damage to any restorations.

The purpose of this investigation was to determine the effects of a commercially available sodium bicarbonate toothpaste as opposed to a leading brand of fluoridated toothpaste on composite restorative material simulated in daily toothbrushing for a six month time period. Sodium bicarbonate, incorporated into a commercial dentifrice, is a relatively new product on the market and although research exists concerning its effects on tooth structure, limited research has been conducted testing its effects on composite material. Consumers also have begun to question the effects of a sodium bicarbonate paste not only on tooth enamel, but also on tooth colored restorative materials such as porcelain and composite. This study examined the effects of the toothpaste on composite material and determined the abrasive effects of the toothpaste over a six month time period.

Statement of the Problem

This *in-vitro* study answered the following research questions:

1. What are the effects of the commercially available sodium bicarbonate toothpaste and fluoridated dentifrice on composite restorative materials?
    a. What amount of abrasion, if any, is present after brushing with the commercially available sodium bicarbonate toothpaste and fluoridated dentifrice on composite restorative materials at the end of the simulated six month time period?
    b. What pattern of abrasion is evident (if any) after brushing with the commercially available sodium bicarbonate toothpaste and fluoridated dentifrice on the composite restorative materials?

Significance of the Problem

The dental hygiene profession strives to provide the public with the highest quality of care and education possible (ADHA, 1993). Oral hygiene education and practice is important especially considering that edentulism in adults over age 65 is decreasing, thereby, increasing the number of at-risk teeth (Douglass, 1992). Recorded trends show that the number of individuals in the 65 to 74 age group had an average of 7.4 teeth in 1962, 9.2 teeth in 1974, 11.4 teeth in 1981, and 17.9 teeth in 1986 (Douglass, 1992). One can infer from these results that today's population has more need for professional oral care and restorative dentistry, not less.

The Food and Drug Administration (FDA) plays a major role in the evaluation of dental products (Bayne, 1992 & Veatch, 1992). The FDA classifies dental materials based on its "(1) good manufacturing practices, (2) quality (by meeting defined laboratory standards), and (3) biocompatibility " (Bayne, 1992). Mandated research is conducted each year as oral hygiene products are tested and retested in laboratory studies to evaluate their effects on gingival health, tooth enamel, and dental restorative materials. However, testing programs for restorative materials, have generally focused on the properties of the material (Mjör, 1992).

Patients/consumers expect quality restorative materials and products. Manufacturers of restorative materials through testing and retesting, attempt to find products that will satisfy the public and pass marketable standards. The longevity of a restoration and its care also is important to the consumer. For example, the toothpastes, mouthrinses, and powders to be used intraorally by individuals with restorative materials must not adversely affect the health of the person or appearance of the restoration.

Oral health products with fluoride are in high demand for dental caries control; but today, fluoride is not the only ingredient manufacturers add to enhance dentifrice. Commercial toothpastes currently are marketed with sodium bicarbonate incorporated as a key agent for its gingival effects and cleansing ability.

Research on the therapeutic benefits of sodium bicarbonate paste as it relates to gingival effects has shown that in addition to reducing plaque and removing stain, sodium bicarbonate is nonirritating to the skin and oral mucosa (Church and Dwight, 1988). The Keyes Technique utilized sodium bicarbonate, hydrogen peroxide, and sodium chloride alone, in combination, or with water in homecare treatments of periodontal disease (Keyes, et al., 1978, 1982, 1983). Research results, however, do not demonstrate any additional therapeutic effects compared to adequate plaque removal techniques alone. Research on the abrasive effects of dentifrices on restorative materials is limited to date. Perhaps future studies will shed more light on the abrasive as well as the therapeutic effects of sodium bicarbonate paste.

Definition of Terms

The following terms were defined for the purpose of this study:

1. Abrasion. The amount of surface removed from the composite sample during polishing as determined by the measurements obtained of surface thickness in comparison to a control surface.
2. Composite shade guide teeth. The sample of restorative material utilized to simulate composite material as it appears in the oral cavity. Filled composite resin covered maxillary anterior shade guides (Vivosit® brand as manufactured by Ivoclar) were used to simulate composite covered teeth as they appear in the oral cavity.
3. Daily toothbrushing. The standard of daily toothbrushing established for this study. The total of 5,040 strokes was selected as the norm based on a toothbrushing session of 10 brushing strokes per tooth, 3 times a day, 7 days a week, for a 6 month time period.
4. Digital microprocessor. A measurement component of the scanning electron microscope (SEM). This device was utilized to measure the surface abrasivity of the three treatments on composite restorative material (i.e. 1-toothbrush with water, 2-toothbrush with sodium bicarbonate toothpaste, and 3-toothbrush with fluoridated toothpaste).
5. Fluoridated toothpaste. A widely recognized brand of

dentifrice containing fluoride which garners the ADA Seal of Approval.

6. Masking technique. The technique used to cover each specimen on the cervical half of its surface by transparent tape. The masked surfaces served as the control in this study.

7. Polishing. A method of attaining a smooth plaque, pellicle, and stain free surface. A toothbrushing machine was utilized to accomplish polishing of the composite surface which in this study was used to simulate toothbrushing.

8. Scanning electron microscope (SEM). A device used to examine, measure, and photograph the surface topography of the composite shade guide teeth. The model used in this study was a Cambridge 5100 manufactured in 1987.

9. Sodium bicarbonate toothpaste. A commercial brand of dentifrice of which the base ingredient is sodium bicarbonate. Sodium bicarbonate or baking soda is often recognized for its benefits as a cleansing, polishing, acid neutralizing, and deodorant agent (Church & Dwight, 1988).

10. Toothbrushing machine. A device used to simulate brushing in the laboratory. A V-8 cross-brushing machine manufactured by Procter & Gamble in the 1960's was used in this study to brush each composite specimen. (Note: Reference for cross-brushing machines

manufactured today is Sabri Enterprises Inc., Downers Grove, Illinois 60515)

11. Toothbrushing strokes. The number of strokes calculated during a daily toothbrushing session. The norm as selected for a simulated six month period was 5,040 strokes (10 strokes per tooth, 3 times a day, 7 days a week).

Assumptions

The following assumptions were made in accordance with this study:

1. The masking technique enabled the investigator to evaluate differences between the treated and the untreated composite surfaces.
2. The SEM (digital microprocessor scanning device) accurately measures changes in surface patterns with composite specimens.
3. The toothbrushing machine eliminated bias in the length and pressure of toothbrushing strokes.
4. Normal brushing is accurately simulated for a six month time period by the number of toothbrushing strokes calculated for this study.
5. The composite shade guide teeth used as specimens are adequate representations of composite material placed in the oral cavity.

Limitations

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

1. The specimens might not have been uniform; therefore, random assignment was used to equalize any inherent differences.
2. Loss of specimens due to cracking or fracturing during treatment was a potential problem; therefore, a sufficient number of specimens were used to obtain an adequate sample size.
3. In-vivo effects on composite materials might differ from those observed in this in-vitro study. Therefore, generalizations to human populations must be done cautiously.

Hypotheses

The following null hypotheses were tested in this study:

1. There is no statistically significant difference at the 0.05 level in the amount of abrasion on composite restorative surfaces when polished with sodium bicarbonate toothpaste, a leading brand of fluoridated toothpaste, and water as measured in microns by the digital microprocessor scanning device.
2. There is no statistically significant difference at the 0.05 level in surface abrasion patterns of the composite specimens when polished with sodium bicarbonate toothpaste, a leading brand of fluoridated toothpaste, and water upon visual inspection of the SEM

photographs utilizing the root surface smoothness test as described by Krupa Lavigne, et al. (1988).

Methodology

An in-vitro, three group, post-test only design was used to determine the abrasive effects of the sodium bicarbonate dentifrice and the fluoridated dentifrice on composite shade guide teeth. Forty-eight composite shade guide teeth were divided randomly into three groups of sixteen. Each specimen was mounted in an acrylic base and covered on the cervical one half of its surface with transparent tape. The covered areas served as the control.

Three independent variables were examined: sodium bicarbonate toothpaste, a leading brand of fluoridated toothpaste, and deionized water. Each specimen was brushed with a brushing machine using constant pressure and length of stroke. A simulated six month time period (5,040 strokes) was used as the time frame. After a simulated three month time period denoted by 2,520 strokes, the toothbrushes were replaced and the brushing continued for the final simulated three month time period. Three months was chosen as the point at which to change the brushes based on current literature which suggests that brushes become worn after use for three months (Abraham, et al., 1990 & ADA, 1984). At the end of the brushing sessions/period, each specimen was sputter coated with 300 Å of gold palladium and mounted for SEM review. The digital microprocessor scanning device, a measurement component of the SEM, was used to quantify the data. Surface roughness was determined using a measure designed by Krupa Lavigne, et al. (1988). The data for amount of abrasion and surface roughness were analyzed using analysis of variance at the 0.05 level of significance. Duncan's multiple range test was employed to locate significant differences. All data were analyzed using the SAS computerized statistical package.

CHAPTER 2

Review of the Literature

Relevant literature to this study is discussed and reviewed in four sections: (1) dentifrice abrasivity, (2) commercially prepared sodium bicarbonate toothpaste, (3) toothbrush abrasion on tooth structures (i.e. cementum, dentin, enamel, etc.), and (4) composite material.

Dentifrice Abrasivity

A dentifrice (toothpaste) is a substance used with a toothbrush or other applicator for removing bacterial plaque, material alba, and debris from the gingiva and teeth and for applying specific agents to the tooth surfaces for preventive, cosmetic, sanitary and/or therapeutic purposes (Wilkins, 1989). The purpose of a dentifrice is to assist the toothbrush in the cleansing of tooth surfaces (Kitchin, et al., 1948; Kluppel, et al., 1986 & Svinnseth, et al., 1987). Most dentifrices contain fluoride to prevent dental caries; several contain pyrophosphate to decrease supragingival calculus formation.

Most dentifrices contain an abrasive, a material composed of particles of sufficient hardness and sharpness, that cuts or scratches a softer material when drawn across its surface to achieve cleaning and polishing of surfaces (Wilkins, 1989). Kluppel, et al. (1986) conducted a study to determine the cleaning power of toothpastes. In this study, they defined a measure known as the polishing effect which rated the reduction of the roughness in enamel as caused by the dentifrice. Types of abrasives incorporated into dentifrices include carbonates, phosphates, silicas, and organic abrasives. Of the abrasives listed, silicas are used most often in the dentifrices manufactured in the United States (Barbakow, et al., 1987).

Abrasives make up 25% to 60% of the dentifrices weight (Barbakow, et al., 1987). The abrasion caused by dentifrices and its effects on oral hard tissues has been examined continually since Miller (1907) reported that damage could be done to teeth. Research shows that "hard tissue damage is most commonly produced by the abrasive agents in the toothpaste whereas lesions in the gingival tissue are produced by the toothbrush" (Sanges, G., 1976). The abrasion study conducted by Harte and Manly was done to evaluate any factors which might affect wear in tooth dentin in addition to the abrasive found in dentifrices. Four variables were studied: (1) two abrasives - calcium pyrophosphate and Syloid 63 brand of silica, (2) two brush brands--hard and soft tuft varieties of two manufacturers' brands (hand brushed), (3) temperature effects--room temperature and 37 degrees Centigrade, and (4) concentration/dilution of the abrasive in mixtures of aqueous sodium carboxymethyl cellulose (CMC) and glycerine. Results indicate that hard brushes cause higher abrasion and glycerine causes lower abrasion of tooth dentin. Despite the specific tests, no single set of variables was found to be a sound method of testing dentifrice abrasion. Today, it is common knowledge that hard toothbrushes are a possible cause of abrasion. The literature suggests a need for other methods of testing abrasion while raising questions about the validity of the ranking of dentifrice abrasiveness to date (Harte and Manly, 1976).

Svinnseth, et al. (1987) conducted an abrasivity study to measure the abrasiveness of 23 available toothpaste on the Norwegian market. The British Standards Institution's specifications for toothpastes was used as the scale of measure. A profilometer was used to evaluate the abrasion while a combination electrode was used to measure the pH of the toothpastes. The toothpastes were classified as having "none/slight", "medium", or "high"' abrasivity. A toothbrushing machine was applied to a block of dentin placed in a resin block and brushed with 20g of each toothpaste for 1000 brushing cycles. Results indicated that the pastes with low pHs had a combined abrasive and erosive effect on the dentin blocks. The study was well planned and researched; however; the author pointed out that ranking of toothpastes as having little, medium, and high abrasion is questionable because many factors influence abrasion. The toothpaste and the toothbrush were found to be two of the major factors.

An <u>in-vitro</u> study was conducted to evaluate the abrasiveness of seven commercially available dentifrices on dentin and microfill composite resin (Settembrini, et al., 1993). Close-up® Tartar Control Gel, Colgate® Tartar Control Gel, Pearl Drops®, Plus White®, Rembrandt® Whitening Toothpaste, Topol® Spearmint Gel, and UltraBrite® Original Flavor were the dentifrices used in the study. The study was conducted in two parts as the dentifrice abrasion on composite resin and the dentifrice abrasion on dentin surfaces were examined respectively. In section one, 42 microfill composite resin samples were made into hardened discs by compressing light-activated resin between glass slabs and photopolymerizing it for 60 seconds after it had been syringed into 2mm deep and 7mm diameter receptacles. The samples were divided randomly into seven groups. In section two, 42 non-carious human molar teeth were ground into 600 grit dentin and mounted in methymethacrylate jigs. The authors state that the groups were used as control groups first and then grouped to test the dentifrice abrasiveness. Each specimen was brushed using slurries of the dentifrice (25g of toothpaste per 40ml of water) for 2400 strokes using a medium bristled toothbrush which had been set at 150g of brush tension. Changes in surface roughness were recorded using a profilometer and scanning electron micrographs. The results of the study showed that the Rembrandt® Whitening Toothpaste was less abrasive to both groups than any of the other dentifrices. The article was well written and succinct. The authors pointed out the drawback with the use of the profilometer (i.e., limited to two dimensional information) while indicating an advantage is that an arithmetic mean of profilometer measurements can be calculated quickly as found by Brundle and Evans (1992).

Each year laboratory tests are conducted by dental corporations to assess dental products and to predict their safety and/or efficacy in clinical use (Yankell, et al., 1993). The American Dental Association (ADA) Council on Dental Therapeutics increased general awareness of dentifrice abrasivity through a report published in 1970 (JADA, 1970). Abrasivity studies which focus on the abrasive agent, as well as, polishing studies are performed on dentifrices prior to their placement on the market. Abrasivity and polishing studies attempt to determine the probable interactions of abrasive and other chemical components as well as their effects on the oral hard and soft tissues (Grabenstetter, et al., 1958; Hefferren, 1976; and Volpe, 1982). Based on these studies the population is assured that sufficient tests have established the safety of the product.

The American Dental Association Dentifrice Program conducted a study to determine the best method to assess the abrasivity of dentifrices (Hefferren, et al., 1984). Ten participating laboratories collaborated to compare and contrast their methods and findings. The study consisted of two phases: an open-ended phase in which each laboratory used the methods they routinely performed and a controlled phase in which each laboratory performed the same test. Four test pastes were evaluated. Two of the pastes were of dicalcium phosphate--one of lower abrasivity (45.08% and 22.54% of the dihydrate material) and one of higher abrasivity (0.92% and 23.46% of the anhydrous material). The other two pastes used were calcium carbonate--one of lower abrasivity (35% and 23% of Sturcal F $CaCO_3$) and one of higher abrasivity (0% and 23% of Waterworks chalk). Three methods of assessing abrasivity were evaluated: Talysurf procedure (a surface profile method), American Dental Association (ADA) method (a radiotracer method), and British Standards Institute (BSI) method (a radiotracer method). Eight teeth were used in each laboratory for abrasion substrates in identical 4 X 4 latin squares. The latin squares were used to control for the order of the pastes and any effects that might be attributable to the teeth used. The teeth were irradiated and treated according to the guidelines and conditions of the ADA method in the controlled phase. In the open-ended phase, all teeth were irradiated and treated according to the guidelines and conditions of the BSI method. A "sandwich design" which consisted of three pastes (reference paste, test paste, reference paste again) was used to limit any trend responses. The measurement unit was the ratio of the abrasivity values of the two reference pastes to the test paste. This study appeared to be planned and delivered well. Inherent problems with the study, as noted by the author, are (1) the "sandwich design" in which the two reference pastes in combination could dilute the effects of the test paste, and (2) the differences in methodology due to the fact that in the Talysurf procedure a tuft of short, stiff filaments was used instead of a full tuft brush as used in the BSI and ADA methods. The results indicated that similar abrasivity values for the test pastes were obtained with the radiotracer method whereas the surface profile method produced different values. It was found that the ADA radiotracer method was superior to the Talysurf and BSI method and required less time. Therefore, Hefferen and associates (1984) concluded that the ADA radiotracer method is useful in assessing dentifrice abrasivity.

A study conducted by Kodaka, Kuroiwa, and Kobori (1993) examined the effects of dentifrice abrasion on tooth enamel. The experimental treatment utilized in this study was commercial toothpaste containing calcium hydrogenphosphate, an abrasive agent without fluoride commonly found in Japanese dentifrices, while water served as the control. A Braun dental d3 toothbrushing machine was used at 120g of pressure for 10 minutes (at 3,300 strokes per minute) to brush a small surface area of twenty caries-free human permanent premolars extracted from 10 to 13 year old individuals for orthodontic purposes. The cervical dentin and mid-coronal enamel were cut with a diamond wheel, placed in epoxy resin, and polished after which one-third of the surface was covered with acrylic resin. The samples were divided into two groups of ten. Seven of the samples from each group were brushed with the dentifrice (5g per 5ml distilled water) while the other three were brushed with distilled water (5ml). The brushed surfaces were evaluated using a scanning laser microscope and a scanning electron microscope. The results indicate that brushing with an abrasive dentifrice caused rough surfaces while when brushing with distilled water, the enamel surface remained virtually the same and the dentin surfaces became smoother. This study was well thought out and planned. Although somewhat insignificant, it is unclear why the samples were grouped as seven and three per experimental and control treatments.

The question of dentifrice abrasivity has been brought into focus by the introduction of toothpaste on the market which promises to whiten teeth and the use of substances believed to be abrasive in toothpaste (Kitchin, et al., 1948). In the United States, any dentifrice measuring below a radioactive dentin abrasion (RDA) of 250 is considered safe (Harfst, 1991). The current literature is replete with published articles which attempt to examine factors and/or causes of abrasion. For example, Kuroiwa, et al. (1993, Microstructural Changes) concluded that when toothbrushing without dentifrice, saliva caused an organic protective membrane to form, while the use of abrasive-containing dentifrice caused abrasion with microwear. Johannsen, et al. (1993) concluded that the silicon oil added to toothpaste decreased the abrasion rate and made the brushed surface smoother (i.e., as tested on an acrylic plate). The present research attempted to build on the studies conducted by Hefferren, et al. (1984) and Kodaka, et al. (1993) to establish a method of assessing dentifrice abrasivity on composite restorative materials.

Commercially Prepared Sodium Bicarbonate Toothpaste

Sodium bicarbonate, or baking soda as it is commonly known, has been in use as a dentifrice by the population for more than 125 years (Church & Dwight, 1988). Sodium bicarbonate is a naturally occurring mineral known as nacholite. The bicarbonate ion itself is present in saliva and plays a role in deodorizing and neutralizing bacterial plaque acids. Commercial toothpaste manufacturing companies have incorporated sodium bicarbonate into a fluoridated dentifrice for everyday use. Although, since 1936, the American Dental Association has rated baking soda as the least abrasive material next to plain water (Newbrun, 1978), the population remains skeptical about the use of a sodium bicarbonate toothpaste because of the sodium content and the abrasive makeup of the content (Lehne & Winston, 1983).

The September 1992 edition of Consumer Reports contained an article of a laboratory study which categorizes groups of toothpastes based on abrasiveness, cleaning ability, and fluoride content (Toothpastes, Consumer Reports, 1992). Samples of the paste were sent to three different laboratories to test and rank the pastes based on abrasiveness, cleaning ability, and fluoride content. In one lab, cows teeth were sectioned, polished, and etched to make staining of the tooth surface easier. Coffee, tea, and other products were used to stain the surfaces. Next, the various pastes were used in combination with water and a toothbrushing machine to remove the stains. An optical instrument and photo ratings were used to determine and rank the cleaning ability of the pastes. At the second lab, human teeth with exposed dentin were radioactivated and studied. A toothbrushing machine was used in this study as well. A group of examiners then ranked the pastes based on three abrasivity levels: low, moderate, and high. The last test conducted on the paste was related to proposed FDA fluoride levels. Of the 25 brands of toothpaste tested, Arm & Hammer® Baking Soda Fresh Mint Toothpaste was judged to be one of the lowest abrasive brands of fluoridated toothpaste available. This study did not indicate the method used for testing the fluoride content of the pastes or the type of scale or criteria used for rating abrasivity.

Church and Dwight, makers of Arm & Hammer® Dental Care dentifrice, published a study which compared 12 different toothpastes and ranked them in order of abrasivity to tooth enamel. All of the products were compared using a ratio of 25 grams of dentifrice per 50 milliliters of aqueous solution. Each paste was then ranked according to a radioactive dentin abrasivity scale (Church & Dwight, 1988) (see Table 1).

Lehne and Winston (1983) conducted a study in which the relative abrasivity of baking soda was compared to that of recent commercial dentifrice formulations. Using radioactive dentin abrasivity (RDA) and radioactive enamel abrasivity (REA) techniques, the enamel abrasion for each product was examined and compared to that of a control (control- 10 grams of tetracalcium pyrophosphate in 50 ml of aqueous carboxymethyl cellulose) by first abrading the crowns of freshly extracted human teeth and then measuring the amount of enamel removed. Dentin abrasion was found by brushing the extracted teeth used in the sample and then measuring the amount of dentin that had been removed. The RDA and REA techniques were applied to measure the amount of dentin and enamel removed. The abrasion test was repeated on eight teeth as an average was taken to obtain the final

Table 1
RDA Values of Leading U.S. Dentifrices
(Church & Dwight, 1988)

Product	RDA	SD
ARM & HAMMER DENTAL CARE® Tooth Powder	37*	11.5
ARM & HAMMER DENTAL CARE® Toothpaste	55*	8.0
Colgate® Toothpaste	64	9.4
Crest® Tooth Gel	76	5.8
Crest® Toothpaste	84	7.2
Colgate® Tooth Gel	86	15.2
Colgate® Tartar Control Toothpaste	94	11.3
Colgate® Tartar Control Gel	94	10.2
Aim® Extra Strength Formula	96	7.2
Crest® Tartar Control Toothpaste	109	5.9
Aqua Fresh®	110	16.0
Crest® Tartar Control Gel	118	4.6

*Significantly lower abrasivity than all other brands at the 95% confidence level. All products were compared using 25g dentifrice/50 ml aqueous solution. Standard 100 is RDA 10g calcium pyrophosphate/50 ml aqueous solution.

RDA = Radioactive dentin abrasivity; SD = Standard deviation
It can be inferred from this table that ARM & HAMMER DENTAL CARE is lower in abrasivity than the other dentifrices.

scores. The results indicated once again that baking soda had the lowest level of abrasivity of all the toothpastes measured (see Table 2). A limitation of the study is that the teeth used, i.e., incisors, premolars, molars, were not disclosed.

The public is concerned with the efficacy of toothpaste. Individuals choose toothpaste that they believe will control bacterial plaque, calculus, and gingivitis (Apple, 1992). Although research studies on dentifrice abrasivity (Church & Dwight, 1988) and the abrasive effect of sodium bicarbonate (Lehne & Winston, 1983) have been conducted, the literature on commercially prepared sodium bicarbonate toothpaste on resorative material is limited. This study adds to the existing body of knowledge not only by testing the effects of the toothpaste on composite material, but also by comparing the abrasivity to another brand of commercially available toothpaste.

Toothbrush Abrasion of Tooth Structures

Toothbrush abrasion is defined as wear to gingiva, tooth structure, or root surfaces as a result of (1) a hard toothbrush with abrasive agents in the dentifrice, (2) horizontal brushing, (3) excessive pressure during brushing, or (4) prominence of the tooth facially (Wilkins, 1989). Research has demonstrated that regular toothbrushing procedures in some instances may lead to damage in teeth and in oral soft tissues (Svinnseth, et al., 1987). Toothbrush

Table 2

Abrasivity Values of Dentifrices
(Lehne & Winston, 1983)

	RDA		REA	
	Average	Standard Deviation	Average	Standard Deviation
Baking Soda	28	6.7	17	5.0
Pepsodent	70	10.9	22	7.3
Aim	74	8.4	--	--
Crest (with Fluoristan)	79	8.5	99	12.3
Close Up	83	8.0	--	--
Colgate Tooth Powder	84	10.9	--	--
Gleem	95	13.2	--	--
Colgate Dental Cream	103	18.1	52	9.4

*Control: 10g tetracalcium pyrophosphate in 50 ml 0.5% CMC solution.

RDA = Radioactive Dentin Abrasivity   REA = Radioactive Enamel Abrasivity abrasion is found primarily on facial surfaces of canines, premolars, and molars (Wilkins, 1989). Recession of the marginal gingiva and wedge-shaped defects in root surfaces near the cementoenamel junction are two of the most common types of damage observed in clients as a result of toothbrushing.

The mechanical action of the toothbrush serves to remove bacterial plaque, extrinsic stain, and oral debris. Despite this knowledge, Harte and Manly (1976) found that the brand and hardness of the toothbrush were not being taken into consideration despite their affect on wear patterns in oral tissue and tooth structure in their study concerning variables of dentin abrasion. Harte and Manly (1976) conducted a study to evaluate abrasion using two abrasives (calcium pyrophosphate and Syloid 63 brand of silica) at 50% concentration (following dilution with 2% carboxymethyl cellulose and water) and 100% concentration at 37oC and room temperature and four toothbrushes (two hard bristled and two soft bristled). Four human dentin pieces were brushed using each abrasive mixture and the hard as well as the soft toothbrushes at 10 gm of pressure for 30 seconds using an alternating current-operated machine which had been developed by Manly, et al. (Influence of Method of Testing Dentifrice Abrasiveness, 1974), but not disclosed. The results of the study indicated that hard brushes caused higher abrasion but that brush brand, concentration of dentifrice, and temperature also play a role. In conclusion, no single variable was found to be sufficient in testing abrasiveness.

In 1974, Schuller, et al. conducted an in-vitro study on the effects of toothbrush brands and bristle tip configuration on an extracted third molar. The in-vitro study examined an Oral B Plus/Ultra 35® and a Butler 411® toothbrush. An extracted third molar was sectioned and mounted for the sample. Ten gram weights were affixed to the brushes prior to their attachment to the toothbrushing machine. Crest® toothpaste was used in the study. The bristles were placed and replaced at periods of one, three, and six months. The bristles were examined by a scanning electron microscope and photomicrographs were taken to compare the bristles at one month, three months, and six months. The authors concluded that bristle tip configuration was a major factor in toothbrush efficiency and tissue management. Little mention was made of the effects, if any, that the brand of toothbrush posed as the bristles were flattened out in both brushes over time. It was noted, however, at the end of the study that the Oral B® bristles were more rounded while the Butler® bristles were flattened and disfigured.

Another study conducted by Taylor, Thomas, and Garnick (1993) comparing hand and automatic toothbrushes on soft tissue abrasion revealed little. Nine beagle dogs were utilized in the study as the subjects. Four quadrants of their mouth were randomly assigned to be brushed using a Braun® automatic toothbrush, an Interplak®, and Oral B® toothbrush(es). Twenty-five grams of pressure were utilized for one minute in each quadrant. Fifteen minutes later, a sample biopsy was taken of the area and prepared for examination using a scanning electron microscope. The tissues were examined for signs of hyperplasia, inflammation, and vascular congestion. The problem with the testing existed in the scheme of morphological differences due to specimen selection and toothbrush type. No experimental conclusion, therefore could be reached.

Harfst (1991) in her review of the benefits of baking soda, addressed the gingival effects, anticaries benefit, ADA seal, sodium ingestion, and abrasiveness of the product. She notes that in 1982 the Federation Dentaire Internationale conducted a review of marketed dentifrices and found that most marketed dentifrices posed no problems or harm to restorations and hard or soft tissue. Harfst concluded that the toothbrush, the pressure applied during toothbrushing, and the method of brushing used, were the most pertinent factors to examine in tests of abrasivity.

Toothbrush abrasion on restorative materials used in the oral cavity has not been a major focus within the profession. For example, the literature commonly contains studies which focus on toothbrushing effects on enamel or gingival surfaces while little attention has been given to these same effects on restored tooth surfaces. Kalili, et al., (1991) found in an investigation conducted on freshly extracted human teeth that bleached enamel is more susceptible to toothbrush abrasion. The present research attempted to add to the existing body of literature in this subject area, while noting any effects that the mechanical action of toothbrushes may have on composite restorative material.

Composite Material

Phillips (1991) defines composite as a materials system composed of a mixture of two more macro elements that are insoluble in each other and differ in form. Phillips also states that modern dental composite restorative material was developed in the late 1950's and early 1960's by R. L. Bowen. Bowen began experiments on ways to reinforce epoxy resins with filler particles when he noticed inherent weaknesses in the epoxy resin system (i.e., slow cure and discoloring of material).

Composite material is composed of inorganic filler particles (glass or silicon), a resin matrix, coupling agent, and other additives. The smaller the inorganic filler particles, the higher the shine of the restoration (Phillips, 1991). Below is a breakdown of the components and their properties:

(1) Filler--One of the major components of the composite

which reinforces the epoxy resin. Composites are available in one of two forms: filled or unfilled particles. Filled particles reduce polymerization shrinkage while reducing water sorption and thermal expansion. Unfilled particles contain more resin material and these composites are not as strong because there is more polymerization shrinkage, water absorption, and thermal expansion.

(2) Resin matrix--The second major component of the composite and is basically the pattern/configuration of the composite material. Most resin material utilizes monomers of which BIS-GMA is the most common.

(3) Coupling agent--The third component of the composite which provides a bond between the filler particles and the resin matrix.

(4) Additive(s)--The fourth component of the composite which includes UV absorbers for color stability and inhibitors such as hydroquinone which prevent early polymerization. Composite material preparation is achieved generally in one of two manners: chemical activation or light activation.

Composite material often is used in the oral cavity for restorative purposes and is noted for its abrasion resistance, compressive strength, elastic properties, and tensile strength (Hahn, 1986 & Hashin, 1982). Some composite resin materials (i.e., resin designed for orthodontic bonding purposes) have been found to release fluoride (Newman, et al., 1994). Composite material also is noted for its improvement over metals in areas subject to diminishing pressure (Salkind, 1972). Composite material is used more often than dental amalgams for anterior restorations because of the insulating and adhesive properties of the materials (Bayne, 1992). The materials also are more aesthetically appealing due to their resemblance in color to tooth enamel and translucence. Another advantage of composite material is that it is "tooth saving," because preparation for placement of the material is often accomplished by etching the enamel with an acidic solution rather than by drilling into the tooth (Mjör, 1992). The material also provides excellent efficiency for the dentist in chair time (Bayne, 1992).

Although there are many advantages to the use of composite materials, several disadvantages are evident. Composite material is subject to debonding, delamination, breakage/fracture, and matrix cracking (Salkind, 1992). One possible reason for these failure modes is that composite material has been found to, like fluoride, absorb water with time (Bayne, 1992). Caries and fractures are two other reasons for failure of composite material (Mjör, 1992). Another disadvantage is adverse patient reactions. Until the present, most published literature on composites has focused on adverse patient reactions and local reactions to pulp chambers (Bayne, 1992). Stanley (1992) found that because composite material is a chemically active mixture, it is often detrimental to the pulp. It is also important to mention that although the chair time required for placement is good, the cost of using composite material is greater than that of dental amalgam (Bayne, 1992). Strassler, et al. (1993) reported that any toothpaste (dentifrice) used on composite restorative material surfaces has abrasive potential. Moreover, various ultrasonic or sonic scalers can abrade the margins of crowns. Quartz, a filler particle, is the abrasive component found in most composite material (Phillips, 1991). Quartz generally is more difficult to polish and is often known to abrade existing opposing restorations (i.e., bridge work or dentures which do not contain quartz) or opposing natural teeth. Composite restorations have the ability to stain where scratches are present. Knowledge of these disadvantages is important to this study because abrasion can lead to staining in the composite surface over a period of time.

The availability of composites has improved since the 1960's. Composite materials were designed originally as a replacement for previous materials utilized for anterior restorations (i.e., silicate cements) (Bowen and Marjenhoff, 1992). It has been speculated that over the last 15-20 years, the quality of resin-based composite materials has improved more than that of dental amalgam materials (Mjör, 1992). In 1986, the American Dental Association Council on Dental Materials, Instruments, and Equipment (CDMIE) developed a program that allowed for the placement of posterior composites in areas of minimal stress (Bowen and Marjenhoff, 1992 & Whall,1992). Today the expected lifetime of a single surface restoration is from six to seven years (Ølio, 1992) while a multi-surface restoration's lifetime is expected to be four years (Mjör, 1992).

Most clinical evaluations have looked at factors such as lifetime and retention, side effects of material placement, or color (Mjör, 1992; Stanley, 1992; and Bowen & Marjenhoff, 1992). In this study, the focus was not on the placement of the material, but rather on the properties of abrasion that are exhibited, if any, following exposure to a sodium bicarbonate toothpaste, a fluoridated toothpaste, or deionized water.

Summary

To assess the effects of a commercial sodium bicarbonate toothpaste on composite material, relevant literature was researched in four different categories. Dentifrice abrasivity in general was reviewed first. Research studies indicated that the mechanical wear of the toothbrush is a greater factor in abrasion of dentin than the use of dentifrice. Another finding was that although the ADA radiotracer method is believed to be a good method of assessing dentifrice abrasivity, no sound method to assess dentifrice abrasivity exists. On the subject of commercial sodium bicarbonate toothpaste, findings support the notion that commercial sodium bicarbonate toothpaste is less, not more abrasive than other pastes which do not contain sodium bicarbonate. Toothbrush abrasion of tooth structures was examined next. Again, the mechanical wear of the toothbrush was found to be more detrimental to hard and soft tissues than any gels or paste used in conjunction with the toothbrush. Last, composite material, was examined in an effort to provide background information as the basis for conclusions about what abrades the material. Drawing on information from each of these subtopics provides the theoretical basis necessary to determine the abrasive effects of a commercial sodium bicarbonate toothpaste, as opposed to a fluoridated toothpaste, and deionized water on composite material.

CHAPTER 3

Methods and Materials

This investigation was designed to determine the effects of commercial sodium bicarbonate toothpaste on composite material. Over a simulated six month time period, the effects of the commercial sodium bicarbonate toothpaste on surface roughness was measured from SEM photomicrographs and the digital microprocessor scanning device.

Sample Description

Forty-eight composite specimens used to simulate composite restorative material as it appears in the mouth were assigned randomly to one of the three treatment groups. All samples met the following standards:

1. Specimens were in the size and shape of adult maxillary central incisors. Composite shade guides (Vivosit® brand as manufactured by Ivoclar) were used to control intersubject variability.
2. Specimens displayed no visually detectable macroscopic defects.
3. Extra specimens were included in case of specimen damage during SEM preparation procedures; a total of 62 specimens were prepared for the study from which 48 were selected randomly.

Research Design

An *in-vitro*, three-group, post-test only design was used to test the abrasive effects of the paste on composite material (see Figure 1). Forty-eight composite shade guide teeth were used to simulate composite restorative material as it appears in the oral cavity.

A commercial sodium bicarbonate toothpaste was used as the experimental treatment on sixteen composite shade guide teeth, a leading brand of fluoridated toothpaste was used as the experimental treatment on another sixteen teeth, and deionized water was used as the control on the remaining sixteen teeth. Each composite shade guide tooth served as its own control through use of the masking technique on one half of its surface (cervical portion).

The research design controlled for the following threats to internal and external validity:

1. Constant length and pressure of stroke were controlled by use of the toothbrushing machine.
2. All specimens were prepared, treated, and reviewed in the same manner.
3. The microprocessor scanning device provided accurate reproducible measurements.
4. Results are direct representations of the specimens studied. No generalizations or inferences are made to *in-vivo* effects.

Figure 1

Research Study Design
Three Group, Posttest Only

Group	Independent Variable	Posttest
E (n = 16)	X1	Y2
E (n = 16)	X2	Y2
C (n = 16)	X3	Y2

X1 = Fluoridated paste

X2 = Commercial sodium bicarbonate dentifrice

X3 = Deionized water

Y2 = Measurement in microns and root surface smoothness test results

Methodology

The shade guide teeth were all mounted in an acrylic base, 1/2 inch wide by 3/4 inches long and square in diameter to fit the physical size of the V-8 cross-brushing machine. A drilling machine was used to make holes in the handles of 96 soft Oral-B® toothbrushes (48 toothbrushes per each simulated 3 month time period) to fit the eight various toothbrush holders/appendages of the cross-brushing machine. A trial was run using transparent tape, masking tape, and surgical tape for 15 minutes to see which tape best adhered to the specimen surface. The transparent tape remained in place better than the masking and surgical tape and therefore, was chosen. Next, 25 grams of paste (commercial sodium bicarbonate paste and leading brand of fluoridated paste) were measured out using a weighted scale and placed in a test tube with 40 ml of water. The contents of the tubes appeared as follows:

Control--50 ml H_20 in 32 tubes

Experimental--25g fluoridated paste + 4Oml H_20 in 32 tubes

Experimental--25g sodium bicarbonate paste + 4Oml H_20 in 32 tubes

The 96 tubes containing the paste and water were prepared to represent the amount of paste used at each brushing sessions. Each tube and its contents were stirred using a pedal driven mixer for 20 seconds prior to its use.

A table was designed by Schemehorn (1993) which allowed for representation of at least one specimen in each run (see Appendix A). Following the preparation of the specimens for placement in the crossbrushing machine, the drilling of the toothbrushes to fit the crossbrushing machine, and the mixing of the slurries in preparation for the test, the tension of the crossbrushing machine was set at 150 grams using constant pressure and length of stroke (based on previous published ADA studies). Each specimen was then brushed for 2,520 strokes or 14 minutes and 10 seconds (based on V-8 machine calculations to equal the number of strokes required to simulate a three month period). At the end of the simulated three month period, the brushes and test tubes were replaced with new brushes and test tubes to represent a second three month period. The test was repeated for another 2,520 strokes to simulate the 6 month time period. Similarly, six separate trials were repeated until all of the specimens were complete. At the end of the study, one test tube from each of the experimental groups was allowed to settle for ten minutes and measured to determine how much paste was left. After 10 minutes the commercial sodium bicarbonate paste remaining in the tube following its separation from the water was 8.8 grams. The leading brand of fluoridated paste never totally settled (even after a 30 minute period) so a measurement could not be obtained. It was inferred by the brushing machine expert that a measurement was obtainable from the sodium bicarbonate paste because the baking soda was less soluble in water than the fluoridated paste (Henry, 1993).

The number of toothbrushing strokes was applied to each specimen to simulate brushing with a soft, multi-tufted toothbrush, three times a day, seven days a week, for a six month time period (or 5,040 strokes). Each specimen was prepared for SEM evaluation by sputter coating with 300 Å of gold palladium. After coating the specimens, the scanning electron microscope was used to examine surface changes in the composite specimens. The specimens were examined at 10,000x magnification and SEM photomicrographs were exposed at 3,000x magnification. The 10,000 magnification level was chosen to visualize the details and obtain measurements of the surface patterns and striations most efficiently because these patterns and striations were indiscernable at lower magnifications. The 3,000 magnification level was chosen for the SEM photomicrographs to represent and visualize the largest surface area and surface patterns possible.

<u>Instrumentation</u>

Three instrumentation devices were used in this study: a toothbrushing machine; the SEM (digital microprocessor scanning device); and the root surface smoothness test developed by Krupa Lavigne, et al. (1988), a visual rating scale of SEM photographs.

<u>V-8 Cross-brushing Machine</u>. The majority of the published

ADA laboratory studies which relate to toothbrushing cite use of the V-8 model (Hefferren, 1976; Harte and Manly, 1975). This machine has eight arm-like appendages which allows eight toothbrushes and specimen to be mounted and consistently brushed simultaneously. One advantage is that each specimen can be brushed using the same amount of pressure and length of stroke. Unfortunately this machine cannot replicate a routine, daily manual toothbrushing session because manual toothbrushing varies for each individual as related to method of brushing, length of time for brushing, pressure used, and stroke length. Validity and reliability of the crossbrushing instrument is established based on previous research (Taylor, et al., 1993; Kuroiwa, et al., 1993).

SEM. The scanning electron microscope's measurement feature, the digital microprocessor scanning device, was utilized to measure changes in surface depths as related to abrasion patterns. The Cambridge 5100 model (manufactured in 1987) was employed in this study. There are several advantages to the use of the SEM and its measurement component the digital microprocessor scanning device: (1) a three dimensional image is captured; (2) rapid specimen preparation may be performed because the SEM accepts specimens of varying size; and (3) the SEM contains a measurement component, the digital microprocessor scanning device, which makes quantifying surface depth, grooves or markings possible. Although there are several advantages to the use of the SEM and the digital microprocessor scanning device, there are also several disadvantages. One disadvantage is that the specimens must be able to withstand high vacuum conditions and be stable to temperature changes to be studied. A second disadvantage is that only non-living or nonvital specimens may be studied. A third disadvantage is that the instrument is often expensive to use.

The SEM works in much the same way as an x-ray machine. There is a column and tungsten filament which produces an electron source. The electron gun contains a cathode and an anode which accelerates the electrons and propels them down through the column to the chamber. At this point, however, the beam flows down the column and strikes the specimen in the chamber. The primary electrons in the beam cause secondary electrons to be knocked out of orbit and electrons are given off by the specimen. The secondary electrons are then picked up by the detector and converted to electrical signals from which an image is received. The reliability and validity of this instrument is often good if the conditions hold stable (i.e., the specimens are prepared properly, or the movement or rotation of the specimen is controlled in the chamber).

<u>Scale of Root Surface Smoothness</u>. The scale of root surface smoothness as described by Krupa Lavigne, et al. (1988) was

employed to rate the SEM photomicrographs of the specimens after applying the experimental treatments (toothpastes) and the control (water) to composite material. The root smoothness scale employs a scale from 1 to 5 using the following categories:

1 = Smooth appearance, no nicking or markings

2 = Relatively smooth appearance with minimal nicking and marking

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 and abrupt fissures and fractures

Intrarater reliability was established prior to rating the test photographs. An independent examiner blind to the treatments and familiar with the rating scaled scored three photomicrographs from each treatment group (see Appendix B) twice. A Pearson's product moment correlation was calculated to establish the reliability of the examiner.

<u>Statistical Treatment</u>

Data collected in the form of microns of surface abrasion were analyzed using a one-way analysis of variance. This test was employed at the 0.05 level to determine differences in the amount of surface abrasion in the composite material within and between the three research design groups. This measurement is appropriate because the data were ratio scaled and continuous. Duncan's multiple range test was selected for use because it minimzes chances of Type I error.

Data obtained from the photomicrographs using the root smoothness test was weighted on a point basis to make it ratio-scaled and continuous; therefore, a one-way analysis of variance was performed at the 0.05 level to identify significant differences and Duncan's multiple range test was employed to determine the source of any differences found between the three groups. Statistical analysis for all data was accomplished using the Statistical Analysis System, SAS.

CHAPTER 4

Results and Discussion

An in vitro study was conducted to determine the effects of a commercial sodium bicarbonate toothpaste on composite restorative material. Forty-eight filled composite resin shade guide teeth were used to simulate composite material as it appears in the oral cavity. A commercial sodium bicarbonate toothpaste was used as the experimental treatment on 16 samples, a leading brand of fluoridated toothpaste was used as the second experimental treatment on another 16 samples, and deionized water was used as the control on the remaining 16 samples. Each composite specimen was masked at the cervical third of the surface using transparent tape. The masked surface, or cervical third of the specimen, served as the control for each specimen. The independent variables in the study deionized water, a leading brand of fluoridated toothpaste, and sodium bicarbonate toothpaste were used in conjunction with a V-8 cross-brushing machine to brush each specimen at the rate of 5,040 strokes (or 28 minutes and 20 seconds) to simulate toothbrushing for a six month time period (i.e., 10 strokes per tooth, 3 times a day, 7 days a week). The cervical (control) and the occlusal (experimental) surfaces were sputter coated with 300 Å of gold palladium and mounted for SEM review. One measurement was taken on each of the experimental and control surfaces using the digital microprocessor scanning device. A root surface smoothness test, Krupa Lavigne, et al. (1988) was utilized by a calibrated examiner to measure roughness observed from the scanning electron microscope photomicrographs. Analysis of variance was used to test for significant abrasive effects and roughness effects of the treatments on composite material and Duncan's multiple range test was employed to locate any significant differences in abrasion. The computerized Statistical Analysis System (SAS) was used for data analysis in this study.

Results

The data were examined to determine if a statistically significant difference existed in material abrasion at the 0.05 level between deionized water, a leading brand of fluoridated toothpaste, and sodium bicarbonate toothpaste when brushed with a crossbrushing machine, as measured in microns by the digital microprocessor scanning device. The mean scores for abrasion in microns were found by subtracting the control surface measurement from the experimental surface measurement (Tables 3, 4, & 5). Analysis of variance revealed no statistically significant differences between the groups ($F = 1.51$, $df = 47$, $p = 0.2315$) (Table 6).

Table 3

Digital Microprocessor Measurements of Abrasion in Microns for the Water Treatment Group

	Measurement		
Specimen Number	Experimental	Control	Abrasion
1	1.360	0.200	1.160
2	0.750	0.380	0.370
3	0.803	0.276	0.527
4	0.536	0.386	0.150
5	0.895	0.164	0.731
6	1.080	0.254	0.826
7	0.619	0.391	0.228
8	0.639	0.375	0.262
9	0.585	0.317	0.268
10	0.555	0.192	0.363
11	0.704	0.235	0.469
12	0.916	0.342	0.574
13	0.482	0.351	0.131
14	0.428	0.151	0.277
15	0.307	0.201	0.106
16	0.275	0.185	0.090

$\bar{x}$ = 0.4082

s.d. = 0.2966

Table 4
Digital Microprocessor Measurements of Abrasion in Microns for the Fluoridated Toothpaste Group

	Measurement		
Specimen Number	Experimental	Control	Abrasion
17	0.452	0.151	0.301
18	0.515	0.150	0.365
19	0.477	0.252	0.225
20	0.625	0.273	0.352
21	0.666	0.317	0.349
22	0.586	0.125	0.461
23	0.344	0.292	0.052
24	0.471	0.225	0.246
25	0.572	0.312	0.260
26	0.644	0.409	0.235
27	0.843	0.290	0.553
28	0.430	0.251	0.179
29	0.371	0.212	0.159
30	0	0	0
31	1.080	0.731	0.349
32	0.552	0.262	0.290

$\bar{x}$ = 0.2735

s.d. = 0.1393

Table 5
Digital Microprocessor Measurements of Abrasion in Microns for the Sodium Bicarbonate Toothpaste Group

	Measurement		
Specimen Number	Experimental	Control	Abrasion
33	1.510	0.385	1.225
34	0.644	0.331	0.313
35	0.343	0.220	0.123
36	0.426	0.301	0.125
37	1.930	0.251	1.679
38	0.891	0.349	0.542
39	0.781	0.364	0.417
40	0.384	0.295	0.089
41	1.180	0.341	0.839
42	0.390	0.340	0.050
43	0.800	0.275	0.625
44	0.605	0.237	0.368
45	0.520	0.386	0.134
46	0.609	0.296	0.313
47	0.390	0.210	0.180
48	0.752	0.325	0.427

$\bar{x}$ = 0.4656

s.d. = 0.4486

TABLE 6
Analysis of Variance for Abrasion of Composite Material

Source	DF	SS	MS	F	p*
Model	2	0.31109488	0.15554744	1.51	0.2315
Error	45	4.62959094	0.10287980		
Corrected Total	47	4.94068581			

*0.05 level of significance

KEY:
DF = Degrees of Freedom
SS = Sum of Squares
MS = Mean Square
F = F Value
p = p Value

Data also were examined to determine if a statistically significant difference in material abrasion existed at the 0.05 level between deionized water, a leading brand of fluoridated toothpaste, and sodium bicarbonate toothpaste evaluated by a calibrated examiner using the root surface smoothness test by Krupa Lavigne, et al. (1988). The examiner's reliability was established at r = 1.0 using two separate scorings of photomicrographs (see Appendix B). The mean scores for root surface smoothness revealed a statistically significant difference between the groups ($F = 3.49$, $df = 95$, $p = 0.0063$) (Tables 7 and 8). Duncan's multiple range test revealed that the water group was significantly rougher than the sodium bicarbonate and the fluoridated toothpaste groups (Table 9). No significant difference was found to exist between the two experimental toothpastes, however. Photomicrographs of samples from each treatment group and a control are depicted in Figures 2 through 5. Figure 2 depicts a sample photomicrograph of composite resin material after a simulated 6 month brushing with a commercial sodium bicarbonate dentifrice. Figure 3 depicts a sample photomicrograph of composite resin material after a simulated 6 month brushing with a leading fluoridated dentifrice. Figure 4 depicts a sample photomicrograph of composite resin material after a simulated 6-month brushing with a commerical sodium

Table 7

Surface Smoothness Ratings of Specimen Photomicrographs

Deionized Water			Fluoride Dentifrice			Sodium Bicarbonate Dentifrice		
NO.	EXP.	CONT.	NO.	EXP.	CONT.	NO.	EXP.	CONT.
1	1	2	17	3	3	33	3	2
2	3	2	18	3	3	34	3	4
3	2	1	19	2	2	35	3	4
4	3	3	20	1	1	36	2	2
5	4	2	21	1	2	37	3	4
6	4	2	22	3	3	38	3	1
7	4	3	23	2	2	39	1	1
8	3	2	24	2	2	40	2	1
9	4	3	25	2	3	41	3	2
10	4	2	26	2	2	42	2	4
11	4	3	27	2	3	43	4	1
12	3	3	28	2	2	44	1	2
13	4	3	29	1	3	45	3	3
14	3	3	30	3	5	46	2	2
15	3	2	31	2	3	47	2	4
16	4	3	32	2	3	48	2	4

(EXP) $\bar{x} = 3.3125$ (EXP) $\bar{x} = 2.0625$ (EXP) $\bar{x} = 2.4375$

(CONT) $\bar{x} = 2.4375$ (CONT) $\bar{x} = 2.6250$ (CONT) $\bar{x} = 2.5625$

KEY:

NO. = Specimen Number
EXP. = Experimental Surface
CONT. = Control Surface

Table 8

Analysis of Variance for Surface Smoothness of Composite Material

Source	DF	SS	MS	F	p*
Model	5	13.55208333	2.71041667	3.49	0.0063
Error	90	69.93750000	0.77708333		
Corrected Total	95	83.48958333			

*0.05 level of significance

KEY:
DF = Degrees of Freedom
SS = Sum of Squares
MS = Mean Square
F = F Value
p = p Value

Table 9

Duncan's Multiple Range Test for Smoothness

Duncan Grouping	Mean	Treatment Groups
A	3.312	Water
B	2.6250	Control for FD
B	2.5625	Control for SBD
B	2.4375	SBD
B	2.4375	Control for Water
B	2.0625	FD

KEY:
FD = Fluoridated Dentifrice
SBD = Sodium Bicarbonate Dentifrice

Critical Range = 0.6199

Groupings with different letters are significantly different from each other

Figure 2

Photomicrograph of Composite Resin Surface After Simulated 6 Month Brushing with Sodium Bicarbonate Dentifrice

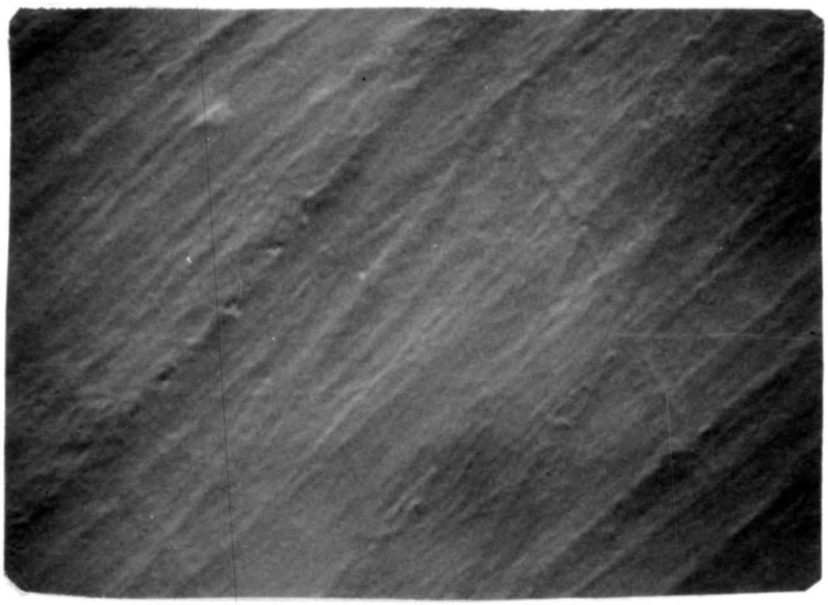

Figure 3

Photomicrograph of Composite Resin Surface After a Simulated 6 Month Brushing with a Leading Fluoridated Dentifrice

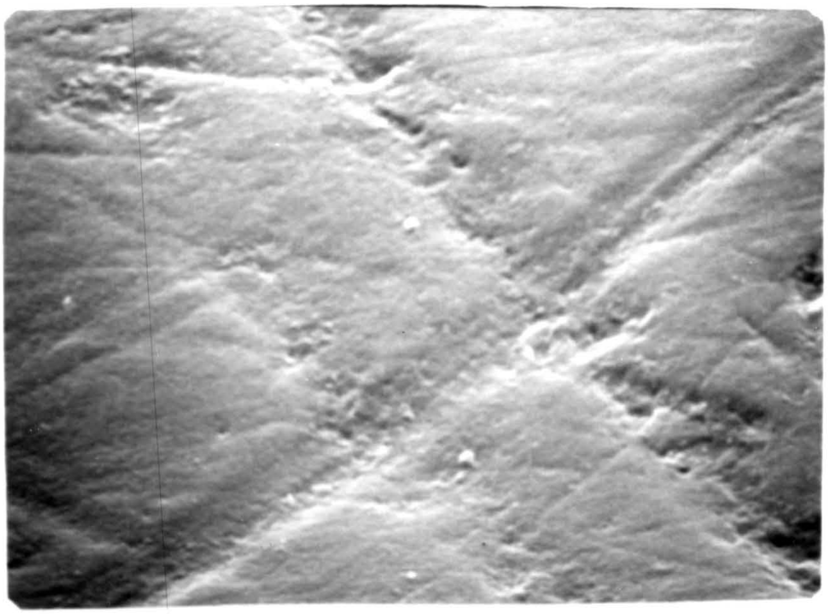

Figure 4

Photomicrograph of Composite Resin Surface After a Simulated 6 Month Brushing with Deionized Water

Figure 5

Photomicrograph of Untreated Composite Resin Surface Which Served as the Control bicarbonate dentifrice, and Figure 5 depicts a sample photomicrograph of an untested composite resin surface which served as the control.

Discussion

Analyses of mean differences in the amount of abrasion on composite restorative surfaces revealed no statistically significant difference at the 0.05 level when polished with sodium bicarbonate toothpaste, a leading brand of fluoridated toothpaste, and deionized water as measured in microns by the digital microprocessor scanning device. Results suggest that a commercial sodium bicarbonate toothpaste, a leading brand of fluoridated toothpaste, and deionized water are similar in their abrasivity toward composite restorative materials when used in simulated toothbrushing. The results obtained from this investigation were expected based on published literature. Previously published studies of dentifrices and dentifrice abrasivity as documented by Svinnseth, et al. (1987) and Schueller (1974) have indicated that the toothbrush is as much a factor in abrasion as the dentifrice itself. The American Dental Association has rated baking soda as the least abrasive material next to water since 1936 (Newbrun, 1978) which further supports the views of the manufacturers of commercial sodium bicarbonate toothpaste (Church & Dwight, 1988). Church & Dwight's (1988) study found a sodium bicarbonate toothpaste (Arm & Hammer® Dental Care toothpowder) to be one of the lowest in abrasion on any tooth surface. In the present study, generalization to in-vivo effects cannot be made since such studies produce different results.

Analyses of mean differences in surface abrasion patterns on composite restorative surfaces revealed a statistically sifnificant difference at the 0.05 level when polished with sodium bicarbonate toothpaste, a leading brand of fluoridated toothpaste, and deionized water upon visual inspection of the SEM photomicrographs utilizing the root surface smoothness test as described by Krupa Lavigne, et al. (1988). Results suggest that the deionized water group yielded a higher rate of abrasion than the sodium bicarbonate dentifrice group and the fluoridated dentifrice group. Finding a statistically significant difference in the surface abrasion patterns of the composite restorative surfaces exposed to sodium bicarbonate toothpaste, fluoridated toothpaste, and deionized water was expected and is supported by other studies like Consumer Reports, (Toothpastes, 1992) who found that Arm & Hammer® Baking Soda Fresh Mint Toothpaste is the lowest abrasive brand of fluoridated toothpaste available. It is known that composite material is subject to fracture and delamination (Mjör, 1992 and Salkind, 1972). It is also known that composite material has the ability to stain where scratches are present and as Settembrini, et al. (1993) found, abrasive pastes can leave striations and rough surfaces or abrasion on composite material. Results from the examination of surface smoothness due to experimental treatments (leading brand of fluoridated dentifrice and commercial sodium bicarbonate dentifrice) support the theory (Svinnseth, et al., 1987; Kluppel, et al., 1986) that the abrasives in the paste, do play a role in smoothing the surface. Therefore, the surfaces brushed with water alone might have been roughened by the action of the toothbrush bristles. This condition was similarly noted by Harte and Manly (1975), Svinnseth, et al. (1987) and Harfst (1991). The only evident pattern of abrasion would appear to follow the motions of the toothbrush, longitudinally across each specimen surface. Otherwise, the surfaces brushed with the toothpastes were relatively smooth with minimal nicking and markings indicating a similarity in abrasive quality of the two toothpastes. This finding may be explained by the fact that both pastes were relatively low in abrasivity as indicated by previous research (Church & Dwight, 1988; Lehne & Winston, 1983).

Randomization of specimen grouping, sufficient number of specimens, the V-8 cross-brushing machine, and the digital microprocessor scanning device were used in an attempt to establish validity and reliability. This study was similar in instrumentation to a study conducted by Settembrini, et al. (1993) which also attempted to determine the abrasivity of several different dentifrices on composite material. Settembrini, et al.'s (1993) study conducted to test the abrasiveness of seven commercially available dentifrices on dentin and microfill composite resin utilized a profilometer (instead of a digital microprocessor scanning device) and SEM photomicrographs to evaluate surface roughness. The results of Settembrini, et al.'s study and this study indicate that abrasive pastes play a role in composite surface material smoothness. While randomization of specimen selection was used to control for inter subject variance and an adequate sample size was used for specimen loss, no inferences can be made to in-vivo effects.

The limitations of this study must be considered when interpreting the results. One limitation of the study is that the contents of the composite shade guide teeth (ie. macro ingredients) and the procedure by which each individual resin shade guide tooth was made are unknown. Differing compositions of the specimens might have affected the abrasive potential of each composite restorative specimen. For example, some specimens could have higher amounts of quartz and thus be less prone to abrasion. Furthermore, light curing and chemical curing could influence the hardness of the composite and thus affect its abrasive potential. Another limitation may be the subjectivity of the root surface smoothness test. One examiner blind to the treatment groups was used in this study; however, one individual's rating with the scale could vary from another individual.

In-vivo effects which could alter abrasivity qualities of toothpaste are lowered salivary pH. When combined with abrasive pastes, acidic saliva can affect erosion and pitting of composite material and decrease retention of composite restorations. Dental hygienists might advise clients of the abrasivity of different pastes, provide appropriate oral hygiene instruction and offer nutritional counseling to those with a high intake of fermentable carbohydrates, consumed especially between meals.

CHAPTER 5

Summary and Conclusions

Summary

Composite material can exhibit a combination of failure modes due to fracture, secondary caries, and surface roughness as caused by abrasive toothpastes and professional oral hygiene practices (i.e. scaling). Limited studies have been conducted, however, testing the effects of toothpastes on composite restorative material. The public is generally skeptical about the use of sodium bicarbonate paste on restorative material because of the assumption that baking soda is abrasive. The purpose of this investigation was to determine the in-vitro abrasive effects of a commercially available sodium bicarbonate paste as compared to deionized water and a leading brand of fluoridated toothpaste on composite restorative material.

This study was conducted at the Oral Health Research Institute, Indiana University School of Dentistry in Indianapolis, Indiana and Old Dominion University, School of Dental Hygiene and Dental Assisting in Norfolk, Virgina. Specimen mounting and toothbrushing was performed in Indiana while preparation of specimens for SEM measurement and operation and SAS analysis were conducted at Old Dominion University. Forty-eight composite resin shade guide teeth were masked at the cervical one-third. The cervical area served as the control while the occlusal area served as the experimental side treated with one of the three independent variables: deionized water, a leading brand of fluoridated toothpaste, or commercially available sodium bicarbonate toothpaste. Each specimen was brushed using a V-8 cross-brushing machine and soft-bristled toothbrushes for 28 minutes and 20 seconds or 5,040 strokes to simulate a six month time period. Specimens were prepared and mounted in 300 Å of gold palladium prior to evaluation with the digital microprocessor scanning device. Measurements were taken of the experimental and control surfaces to determine the abrasion and the amount of surface roughness present. A three-group, post-test only design was used in the study. Analysis of variance was used to determine differences between treatment groups in (1) the amount of abrasion in micron measurements and (2) the abrasion patterns as based on the Krupa Lavigne, et al. (1988) root surface smoothness test.

The findings from the statistical analyses revealed that deionized water, a leading brand of fluoridated toothpaste, and a commercially available sodium bicarbonate toothpaste created similar amounts of abrasion and abrasion patterns on composite shade guide teeth. Further, specimens brushed with water alone had a rougher surface than specimens brushed with either of the two pastes; however, both pastes created relatively smooth surfaces with minimal nicks and marks.

Conclusions

After considering the discussion and limitations of the study, the following conclusions are drawn:

(1) Simulated toothbrushing with commercial sodium bicarbonate toothpaste is no more abrasive to composite restorative material than brushing with a leading fluoridated toothpaste or deionized water.

(2) The patterns of abrasion found in simulated toothbrushing with a commerical sodium bicarbonate toothpaste are not significantly different from the patterns of abrasion evident with simulated toothbrushing with a leading brand of fluoridated toothpaste.

(3) The composite resin surface roughness is greater when brushing in a simulated situation with water alone than when it is brushed with commercial sodium bicarbonate toothpaste or a leading fluoridated toothpaste.

After considering the results and overall design of the research, the following recommendations for future investigations are made:

(1) The study should be repeated and evaluated over greater than a six month time period to determine if increased abrasion or different patterns of abrasion occur over a long term.

(2) An <u>in-vivo</u> study should be conducted to determine the

effects of the toothpaste on composite restorative material and surface roughness over time.

(3) A study should be conducted comparing the different commercially available sodium bicarbonate toothpastes currently available on the market to determine their effects on composite restorative material.

Based on the results of this study, commercial sodium bicarbonate toothpaste appears to be no more abrasive to composite restorative material than a leading brand of fluoridated toothpaste. With increased research, both in-vitro and in-vivo, more may be learned about the abrasive effects of sodium bicarbonate toothpaste as well as the leading fluoridated toothpaste in daily maintenance care of composite restorative surfaces.

BIBLIOGRAPHY

Abraham, N. J., Cirincione, U. K., & Glass, R. T. (1990). Dentists and dental hygienists attitudes toward toothbrush replacement and maintenance. Clinical Preventive Dentistry, 12, 28-33.

American Dental Association, Council on Dental Therapeutics. (1970). Abrasivity of current dentifrices. Journal of the American Dental Association, 81, 1177-1178.

American Dental Association. (1984). Daily Brushing Pamphlet. Chicago, IL: Author.

American Dental Hygienists' Association (1991). ADHA Mission Statement. Chicago, IL: Author.

American Society for Testing and Materials. (1972). Composite Materials: Testing and Design. (2nd conference). Baltimore, MD: ASTM.

Anderson, P. & Elliott, J. C. (1992). Subsurface demineralization in dental enamel and other permeable solids during acid dissolution. Journal of Dental Research, 71, 1473-1481.

Apple, W. (1992). What do consumers want? The Journal of Public Health Dentistry, 52(Special Issue), 379-382.

Barbakow, F., Lutz, F., & Imfeld, T. (1987). Abrasives in dentifrices and prophylaxis pastes. Quintessence International, 18, 17-22.

Barnett, M. L. (1992). ADA dental product evaluation: Case history. The Journal of Public Health Dentistry, 52, 343-345.

Bayne, S. C. (1992). Dental composites/glass ionomers: Clinical reports. Advances in Dental Research, 6, 65-77.

Bowen, R. & Marjenhoff, W. A. (1992). Dental composites/glass ionomers: The materials. Advances in Dental Research, 6, 44-49.

Brundle, C. R., Evans, C. A., & Wilson, S. (1992). Encyclopedia of Material Characterization. Boston: Butterworth-Heinemann.

Church & Dwight Co., Inc. (1988). Arm & Hammer dental care(TM) toothpaste and toothpowder: Scientific Brochure.

Douglass, C. W. (1992). Future needs for dental restorative materials. Advanced Dental Research, 6, 4-6.

Grabenstetter, R. J., Broge, R. W., Jackson, F. L., & Radike, A. W. (1958). The measurement of the abrasion of human teeth by dentifrice abrasives: A test utilizing radioactive teeth. Journal of Dental Research, 17, 1060-1068.

Hahn, H. T. (1986). Composite Materials: Fatigue and Fracture. Philadelphia, PA: American Society for Testing and Materials.

Harfst, S. (1991). Baking Soda Revisited. Dental Hygienist News, 4 (4), 7-8.

Harte, D. B. & Manly, R. S. (1975). Effect of five variables on dentin abrasion. Journal of Dental Research, [Special issue A]: Abstract No. 188.

Harte, D. B. & Manly, R. S. (1975). Effect of toothbrush variables on wear of dentin produced by four abrasives. Journal of Dental Research, 54, 993-998.

Harte, D. B. & Manly, R. S. (1976). Four variables affecting magnitudes of dentrifice abrasiveness. Journal of Dental Research, 55, 322-337.

Hashin, Z. & Herakovich, C. T. (1982). Mechanics of Composite Materials: Recent Advances. New York: Permagon Press.

Hefferren, J. J. (1976). A laboratory method for assessment of dentifrice abrasivity. Journal of Dental Research, 55, 563-573.

Hefferren, J. J., Kingman, A., Stookey, G. K., Lehnhoff, R. & Muller, T. (1984). An international collaborative study of laboratory methods for assessing abrasivity to dentin. Journal of Dental Research, 63, 1176-1179.

Henry, G. (1993). Personal communication. University of Indiana. Indianapolis, Indiana: November 3.

Johannsen, G., Redmalm, G., & Ryden, H. (1993). The influence of silicone oil in toothpaste on abrasion in vitro. Swedish Dental Journal, 17, 117-122.

Jones, S. A., Lozdon, J., & Boyde, A. (1972). Tooth surfaces treated in situ with periodontal instruments: Scanning electron microscope studies. British Dental Journal, 132:57-64.

Kaaber, S. (1990). Allergy to dental materials with special reference to the use of amalgam and polymethylmethacrylate. International Dental Journal, 40, 356-365.

Kalili, T., Mito, R., Caputo, A. A., Sperbeck, G. L., & Matyas, J. (1991). In vitro toothbrush abrasion and bond strength of bleached enamel. Journal of Dental Research, 70, 546.

Kitchin, P. C. & Robinson, H. B. G. (1948). How abrasive need a dentifrice be? Journal of Dental Research, 27, 501-506.

Kluppel, H-J, Ploger, W., Forg, F., & Umbach, W. (1986). Parameter for assessing the cleaning power of toothpastes. Journal of the Society of Cosmetic Chemists, 37, 211-223.

Kodaka, T., Kuroiwa, M., & Kobori, M., (1993). Scanning laser microscopic surface profiles of human enamel and dentin after brushing with abrasive dentifrice in vitro. Scanning Microscopy, 7, 247-254.

Kuroiwa, M., Kodaka, T., & Kuroiwa, M. (1993). Microstructural changes of human enamel surfaces by brushing with and without dentifrice containing abrasive. Caries Research, 27, 1-8.

Krupa Lavigne, C., Nauman, R. K., Munley, M. M., & Suzuki, J. B. (1988). In vitro evaluation of air-powder polishing as an adjunct to ultrasonic scaling on periodontally involved root surfaces. Journal of Dental Hygiene, 62, 504-509.

Lehne, R. K. & Winston, A. E. (1983). Abrasivity of sodium bicarbonate. Clinical Preventive Dentistry, 5, 17-18.

Miller, W. D. (1907). The wasting of tooth tissue variously designated as erosion, abrasion, chemical abrasion, denudation. Dental Cosmos, 49, 1-23.

Mjör, I. (1992). Problems and benefits associated with restorative materials: side effects and long term costs. Advances in Dental Research, 6, 7-16.

Mjör, I. (1992). Biocompatibility of non-mercury containing restorative materials. Submitted to Ad Hoc Subcommittee on Benefits of Dental Amalgam (to coordinate environmental health and related programs). Sponsored by NIDR, Bethesda, MD. June 1991.

Mjör, I., Jokstad, A., Qvist, V. (1990). Longevity of posterior restorations International Dental Journal, 40, 11-17.

Newbrun, E. (1978). Cariology. Baltimore: Williams & Wilkins.

Newman, S. M. & Rudolph, S. L. (1994). Fluoride release from composite resins. Journal of Dental Research, 73, (From Craniofacial Biology/Dental Materials, Abstract no. 632)

Øilo, G. (1992). Biodegradation of dental composite/glass ionomer cements. Advances in Dental Research, 6, 50-54.

Pameijer, C. H., & Stallard, R. E. (1972). Application of replica techniques for use with scanning electron microscopes in dental research. Journal of Dental Research, 51, 672.

Phillips, R. W. (1991). Skinner's Science of Dental Materials (9th ed.). Philadelphia: W. B. Saunders Company.

Rauch, H. W., Sutton, W. H., & McCreight, L. R. (1968). Ceramic Fibers and Fibrous Composite Materials. (Vol. 3). New York: Academic Press.

Salkind, M. J. (1972). Fatigue of composites. Composite Materials: Testing and Design (Second Conference). ASTM STP 497, American Society for Testing and Materials, 1972, 143-169.

Sanges, G. (1976). Traumatization of teeth and gingiva related to habitual tooth cleaning procedures. Journal of Clinical Periodontology, 3, 94-103.

Schemehorn, B. R., Ball, T. L, Henry, G. M. & Stookey, G. K. (1992). Comparing dentifrice abrasive systems with regard to abrasion and cleaning. Journal of Dental Research, 72 (Special Issue), Abstract No. 352).

Schemehorn, B. R. (1993). Personal communication. University of Indiana. Indianapolis, Indiana: November 3.

Schueller, P. D., Hinkelman, K. W., & Thompson, G. W. (1993). Changes in toothbrush bristle tip configuration after various brushing periods. Journal of Dental Research, 72 (From Periodontal Research/Pharmacology, Therapeutics, & Toxicology, 1994, Abstract No. 1843).

Settembrini, L., Penugonda, B., & Fischer, E. (1993). Dentifrice abrasiveness on microfill composite resin and dentin: A comparative study. The Journal of Clinical Dentistry, 4, 55-60.

Shannon, H., Spencer, P., Gross, K., & Tira, D. (1993). Characterization of enamel exposed to 10% carbamide peroxide bleaching agents. Quintessence International, 24, 39-44.

Staff. (1992, September) Toothpastes. Consumer Reports, 602-206.

Stanley, H. R. (1992). Local and systemic responses to dental composites and glass ionomers. Advances in Dental Research, 6, 55-64.

Stookey, G. K., Burkhard, T. A., & Schemehorn, B. R. (1982). In vitro removal of stain with dentifrices. Journal of Dental Research, 61, 1236-1239.

Strassler, H. E., Moff, H. H. & University of Maryland Dental School. (1993). The surface texture of composite resin after polishing with commercially available toothpastes. Compendium of Continuing Education in Dentistry, 8, 826-830.

Svinnseth, P. N., Gjerdet, N. R., & Lie, T. (1987). Abrasivity of toothpastes: An in vitro study of toothpastes marketed in Norway. Acta Odontol Scand, 45, 195-202.

Taylor, J., Thomas, D., & Garnick, J. (1993). Comparison of automatic and hand toothbrushes on soft tissue abrasion. Journal of Dental Research, 72, (From Periodontal Research/Pharmacology, Therapeutics, & Toxicology, 1994. Abstract No. 1845).

Tilliss, T. S. I., & Hicks, M. J. (1987). Enamel surface morphology comparison: Polishing with a toothpaste and a prophylaxis paste. Dental Hygiene, 3, 112-115.

Veatch, R. M. (1992). Ethical perspectives on the FDA and ADA evaluation of dental products. The Journal of Public Health Dentistry, 52 (Special Issue), 387-390.

Volpe, A. R. (1982). Dentifrices and mouthrinses. In: A Textbook of Preventive Dentistry, 2nd Edition. Stallard, R. E.: Philadelphia, PA: W. B. Sanders Co., 176-216.

Whall, C. W. (1992). The how and why of the ADA's evaluation program for dental therapeutic products. The Journal of Public Health Dentistry, 52(Special Issue), 338-342.

Wilkenson, R. F. & Maybury, J. E. (1973). Scanning electron microscopy of the root surface following instrumentation. Journal of Periodontology, 44, 559-563.

Wilkins, E. (1989). Clinical Practice of the Dental Hygienist. (6th ed.). Philadelphia, PA: Lea & Febiger.

Yankell, S. & Emling, R. C. (1992). Comparative laboratory evaluation of two new toothbrushes regarding interproximal access efficacy. The Journal of Clinical Dentistry, 3 (Suppl. C) C5-C8.

APPENDIX A

Position for Specimens in Cross-brushing Machine During the Six Trials

Appendix A

Position for Specimens in Cross-brushing Machine During the Six Trials

	POSITION							
	1	2	3	4	5	6	7	8
RUN 1	1 (W)	17 (FP)	33 (CSB)	2 (W)	18 (FP)	34 (SBP)	3 (W)	19 (FP)
RUN 2	35 (SBP)	4 (W)	20 (FP)	36 (SBP)	5 (W)	21 (FP)	37 (SBP)	6 (W)
RUN 3	22 (FP)	38 (SBP)	7 (W)	23 (FP)	39 (SBP)	8 (W)	24 (FP)	40 (SBP)
RUN 4	9 (W)	25 (FP)	41 (SBP)	10 (W)	26 (FP)	42 (SBP)	11 (W)	27 (FP)
RUN 5	43 (SBP)	12 (W)	28 (FP)	44 (SBP)	13 (W)	29 (FP)	45 (SBP)	14 (W)
RUN 6	30 (FP)	46 (SBP)	15 (W)	31 (FP)	47 (SBP)	16 (W)	32 (FP)	48 (SBP)

KEY:
1-16......Water (W)
17-32.....Fluoridated Paste (FP)
33-48.....Sodium Bicarbonate Paste (SBP)

Position shifts set by:
Bruce Schemehorn, Assistant Director of Preclinical Trials, Indiana University School of Dentistry, Oral Health Research Institute

APPENDIX B

Photomicrograph Intra-Rater Reliability Scoring

APPENDIX B

Photomicrograph Intra-rater Reliability Scoring

Directions: The examiner is to score the sample photomicrographs representative of each of the three groups at three separate test trials. The photomicrographs should be scored at approximately the same time of day for each of the three test sessions. The purpose of this testing is to establish intra-rater reliability. The examiner should, utilizing the Krupa Lavigne, et al. (1988) root surface smoothness test, circle the score that best describes the photomicrograph(s). At the end of each test session, the examiner is to mail the results back to the investigator in one of the self-addressed envelopes. The object in this case is to decrease the opportunity for bias as the examiner will not have access to previous scores.

Forms Used For Test Sessions 1 & 2

Date__________ Time__________

Photomicrograph	Score				
(1)	1	2	3	4	5
(2)	1	2	3	4	5
(3)	1	2	3	4	5
(4)	1	2	3	4	5
(5)	1	2	3	4	5
(6)	1	2	3	4	5
(7)	1	2	3	4	5
(8)	1	2	3	4	5
(9)	1	2	3	4	5

Legend

1 = Smooth appearance, no nicking or markings due to instrumentation
2 = Relatively smooth appearance with minimal nicking and marking
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 and abrupt fissures and fractures

Scoring of Specimens for
Interrater Reliability Assessment

PHOTOMICROGRAPH	TEST #1	TEST #2
1	2	2
2	3	3
3	2	2
4	2	2
5	3	3
6	2	2
7	4	4
8	3	3
9	2	2

$r = 1.0$