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Become a Critical Reader

MA Gaston

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Keywords: Critical thinking, critical reading, publication, peer review

Have you noticed that you now have to read more than ever before to keep up with the changes in practice technology, and you have to read even more to stay current with the vast array of new consumer oral care products? Have you noticed that many oral health-related publications, both paper and online, are now offered to you at no cost? Are you impressed by the volume and variety of continuing education courses advertised to dental hygienists throughout the year in various publications, in brochures delivered through the mail, and in messages posted on the Internet? Do you ever have time to read everything that proposes to make you a better practitioner? Do you sometimes think you may be suffering from information saturation?



I am certain about one thing-dental hygienists who are serious about maintaining their knowledge and skills at the cutting-edge level must now review and process more information more quickly than ever before. While most dental hygienists think of themselves as well-informed professionals, they readily admit that they sometimes have to search for answers to questions that come up in the normal flow of their practices. Furthermore, finding the best answer can require them to search the literature on a topic, and then distill their findings into concise, understandable lay terms. So, how do busy dental hygienists select credible information sources? I suggest that we must first become critical readers.

We have heard and read much about critical thinking skills over the past two decades, and while those skills are essential for today's practice, critical reading skills may be equally important. Like critical thinking skills, critical reading skills can be learned. The first step is to gather some basic information about the publications you most often read and consider good information sources. When reviewing a publication, ask questions such as, "Is its purpose to inform, persuade, introduce new products or techniques, present new research findings, or to review clinical treatment protocol?" Then, consider the credentials of the people involved in the publication process; are they respected by their peers for their integrity and professional expertise? It is important to examine the sponsorship of the publication in order to identify any possible conflicts of interests, so that you can feel confident that the articles it publishes will be unbiased. These are only a few of the major points to consider even before you begin to read the contents of any publication.

The matter of peer-reviewed and non-peer-reviewed publications is important when selecting sources of professional information. To become a critical reader of professional publications, one should be clear about the meaning of these very important terms.

Professional and scientific journals are peer-reviewed publications that document the scientific foundation on which a profession's practice is based. They publish new knowledge or discoveries that add to the existing body of knowledge that is unique to a given profession. This is one primary characteristic, in addition to the blind peer-review requirement, that sets professional scientific journals apart from professional newsmagazines and informational practice-related publications.

Peer-reviewed, or refereed, scientific publications are those that publish reports of original research that have not previously been published elsewhere, and that have been subjected to the critical blinded review of experts in the specific area of scientific investigation. A major purpose of the blinded review by experts is to determine whether or not the research process by which the new knowledge was discovered met universally accepted scientific standards for such research. The blinded review further determines whether or not appropriate statistical analyses were used, and the reported research results met universally accepted standards for reliability and validity. The process ensures that any claims made and conclusions drawn by the researchers were justified by the results of the research. Peer review of scientific research is extremely important to society because it protects the integrity of the scientific process and shields the public from unscrupulous individuals who, because of self interest, might be tempted to act unethically and endanger the health and welfare of the less-informed lay public.

The *Journal of Dental Hygiene* is the dental hygiene profession's peer-reviewed, or refereed, scientific publication and is published quarterly by the American Dental Hygienists' Association. The vast majority of articles now published in the *Journal* are reports of original research conducted by dental hygienists, although some well-presented short reports of unusual case studies, education and practice innovations, and comprehensive literature reviews also are published. Regardless of the manuscript type, all are subjected to the same rigorous, blinded peer-review process prior to being accepted for publication.

The ADHA newsmagazine, *Access*, is a good example of an informational professional publication that does not claim to be peer reviewed, even though certain articles in each issue undergo peer review. This review should not be confused with the refereed process used for professional and/or scientific journals. In publications like *Access*, the articles reviewed do not present new, previously unpublished research results or new discoveries. The original research that produced the core knowledge on which the article was based was previously published in a refereed scientific publication, and later presented in *Access* in a different format, to inform a different audience for different purposes. Many publications that are targeted to dental hygienists today fall into this category. These articles usually offer a clinical application of previously published research findings that is of particular interest to dental hygienists. Peer review of single articles is important in facilitating the appropriate application of research results to practice.

I don't know about you, but my reading time is always limited and must be worked in among other commitments. I suspect that you may be like me. Becoming a more selective and critical reader will help you make the most efficient use of your available information-seeking time. As a critical reader you will be able to quickly identify the professional journals, reports, meeting proceedings, and newsmagazines that consistently meet or exceed the publications' purpose and goals and can be trusted to only publish unbiased, accurate, and reliable information. By being a critical reader you will save time and energy by scanning, selecting, reviewing, and interpreting published materials related to professional practice. Finally, as a critical reader you must be cautious about what you accept as truth. You should always be wary of statements that are unsupported by references, and all such statements should be rejected if references are unavailable regardless of who made the statement.

I am pleased that so many dental hygiene publications are now available in print and online. Once upon a time, the *Journal* was the profession's lone publication, and it was difficult for it to be an all-purpose journal without sacrificing its scientific and scholarly purposes. When *RDH* came along in 1981, it was widely welcomed by clinical practitioners because it spoke directly to them through the stories, case studies, and articles they found useful in their practices. Then came *Access* in 1987, designed to provide timely information of interest to dental hygienists in a variety of practice settings and, especially, to inform people of the nationwide political activities affecting the profession and oral health. Since *RDH* and *Access* began, a number of other informational, practice-oriented publications have been introduced, providing more and more choices for dental hygienists interested in continuing to learn. This trend will no doubt continue into the future, with many

more appearing online, rather than in paper format. Each one will serve its own purpose, and there will no doubt be some overlapping of information, which doesn't matter. With more choices, more dental hygienists will be reading. Hopefully, more will be critical readers. That can't help but make the publications better.

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Upfront

Kristen Romanowski

Kristen M. Romanowski is staff editor of the Journal of Dental Hygiene and staff writer for Access

Major Clinical Trial Suggests Alzheimer's Diagnosis May Be Delayed

Patients with mild cognitive impairment (MCI) who took donepezil, a cholinesterase inhibiting drug, slowed the progression of their dementia to an Alzheimer's diagnosis, according to a study funded by the National Institute on Aging.

The purpose of the Memory Impairment Study was to find if donepezil or vitamin E might delay a clinical diagnosis of Alzheimer's in people with MCI and a genetic risk factor for late-onset Alzheimer's disease.

Subjects who took donepezil were at reduced risk of Alzheimer's diagnosis in the first year of the trial. By the end of the three-year study, however, these subjects received no benefit from the drug. Vitamin E was found to have no effect at any point in the study when compared with placebo.

"While the delay in progressing to Alzheimer's disease had a limited effect in this case, it comes at an early stage of memory loss, a critically important time for patients and families hoping that the disease can be held at bay," says Neil Buckholtz, chief of the Dementias of Aging Branch at the National Institute on Aging.

Of 769 study participants with MCI, 212 developed possible or probable Alzheimer's disease within the three years. For the group taking donepezil, the risk of progression to Alzheimer's diagnosis was cut by 58 percent after one year, and by 36 percent the second year. By the end of the study, no risk reduction was shown for this group.

These findings show the possibility for considering donepezil therapy in certain cases. Reported in the April 14, 2005 online issue of *The New England Journal of Medicine*, these findings are the first to suggest that any agent can delay a clinical diagnosis of Alzheimer's disease in people with MCI.

"These findings give me a great deal of hope," Ronald Petersen, PhD, MD, the study's principal investigator, says. "We have not answered the question of whether donepezil reduces the underlying brain changes in Alzheimer's disease, but now we know that for some people, drug therapy did make a real, clinical difference. I think there will be real opportunities in the future to test other therapies for patients with MCI."

Could NSAIDs Protect Smokers from Oral Cancer?

To protect themselves against oral cancer, smokers may want to pick up a new daily habit-taking nonsteroidal anti-inflammatory drugs (NSAIDs). Light to moderate tobacco smokers who took NSAIDs over extended periods of time had a 65 percent lower risk of developing oral cancer than smokers who did not, according to a population-based study on patients from the Norwegian Institute of Public Health and the Norwegian Cancer Registry.

"The use of NSAIDs among smokers protected against oral cancer development," lead study investigator Jon Sudbo, MD, PhD, DDS, says. "The results of a significant reduction in oral cancer risk, particularly in light to moderate active smokers,

suggest that NSAID use may provide anti-carcinogenetic effect while the smokers are subjecting themselves to tobacco insult."

Sudbo and his colleagues in Norway and the United States analyzed health data on 908 subjects, half of whom had been diagnosed with oral squamous cell carcinoma. They considered the use of acetaminophen and six NSAIDs: aspirin, ibuprofen, naproxene, indomethacine, piroxicame, and ketoprofene. All six types of NSAIDs were effective at reducing the rate of oral cancer.

The effect of the NSAIDs was best for those smokers who were considered 30 or less "pack-year" consumers of tobacco. A pack-year of smoking is defined as averaging one pack of cigarettes per day per year. A person who smokes one pack a day for 30 years is considered a 30 pack-year consumer.

But those who smoke three packs a day for ten years, or two packs a day for 15 years, are also considered 30 pack-year consumers. The effectiveness of taking NSAIDs diminished for smokers whose consumption was greater than a 30 pack-year level. Acetaminophen, a non-aspirin pain relief medication, was found to be ineffective at reducing the risk of developing oral cancer among smokers.

These results were presented at the 96th Annual Meeting of the American Association for Cancer Research, in April 2005.

NIDCR Awards Grants for Practice-Based Oral Health Research Initiative

The National Institute of Dental and Craniofacial Research (NIDCR) has awarded \$75 million in grants to establish regional, practice-based research networks that will investigate everyday issues in the delivery of oral health care.

Over the next seven years, each network will conduct 15 to 20 short-term clinical studies to compare different dental procedures, materials, and prevention strategies under a range of patient and clinical conditions. They will also conduct anonymous chart reviews to generate data on diseases, treatment trends, and the prevalence of less common oral conditions.

The goal of the initiative is to build a better evidence base in oral health care. A lack of high-quality research data to guide treatment decisions has led some dentists and dental hygienists to rely on clinical experience alone in some cases, says Lawrence Tabak, NIDCR director.

"What's unique about these networks is they are practice-based," Tabak says. "Practicing dentists and [dental] hygienists will propose and conduct each clinical study in close collaboration with their network colleagues. Thus, the networks will address practical, real-world issues and generate data that will be of immediate interest to practitioners and their patients."

Two years ago, the NIDCR began developing the General Dental Practice-Based Research Networks (PBRN) initiative to expand the evidence base in dentistry. The grants have been awarded to New York University, which will coordinate the East Coast network; the University of Alabama at Birmingham, which will cover the South; and the University of Washington in Seattle, which will oversee the West Coast network. Each network will be a grassroots effort, with 100 or more practicing community dentists and dental hygienists participating in each region.

"Although the PBRNs are located in just three regions of the country, dental professionals in the Midwest, Southwest, Rocky Mountains, or any other part of the country still can get involved," Bruce Pihlstrom, acting director of NIDCR's Division of Populations and Health Sciences, says. "I would encourage dentists and [dental] hygienists who want to get involved to contact the PBRN nearest to them for more information."

Dental professionals may propose clinical studies once the networks are established. The networks will consider each project proposal and, if it considers a project feasible and worthy, will design a study. "The PBRN protocols generally will be short-term studies that involve relatively straightforward procedures," Pihlstrom says. "For example, protocols might evaluate the outcomes of two comparable root canal procedures, third molar extractions, or even different ways of placing a filling. The key is we don't want to overload busy practitioners with tedious, time-consuming protocols that require multiple in-office calibrations. We want to make this as practice and patient friendly as possible."

Extra Pounds Don't Necessarily Lead to Early Death, says CDC

It's no secret that America has a weight problem. Children, adolescents, and young adults today are more overweight than any previous generation in our nation's history. Sixty-five percent of Americans 20 years and older are overweight or obese, and 16 percent of children and adolescents aged 6 to 19 are overweight, according to the latest National Health and Nutrition Examination Survey (NHANES) data.

Research has linked obesity with diseases like diabetes, cancer, heart disease, stroke, and osteoarthritis, to name a few. According to *The Surgeon General's Call to Action to Prevent and Decrease Overweight and Obesity*, obesity in 2000 cost the United States more than \$117 billion in medical and related costs. So, it may have been surprising to some when the Centers for Disease Control and Prevention (CDC) announced that a recent study found that being overweight was not associated with excess mortality. The study, published in the April 20, 2005 issue of the *Journal of the American Medical Association (JAMA)*, found that 87,000 fewer deaths than expected were associated with being overweight.

To estimate the number of deaths associated with body weight in 2000, researchers examined body-mass index (BMI) and mortality rates of U.S. adults participating in the NHANES. BMI is a measure of one's weight to height; 25 or higher is considered overweight by federal guidelines, and 30 and above is considered obese.

The study revealed that those people who were moderately overweight had no greater risk of death than those of normal weight (BMI 18.5 to less than 25). Being obese carried a greater risk of death, but the risk was smaller than previous studies have indicated and appeared to have decreased over time.

The researchers attribute their lower and declining mortality risk estimates to their study methods and to improvements in medical care, especially for cardiovascular disease, the number one cause of death among the obese. Data were taken from nationally representative surveys in which the heights and weights of participants were actually measured, rather than self-reported. The data analysis also accounted for confounding factors like age, sex, race, and tobacco and alcohol consumption.

According to a separate study published in the same issue of *JAMA*, all cardiovascular disease risk factors except for diabetes have decreased at all BMI levels, and the decline appears to be even greater in higher BMI populations. The study found that, over the past 40 years, the prevalence of elevated cholesterol and blood pressure dropped by almost half in all U.S. adults ages 20 to 74, while smoking dropped by about a third. Reductions in the prevalence of high cholesterol levels were most substantial among obese compared to lean individuals. Cardiovascular disease risk factors for obese people have dropped so much, in fact, that they are now lower than those of normal weight people 20 to 30 years ago.

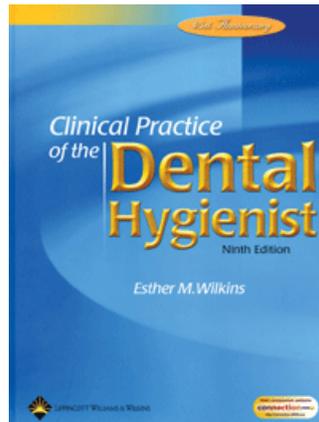
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Review of: Clinical Practice of the Dental Hygienist, Ninth edition

Jacqueline Brian

Reviewed by Jacqueline Brian, LDH, MSED, professor at Indiana University-Purdue University, in Fort Wayne, Indiana.

Clinical Practice of the Dental Hygienist



Ninth Edition

Wilkins EM

Lippincott Williams & Wilkins, 2005

Philadelphia, Pennsylvania

1,024 pages, illustrated, indexed, hardcover

ISBN: 0-7817-4090-8

\$74.95

It is apparent that the ninth edition of *Clinical Practice of the Dental Hygienist* is the "gold standard" for dental hygiene texts. The basic objectives that were in the original textbook some 45 years ago still remain in this latest edition. However, the information has continually been updated to keep current with the extensive scientific knowledge and technical inventions that are so much a part of today's practice.

This textbook is conveniently organized into seven comprehensive sections. Section I orients the reader to the profession of dental hygiene and the dental hygiene process of care. Sections II through VI focus on each aspect of the process of care, including assessment, dental hygiene diagnosis, care planning, and implementation and evaluation. Section VII provides in-depth information on patients with special care needs.

There are four new chapters that provide superb material: "Protocols for Prevention and Control of Dental Caries," "Pediatric Oral Health Care," "Infancy through Age 5," "Family Abuse and Neglect," and "Patients with Respiratory Diseases." Two chapters have been combined and two chapters have been divided to provide more extensive coverage on "Planning Dental Hygiene Care," "Interdental Care," and "Chemotherapeutics and Topical Delivery Systems."

Several incomparable features complement the traditional outline format. Visually, more colorful artwork creates better highlights and draws attention to the essential sections. The use of bullets makes the text much easier to read and not as intimidating. There are 532 illustrations, photos, tables, and boxes that have been strategically placed to emphasize and explain important points.

Another unique feature is the "Everyday Ethics" section which highlights case studies and includes questions that can guide open discussions of everyday situations. This section is very valuable in bridging textbook information with clinical experiences, which helps reinforce learning about the practice of dental hygiene.

Two exciting additions compliment this edition: the student workbook and the instructor's Web site. The workbook was created to give students exercises at different levels, beginning with basic knowledge, continuing through competency, and beyond to discovery. The instructor's Web site includes information not in the text, as well as case studies, quiz questions, PowerPoint slides, and active learning exercises. This Web site has powerful new material and is a wonderful resource for the educator to use to facilitate understanding.

This text far surpasses any comprehensive dental hygiene text on the market today. Its use is essential to keep abreast of evidence-based practice-not only for students, but for practicing dental hygienists as well. Most certainly, this text would be an invaluable asset in the library of any educator or practicing dental hygienist.

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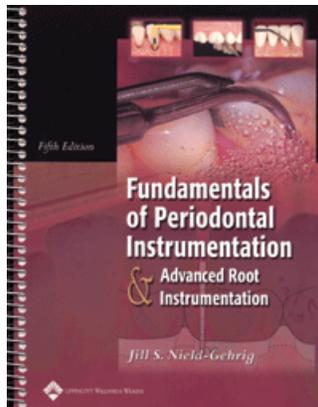
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Review of: Fundamentals of Periodontal Instrumentation and Advanced Root Instrumentation

Diane P Kandray

Reviewed by Diane P. Kandray, RDH, MEd, assistant professor in the Dr. Madeleine Haggerty Dental Hygiene Program at Youngstown State University, in Youngstown, Ohio.

Fundamentals of Periodontal Instrumentation and Advanced Root Instrumentation



5th Edition

Nield-Gehrig JS

Lippincott Williams & Wilkins, 2004

Baltimore, Maryland

640 pages, illustrated, indexed, paperback

ISBN: 0-78-174-606-X

\$58.95

Fundamentals of Periodontal Instrumentation and Advanced Root Instrumentation is an instructional manual for dental hygiene students. This manual may be used to teach periodontal instrumentation to the beginner as well as to the advanced student because of its broad content and progression of the modules. It is definitely an essential textbook for a dental hygiene curriculum.

The text is divided into 26 modules, beginning with basic skills and ending with advanced instrumentation techniques. This book goes beyond instrumentation by including information on evidence-based practice, advanced topics such as

ergonomics, sonic and ultrasonic instrumentation, instrument sharpening, maintenance of implants, and polishing techniques. An instructor resource CD is available by request and contains images and test questions.

Each module opens with an overview, an outline, key terms, and learning objectives. The end of each module contains helpful reference sheets on the content as well as skill evaluation sheets to encourage students to perform self-assessment on their newly acquired skills. Case-based patient exercises are helpful for transferring technical knowledge to the clinical setting. Also included in this new edition is a glossary of instrumentation terms and critical thinking activities.

The numerous color photographs and illustrations are outstanding features. The text uses shaded illustrations to orient the reader to tooth surfaces toward the operator and tooth surfaces away from the operator. Detailed photographs on holding the instrument and using the fulcrum and mouth mirror are extremely helpful. The instructions are equally well presented for the left-handed clinician. The edges of the pages are conveniently tabbed to identify the pages for right- and left-handed clinicians. Detailed photos for operator positioning assist the student and instructor to navigate various positions for instrumentation while maintaining ergonomically correct posture and hand positioning.

While the text is spiral-bound to enable students to use it as a chairside reference while learning instrumentation, the large 8.5 x 11-inch size makes the book somewhat awkward to use. In addition, the author uses the terms "dominant hand" and "nondominant hand" to identify hand positioning in the mouth. Although these terms are meant to differentiate between the hand that holds the instrument and the hand that holds the mouth mirror, the terms may take some familiarization.

The authors' goal was to provide a textbook that makes it simple for students to learn, and easy for faculty to teach, instrumentation. The objective was achieved. This is a very comprehensive, up-to-date guide on periodontal instrumentation. Because of the recent focus on ergonomics and the paradigm shift in the area of gross scaling versus periodontal debridement, this text would also be a valuable guide to practicing dental hygienists.

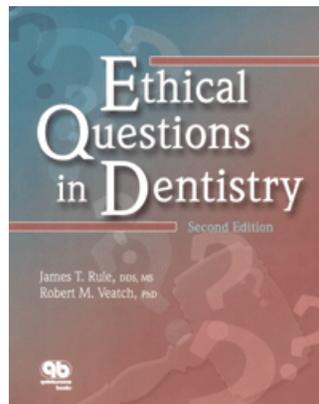
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Review of: Ethical Questions in Dentistry

Judith A McCauley

Reviewed by Judith A. McCauley, RDH, MA, associate professor in the Dental Health Services Department of Palm Beach Community College, in Lake Worth, Florida.

Ethical Questions in Dentistry



Rule JT, Veatch RM

Quintessence, 2004

Carol Stream, Illinois

320 pages, paperback

ISBN 0-86715-443-8

\$32.00

Ethical Questions in Dentistry provides a sound theoretical approach to help sensitize the health professional to the important role of ethics in the dental health field. The text discusses practical issues in ethical reasoning pertaining to dental-related problem solving. This second edition includes an entirely new section about the development of professions and how to understand their structure and function in today's society. It makes frequent reference to dentistry, presenting the traditional, ideal perspective of the profession, as well as views from its critics. Another positive feature of this book is the expansion and modification of case discussions, which are included in all chapters. They include increased background information and additional support in the techniques of ethical problem solving. Readers will find answers to ethical questions and dilemmas that dental health care providers face on a daily basis.

The primary goal of this book is to present ethical problems and suggest approaches to resolving them. It is organized into three parts. Part I discusses major ethical theories and principles, including society's increasing concerns for the maintenance

of ethical standards of all aspects of health-related practice. It also examines how dentists perceive ethical problems and the actual ethical issues faced by dentists, such as quality of care, advertising, and extraprofessional relationships. Part I of this book goes on to look at the history, definition, and characteristics of a profession, which are important elements in understanding the patient-dentist relationship. Ethical principles are discussed, including nonmaleficence, beneficence, justice, and confidentiality—all of which contribute to the foundation of a Code of Ethics that guides the practicing dental health care professional in properly serving the public.

Part II reviews general theories in dental ethics. Its emphasis is on the rights and duties that accompany a dental professional-patient relationship. Since the health professional is supposed to do good for the patient and protect the patient from harm, this part of the book examines what counts as a "dental good" as opposed to a "total good." How high should the standard of care be? What is informed consent, and which patients are competent to make their own decisions? By examining the ethical principles of autonomy, fidelity, veracity, and justice, the authors assist the professional in determining whether an action or practice is morally right or wrong. It includes a practical approach for resolving ethical dilemmas and effective decision-making within a dental practice.

Part III of this book provides current case studies relevant to everyday ethical problems that arise in dental practices. Discussions start with ethical issues that arise during the formative stages of a dentist's professional life and the moral conflicts that arise in the clinical training of the dentist. Included are topics concerning morality in academic life, cultural diversity, protecting the welfare of patients, cheating, and ethics in dental school administration. All of these issues are crucial during the formative stages of the dentist's professional life. Other current topics discussed in this section are third-party financing and ethical principles pertaining to the economics of dentistry, the dentist's relationship with insurers, and setting financial limits. The authors address situations concerning patients with HIV and other bloodborne diseases directly related to the duty to treat the patient fairly, clinical decisions, and the ethics of the cost of dental care. The last chapter of this book addresses the issue of illegal practice and the incompetent, fraudulent, and dishonest practitioner—all very real issues that are present in the practice of dentistry. The ethical applications included at the end of all case studies provide an awareness of the nature of commitments to patients and the profession.

Ethical Decisions in Dentistry accomplishes its goal of providing the reader with the basic fundamentals of ethics and a broad perspective on the types of ethical issues that dentists encounter. Excellent case studies that relate to many dental ethical concerns are presented. This book gives the reader a solid base for ethical reasoning and provides useful guidelines for the resolution of ethical problems.

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Student Retention Practices in Associate Degree, Entry-Level Dental Hygiene Programs

Marianne P Holt

Marianne P. Holt, RDH, PhD, is an adjunct faculty member and instructor at Santa Rosa Junior College, Department of Dental Hygiene, and provides preventive services and periodontal phase-one therapy in private practice, in Santa Rosa, California. She was professor and dental hygiene director at William Rainey Harper College in Palatine, Illinois, from 1983 to 1999.

Purpose. The main purpose of this study was to investigate student retention strategies and practices implemented in associate degree, entry-level dental hygiene programs. Included are student attrition issues, academic standards, re-entry policies, and clinical remediation strategies.

Methods. A survey consisting of forced choice and open-ended questions was mailed to 31 randomly selected associate degree, entry-level dental hygiene programs. Surveys were analyzed using descriptive statistics and frequency distributions. Open-ended questions were analyzed using the constant comparative qualitative method to identify recurring themes.

Results. There was an 80% (n=25) return response to the survey. The findings of this study determined that dental hygiene programs are graduating, on average, a higher percentage (83%) of students when compared to two-year, associate degree programs in general (46%). The primary reasons reported by respondents for student attrition included: academic difficulties (88%), dissatisfaction with career choice (76%), family/personal responsibilities (72%), and clinical skill difficulties (56%). A wide variety of retention strategies were reported. Those most often cited were academic remediation (92%), clinical skill development/remediation (84%), academic advising (84%), financial aid assistance (84%), and tutoring (80%). Participating programs also reported setting high academic and ethical standards. Specific criteria for student re-entry were discussed.

Conclusion. The findings of this study suggest that associate degree, entry-level dental hygiene programs are committed to student retention and make considerable efforts to help students succeed. Student retention efforts could be enhanced for those student groups identified as possibly being at high risk for attrition. The findings and recommendations in this investigation may assist associate degree, entry-level dental hygiene programs in their efforts to retain a higher percentage of students.

Keywords: Dental hygiene education, retention, attrition, academic standards, remediation

Introduction

In post-secondary education, the issue of student retention and degree or program completion has often been a concern among institutional leaders. Colleges and universities expend a significant amount of resources to identify and attract potential students, but if students who enroll do not complete their program, the institution's expenditures on these students become losses. This issue is of special concern in dental hygiene education. Dental hygiene programs are, traditionally,

limited enrollment programs with lockstep, sequential curriculums. If a student does not complete the program, it is generally very difficult to replace that student. Due to accreditation standards and clinical competency criteria, programs traditionally have low faculty to student ratios. Additionally, self-contained patient clinics have high budgetary expenditures.

Given these fiscal realities, it is imperative to maintain full enrollment at all times. The main purpose of this study was to describe retention strategies and practices implemented in associate degree, entry-level dental hygiene programs. Student attrition issues, academic standards, student re-entry policies, and clinical remediation strategies were also investigated. The results of this study would be helpful to dental hygiene education programs in their efforts to both identify potential issues that contribute to student attrition and to identify retention success strategies.

Review of the Literature

Although student retention and completion issues are a high priority in dental hygiene education programs, there is limited research and policy information available in the dental and allied dental literature. Literature on these topics in other general post-secondary education, on the other hand, is prolific. A major portion of completion and retention issues in such post-secondary literature focuses on the empirical research and conceptual models of Vincent Tinto.^{1,2} Tinto's (1975) model suggests that persistence behaviors are largely determined by the student's integration into the social and academic systems of the college.¹ The more a student interacts with an institution, he found, the more likely the student will be committed to staying at the institution. In Tinto's 1987 work, he postulated that the educational institution or program must be committed to each student's success.² According to Tinto, institutional commitment comprises six main actions or principles that lead to successful student retention:

1. Institutions should ensure that new students enter with or have an opportunity to acquire the skills needed for academic success.
2. Institutions should reach out to make personal contact with students beyond the formal domains of academic life.
3. Institutions' retention actions should be systematic in character.
4. Institutions should start as early as possible in efforts to retain students.
5. The primary commitment of institutions should be to their students.
6. Education, not retention, should be the goal of institutions.³

Issues of student retention are sparsely reported in the dental literature. Although minority issues are not specifically the focus of this study, a few dental schools have reported minority retention strategies that may be of value to the review of retention practices in general. Chalkley utilized the six components of Tinto's (1987) model of institutional commitment to investigate minority student recruitment and retention efforts in dental schools. Responses were received from 93% of participating schools. It was determined that an average of only 38% of the 54 participating dental schools included in the investigation demonstrated institutional commitment strategies towards retention. Those strategies most frequently embraced were early efforts to retain students, personal contact with faculty beyond academic life, a commitment to students' education, and systematic retention actions. It was concluded that an increase in institutional commitment would increase the retention of minority students.³

In an effort to increase and maintain minority dental student enrollment, Sinkford, Harrison, and Valachovic identified policy strategies that enhanced student recruitment and retention. These included collaborative efforts with major dental organizations, curriculum changes, and sustained federal funding made possible through legislative incentives.⁴ Additionally, Wadenya, Schwartz, Lopez, and Fonseca reported recruitment and retention strategies of underrepresented minority students at the University of Pennsylvania School of Dental Medicine. Major recruitment and retention efforts focused on leadership, financial support, institutional commitment, and the creation of an inclusive environment. Additionally, retention was encouraged through a mentorship program.⁵

Although Tinto's conceptual model of student persistence has demonstrated predictive validity and is widely accepted in institutions of higher education, the model is not widely supported in two-year, commuter colleges (non-residential), where students travel daily from home to school. Pascarella, Duby and Iverson developed a theoretical model for commuter colleges based on the reconceptualization of Tinto's model.⁶ Institutions were grouped by type (four-year residential, four-year commuter, and two-year commuter) in order to investigate persistence behaviors in commuter colleges. They found that academic integration (variables measured by students' academic activities and college grade point average) is more influential than social integration in commuter institutions. Another variable is the intent to persist or to leave. Students at commuter colleges attend for a variety of reasons, and intention is a good predictor of persistence.⁶

Nippert investigated influences on educational degree attainment in two-year colleges.⁷ She determined that many students attending two-year institutions are often older commuters who attend part-time. These students are environmentally pressed (stressed) with personal, family, and financial responsibilities while attending college. Thus, these students generally have less interaction in the college environment and much greater interaction with the non-collegiate or external environment. Additionally, students in two-year institutions are more likely to be first-generation college students and members of a minority group.⁷ It has been shown that 55% of minority students in public higher education attend community colleges.⁸ Additionally, it has been shown that, in general, only 46% of entering students in two-year colleges will persist over a two-year period to eventually obtain a degree.⁷

Astin found that, for all institutional types, learning, academic performance, and retention are positively associated with academic involvement, positive relationships with faculty, and involvement with student peer groups.⁹ Outcomes are more negative if students are isolated from peers or removed from the campus physically by commuting or being employed off campus. He also found that majoring in a health-related field has positive effects on students' commitment to job-related skills and their chosen professions.⁹ Additionally, Terenzi and Wright conducted a longitudinal, *ex post facto* study of 1,105 freshmen over a four-year period.¹⁰ The results of their study determined that students' perception of academic success was influenced by the frequency and quality of student and faculty formal and informal contact in a variety of settings during the first two years of academic preparation.¹⁰ In addition to contact with faculty for academic purposes, some examples of informal contact with students would be participation in student association activities, receptions, or opportunities to discuss coursework with professors outside of class.

Noel, Levitz, Saluri, and associates have identified attrition themes in which retention efforts can be focused.¹¹ These are especially reflective of two-year, associate degree institutions and the first and second year of baccalaureate programs. These include academic boredom, uncertainty about major and career goals, transition and adjustment difficulties, limited or unrealistic expectations of college, academic under-preparedness, incompatibility, and relevance.¹¹

The purpose of this study was to investigate student retention strategies and practices implemented in associate degree, entry-level dental hygiene programs. The results of this study may give additional insights for student retention strategies in dental hygiene education programs by identifying potential issues that contribute to students at risk. Programs may also benefit from the data regarding academic standard policies, program re-entry policies, and clinical remediation strategies when designing or revising their own policies.

Methods and Materials

The population for this study consisted of a small convenience sample of 31 randomly selected associate degree, entry-level dental hygiene programs. Programs were identified from a 2000 list of 262 accredited entry-level dental hygiene education programs made available through the American Dental Hygienists' Association (ADHA).¹² A survey instrument was developed by the researcher to investigate the retention strategies of the 31 institutions. The survey instrument consisted of 15 forced-choice and open-ended questions. Sections regarding student attrition issues, program re-entry criteria, academic standards, retention strategies, and clinical remediation strategies were included. Anonymity and confidentiality of participants were protected by the use of a random code number assigned to participants for tracking purposes only.

The survey instrument was piloted by a non-participating associate degree, entry-level dental hygiene program. All recommendations for change were incorporated into the survey.

Following completion of the pilot study, surveys with a letter of introduction were mailed on September 29, 2001 to program directors of the 31 randomly selected, two-year, entry-level dental hygiene program programs. On October 21, those programs not responding were contacted by email with a reminder and a second survey as an attachment. Lastly, on November 8, an additional survey was mailed to all outstanding non-responding programs. By November 27, 2001, 80% (n=25) of the surveys were returned. Returned survey data were analyzed using descriptive statistics and frequency distributions. Open-ended question responses were analyzed using the constant comparative qualitative method to identify recurring themes. This method of analysis quantifies and interprets repetitive themes.

Results

The survey revealed that 92% (n=23) of the responding institutions were either community or junior colleges or technical colleges. An associate degree was awarded by 92% (n=23) of the programs, and a certificate by 8% (n=2). Twenty-one programs (84%) were two years in length, with 16% (n=4) requiring three years for completion. Most programs reported requiring prerequisite coursework. Twenty programs (80%) reported scheduling a summer program for a mean of seven weeks in length. The majority (94%, n=24) of programs admitted only one freshman class per academic year with an average of 23 students. Programs were asked to report the number of students who graduated over the last three years. A wide range (50% to 100%) of retention rates was reported, with a mean of 83% graduation rate reported (Table I).

Table I: Background Information

Institutional Type (N=25)		
Community/Junior College	80%	n=20
Technical College	12%	n = 3
Dental School	4%	n = 1
University or College	4%	n = 1
Type of Degree Granted (N=25)		
Associate degree	92%	n=23
Certificate	8%	n = 2
Length of Program in Academic Years (N=25)		
Two-year program*	84%	n=21
Three-year program	16%	n = 4
*many programs also require pre-requisites		
Summer Session Offered (N=25)		
Yes	80%	n=20
No	20%	n = 5
Weeks in Summer Session (N=20)		
Range	2 to 15 weeks	
Mean	7 weeks	
Median	8.5 weeks	
Mode	10 weeks	
Number of Freshman Students Admitted (N=25)		
Range	12 to 36	
Mean	23	
Median	24	
Mode	24	
Average Graduates Over a Three-Year Period (1999-2001) (N=24) (One program was new, with one graduating class)		
Range	50% to 100%	
Mean	83%	
Median	91%	

Student Attrition

From a list of prescribed forced choices, participants were asked to report all the situations that have influenced student attrition in their dental hygiene education programs. An opportunity to report additional attrition issues was also made available. Those situations most often reported were academic underachievement (88%, n=22), dissatisfaction with career choice (76%, n=19), family and personal responsibilities (72%, n=18), and clinical skills not developing (56%, n=14) (Table II).

Table II: Reasons for Student Attrition (N=25)

A. Academic underachievement	88%	n=22
B. Dissatisfaction with career choice	76%	n=19
C. Family and personal responsibilities	72%	n=18
D. Clinical skills not developing	56%	n=14
E. Not adhering to departmental or college policies	36%	n = 9
F. Financial difficulties	28%	n = 7
G. Time restraints due to work commitments	16%	n = 4
H. Cultural issues/conflicts	04%	n = 1
I. Geographic relocation	04%	n = 1
J. Climate of classroom or campus	0%	n= 0
K. Dissatisfaction with program or school choice	0%	n= 0
L. Other – Disability hindered skill development	04%	n = 1

Academic Standards Policy

In a forced-choice format, dental hygiene program directors were asked to report their academic standards policy regarding students' continued retention in their programs. All programs (100%) expected students to maintain a grade of 'C' or better in all dental hygiene courses. One program allowed a grade of 'D' in a non-dental hygiene course while still maintaining full academic status. Respondents were asked in an open-question format to describe what constituted probation in their program. Responses included: earning a grade of 'D' or below, not maintaining an acceptable grade point average (GPA), not maintaining a specific course average, and disciplinary or professional policy violations (Table III).

Table III: Retention Issues

Academic Standards

Must maintain a grade of 'C' or better in dental hygiene courses. Yes=100% n=25

Probation Criteria (open-format themes):

- A grade of 'D' or below
- Unacceptable GPA
- Unacceptable course average
- Discipline or professional policy violations

Re-entry Policies

Possible opportunity to re-enter the program if dismissed	Yes=100%	n=25
Opportunity to repeat course with unacceptable course grade	Yes=100%	n=25
Wait a full term to repeat course with unacceptable grade	Yes=92%	n=23

Conditions for re-entry (open-format themes):

- Reapplication and compliance with admission criteria
- Available space in the following class
- Evaluation and permission from administration or admissions committee
- Adherence to a specific contract or goals and objectives

Conditions for non-reentry to program (open-format themes):

- Not continuing to maintain acceptable GPA
- Continuing poor academic performance
- Ethical issues with patients, self, or peers
- Cheating and academic dishonesty

Re-entry Policies

Respondents were asked to respond to a forced-choice "yes or no" question that asked: "If a student is dismissed from your program due to academic or clinical underachievement, is that student allowed to re-enter the program?" All participants

(100%) reported that, in most instances, students would have an opportunity to re-enter the program. In an open-ended format, the conditions for re-entry were also revealed. Various readmission themes surfaced, including reapplication to the program with compliance to established admission criteria; readmission contingent upon available space in the following class; and consideration for readmission would require evaluation and permission from an administrator, counselor, or an academic committee. Many programs further developed specific guidelines, contracts, or goals and objectives that the student would need to accept and comply with upon re-admittance. In two additional "yes or no" forced-choice questions, all programs (100%) reported that, upon re-admittance, the student would be required to repeat any coursework that was not satisfactorily completed. Additionally, 92% (n=23) of the programs reported students would have to wait a full term to repeat the class(es) in question (Table III).

Participants were asked in an open-ended format to describe the circumstances in which a student would not be allowed to re-enter the dental hygiene program. In addition to not continuing to maintain a specific overall GPA or poor academic performance, denial for re-admittance included ethical violations, such as unsafe, neglectful, or unethical conduct related to patient care, self, faculty, and peers. Additionally, participants reported denial for cheating or academic dishonesty.

Retention Strategies

From a list of 26 possible choices, participants were asked to report all the strategies their dental hygiene program might use to strengthen student retention. An opportunity to report additional retention strategies was also made available. The respondents reported using numerous retention strategies, including academic remediation (96%, n=24), clinical skill development/remediation (84%, n=21), academic advising (84%, n=21), financial aid assistance (84%, n=21), and tutoring (80%, n=20). Those strategies least reported were learning anytime/anywhere technology (4%, n=1), part-time option available (12%, n=3), and distance education/access (16%, n=4) (Table IV).

Table IV. Retention Strategies Implemented (N=25)

A. Academic remediation	96%	n=24
B. Clinical skill development/remediation	84%	n=21
C. Academic Advising	84%	n=21
D. Financial aid assistance	84%	n=21
E. Tutoring	80%	n=20
F. Faculty professional development to enhance learning or management	76%	n=19
G. Academic support Services	72%	n=18
H. Preadmission counseling or program career info. session	72%	n=18
I. Personal/psychological counseling	68%	n=17
J. Early problem identification & goals developed	68%	n=17
K. Prior dental experience or office observations	68%	n=17
L. Disability services	64%	n=16
M. Library and learning resources	64%	n=16
N. Encourage or organized study groups	64%	n=16
O. Availability of faculty, staff and space	56%	n=14
P. Developmental services	44%	n=11
Q. Encourage family support of goal attainment	40%	n=10
R. Mentoring program	32%	n = 8
S. Peer networking	32%	n = 8
T. Encourage involvement in program or campus activities	28%	n = 7
U. Diversity training	24%	n = 6
V. Required prerequisite dental hygiene introductory course	24%	n = 6
W. Distance education/access	16%	n = 4
X. Part-time program option available	12%	n = 3
Y. Learning anytime/anywhere technology	04%	n = 1
Z. Other - community service & volunteering	04%	n = 1

Clinical Remediation

This study also investigated ways in which dental hygiene programs implemented clinical skill development/remediation opportunities for students and how these efforts were funded in the curriculum. In an open-ended response format, most participants reported that clinical remediation was managed with individual, one-on-one instruction to students needing additional assistance with clinical skill development. These remediation instructions were usually conducted during open clinic times or in regularly scheduled clinics. Other responses included small group clinical remediation sessions in open or scheduled clinics, a separate clinical course for skill development, and an independent study for students needing psychomotor skill development.

Program respondents were also asked in an open format if faculty received additional compensation for providing remediation assistance to students. Not all participants thoroughly explained their programs' remuneration policy for student remediation. Of those responding, eight programs stated that faculty did not receive additional compensation. Two programs reported that tutors were engaged and students personally compensate them. For those programs offering a separate remediation course or independent study, students incurred tuition fees, and faculty were compensated according to institutional salary policy.

Discussion

There was an excellent response rate (80%) to this investigation, which helped validate the results of this study. The findings of this study suggest that associate degree, entry-level dental hygiene programs are graduating a higher percentage (83%) of students with a degree than the average two-year institution (46%). These results for dental hygiene education programs reflect a much higher completion rate than reported in the literature for two-year institutions in general.⁷ Several possible reasons for this can be found in the literature. Dental hygiene students usually enter a program with a strong intention to succeed and with generally well-defined career goals.^{9,10,11} Programs are intense, with numerous hours of close faculty and peer contact.^{9,10} Many students attending dental hygiene programs have previous college experience and are familiar with college protocols.¹¹ Additionally, most dental hygiene programs apply selective admission criteria to prospective students, usually resulting in classes filled with high academic achievers.

The primary reasons reported for student attrition in this study included academic and clinical difficulties, family and personal responsibilities, as well as dissatisfaction with career choice. This study suggests that these student groups are at a greater risk for experiencing difficulties or not completing the program successfully. Although dental hygiene programs enjoy a greater completion rate than two-year institutions in general, there are still concerns regarding attrition due to academic and clinical underachievement. As the literature revealed, one reason for this disparity may be the effect of environmental stressors on the non-traditional student.⁷ Many dental hygiene students in two-year institutions are older, with personal, family, and financial responsibilities in addition to their academic career goals. Some students may also have trouble adjusting to high academic expectations and may find themselves under-prepared for the scholastic rigors of the profession.¹¹ It is surprising to learn the high percentage (76%, n=19) of student attrition related to dissatisfaction with career choice. This area reflects uncertainty about career goals and unrealistic expectations.

Numerous strategies are employed by programs to assist students in their efforts to succeed. Those most often reported by respondents were academic and clinical remediation, academic advising, and financial aid. It appears that few programs participating in the survey use strategies for busy, stressed students, such as part-time options or technology that allows students to learn at their convenience.⁷ Those programs implementing clinical remediation strategies reported primarily using one-on-one assistance during prescribed clinic sessions or in open clinics. Most faculty were not compensated additionally for their efforts. A significant portion of students' academic success hinges on acquiring competent clinical skills. The results of this portion of the study paralleled the research of Branson and Toevs, who investigated the remediation policies and procedures in 227 dental hygiene programs.¹³ It was determined that the majority of programs engaged in one-on-one faculty remediation instruction, with most faculty not receiving additional financial compensation. Faculty

met regularly to discuss student clinical progress. These authors recommended that educators apply psychomotor skill acquisition theory to increase remediation effectiveness.¹³

The 31 dental hygiene programs participating in this study appeared to be committed to graduating students with well-developed entry-level competencies. In order to develop competent health care providers, high academic standards were reported by respondents. All participating programs required students to maintain a grade of 'C' or better in all dental hygiene courses, and to repeat the course if not successful. When students earned an unsuccessful grade, they were placed on probation and usually had to wait a full academic year to repeat the course. In addition to not earning a successful class grade, students may be placed on probation for not maintaining an acceptable GPA or for violating discipline or professional policy. These high standards reflect the profession's expectations that entering dental hygienists enter the profession prepared to enhance and promote the total health of their patients. As with other health professions, this expectation is best achieved through the attainment of professional entry-level knowledge, skills, and competencies.^{14,15}

It was further reported that students not completing the prescribed program would, in most instances, be allowed to re-enter the program if space was available. Specific procedures and guideline for re-entry were reported. Instances of student behavior that resulted in not allowing re-entry included continued poor academic performance, academic dishonesty, and unethical conduct. Warman and Weidman, and Westerman, Grandy, Lupo, and Tamisiea investigated attitudes toward cheating in the dental school environment.¹⁹ Six factors influencing cheating were identified: stress, environment, intelligence, personality characteristics, definitions of cheating, and moral judgment. Justifications for cheating were rarely endorsed among dental students. Students in both studies agreed that cheating behaviors should be confronted and appropriate personal responsibility enforced.^{16,17} To be responsible means that one holds oneself accountable according to the institution's policies and standards.¹⁸ Maintaining high standards and ethical behaviors are essential when preparing students to provide quality patient care. *The Code of Ethics for Dental Hygienists* is meant to influence dental hygienists throughout their careers, beginning with the student experience. This professional responsibility places patient welfare before personal gain.¹⁹

Recommendations

Since student retention is generally believed to be one of the best indicators of a program meeting its goal of student success, the literature on student retention offers several recommendations that may be considered by dental hygiene programs to strengthen their student retention efforts. In general, all faculty and staff, starting during the admissions process, should develop a climate of student retention. The first introduction of the student to the college program needs to be as personalized as possible. In addition to sharing information at orientation sessions, faculty are encouraged to give students personalized attention with appropriate interactions. It is recommended that faculty be involved in early student contacts, so as to lay a foundation for faculty-student integration.^{2,7,20,21} This personalized approach needs to be extended into the formal and informal educational experience. It has been shown that the frequency and quality of student and faculty contact is very important for student success.^{2,9,10}

Advising

As discussed earlier, Pascarella et al. found that students attending two-year, commuting institutions are better integrated into the program through their academic experiences rather than social contacts.⁶ Dental hygiene programs should consider helping students to get started on the right path by anticipating and meeting their academic and adjustment needs as they enter.² Immediate and proactive strategies should be used to reach first-year students before they have an opportunity to experience feelings of failure, disappointment, and confusion.¹³ The assignment of a faculty advisor or mentor to meet regularly with students to discuss their needs and concerns is highly recommended.^{5,7,21} These regularly scheduled, two-way communications between students and an assigned faculty advisor should be started early in the students' academic experience and be ongoing throughout their professional preparation.

Students attending two-year, commuter dental hygiene programs can be stressed with personal, financial, and family responsibilities in addition to their academic demands.⁷ Families of dental hygiene students are often unaware of the rigorous academic demands and long clinical hours required to develop competencies. An open dialogue with students' families in the form of activities such as an open house or "family day" can help families understand and encourage students to succeed. Additionally, students experiencing difficulty achieving their educational goals due to personal or family responsibilities might benefit from alternative curriculum strategies. Programs are encouraged to consider developing non-traditional teaching and learning opportunities such as part-time enrollment options, distance education access, and learning anytime/anywhere technology.

Students experiencing financial difficulties should be referred to the campus's financial aid office for personalized assistance and support. It is always considered important to advise students to evaluate their financial needs prior to enrollment in the program, thus helping to minimize any future financial problems. Most dental hygiene programs routinely include pre-admission financial aid information in their admission packet to prospective students.

One major reason frequently reported (76%) for attrition was "dissatisfaction with career choice." Dental hygiene programs may benefit from requiring or recommending that students have prior dental office experience or observations to familiarize themselves with the dental hygiene field. DeAngelis and Goral determined that dental assisting experience was positively correlated with initial dental hygiene clinical performance.²² This suggests that experience does support academic performance and career satisfaction. Additionally, the inclusion of a required prerequisite dental hygiene introductory course for students to become more confident with their career choice could be advantageous. It is also recommended to implement early, high quality, and ongoing advising with caring faculty and staff to assist students with career uncertainty.²³

Academic

Faculty need to create an inclusive environment for students, provide timely feedback about academic performance, and identify quickly those who are struggling academically.²¹ If a student is experiencing academic difficulty, an immediate, individualized approach that is expeditiously implemented should be developed.²⁰ *Collegeways Retention Resources* has developed a retention formula that faculty may want to consider adopting to help students succeed academically: Retention = Early Identification + (Early + Intensive + Continuous) Intervention.²⁴ In addition to an immediate intervention plan for academic concerns, the institution should provide accessible, efficient, and effective support services.

Clinical

Psychomotor skill theory stipulates that the development of dental hygiene skill is facilitated when students know the criteria that define an acceptable performance and product, and when students and faculty can accurately evaluate students' efforts. It is recommended that dental hygiene programs have students self-evaluate the difference between one's desired and actual outcomes. Faculty should provide feedback to guide students in self-evaluation to facilitate psychomotor skills with examples of desired outcomes.^{13,25} If a student requires remediation, the strategies used must meet the specific needs and weakness of the learner. In addition to the clinical remediation strategies identified in this study, additional non-traditional methods recommended include peer tutoring, videotaping, student as observer, interactive computer programs, and faculty serving as patients.¹³ Regardless of the method employed, it is important for the student to use criteria and to accurately self-evaluate. It is also highly recommended that dental hygiene programs develop written policies on remediation that are precisely communicated to students.²⁵

Maximum and lasting retention strategies also require a long-term systematic approach. Exit interviews should be conducted whenever possible to gain potentially valuable insight into the existence of problems that may be impeding student success. A systematic approach to track students from entry until completion of their educational goals will allow programs to identify students who may be experiencing difficulties and employ appropriate intervention strategies. Data collection should be timed to obtain information at different points during the course of a student's education.⁷

The reasons for student attrition can be complex, and it is recommended that additional research in this area be conducted to further explore attrition and retention issues in dental hygiene education. Additionally, the results of this study should be viewed with caution because the sample of participants was small and limited to associate degree, entry-level dental hygiene education programs. Conducting another study that includes a larger sample and four-year, bachelor degree entry-level programs could enhance the validity and reliability. These enhancements would make the results more predictive and generalizable to all dental hygiene programs. It would also be of interest to compare the retention practices and policies between associate and baccalaureate entry-level dental hygiene programs, since the populations in these programs may be different.

Conclusion

This study examined the retention practices and policies in 25 associate degree, entry-level, dental hygiene programs. Although this is a small study, this investigation paints a picture of associate degree, entry-level dental hygiene education programs that are primarily successful in educating, maintaining, and graduating students for careers in the dental hygiene profession. Outstanding efforts were reported to maintain high academic and ethical standards, and to assist students in reaching their educational goals. Further investigating student groups that are at a greater risk for experiencing difficulties or not successfully completing the dental hygiene program could enhance retention efforts. Closely evaluating the reported student attrition issues and correlating them with suggested retention strategies in this study might assist programs in identifying strategies to enhance student retention. Additionally, the findings and recommendations in this study may be helpful to all dental hygiene programs in their efforts to retain and graduate competent, entry-level health care providers.

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Notes

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Web-based vs. Traditional Classroom Instruction in Gerontology: A Pilot Study

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***Purpose.** Numerous studies have documented comparable outcomes from Web-based and traditional classroom instruction. However, there is a paucity of literature comparing these two delivery formats for gerontology courses in dental hygiene curricula. This study examines the effectiveness of alternative methods of course delivery by comparing student profiles and instructional outcomes from a dental hygiene gerontology course offered both on the Web and in a traditional classroom setting.*

***Methods.** Questionnaires were sent to both groups of students completing the course. The instrument was designed to establish profiles of the participating students. The data collected included familiarity with Web-based instruction, extent of prior computer training, previous interaction with the elderly, and student evaluations of course effectiveness. Traditional instructional outcomes from evaluated course work were compared, as were post-course exam outcomes that assessed retention of course information six months after course completion. The statistical significance of these data was determined using Statistical Package for Social Scientists software (SPSS, Inc., version 12.0, Chicago, IL).*

***Results.** A comparison of student characteristics enrolled in the two course formats revealed marked differences. The Web-based group (n=12) included dental hygiene students (67%) and other health care providers (25%). All participants in the traditional classroom format (n=32) were dental hygiene students. Half of the Web-based respondents were over 25 years of age, and the majority (n=8) had previously taken an online course. The majority of traditional classroom students were 25 years of age or younger (n=21) and had never taken a Web-based course (n=20). Statistically significant differences in instructional outcomes were observed between students enrolled in these two formats. Student retention of course material six months after completion of the course was greater in the Web-based format.*

***Conclusions.** Students selecting a Web-based course format demonstrated greater motivation and learning success based on final course grades, completion of assignments, and knowledge retention over time. Age, previous experience with online courses, and selection of teaching mode are factors that may confound course delivery method to influence instructional outcomes in a gerontology course within a dental hygiene curriculum.*

Keywords: Gerontology, Web-based instruction, distance education, dental hygiene education

Introduction

This country's rapidly increasing elderly population, and its diversity, has inspired educators to include the study of aging in many academic and professional programs. This trend is reflected in an increase in gerontology content incorporated into dental school curricula in the United States and Canada.¹ Geriatric education has grown in dental education in recent years, and at least 30% of dental schools surveyed in 2001 planned to expand their existing geriatric curricular content.² When surveyed, a high proportion of dental school senior students believed that geriatric dentistry should represent more hours in the dental curricula.³ Increasing the exposure of students to geriatrics was shown to significantly improve students' self-assessed competencies in geriatric dentistry.⁴

The recognized need for increased exposure of health professionals to gerontology education has prompted the University of Pittsburgh Dental Hygiene Program to include a gerontology course, "Gerontology: Perspectives on Aging," in the core curriculum. The students participating in this study were enrolled in this gerontology course offered in both a Web-based and a traditional classroom format. This upper-level, social gerontology course addresses the processes, effects, and trends of aging in today's society from biological, psychological, and social perspectives. Students relate and apply their specific disciplines through assignments, exercises, and a case study project. The University of Pittsburgh distance education and advanced computer technology services supported the design and delivery of the Web-based gerontology course. The traditional gerontology course was offered simultaneously, with the same content and instructor. The purpose of this study was to compare the effectiveness of a Web-based course with a traditional classroom course, in terms of the instructional outcomes of both formats. The study reported here also compares characteristics of students that might influence their choice of teaching methods and learning outcomes in a gerontology course.

Review of the Literature

A Web-based gerontology course offers a learning environment in which students can participate at different times and places than the course instructor and support staff.⁵ A significant number of today's students must achieve their academic goals while meeting other important personal and professional responsibilities. Because of this trend, teaching gerontology by distance education has been gaining in popularity in recent years.⁶ A description of various approaches to gerontology education using distance learning methods can be found in Schneider et al,⁷ and in Braun, Roberts, Dubanoski, Lenzer, and Goodman.⁸

The distance learning format offers many advantages over the traditional classroom teaching style. Broader course accessibility, increased scheduling flexibility, adaptability for working and part-time students, and less strain on the physical resources of a university have all been reported.^{5,9,10} Yet, the debate continues over the quality of learning achieved by Web-based distance instruction compared with traditional classroom methods.^{5,9,10}

As of 2002, distance education had been introduced into the curricula at 22% of the 255 dental hygiene programs in the United States.¹¹ In 1993, Northcentral Technical College (NTC) in Wausau, Wisconsin, was the first dental hygiene program to provide its entire didactic, non-clinical curriculum online. Olmstead (2002) reported no statistically significant differences between the scores on the National Board of Dental Hygiene Examination (NBDHE) achieved by students taking traditional classroom instruction and students using the distance learning mode.¹² An online course in dental terminology, first developed in 1999 at the University of Vermont Department of Dental Hygiene, has also been assessed. No statistically significant differences were observed between the learning outcomes of students taking the course in a distance learning or traditional approach, although a small sample size limits the validity of this report.¹³

As pointed out by Piercy, it is important that educators choosing to develop and offer a course using Web-based distance methods determine the effectiveness of these formats.⁶ However, the amount of research concerning dental hygiene student performance in distance education is limited. Traditionally accepted measurements of educational outcomes include performances on assignments, class projects, examinations, and final course grades.¹²

It is reasonable to assume that individual student attributes impact learning styles and, thereby, affect instructional outcomes. For example, student levels of maturity, mastery of necessary computer skills, and motivation contribute to successes in learning.¹⁴ Sherry points out that the greater ability students have to handle autonomy and to complete assignments independently, the greater the impact on their mastery of the learning objectives in a Web-based course.¹⁵ Thus, the paucity of literature on the instructional outcomes of gerontology courses offered online highlights the benefit of introducing and evaluating the effectiveness of such courses in dental hygiene curricula.

Methods and Materials

Study Design

This study, which was approved by the Institutional Review Board of the University of Pittsburgh (IRB# 01001105), was designed to compare similarities and differences in student outcomes, learning, and satisfaction in a gerontology course. The same course content was offered both online and in a traditional classroom setting. Baccalaureate degree completion and career entry-level dental hygiene students were allowed to choose their preferred teaching mode. Both courses were taught by the same instructor using the same required textbook and assignments. Student responses to a student profile questionnaire, grades on assignments, student exam results, grades on a case study project, the final course grade, and the result of a content retention review questionnaire were collected and compared. The student profile questionnaire was sent to all students enrolled in each course, along with a description of the project and a self-addressed stamped envelope. The students were asked to complete and return the anonymous questionnaire within 30 days. Compliance with the study and completion of the questionnaire had no impact on the students' course grades.

Data was summarized as means and standard deviations. The statistical method one-way analysis of variance was used to identify the significance of differences observed. The non-parametric test, Wilcoxon Mann-Whitney was used to concur with the study's findings given the non-normal distribution of the data. Analysis was done using Statistical Package for Social Scientists software (SPSS Inc., version 12.0, Chicago, IL). $P < 0.05$ was considered as statistically significant.

Student Profile Questionnaire

The student profile questionnaire was developed to identify any pre-existing variability in experience with computers and Web-based instruction between student groups prior to enrolling in this gerontology course. Specifically, students were asked for their ages, occupational goals, computer competencies, extent of their prior interactions with persons over 65 years of age, formal exposure to the discipline of gerontology, and any prior course work in gerontology. The student profile questionnaire information was compared to identify and distinguish characteristics among the students selecting the different instructional methods. The students were also asked to provide their evaluation of the effectiveness and benefit of the gerontology course that they completed. These responses provided the students' general opinions on the value of the course and its content.

Instructional Outcomes

The coursework assessed consisted of weekly assignment grades, course examination scores, completion of a case study project, and final course grades. The two course examinations consisted of multiple choice and essay questions. The case study was based on an interview with an elderly person to learn about his or her aging experience.

Post-Course Retention Questionnaire

Six months after completing the course, both groups were sent 20 multiple choice review questions to answer and return. The review questions addressed course content on demographics, biological and psychological dimensions, social perspectives, and general terminology used in the text. These results were compared to determine if one method of instruction appeared more effective than the other, based on information retention.

Results

Student Profile Questionnaire

The profile questionnaire response rate was favorable, with 34 of the 44 (77%) returned. The majority of students returned the questionnaire in both the Web-based (n=11) and the traditional classroom (n=23) formats.

All students in the traditional course were dental hygiene students, while 67% of the Web-based students were dental hygiene students. The remaining 25% of Web-based students were in other health care disciplines (Table I). In the traditional course, 66% of the students were between 18 and 25 years of age, as compared to 42% of the students in the Web-based course. A third of the students in the Web-based course were between 26 and 35 years of age, and 17% were between 36 and 46 years of age (Table II).

Table I: Occupation of Students in Web-based and Traditional Classrooms

Future Occupation	Web-based Students	Traditional Classroom Students	Totals
Health Care Provider	3 (25%)	0	3 (7%)
Dental Hygienist	8 (67%)	32 (100%)	40 (91%)
Unknown	1 (8%)	0	1 (2%)
Totals	12	32	44

Table II: Age of Students in Web-based and Traditional Classrooms

Age	Web-based Students	Traditional Classroom Students	Totals
18 – 25 years	5 (42%)	21 (66%)	26 (60%)
26 – 35 years	4 (33%)	2 (6%)	6 (14%)
36 – 46 years	2 (17%)	0	2 (4%)
Unknown	1 (8%)	9 (28%)	10 (22%)
Totals	12	32	44

A majority of responding students in both groups owned computers (Table III) and reported more than three years of experience using computers (Table IV). The similarity of the groups in this regard suggests that neither ownership nor experience using a computer determined the course delivery mode selected by the students. Nearly three-quarters of the students that selected the Web-based format reported experience using the CourseInfo course management system with one or more courses. Fewer than half of the students selecting the traditional classroom mode reported experience with at least one course using the CourseInfo system (Table V). Prior experience with an exclusively online course also influenced the course mode selection. More than half of the students in the traditional course format had never taken a Web-based course, while more than half of the students in the Web-based course had previously taken at least one Web-based course (Table VI).

Table III: Computer Ownership

Computer Owner	Web-based Students	Traditional Classroom Students	Totals
YES	10 (83%)	20 (63%)	30 (68%)
NO	1 (8%)	3 (9%)	4 (9%)
Unknown	1 (8%)	9 (28%)	10 (23%)
Totals	12	32	44

Table IV: Years of Computer Use

Years of Computer Use	Web-based Students	Traditional Classroom Format	Totals
Never	0	2 (6%)	2 (5%)
1 year	0	1 (3%)	1 (2%)
2 years	0	2 (6%)	2 (5%)
3 years	2 (17%)	0	2 (5%)
4 or more years	9 (75%)	18 (56%)	27 (61%)
Unknown	1 (8%)	9 (28%)	10 (23%)
Totals	12	32	44

Table V: Experience with CourseInfo Enhancements

Experience with CourseInfo Enhancements	Web-based Students	Traditional Classroom Students	Totals
None	2 (17%)	16 (50%)	18 (41%)
One Course	7 (58%)	2 (6%)	9 (20%)
Two Courses	1 (8%)	2 (6%)	3 (7%)
Three Courses	0	1 (3%)	1 (2%)
Four or More Courses	1 (8%)	2 (6%)	3 (7%)
Unknown	1 (8%)	9 (28%)	10 (23%)
Totals	12	32	44

Table VI: Experience with Exclusively Online Courses

Experience with Exclusively Online Courses	Web-based Students	Traditional Classroom Students	Totals
None	3 (25%)	20 (63%)	23 (52%)
One Course	7 (58%)	2 (6%)	9 (20%)
Two Courses	1 (8%)	1 (3%)	2 (5%)
Three Courses	0	0	0
Four or More Courses	0	0	0
Unknown	1 (8%)	9 (28%)	10 (23%)
Totals	12	32	44

A majority of students in both instructional formats described their familiarity with the elderly as moderately familiar. More than half of the students in both groups reported at least weekly interactions with persons over 65 years of age. A majority of students in both courses described their exposure to formal gerontology as less than moderate. Most of the students had never taken a course with a gerontology component (Table VII).

Table VII: Prior Experience with the Discipline of Gerontology

Query	Options	Web-based Students	Traditional Classroom Students	Totals
How familiar are you with the elderly?	Not at all	0	1 (3%)	1 (2%)
	To a small degree	0	4 (13%)	4 (9%)
	Moderately familiar	9 (75%)	17 (53%)	26 (59%)
	Very familiar	2 (17%)	1 (3%)	3 (7%)
	Unknown	1 (8%)	9 (28%)	10 (23%)
	Totals	12	32	44
How often do you interact with a person over 65 years of age?	Daily	2 (17%)	3 (9%)	5 (11%)
	Once a week	6 (50%)	13 (41%)	19 (43%)
	Once a month	2 (17%)	7 (22%)	9 (21%)
	Once a year	1 (8%)	0	1 (2%)
	Unknown	1 (8%)	9 (28%)	10 (23%)
	Totals	12	32	44
Prior to this course, how much formal gerontology exposure have you had?	None	4 (33%)	7 (22%)	11 (25%)
	Slight	3 (25%)	13 (41%)	16 (36%)
	Moderate	4 (33%)	3 (9%)	7 (16%)
	Extensive	0	0	0
	Unknown	1 (8%)	9 (28%)	10 (23%)
	Totals	12	32	44
Before this course, how many courses have you taken that included a gerontology component.	None	6 (50%)	17 (53%)	23 (52%)
	One	4 (33%)	6 (19%)	10 (23%)
	Two	1 (8%)	0	1 (2%)
	Three	0	0	0
	Four or More	0	0	0
	Unknown	1 (8%)	9 (28%)	10 (23%)
	Totals	12	32	44

As shown in Table VIII, all of the students reported that the course format they selected was an effective instructional method for this gerontology course. There was a minor difference in opinion regarding the benefit each student derived from the course. While 50% of the students in the Web-based course described the experience as greatly beneficial, 31% of the students in the traditional classroom course considered their experience greatly beneficial and 38% considered their experience moderately beneficial.

Table VIII: Student Evaluations of Course Effectiveness

Query	Options	Web-based Students	Traditional Classroom Students	Totals
Do you agree that the format you elected was effective for this course?	Yes	11 (92%)	23 (72%)	34 (77%)
	No	0	0	0
	Unknown	1 (8%)	9 (28%)	10 (23%)
Totals		12	32	44
How much did you benefit from this course?	Not at all	0	0	0
	Slightly	1 (8%)	1 (3%)	2 (5%)
	Moderately	4 (33%)	12 (38%)	16 (36%)
	Greatly	6 (50%)	10 (31%)	16 (36%)
	Unknown	1 (8%)	9 (28%)	10 (23%)
Totals		12	32	44

Instructional Outcomes

Instructional outcomes were compiled for the two courses to determine possible differences in learning success between the two instructional formats. The criteria considered included letter grades on assignments, a case study project grade,

grades on two examinations, and the final course grade. The mean, standard deviations, and the statistical significances of differences in these instructional outcomes are summarized in Table IX and were derived using a one-way ANOVA test. With the exception of the first exam, a statistically significant difference was observed in student performance between the two instructional formats. Students enrolled in the Web-based format scored significantly higher on the second exam, assignments, the case study project, total final points, and final percent. The final course grades assigned to the students in the two teaching formats revealed that students in the Web-based course had greater success in accomplishing the learning objectives of this course, compared to the students in the traditional classroom course.

Table IX: Statistical Analysis of Outcomes

Variable	Web-based (N=12)				Traditional Classroom (N=32)				Significance (P value)
	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD	
Exam #1	64	92	82.1	7.6	70	97	82.7	6.6	0.885
Exam #2	80	93	88.4	3.6	73	91	83.5	5.33	0.005*
Project	100	100	100	0	85	100	93.6	5.4	<0.001*
Assignments	55	55	55	0	35	55	50.8	6.4	0.028*
Final Points (Total)	317	344	334.7	8.5	285	347	317	14.9	<0.001*
Final Percent	89	97	94.3	2.5	80	98	89.3	4.3	<0.001*

* Denotes significant differences ($P < 0.05$)

Post-Course Retention Questionnaire

Assessment included a measure of post-course retention (Table X). Six months after the completion of the course, each student was mailed a 20-item multiple choice objective test to be returned within the following 30 days. Willingness to participate in the retention exercise, as indicated by the completion and return of the post course test, was generally high for both groups. Most of the students who had taken the gerontology course by the Web and by traditional classroom format returned completed retention tests (75% vs. 78%, respectively). Overall, the response rate was 77%.

Table X: Retention of Course Content Six Months after Course Completion

#Correct Responses/ 20 items	Web-based Students	Traditional Classroom Students	Totals
20 (100%)	0	0	
19 (95%)	1 (8%)	0	1 (2%)
18 (90%)	2 (16%)	3 (9%)	5 (11%)
17 (85%)	4 (33%)	6 (19%)	10 (23%)
16 (80%)	1 (8%)	1 (3%)	2 (4%)
15 (75%)	0	6 (19%)	6 (14%)
14 (70%)	1 (8%)	5 (16%)	6 (14%)
13 (65%)	0	0	0
12 (60%)	0	1 (3%)	1 (2%)
11 (55%)	0	1 (3%)	1 (2%)
10 (50%)	0	2 (6%)	2 (4%)
Unknown***	3 (25%)	7 (22%)	10 (23%)
Totals	12	32	44

***Response rate was 34/44: 9 of the 12 Web-based students returned the post-course test and 25 of the 32 traditional classroom students returned the post-course test.

Retention of information presented in the gerontology course was highest among the students who had taken the course in the Web-based format. All of the responding students in the Web-based course answered 70% or more of the test questions correctly, while 84% of the students in the traditional classroom scored as high (Table X). Eighty-nine percent of the Web-based students who responded answered between 75% and 95% of questions correctly, while only 64% of the traditional class students performed in the same range. The highest score achieved on the review test was a 95%, which was achieved by a student in the Web-based course (Table X).

Discussion

Prior to the report published by Grimes, there were no published descriptions of Web-based courses in a dental hygiene curriculum. Among the courses described by Grimes, no dental hygiene program used distance education methods to teach a gerontology course.^{11, 13} A need for research on student performance in distance learning courses in dental hygiene curricula has been noted.¹² This study provided measures of the instructional outcomes and student perspectives resulting from Web-based delivery of a gerontology course offered to dental hygiene and other health care students.

Student profiles from this study revealed that younger dental hygiene students preferred to take the gerontology course in the traditional classroom format. This choice may reflect past computer experience and/or familiarity with the Blackboard or CourseInfo System used for the Web-based course. The younger students were expected to come to the course with greater computer confidence and experience than the older students. However, the student profiles revealed that the older students that elected the Web-based format had used the computer for a greater number of years and had more experience with online instruction. These latter considerations may have outweighed the initial age-dependent prediction that the younger students would show a greater interest in the online course format. In the University of Vermont Department of Dental Hygiene, four out of 19 students (21%) chose to take a dental terminology course online. No student profiles were given, so factors that may have influenced the online students are unknown.¹³ The student profile data in this study suggest that previous experience with online courses, the online system, and/or general computer use were the most influential factors in choosing between a Web-based or traditional format. The students' life circumstances may have also played a part in the decision. Students in the Web-based course may have been selecting a format to accommodate conflicting adult and professional demands, as well as comfort levels with technology.

Prior experience with the discipline of gerontology covered a wide range in both groups of students. The student profile information revealed that, while 33 % of the students in the Web-based course had at least one previous course with gerontology content, only 19% of the students in the traditional classroom had at least one previous course with gerontology content. Familiarity with the elderly may have been a characteristic that provided a broader knowledge base and, therefore, contributed to the better score by the Web-based students on the test that measured retention of the gerontology course content, rather than the effectiveness of the course itself. Similarly, the applicability and relevance of the topic may have been more apparent to the older students, many of whom were already working professionally.

Thus, the instructional outcomes measured by test scores and graded assignments and projects present a distinction between the effectiveness of the Web-based and the traditional classroom methods of teaching a gerontology course in a dental hygiene program. Although a statistically significant higher level of performance by the students enrolled in the Web-based format was observed, the sample size of this preliminary report limits the strength of the study findings. This observation is not consistent with most reports in the literature, as others have failed to find a significant difference in student performance when comparing distance learning to learning that results from teaching a course in the traditional classroom.^{12, 16, 17}

Grimes asked dental hygiene program directors to indicate their satisfaction with distance education.¹¹ Overall, they were satisfied. This study surveyed the students enrolled in the gerontology course to learn their level of satisfaction with the Web-based vs. traditional classroom formats. Students in both course formats unanimously agreed that the method of instruction they chose was effective. All but one student in each course reported that they benefited moderately or greatly from this gerontology course. The Web-based students were more likely to report "greatly beneficial," as compared to more "moderately beneficial" reported by the traditional classroom students. Interestingly, the Web-based students were also more likely to return the questionnaire than the traditional group.

In spite of the modest differences, it might be suggested that the older students selecting the Web-based course were more likely to have background knowledge on the topic of gerontology and to recognize the relevance and professional applicability of the issues covered in the course, while the dental hygiene students had not yet entered professional practice. Students in both groups were satisfied with their choice of course delivery formats, suggesting that the student's individual circumstances in relationship to the discipline studied determines the most suitable delivery mode for them at any given time. There are both disadvantages and advantages to developing and teaching a course online. Grimes summarized those reported by dental hygiene program directors.¹¹ Experiences of these researchers, and those shared by the students in this study, add to this compilation. A major disadvantage for the instructor is the time and effort expended in the design and development of a Web-based course. Burrow et al. estimated that a basic online course could be developed in six months if release time from other faculty responsibilities was provided.¹⁶ In general, an instructor can expect to devote at least a year to developing a course for distance education, as release time is limited for most faculty. Web-based delivery may, however, reduce the time required for face-to-face meetings with students. Students must have compatible software and computer hardware to access the course material to avoid delays at the beginning of the term. Students electing to take a course online must have the self-discipline to work independently and practice efficient and effective time management. These skills may be more evident with older adult students who also tend to select Web-based instruction.

The advantages of Web-based course delivery include flexible monitoring of work and assignments and flexibility of communicating with students through email and online announcements. Students can also access their grades at any time, if a grade book is incorporated into the software used in the Web-based course. Distance learning has obvious utility for working health care providers completing degree course work. Enrolling in courses offered online may be the only way for some students to continue their educations.

Many health care professionals are treating an increasing percentage of older adults in their practices, but they may have received little, if any, formal training in gerontology while in school. Self-reported surveys of dental professionals revealed that only 17% of dental hygienists and 11% of dentists had a geriatric dentistry course in their dental hygiene or dental curricula. Further, 37% of the dental hygienists and 31% of the dentists attempted to fill this deficiency by taking continuing education courses in geriatrics sometime after graduation.^{18,19} Web-based gerontology courses could help to better prepare these health care providers to meet the special needs of older adults.

These data will be collected over a five-year period, and instructional outcomes and student perceptions will again be assessed. A larger sample size should allow for more reliable and sophisticated statistical analysis. We encourage continued assessment of Web-based instruction, as it interacts with different disciplines, different student populations, and different learning and instructional styles. Identifying institutional and personal characteristics that differentially interact with instructional delivery modes would enhance educators' abilities to optimize instructional outcomes for a diverse student population.

Conclusion

The students choosing a Web-based course over a traditional format were older, had previously taken coursework online, and were familiar with the online system software that supported this course. The scores on measures of instructional outcomes were significantly higher for students enrolled in the Web-based format. In addition, post-course retention was highest among students who had taken the course in the Web-based format. The small overall number of students and the unequal size of the two groups limit the variability within and between groups and, therefore, the validity of these results.

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Notes

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Cross-contamination of the PSP Sensor in a Preclinical Setting

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Purpose. *This study tested an infection control protocol for photostimulable phosphor (PSP) sensors while simulating multiple uses.*

Methods. *Dental hygiene students (n=36) were randomly assigned to a control group (dry wipe) or test group (disinfectant wipe). A sterile, barriered sensor was placed in a peer patient's mouth to simulate an exposure. After simulation, the barriered sensors were disinfected, placed into a new barrier, and inserted into the same peer patient's mouth. Following the fourth placement and treatment, sensors were vortexed in specimen cups containing trypticase soy broth (TSB) and incubated at 37C to detect contamination by oral bacteria.*

Results. *Bacterial growth in TSB was monitored as a change in optical density and by quantitation of oral streptococci on Mitis-salivarius agar. The barrier-protected sensors were minimally contaminated (<10⁵ colony forming units/ml at baseline) regardless of treatment. After culture amplification, the control TSB had more samples that remained negative through 48 hours (5/18 vs. 0/18 for test group, p<0.05).*

Conclusion. *Barrier envelopes used with the PSP sensors appeared to be an effective way of reducing microbial contamination.*

Keywords: Infection control, cross-contamination, barrier-protected sensor, oral radiography, microbial contamination

Introduction

Previous studies on film-based imaging have shown the need to exercise universal precautions in intraoral radiography.¹⁻¹² These findings resulted in a recommendation by the American Dental Association (ADA) and the Centers for Disease Control and Prevention (CDC) for dental health professionals to employ effective disease prevention procedures while providing radiographic dental services.^{1-6, 8-12} Unlike many clinical dental procedures, exposing and processing intraoral radiographs present infection control issues that may not be addressed by standard disinfection and sterilization techniques. Saliva and blood can contaminate a number of surfaces, such as the processor, darkroom surfaces, and radiographic equipment, all of which cannot be easily sterilized or disinfected.^{4, 5, 11, 13} Thus, the prevention and elimination of contamination is necessary for both the radiography operatory and darkroom. In 2001, Bartoloni published infection control recommendations for intraoral film-based imaging, which included wiping the saliva from the film with a paper towel, wearing gloves when opening film packets in the darkroom, using barriers on equipment and film, disinfecting surfaces,

and sterilizing film holders to decrease cross-contamination.¹⁴ Recent protocols have employed one or more of these suggestions, with some techniques being more effective than others in reducing contamination when using conventional dental film.^{2,3,7,9,10,13,15}

The Organization for Safety and Asepsis Procedures (OSAP) also published infection control recommendations to guide the use of surface disinfectants.²¹ OSAP recommended that surfaces be disinfected by a two-step cleaning and disinfecting process referred to as the "spray-wipe-spray" technique. In this technique, any contaminated surface is sprayed with an appropriate surface cleaner, wiped clean, and subsequently sprayed with disinfectant, which is allowed to remain in contact with the contaminated surface for disinfection according to the product's recommendations. For effective surface disinfection, this technique (surface cleaning with subsequent disinfection) must follow the two-step sequence for the indicated contact time in order to eliminate microorganisms from contaminated surfaces.

Through advancements in technology, film-based imaging is slowly becoming an imaging technique of the past, and digital imaging is emerging as the new standard of practice for dental radiographic imaging. This evolution has created new infection control concerns because, unlike film-based imaging, intraoral digital image sensors are used repeatedly from patient to patient. This, in combination with the inability to heat-sterilize the digital sensors, increases the risk of cross-contamination.¹⁶⁻¹⁹ Therefore, a new challenge-preventing cross-contamination when using digital sensors for intraoral radiography-has been created.

To date, three articles and one abstract have been published that address cross-contamination with digital sensors.^{16-18, 20} Common infection control issues addressed in these studies included the inability to sterilize the sensor, difficulty tearing the barrier envelope, and the accidental contamination of the sensors when removing them from the barrier envelope.

The earliest documented study was conducted by Wenzel et al.¹⁸ His concern involved the potential contamination that may occur with the repeated use of the sensor among patients. This investigator hypothesized that the sensor became contaminated when removed from the barrier envelope.¹⁸ One method he tested was to remove the sensor from the barrier envelope and the plastic sheath using sterile tweezers. The procedure was evaluated using both the charged coupled device (CCD) and photostimulable phosphor (PSP) digital sensors. His results indicated that bacterial contamination posed a minor problem in both radiographic procedures.¹⁸

In a second study conducted in 2000, Hockett et al. evaluated the presence of barrier tears after use with a CCD sensor.¹⁶ Results indicated that perforations occurred in 44% to 51% of the plastic sheaths. The author stated that tears may have occurred when placing or removing the CCD sensor from the plastic sheath, causing perforations to occur. When a finger cot was used in conjunction with the plastic sheath to cover the sensors, significantly fewer perforations of the sheath occurred (approximately 6%).¹⁶

In 2000, an additional study conducted by Hubar et al. evaluated six possible ways to insert a CCD receptor covered by a plastic sheath into various film holding devices.¹⁷ Results from this study indicated that four of the six barrier systems exhibited 6% to 83% perforations. The two barrier systems that did not exhibit any perforations were the XCP. that was covered with the plastic sheath only and the plastic sheath in conjunction with the Snap-a ray.¹⁷ Unlike Hockett's study, the sensor used with the finger cot exhibited 5% to 55% perforations.

A published abstract by Peterson et al. also addressed cross-contamination with intraoral digital sensors.²⁰ In this study, the infection control effectiveness of using a barrier envelope and alcohol wipe with a PSP sensor was evaluated. The results indicated that 100% of the sensors were culture positive on *Mitis-salivarius* broth (MSB), with 25% of the disinfected sensors being positive. Results indicate that the manufacturer's recommended protocol for infection control was not adequate for eliminating contamination.

To date, only four studies have been published that address infection control with digital intraoral sensors.^{16-18, 20} Of these four studies, two investigated contamination of PSP sensors. In both studies, the experienced principal investigator solely performed the infection control procedures that were tested, thus minimizing the contamination variability of the sensors.

Wenzel et al. focused on finding a technique that would eliminate the sensor from touching the barrier envelope. On the other hand, Peterson et al. used the manufacturer's recommendation of an alcohol wipe to clean the PSP barrier envelope, but conducted the study in a laboratory setting. Though both studies have researched ways to minimize contamination, none have assessed the effectiveness of infection control techniques in a simulated clinical environment using the PSP sensor multiple times. Therefore, the purpose of this study was to evaluate an infection control protocol for the PSP digital sensor while simulating multiple uses.

Methods and Materials

Sample Population

The sample population consisted of 36 first-year dental hygiene students enrolled in a pre-clinical radiology course at the University of North Carolina at Chapel Hill. Prior to the study, subjects were required to demonstrate a minimum technical competency level when exposing a film-based full mouth series on a DXTTR manikin (DENTSPLY Rinn) using both XCP and Stabe film holding devices. Two film holding devices frequently used in clinical practice were employed in the study: the extension cone paralleling (XCP) (DENTSPLY Rinn, DENTSPLY International) device, and the Greene Stabe (DENTSPLY Rinn) disposable film holding device. The XCP film-holding device, which is made of plastic, aligns the beam to the receptor. The Stabe device, which is made of Styrofoam, does not align the beam to the film. Due to a limited number of radiographic operatories, the study was conducted on two separate days. Prior to the start of the study, subjects participated in an informational session on the clinical use of PSP sensors followed by a demonstration of the placement of the PSP sensor into the manufacturer barrier envelope.

The digital sensors used in the study were the PSP Size 2 DenOptix imaging plates made by DENTSPLY Gendex (DENTSPLY International, Gendex Division). These were comparable to the size and shape of a Size 2 conventional dental film. Each sensor was sterilized prior to its initial use in the study using ethylene oxide and placed aseptically into a barrier envelope. The barrier envelopes used were Size 2 DenOptix Barrier Envelopes (DENTSPLY Gendex, Gendex Dental X-ray Division, Dentsply International) designed for use with the digital sensors. Two infection control protocols were used in the study: the control group wiped the barrier-enveloped sensor with a dry paper towel prior to opening the barrier envelope, and the test group wiped the barrier-enveloped sensor with a dry paper towel and subsequently wiped the barrier envelope with a Prophene (O-phenylphenol) plus disinfectant-sprayed paper towel prior to opening the barrier envelope. The protocol used for this study was reviewed and approved by the University of North Carolina at Chapel Hill School of Dentistry Committee on Research Involving Human Subjects.

Preclinical Procedure

The 36 subjects were randomly assigned to one of two treatment groups. Eighteen were assigned to the control group (wipe barrier envelope with dry paper towel), and 18 were assigned to the test group (wipe barrier envelope with dry paper towel followed by the Prophene plus wipe). Each subject was given a coded paper cup containing a sterile barrier-enveloped sensor. Students were paired as patient and operator to simulate placement of four intra-oral radiographic projections (two anterior and two posterior projections). Written instructions were provided to each subject specifically outlining the infection control steps that were to be used based on the treatment group assignment. Subjects were advised to read the directions prior to the process and follow the specified directions. Due to the insufficient number of XCP film holding devices, Group 1 (control) used the XCP and Group 2 (test) used the Stabe film holding device.

The barrier-enveloped sensors were placed in the film holding device and inserted into the peer patient's mouth to simulate the radiographic exposure with tubehead alignment. No radiation exposure of the sensor occurred. After simulation, the barrier-enveloped sensor was wiped using the assigned infection control protocol and placed in a clean paper cup. Group 2 (disinfectant) needed two cups for this step: one for the dry-wipe step and the other for the disinfectant-wipe step. Subjects then removed their gloves, washed their hands, and donned clean gloves. With clean gloves, subjects tore the barrier envelope at one end and aseptically dropped the PSP sensor from the barrier envelope into another clean paper cup. Finally, student operators removed their gloves, washed their hands, donned clean gloves, and aseptically inserted the same sensors into clean, unused barrier envelopes for placement into the subjects' mouths for the subsequent simulated projection. This

process took place for all four simulated projections performed on the peer partner. On the fourth sensor placement projection, the barrier-enveloped sensor was treated again according to the assigned infection control protocol, but was not removed from the sealed barrier envelope. Each barriered sensor was placed in a coded paper cup with each subject's number and was transported to the laboratory for analysis.

Laboratory Procedures

With clean, gloved hands, the principal investigator removed each PSP sensor from the hand-torn barrier envelope following standard infection control procedures. Each PSP sensor was dropped into a sterile 110 ml specimen cup (Becton Dickinson Labware, Franklin Lakes, NJ) containing 50ml of trypticase soy broth (TSB). The cups were labeled with each subject's number and all lids were secured. Sterile cups were vortexed (mechanically mixed with liquid moving in a circular motion) for 20 seconds and assessed for visual turbidity by the principal investigator. Discernible cloudiness was observed, and the extent of turbidity was estimated on a positive (+), not sure (+/-), and negative (-) scale at 0 time (baseline), 24, and 48 hours. Since this procedure was not limited to oral *streptococci*, ten 1 volumes of culture supernatants were removed with a sterile pipette initially at 0 time and subsequently at 24 hours and spotted on *Mitis-salivarius* (MS) agar (Difco) for colony forming units (CFU). The plates were incubated in a CO₂ incubator at 37C until the CFU of oral *streptococci* were counted.

In addition, at 0, 24, and 48 hours, 100l volumes of TSB from each sample were pipetted into a 96-well microtiter plate in quadruplet. The microtiter plate reader was a spectrophotometer (Molecular Device Corp., CA, VMax kinetic microplate reader) that measures the amount of light (wavelength=660nm) transmitted through each volume as a measure of the absorbance ($A_{660\text{nm}}$). Its function was to detect the growth of all types of bacteria that could grow aerobically at 37C and, unlike MS agar, was not limited to oral *streptococci*.

Follow-up Survey

A week after the study, subjects were placed in a classroom and asked to complete a five-item, open-ended questionnaire that inquired about the use of the PSP sensors in regards to the infection control procedures (Figures 1, 2, 3 4). The principal investigator distributed the survey, with directions on how to complete the survey written at the top of the page. The purpose of the questionnaire was to explore the subjects' experiences and perceptions during the implementation of the infection control protocol.

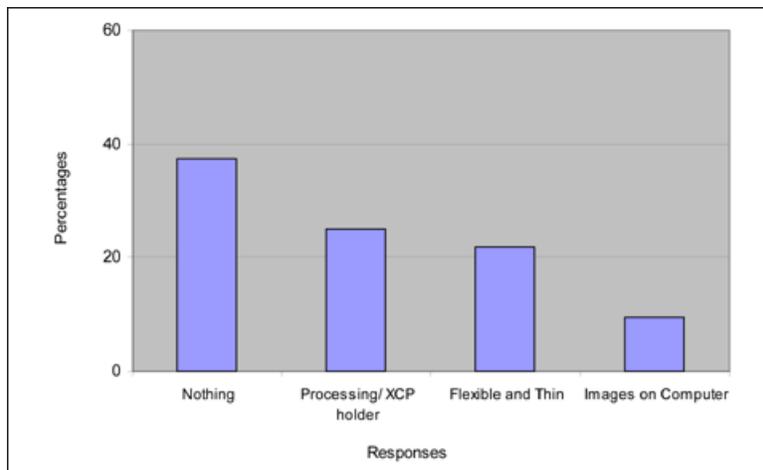


Figure 1: Responses of students when asked: "What did you like most about using the PSP sensor?" (N=32)

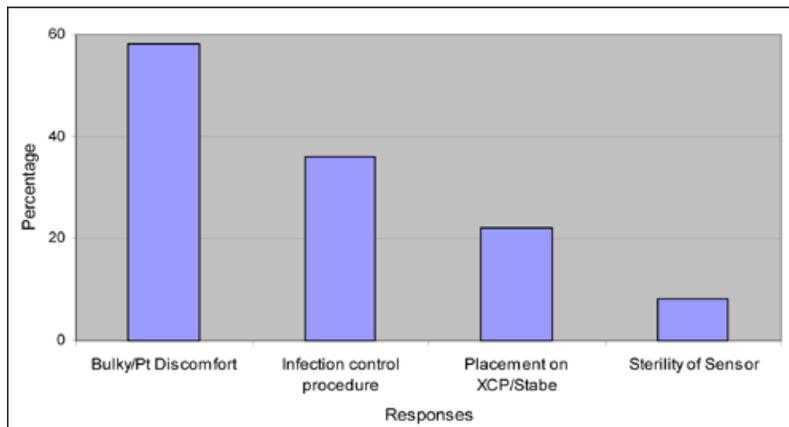


Figure 2: Responses of students when asked: "What do you like least about the PSP sensor?" (N=36)

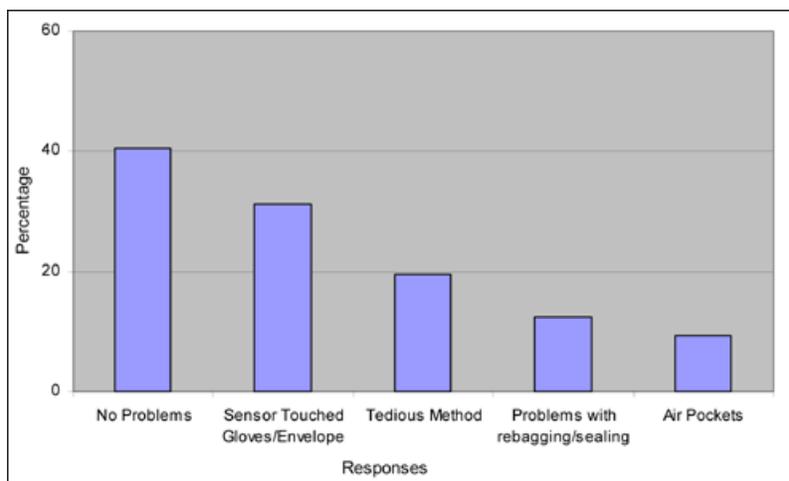


Figure 3: Responses of students when asked: "Describe any problems with infection control procedures." (N=32)

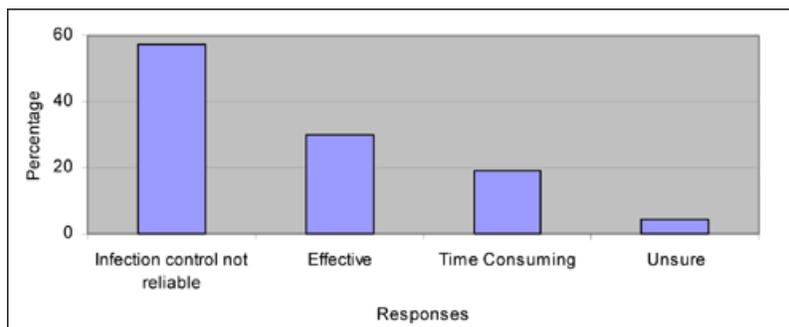


Figure 4: Responses of students when asked: "What was your perception of the infection control protocol used on the PSP sensor?" (N=32)

Statistical Analysis

Visual turbidity is a categorical variable and has meaningful order (-1, 0, 1); therefore, a Mantel-Haenszel chi-square test was performed to determine statistical significance. For optical density and *streptococci* plating, the data did not follow a normal distribution. Therefore, a nonparametric method was applied. A Mantel-Haenszel chi-square test was used to

determine if any statistical difference was observed between groups at each time point. Subject questionnaires were analyzed using frequencies.

Results

A total of 36 first-year dental hygiene students participated in this study, achieving a 100% participation rate. Characteristics of the study population for the dry and disinfectant groups were as follows. Of the 36 subjects in the study, 34 were female and two were male, with 18 females for the dry-wipe group, and 16 females and two males for the wet-wipe group. Twelve of the subjects, seven from the dry-wipe group and five from the disinfectant group, were dental assistants prior to entering the study. All study participants demonstrated the minimum competency performance level of 86% when exposing radiographic film using the XCP film holding device and the Stabe film holding device.

Table I shows the subjective measurement of visual turbidity of PSP sensors from baseline to 48 hours. At baseline, neither group demonstrated a positive visual turbidity test ($p=1.00$). After 24 hours of incubation, Group 1 (dry-wipe) had 27.8% positive sensors, and Group 2 (disinfectant) had 22.2% positive sensors, but no statistically significant difference was found in visual turbidity between groups ($p=0.625$). When examined after 48 hours, bacterial growth was evident by the increased turbidity that had occurred in almost all of the samples. In the dry-wipe group, 72% of the digital sensors resulted in discernible growth in TSB, and in the disinfectant group, 100% of the sensors resulted in visible bacterial growth. The apparent increase in contamination in the disinfectant group approached, but did not reach, significance ($p<0.06$).

Table I. Bacterial growth was assessed as an increase in visual turbidity after incubation of the PSP sensors in TSB for 24h and 48h at 37°C. There was no detectable turbidity immediately after vortexing in any of the samples tested (Baseline).

Time	Group	No Turbidity (-)	Not Sure (+/-)	Positive (+)	Total	P Value
Baseline	1 (Dry)	18	0	0	18	$P=1.00$
	2 (Disinfectant)	18	0	0	18	
Total		36	0	0	36	
24 hours	1 (Dry)	9	4	5	18	$P=0.63$
	2 (Disinfectant)	11	3	4	18	
Total		20	7	9	36	
48 hours	1 (Dry)	4	1	13	18	$P=0.06$
	2 (Disinfectant)	0	0	18	18	
Total		4	1	31	36	

Aliquots of the TSB were sampled at 0, 24, and 48 hours after incubation at 37 C, and the optical densities at 660nm were determined in microtiter format. An $A_{660\text{ nm}} > 0.10$ is visually detectable and was considered positive. Table II presents the contamination status of each sample by time after incubation of the TSB samples. As with visual turbidity, all of the sensors were negative at baseline for bacterial growth. After incubation for 48 hours, five of the 18 dry-wiped sensors remained negative. In contrast, all of the wet-wiped sensors achieved $A_{660\text{ nm}} > 0.10$ by 48 hours. A sensor sample that failed to show a change in optical density at 24 hours but became positive at 48 hours was indicative of less contamination than with a sample that was positive at both 24 and 48 hours. The dry-wipe group consistently had lower sensor contamination than the disinfectant group over 48 hours. The bacterial contamination differed among groups ($p=.02$).

Table II. Bacterial growth was monitored by measuring optical density at 660nm of the TSB containing the PSP sensors at day 0, 1 and 2 after incubation at 37°C. All samples were negative at baseline (0 hour). $A_{660nm} > 0.10$ was considered positive.

Group	Negative at 48h	Negative at 24h, but positive by 48h	Positive by 24h	Total	P Value
Group 1 (Dry)	5	7	6	18	$P=0.02$
Group 2 (Disinfectant)	0	6	12	18	
Total	5	13	18	36	

The change in optical density in TSB would be indicative of any bacterial contamination. A primary concern of the current study was the extent of bacterial contamination that could be attributed to the oral flora. In addition, an increase in optical density is relatively insensitive, requiring a density of $>10^7$ CFU/ml to be considered positive. The fact that optical densities increased after incubation (amplification) for 24 and 48 hours suggested that there was a low level of contamination that was not detectable by optical densities at baseline. Oral *streptococci* dominate the microbial flora of the oral cavity and of saliva and would not be expected as an environmental contaminant. *Mitis-salivarius* agar is selective for oral streptococci and does not permit the growth of environmental contaminants. Table III shows the numbers of TSB samples containing oral *streptococci* between the dry and the disinfectant group at baseline and 24 hours of incubations of the TSB. Only 22.2% and 5.56% of the respective groups (dry-wipe and disinfectant-wipe) had detectable CFU on initial plating. None exceeded 104 CFU/ml. These differences were not significant ($p=0.337$). Following 24 hours of incubation, 38.9% of the samples from the dry-wipe group had no detectable CFU. In contrast, 100% of the sensors from the disinfectant-wipe group had detectable CFU, resulting in statistical difference between groups ($p=0.05$).

Table III. TSB samples containing PSP sensors were plated at time 0 (Baseline) and after 24h incubation for quantitative recovery of oral *streptococci* colony forming units (CFU)/ml on selective MS agar. The limit of detection was 100 CFU/ml.

Incubation Time for TSB	Negative <100 CFU/ml	Positive <10 ⁵ CFU/ml	Positive >10 ⁵ CFU/ml	Total	P Value
Baseline 0 hr					
Group 1 (Dry)	14	4	0	18	$P=0.34$
Group 2 (Disinfectant)	17	1	0	18	
Total	31	5	0	36	
Day 1 24 hr					
Group 1 (Dry)	7	5	6	18	$P=0.05$
Group 2 (Disinfectant)	0	9	9	18	
Total	7	14	15	36	

Figures 1 through 4 show subjects' responses to the questionnaire related to the use and disinfection of the PSP digital sensors during preclinical use. Due to multiple responses given by subjects for each question, the percentages may be higher than 100%. In Figure 1, subjects were asked what they liked most about using the PSP sensor. Twenty-five percent ($n=8$) indicated processing/XCP. film holding device used with the sensor, 21.9% ($n=7$) indicated the flexibility and thinness of the sensor, and 9.4% ($n=3$) stated that they liked to view the images on the computer. The remaining 12 subjects indicated that there was nothing they liked about using the PSP sensor.

In Figure 2, subjects were asked to state what they liked least about using the PSP sensors. Almost 60% (n=21) of respondents stated that, when placed inside the mouth, the sensor was bulky and uncomfortable for the patient. Another 36% (n=13) felt the infection control procedure was excessive, had too many steps, and took too much time. A smaller portion of the respondents did not feel comfortable with the sterility of the sensor (n=3) and felt that the sensors did not fit well on the film holding devices (n=8).

Subjects were then asked if they had any problems when performing the infection control protocol. The most frequent response, given by 40% (n=13) of the subjects, was that no problems occurred with following the infection control protocol, while 31% (n=10) stated that at one point the sensor touched the barrier envelope and/or gloves. A smaller group of respondents (n=7) commented that the infection control protocol they were assigned had too many steps to follow and, therefore, produced more work in preventing contamination of the sensor. The remaining seven subjects replied that they had a problem with re-inserting and sealing the sensor into the barrier envelope for fear that the sensor would fall on the countertop or create air pockets that could cause a problem when placing the sensor in the film holding device.

Lastly, in Figure 4, subjects were asked to describe how they perceived the infection control protocol used on the PSP sensor. Perceptions deviated into two major groups: 55% (n=18) of the subjects indicated the infection control protocol was not reliable in clinic, while 30% (n=10) felt the infection control protocol was effective in reducing contamination of the sensor. A smaller number of respondents felt the procedure was time consuming (n=6), and 3% (n=3) were unsure about the procedure and felt that more research was needed to determine if the infection control techniques used with the sensor were reliable in clinic. Subjects were also asked if they had any tears in the barrier envelope when removing the sensor from the oral cavity. Ninety-seven percent (n=32) stated they had no tears, while 3% (n=4) experienced tears.

Discussion

The transition from conventional film to intraoral digital sensors has created a new challenge to preventing cross-contamination in the dental setting. The purpose of this study was to test an infection control protocol for PSP digital sensors while simulating multiple uses in a preclinical setting.

In the study, when examining the PSP sensors for visual turbidity, discernable cloudiness was exhibited after 24 hours. Bacteria appeared to be present with nine of the 36 sensors (25%), but by 48 hours, 31 out of the 36 sensors were contaminated (86%). This result was validated by evaluating bacterial presence using optical densities. After incubation for 48 hours, 31 out of the 36 were contaminated (86%). Because optical density is not specific by bacterial type, the digital sensors were plated on MS agar to determine the presence of oral streptococci. The results of the plating concurred with the previous visual turbidity and optical density findings. By 24 hours, 61% of the sensor treated with the dry wipe and 100% of the sensors treated with the disinfectant wipe were contaminated with oral streptococci bacteria.

The results of this study create four issues for discussion. First, all the PSP sensors became contaminated with both infection control techniques after multiple uses. Two weeks prior to the study, subjects heard a lecture and observed a demonstration on how to remove sensors from the barrier envelope, but were not given the opportunity to practice the technique. Therefore, these inexperienced clinicians had never disinfected, torn, re-bagged, or placed the PSP sensor in a film holding device prior to participation in the study. The lack of experience resulted in four of the barrier-enveloped sensors not being sealed when they were removed from the cup for laboratory analysis. Because barrier envelopes were not sealed, infection control procedures may not have been followed correctly, which might explain the contamination found with the dry and disinfectant wipe. An alternative approach would be to calibrate the subjects before conducting the study to reduce the risk of error in infection control techniques used in the study. Despite this weakness in the study, the bacterial levels found in the study were low. Therefore, the barrier envelope proved to be an effective mechanism in reducing the amount of bacterial contamination on the PSP sensor. Even at 48 hours, the growth apparent on the sensors was low (10^8 CFU).

Another possible reason for the contamination of sensors with both infection control techniques may have resulted from perforations in the barrier envelope. In the questionnaire given to subjects one week following the study, subjects were asked if they had experienced any tears in the barrier envelope, and 5.6% indicated that they had. In contrast, in the Hubar et al. study, perforations occurred in 83% of the plastic sheaths.¹⁷ The difference in these findings between the studies

could have occurred because of the one week that lapsed between the preclinical experience and the questionnaire administration. Students' responses may not have accurately reflected what occurred in relation to the perforations.

A third point that can be summarized when examining the results of the study was that the dry-wipe group appeared to be more effective in preventing cross-contamination of the PSP digital sensor than the disinfectant-wipe group. Upon closer examination, these results may have occurred because the prophene was not used as a surface disinfectant (i.e. the disinfectant did not remain on the surface of the packet an adequate length of time to kill the bacteria). Prophene disinfectant, which is derived from phenol, is effective in killing bacteria on a variety of surfaces because it attacks and deteriorates the bacterial cell wall. For this to occur, the barrier envelope must initially be cleaned by spraying and wiping to reduce bioburden, then disinfected by reapplying the disinfectant and allowing the chemical to sit for at least 10 minutes on the contaminated surface to air dry.²¹

Regarding the study protocol, the disinfectant did not dry on the surface of the barrier envelope for 10 minutes. Instead, subjects immediately tore the barrier envelope after using the disinfectant as a cleaning agent. Because the surface of the barrier envelope may have still been wet, the barrier may have been more difficult to open, causing subjects to touch the sensor with contaminated gloved hands. In the questionnaire completed by each subject, almost 40% reported that the barrier envelope and gloves touched the digital sensor. Because residual saliva could have been left on the barrier envelope and/or gloves, cross-contamination of the sensor could have possibly occurred.

The results of the questionnaire concurred with Packota et al., who tested a one- and two-wipe method to disinfect conventional film.¹⁵ In the one-wipe method, test packets were wiped with a piece of sterile, moistened complex phenol solution followed by a dry paper towel, while the disinfectant was still wet on the surface. In the two-wipe method, the test packets were wiped with a dry paper towel to remove visible debris, then wiped again with the disinfectant and allowed to dry on the surface. Packota et al. discovered that the two-wipe method grew no bacteria, while the one-wipe method did. He stated that leaving the chemical disinfectant on the surface to air dry may eliminate any remaining organisms.¹⁵

Another explanation for the findings might be that, because the disinfectant was not given the opportunity to air dry, the wet solution on the surface of the film packet could have increased the spread of microbes and provided viable living conditions for the bacteria. Furthermore, the mixing of the disinfectant chemicals was not standardized. This may explain why the wet-wipe group was not effective in reducing microbial contamination. Differences in concentration of the disinfectant mixtures could have caused some solutions to be less potent than others. Also, the amount each subject sprayed on the paper towel to disinfect the barrier envelope was not standardized. To eliminate the variability in spraying a paper towel, a previous investigator submerged the packets into the disinfectant for approximately 60 seconds and then allowed them to air dry.⁴

Although the results of the study found contamination on both sensors, the amount of bacterial growth was minimal at baseline and 24 hours. If the disinfectant was not applied as a tuberculocidal agent, then one would have expected the bacterial contamination to have been prominent on all of the sensors, which was not indicated in the results. Sensors had >10⁸ bacterial growth only after sensors were amplified during incubation.

The results of this study suggest that radiographers should re-evaluate their infection control protocol for the use of intraoral digital sensors. Considerations should be given to the use of a dry-wipe over a wet-wipe procedure. Although sensors became contaminated with both infection control techniques, the bacterial load was less in the dry-wipe group after 24 hours of incubation. These findings were supported by the questionnaire data that revealed that half of the subjects believed the infection control procedures were unreliable. A questionnaire response revealed that subjects felt that the wet-wipe required too many steps and believed steps could be easily skipped or not followed correctly, causing cross-contamination to occur. Limitations to the study can be related to the study population. Although subjects were randomized into two test groups, the population was not stratified by mean average of radiographic competencies, prior dental assisting experience, or male to female ratios. Another possible weakness to the study was that more subjects were present on day one of the study than were on day two. Furthermore, due to the lack of XCP instruments, half of the subjects used the Stabe) for the study, resulting in differences between both study days. The results of this study are confined only to this study population.

Conclusion

The effectiveness of two infection control techniques was tested with cross-contamination of the PSP digital sensor occurring with both techniques. Though contamination was evident, the amount of bacterial contaminants was low. However, it appeared that the dry-wipe method was more effective in reducing the risk of bacterial contamination of the PSP sensor when compared to the disinfectant wipe. The question still remains as to whether barrier-enveloped sensors treated effectively with a surface disinfectant will eliminate cross-contamination with multiple uses of the digital sensors. Additional research needs to be conducted to evaluate the most effective infection control procedure and to develop an appropriate protocol for use of PSP sensors.

Acknowledgements

Notes

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Identification of a Giant Cell Fibroma

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Fibrous hyperplastic connective tissue lesions are common in the oral cavity and may be similar both clinically and histologically. A giant cell fibroma, a type of fibrous hyperplasia, was discovered during a preventive patient visit in the dental hygiene clinic at a Midwestern university. The patient, a 19-year-old female, presented with a dome-shaped lesion of normal mucosal color on the attached gingiva apical to tooth number 11. She was referred to the dental school for biopsy, which revealed fibrocollagenous connective tissue exhibiting large stellate fibroblasts. She returned after 10 months and was referred to the graduate periodontal department, where the lesion was removed. Several fibrous hyperplastic lesions can be considered in the differential diagnosis of giant cell fibroma. Dental hygienists should be familiar with the different fibrous hyperplasias, noting lesions during the intra- and extra-oral examinations for further evaluation by the dentist.

Keywords: Fibrous hyperplasias, giant cell fibroma, oral lesions

Introduction

Fibrous hyperplastic lesions of the oral cavity are very common and are manifested in various locations. Fibrous hyperplasias are generally considered to be reactive in nature rather than neoplastic; they are simply the overgrowth of tissue in response to a stimulus. Many times, the stimulus is chronic irritation. Until the early 1970s, the giant cell fibroma (GCF) was one among this group of similar lesions referred to as fibrous hyperplasias, fibroepithelial polyps, or, simply, fibromas. Since then, clinical and histologic features have enabled pathologists to classify a number of these lesions as separate entities, although they may share common characteristics. The following case study concerns one of the lesions in the group, the GCF.

Review of the Literature

History of the Giant Cell Fibroma

The GCF was first described as a separate entity among fibrous hyperplastic soft tissue lesions by Weathers and Callihan in the early 1970s. It was named for its characteristically large, stellate-shaped, mononuclear and multinucleated giant cells.¹ The authors examined more than 2,000 specimens in a group of fibrous hyperplasias, and 108 met their criteria for

this "new" lesion which they called GCF. Before Weathers' and Callihans' distinction of GCF, Eversole and Rovin compared and contrasted 279 fibrous hyperplastic gingival lesions, which fell into four categories: pyogenic granuloma, peripheral gingival fibroma, peripheral giant cell granuloma, and peripheral ossifying fibroma. Each has its own diagnostic histopathologic characteristics but exhibit overlap of clinical presentation. Speculations from the study were that all four types of lesions are merely varied histologic responses to common etiologic factors,² but similar to one another and to other fibrous hyperplasias.

After distinguishing GCF among fibrous hyperplasias, Weathers and Campbell further elucidated the structure of the lesion when they studied them under light microscopy. They concluded again that dominant cells in the GCF were indeed unique, and that GCF merited its own classification.³ In the following few years, reports appeared in the literature about other lesions with the same types of cells in extra-oral sites, such as the nose and glans penis. In 1982, Houston completed a retrospective study of 464 GCFs from files at the Indiana University School of Dentistry and agreed that this GCF was indeed a distinctive lesion.⁴

Not all of those involved in oral pathology, however, agreed with Weathers' and Callihans' description of the diagnostic features for GCF. Conclusions from a study by Reibel,⁵ as well as one by Savage and Monsour,⁶ disputed the distinction of the lesion as a separate entity among fibrous hyperplasias and tumors. Reibel reviewed 1,550 cases of oral fibrous hyperplasias containing stellate and multinucleated cells. He concluded that, due to the varying nature of the lesions and different ages at which the stellate and multinucleated cells are found, the so-called GCF should not be considered as belonging to a separate entity. In addition, Savage and Monsour retrospectively reviewed the histologic features of all lesions designated as fibrous or fibroepithelial polyps over a 10-year period from an oral biology and oral surgery department of an Australian university. They concluded that the histologic features were not sufficiently unusual or characteristic in normal or pathologic tissues to warrant grouping the lesions as a separate and distinct entity.

In spite of discrepancies about its distinction, American authors apparently have adhered to the separate designation because GCF is currently described as a separate entity in oral pathology textbooks.^{7, 8, 9, 10, 11, 12} Further investigation over the years has led to the belief that the GCF is simply a histologic variant of focal fibrous hyperplasia, or irritation fibroma, the most common reactive connective tissue lesion in the oral cavity.⁷ However, as recently as 1996, authors of a study in the United Kingdom noted that it was unclear if the GCF was a distinct entity or a variant of the fibroepithelial polyp.¹³ In another study shortly thereafter, the same authors found reason to believe there was a distinct difference between the two.¹⁴ Variant of another lesion or otherwise, the GCF will be discussed in this case study as first defined by Weathers and Callihan.

Etiology

Fibrous hyperplasias are considered reactive proliferations of fibroblastic tissue rather than neoplastic proliferations.⁷ Most are the result of chronic injury or irritation. GCF was at one time hypothesized to be virus-induced,⁵ but that claim was never substantiated; therefore, it is believed to arise as a result of a stimulus, the source of which cannot always be determined.¹¹

Clinical Features

There is no gender predilection for GCF, but it is a lesion of the young, found most commonly in the first three decades of life.^{1, 4, 6} It presents clinically as an asymptomatic raised lesion, one centimeter or smaller in diameter.^{1, 4} Most GCFs have a bosselated or pebbly surface,¹ which can result in a clinical misdiagnosis of papilloma.^{1, 8, 9, 15} It may be pedunculated or sessile and is found most commonly on the gingiva, with the mandibular gingiva being affected more than the maxillary.^{1, 4, 8, 15} (Figure 1) It may also be found in extragingival sites, including the tongue, palate, and buccal mucosa.¹ It is typically of normal mucosal color unless traumatized during mastication or oral hygiene procedures.^{1, 4}

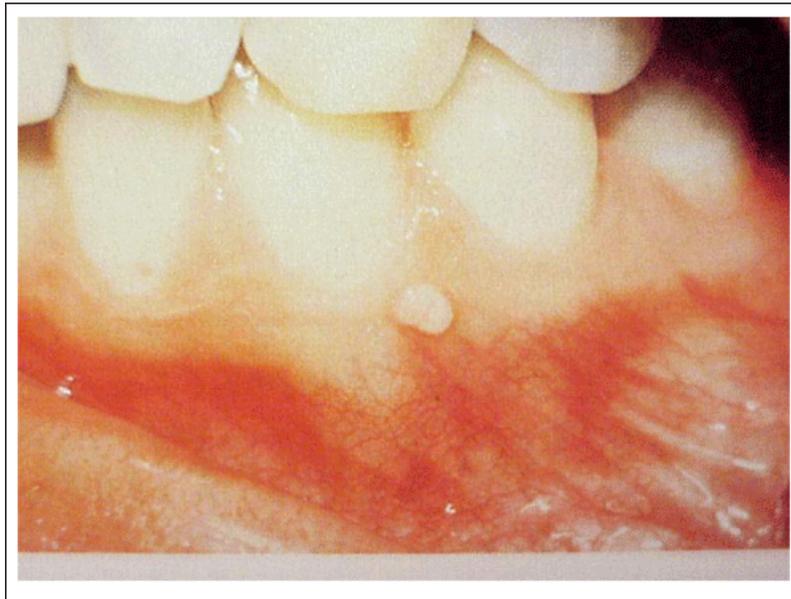


Figure 1. Giant cell fibroma, mandibular anterior attached gingiva of a 27-year-old male
(Photograph used with permission from *RDH*)

Histology

The histologic composition of GCF is the consistent diagnostic feature of the lesion.^{6,15} Microscopic examination reveals multiple large stellate-shaped and sometimes multinucleated fibroblasts (giant cells) in a loosely arranged vascular fibrous connective tissue.^{1,3,4,5,6,8,10} These cells have oval nuclei with abundant eosinophilic cytoplasm and are most copious just under the epithelium, but they may also be distributed throughout the lesion.

Treatment

The treatment of choice for the GCF is conservative surgical excision.^{7,8,9,10,15} GCF seldom recurs, nor does it regress spontaneously because the excess collagen in the lesion is permanent tissue.^{7,8,9} Periodontal root planing is also suggested during excision to remove possible sources of irritation.^{7,10,11}

Patient History

A 19-year-old female presented for oral examination and prophylaxis in the dental hygiene clinic at a Midwestern university. She was in good general health with no significant findings on the medical history. Dental history revealed only sporadic previous dental care. Oral examination revealed moderate generalized plaque and calculus, with light staining from tobacco. An incidental finding during oral examination was a firm, asymptomatic, 1 x 0.5 cm dome-shaped lesion of normal mucosal color on the facial surface of the attached gingiva apical to tooth #11 (Figure 2). Radiographs were not exposed at this visit, and the patient was reappointed for preventive care and the necessary radiographs. She did not, however, follow up with subsequent appointments.



Figure 2. Case study patient, first recognition of lesion

Three years later the patient returned to the clinic, seeking preventive care. She had received no dental care in the interim and was now four months pregnant. Oral conditions were similar to her previous visit, but she was now concerned about the appearance of the dome-shaped lesion on the maxillary facial gingiva detected during the previous examination. It now measured 1.4 x 0.8 cm, extended to the mid-facial of the adjacent teeth, and exhibited greater buccal expansion (Figure 3). Because she was pregnant, the patient requested no radiographs. She completed preventive care but wished to wait and seek treatment for the lesion post-partem. Financial constraints prohibited referral to a local oral surgeon, so she was referred to the university's dental school—a two-hour drive from the dental hygiene clinic—for evaluation and treatment of the lesion.



Figure 3. Case study patient, three years later

After delivering a healthy baby boy, the patient again returned to the dental hygiene clinic for preventive care the following year. She reported that the lesion noted at the two previous visits seemed to increase in size during her pregnancy. It had since been biopsied at the dental school but had not been totally excised (Figure 4). Per her request, a follow-up report was received from the dental school for her records in the dental hygiene clinic, as it remained her primary source of dental care. The report stated that radiographs of the lesion exposed at the dental school were unremarkable, and the clinical diagnosis was ossifying fibroma. The lesion was biopsied in the oral surgery department and submitted for histologic evaluation. A note was included about a grainy or gritty feel to the lesion during excision. The pathology report revealed parakeratinized stratified squamous epithelium on the lesion's surface. The submucosa was composed of fibrocollagenous connective tissue exhibiting large stellate fibroblasts. Diagnosis by the pathology department was GCF.



Figure 4. Case study patient, 10 months after biopsy

The patient did not return for post-operative evaluation at the dental school until 10 months after the biopsy. There remained what was noted as a "swelling" in the area of teeth #s 10, 11, and 12. Complete excision of the fibroma was advised. Due to aesthetic concerns about gingival contour, she was referred to the graduate periodontal department where the lesion was fully excised (Figures 5, 6, 7, 8, 9). A second pathology report was requested with a diagnosis of "consistent with focal fibrous hyperplasia-gingiva." The patient was informed about the fibroma's possible recurrence, which might require extractions and ostectomy. At post-operative visits she expressed concern about the apically positioned gingival margin and the aesthetic difference when compared to the right side. Discussions were started about possible gingivoplasty after healing. The patient again requested release of information to the dental hygiene clinic and is contacted for routine recall appointment.

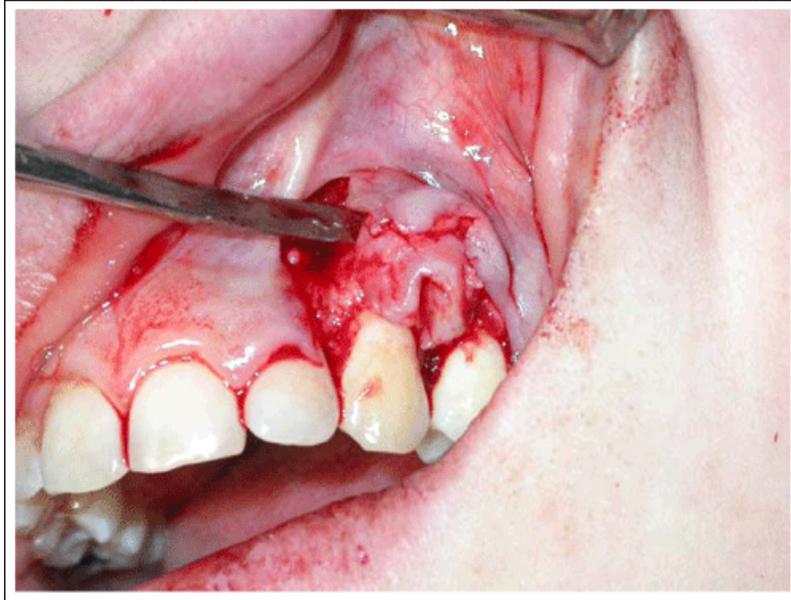


Figure 5. The surface epithelium is reflected, exposing the underlying connective tissue.

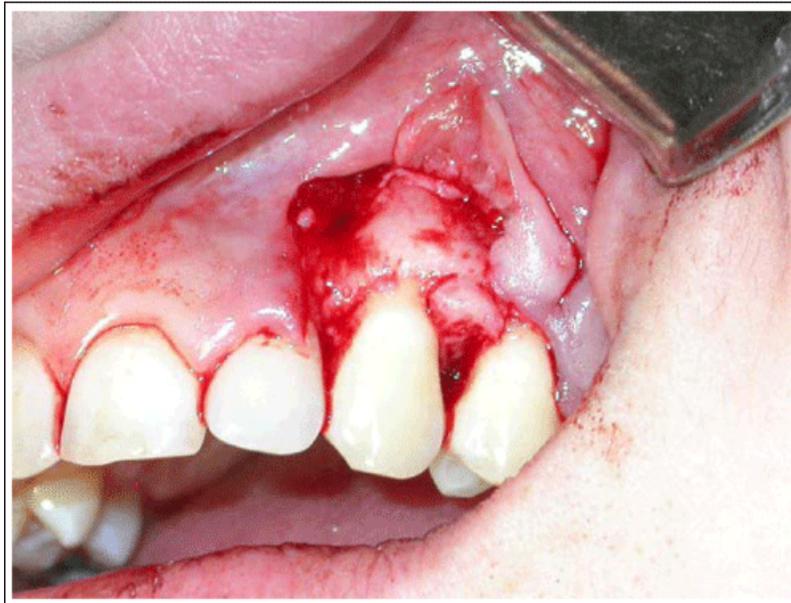


Figure 6. The connective tissue lesion is excised and submitted for histologic examination and diagnosis

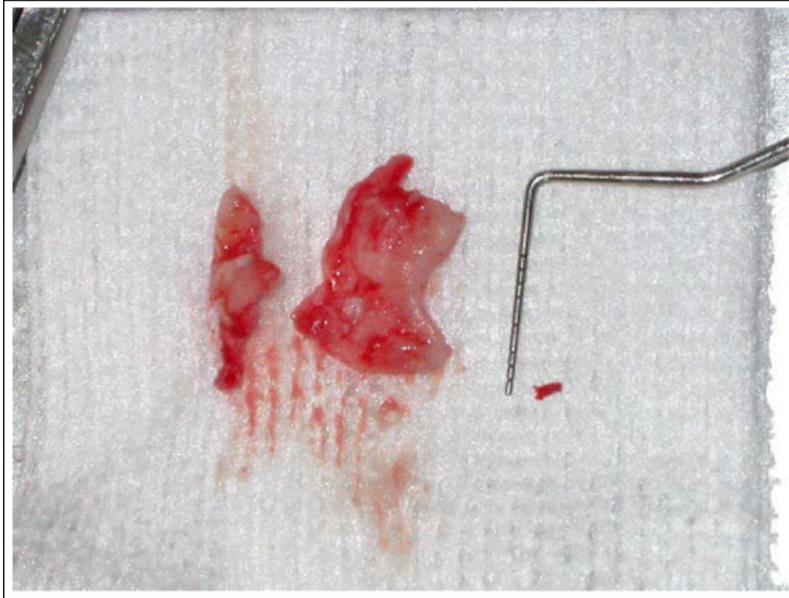


Figure 7. The fibroma after excision measuring >10mm



Figure 8. One week post-op



Figure 9. Three weeks post-op. Note the position of the marginal gingiva, apical to the CEJ, tooth # 11

Discussion

As evidenced in this case study, and in diagnosing lesions in general, both clinical and histologic features are important in determining a final diagnosis.¹⁶ Though the GCF is very similar histologically to other fibrous hyperplasias, clinical features may aid in distinguishing it from other lesions.⁷ Several lesions should be included in the differential diagnosis and, only after all diagnostic characteristics are considered, a final diagnosis rendered.

In spite of similar histology, several distinctions can be made between a number of fibrous hyperplasias according to characteristics such as age distribution, gender predilection, location and etiology.¹⁰ GCF usually develops sometime in the first three decades of life, whereas irritation fibroma, possibly the lesion most similar to GCF, is found in older adults, in the fourth to sixth decades. Irritation fibroma is also found more in females (2:1), while GCF is generally considered to have no gender predilection. As for location, the irritation fibroma is located more commonly on the buccal or labial mucosa along the line of occlusion, as opposed to the gingiva for GCF (Figure 10).



Figure 10. Irritation fibroma on the buccal mucosa of a middle-aged male

Location is a diagnostic characteristic of another histologically similar lesion as well, the retrocuspid papillae (Figure 11). Some sources define it as merely another form of GCF,^{8,10} but the retrocuspid papilla has a very characteristic location on the mandibular lingual attached gingiva, inferior to the canine. It is a small, pink papule measuring up to 5mm and is frequently bilateral.⁸ The retrocuspid papilla is considered by some to be developmental^{7, 8, 16} and, due to its clinical appearance and characteristic location, does not warrant biopsy, whereas irritation fibroma and GCF both require biopsy for definitive diagnosis.⁸

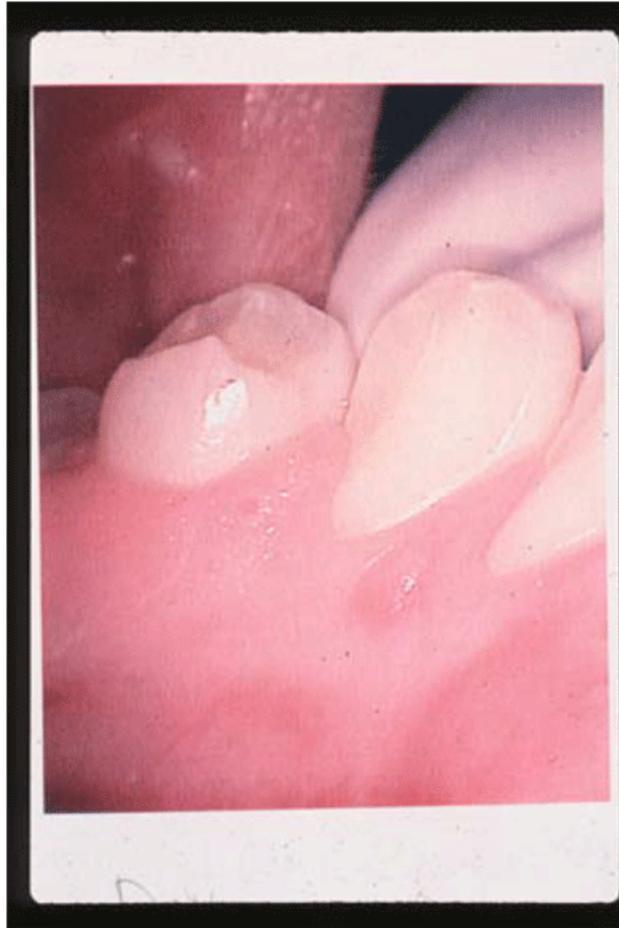


Figure 11. Retrocuspid papilla in a young female college student

The clinical diagnosis of ossifying fibroma was a logical inclusion in the differential diagnosis of this lesion, as it can look much like the GCF clinically.¹⁵ (Figure 12) Ossifying fibromas are typically normal mucosal color like GCFs, but they have islands of osteogenic cells dispersed throughout the lesion.^{7,8,9,10} Unlike GCF, peripheral ossifying fibroma is found only in the gingiva, occurs more in females, and is thought to arise from the periodontal ligament.^{7,8,9,17} Like GCF, it is found more in young adults and recommendations for excision include periodontal root planning.^{7,8,9} The gritty or grainy feel noted during the biopsy may have also reinforced the surgeon's original impression concerning the type of lesion being excised. The clinical diagnosis was not likely to have been papilloma, which is a common misdiagnosis of GCF. Most have a bosselated or papillary surface, but this was merely a smooth, round, sessile enlargement of the attached gingiva.



Figure 12. Ossifying Fibroma, maxillary anterior
(Photograph used with permission from *RDH*)

Color and vascularity of lesions can also be distinguishing features when diagnosing fibrous hyperplasias. Most irritation fibromas are of normal mucosal color, unless traumatized, in which the lesion could appear reddened, or whitish due to hyperkeratinization, the result of continued irritation after development of the lesion. Pyogenic granuloma, on the other hand, is commonly found on the gingiva (like GCF), but tends to be red⁷ and bleeds easily if manipulated,⁸ unlike most GCFs and the lesion in this case study (Figure 13). It was of normal mucosal color and had no associated bleeding. Had the patient first visited the clinic during her pregnancy, it is conceivable that the lesion could have been mistaken for a pyogenic granuloma, which is commonly found on the gingiva of pregnant women and, if a mature lesion, can be pink instead of red.⁸ It is interesting, however, that she perceived the lesion to increase in size during her pregnancy.

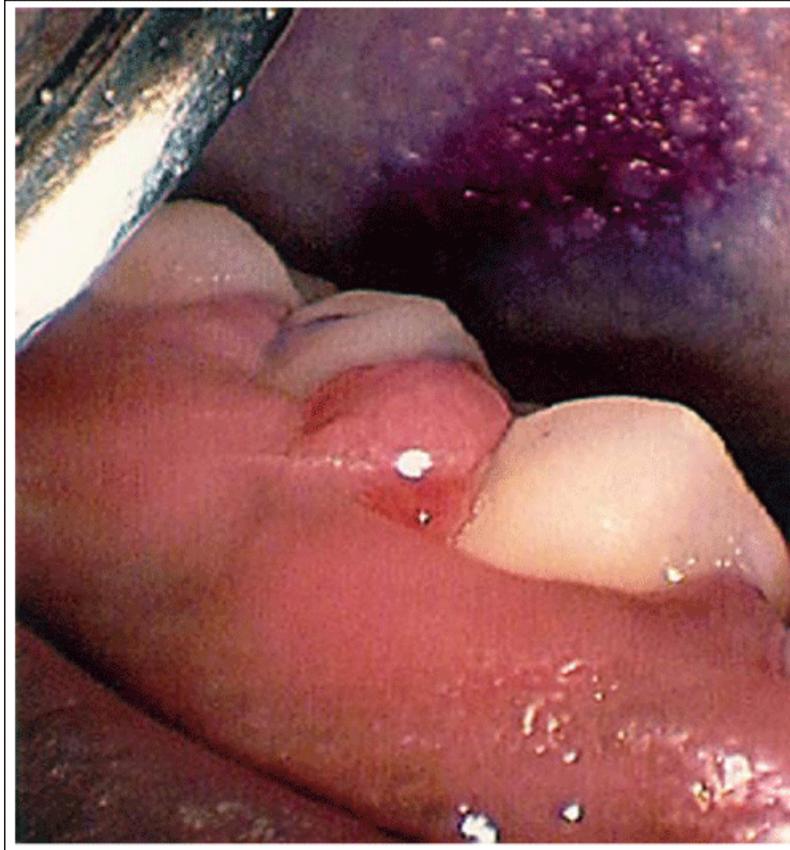


Figure 13. Pyogenic granuloma, interdental papilla area, #'s 28 & 29

Although most fibrous hyperplasias are relatively innocuous lesions, histologic examination of the tissue is necessary in most cases to rule out the possibility of malignancy. Though they are not considered true tumors, fibrous hyperplasias may continue to increase in size until the stimulus or irritation is removed or the lesion is excised. The patient in this case study was a smoker, a trait which places her at greater risk for oral cancer, making early diagnosis more paramount. The delay in complete excision of the lesion may have required more extensive surgical intervention than if the patient had returned for post-operative visits following the initial biopsy.

Conclusions

Several fibrous hyperplastic lesions are similar both clinically and histologically, requiring biopsy for definitive diagnosis. Dental hygienists should be familiar with the different types of fibrous hyperplasias they may encounter during patient treatment and should note such lesions for further evaluation by dentists.

As demonstrated in this case study, GCFs may continue to proliferate until completely removed. A case can be made for early recognition and treatment of lesions to minimize surgical intervention.

Acknowledgements

Notes

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Genes Underlying Familial Hypodontia: A Review and Discussion of the Role of Dental Hygienists in Future Research

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Congenitally missing teeth, or hypodontia, is one of the most common abnormalities of the human dentition and has a critical and often lifelong impact on the oral health of affected individuals. Here we review hypodontia and describe the patterns of inheritance it can display. A short review of tooth development and a primer in human genetics are presented. Approaches used to determine the underlying cause for various forms of hypodontia are discussed and information about genes discovered to date is reviewed. The role that the dental hygienists can play in facilitating the discovery of novel genes for hypodontia is illustrated.

Keywords: Hypodontia, missing teeth, families, inheritance, genes

Introduction

Having healthy and normal dentition is crucial to one's well-being. Teeth are necessary for tasting, chewing, and swallowing food. Teeth are integral in the balance of the orofacial complex and are also important for clearly discernible speech and for proper smiling and kissing. Ultimately, these attributes contribute to facial aesthetics and, as a direct consequence, to one's emotions, appearance, and self-esteem. The importance of a healthy mouth and teeth is most apparent when an individual encounters problems such as a toothache, bad breath, or missing teeth. These dental problems may trigger feelings ranging from anxiety or embarrassment to severe pain and dysfunction. Congenital lack of teeth is a condition that can seriously compromise the oral health of the affected individual. Dental hygienists have a very important role in detecting, treating, and explaining to the family the implications of congenitally missing teeth. The purpose of this article is to provide dental hygienists with a primer in human genetics, a general review about familial hypodontia, patterns of inheritance, and the technologies that are used to detect the molecular causes of this disorder. Dental hygienists have the potential to become important referral sources to geneticists interested in determining the cause of familial hypodontia. This article also highlights the need for dental hygiene education to include the genetic content necessary to keep pace with this burgeoning area of research and dental hygienists' potentially important role therein.

Overview of Teeth Development

Tooth development results from the interaction of epithelial and mesenchymal cells in the human embryo, which ultimately results in 20 primary and 32 permanent teeth. This physiological process includes initiation, proliferation, differentiation,

morphogenesis, and maturation. After initiation (sixth week), tooth development proceeds through the basic stages: bud (eighth week), cap (ninth to 10th week), and bell (11th to 12th week), where precise and intricate interaction of a multitude of proteins directs the development of the different types of teeth.

Figure 1 shows the stages in tooth development and the many growth factors and transcription factors that have been implicated in the process through studies in mice. At the initiation stage, around the sixth week of human development, the oral ectoderm gives rise to the oral epithelium, and then to the dental lamina adjacent to the deeper mesenchyme separated by a basement membrane. Around the eighth week, the bud stage occurs, which is characterized by the rapid proliferation of the dental lamina that penetrates the mesenchyme. These structures will develop into the tooth germ and its associated supporting tissues. The cap stage occurs between the ninth and 10th week of human prenatal development. The proliferation continues, but the tooth bud does not grow anymore. Instead, there is an unequal growth in different parts of the bud, giving rise to a cap shape attached to the dental lamina. The tooth germ, composed of the enamel organ, dental papilla, and dental sac, is formed at this point. At the bell stage, differentiation at all levels occurs to its furthest extent, and the cap shape of the enamel organ assumes a bell shape. The final stages (differentiation) of odontogenesis include apposition, during which the enamel, dentin, and cementum are secreted as a matrix. The matrix is partially calcified and serves as a framework for later calcification and maturation, which is reached when the dental tissues are subsequently fully mineralized.^{1,2,3}

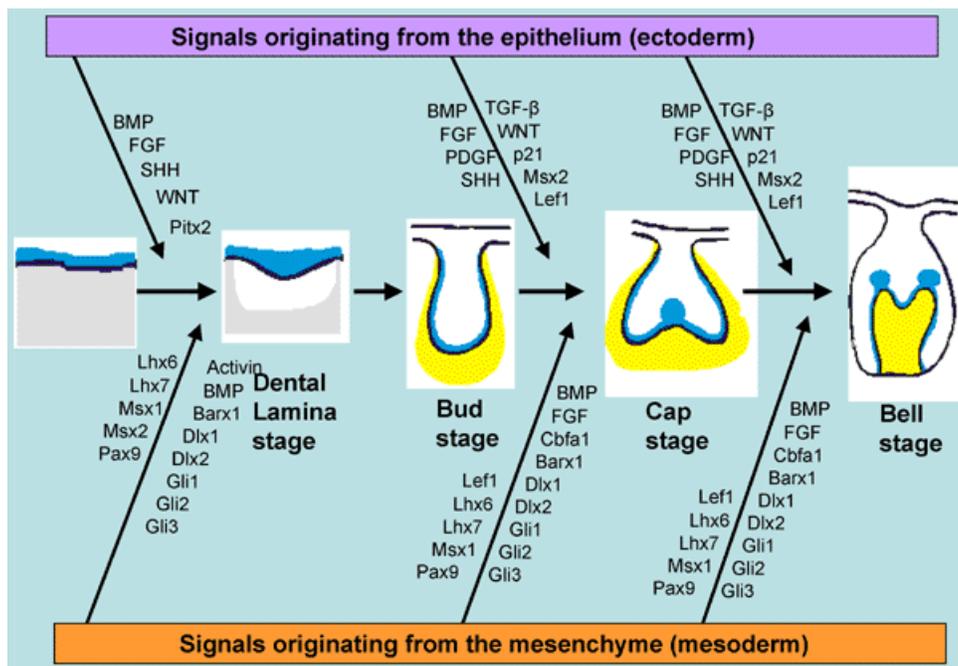


Figure 1. Schematic diagram showing the different stages in tooth development and the many growth factors and transcription factors that have been implicated in the process through studies in mice. Growth factors are shown in capital letters and transcription factors are shown in lower-case type.

Tooth Agenesis: Definition and Characteristics

Tooth agenesis can occur in association with syndromes, often involving multiple organ systems such as ectodermal dysplasia,⁴ or it can occur as an isolated condition when it is referred to as non-syndromic hypodontia. The absence of teeth is broadly referred to as hypodontia, with some authors drawing a distinction between the congenital absence of one to six teeth (excluding third molars) as hypodontia, and the absence of more than six teeth (excluding third molars) as oligodontia. Anodontia refers to the complete absence of teeth.^{5,6}

The agenesis of third molars occurs in approximately 25% of the population. Mandibular second premolars are missing twice as often (5%) as the mandibular second premolars (2.5%). The maxillary lateral incisors are absent in about 2.5% of the population, whereas the mandibular central incisors are absent in less than 1%.⁷ The agenesis of canines is very infrequent, as is that of maxillary central incisors, which are commonly absent in Axelfeld-Rieger syndrome, characterized by specific anomalies, both ocular (such as iris hypoplasia, iridocorneal adhesions, and microcornea with opacity) and dental (ranging from small teeth to partial or complete hypodontia).⁸

Some relationship exists between malpositioning of permanent canines and hypodontia. Several studies indicate a significantly elevated prevalence rate for tooth agenesis in association with a palatally displaced canine.⁹ The palatally displaced canine (PDC) and mandibular lateral incisor-canine malposition (Mn.12.C) appears to be associated with agenesis of third molars, and maxillary canine-first premolar transposition (Mx.C.PI) appears to be associated with elevated maxillary incisor agenesis.¹⁰

Human Genetics: A Primer

The human body is made up of 1013 cells, each of which contains the same genetic instructions that specify the information needed to build and maintain the individual. This complete set of instructions comprises the human genome. The genome consists of DNA that is organized into compact structures called chromosomes within the nucleus of each cell. Each chromosome consists of two long DNA strands twisted around each other. Four repeating building blocks (nucleotides), namely A, C, G, and T, constitute the backbone of each DNA strand. DNA sequence refers to the order of these four nucleotides, and it is the particular order of nucleotides in each person that determines their unique characteristics. A gene is a stretch of DNA sequence on a chromosome that specifies the information needed to encode a specific protein. The human genome is currently thought to encode 20,000 to 25,000 genes. Proteins play a key role in the structure and function of a cell. Each tissue in the human body, while having the same exact DNA, has a unique set of proteins, as different genes are active in different cell types, depending on the specific function of the cell.

The DNA within the nucleus of humans is organized into 46 chromosomes that comprise of two sets of chromosomes, one inherited from the father and the other inherited from the mother. There are 23 chromosomes in each set: 22 autosomes and a sex chromosome (either an X or a Y chromosome). Males have 22 pairs of autosomes and an X and a Y chromosome, while females have 22 pairs of autosomes and two X chromosomes.

Some human anomalies are caused by defects in chromosomes that can actually be visualized under a microscope, such as an extra copy of chromosome 21 in Down's syndrome or a deletion of a large segment of chromosome 17 in Smith-Magenis syndrome. However, the vast majority of human diseases are caused by very subtle changes in DNA called mutations. The most common type of DNA mutation is a single nucleotide change. For example, a change from an A to a G in the DNA sequence results in an altered protein whose function is either compromised or completely lost. The vast majority of mutations in DNA are, however, silent, with no phenotypic consequence. Other types of mutations include deletion or addition of one or more nucleotides in the DNA sequence.

Mutations can be either inherited from a parent or acquired during an individual's lifetime. In the former case, the mutation is present in all cells of the body, while in the latter case, it could be restricted to a particular part of the body, depending upon the stage of the life in which the mutation was acquired. Most mutations are repaired using enzymes whose role is to edit the DNA while the cell is dividing; but, as people age, the repair machinery can become inefficient. The cell has an elaborate repair system to prevent mutations from occurring when the cell is dividing by "proofreading" the DNA while it is replicating, but this system can go awry occasionally, especially as humans age. In addition, environmental agents such as radiation or toxic chemicals can damage DNA, thus introducing mutations.

Inherited human diseases can pass through families in a dominant, recessive, or complex mode (Figure 2). A dominant disease results if one copy of the two copies of a given gene is defective. Examples of inherited dominant diseases include achondroplasia (or short-limb dwarfism), myotonic dystrophy, and Huntington's disease. Even though one copy of the gene is normal, the abnormal copy of the gene is able to override it, causing disease. Dominant diseases can be traced

through family pedigrees and appear to spread vertically because everyone carrying a dominant mutant allele (form of the gene) generally shows the disease symptoms.

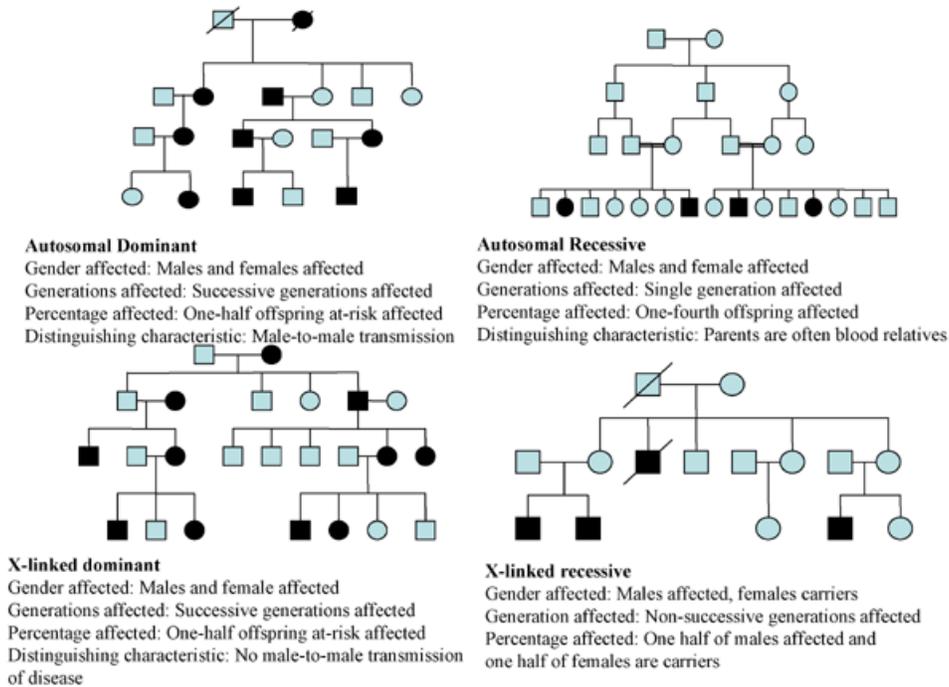


Figure 2. Sample pedigrees showing various patterns of Mendelian inheritance of a disease. Squares = males, circles = females, affected individuals = filled symbols, diagonal line = deceased individual.

Recessive inheritance means that two abnormal copies of the gene must be present for the individual to be affected. Cystic fibrosis, a disease in which breathing and digestion are impaired, is an example of a recessive disease. Tay-Sach disease, which is common in people of Ashkenazi Jewish origin, is another recessive disease. In a recessive disease, both copies of the gene must be mutated to produce the disease. Parents of the affected individual show no symptoms even though they carry one mutant copy of the gene. If both parents are carriers of the gene, the child has a one in four chance of receiving a recessive allele from each parent and inheriting the disease.

When the mutation in a gene underlying a disease that is located on the X-chromosome is dominant, both males and females are affected, although the females are usually less severely affected. This is because females have two X chromosomes and, during development, one of the two X-chromosomes is selected at random and inactivated to allow X-chromosome gene dosage between males and females to be balanced. Thus, in some cells of the body, the X-chromosome carrying the disease allele is inactivated and, in others, the "normal" X-chromosome is inactivated. An example of an X-linked dominant disease is hypophosphatemia. If the mutation on the X-chromosome is recessive, males are affected and females are typically carriers with no symptoms or very mild symptoms. An example of such a disease is hemophilia.

Diseases associated with mutations in multiple genes and whose phenotypes can be influenced by non-genetic factors, such as environmental influences, display a complex inheritance pattern. Figure 1 shows the different modes of Mendelian inheritance and their particular characteristics.

Etiology and Inheritance

Non-syndromic hypodontia can be caused by environmental and/or genetic factors. Environmental factors that can arrest tooth development include trauma, chemotherapy, systemic diseases, or endocrine disturbances.¹¹ Mutation of one or more genes can also cause hypodontia and often results in the prevalence of hypodontia among several members of the same

family in multiple generations. Familial hypodontia can display several different patterns of inheritance. These can be autosomal or X-linked dominant or recessive patterns, or polygenic inheritance patterns.¹²

Molecular Approaches

If genetic factors are assumed to cause hypodontia, there are two basic approaches used to identify the causative gene: functional and positional cloning. In functional cloning, the identification of the gene is based on knowledge of the specific biochemical defect in the disease, which is then used to clone the gene encoding the protein. For instance, it was long known that patients with phenylketoneuria (PKU) were deficient in phenylalanine hydroxylase (PH). Antibodies to PH were used to clone the corresponding gene. If, however, only the phenotype of the disease is known, with no clues to the underlying biochemical defect, the gene has to be sought on the basis of its chromosomal location. This method is called positional cloning and is done by linkage analysis, which is based on the segregation of genetic markers with the disease in families.¹³

Gene Mapping by Linkage Analysis

Positional cloning refers to the process in which the gene underlying the disorder is localized and identified in the genome, beginning with comparison of the inheritance of the disease and genetic marker loci in affected families. Success of gene identification by this method has four requisites: (1) large families with several affected individuals; (2) an accurate diagnostic test enabling clear distinction of affected and unaffected individuals; (3) a defined Mendelian pattern of inheritance; and (4) polymorphic DNA markers. A genetic marker is a segment of DNA with an identifiable physical location (locus) on a chromosome whose inheritance can be followed because it is "polymorphic." A polymorphism is a variation in DNA sequence that is seen in at least 1% of chromosomes within a population, and it allows distinction of the maternal and paternal chromosomes of an individual. Microsatellites are short tandem repeat markers with a high rate of polymorphism and dense distribution throughout the genome. These short sequences of DNA are used as gene markers to track inheritance in families. These markers, combined with the polymerase chain reaction (PCR) technique, can detect length of polymorphisms in microsatellite regions that can be traced in several generations.¹⁶

Because DNA segments that lie near each other on a chromosome tend to be inherited together, markers are often used as indirect ways of tracking the inheritance pattern of a gene that has not yet been identified. The first step is to define the clinical features, or phenotype, and to examine how the absence of teeth segregates within the family, thereby establishing the pattern of Mendelian inheritance for the trait. Markers spanning the genome and spaced at regular intervals, and the segregation of those markers in relation to the disease, determine the genotype of the families. If the marker and the disease loci are close enough, they will tend to segregate together.¹⁴ This segregation happens more often than expected by chance. The association of genes and/or markers that lie near each other on a chromosome is termed "linkage." Linkage analysis is the method most often used in mapping studies (Figure 3). In linkage analysis, the co-segregation of the prospective gene that causes hypodontia and genetic markers in a family are followed and measured. If two loci are close to each other on the same chromosome, the chance of recombination between them is low and they are linked. Statistical analysis is necessary to calculate the probability of linkage in a pedigree.¹⁵

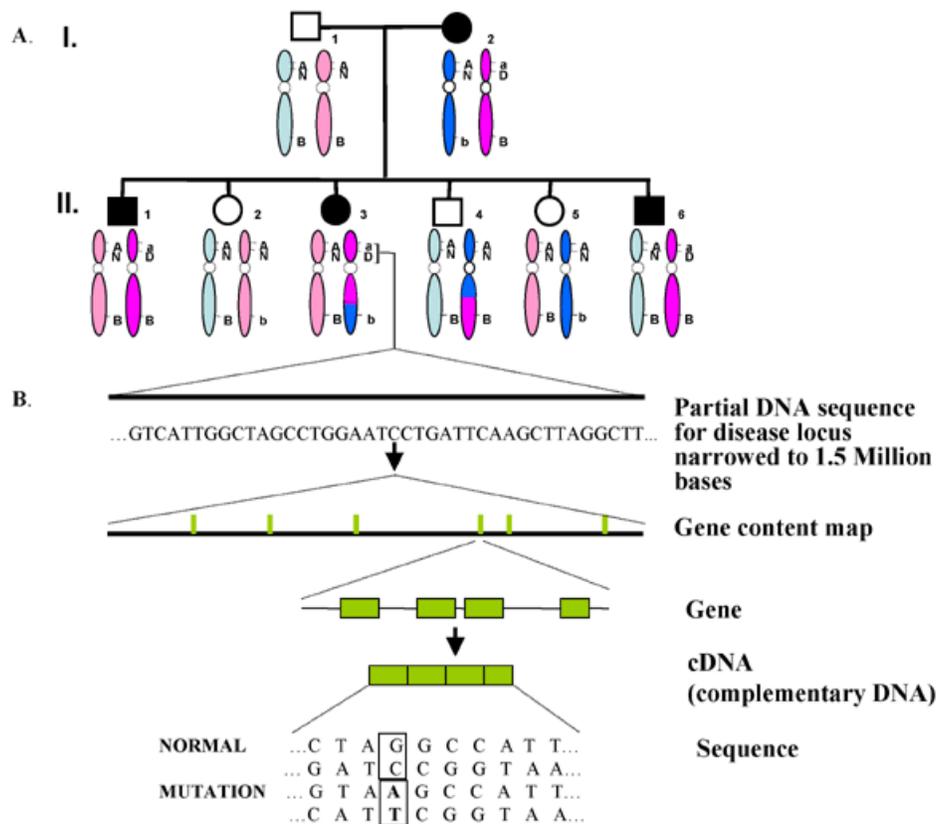


Figure 3. Schematic diagram of positional cloning of a disease gene by linkage analysis.

(A) The gene is initially mapped to a particular chromosomal region by linkage analysis which tracks the segregation pattern of marker loci and the disease within members of a given kindred. Symbols are as described in Figure 2. The segregation pattern of allele systems A/a and B/b at the marker loci on the short arm and the long arm of a hypothetical chromosome, respectively, indicates that the disease allele D segregates with the allele a but shows random segregation with alleles B or b due to recombination.

(B) Fine mapping and identification of the disease gene. The overall strategy used to identify the mutation within a candidate gene is shown, beginning with the DNA sequence of the large region, narrowed by linkage analysis obtained from public databases, to the identification of a single base change leading to the disease.

Genes Associated with Hypodontia

The morphogenesis of the teeth, like the development of the whole embryo, is under strict genetic control. More than 200 genes have been demonstrated to participate in tooth formation, including genes encoding growth factors, second messengers, and transcription factors.^{17,18,19} Experiments with mice have demonstrated that deficient function of several transcription factors that are part of the signaling network results in arrested tooth morphogenesis.^{20,21,22}

In recent years, three specific sites in the genome have been associated with hypodontia. Absence of second premolars and third molars is associated with mutations in a protein called MSX1.²³ Mutations in PAX9, another transcription factor, cause oligodontia involving molar teeth.²⁴ The absence of multiple permanent teeth in a large Chinese kindred has been mapped to a chromosome 10q11.2 with the gene yet to be identified.²⁵

Some genes play a critical role in cell differentiation during the early stages of embryogenesis. Expression of these genes like Msx1 has been strongly implicated as crucial to the normal development of various craniofacial structures.^{26,27} Msx1, a transcription factor, is strongly expressed in the dental mesenchyme and excluded from the dental epithelium throughout the bud, cap, and bell stages of dental development.²⁸ The role of Msx1 function is evidenced in the mice lacking this gene, which manifest a secondary cleft palate, deficiency of the alveolar complex of the mandible and maxilla, and failure of tooth development.²⁹ Msx1 plays a critical role in mediating epithelial-mesenchymal interactions during craniofacial bone and tooth development.^{29,30} Several mutations in Msx1 have been reported in familial hypodontia, including missense mutations³¹ and mutations that cause a truncated dysfunctional MSX1 protein.³² Despite information of the regulation of Msx1 gene expression, the target genes controlled by Msx1 during organ formation remain unknown.

Pax9 is a member of a family of transcription factors that play a key role in development. The complex expression pattern of Pax9 during mouse development suggests that it plays a crucial role in the development of several organs. Complete absence of the Pax9 protein in mice causes arrested development of teeth at the bud stage and malformations of the palate, thymus, and parathyroid glands, among other malformations.³³ Several investigators, including those in the authors' laboratory, have demonstrated a direct relationship between mutations within these genes and familial hypodontia.³⁴ Different kinds of mutations, including loss of the entire Pax9, gene have been identified^{35,36,37} in hypodontia families.³⁸

The Role of the Dental Hygienist

Congenitally missing teeth, whether they are isolated conditions or associated with a syndrome, can affect the oral and overall health of individuals. Depending on the severity of the hypodontia, individuals with missing teeth may make nutritional choices based on comfort and ease of ingestion, rather than based on nutritive value of foods. Thus, affected individuals may choose soft foods and avoid fresh fruits and vegetables, which could have an adverse effect on the overall health of the individual. Dental hygienists should be aware of these effects and discuss them with primary care dentists and patients as appropriate.

The impact of congenitally missing permanent teeth on the developing dentition can be significant. When treating patients, many factors need to be taken into consideration including, but not limited to, aesthetics, patient age, and growth potential, as well as periodontal and oral surgical needs. If, by casual conversation, a dental hygienist learns that a patient has a family history of the condition, he or she needs to inform the dentist in order to evaluate both immediate and long-term management of the patient's oral care. An appropriately trained and/or experienced dentist should manage the patient, and a team approach may be needed.

The goal of the Human Genome Project was to determine the DNA sequence of the entire human genome and to map all the genes in the human genome, which will ultimately allow one to ascribe a function to these genes in normal human development and in disease. The completion of the Human Genome Project in March 2003 has made available almost the entire DNA sequence of all 24 human chromosomes. DNA sequence of the mouse, rat, and other model organisms has followed in rapid progression, and this explosion of genomic information has opened the door to the identification of the genetic etiology of various inherited disorders at a very rapid pace. With the addition of more polymorphic markers throughout the entire genome, better and more cost- and time-effective approaches will be available to tackle Mendelian and complex human diseases, including familial hypodontia. The discovery of new genes important for human tooth development will enable us to develop a complete picture of all the factors necessary for the formation of a specific tooth, which will have applications in the treatment of both inherited and acquired tooth agenesis. However, these advances will have no meaning if the rare families affected with hypodontia and other dental anomalies remain anonymous. The role of the dental hygienist in identifying patients with this problem cannot be over-emphasized.

Dental hygienists can be important facilitators for the molecular geneticist, as they have regular contact with a wide range of patients who seek routine or specialized dental care. In contrast to general dentists or orthodontists, dental hygienists spend more time with the patient, which may provide opportunities to determine if the hypodontia is likely familial. Thorough exploration, dental hygienists may help identify the relationship of an individual patient's hypodontia to the

same condition presenting in other family members. Dental hygienists are in a unique position to refer the patient to a molecular geneticist in order to facilitate gene identification.

Thus, dental hygienists are not only promoters of oral health, but are also referral sources for persons with familial hypodontia, explaining to them the importance of participating in research studies that ultimately benefit the whole population.

Those wishing to participate as a collaborator in a familial non-syndromic hypodontia project, or other projects, are invited to please contact the principal investigator, whose laboratory is focused on determining the causes of various inherited dental abnormalities.

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Notes

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Notices

Dental Hygiene: Focus on Advancing the Profession

Dental Hygiene: Focus on Advancing the Profession has been adopted by the American Dental Hygienists' Association (ADHA) Board of Trustees and was unveiled at the ADHA 82nd Annual Session in Las Vegas, Nevada, held June 22-29, 2005. Formerly titled *Dental Hygiene: Focus for the Future*, the document is now titled to more accurately reflect its content and purpose.

Dental Hygiene: Focus on Advancing the Profession provides a historical overview of dental hygiene as a developing discipline, and presents a clear picture of the current state of the profession in the context of today's evolving health care system and the public that it serves. The document sets goals and makes recommendations for establishing a framework for the future of dental hygiene in the areas of research, education, practice and technology, licensure and regulation, public health, and government. In particular, it emphasizes the need for professional socialization and cross-disciplinary relationships within health care and outside it.

Dental Hygiene: Focus on Advancing the Profession was prepared by a working committee of individuals drawn from all areas of dental hygiene practice, education, and research. ADHA and the ADHA Board of Trustees wish to formally thank these individuals for their visionary work.

For more information about obtaining a copy of *Dental Hygiene: Focus on Advancing the Profession*, please visit www.adha.org and upcoming issues of *Access*.

ADHA Announces First Dental Hygienist Executive Director

The ADHA Board of Trustees and Executive Director Search Committee are pleased to announce that Ann Battrell, RDH, MSDH(c) has been selected as ADHA's executive director. Battrell is the first registered dental hygienist and the first former ADHA president to serve in this position.

Battrell, who has most recently served as assistant executive director for strategic planning and education for the association, will assume comprehensive responsibilities for all elements of ADHA's operation as executive director on July 1. As the largest association representing the professional interests of the more than 120,000 registered dental hygienists in the United States, ADHA operates an annual budget of more than \$6 million and has approximately 40 employees.

"Ann brings her dedication to advancing the profession of dental hygiene and improving the oral health of the public to her new role with ADHA. This is exemplified by her leadership in developing a flourishing continuing education symposium named Center for Lifelong Learning," said Helena Gallant Tripp, RDH, ADHA president. "Ann has also been instrumental in partnering with varied health organizations and leading strategic initiatives that have proven successful for the growth of the dental hygiene profession. She is an exceptional choice to lead ADHA through the exciting opportunities that lie ahead."

As executive director, Battrell will build on her existing role of representing the organization to governmental bodies and educational institutions, among other related associations, and building valuable relationships for ADHA such as with corporate partners. She will also oversee a host of staff programs from membership recruitment to consumer awareness.

"I will continue working on several key ADHA projects within our strategic plan, such as increasing ADHA membership, access to oral health care and the advanced dental hygiene practitioner initiative," said Battrell. "ADHA will focus our efforts on improving the public's oral health through advancing dental hygiene practice and increasing the public's direct access to dental hygienists."

Advanced Dental Hygiene Practitioner Update

The 2004 ADHA House of Delegates adopted three important resolutions related to the Advanced Dental Hygiene Practitioner (ADHP). During the past year, the ADHA Council on Education developed a draft of the curriculum framework and specific competencies for the ADHP. The Educators' Forum workshop at ADHA's 82nd Annual Session will provide an update on the ADHP curriculum framework and competencies. A question and answer session will follow a presentation by the ADHA Council on Education.

International Journal of Dental Hygiene

The *International Journal of Dental Hygiene*, the official scientific peer-reviewed journal of the International Federation of Dental Hygienists (IFDH), brings the latest scientific news and high-quality commissioned reviews, as well as clinical, professional, and educational development and legislative news to the dental hygiene profession worldwide.

The journal is intended as a forum for the exchange of relevant information and the enhancement of the dental hygiene profession, with the purpose of promoting oral health for patients and communities.

For more information on the quarterly journal and to subscribe, please visit <http://www.ifdh.org/publication.shtml>.

In Memory of Roxie Stitzer

Roxie Stitzer, RDH, long-time dental hygiene educator and ADHA member, died May 2, 2005, at her home in Columbus, Georgia.

Stitzer was born March 16, 1915 in Ashland, Pennsylvania, and raised in Aristes, Pennsylvania. She studied pre-med at Bucknell University before completing her education in dental hygiene at the University of Pennsylvania School of Dental Medicine, where she also received the Charlotte J. Sullivan Memorial Award.

A dedicated educator for 43 years, Stitzer directed the dental hygiene program at West Liberty College in West Virginia from 1940 to 1959. In 1940, she was the director of the only dental hygiene program that was not associated with a dental school.



Roxie Mae Stitzer, October 1997

After leaving West Liberty, Stitzer directed dental hygiene programs at Broome Community College in Binghamton, New York, and at Coastal Carolina Community College in Jacksonville, North Carolina. In 1975, she became a dental hygiene professor at Columbus State University in Columbus, Georgia, where she taught until her retirement in 1983.

"She was always happy and outgoing," says friend and Columbus State colleague Tena McQueen. "She loved teaching the students, and she was so dedicated to dental hygiene."

Stitzer served on different ADHA committees throughout her career and was recognized by the West Virginia Board of Regents for her outstanding contributions to the field of dental hygiene.

Stitzer was also an active member of St. Luke United Methodist Church and the Telephone Sunday School Class in Columbus. Survivors include her schnauzer, Schatzi, her St. Luke church family and other extended family members, especially her close neighbors.



Stitzer, earlier in her dental hygiene career