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The View from 30,000 Feet

Rebecca S Wilder, RDH, BS, MS

Rebecca S. Wilder is an associate professor at the University of North Carolina Chapel Hill School of Dentistry and Director of the Master of Science Degree Program in Dental Hygiene Education. She is the current editor-in-chief of the Journal of Dental Hygiene.



By the time you read this editorial, I will have returned from the American Dental Hygienists' Association (ADHA) Annual Session in Albuquerque, NM. I have never been to Albuquerque, but when I think of the city, I think of hot air balloons. It amazes me to think of the heights the balloons can reach and the view the passengers can see when they look down and across the landscape at several hundred feet in the air. The analogy to this concept in the business world is heard frequently as "seeing the view from 30,000 feet." The editorial review board of the *Journal of Dental Hygiene* functions much like the concept of the view from a hot air balloon, or the view from 30,000 feet. These volunteers are made up of teachers, administrators, clinicians, researchers, public health dental hygienists, dentists, corporate businessmen and women, and private consultants. They help me lead the journal in the right direction and see things from different perspectives. To obtain a different view, this past year I instituted an Executive Board for *JDH*, made up of 4 world-renowned ADHA members and editorial review board members representing the academics, research, corporate, business, and consulting. Those individuals are Dr. Margaret (Peg) Walsh from the University of California at San Francisco, Ms. Wendy Kerschbaum from the University of Michigan, Dr. Ann Eshenaur Spolarich, a private contractor and faculty at the University of Southern California and the Arizona School of Dentistry and Oral Health, and Ms. MaryAnn Cugini from the Forsyth Institute. I want to thank these individuals for their vision and interest in our profession.

I want to especially thank Dr. Karen Williams from the University of Missouri-Kansas City for her quarterly contributions in the *JDH* through the section "Linking Research to Clinical Practice." Her timely review of papers of interest to clinical dental hygienists is important and a "must read" for all of our members.

Since last year at this time, we have published 3 hard copy supplements to *JDH*. This effort would not have been possible without the assistance of the staff at ADHA. I want to thank Jeff Mitchell, Director of Communications, Katie Barge, Manager of Communications and Staff Editor, and Jean Majeski, Managing Editor of Access magazine, for their talent, time, and support of *JDH* and special projects. I also want to thank Executive Director Ann Battrell for the view she provides for the entire organization.

Finally, I would like to take this opportunity to thank the authors who contributed to each issue of the *Journal of Dental Hygiene* and also to the Editorial Review Board for the time and commitment they have to the ADHA and especially to the *JDH*. It is a time consuming process, but so essential to the quality of a peer-reviewed journal. Thank you Editorial Review Board members for caring about our profession and working to improve the quality of our scientific journal. The following are members of the *JDH* Editorial Review Board:

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Review of: Mosby's Dental Hygiene: Concepts, Cases, and Competencies Textbook, Second Edition

Harold A Henson, RDH, MEd

Reviewed by Harold A. Henson, RDH, MEd, assistant professor, Department of Periodontics, School of Dental Hygiene, The University of Texas Dental Branch at Houston.

Mosby's Dental Hygiene: Concepts, Cases, and Competencies Textbook, Second Edition

Daniel SJ, Harfst SA, Wilder R

Mosby

Philadelphia, PA, 2008

1040 pages, 795 illustrations, textbook, hardcover

ISBN: 0-32304-352-6

\$84.95

Mosby's Dental Hygiene: Concepts, Cases, and Competencies is a comprehensive textbook for dental hygiene students and clinical practitioners. The second edition provides a contemporary view on dental hygiene theory practice. There are new chapters on: evidence-based decision making, inflammation and the immune response, esthetics, orthodontics, oral malodor, HIV and AIDS, and practice management. This is a learner-centered textbook and it engages a variety of learning styles through the use of the interactive CD-ROM and Clinical Companion Study Guide.

The CD-ROM contains a myriad of learning activities. There are patient-based exercises divided into a variety of navigation panels such as: patient profile, health history, prevention survey, intraoral photographs, radiographs, intraoral and extraoral exam forms, periodontal chart, dental charting, and a 24-hour food diary. A unique option in the CD-ROM is the ability for the learner to create an electronic portfolio. It contains subject items such as a philosophy of practice, needs assessment, career goals, and evaluating career paths. This feature provides the learner a wonderful professional development roadmap. In addition, this portfolio can be saved and e-mailed to the faculty member for assessment and review. There are embedded video clips within the CD-ROM that cover such topics as: instrument sharpening, pain and anxiety control, periodontal probing, and powered instrumentation. One note on the CD-ROM is that it lacks a full screen icon in the upper right hand corner. One way to remedy this is to drag the borders to the screen length in order to read the information.

There are also 2 supplemental textbooks titled the *Clinical Companion Study Guide* and the *Instructor's Resource Manual*. The *Clinical Companion Study Guide* contains critical thinking activities, process performance forms, and review questions with answers and rationales. The companion guide engages the learner with key questions:

- WHY do I need to know about ____ (this particular area)?
- WHAT will I be able to do with this knowledge?
- HOW do I prepare myself to transfer this knowledge to patient care?

- HOW do I perform these skills?
- HOW can I more effectively use this knowledge?

These questions stimulate the processes of: critical thinking, self assessment, and reflective practice. The *Instructor's Resource Manual* ties in the textbook, CD-ROM, clinical companion guide, and website into an integrated teaching tool. The instructor's manual refers back to the learning outcomes for the respective textbook chapters. There are number of teaching strategies on how to convey the topic to the students. This is an excellent component to assist faculty in thinking "out of the box."

The *Evolve* website contains a plethora of resources for faculty and students. There are 2 valuable features that will enhance teaching. One is the *Electronic Image Collection* and the second is the *Test Bank*. The *Test Bank* contains over 500 questions. There are also instructions on creating quizzes and examinations. This is a helpful feature for both new and seasoned faculty. Students will enhance their learning using critical thinking activity worksheets, patient education handouts, and additional website references, readings, and resources.

Combining the Textbook, Instructor's Resource Manual, Clinical Companion Study Guide, and the Evolve website creates a true comprehensive learning package. When all 4 of these components are combined it creates a learner-centered environment that emphasizes the core principles of case-based and competency-based education.

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Review of: Textbook and Color Atlas of Traumatic Injuries to the Teeth, Fourth Edition

Mary Danusis Cooper, LDH, MSED

Reviewed by Mary Danusis Cooper, LDH, MSED, professor, Indiana University-Purdue University Fort Wayne, Ind.

Textbook and Color Atlas of Traumatic Injuries to the Teeth, Fourth Edition

Edited by Andreason J, Andreasen F, and Andersson L

Wiley-Blackwell

Oxford, UK, 2007

912 pages, illustrations, indexed

ISBN: 1-40512-954-1

\$299.00.

It has been more than 30 years since the first publication of this textbook. Since then, the acute treatment of dental injuries has evolved immensely. The practice to extract traumatized teeth or reposition them into an anatomically correct position is being reconsidered. Great strides have been made in the treatment of such injuries, in addition to the importance of optimal healing. Therefore, the emphasis of this new edition has been on understanding the nature of trauma, its healing aspect, as well as the importance of treatment interventions during healing.

This text has 35 complete chapters, each illustrated with wonderful color photos and drawings. Some chapters concentrate on specific dental traumas, such as root fractures. In each of these chapters, specific treatment modalities are addressed to optimize the healing process. The editors have made it a point to focus on the nature of trauma and healing events, emphasizing how critical healing is for complete recovery. At the end of each chapter, thorough and complete references are listed supporting the content with clinical and experimental research.

In addition, chapters have been added since the last publication of this text 10 years ago. It was important for the editors to address the impact a traumatic event can have on the mental health of a patient. Not only can a traumatic event psychologically affect a patient but it can also cause esthetic problems. As a result, another new chapter was written to focus on the esthetic rehabilitation of the traumatized patient.

Statistics from most countries document that 33% of all preschool children have suffered from dental trauma involving the deciduous dentition, while approximately 25% have suffered dental trauma to the permanent dentition. These statistics prove that the dental team will more than likely have patients who will experience dental traumas in their practice. Although dental specialties such as endodontists, oral surgeons, and pediatric dentists would benefit most from the information provided in the text since they will more than likely deal with such emergencies, this text would still benefit general practitioners who may also deal with such traumas. Overall, this textbook provides valuable information and should be available as a resource for all dental offices and dental schools.

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Review of: Oral-Based Diagnostics (Annals of the New York Academy of Sciences)

Margaret J Fehrenbach, RDH, MS

Reviewed by Margaret J. Fehrenbach, RDH, MS, dental hygiene education consultant and technical writer, Seattle, Wash. For more information about the work she does, please visit her website at www.dhed.net.

Oral-Based Diagnostics (Annals of the New York Academy of Sciences)

Edited by Malamud D and Niedbala RS

Wiley-Blackwell, 2007

352 pages, illustrated, indexed

ISBN: 1-57331-661-X

\$125.00

Science dealing with salivary diagnostics has now moved on to the wider base of oral-based diagnostics, as this collection of recent presentations indicates from a national conference on the subject by the New York Academy of Sciences. What was once a "Salivation Army" of a few, now has many "members" interested in its use.

Oral-based diagnostics have the potential to detect systemic disease and evidence of exposure to various harmful substances, as well as provide biomarkers of health and disease status. Integration of novel approaches to oral-based diagnostics is expanding to include genomics, proteomics, bioinformatics, and nanotechnology. Improved technologies for diagnostics are resulting in more user-friendly methods.

Efforts to translate bench assays to commercial products in the area of oral diagnostics have increased recently as witnessed by the appearance of several new oral-based diagnostic products in the market place. Noninvasive diagnostic methods have a great appeal to our patients. Use of salivary methods reduce the transmission of infectious disease by eliminating the potential for accidental needlestick, and are economical. One of the papers discusses the home drug testing sales found on the Internet. Through this overwhelming surge of interest and products, ethical, legal and, social implications come to the forefront as discussed by one of the contributors.

Not only do these methods look toward diagnosis of disease but also the other benefits of salivary analysis, including drug usage, as salivary analysis reflects many drugs' unbound fraction in plasma. This is an important area of discovery with meth abuse. Discussion of detection of oral cancer by analysis in genetic changes in the cellular compartment is also included since late diagnosis of oral cancer is such an overwhelming problem. These would not replace conventional methods but enhance them, especially in high-risk populations.

Studies are now also being done to correlate tests done for cardiovascular disease and salivary components in their relationship to periodontal disease. Particularly exciting for dental hygiene clinicians is lab-on-a-chip (LOC) methods for point-of-care measurements (POC) for periodontitis, which would use biomarkers. There has been an increased push by

NIDCR and WHO for these methods especially due to the relationship of this oral disease to systemic diseases. It does not appear that a single stand-alone marker will be sufficient for this complex host disease.

This collection would be particularly useful as a current reference for all dental hygiene programs that want to keep informed about the latest technology in our field. Clinicians will enjoy increasing their information in this area as it undergoes enormous changes in the next few years. It is wonderful to have this complete guide to oral-based diagnostics available in one easy-to-read and understand source.

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Review of: Minimally Invasive Dentistry: The Management of Caries

Celeste M Abraham, DDS, MS

Reviewed by Celeste M. Abraham, DDS, MS, clinical assistant professor, Baylor College of Dentistry, Dallas, Tex.

Minimally Invasive Dentistry: The Management of Caries

Edited by Wilson NHF

Quintessence Publishing Company United Kingdom

Year published: 2007

168 pages, color illustrations, hardcover

ISBN: 978-1-85097-105-4

\$98.00

Minimally Invasive Dentistry: The Management of Caries is a first-rate dental text, which opens the eyes of the reader to a wide selection of dental restorative materials and techniques that are used in the contemporary setting. Published in 2007, this tightly condensed 12 chapter resource is a revelation to the general dentist that there is more than one way to find a cavity, restore a cavity (without having to destroy too much tooth structure), and prevent a cavity from beginning in the first place.

The editor carefully focused the reader's thoughts on the importance of going beyond the usual procedures employed in operative dentistry. He compiled an assortment of cutting-edge techniques which he urges to follow, and which compel the engaged reader to investigate further. The plethora of current references at the end of each chapter allows one to do just that. Topics covered in the text include bacteria and enzymatic test, remineralization, and the use of sealants. Also covered are noninvasive methods of cavity preparation such as sonic techniques and the use of lasers. There is a chapter set aside specifically on how to select restorative materials for the precise cavity preparation that has been created. The chemomechanical treatment of caries is a chapter that stands out in the text; the photographs are vivid with respect to the use of Carisolv.

Additionally, the text utilized a diversity of visual aids to help the reader remember the information. From bar graphs to pie charts, and histologic sections, the reader has a wide range of tools designed for retention of the dental concepts discussed. The clinical, color photos of carious lesions are clear to observe (a fantastic example is on page 3). Schematic diagrams are simple to visualize and commit to memory. Some chapters even have a "further reading" segment, which augmented the list of references. Conclusions at the end of each chapter assist the reader in pinpointing the author's intent.

Minimally Invasive Dentistry will allow the dental hygienist a glimpse into the world of operative dentistry in the dental offices where they practice. Although it seems to be written for practicing dentists and undergraduates as well as graduate dental students, there are a few chapter sections which appear to be just tailor-made for the dental hygienist. Chapter 3 is

a prime example. In it, there is a section on the clinical application of the Clinpro Cario Diagnosis L-pop (CCLP) and the Clinpro Cario Diagnosis (CCD) tests. The points that are important for the dental hygienist to consider, which are adjunctive to these tests, are oral hygiene instructions, specific tooth-brushing teaching for their patients, and methods to improve plaque control. The brief step-by-step pictorial description in chapter 3 allows the reader to get a quick idea of how to apply any one of the novel technologies that are reviewed.

Chapter 4 has a few methods that the dental hygiene professional can use in the initial clinical dental exam for the diagnosis of caries. These include visual-tactile techniques, the use of dental floss, and trans-illumination. The other chapter that is pertinent to the work of a dental hygienist is chapter 11. Here, the aging dental population is addressed, and the main point stressed is the importance of catering all our dental techniques to those whose manual dexterity and physical condition is diminished. It appears that chapter 11 would have been more suitable as a factor or section of chapter 3. Dental hygienists can definitely benefit from this body of work. Even though they may not directly operate the immediate equipment and technology, they can be a superb source of the innovative information that this book provides to the dentists with whom they work. They can offer suggestions to their offices as to what is available today in the detection of caries. The knowledge they gain will ultimately be an asset to the profession and a benefit to the ultimate preservation of the dentition.

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Review of: Essential Endodontology: Prevention and Treatment of Apical Periodontitis, Second Edition

Ruth Fearing Tornwall, RDH, MS

Reviewed by Ruth Fearing Tornwall, RDH, MS, associate professor at the Lamar Institute of Technology in Beaumont, Tex.

Essential Endodontology: Prevention and Treatment of Apical Periodontitis, Second Edition

Orstavik D and TP

Wiley-Blackwell

Oxford, UK, 2008

488 pages, illustrated, indexed, hard cover

ISBN: 1-40514-976-0

\$179.99

Essential Endodontology: Prevention and Treatment of Apical Periodontitis is a major comprehensive text on apical periodontitis. The book is written primarily for graduate students of endodontology, specialists or interested general practitioners, and more recently for undergraduate students. It may also be of interest to dental hygienists or dental hygiene faculty who have a special interest in this area and wish to have a significant document for reference in their own library.

This edition reflects the progress in scientific and clinical research, which has led to an increased understanding of the diagnosis, treatment, prevention, and etiology of apical periodontitis. At the same time it has kept its basic core information from its first edition on apical periodontitis as a specific disease entity. There are 14 chapters that cover this information in detail. Chapters are broken into outlined numbered sections covering the specific topic. Each chapter contains extensive references that provide the support for the information in the chapter. The references also document research activity. The chapters are complemented with pictures, both colored and black and white, histological pictures, diagrams, schematics, and photomicrographs.

Chapter 1 begins with an introduction into apical periodontitis, terminology, and the biological and clinical significance of this disease entity. Chapter 2 provides foundation information on the pulp tissue, dentin, blood flow within the pulp, inflammatory reactions, the periodontium, periodontal ligament, cementum, and alveolar bone. Chapter 3 describes the pathogenesis of pulpal and periapical inflammations, and discusses the mechanisms of their development. Chapter 4, Pathobiology of Apical Periodontitis, discusses the microbes and host defense as a dynamic encounter, which results in favor of the host or a variety of categories of lesions of apical periodontitis. Chapter 5 provides an extensive discussion of the microbiology of apical periodontitis. Chapter 6 is concerned with radiology as a diagnostic aid and as a tool for follow-up assessment and epidemiological studies. Chapter 7, Clinical Manifestations and Diagnosis, emphasizes the importance of correct pulpal diagnosis as the key to all endodontic treatments. The author states the clinical diagnosis should be based on history of symptoms, presenting symptoms, diagnostic tests, and clinical findings. Therapy should not be initiated until the diagnosis can be established. Other chapters cover the epidemiology of apical periodontitis, prevention

and management in primary teeth, treatment of the exposed pulp-dentin complex, and endodontic treatment of teeth with and without apical periodontitis. Chapter 13 discusses surgical treatment. The last chapter reviews reports on the outcomes in the prevention and treatment of apical periodontitis, defines the prognosis of these treatments and identifies predictors of their outcomes.

The text is very successful in providing a systematic analysis of the most recent relevant research in the area of apical periodontitis. The text would be an asset to any dental professional who has an interest in this area.

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Exploring Your Research Potential!

Mary Jacks, RDH, MS and JoAnn D Jordan, RDH, BS

Mary Jacks, RDH, MS, assistant professor and director of advanced degrees, Department of Dental Hygiene; JoAnn D. Jordan, RDH, BS, research study coordinator, Department of Periodontics. Both are with the University of Texas Health Science Center at San Antonio. Mary Jacks, RDH, MS, assistant professor and director of advanced degrees, Department of Dental Hygiene; JoAnn D. Jordan, RDH, BS, research study coordinator, Department of Periodontics. Both are with the University of Texas Health Science Center at San Antonio.

When your career as a dental hygienist began, did you think about research? Consider for a moment the ways research has changed patient care. For example, we no longer scale until the root is glassy smooth. Why did this theory change? Through the discovery of biofilm and the influence of the host response, we now believe that extensive scaling is not beneficial. Research has become the scaffolding for building better health care models and allows the dental hygienist an opportunity to expand professionally. Although, dental hygienists are well prepared to work in research, many are unaware of the possibilities.

Education standards require that all dental hygiene students receive a foundation in general education, biomedical sciences, dental sciences, and dental hygiene sciences. The goal is to produce a dental hygienist capable of caring for the public's oral health needs in both private and public health settings. Anecdotal reports from those who transitioned from patient care to a research corporation say that dental hygienists make excellent research employees. Below are some of the reasons cited:

- Collecting and synthesizing information learned through taking a medical history is a skill that can be transferred to collecting research data
- Attention to detail in every aspect of patient care is another trait that is essential in the process of conducting research.
- Organizational skills learned for patient care are very important when juggling several research processes at the same time.
- Communication with patients is likely the single most important skill.

Research is an avenue that hygienists should consider as an alternative to private practice, or for a change of pace. A common misconception is that research will not include direct patient care. The beauty of research is that you can choose to work with patients, or have no patient contact. Those who work as research dental hygienists treat patients as they normally would in private practice except that their treatment is part of an investigation. This entry-level position in research is called a clinical research assistant, and often requires a bachelor's degree.

Clinical research assistants (CRAs) are integral to collecting reliable data for a study. Studies can involve many sites across the country, and because quality research requires the CRA to be very structured in the collection of data, calibration meetings are held to ensure consistency among all CRAs. These calibration meetings provide an opportunity to collaborate with colleagues from different cities and with a variety of medical backgrounds. A dental hygienist learns skills that give new meaning to the term, "expansion of duties," by mastering duties such as drawing blood or collecting medical specimens. The outcome of a calibration session is a knowledgeable, well-organized CRA with a large network of medical and dental colleagues.

A dental hygienist with the desire to participate more in the research arena beyond the level of CRA maybe qualified to seek a variety of positions within a research company. While these opportunities vary among companies, a common step up is to Research Coordinator (RC). The role of the RC is often focused on the administrative aspect of managing the study protocols; as a result, most coordinators spend less time with patient care. As the responsibilities within the research company increase, so does the educational requirement. A RC is generally required to have a bachelor's or master's degree.

The RC will use negotiating skills, which were learned chair side with challenging patients, organizational, and communication skills when setting up a study. They establish guidelines for patient recruitment, taking into consideration the patient population, and the best way to recruit patients. The RC will also establish protocols to gather and enter data, write reports for the sponsor and/or IRB, and organize many schedules to complete the project. Whether there is a research sponsor or a single doctor conducting the research, the coordinator has the responsibility to manage the study protocols.

For the associate degree dental hygienist with a natural curiosity, or a desire to enter the world of research, the bachelor's degree program or the bachelor's degree completion (BSDC) program provides a flexible curriculum and time to focus on specific areas of interest such as research. A list of all programs can be found at www.adha.org. In several cases, the BSDC programs can be completed from a distance. For example, at the University of Texas Health Science Center at San Antonio (UTHSCSA), the BSDC program is currently 95% online, and includes tracks of study designed to meet the students learning goals. A student interested in research could complete a project under the direction of UTHSCSA faculty with agreed mentorship at the student's location of choice.

A master of science degree will allow additional opportunities for advancement in the research industry. For one major research company in the southern US, approximately 50% of the clinical site managers hold a master of science degree or are in the process of obtaining their MS. Learning the research process, from reviewing the literature, formulating questions, conducting a study, and reporting the findings, is integral to the MS degree and serves as a foundation for the experimental process. A colleague, Stacy, who is now the head of a therapeutic group within project management reports:

"One course that I found extremely valuable was "Analysis of the Literature." I can't count how many times each day I look up information on PubMed or another internet provider, and review client proposals including their statistical design and/or prior publications. I need to understand the scientific process as well as how studies are structured to understand that no research is perfect and most can be interpreted in many different ways. This also assists me in understanding FDA guidance documents for drugs and why certain decisions are made about safety profiles."

Opportunities for dental hygienists to participate in research exist in both Universities and the private industry. Schools are by nature the training ground for research methodologies, and a place that brings curious people together, and the combination of these 2 factors leads to discovery. Much of the time discovery is done for pleasure, but often the research dollars drive greater competition. In addition, the budget for most institutions of higher learning is enhanced with the dollars generated through research grants. In the world of private industry, several large research companies conduct trails for new drugs or treatment procedures.

Research has no failures. It establishes the format for more questions to be answered and hence, more research to be done. Questions in the dental field are endless and the need for exploration of different models, medicines, and procedures is never ending. The dental hygienist should remember the opportunities that research can provide in furthering a career.

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Effectiveness of Er:YAG Laser Therapy in Periodontal Patients

Karen B Williams, RDH, PhD

Karen B. Williams, RDH, PhD, is a professor and director of the Clinical Research Center at the University of Missouri-Kansas City. She received her certificate in dental hygiene and BS in education at The Ohio State University, her MS in dental hygiene education at the University of Missouri-Kansas City, and PhD in evaluation, measurement and statistics at the University of Kansas. Dr. Williams has been active in clinical dental hygiene for over 35 years and in clinical research for 23 years. Her areas of specialization include research design and statistics, educational methods, dental product efficacy, health outcomes research, and clinical dental hygiene. She is a research consultant for numerous dental manufacturers. Dr. Williams has presented papers and continuing education programs throughout the United States and internationally.

The purpose of *Linking Research to Clinical Practice* is to present evidence-based information to clinical dental hygienists so that they can make informed decisions regarding patient treatment and recommendations. Each issue will feature a different topic area of importance to clinical dental hygienists with A BOTTOM LINE to translate the research findings into clinical application.

Microbiological findings after periodontal therapy using currettes, Er:YAG laser, sonic, and ultrasonic scalers. Journal of Clinical Periodontology. 34(7):588-98, 2007 Jul.

Derdilopoulou FV, Nonhoff J, Neumann K, Kielbassa AM.

Department of Operative Dentistry and Periodontology, University School of Dental Medicine, Campus Benjamin Franklin, Charite Universitätsmedizin Berlin, Berlin, Germany.

Abstract

Objective. To evaluate and compare the microbiological effects of hand instruments, Er:YAG-laser, sonic, and ultrasonic scalers in patients with chronic periodontitis. Patient perception of each treatment was documented.

Methods and Materials. From 72 patients, bacterial samples were collected from the deepest pocket in each quadrant (total: 288 sites). A polymerase chain reaction kit estimated the amount of *Aggregatibacter (Actinobacillus) actinomycetemcomitans (Aa)*, *Porphyromonas gingivalis (Pg)*, *Prevotella intermedia (Pi)*, *Tannerella forsythensis (Tf)*, and *Treponema denticola (Td)* at baseline as well as 3 and 6 months after therapy. One quadrant in each patient was randomly assigned to currettes (H-group), Er:YAG laser (L-group), sonic device (S-group), or ultrasonic device (U-group).

Results. Three months post-operatively, the amounts of Pg, Pi, Tf, and Td were significantly reduced in all groups. Laser and sonic instrumentation failed to reduce Aa. Six months after therapy, significant differences were still detected for Pg (L- and U-group), for Pi and Tf (S-group), and for Td (L-, S- and U-group). Patients rated ultrasonic treatment as more preferable than hand and laser instrumentation.

Conclusion. The various treatment methods resulted in a comparable reduction of the evaluated periodontal pathogens, and bacterial increase was only partially different 6 months post-operatively. Ultrasonic instrumentation caused less discomfort.

Commentary

Over the past several years, laser therapy has been recommended as an alternative to traditional periodontal treatments such as scaling and root planing based on the assumption that lasers eradicate subgingival periodontal pathogens and inactive bacterial toxins from cementum. While many clinicians have embraced these procedures, little empirical evidence exists to support effectiveness of lasers in this regard or their advantage over traditional therapy. Consequently, this study was designed to evaluate the microbiological effects of Er:YAG laser, hand, ultrasonic, and sonic scaling. Specifically, researchers were interested in the effectiveness of these treatment modalities on reductions of 5 periodontal pathogens: *Aggregatibacter* (formerly *Actinobacillus*) *actinomycetemcomitans* (Aa); *Porphyromonas gingivalis* (PG); *Prevotella intermedia* (PI); *Tannerella forsythensis* (Tf); and *Treponema denticola* (Td). In order to qualify for participation, healthy subjects had to have moderate periodontitis defined as having at least 1 pocket in each quadrant with ≥ 4 mm of bone loss. Once recruited, subjects participated in a 3 to 5 week pre-trial oral hygiene phase in which oral hygiene procedures were mastered, and caries/defective restorations/pulpal pathology were eliminated to reduce the oral microbial load.

Seventy-two subjects were clinically and microbiologically assessed at baseline, and one site in each quadrant (within individual) was randomly assigned to be treated with one of the 4 treatments: laser, sonic, ultrasonic, or hand instrumentation. This 4 quadrant design, in which each subject contributes 4 sites, one site to each treatment modality, effectively removes other competing explanations related to treatment differences since each subject acts as their own control. Microbiological assessment and PPD were accomplished again at 3 months and 6 months post-treatment, and subjects were queried about their perception of pain, unpleasantness, and inconvenience experienced during therapy. A single blind examiner performed all clinical measurements and microbiological assessments. Examiner consistency was assessed and this individual demonstrated a $> 90\%$ agreement in obtaining PPD measurements. Microbiological samples were obtained from sites in each of the 4 quadrants using a sterile paper point, and identification of species was performed using polymerase chain reaction (PCR)/ DNA probe test.

In order to ensure maximal efficiency of the treatment interventions, all treatments were rendered under local anesthesia by the same clinician within a 24-hour period. Hand, sonic, and ultrasonic instrumentation was performed until the clinician was satisfied that root surfaces were debrided and planed. Laser instrumentation was performed until the laser's detection system indicated the root surfaces were free of deposits. The average time required to instrument single rooted teeth was 6.5 minutes, 9.7 minutes, 7.3 minutes, and 8.2 minutes for laser, hand, sonic, and ultrasonic, respectively. For multirooted teeth, times were considerably greater at 11 minutes for laser, 15 minutes for hand, 13 minutes for sonic, and 15 minutes for ultrasonic. Over the remaining 6 months, patients received a dental prophylaxis every 2 weeks for the first 3 months, and then once a month for the remaining 3 months of the trial.

Overall, the results indicated that there were few differences between the 4 treatment modalities for most of the periodontal organisms. While Aa was reduced significantly for hand and ultrasonic instrumentation at 3 months, this effect was not sustained at the 6-month evaluation. For Tf, Td, Pi, and Pg, all treatment resulted in a significant reduction from baseline at 3 months. However, at 6 months, only Pg was different from baseline for the laser and ultrasonic treatments, whereas Pi and Tf were less than baseline only in the sonic group. Td was significantly less from baseline in all groups. It is most noteworthy that none of the treatments resulted in a total eradication of the organisms. With respect to perception of discomfort, sonic scaling was rated as less uncomfortable than either hand or laser instrumentation immediately after treatment and one month later. In addition, hand scaling was rated as worse than sonic and ultrasonic instrumentation. No summary data were provided for change in PPD over time.

This study used an efficacy approach to examine whether there were differences in microbiological effects from the 4 nonsurgical treatments. Efficacy studies evaluate therapeutic outcomes when treatments are rendered under "ideal conditions". In this case, instrumentation time per tooth was fairly extensive, and the supportive therapy delivered over the 6-month period was intended to provide the best possible infection control. In spite of this, the microbial reductions observed at 3 month were not sustained at 6 months. The authors suggest that this rebound effect may be partially attributable to the ability of periodontal pathogens to invade and form reservoirs within the surrounding periodontal tissues. They also suggest

that these pathogens may also remain viable in dentinal tubules and niches on the root surfaces, as well as at other oral sites such as tongue, mucosa, and tonsils, allowing for repopulation over time. One can certainly argue that if differences were not observed between therapies under these relatively ideal conditions, it is highly unlikely that one would observe differences under typical clinical conditions. Apparently, hand, sonic, ultrasonic, and laser nonsurgical treatments provide similar efficacy on reducing subgingival microbial load. It is notable, however, that the research subjects in this clinical trial, who experienced each of the 4 treatments in different quadrants, clearly rated ultrasonic instrumentation as more pleasant, and less painful/inconvenient compared to hand and laser therapy. As dental hygiene clinicians, providing competent care that is acceptable to patients is always a primary goal. This study provides good evidence that can be applied in the clinical setting.

Short-term clinical and microbiologic effects of pocket debridement with an Er:YAG laser during periodontal maintenance. Journal of Periodontology. 77(1):111-8, 2006 Jan.

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Abstract

Background. The erbium-doped:yttrium, aluminum, and garnet (Er:YAG) laser is considered a useful tool for subgingival debridement because the laser treatment creates minimal damage to the root surface and has potential antimicrobial effects. The aim of this randomized controlled clinical trial was to evaluate clinical and microbiologic effects of pocket debridement using an Er:YAG laser in patients during periodontal maintenance.

Methods. Twenty patients at a recall visit for maintenance were consecutively recruited if presenting at least four teeth with residual probing depth (PD) \geq 5 mm. Two pockets in each of two jaw quadrants were randomly assigned to subgingival debridement using 1) an Er:YAG laser (test) or 2) an ultrasonic scaler (control). The laser beam was set at 160 mJ with a pulse frequency of 10 Hz. Clinical variables were recorded at baseline, 1 month, and 4 months after treatment. Primary clinical outcome variables were changes in PD and clinical attachment level (CAL). Microbiologic analysis of subgingival samples was performed at baseline, 2 days, and 30 days after treatment using a checkerboard DNA-DNA hybridization technique against 12 periodontal disease-associated species.

Results. The mean initial PD was 6.0 mm (SD: 1.2) in the test group and 5.8 mm (SD: 0.9) in the control group. At 1 month post-treatment, the PD reduction was significantly greater for test than control sites (0.9 versus 0.5 mm; $P < 0.05$). The CAL gain also was significantly greater (0.5 versus 0.06 mm; $P < 0.01$). At the 4-month examination, no significant differences were detected in PD reduction (1.1 versus 1.0 mm) or CAL gain (0.6 versus 0.4 mm). Both treatments resulted in reduction of the subgingival microflora. No significant differences in microbiologic composition were identified between the treatment groups at various time intervals. Degree of treatment discomfort scored significantly lower for the test than the control treatment modality.

Conclusion. The results of the trial failed to demonstrate any apparent advantage of using an Er:YAG laser for subgingival debridement, except less treatment discomfort perceived by the patients.

Commentary

As with the previous study, this team of researchers investigated whether there were any clinical or microbiological differences between teeth treated with the Er:YAG laser or ultrasonic scaling. In this study, a single examiner, who was blind as to treatment group, evaluated Plaque, Probing Pocket Depth (PPD), Bleeding on Probing (BOP), Clinical Attachment Level (CAL), Dentin Sensitivity, and Perception of Discomfort at baseline, 1 month, and 4 months after treatment. In addition, the following periodontal pathogens were assessed by DNA probe before treatment, 2 days after treatment, and 1 month following treatment: *Porphyromonas gingivalis* (PG); *Prevotella intermedia* (PI); *Tannerella forsythensis* (Tf); *Aggregatibacter* (formerly *Actinobacillus*) *actinomycetemcomitans* (Aa); *Fusobacterium nucleatum* (Fn); *Treponema denticola* (Td); *Peptostreptococcus micros* (PM); *Campylobacter rectus* (Cr); *Eikenella corrodens* (Ec); *Selenomonas noxia*

(Sn); and *Streptococcus intermedius* (Si). Twenty healthy subjects with moderate periodontitis (defined as having at least 4 nonadjacent teeth with > 5mm pocket depths in 2 quadrants) who had not had any periodontal instrumentation in the past 6 months, participated in this trial. The 2 sites in each quadrant were randomly assigned to receive either laser or ultrasonic subgingival therapy following baseline assessment of clinical and microbiological parameters. All treatment was provided by a dental hygienist, who was trained in use of both the laser and ultrasonic devices, at a single visit. Instrumentation was performed on each site until either the laser detection system indicated that the surface was clean (for laser-treated teeth) or the clinician judged that root surfaces were adequately debrided. The average treatment time for the 2 sites treated with laser was 3.6 minutes (SD = 1.3) compared to 4.0 minutes (SD = 1.1) for ultrasonic instrumentation. No anesthesia was provided to the subjects during this study, however, 0.12% chlorhexidine oral rinse was provided for 1 week post-instrumentation.

Change in BOP from baseline to 4 weeks was virtually identical between the 2 treatments, and decreased from 92% at baseline to 60% and 40%, at 1 and 4 months, respectively. For PD and CAL, both groups showed a statistically significant improvement compared to baseline. At 1 month post treatment, there was a slight (less than 0.5 mm), but statistically significant advantage for the laser treated sites for PD reduction and CAL gain, however, this advantage was no longer evident at the 4-month evaluation period. With regard to periodontal pathogens, 3 of the microbial species (*Cr*, *Ec* and *Sn*) were not found at any time point. A comparison of other periodontal pathogen between laser and ultrasonically treated sites showed no difference in levels at either 2 days or 1 month post treatment. Consistently, there was a reduction in all species over time with a slight tendency favoring ultrasonic scaling. Considering only the "red complex" organisms (those organisms most strongly associated with periodontitis - *Pg*, *Tf*, and *Td*), there was a statistically significant reduction at 2 days post treatment for both treatment modalities, however, no differences were observed for sites treated with laser versus ultrasonics. Subjects reported a higher level ($p < .05$) immediately following instrumentation, but discomfort at one month was low for laser and ultrasonic treated sites.

This study failed to show that the Er:YAG laser (which was also equipped with a calculus detection system) provides any clinical advantage to ultrasonic scaling when used in an "effectiveness study." An "effectiveness study" compares therapeutic interventions in settings that more closely approximate normal clinical care. The instrumentation time for both laser and ultrasonic treated sites in this study was more typical of the time normally allotted for nonsurgical periodontal treatment in a private dental office. One might argue that providing both interventions without local anesthesia may reduced thoroughness of instrumentation, and thus attenuate any treatment effects. As 40 of the 50 United States currently allow dental hygienists to administer local anesthesia, this indeed may be a limitation to whom, and under what conditions, these results may be generalized. While laser manufacturers claim that the Er:YAG laser has the potential to eliminate subgingival microbes and remove endotoxin from root surfaces, results from this study suggest that this claim is unwarranted. The authors are quick to note that use of DNA probe allows for assessment of bacterial genetic material, not viability, and further suggest that future studies may wish to culture organisms to determine if various non-surgical periodontal treatments differentially affect periodontal pathogen viability.

The Bottom Line

In the past decade, use of lasers in dental practice has become more common. As dentists may invest upwards of \$20,000 for these devices, they often fall prey to outrageous claims that the laser "sterilizes" pockets or provides clinical outcomes equivalent to surgery. As a result, dental hygienists may find themselves faced with the dilemma of whether to change their treatment procedures to incorporate lasers or continue with traditional nonsurgical therapies. Evidence-based dental hygiene care incorporates emerging scientific evidence, along with clinician expertise and patient preferences in the decision-making process for patient care. Given this, these 2 studies provide no substantial evidence that the Er:YAG laser, equipped with a calculus detection system, is more effective clinically than hand scaling or sonic/ultrasonic instrumentation. In fact, these findings provide continued support that nonsurgical periodontal intervention may impact microbiological and clinical parameters over the short term, but that the effects then diminish over a 4 to 6 month period. The equivocal findings regarding patient comfort are likely attributable to use of local anesthetic in the one study versus not in the other study. In order to perform maximally effective subgingival instrumentation, the current standard is to use local anesthetic for patient comfort and clinician effectiveness. In situations where local anesthetic may not be practical, laser may provide an acceptable alternative; however, the smell associated with laser use was rated as undesirable in the

Derdilopoulou et al study, and should be considered by clinicians as well. Collectively, results from these 2 recent randomized clinical trials suggest that the Er:YAG laser is not superior to hand, sonic, or ultrasonic instrumentation at 4 and 6 months following treatment. Future studies should be conducted to examine whether there is a differential effect of these interventions applied repeatedly in a supportive therapy manner over longer periods of time. Only then can clinicians make determinations about the clinical utility of various nonsurgical periodontal treatments.

Therefore, the following recommendations can be made based on the findings in these 2 studies:

- "Hand, ultrasonic, sonic, and Er:YAG periodontal instrumentation produce an initial reduction of periodontal pathogens, but the effect is short lived.
- "The Er:YAG laser is not superior at reducing periodontal pathogens or improving clinical parameters compared to ultrasonic, sonic, or hand instrumentation.
- The acceptability of lasers in a periodontal population is equivocal when compared to ultrasonic instrumentation.

Summary

Dental hygiene clinicians must continually revise and assess their decisions about providing appropriate and effective care as new evidence is generated. In this technological world, clinicians are often faced with claims that, at face value, sound exciting and promise "best outcomes" without evidence to support such claims. In addition, dentist employers may expect dental hygienists to begin incorporating laser therapy into nonsurgical periodontal treatment for patients as one means to offset their financial investment in the device. These studies provide early evidence that the Er:YAG laser therapy may provide similar, but not superior, outcomes in nonsurgical periodontal treatment. It is important to note that both studies used the Er:YAG laser at an energy level of 160mJ/pulse with a pulse frequency of 10Hz, with water irrigation. At higher energy levels, in-vitro use of the Er:YAG has been shown to cause root surface damage consisting of surface charring and crater-like defects. Clinicians interested in using laser for periodontal therapy need to be fully cognizant of the manufacturers recommendations for energy settings and directions for use.

As technologies advance, the same standards for evidence-based clinical decision making should be applied to new therapies and devices. Randomized clinical trials still provide the "best evidence" for single studies, assuming that these studies conform to quality standards by using random assignment, examiners who are calibrated and blind to treatment group assignment, control treatment(s), appropriate statistical analyses, and control for various confounders. The current 2 randomized clinical trials conform to these standards of quality, and, not surprisingly, obtained similar findings. Collectively, the results from these 2 studies suggest no difference between traditional nonsurgical interventions and laser therapy with regard to clinical/microbial outcomes. Clinicians should be wary of claims that are not independently supported by empirical findings.

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Can a Clinical Continuing Education Course Change Behavior in Dental Hygiene Practice?

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Can a clinical continuing education course impact practitioner provision of care in everyday practice? National recommendations call for continuing education that is closely linked to practitioner learning at the point of care and for outcome assessment that measures the effectiveness of learning activities on the learner's practice behavior. Educational research has shown that interactive learning with clinical participation and the opportunity to practice is one of the most effective educational interventions. This study used an interactive educational intervention during a 3-day clinical course designed for dental hygienists. A follow-up survey was sent to determine whether the knowledge and skills that were taught in the course were applied subsequently to patients in practice. Sixty-one of 97 surveys were returned for a 63% response rate. Descriptive data including frequencies, means, medians, and standard deviations were obtained for all survey items. The majority of respondents reported moderate to high gains in knowledge and skills as well as application to patients in practice. The majority also identified continuing education as the primary source of information used when making changes in practice.

Keywords: Outcome assessment, evidence-based clinical practice, effectiveness of continuing education, quality improvement, continuing professional development, diffusion of knowledge

Introduction

Continuing competency continues to be a concern for practitioners, educators, and regulatory agencies alike. One important measure of continuing competency is the application of current clinical evidence in practice. Continuing education courses are a common vehicle for the dissemination of clinical evidence to practitioners. Specifically, clinical continuing education courses are well suited to provide an opportunity to practice new skills on patients as they may be applied subsequently in practice. This study was conducted to see whether a specific clinical continuing education course that included an interactive element could change dental hygiene practice, and thereby contribute to bridging the gap between emerging research, technology, and professional practice.

Review of Literature

In April of 2000, 9 organizations committed to continuing professional development of physicians sponsored a continuing medical education summit on practices, opportunities, and priorities for the new millennium. One of the key issues identified

from the summit was that research including outcome assessments should be used to shape continuing professional development.¹ Measuring the long-term effects of continuing education on professional practice is an important piece of outcome assessment and is directly related to this issue.

Today, there is general agreement in the medical and dental community that practitioners need to make changes in practice based on the currently available scientific evidence in order to improve client outcomes. However, practitioners have difficulty accessing, interpreting, and applying current evidence.² In addition, evidence-based practice relies not just on the dissemination of the evidence but also on the readiness of practitioners to integrate the changes into everyday practice. Barriers to applying evidence in practice include practitioner factors such as clinical uncertainty and adherence to obsolete knowledge, practice factors such as time and organization, and educational factors such as outdated or inappropriate continuing education.³

Educational research has demonstrated that health care professionals use different educational strategies during their stages of readiness to change. Garcia⁴ has described the following 5 stages of learning and change in physicians: 1) priming/preparation, where the professional is dissatisfied with the current knowledge or skill; 2) focusing, where the professional is aware of new ideas or methods; 3) follow-up, where the professional is actively seeking new information or skills; 4) making change, where the professional implements the change; and 5) solidifying change, where the professional is seeking support for the change and is trying to convince others. Although continuing education as a learning method was found to be most effective during the follow-up phase, it was also used during the preparation and solidifying phases of change. Garcia also reported that change motivators were significant because they precede and effect change regardless of the quality of the educational experience.

However, it should be noted that change in practice cannot be expected from all health care professionals who are attending continuing education courses because not all practitioners are attending either with the intent or the readiness to change, ie, priming, focusing, and confirmation stages of learning either precede or follow change. In addition, there can be considerable variation in the time taken to make changes. Davis reported an average of 15 to 22 months for physicians to implement changes in practice, and that even when provided with sound information, clinicians can take 15 years to substantially change the way they practice.⁵ No literature was found relating to dental hygienist changes.

Although continuing professional education is a common vehicle for dissemination of scientific knowledge⁶, not all educational interventions are equally effective in promoting change. Numerous researchers in continuing medical education⁷⁻¹³ have conducted studies that rate educational interventions based on their effectiveness in promoting change. Bero et al⁷ found educational outreach visits as particularly effective in changing prescribing habits among physicians. An outreach visit consisted of a follow-up visit by a facilitator in the work setting to see if different prescribing patterns were implemented in practice. Tu and Davis⁸ stated that change was more likely if specific behavior was targeted rather than giving general guidelines or multiple recommendations.

Grimshaw et al⁹ found the most effective single educational interventions to be: 1) interactive sessions, where professionals engage in clinical participation and have opportunity to practice; 2) educational outreach visits, where an educator serves as a resource in the practice setting; 3) reminders, via mail, phone, or computer; 4) opinion leaders, where influential peers disseminate current information; and 5) patient-mediated interventions, where patients are given current information to discuss with practitioners. An example of a patient-mediated intervention would be to disseminate information on the dangers of smoking directly to patients with instructions to discuss this information with their health care providers.

Khan and Coomarasamy¹³ found that interactive workshops improved education and patient outcomes where didactic teaching alone increased knowledge but not skills, attitudes, and behaviors in practice. In general, interactive educational interventions were found to be effective in promoting changes in physicians.⁷⁻¹³ In a systematic review, O'Brien et al¹⁴ conducted a comparison of 32 studies of randomized trials or well-designed quasi-experimental studies in continuing medical education for their effects on professional practice and health care outcomes (N = 2995). These authors also concluded that interactive workshops resulted in moderately large changes in professional practice of physicians but that didactic sessions alone were unlikely to change professional practice.

In a narrative review of 16 syntheses across the health professions, Robertson, Umble, and Cervero¹⁵ reported that although continuing education has been demonstrated to improve knowledge, skills, attitudes, behaviors, and patient health outcomes, that a specific continuing education program cannot be fully understood unless the context of the health professionals practice is considered. These authors described learning as a social activity that takes place on 3 levels: 1) patient-professional interaction; 2) organizational systems and processes that comprise the practice; and 3) social, political, and economic systems that frame the practice.

Several studies have also documented positive outcomes following continuing professional education in nursing.¹⁶⁻¹⁸ Wilkinson et al¹⁶ reported that communication skills following a 3-day continuing education program were improved from precourse to postcourse, and also at 6 weeks following the course. Williams et al¹⁷ found improvements in knowledge and attitudes toward HIV/AIDS patients following a 5-day lecture/discussion workshop. Edwards et al¹⁸ measured change in knowledge and attitudes of nurses toward childhood fever management. They reported that peer group discussion helped draw attention to the importance of the topic and helped sustain the knowledge and attitude changes following the program.

Heaven, Clegg, and Maguire¹⁹ reported increased communication skills among nurses following a 3-day training program. However, they concluded that despite effective learning and motivation to change, improvements in communication skills of nurses were not automatically transferred back into the workplace, and were not maintained or generalized in a clinically meaningful way unless some kind of intervention was offered. They demonstrated that clinical supervision as an intervention strategy in the practice setting improved the integration of the skills gained from the communication training into nurses' everyday practice.

Alternatively, several authors²⁰⁻²² reported that commitment to change statements predicted subsequent changes in practice. The commitment to change process was described as: 1) asking practitioners during the course what changes they intended to make in practice based on the material covered; 2) following up in practice to find out whether the intended change was made; and 3) finding out what prevented the change if the intended change was not made.

Lockeyer et al²³ reported encouraging changes in practice following reflection exercises combined with case-based discussion, needs assessment, and commitment to change exercises. They described reflection as the engine that shifts surface learning to deep learning, understanding, and change in practice. Schön²⁴ has described the process of reflection-in-action as thinking critically on the main problem, reframing it, and working out consequences and implications to new elements.

In a recent study of occupational therapists, Lowe et al reported interactive learning activities grounded in evidence-based dental medicine. In 2007, the American Dental Hygienists' Association (ADHA) published *Standards for Clinical Dental Hygiene Practice*. Professional responsibilities outlined in this document include: "commitment to lifelong learning to maintain competence in an evolving healthcare system."²⁷

Although there have been several studies in medicine and nursing, few studies have been conducted in dentistry and dental hygiene that demonstrate positive outcomes from continuing education courses that were applied subsequently in the practice setting. In one such study, Grembowski and associates²⁸ reported greater rates of fluoride varnish and sealant application in dental offices after a single didactic educational intervention when compared to a control group. However, the changes were not statistically significant. Asadoorian and Locker²⁹ surveyed 1750 Canadian dental hygienists and compared dental hygienists who were under a traditional mandatory continuing education system (control group), with dental hygienists who were under a system where individual needs assessment and goals in continuing education were pre-identified (experimental group). They found no differences in the total number of continuing education activities between the groups. However, they reported that dental hygienists in the experimental group were more likely to select continuing education courses that yielded greater change opportunities that were relevant to their practice and learning needs.

Several investigators have shown positive changes in practice after multiple educational interventions among dentists.³⁰⁻³² Using a randomized controlled study design and multiple educational interventions, Best and Messer³⁰ in 2003 reported

increased knowledge in oral health care, ethics, legal aspects, and infection control of dentists in Australia. Brown and Spencer³¹ reported improved recording of periodontal information in patient records of dentists in Australia following multiple educational interventions using a record audit and a comparison group. Bader et al³² also noted improved notation of periodontal conditions by dentists in North Carolina following multiple educational interventions using a record audit and a control group. However, all of these dental studies included a continuing education experience together with other educational strategies. Although encouraging, more studies are needed to evaluate the relative effectiveness of educational interventions including single intervention strategies for promoting change in dental and dental hygiene practice.

Based on a review of the literature, interactive clinical participation with opportunity to practice was selected as the educational intervention for this study because research has shown that interactive education is one of the most effective single intervention strategies in promoting changes in professional practice.⁷⁻¹⁴ The purpose of this study was to determine what knowledge and skills participants thought they acquired in a continuing education course, if this knowledge and these skills were subsequently applied to patient care, and what were their most important sources of information when making changes to their dental hygiene practice.

Methods

The study group was comprised of 97 dental hygienists who completed a 3-day lecture and clinical continuing education course on nonsurgical periodontal therapies at a dental school in the upper Midwest region of the United States. In order to increase the sample size, participants who participated in the course during a 5-year period were included in the study.

An author designed and pretested the survey and it, along with a cover letter, was sent to the 97 participants. The cover letter provided information on informed consent and consent was assumed upon receipt of the completed survey. The surveys were coded and blinded to ensure anonymity. The questionnaires were mailed 6 months following the last course of the 5-year period. A reminder post card was sent 6 weeks after the initial survey was sent. Sixty-one dental hygienists completed the survey yielding a 63% response rate.

Survey questions were designed to: 1) identify demographic information about the course participants; 2) determine self-reported knowledge and skills attained during the course; and 3) determine self-reported outcomes of the course applied later to patients in the practice setting. The knowledge and skill items that were selected for the survey were those that were taught in the course and the items that we selected specifically for their ratings of "skill improvement" and "performance with patients" were those skills that they had practiced on patients during the 3-day course (periodontal probing and charting, hand instrumentation, and ultrasonic instrumentation).

Descriptive statistics that included frequencies, means, medians, and standard deviations were used to analyze all the data. In addition, correlation analyses were performed on the following variables: 1) number of continuing education hours completed per year in relation to the number of years in practice; 2) number of continuing education hours completed per year in relation to the rating of skill improvement on patients in practice; and 3) whether the employer paid for the continuing education course in relation to the rating of skill improvement on patients in practice.

Results

Demographic Data

Thirty-eight percent of the respondents were members of their professional association with 3% holding leadership positions. Forty-one percent participated in volunteer community service activities. The average number of continuing education credits reported by the study participants was 16 hours per year (SD = 11). Continuing education was mandatory for relicensure for 75% of the study participants. The group averaged 9.5 years since attaining their dental hygiene degree (SD = 9.4).

The course participants averaged 32.5 hours of practice per week (SD = 4.6). The group averaged 6.4 years of full-time clinical practice (SD = 6.2) and 7.8 years of part-time clinical practice (SD = 9.7). Seven of 61 dental hygienists reported from 1 to 7 years during which they did not practice dental hygiene. The group averaged 5.1 years of practice in their primary practice setting (SD = 5.3).

Most (80%) of the study participants were employed in one practice, 9% in 2 practices, and 2% in 3 or more practices. The majority (92%) were employed in a general practice, 3% in a periodontal practice, 1% in a pediatric practice, 1% in a public health setting, and 1% were not currently employed. Fifty-eight percent worked for a solo practitioner, 40% worked in a group practice, and 2% practiced in a community practice setting. Eighty-eight percent of the respective employers paid the tuition for course participants.

Changes in Knowledge

The course participants were asked to rate the amount of knowledge acquired during the course on the subjects of root morphology, instrument sharpening, patient assessment, hand instrumentation, ultrasonic instrumentation, new periodontal products available for office and home use, and integration into practice (ie, dental insurance and case studies). In addition, they were asked to assess any skill improvement in periodontal probing and charting, hand instrumentation, and ultrasonic instrumentation. The rating scale was from 1 to 5 with 1 as no change, 2 as low, 3 as medium, 4 as high, and 5 as very high gains in knowledge or skill.

Median scores were reported because they provided the most representative picture of the overall group responses and the measurement scales were ordinal. The median scores for the following variables on acquisition of knowledge were: root morphology- 3; instrument sharpening- 4; patient assessment- 3; hand instrumentation- 4; ultrasonic instrumentation- 4; new periodontal products- 4; and integration into practice- 3. The median scores for the following variables on skill improvement were: instrument sharpening- 3; periodontal probing and charting- 3; hand instrumentation- 4; and ultrasonic instrumentation- 4.

Changes in Practice

The course participants were also asked to assess how their treatment of patients in practice had improved as a result of the 3-day periodontal nonsurgical therapies course. Changes regarding patient probing and charting skills were selected because they were emphasized during the course and because it was deemed important to identify the location and depth of periodontal pockets in order to provide proficient hand and ultrasonic instrumentation. Most study participants rated gains in skills to be medium or high (See Table I). Written comments included: "I was already performing periodontal probing and charting prior to the course" and "my dentist does all the charting."

Table I- Post-course patient probing and charting skills
(self-assessment of gains in skills)

Level	Frequency	Proportion
1 No change	11	19%
2 Low	7	12%
3 Medium	17	29%
4 High	18	31%
5 Very High	5	9%

N = 58

The course participants were also asked to assess their postcourse hand and ultrasonic instrumentation skills. Most respondents indicated high levels of gains in skills for both. Results are summarized in Tables II and III. Written comments for postcourse hand and ultrasonic instrumentation skills included: "I was already doing these procedures" and "I was not working after the course."

Those who indicated no postcourse changes in practice gave the following reasons: 1) not working enough to implement changes; 2) inadequate feedback; and 3) inadequate time per patient in practice.

Course participants were also asked "what is your primary source of information when you wish to make a change in clinical practice?" Their choices for responses were: 1) continuing education courses; 2) dentists; 3) other dental hygienists; 4) journal articles; 5) sales representatives; and 6) other (please identify). The results are reported in Table IV.

Table IV- Primary source of information used when making changes in practice

Source	Frequency	Proportion
Continuing Education Courses	39	75%
Dentists	3	6%
Other Dental Hygienists	9	17%
Professional Journals	1	2%
Sales Representative	0	0%
Other	0	0%

N = 52

The selection of correlational tests was determined by the type of data, ordinal or continuous, and the small sample size. Because of the variability in the number of continuing education hours reported by the group (SD= 11), the statistical tests that involved comparisons to continuing education hours were computed both for all respondents and for respondents under 35 hours. The results that follow are only for the group of respondents under 35 hours, which excludes the 2 outliers with very high hours who could have disproportionately influenced the results. However, in all cases, no relationships were found.

No significant relationships were shown between the number of continuing education hours completed by the course participants and the number of hours practiced per week, as indicated by linear regression analysis (slope estimate = -0.04; $p = .68$). There were no relationships demonstrated between the number of continuing education hours completed per year and the self-reported improvements in skills with patients in practice for this particular continuing education program. One-way ANOVA tests were conducted to analyze the relationships between the number of continuing education hours completed and: 1) periodontal probing and charting ratings (F ratio = .5192; $p = .722$); 2) hand instrumentation ratings (F Ratio = 1.9816; $p = .1116$); and 3) ultrasonic instrumentation ratings (F ratio = 1.2269; $p = .3133$) (Tables II and III). There were no relationships found between whether the employer paid and self-reported improvements in skills with patients in practice. Pearson chi square tests were used to assess the relationships among whether the dentist paid for the course and: 1) periodontal probing and charting ratings (chi square = 1.238; $p = .5385$); 2) hand instrumentation ratings (chi square = 2.152; $p = .3409$), and; 3) ultrasonic instrumentation ratings (chi square = 2.045; $p = .3596$).

Table II- Post-course hand instrumentation skills
(self-assessment of gain in skills)

Level	Frequency	Proportion
1 No change	3	5%
2 Low	8	14%
3 Medium	18	31%
4 High	23	40%
5 Very High	6	10%

N = 58

Table III- Post-course ultrasonic instrumentation skills
(self-assessment of gain in skills)

Level	Frequency	Proportion
1 No change	6	10%
2 Low	2	3%
3 Medium	14	24%
4 High	26	45%
5 Very High	10	17%

N = 58

In general, the results of the study indicated that participants felt they increased their knowledge and skills on all items at medium to very high levels, and applied these skills to their practice of dental hygiene. Over 90% of the participants indicated that they received new professional information from continuing education courses and/or other dental hygienists.

Discussion

To document whether continuing education can serve as an effective bridge between research and practice, as recommended by the continuing medical education summit,¹ the ADA,²⁶ and others, outcome assessment of changes in health care practice is needed. Schön²⁴ described professional schools as ideally positioned to bridge the gap between research and practice. He stated that professional schools have a dual orientation: on the one hand to provide discipline-related fundamental research as part of their university role, and on the other hand to provide applied research as part of their responsibility to the practicing community.

The applied research study reported here showed self-reported outcome gains in knowledge acquired for all of the subject areas covered during the continuing education course as well as for all the clinical techniques taught during the course. In addition, the group reported high utilization of the information and skills in everyday practice.

The median rating score of 4, indicating high change, was reported for both hand and ultrasonic instrumentation. This was true both in their ratings of skill improvement and in their ratings of improved performance with patients as a result of the course. In other words, the respondents believed that their skills in hand and ultrasonic instrumentation were highly improved and that the improved skills were transferred to patient performance in practice. Because there is some evidence that intent to change is related to actual change this finding is encouraging.⁴

It was postulated that a greater number of continuing education hours may be related to their practice experience, ie, less experience and greater need for continuing education, or to their self-assessment of skill improvement, ie, more continuing education hours and more skill improvement attained and reported. We also believed that if their employers had paid for the course there may be greater support for implementing and refining the subsequent skills in practice. In essence, we wanted to see if certain factors may be related to transfer of skills into the practice setting.

We expected to find some association between level of continuing education participation and practice experience, with possibly the less experienced seeking more continuing education courses. However, the lack of relationship demonstrated in this study may indicate that the dental hygienists who took the course and responded to the survey were more proficient at selecting a specific course based on their needs rather than just attending a large number of courses. This would support findings from Asadoorian and Locker²⁹ who reported that dental hygienists in Canada who had preidentified their learning needs and goals were more efficient in selecting their continuing education courses.

Although participants in this study were primarily from states with mandatory continuing education they averaged 16 hours of continuing education credit per year. On average, they worked 32.5 hours/week, mostly for general practitioners. The minority were members of their professional association (38%) and participated in volunteer community service activities (41%).

The lack of relationship between the number of continuing education credits taken and the ratings of clinical skill improvement may not be surprising since there is a diversity of continuing education courses available for credit, many of which may not relate directly to clinical skills. However, we expected to see a relationship between the employers' payment, which demonstrated their support for the course, and their ratings of clinical skill improvement. Especially because some literature suggests that management support is key to the successful transfer of skills to professional practice.^{15,19,25}

On the other hand, the lack of relationship between payment for the course by the dentist and ratings of skill improvement may be a reflection of the practice mode of dental hygienists. Within the time constraints of the overall appointment, dental hygienists may have a fairly wide range of choices in how to spend appointment time. In other words, improving one's level of probing, hand, and ultrasonic skills may not require additional support to implement since these procedures are already inherent in the dental hygiene appointment. However, management support may be needed if new equipment or additional patient time is required in order to implement the new or improved skills.

We have identified 5 main limitations of the study that reduce the capacity to generalize from the results. First, the study utilized self-assessment and self-report, which is subject to individual bias and may reflect perceptual changes rather than observed changes. Second, the sample was comprised of a 5-year period of course participants. Individuals who participated

during the first years of the course simply may not have remembered the effects of the course on their skill level and performance with patients. In addition, they may have taken several interactive courses in the interim that may have had an impact on their knowledge and skills. Third, the results of studies reviewed may not be generalized to the results of this study as the subjects in the studies reviewed were generally physicians who have different educational and health care systems as well as barriers to change. Fourth, the study did not include a control group. If we had also surveyed a control group of dental hygienists who had not taken the 3-day periodontal course, or had completed the lecture but not the hands-on component, the comparative results would be more meaningful. And fifth, there might be some question as to the reliability and the validity of the questionnaire instrument itself.

Nonetheless, it was encouraging to find that 75% of the study respondents use continuing education as their primary source of information when making changes to practice. If this were true of the general population of dental hygienists, continuing education as a methodology would be well positioned to bridge the gap between research and practice. It was also encouraging that no one identified sales representatives as a primary source of information.

There are 2 major perspectives to keep in mind when addressing continuing education and its potential to change professional practice. First, how can we improve individual courses and thereby effect individual practitioners? In essence, this would be changing the world one person at a time. And second, how can we design a quality assurance system that is meaningful for practitioners and the public across a practitioner's career span? This study was aimed at the first perspective.

However, regulatory agencies together with the health professions are charged with the perspective of quality assurance. Recently 16 major stakeholder organizations in continuing medical education met as a conjoint committee in order to propose changes to the existing continuing medical education system with the goal of improving the quality and effectiveness of continuing medical education, thereby supporting the profession and improving health care quality.³³ Their recommendations reach beyond individual courses to defining core curricula and core competencies for maintaining currency. They have called for the development of general competencies for all physicians as well as specialty competencies, and they have defined stages of learning from novice through mastery for each competency.

The American Dental Hygienists' Association (ADHA) has taken similar steps in formulating guidelines for clinical dental hygiene practice.²⁷ These guidelines lay at the foundation for dental hygiene practice and as such could be the basis for developing a core curriculum and core competencies for maintaining currency in the practice of dental hygiene across a career span. Thus, a core curriculum would be the framework for developing a continuing education curriculum that mirrors the core competencies.

However, even if a core continuing education curriculum in dental hygiene practice was developed and adopted by relevant agencies, the actual transfer of new information and skills to professionals in practice would still rest on the continuing educational system. In other words, we would still be left with how to develop, implement, and evaluate effective individual courses within the core competency framework.

Looking to the future, these authors believe the following strategies have great potential to effect change in professional practice through continuing education. First, interactive educational programs have great potential to affect professional practice, and identifying learning needs and goals prior to the course is more likely to effect practice.²⁹ Second, it is recommended that reflection and commitment to change exercises be utilized.²⁰⁻²⁵ Asking participants to reflect on what they have learned, anticipating problems with implementation in practice, and discussing the issues during the course, would be a fairly easy strategy to implement in any continuing education course. Finally, asking practitioners what they intend to change in practice and to follow up with them at a later date about whether they implemented the changes and if not, why, would also provide important information for continuing education developers and professional regulators.

In addition, it may be significant to include a focus on the practice setting following the continuing education activity since clinical supervision in practice¹⁹ and peer group discussion outside of the classroom¹⁸ have been shown to increase and sustain integration of knowledge, attitudes and skills into professional practice. In addition, Robertson et al¹⁵ described continuing education as a social activity that includes not only the organizational systems that comprise the practice but also external systems that frame the practice. They reported that changes in professional practice could only be understood within the larger context of organizational and societal support.

Additional research needs to be conducted to measure the impact of continuing education on professional dental hygiene practice. It is important to determine if the findings from research on physicians and other health care providers hold true for dental hygienists and what are the specific learning needs and barriers to change in dental hygiene practice. Studies addressing these suggestions relate to the ADHA Research Agenda.

There may be benefits gained from evaluating the effects of reflection and commitment to change as educational strategies utilized during continuing education courses. Multiple intervention studies such as continuing education together with clinical supervision, peer group discussion, or other post-course interventions may be most elucidating in promoting changes to professional practice. Finally, study designs utilizing precourse and postcourse comparisons or ideally control group comparison would be extremely beneficial in extending our understanding of actual changes in professional practice as a result of a continuing education experience.

Conclusion

In conclusion, results of the study reported here showed that the majority of respondents self-reported moderate to very high gains in professional practice for improvements in probing and charting skills as well as for hand and ultrasonic instrumentation skills following a continuing education course that included lecture and interactive experiences. The majority of respondents also reported that continuing education was the primary source of information that they used when making changes in practice. These findings together demonstrate that this group of dental hygienists perceived continuing education as an important vehicle for facilitating change to practice. Although course participants self-reported clinical gains that were applied in professional practice, their perceptions cannot be treated as behavioral evidence.

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Notes

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Effects of 5 Different Finger Rest Positions on Arm Muscle Activity During Scaling by Dental Hygiene Students

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Purpose. *This study was conducted to determine the effects of 5 different finger rest positions: opposite arch, standard intraoral, basic extraoral, cross arch, and finger on finger on the muscle activity of 4 forearm muscles (extensor carpi radialis longus, flexor carpi ulnaris, biceps brachii, and pronator teres) during a simulated periodontal scaling experience.*

Methods. *A convenience sample of 32 consenting senior dental hygiene students who met inclusion criteria participated. Using a 4 x 5 counter-balanced research design, each participant used a Gracey 11/12 curet to scale one cc of artificial calculus from first permanent molar typodont teeth (#3,14,19,30). Five different typodonts were set up for each participant with fulcrums randomly assigned for use on each typodont. While scaling, the participant's muscle activity was measured by surface electromyography. Two-way analysis of variance with repeated measures was used to determine if significant differences existed in the amount of muscle activity generated with each fulcrum.*

Results. *Results revealed no statistically significant interaction effect between area of the mouth scaled, muscle activity, and fulcrum used. Similar muscle activity was produced throughout the mouth regardless of the fulcrum used. The upper right quadrant produced the most muscle activity ($p = 0.0101$) and the lower left quadrant produced the least ($p < .0001$). When comparing the overall muscle activity generated with each fulcrum, only the cross arch fulcrum when compared to the opposite fulcrum produced statistically significant results ($p = 0.0110$).*

Conclusions. *Based on the results, similar muscle activity is produced when using any of the 5 fulcrums in each quadrant of the mouth. Clinicians appear to experience minimal ergonomic advantage in terms of fulcrums used and area of the mouth scaled during a simulated scaling experience.*

Keywords: Dental hygiene, finger rest positions, musculoskeletal disorders, fulcrum

Introduction

The well-documented, high incidence rate of musculoskeletal and cumulative trauma disorders (CTD) in dental hygienists attests to the musculoskeletal trauma experienced by dental hygienists.¹⁻⁸ Dental hygiene practice is physically demanding, requiring dental hygienists to use high prehension forces, perform highly repetitive hand and wrist motions, apply heavy pressure to fulcrum fingers, and hold their wrists in awkward positions for long periods of time. Researchers have been

challenged with determining causes and preventive strategies for CTD in dental practitioners since these disorders threaten productivity, career longevity, and health of the professionals affected. Risk factors associated with CTD in dental hygienists include repetitiveness of task, posture, and mechanical stresses. Many different strategies have been promulgated to decrease CTD risk in dental practitioners. Preventive strategies include the use of powered scaling devices, larger diameter instrument handles, improved work pacing, and the use of fulcrums during instrumentation.⁹⁻¹⁴ However, minimal quantitative evidence is available to support these strategies.

In dental hygiene, a fulcrum is a finger rest used by a practitioner to stabilize the hand and reduce muscle stress while performing clinical procedures such as therapeutic scaling on a patient's dentition. Use of a fulcrum during instrumentation has been advocated since 1915.¹⁵ However, minimal evidence exists concerning what instrument fulcrums pose the greatest protection against CTD. Moreover, dental hygienists are educated to use a variety of instrument fulcrums to provide therapy, stabilize the instrument and reduce muscle stress, yet there is limited research, based on sound ergonomic theory, to support the use of these fulcrums.

To date, only one study has been found that compared fulcrums and muscle activity during scaling. In the one identified study on fulcrums, Dong et al used 12 pre-dental students as participants to determine the effects of 3 different fulcrums on muscle activity and pinch force in a simulated periodontal scaling experience.⁹ With surface electromyography (sEMG), hand muscle activity was measured in relation to 3 different fulcrums: extra oral, intraoral with one finger rest, or intraoral with 2 finger rests when scaling tooth number 13. Each participant was provided with typodont teeth coated with nail polish to simulate calculus. Participants had no previous scaling experience and were instructed in scaling techniques prior to the study. Participants scaled the typodont tooth using each of the fulcrums for up to 2 minutes. Results revealed that muscle activity reduced when oral fulcrums were used compared to no fulcrum. As a way to reduce CTD, the authors concluded that dental practitioners would benefit from using fulcrums.

Dong and colleagues used 4 extrinsic hand muscles, which were very close together and likely with sEMG, had cross-talk susceptibility confounding the results.⁹ The 12 participants were evaluated in one quadrant of the mouth, on one tooth, and coupled with no scaling experience, limit generalization of the results. Clearly, more research is needed to clarify the role of fulcrums in the ergonomic practice of dental hygiene. To compensate for these limitations, this present study used 4 muscles, far enough apart, to reduce the probability of cross-talk. The comparative effects of 5 different finger rests on forearm muscle activity in 32 senior dental hygiene students who had scaling experience in all 4 quadrants of the mouth, were used to ensure valid and reliable research outcomes. Therefore, the purpose of this study was twofold: 1) to compare the effects of 5 different finger fulcrums-opposite arch (OA), standard intra-oral (IO), basic extra-oral (EO), cross arch (CA), and finger-on-finger (FF)-on the arm muscle activity of 4 muscles, (extensor carpi radialis longus, flexor carpi ulnaris, biceps brachii, and pronator teres) during a simulated periodontal scaling experience, and 2) to determine if there was an interaction effect between quadrants scaled, muscle activity, and fulcrums used. Kinesiological sEMG was used to determine change in muscle activity.

Methods and Materials

Prior to study initiation, the protocol was reviewed and approved by the University Institutional Review Board for the Protection of Human Subjects. Participants comprised a convenience sample of 31 female and 1 male, first-semester, right-handed, senior dental hygiene students ranging in age from 22-44. Participants were recruited by distributing an invitational letter to second year dental hygiene students. To determine whether interested participants met the inclusion and exclusion criteria, a preliminary screening questionnaire was completed. Any past or present injury or disability of the working hand, wrist, forearm, or shoulder excluded participants from the study. Exclusion criteria controlled for past injury, which might skew the sEMG readings. Potential participants who qualified were invited to participate and given an informed consent form explaining the purpose of the study, procedures involved, and the risks and benefits. Those that qualified and agreed to participate signed a written informed consent form prior to the study's initiation. Random assignment of participants to the various trials controlled for sequence effects, selection bias, investigator bias, and any unanticipated participant-relevant variable.

Dental chair-mounted typodonts equipped with an artificial face were used to simulate a client's oral cavity during scaling. Teeth numbers 3, 14, 19, and 30 were coated with up to one cc of artificial calculus on the mesiobuccal surfaces. Artificial calculus (Columbia Dental, NY) was dispensed using a 6 cc syringe and placed from midbuccal to the mesiobuccal embrasure of the test teeth and covered to the height of the crown from the gingival margin. To standardize the calculus application process, a paint mask was placed over each molar before the artificial calculus was applied.

A pilot study was conducted with 2 participants to test and refine the methods. The pilot included placing the sEMG electrode sensors on the right forearm of each of the 2 pilot participants and collecting muscle activity data during dental hygiene instrumentation. Participants performed movements planned for in the study and an examiner measured muscle activity. The pilot study was conducted to determine set up time, accuracy of readings, characteristics of the software, and data recording.

Electromyography

With 32 participants and 20 trials per participant, sEMG measured muscle activity on 4 superficial muscles independent of each other. As an electrodiagnostic test, sEMG is a valid and reliable measure of real-time muscle activity and has been used in multiple studies evaluating musculoskeletal disorders.^{9,14,16-19} Physical therapy consultants verified the 4 muscles selected for testing. sEMG muscle cross-talk susceptibility was decreased by placement of each electrode sensor directly over the middle of each of the identified muscles. Each sensor was placed at least 2 cm apart from the other according to accepted protocol (Figure 1).²⁰⁻²² A sensor was placed on the biceps brachii muscle as the examiner palpated the middle of the anterior belly exposed with the forearm supinated. The orientation of the sensor was parallel to the muscle fibers. Once the sensor was placed and secured by tape, the participant made a fist, flexed the forearm at the elbow joint, and Maximum Voluntary Isometric Contraction (MVIC) was tested and recorded with the examiner applying forced resistance pulling on the forearm at the wrist with the participant resisting the pull.

Figure 1. Surface Electromyography sensors attached to muscles while scaling



A sensor was placed on the pronator teres muscle as the examiner briefly palpated the proximal anterior forearm with the forearm partially flexed at the elbow joint and slightly pronated. The sensor was placed parallel to this muscle. Once the sensor was secured by tape, the MVIC was tested and recorded with the examiner applying forced resistance to the participant's clenched fist, resisting the twisting pressure from pronated to supinated position.

A third sensor was placed on the flexor carpi ulnaris muscle as the examiner palpated the muscle and the participant flexed the wrist and adducted the hand at the wrist with fingers extended. From the anterior view, the sensor was placed medially mid-way between the wrist and the elbow, parallel to the muscle and secured by tape. The MVIC was tested and recorded with the examiner applying forced resistance to the participant's ulnar deviation of the hand at the wrist joint.

A fourth sensor was placed on the extensor carpi radialis longus muscle as the examiner, with the forearm pronated, asked the participant to make a fist and squeeze. The muscle contraction could be palpated with the fist squeeze. The sensor was placed parallel to the muscle on the lateral side of the forearm midway between the wrist and elbow. Once the sensor was secured by tape, the MVIC was tested and recorded with the examiner applying forced resistance to the participant's fingers in a fist.

Data from the sEMG readings were collected during MVIC for each of the muscles by one physical therapy examiner. MVIC values were considered 100% activity for that muscle. The sEMG activity measured during scaling was expressed as a percentage of MVIC activity. This standard method has been reevaluated and found to be reliable for use with surface electrodes.¹⁹⁻²¹ It also controls for any baseline activity/noise, because this noise would be present in both the MVIC readings and the scaling activity readings, and is thus cancelled.^{13,18-21}

On each of the sEMG electrodes are 3 medical-grade stainless steel 12 mm disks. Electrode contact surfaces come in contact with the skin. There is a fixed distance of 22 mm between the centers of the active surfaces and the reference or ground electrode in the middle of the row of electrodes.

The electrodes are linked by coaxial cable to an amplifier that is connected to a personal computer with a DataQ data acquisition board. Lead wires from the electrodes allowed the participant to move and work. The computer program, produced by DataQ Instruments (Akron, Ohio), collected and analyzed the sEMG data. A sampling rate of 1000 samples per second per channel was used. The University Physical Therapy Motion Lab's sEMG system used in this study is a 10-channel, cabled, biological signal-acquisition system that records the electrical activity of superficial muscles using MA-110 surface electrodes with preamplifiers from Motions Lab Systems, Inc (Baton Rouge, La). Four channels were used since the study measured only 4 muscles, with one muscle per channel measured by sEMG.

Procedures

To ensure standardization of the participants, a 20-minute fulcrum training and practice session was conducted by the principal investigator. The training occurred immediately before the experiment. To simplify the process, only supragingival scaling was used. To further ensure standardization, one physical therapy examiner conducted all of the sEMG recordings; a second physical therapy examiner timed the 20 second measurement period during each one minute of scaling.

Typodonts were prepared and set up by the principal investigator. Five different typodonts were set up for each participant with a different fulcrum: opposite arch, standard intra-oral, basic extra-oral, cross arch, and finger-on-finger (IO, EO, OA, CA, and FF), and were randomly assigned for use on each of the typodonts. To ensure blinding, the principal investigator was blind to the order of the fulcrums. The research assistant randomized the fulcrums, signaled to the physical therapy student the beginning and ending of scaling, and completed participant paperwork. Each participant was provided with a new Premier Gracey 11/12 curet (Plymouth, PA), personal protective equipment, and instructed to hand scale the mesiobuccal surfaces of the permanent first molars in each of the 4 quadrants (UR, UL, LL, and LR) for up to one minute using one of the assigned fulcrums per typodont. The process continued until all 5 fulcrums were used resulting in 4 readings per typodont. Testing took approximately one hour per participant. The one minute rest between quadrants allowed sufficient time for recovery from any muscle fatigue that might occur. Also projected was the counterbalanced design of fulcrum assignment would eliminate any systematic error that fatigue might cause. Considering the pace at which dental hygienists normally practice, the rest period was sufficient.

Statistical Treatment

The University Physical Therapy Motion Lab's sEMG system utilizes a Windows-based operating system for collecting MVIC for each of the muscles. Measurements were averaged using root mean squares (RMS); sEMG activity was expressed as a percentage of MVIC activity. Two-way ANOVA with repeated measures was used to analyze the data collected. If significant interaction occurred between quadrants and fulcrums, the Tukey post hoc test was run to locate significant differences.

Results

The overall muscle activity means and standard deviations for the 5 fulcrums in each of the 4 quadrants is found in Table 1. The combined muscle activity means versus the 4 quadrants for the 5 fulcrums is graphically presented in Figure 2. Data reveal the opposite arch fulcrum generated the least amount of muscle activity; however, no statistically significant interaction among quadrants, muscle activity, and type of fulcrums ($p=0.4727$) was found (Table 2).

Figure 2. Combined Muscle Activity Means vs. Quadrants for the Five Fulcrums.

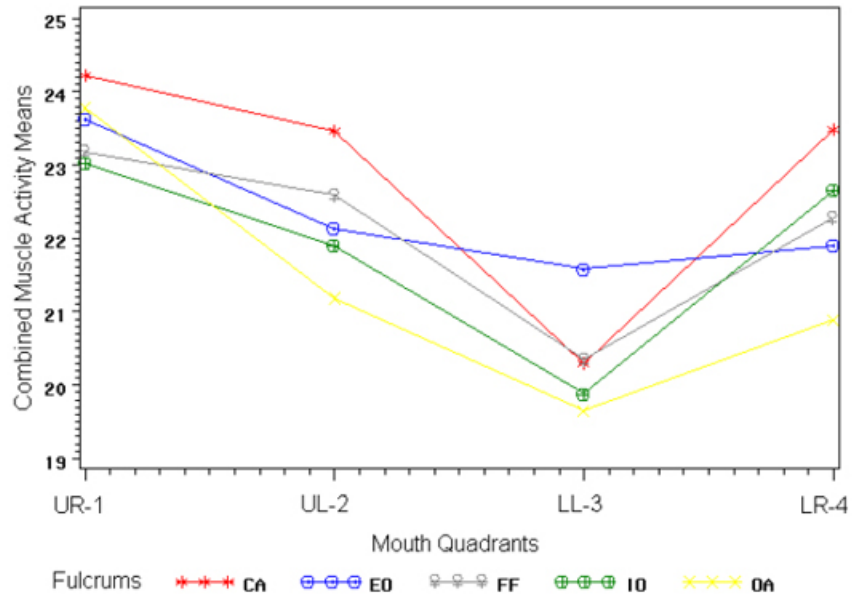


Table 1. Muscle Activity Means and Standard Deviations Using Four Quadrants and Five Fulcrums per Quadrant.

Analysis Variable : Combined Muscle Activity Quadrants vs. Fulcrums							
Quadrants	Fulcrums	N Obs	N	Mean Muscle Activity	Std Dev	Minimum	Maximum
UR - 1	CA	32	32	24.22	7.99	13.14	46.00
	EO	32	32	23.62	10.66	11.44	59.96
	FF	32	32	23.18	7.71	11.36	36.66
	IO	32	32	23.02	8.74	12.30	52.43
	OA	32	32	23.77	10.53	12.42	51.14
UL - 2	CA	32	32	23.47	9.16	11.70	53.07
	EO	32	32	22.14	9.73	11.62	53.67
	FF	32	32	22.59	9.41	12.05	53.06
	IO	32	32	21.91	9.65	10.18	53.64
	OA	32	32	21.18	8.74	10.06	41.60
LL - 3	CA	32	32	20.29	8.65	11.02	47.34
	EO	32	32	21.59	10.64	8.68	66.76
	FF	32	32	20.36	8.72	8.89	48.93
	IO	32	32	19.88	7.83	8.88	45.21
	OA	32	32	19.65	7.50	10.04	39.39
LR - 4	CA	32	31	23.49	9.43	11.73	54.69
	EO	32	32	21.90	9.32	10.56	46.61
	FF	32	32	22.28	8.69	9.82	47.16
	IO	32	32	22.66	9.15	10.40	45.75
	OA	32	32	20.89	7.98	9.89	44.96

Table 2. Repeated Measures Two-Way ANOVA Test Results

Test Effect	df	F value	p value
Quadrants	3	20.88	<.0001*
Fulcrums	4	2.95	0.0226*
Quadrants paired with fulcrums	12	0.97	0.4727

*Significance

Participants' overall muscle activity mean scores correlated with each fulcrum are found in Table 3. When comparing overall muscle activity for each fulcrum, results revealed statistically significant differences (F=2.95, df=4, p=0.0226). However, out of 20 repeated ANOVA measures, Tukey's test revealed only one pairing resulted in significant results (Table 4). The cross arch fulcrum produced statistically significant more muscle activity only when compared to the opposite arch fulcrum (p=0.0110). The cross arch fulcrum produced the most muscle activity regardless of area scaled.

Table 3. Muscle Activity Means and Standard Deviations Using Five Fulcrums.

Analysis Variable : Combined Muscle Activity for Each Fulcrum						
Fulcrum	N Obs	N	Mean Muscle Activity	Std Dev	Minimum	Maximum
CA	128	127	22.87	8.85	11.02	54.69
EO	128	128	22.31	10.01	8.68	66.76
FF	128	128	22.10	8.62	8.89	53.06
IO	128	128	21.87	8.85	8.88	53.64
OA	128	128	21.37	8.79	9.89	51.14

Table 4. Tukey's Significance Testing Comparing Muscle Activity Between Fulcrums ("+" if $p > 0.05$, "-" if $p < 0.05$).

CA Mean 22.87 N 32 SD 8.85	EO Sig 0.7233 +	FF Sig 0.4367 +	IO Sig 0.1802 +	OA Sig 0.0110* -
EO Mean 22.31 N 32 SD 10.01	FF Sig 0.9911 +	IO Sig 0.8676 +	OA Sig 0.2478 +	
FF Mean 22.10 N 32 SD 8.62	IO Sig 0.9856 +	OA Sig 0.5021 +		
IO Mean 21.87 N 32 SD 8.85	OA Sig 0.8162 +			
OA Mean 21.37 N 32 SD 8.79				

*Significance

Muscle activity means and standard deviations were calculated for each of the 4 quadrants (UR, UL, LL, and LR) (Table 5). Two-way ANOVA with 20 repeated measures comparing muscle activity generated in each of the 4 quadrants revealed statistically significant differences ($F=20.88$, $df=3$, $p<.0001$). Tukey's test revealed that when hand scaling, regardless of fulcrum used, the maxillary right quadrant generated significantly more muscle activity when compared to the other 3 quadrants ($p=0.0101$) (Table 6). Further, the mandibular left quadrant consistently produced the least muscle activity when paired with the other 3 quadrants ($p<.0001$). Data suggest moderate to high muscle activity in all quadrants, ranging from 19.65% MVIC to 24.22% MVIC.²³ Hand scaling in the UL or UR quadrants regardless of fulcrum used exhibited the same amount of muscle activity.

Table 5. Muscle Activity Means and Standard Deviations Using Four Quadrants of the Mouth.

Analysis Variable : Combined Muscle Activity for Each Quadrant						
Quadrant	N Obs	N	Mean Muscle Activity	Std Dev	Minimum	Maximum
UR - 1	160	160	23.56	9.10	11.36	59.96
UL - 2	160	160	22.26	9.26	10.06	53.67
LL - 3	160	160	20.35	8.65	8.68	66.76
LR - 4	160	159	22.24	8.86	9.82	54.69

Table 6. Tukey's Significance Testing Comparing Muscle Activity Between Quadrants

Quadrant	Quadrant	Adjusted p value
UR - 1	UL - 2	0.0101*
UR - 1	LL - 3	<.0001*
UR - 1	LR - 4	0.0100*
UL - 2	LL - 3	<.0001*
UL - 2	LR - 4	1.0000
LL - 3	LR - 4	<.0001*

*Significance

Discussion

No significant interaction was found among quadrants, muscle activity, and type of fulcrums used when hand scaling in a simulated environment. Results suggest the amount of muscle activity generated when scaling, regardless of quadrant scaled, is not affected by the use of different fulcrums. Use of a different finger fulcrum does not reduce the amount of muscle activity experienced by participants during calculus removal.

Dong et al reported that intraoral finger rests reduced muscle activity when scaling compared to no finger rests.⁹ The extraoral fulcrum used in this present study can be compared to the no finger rest described by Dong et al. Their study had participants scale in only the maxillary left quadrant, the different results obtained from this study with the extraoral fulcrum may be expected since all quadrants of the mouth were studied. Extraoral fulcrum as reported by Dong et al produced more muscle activity in the maxillary left quadrant than standard intraoral fulcrums. Differences in sample size, characteristics of participants, number of fulcrums, muscles investigated, and quadrants tested may explain the conflicting outcomes between the 2 studies. In addition, this present study looked at the pronator teres and biceps brachii muscles, which were not evaluated by the Dong study.

Although statistically significant differences were found in muscle activity when comparing the 5 fulcrums to each other ($p=0.0226$), only the cross arch fulcrum exhibited significantly higher mean muscle activity scores when compared to the opposite arch. These results might be attributed to difficulty keeping a neutral wrist position when using the cross arch fulcrum, especially in the upper right quadrant. Likewise the stretch of the hand across arches and the position of the wrist as it deviated from neutral might have contributed to the increased muscle activity when compared to the opposite arch. Advanced fulcrumming techniques are used selectively when another fulcrum is not effective or it is not possible to preserve fundamental scaling techniques. Cross arch fulcrums make it difficult to preserve a neutral wrist position while also achieving lower shank parallelism, access to deep pockets, appropriate muscle coordination, and calculus removal. Given the findings, selecting a fulcrum should be based on its benefits and disadvantages with a particular area of the mouth over the amount of muscle activity generated.

In general, results suggest that each of the 5 types of fulcrums produce similar amounts of muscle activity regardless of area scaled. Dental hygienists should continue to use alternative fulcrums to improve ergonomic instrumentation based

on individual needs and preferences. Patient characteristics and clinical needs should drive the selection process. Larger studies are needed, however, to determine the relationship between fulcrums and muscle activity while hand scaling.

The standard intraoral fulcrum was not significantly different in muscle activity when compared to the others. Since the opposite arch fulcrum had the least muscle activity, it might be an excellent alternative for the standard intraoral fulcrum when deep pockets with heavy calculus require variation in the technique.

Regardless of where calculus removal was started, more muscle activity was generated in the upper right quadrant. Results may be attributed to the angle of the wrist and forearm in the upper right being manipulated in a way that required more muscle movement and more force and effort to remove the deposits. These findings support Nield-Gehrig's belief that maxillary molar teeth are especially difficult to treat with the standard intraoral fulcrum and often require advanced fulcrums.¹²

Results suggest that dental hygienists may wish to start scaling in the upper right quadrant since scaling in that area, regardless of the fulcrum used, produced more muscle activity. By starting in the upper right instead of scaling this area last, fatigue may be less of an issue. Also, since the study revealed that scaling in the lower left quadrant produces the least amount of muscle activity, perhaps that quadrant could be scaled when most fatigued. As fatigue becomes an issue, clinician scaling may be less effective. Lastly, variable muscle activity might reflect improper wrist-forearm movement, incorrect finger placement, or artificial calculus being burnished during scaling.

Several limitations are worth noting when interpreting the results of this study. Because the study was conducted in a simulated environment with student dental hygienists, results can only be generalized to this population. Future research using patients with calculus and experienced dental hygienists in a real world environment is recommended. Human error could have influenced the results recorded on the University Physical Therapy Motion Lab's sEMG system computer; however, using the same 2 experienced physical therapy students minimized this risk. Also affecting muscle readings, may have been the rest some participants received when the typodonts dislodged from the manikin heads requiring a pause to reattach the devices for appropriate performance.

Conclusions

Based on the result of this study, fulcrums have uniform impact on muscle activity during hand scaling in first semester, right-handed, senior-year dental hygiene students in a simulated clinical setting. Clinicians therefore appear to experience minimal ergonomic advantages in terms of muscle activity, fulcrums used, and area of the mouth scaled. Since performing a comprehensive service to the client includes examination and treatment of the entire dentition, more research should be conducted to determine how forearm muscles are affected by varying fulcrums while scaling, using different scaling instruments, or whether differing fulcrums affect grip and pinch force. Findings in this study do not support changes in clinical instrumentation protocols at this time, but do emphasize the need for more research in order to better understand fulcrums and arm muscle activity related to musculoskeletal disorders.

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Accuracy of Automated Blood Pressure Monitors

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Purpose. *The purpose of this study is to determine if automated and aneroid manometers are as accurate a means of determining blood pressure as the mercury manometer. Obtaining vital signs for patients is considered standard of care, yet many dental offices do not routinely perform this health service because of technique inconsistencies and time constraints. The use of automatic blood pressure monitors addresses both concerns. The mercury column manometer, the control in this study, has long been considered the most accurate and preferred instrument for obtaining blood pressure measurements.*

Methods. *During this study, 94 participants (19 years of age and older) consented to having blood pressure taken by each of 4 different monitors. These included the mercury column manometer and stethoscope, the aneroid manometer and stethoscope, the automatic arm blood pressure monitor, and the automatic wrist blood pressure monitor. Each of 3 investigators was assigned to and calibrated for a specific monitoring device. All measurements were taken from the left arm with 5 minutes allowed between measurements. Identical stethoscopes were used with the manual monitors. Strict adherence to the manufacturers' directions and patient preparation was followed for all monitors. Investigators were not aware of readings obtained by other investigators during testing. Eighty-three subjects completed all tests.*

Results. *Review and analysis of data indicates little difference for pulse readings between the automated and digital methods. Systolic readings by automated wrist manometers were the most unreliable. Automated arm monitors tended to provide higher measures than the mercury standard on average, and demonstrated significantly different diastolic readings in one age group compared to the control. All monitors exhibited low reliability for participants over age 50 compared to the control.*

Conclusion. *This study demonstrates there is inaccuracy in the use of automated blood pressure monitors and traditional aneroid manometers when compared to the gold standard mercury column manometer for subjects of all ages and blood pressure ranges.*

Keywords: hypertension, accuracy, automated, monitor, validation

Introduction

The purpose of this study is to assess the accuracy of analogue and automated arm and wrist blood pressure (BP) monitors when compared to the mercury manometer on a large number of individuals of varying ages. This study matches the Health

Promotion/Disease Prevention category identified in the American Dental Hygienists' Association's National Dental Hygiene Research Agenda, 2007. The agenda identifies the need to "Validate and test assessment instruments/strategies/mechanisms that increase health promotion and disease prevention among diverse populations"¹. Recording patients' vital signs has long been considered a standard of care in dentistry. In the 2007 draft of the American Dental Hygienists' Association Standards of Clinical Dental Hygiene Practice, the taking and recording of patient BP is identified as a standard component of patient assessment.² Most commonly, BP, pulse rate, and respiration rate are recorded. This health care standard serves as a screening tool, alerts the provider to alter planned treatment when abnormal readings are found, and provides a baseline in emergency situations. Obtaining BP has been identified as one of the most important measurements in clinical medicine.³ Traditionally, the patient's BP has been found with an aneroid or mercury column manometer and stethoscope using the auscultatory method, requiring the operator to listen for Korotkoff sounds. This technique, which has been used for nearly 100 years, has experienced few changes.⁴ Current concern regarding the safety of mercury has resulted in the banning of this sphygmomanometer within Veterans Administration hospitals, other locations in this country, and other countries as well.⁵ This safety concern, plus the required attention to detail and the time involved in obtaining BP with auscultatory methods, has resulted in an increased use of electronic units and development of alternative nonmercurial manometers. In fact, the primary reason 55% of dental hygienists in one 2006 study did not take BP on patients was lack of time during the appointment.⁶ Electronic units record BP at the wrist, upper arm, or finger with the oscillometric technique. Utilizing automated BP measuring devices that give inaccurate results defeats the purpose of taking BP measurements, when those readings can indicate potential cardiovascular incidents.

Review of the Literature

There are accuracy issues with all types of BP monitoring devices. Observer bias and hearing acuity are major disadvantages of both traditional mercury and aneroid devices, as is mechanic wear of the aneroid unit.⁷ Mercury manometers tend to maintain function and accuracy for years, while aneroid units need frequent calibration to ensure accuracy.⁸ Inaccuracies with oscillometric units at specific BP levels appear to be related to equipment algorithm insufficiencies rather than patient individuality.⁹ Another study found decreased performance of automated devices over time.⁸ In addition, automated arm units are difficult to calibrate and are not suitable for those with arrhythmias.^{3,7} The same holds true for wrist and finger units, with the additional indication that wrist devices are extremely sensitive to heart level positioning, and finger devices cause erroneous readings in individuals with cold or slender fingers.⁷

Yarows and Brook (2000) found little difference between BPs taken by 12 automated devices on 2 normo-tensive subjects when compared with those of mercury or aneroid and validated automated manometers. Also found were similar ranges of deviation between traditional and automated methods of measurement, indicating operator interpretation during traditional methods are as variable as output by automated devices with digital displays.¹⁰ Terra et al (2004) found consistency, yet inaccuracy, in healthy participants when BPs were measured with an automated arm device and a mercury manometer; systolic BPs consistently measured 3-5 mmHg higher by automated units than by the control, while diastolic BP measures consistently measured 3-5 mmHg lower than the control.¹¹

In a study by Stryker et al (2004), hypertensive individuals without arrhythmias, who owned automated BP units, participated in a study to determine accuracy of self-measurement. Results found well-trained, at-home users of newer automated monitors could take accurate BP measurements. Inaccuracy levels of monitors used in the study were: arm units (14%) and wrist and finger monitors (33% and 33%, respectively).¹² Newer monitors are more likely to be accurate than earlier versions.¹² In another study, researchers concluded that BP measured by wrist devices was unreliable.¹³

Due to continued inconsistencies in study data, use of only validated automated arm units is recommended, while no general recommendations for wrist and finger devices have been made at this time.^{4,14}

O'Brien et al (1996), strictly followed British Hypertension Society (BHS) and Association for the Advancement of Medical Instrumentation (AAMI) protocol in evaluating 3 automated BP devices. Only one manometer passed criteria of both agencies for normal range BP, although it was inaccurate at high blood pressure (HBP) ranges. Failure of the other 2 devices was primarily due to inaccurate systolic readings.¹⁵

Positioning of the patient is vital to obtaining proper BP results. In 2005, Mourad et al found that currently recommended arm positioning may lead to inaccurate outcomes in many studies of wrist-cuff automated manometers. Placing the arm midsternally, in opposition to American Heart Association guidelines and those of some manufactures, produced more consistent readings between the wrist cuff and the arm cuff.¹⁶

The need to rely on experienced and reliable testing agencies to provide validation outcomes for BP monitoring devices on the market is indicated by the many conflicting study outcomes. Until arm and wrist positioning is standardized by device manufacturers and national and international guidelines, it will continue to be difficult for researchers and clinicians to be assured they are obtaining accurate results.

Need for Vital Signs Review in Dental Offices

BP is defined as the amount of pressure exerted by the blood circulating in the arteries. It is measured in mmHg and recorded as a fraction, ie, 110/70. Readings are more accurate when the patient is rested and in a sitting position, which allows the upper arm to be at heart level. Operators should be aware that right and left arm BPs vary, and using incorrectly-sized cuffs can lead to inaccurate readings. The upper number of a BP measurement, known as the systolic pressure (SP), is obtained when the heart is in systole or is contracting. The second number of the fraction is known as the diastolic pressure (DP) and is the arterial pressure during dilation of the heart. On any given day, a person's BP may be affected by muscle tension and/or anxiety, respiration, exercise, meals, pain, temperature, bladder distension, arm position, background noise, talking during the procedure, alcohol or nicotine consumption, or stimulants.¹⁷ A diagnosis of HBP or hypertension is not made with just one higher reading but with consistently higher readings.

The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure in 2003 defined normal BP for an adult (18 years and older) at levels below 120 mmHg systolic and 80 mmHg diastolic pressure.¹⁹ Prehypertension, a new classification defined in this same publication, is a reading of 120-139/ 80-89; levels previously considered within normal range.¹⁹ Individuals with prehypertension are more likely to develop HBP and are encouraged to make diet and lifestyle modifications to bring levels into normal range. Approximately one-fourth of the adults in this country have BP measurements in this category.²⁰ The 2003 report estimates 30% of the United States population is unaware they have HBP.²⁰ It is estimated that 65 million or 1/3 of the adults in the United States have been diagnosed with HBP (readings \leq 140/90 mmHg) or take antihypertensive medication.^{1,2} In addition, the risks of developing high blood pressure increase with age; individuals over 50 years of age have a 90% chance of developing HBP.^{19,21} These statistics show the importance of obtaining BP as a screening tool in the dental setting.

Most medical emergencies in the dental office can be avoided when adequate information is obtained from the patient prior to treatment. Historically, this information has included the patient's medical and dental history. To be complete, it must also include the patient's BP, pulse rate, and respiration rate. A higher than normal BP measurement increases the risk of a stress-related emergency. Patients with hypertension present with a greater risk for stroke, heart failure, myocardial infarction, and kidney dysfunction.²⁰ A normal pulse rate for the adult patient is 60-100 beats per minute (bpm). An irregular pulse at 120 bpm or greater for unknown reasons should alert the operator to a potential emergency situation, and a fast, irregular pulse is the most common precursor to cardiac arrest²⁰. Further, elective dental treatment should be postponed when the BP level is \geq 180/110.²¹

The American Society of Anesthesiologists (ASA) risk classification was developed to estimate the risks to a patient during procedures using anesthesia. The ASA classification is also used to determine treatment risks when anesthesia is not used.²²

Patients are classified into ASA categories depending on current or past medical conditions, age, anxiety level, and BP measurements. A healthy patient with no current or past systemic disease and no medications is considered an ASA I. The same patient presenting with a BP of 140/90 is moved to ASA II, indicating the operator should perform treatment with caution.²² When the BP reaches 160-199/95-114, the patient becomes an ASA III, while a level of $\geq 200/115$ categorizes the patient as an ASA IV with elective care not recommended as associated risks are too great and pain and infection management should be palliative.²²

BP measurements should be taken every 6-12 months for patients with levels within normal range and no history of hypertension or related medications. When the BP is higher than normal and/or the patient is taking antihypertensive medication, or has a history of diabetes, hyperthyroidism, kidney disease, and/or heart disease, this vital sign should be checked at every dental appointment. If local anesthetics with vasoconstrictors or nitrous oxide/oxygen sedation are to be used, a baseline BP measurement is imperative.^{22,23}

Monitoring Device Components

Components of BP monitoring devices include the cuff, manometer, and stethoscope or digital monitor. Arm cuffs are available in child, adult, large arm, and extra large (thigh) sizes. Cuff width is significant; an erroneously high reading results when using a cuff that is too small; likewise, using a cuff that is too large will result in mistakenly low readings.^{3,4,24} Studies indicate that when cuff width is accurate, the length of the cuff is also correct.²⁴

Types of Monitors

Mercury Manometers

Mercury column sphygmomanometers consist of a portable or wall-mounted unit containing a glass column where mercury resides in a bowl at the base of the column. Using the auscultatory method, the bulb is pumped to inflate the cuff, causing the mercury to rise in the glass column that is demarcated in millimeters of mercury (mmHg). Mercury manometers retain their accuracy because of their nonmechanical design (Figure 1). Mercury are considered the gold standard in accuracy and their use is critical when determining the accuracy of all other BP devices.^{3,4}



Figure 1.

Aneroid Manometers

Aneroid manometers (Aneroid) consist of a portable or wall-mounted unit that contains springs and other mechanical parts. The manometer needle should always be located at zero prior to inflating the cuff. The auscultatory method is used to take BP. One disadvantage of aneroid units is that the mechanical parts tend to dysfunction over time and when handled roughly (Figure 2).^{3,4} Wall mounted units are less susceptible to trauma and therefore, more accurate.²⁵



Figure 2.

Automated Arm Manometers

Automated arm BP devices (Arm) consist of a portable or wall-mounted unit that uses oscillometrics to determine BP taken from the upper arm. Patient positioning and cuff placement are the same as for the mercury and aneroid methods. Automated units use algorithms to determine BP in a digital display. The automated devices provide a large digital display of BP and pulse readings that is easily read by the operator, patient, and home user. Most units store results in memory. A major disadvantage of many automated units is lack of validation for accuracy. Automated devices are not recommended for persons with arrhythmias or arterial stiffness, which affects many middle-aged and older adults.

Automated Wrist Manometers

Automated wrist BP devices consist of a portable unit that uses oscillometrics to determine BP taken from the wrist, unlike the mercury, aneroid, and automated arm manometers. Like the automated arm units, the visual display of BP and pulse is a positive feature. However, algorithms and mechanics involved in the production of BP readings and accuracy is problematic, as is use of these devices on persons with arrhythmias or arterial stiffness.

Proper Patient Positioning

According to Jones, et al (2003), under or overestimating BP by 5 mmHg would affect the treatment, or lack of, for 48 million people.²⁶ Regardless of the type of monitoring device used to test BP, it is important to understand and use proper technique and procedure when taking vital signs. The patient is seated with their elbow resting on a table or chair arm, positioning the upper arm at heart level. If the upper arm is placed above heart level, an inaccurate lower BP reading will result; if positioned below heart level, an inaccurately higher reading will result.^{3,4} Both systolic and diastolic readings will be 2-3 mm higher with the patient seated as compared to positioning supinely.^{3,4} Patients should be sitting with their

legs uncrossed and their back and arm supported. The BP device is placed according to manufacturer's directions (see specific instructions under type of monitor).

For the mercury, aneroid, and arm monitors, the patient should be asked to roll up his/her sleeve so the cuff can be placed directly on the skin, with the bottom of the cuff one inch above the antecubital fossa (the inside crease of the patient's elbow). The cuff should be placed snugly, allowing 2 fingers to fit between the cuff and patient's arm (picture). Most cuffs have an arrow that indicates placement of the cuff over an artery. For the wrist monitor, the cuff is placed snugly over bare skin at the wrist, with the digital display located on the distal surface of the wrist.

BP may vary as much as 10 mmHg from an individual's right to left arm,¹⁸ making it necessary to indicate which arm or wrist is used for measurement. Also, BP measurements tend to drop if taken sequentially; recommendations vary regarding resting periods between readings, with most experts recommending at least 30 seconds and up to 5 minutes rest between readings.^{18-20,27}

For manual units, the cuff is inflated until the radial pulse can no longer be felt; the cuff is then inflated 20-30 mm higher.^{18,19,27} Neither the patient nor operator should talk during the procedure. The transducer or diaphragm is placed in the antecubital fossa without contacting the cuff. As the cuff is deflated at a rate of 2-3 mm per second, the first Korotkoff sound should be heard close to the point where the radial pulse ceased. This first sound is the systolic reading and the last Korotkoff sound is the diastolic pressure. To assure there are no additional sounds, continue to slowly release the gauge for another 10 mm before complete deflation. When reading mercury column or aneroid manometers, operators tend to error by recording a zero as the last digit in the systolic and diastolic reading rather than the nearest 2 mmHg; for example, 116 becomes 120 or 74 is recorded as 70.3

Automated or digital BP monitors are easy to use. Once the patient and cuff are positioned properly, the operator needs only to press a button on the unit to begin measuring BP with the oscillometric technique. No stethoscope is needed and BP and pulse readings are displayed on the unit's screen (Figures 3 & 4). Oscillations of pressure are recorded during the slow deflation of the cuff. Since the oscillations begin much higher than the systolic pressure and continue well below the diastolic, each unit has an empirical algorithm to estimate systolic and diastolic pressures.^{3,4} Algorithms are specific to individual units/manufacturers and are not public record.^{26,28} Using the correct cuff size is crucial, a requirement often overlooked as automated units are generally packaged with a standard adult-sized cuff. Alternative cuffs may be available for an additional cost. With proper training on the specific unit and close attention to positioning, fewer operator errors occur. In a study by Stryker et al (2004), 80 subjects were observed taking their own BP with their personal automated units, and then were given training and observed again.¹² After the 10-minute training on proper technique, a significant improvement in the accuracy of readings was evident.¹²

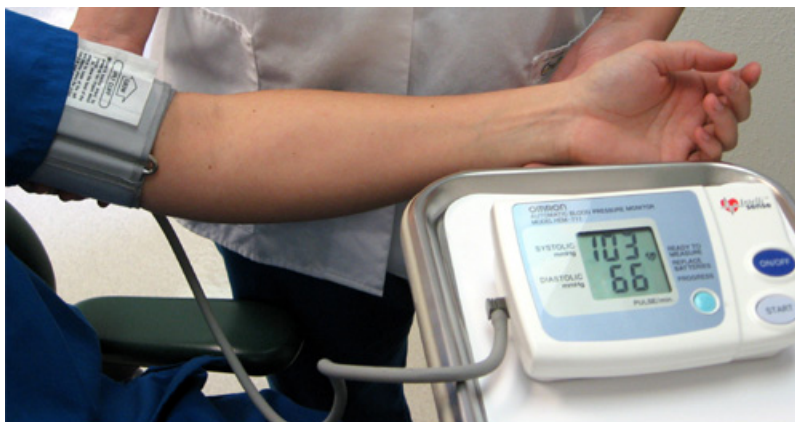


Figure 3.



Figure 3.

Studies show patients fabricate or fail to record digital readings more often than not.^{3,4} An advantage of some automated units is the capability to print the measurements and/or store them in memory, eliminating operator bias. Outside noise is not a concern as with the auscultatory technique. Home use may eliminate higher readings for the 20-35% of individuals who experience the white coat effect of upwards of 30 mmHg higher BP reading when taken by a health care worker.^{4,19} In addition, frequent BP testing at home allows patients and health care providers to monitor how lifestyle and/or medications affect cardiovascular health; self-monitoring with memory or printouts is more reflective of actual pressures than intermittent readings in a medical setting.^{3,19} To date, finger monitors and finger cuff methods of obtaining BP are considered inaccurate and not recommended.^{3,29}

Ambulatory BP measurements (ABPM), taken over a 24-hour period in a home environment during normal activities and sleep, have been shown to more accurately reflect BP than readings recorded in medical settings.³⁰ Obtaining the mean level of these measurements can help identify patients with white coat effect, thereby preventing unnecessary medicating.^{28,30} In this country, APBM has been approved for reimbursement by Medicare and Medicaid.^{4,19} Studies show ambulatory pressures are a better predictor of cardiovascular risk than measurements obtained in a medical setting.^{4,19}

Validation

The Association for the Advancement of Medical Instrumentation (AAMI), the British Hypertension Society (BHS), and the European Hypertension Society (EHS) have developed protocols for the validation of BP devices. The AAMI validation protocol was most recently revised in 2002, with the latest BHS revision in 1993.³ The International Protocol of the EHS is a recent development as a replacement for the more cumbersome aforementioned protocols.³ Both AAMI and BHS protocols involve 85 participants having BP recorded at 3 separate instances with the mean expected to fall within 5 mmHg and a SD of 8 mmHg.³¹ Needing such a large number of subjects for obtaining validation is difficult, therefore many units are not independently evaluated.^{3,32} The BHS system grades performance using letter grades A, B, C, and D; grades A and B indicate accuracy.³³ An easier method of validation, the International Protocol, requires BP comparisons on 33 subjects by 2 trained observers, plus a supervisor and a medical doctor. Subjects must be 30 years or older, represent both genders, and have BP readings distributed among 6 categories based on high, medium, and low levels of both systolic and diastolic readings.³² Units with measurements within 5 mm are considered very accurate; within 6-10 mm are slightly inaccurate; and within 11-15 mm are moderately inaccurate; and those with greater than 15 mm differences are very inaccurate.

Validation is awarded when one-half of the systolic and diastolic readings are within 5 mm of each other.³² Manufacturers are not required to meet either AAMI or BHS standards before units are sold in the United States.³ There are several online source lists of validated BP monitoring devices, including the BHS website³⁴ and the dabl Educational Trust website.³⁵

The first mercury-free, nonautomated BP device to pass the international protocol for accuracy is the Accoson Greenlight 300.³⁶ BP is taken in the traditional manner, listening for Korotkoff sounds, but the readings are displayed digitally. Another, the hybrid monitoring device, uses the auscultatory technique but replaces the mercury component with an electronic pressure gauge.^{3,28}

Calibration

According to the BHS, aneroid units should be calibrated with a mercury manometer biannually using Y-tubing (See Figure 5). To be considered accurate, the aneroid unit should test within 4 mm of the mercury at both 100 and 200 mm inflation levels.^{3,4} Aneroid and automated units calibrated against the mercury manometer and found to be inaccurate should be returned to the manufacturer.²⁶ As reported by Dr. Grim at the National High Blood Pressure Education Program, National Heart Lung and Blood Institute, and American Heart Association Working Meeting on BP Measurement (2002), 35% of aneroids are inaccurate by at least 6 mmHg.³¹ In a study by Coelman et al (2005), 18% of BP units used in 45 London medical practices were inaccurate; aneroid devices being most affected.⁸ Additionally, the study found that promotional devices provided by pharmaceutical or other companies were the most inaccurate.²⁸ Inaccuracy rates of 1-44% have been found for aneroids in hospital settings.^{3,4}



Figure 5.

Methods & Materials

In this study, investigators used the Omron 711A with Intellisense Automatic BP Monitor, the Omron HEM-608 Portable Wrist BP Monitor, and a Prestige Medical CEO120 traditional certified analogue unit. The control was an Omron 12-605 mercury sphygmomanometer. The automated units were selected because they could be purchased locally. None of the units were validated against the mercury manometer prior to use in the study, as lack of validation of purchased units and resultant inaccuracy was the focus of this study. The Omron wrist unit and the Omron arm unit both were used by one investigator because they automatically outputted BP and pulse readings. A second investigator took BP readings using the standard analogue unit and took pulse measurement manually by finger pressure on the radial artery. The third investigator used the Omron mercury monitor to test BPs and took pulse measurements manually, also. All 3 investigators have expertise in obtaining BP and pulse rates as they teach dental hygiene students how to perform vital signs procedures for all patients. In addition, they familiarized themselves with the machines and the manufacturers' use protocols, plus calibrated their results on at least 5 volunteers before beginning the study. Calibration consisted of following proper manufacturer's recommendations for each manometer and taking BP at least twice on each of 5 volunteers using the same technique and device to assure that results were consistent per device. No statistical calibration was done.

The pool of 94 volunteer participants, ranging in age from 19-92, was recruited from the University of South Dakota Department of Dental Hygiene and from an apartment residence for older adults. University of South Dakota Institutional Review Board clearance was obtained prior to beginning the study. Participants read and signed a consent form, and were given separate identification numbers. Only the ages and names of the participants were collected on the consent forms. The ID number and age of each participant was placed on a card that the participant carried to each investigator, maintaining confidentiality while allowing the investigators to verify that a particular method of BP was completed. This helped reduce confusion among the participants and allowed for a more efficient use of time. Investigators sat at a single round table and participants randomly sat at one of the testing stations, depending on availability. After each testing, the participant walked about 3-5 feet to the next station and rested prior to additional testing. There was neither consistent sequence nor purposeful randomization to the testing order. Using the same arm per participant, BP was taken by all 4 methods; a 5-minute rest was allowed between measurements. Manufacturers' recommendations were followed for proper positioning of the participants and proper use of the machines. At each of the 4 BP monitoring stations, the investigators recorded which arm was used for testing, the ID number of the participant, and the obtained BP and pulse values. These same values were recorded on similar forms at each station. Once all 4 methods of testing BP were completed for each participant, the validation card was kept by the investigators.

Results

A total of 94 subjects participated, with an average age of 37.21 (SD = 21.81, range 19 to 92; 1 subject did not report age). Subjects for whom we were unable to obtain a blood pressure measurement were eliminated from the study; the most common reasons for inability to obtain measurements were too large of arm for the standard cuff, digital error messages, and inability to hear Korotkoff sounds. Due to these eliminations, analyses were conducted on a final sample of 83 subjects (mean age = 36.52, SD = 21.73, range 19 to 92; one subject did not report age).

Descriptive statistics

Table 1 contains the 95% confidence interval for all BP devices and measurements. Systolic BPs by mercury sphygmomanometer ranged from 84-158 mmHg, while diastolic pressures ranged from 56-100 mmHg. Pulse rates ranged from 50-108 bpm.

Table 1: Descriptive Statistics for all Blood Pressure Devices

Variable	Mean	SD	Minimum	Maximum	95% confidence interval	
					Upper	Lower
Mercury	116.67	16.68	84	160	113.03	120.32
Aneroid	116.70	13.51	96	168	113.75	119.65
Wrist	118.57	18.43	91	169	114.54	122.59
Arm	125.78	22.34	95	192	120.91	130.66
Mercury	74.24	9.65	56	100	72.13	76.35
Aneroid	72.98	9.66	58	108	70.87	75.08
Wrist	76.04	17.28	56	195	72.26	79.81
Arm	76.69	10.93	58	107	74.30	79.07
Mercury	75.25	9.97	50	96	73.08	77.43
Wrist	77.71	13.76	55	131	74.71	80.72
Arm	76.88	11.13	54	110	74.45	79.31

Note: The 95% confidence interval about the mean represents the range within which we would be 95% confident that the true population mean would fall.

Differences in pressure and pulse measurements by type of monitor and by age

The measurements were analyzed via mixed model ANOVA with monitor type as a within-subjects variable and age as a between-subjects variable. Tests of each effect (age, monitor type, and interaction) control for the other effects. For example, when interpreting the effects of monitor type, be aware that it controls for age (ie, the analysis statistically factors out differences due to age so that the differences due to type of monitor can be isolated).

Systolic

Systolic pressure significantly increased with age, $F_{1, 80} = 80.96$, $MSE = 508.35$, $P < .0001$. While systolic pressure did not significantly differ by monitor, $F_{3,240} = 1.98$, $MSE = 66.40$, $P = .12$, the interaction of monitor and age was significant, $F_{3,240} = 14.48$, $P < .0001$. Thus, the differences among monitors changed with age (Table 2).

Table 2. Mean differences in systolic pressure measurements by each monitor and the mercury by age (monitor-mercury)

Age	Monitor	n	Mean Difference	SD	Cohen's <i>d</i> Effect Size
<=21	Aneroid	27	1.85	8.54	0.22
	Wrist	27	3.41	13.41	0.25
	Arm	27	5.70**	10.06	0.57 ^M
21- 24.5	Aneroid	18	0.78	9.05	0.09
	Wrist	18	0.22	10.32	0.02
	Arm	18	8.33***	6.59	1.26 ^L
24.5 - 50	Aneroid	16	0.88	8.97	0.10
	Wrist	16	-1.63	8.44	-0.19
	Arm	16	6.94*	9.62	0.72 ^L
> 50	Aneroid	22	-3.45	12.50	-0.28
	Wrist	22	3.95	15.82	0.25
	Arm	22	15.50**	17.95	0.86 ^L

Note: * $P < .05$, ** $P < .01$, *** $P < .001$; ^Mmedium effect size, ^Llarge effect size. All other effects are small.

To better understand the interaction of monitor by age, subjects were divided into 4 groups based on age. To form groups, subjects were divided into fourths by age with roughly 25% of subjects per group. Results are reported in Table 2. The groups included those aged less than 21 ($n = 27$), 21-24.5 ($n = 18$), 24.5-50 ($n = 16$), and greater than 50 ($n = 22$). The number of measurements in each fourth is not exactly equal to 25% because there were several individuals with ages exactly at the cut-off values (ie, 21, 14.5, 50). The difference between measurements of each monitor and those of the mercury monitor was averaged for each age group (monitor-mercury) and tested via dependent t-tests. For all age groups, the arm measurement was significantly higher than the mercury device ($P < .05$). However, this difference changed as a function of age. The difference was largest for those aged 21-24.5 (Cohen's $d = 1.26$, a large effect, see discussion of effect size below), followed by those aged 24.5 to 50 ($d = .72$, a large effect), and those less than 21 years old ($d = .57$, a medium effect). The measurements from the arm monitor were consistently higher than from the mercury monitor for those aged less than 50 years old. However, the differences between arm and mercury measures were highly variable for those over 50. For some individuals, the arm measures were much higher and for others they were lower than the mercury measures. This indicates poor reliability of the arm monitor, especially for those over 50 years old. The measurements from the other monitors did not significantly differ from the mercury at any age.

In addition to statistical significance tests, measures of effect size (Cohen's d) were also provided. Cohen's d is a measure of the difference in readings (monitor-mercury) divided by standard deviation. With smaller sample sizes, as we see when we divide the data into age groups, power is lower. This results in a lower probability of correctly rejecting the null hypothesis. The benefit of effect size is that it provides a standardized measure of the strength of the effect removing the potential influence from sample size. As such, it allows one to compare effects across analyses to determine which are the strongest and weakest effects. Effect size measures can be classified as large, medium, or small.³⁷ A large effect is one that could typically be discerned by lay people in real-world settings. A medium effect could be detected by trained professionals. A small effect, while still possible meaningful, is not likely to be easily noticed even by trained professionals in real-world settings.

We also explored the variability of the differences between alternate and mercury monitors across individuals. The consistency with which the alternate monitor varies from the mercury is a measure of reliability. It should be noted that the variability of the differences (monitor-mercury) was highest for wrist measurements in all age groups, except for participants aged 24.5-50. This indicates lower reliability for the wrist measurements relative to the other measures. There appeared to be greater variability in differences with increased age. To test this, variances in difference scores

(monitor-mercury) across age were statistically tested with F tests of variances, using $P < 0/5$ for all tests of variance. Results indicate that theaArm monitor was significantly more variable among those aged over 50 than at any other age. The Aneroid monitor was significantly more variable among those aged over 50 than for those 21 or younger, and the wrist monitor was significantly more variable for those over age 50 than for those 21-24.5 and from 24.5 to 50 years of age.

In sum, the measurements of each monitor were compared to the mercury standard. The aneroid and wrist measures did not significantly differ from mercury measures at any age. However, it was found that the arm measures, on average, provided measures greater than the mercury standard, $P < .05$. For individuals over 50 years of age, the differences between arm and mercury measures were less consistent. In some cases, the arm measurement was higher than the mercury measures and lower in others, indicating especially low reliability for the arm measurement for those aged 50 years old. Similarly, the wrist measurements, as compared to mercury, were also more variable for those over 50 than at other ages.

Diastolic

Diastolic pressure significantly increased with age, $F_{1, 80} = 20.72$, $MSE = 314.74$, $P < .0001$. Diastolic pressure did not significantly differ by monitor, $F_{3, 240} = 1.92$, $MSE = 67.34$, $P = .13$, but the interaction of monitor and age was significant, $F_{3, 240} = 3.80$, $P < .05$ (Table 3), indicating that the increase in diastolic pressure across age is different across types of monitors.

Table 3. Mean differences in diastolic pressure measurements by each monitor and the Mercury by age.

Age	Monitor	n	Mean Difference	SD	Cohen's <i>d</i> Effect Size
<=21	Aneroid	27	-1.70 [†]	4.95	-0.34
	Wrist	27	1.56	9.96	0.16
	Arm	27	0.93	6.37	0.15
21- 24.5	Aneroid	18	-2.00	7.82	-0.26
	Wrist	18	-0.39	5.40	-0.07
	Arm	18	3.39*	5.67	0.60 ^M
24.5 - 50	Aneroid	16	0.75	5.11	0.15
	Wrist	16	-2.06	6.26	-0.33
	Arm	16	3.13	7.90	0.40 ^{S-M}
> 50	Aneroid	22	-1.59	6.08	-0.26
	Wrist	22	6.68	25.37	0.26
	Arm	22	3.05	11.26	0.27

Note: [†] $P < .10$, * $P < .05$, ** $P < .01$, *** $P < .001$; ^{S-M}small to medium effect size, ^Mmedium effect size. All other effects are small.

To further explore the interaction, the difference between measurements of each monitor and those of the mercury (monitor-mercury) was averaged for each age group, divided into fourths, and tested via dependent t-tests. For those less than 21, the aneroid monitor was significantly lower than the mercury measurement ($P = .086$, Cohen's $d = .34$, a small effect) and the arm measurement was significantly greater than the mercury for those 21 to 24.5 ($d = .60$, a medium effect).

The variability of the differences between these measurements and the mercury was highest for participants over age 50, with the exception of the aneroid. Further, the variability of the difference between wrist and mercury measures was significantly higher than other monitors for participants over age 50. Thus, the reliability of the wrist and arm measures is lowest for participants over age 50. This is especially true of the wrist monitor.

In sum, the differences between measurements from alternate monitors and the mercury monitor were small, for the most part. The only exception was that the arm measurement tended to be somewhat higher than mercury for those aged 21-24.5.

Differences between alternate measures and mercury tended to be most variable for those over 50, indicating lower reliability for those in the older category.

Pulse

Pulse did not change significantly with age, $F_{1,80} = 0.03$, $MSE = 310.24$, $P = .86$. Further, pulse did not significantly differ by monitor, $F(2, 160) = 2.33$, $MSE = 45.33$, $P = .10$; the interaction of monitor and age was also not significant, $F_{2,160} = 0.63$, $P = .53$ (Table 4).

Table 4. Mean differences in pulse between measurement by each monitor and the Mercury by age

Age	Variable	N	Mean Difference	SD	Cohen's <i>d</i> Effect Size
<=21	Wrist	27	4.07 [†]	11.33	0.36
	Arm	27	1.56	8.97	0.17
21- 24.5	Wrist	18	0.83	10.17	0.08
	Arm	18	3.11	9.68	0.32
24.5 - 50	Wrist	16	5.56	15.84	0.35
	Arm	16	2.94 [†]	5.95	0.49 ^M
> 50	Wrist	22	-0.45	6.36	-0.07
	Arm	22	-0.45	6.22	-0.07

Note: [†] $P < .10$; ^Mmedium effect size. All other effects are small.

Even though the interaction was not statistically significant, we examined the effect sizes (Cohen's *d*). The effect size for the difference between arm measure and mercury for those aged 24.5-50 was of medium size ($d = .49$), but only marginally statistically significant ($P = .07$). The discrepancy between lack of statistical significance and effect size is due to low power for the significance test. This evidence would not support a claim that the arm measurements do not deviate from the mercury measurement.

For pulse measurements, the pattern of variances was different from that of the systolic and diastolic pressures. The biggest difference in variability was seen for participants in the 24.5-50 years of age category, where the differences from the wrist monitor were significantly more variable than those from the arm monitor (Table 4).

In sum, pulse measurements from alternate monitors were not significantly different from mercury measurements at any age group. This does not mean that the difference in measurements was small for all individuals. In fact, for those 24.5 to 50, the wrist monitor yielded significantly more variable results than at any other age and other monitors. Thus, pulse measures are likely to be more reliable than either systolic or diastolic BP measures, at all ages. However, there is reason to further explore the differences seen with the wrist monitors for those aged 24.5 to 50.

Overall, measures from alternate monitors deviated somewhat from mercury measures. Further, the differences between alternate monitor and the mercury monitor varied by age. The biggest mean differences from mercury standard were seen for systolic pressure, especially from the arm monitor. The arm monitor consistently yielded measurements higher than the mercury monitor. Measures of diastolic pressure from alternate measures differed from the mercury to a lesser extent. Although, the arm monitors still tended to yield measures greater than the mercury. It is interesting that the difference was greater for those in middle adulthood (aged 24.5 to 50) than those over 50 and less than 21 years old. Pulse measures from alternate monitors did not significantly differ from the mercury.

If given grades for accuracy, based on BHS standards, no monitor was rated acceptable for all measurements (ie, systolic, diastolic, and pulse). All monitors of systolic pressure and pulse would be given grades of lower than C. With regard to diastolic pressure, the wrist measure would be graded lower than C, but the arm and aneroid measures would receive B grades.

In addition to exploring the mean difference between the alternate and the mercury monitors, we also compared the variability of these differences. The consistency with which the alternate monitor varies from the mercury is a measure of reliability. That is, can we count on the pattern of results being similar from person to person and reading to reading? Systolic and diastolic measures from alternate monitors, especially arm monitors, were least reliable for those over 50 years of age. For these individuals, alternate monitors yielded a wide range of results, sometimes higher and sometimes lower than the mercury, with little consistency. Interestingly, the reliability of pulse measurements, though, was lowest for those aged 24.5 to 50 years than for those less than 21 or greater than 50.

Analysis of data indicates little difference for pulse readings between automated and digital methods. We can conclude, with regard to systolic pressure, that the automated arm and wrist measures are least reliable, and the automated arm monitors tended to provide higher measures than the mercury standard, on average. All monitors exhibited low reliability for those over age 50 compared to the control. For diastolic pressure, the only significant difference between monitor measure and the mercury standard was for the automated arm measurements of those aged 21-24.5. Again, the differences between each monitor's reading and the mercury readings were most variable for participants over age 50. This suggests a pattern in which these alternate BP monitors are least reliable for those older than 50 years. In direct contrast, pulse measures using the wrist monitors were variable for all age groups, but most consistent for those in the over 50 age group.

Discussion

This study had an adequate number of subjects in the convenience sample, although including similar numbers of subjects at each age range would have been beneficial. Some of the limitations of this study include the lack of statistical analysis of investigator calibration, the limited number of participants with low and high BP, the limited number of BP measuring devices used, and the limited number of participants in some age groups (middle and old). The limitations are similar to those of other studies of BP monitoring devices. In fact, validation protocols for BP devices have recently been changed because of the difficulty of obtaining large enough subject pools to ensure adequate representation at all ranges of age and BP.³²

It has been the personal experience of the authors, and supported by the literature, that automated wrist and arm manometers are being used in health care settings and by many individuals in their homes. In addition to not consistently following proper technique for taking BP, health care personnel record readings from automated manometers in the permanent patient record, which may erroneously be used in diagnosis and treatment. This study and others demonstrate the inaccuracy of automated BP monitors and traditional aneroid manometers when compared to the gold standard mercury column manometer, especially for different age groups.^{3,4,7-9,11-13, 15} In particular, the low reliability of measurements taken by nonmercury monitors on individuals older than 50 years of age is a major source of concern. Using nonvalidated devices can negatively impact dental care, in particular for patients over age 50, since false results limit identification of patients at risk of cardiovascular incidents associated with the use of vasoconstrictors or during times of stress or anxiety during a clinical appointment.

The authors recommend the exclusive use of validated BP monitoring devices for use at home and in health care settings. It is also essential to recognize the need for frequent calibration of aneroid units with the mercury column manometer.

Continued research and validation of the mercury-replacing BP devices is necessary, particularly automated manometers, as their popularity is sure to increase. With new products continually entering the market, the need to validate accuracy and reliability of the products must occur. Of particular interest for study are the wrists and finger cuff models.

Education of health care personnel and home users regarding validation of devices and proper technique is vital. The best technique will not make up for an inaccurate device, nor will poor technique allow an accurate device to provide precise data. The need for a properly fitted arm cuff cannot be over emphasized.

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Conclusions and Recommendations

As in other studies and reports,^{7,9,12,15} our study found that the automated arm and wrist units and the aneroid sphygmomanometer used in the study did not pass standards set forth by the BHS and AAMI due to variability of systolic and diastolic BPs in mmHg when compared to the control. Whether the inaccuracies are due to arm positioning at heart level, as observed in the study by Mourad et al (2005), or due to inadequate algorithms, as indicated in the study by Dieterle et al (2005), there is evidence that more study is needed before mercury manometers are formally replaced by other devices.^{9,16} BP measurement should be an exact science since it is used in diagnosis and treatment, yet many studies indicate there are far too many variables, such as operator variability and training,^{7,10,12} arm positioning,¹⁶ and software⁹ or mechanical functioning.⁸

Dental hygienists routinely assess patient oral and general health. The standard of care for clinical dental hygiene includes the taking and recording of patient blood pressure. The results of our study indicate that dental hygienists should follow these recommendations in order to be assured their results are accurate:

Use only validated BP measuring devices. Check validity by using BHS or dabl Educational Trust websites prior to purchasing such units.

Use mercury and calibrated aneroid-style monitors since they are the most accurate means of taking BP. Limitations of these devices are typically due to operator error in rounding off readings, in hearing Korotkoff sounds, and in ensuring the gauge is set to zero at pre- and post-measurement.

Limit use of automated BP monitors to those that are independently validated and biannually calibrated. These units are quick and easy to use and provide a large digital display that gives a distinct reading. Limitations of these devices include standard-only cuff sizes and inaccurate readings for patients with arrhythmias and hardening of the arteries.

Calibrate BP manometers (aneroid and automatic) twice each year against a mercury manometer, and/or return to manufacturer for calibration and repair.

Place patients in an upright position with the arm supported at heart level. Let the patient rest at least one minute prior to or between BP readings. Discourage movement or talking during the procedure to improve accuracy.

Educate the dental team and other health care providers regarding accuracy of BP monitoring devices, and review proper patient and equipment positioning annually.

Notes

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