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The *Journal of Dental Hygiene* is the refereed, scientific publication of the American Dental Hygienists' Association. It promotes the publication of original research related to the profession, the education, and the practice of dental hygiene. The journal supports the development and dissemination of a dental hygiene body of knowledge through scientific inquiry in basic, applied, and clinical research.

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Inside

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Features

Editorial

Rebecca S. Wilder, RDH, BS, MS

Dental Hygienists and Interprofessional Collaboration: Thoughts from 1927

The 2000 Surgeon General's Report on Oral Health in American nationally recognized the importance of the connection between good oral health and good overall health.1 Since that time, professional groups have been conversing about the need for increased collaboration and education among the various health professional groups. Interprofessional education, including dentistry and dental hygiene, has been a frequent topic at national conferences and written about in professional publications.

But the idea of different health care professionals working together is not a 21st century idea. In 1927, Ethel Covington, the first dental hygiene author of a paper in the Journal of the American Dental Hygienists' Association (now the Journal of Dental Hygiene), wrote about the risk of specialization and how dental hygienists need to know more about other professions.2 Below are excerpts from that article:

"As an auxiliary branch of dentistry, having limited field of service, we may be compared to any specialized group with the same grave danger of knowing too little about the things to which our work is related."

"While we know the value of specialization, and the dental hygienist is a specialist in that her field is limited to oral hygiene, it should be one of the most important aims of our Journal and our American Dental Hygienists' Association to keep us broadly informed with the greater field of which we are a part, dentistry in its relationship to better health."

On the limitations of specialization she wrote:

"The Tuberculosis Associations have accomplished a noticeable reduction of tuberculosis in the United States. Psychiatrists and the National Committee for Mental Hygiene have given much information on child training to parents and teachers which is manifest in the attitude of progressive mothers and teachers toward children. State Departments of Health, the Visiting Nurses Association, and other agencies have greatly improved sanitary conditions and reduced the danger of epidemics. The Red Cross, the groups of physicians and dentists interested in health, each has a special part of the great health program to perform. Yet how little we know of the scope and the work of the separate groups."

"The most rapid progress and the most far reaching good will be accomplished only when there is coordination of effort among all of these related health groups. It should be the aim and the ideal of our American Dental Hygienists' Association to promote high stands of service through an understanding and appreciate on the value of dental health in its relationship to general health."

In 2008, a study was published on Periodontal-systemic disease education in United States dental hygiene programs.3 One of the survey questions asked dental hygiene program directors about interprofessional education regarding oral-systemic disease. Only 4% indicated that they teach periodontal oral-systemic content to interdisciplinary student groups. When interdisciplinary teaching did occur, it was usually with nursing or other allied health students. Two program directors reported that their students conduct a project or patient education related to oral-systemic disease with other health professions students. Hopefully the number of dental hygiene programs who are incorporating interprofessional education and collaboration with dental schools or health sciences/allied/nursing programs has increased since that time.

In May, 2013, Dr. Rick Valachovic (President and CEO of the American Dental Education Association) wrote an interesting article in Charting Progress titled, Interprofessional Education (IPE) is Here to Stay.4 In it he reports that IPE is maturing. A number of dental schools now have IPE initiatives underway. One of the most interesting collaborations is at New York University (NYU). In 2005, the NYU College of Nursing moved into the NYU College of Dentistry. Since that time the College of Nursing has established a nurse faculty practice in the dental school. A benefit of that collaboration is that nurse practitioners are frequently on the dental clinic floor available for consultation. Twice a week, nursing faculty work with dental students as they

chart medical histories, educating them about conditions that might impact dental treatment. Faculty from each program are teaching in the other programs. Interprofessional collaboration is happening with grant funding and presentations.

Many schools of dental hygiene are located on health sciences campuses that also educate nurses, physical therapists, occupational therapists, pharmacists and other professional groups who should know about the importance of oral hygiene and its relationship to general health. As written by Covington in 1927, "The most rapid progress and the most far reaching good will be accomplished only when there is coordination of effort among all of these related health groups." Dental hygienists are a vital part of the IPE team. IPE is here to stay and ADHA is working hard to make sure that dental hygienists are a vital part of the team!

Sincerely,

Rebecca Wilder, RDH, BS, MS
Editor–in–Chief, Journal of Dental Hygiene

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A Retrospective Comparison of Dental Hygiene Supervision Changes from 2001 to 2011

April V. Catlett, RDH, BHSA, MDH; Robert Greenlee, PhD

Abstract

Purpose: The purpose of this study is to evaluate the extent of change in the professional practice environment for dental hygienists in the 50 states and District of Columbia by comparing the state supervision requirements for dental hygienists during 2001 to 2011 to the previous 7 year period, 1993 to 2000.

Methods: A retrospective comparison evaluation was conducted using the 2 tables entitled "Tasks Permitted and Mandated Supervision of Dental Hygienists by State, 1993, 1998 and 2000" and "Dental Hygiene Practice Act Overview: Permitted Functions and Supervision Levels by State." To score the net change in supervision, a numerical score was assigned to each level of alteration in supervision with a +1 or -1 for each level of change.

Results: With a 95% confidence level, the mean change in dental hygiene supervision from 2001 to 2011 was 6.57 with a standard deviation of 5.70 (p-value=0.002). The mean change of supervision from 1993 to 2000 was 2.61 with a standard deviation of 4.36 (p-value=0.0002). The difference in the mean scores for the periods 1993 to 2000 and 2001 to 2011 was 3.96 (p-value=0.06).

Conclusion: This study shows that the majority of the states are moving toward a decrease in dental hygiene supervision. Study results suggest that the movement appears to be accelerating with more states adopting fewer supervision regulations at a faster rate. Therefore, direction is moving toward more access to dental health care for underserved populations.

Keywords: dental hygiene, access to dental care, supervision level, community partnerships, autonomy

This study supports the NDHRA priority area, **Health Services Research:** Identify how public policies impact the delivery, utilization, and access to oral health care services.

Introduction

Several factors contribute to the poor dental health of low-income populations in the U.S. Some of the most significant factors that contribute to this lack of access to care are a shortage of dentists, poor participation of dentists in public assistance programs and dental hygiene practice acts.[1] The dental hygiene practice act supervision requirements, dictated by state dental boards, limit the dental workforce conditions. In 2006, the dentist-to-population ratio in the U.S. was 5.8 dentists per 10,000 residents.[1] In May 2010, there were over 25% more dental hygienists as general dentists in the U.S.[1] Some states are not utilizing dental hygienists to fill the need in providing dental health care to their underserved populations. In a 2010 survey, 1,824 dental hygienists representing 42 states reported frustrations related to their career growth due to the trend of too many dental hygiene programs, a reduction in benefits and salaries, and a shortage of available dental hygiene positions.[2] The dental hygiene workforce is available; therefore, it needs to be utilized.

In addition to the shortage of dentists in the U.S. and a lack of dental participation in public assistance programs, public policy plays a substantial barrier to dental care. In most states the state dental boards, which are comprised mostly of dentists, oversee the regulation of dental hygienists and in some cases have the ability to determine which dental hygiene procedures may be legally performed by dental hygienists and determine whether dental hygienists are required by law to be directly supervised. Direct supervision limits the conditions and locations in which dental hygienists may provide preventive dental services; direct supervision confines the dental hygienist to a facility where the dentist is physically present. Also, there are state differences in dental procedures that may be performed by dental hygienists. Over the past decade several states have passed legislation to allow more dental procedures to be performed by dental hygienists without the direct supervision of a dentist. Other states have not made any changes in dental hygiene legislation over the past 2 decades.

According to a study conducted in 2004 by The Center for Health Workforce Studies at the University of Albany, along with other previous studies, the expansion of dental hygiene professional practice acts has been shown to improve the access to and utilization of oral health care services along with oral health outcomes.[3-7] The findings of these studies confirm that a decrease in dental hygiene supervision requirements in the U.S. could allow an expansion in professional practice opportunities for dental hygienists. By expanding dental hygiene practice regulation, access to preventive dental care could be made more available in underserved populations, including non-traditional settings such as schools, prisons, nursing homes and private homes, for homebound individuals. Some states, such as Colorado, Washington, Oregon, California and New Mexico, have had more lenient scope of practice and dental supervision laws which has resulted in more access to dental health care for their underserved populations.[3] By allowing dental hygienists to serve individuals in nursing homes, public health clinics and rural areas there is a higher access to dental care with no effect on the number of patients seen in dental offices since these individuals are not accessing care in a private dental office. Mandating dentists' physical presence for the provision of dental hygiene care is unnecessary since there is little possible danger in most dental hygiene services provided.[3] And states that have allowed dental hygienists to provide unsupervised services to more medically compromised individuals in long-term facilities, dental hygiene programs and to homebound patients have determined dental hygienists should be allowed to serve patients who are less medically compromised in all dental settings unsupervised.[3]

According to the previous Surgeon General David Satcher, oral health is an integral part of general health, and in his 2000 report, Oral Health in America, he stated that dental caries is a "silent epidemic."[4] Most dental conditions may not be life threatening and may be easily treated, but there are some dental conditions that result in pain, loss of teeth, infection, severe disability or even death. Early diagnosis and treatment of dental conditions, such as oral cancer, are important to ensure a good quality of life.[5] Studies have shown how the prevalence of dental caries is historically higher among those who live in poverty and rural areas and in minority groups.[4,6,7] Low-income and minority families experience 80% of all dental conditions, but only account for approximately half of the total number of dental visits in the U.S.[6] In 2005, almost 3 out of 4 shortage areas of dental health professionals were in rural areas where families experience transportation barriers and had reduced access to community water fluoridation.[5] Lacking a dental health care provider is a major risk factor for receiving inadequate preventive dental health care. A 2000 national survey of physicians found that 38% of patients enrolled in Medicaid and 55% of uninsured patients encountered difficulties in making a dental appointment with a dentist.[6]

Public policy has attempted to address the shortages in access to dental health care by providing incentives to dentists who serve low-income populations (thereby increasing the supply of dentists in rural areas), by using medical health care providers to provide dental health care services (such as fluoride varnish treatments) and by encouraging foreign dental school graduates to become licensed dentists in the U.S.[5,8-10] These attempts have resulted in little or no success in an increase in dental health care access. The National Conference of State Legislatures has recommended that each state consider dental hygiene licensing arrangements that will improve access to dental health care for underserved families.[6] A study performed by the National Center for Health Workforce Studies suggests that there is a positive correlation between access to dental health care and the autonomy of dental hygienists.[3]

Methods and Materials

A retrospective comparison evaluation was conducted using the 2 tables. "Tasks Permitted and Mandated Supervision of Dental Hygienists by State, 1993, 1998 and 2000," was developed in a study funded by the National Center for Health Workforce Analysis Bureau of Health Professions Health Resources and Services Administration in April 2004. "Dental Hygiene Practice Act Overview: Permitted Functions and Supervision Levels by State" was developed by the American Dental Hygienists' Association in June 2011 (Tables I, II).[3,11] The scoring instruments were designed by the initial researchers to quantify particular aspects of the legal practice acts and board regulations for dental hygienists within each state which permit greater access to dental hygiene services particularly for underserved populations.[3,11] The comparison of these 2 tables details the net change in the state supervision level required for 11 dental hygiene tasks from 2001 to 2011. The 11 dental hygiene tasks selected were intended by the initial researchers to capture characteristics of professional dental hygiene practices that enable dental hygienists to provide dental services and were based on conditions that are perceived to affect access in a variety of dental hygiene settings.[3,11] In order to score the net change in state dental hygiene supervision, a numerical score, which was

Table I: Change in Supervision Levels for Dental Hygienists by State, 1993 to 2000

State	X-Rays	Coronal Polish	Apply Fluoride	Apply Sealants	Perio. Dressings	Removal of Sutures	Monitor N2O	Admin N2O	Admin Block Local	Place Amalgam	Sub-gingival Scaling	Net Change
AL	0	0	0	0	0	0	0	-1	0	0	0	-1
AK	1	0	0	0	0	0	1	1	0	0	0	3
AZ	0	0	0	0	1	2	1	1	1	1	0	7
AR	1	1	1	0	1	1	1	1	1	0	1	9
CA	3	0	2	0	0	0	1	0	0	0	2	8
CO	0	0	0	0	0	0	0	1	0	0	0	1
CT	0	0	0	0	0	-3	0	0	0	0	0	-3
DE	0	0	0	0	0	0	3	3	3	3	0	12
DC	0	0	0	0	0	0	0	0	0	0	0	0
FL	0	0	0	0	-2	0	0	0	0	1	0	-1
GA	0	0	0	0	0	0	0	0	0	1	0	1
HI	0	0	0	0	0	0	0	0	1	1	0	2
ID	0	0	0	0	-1	0	1	1	0	0	0	1
IL	0	0	0	0	1	0	1	0	0	1	0	3
IN	0	0	0	0	0	0	-1	0	0	0	0	-1
IA	0	0	0	0	0	0	0	0	1	0	1	2
KS	0	0	0	0	0	0	0	0	0	0	0	0
KY	0	-1	-1	-1	0	0	0	0	0	0	-1	-4
LA	-1	0	-1	-1	0	-1	1	0	1	0	0	-2
ME	0	0	0	0	1	0	-1	2	2	-1	0	3
MD	-1	0	2	0	0	1	0	0	0	0	0	2
MA	0	0	0	0	0	0	-1	0	0	0	0	-1
MI	0	0	0	0	0	0	1	0	0	0	1	2
MN	0	0	0	0	0	0	0	1	1	0	0	2
MS	0	0	0	0	0	0	0	0	0	0	0	0
MO	1	1	1	1	0	-1	0	0	0	1	1	5
MT	0	0	0	0	0	0	2	3	1	0	0	6

Key:	
0	No Change
+1 to +21	Degree of Decrease in Supervision Requirements
-1 to -21	Degree of Increase in Supervision Requirements

developed by the National Center for Health Workforce Analysis Bureau of Health Professions Health Resources, was assigned to each state's supervision level in each year as follows:

- 0 - Direct Supervision
- 1 - Indirect Supervision
- 2 - General Supervision
- 3 - No Supervision

After each numerical value was assigned to each supervision level for each year, the level of supervision numbers for the 11 dental hygiene tasks in the year 2001 were subtracted from the level of supervision numbers in that same dental hygiene task for the year 2011. This occured for each of the 50 states and the District of Columbia.[3]

Each dental hygiene preventive service and extended occupational task was totaled to calculate a mean change for each task, a net change for each state and a net change for each task. Then, a total mean change and a total net change was calculated for all 50 states and the District of Columbia from 2001 to 2011 to evaluate the degree of supervision requirement changes that has occurred during that decade for the entire U.S.[3]

This review of documents provides a longitudinal description of the level of required supervision for

Table I: Change in Supervision Levels for Dental Hygienists by State, 1993 to 2000 (continued)

State	X-Rays	Coronal Polish	Apply Fluoride	Apply Sealants	Perio. Dressings	Removal of Sutures	Monitor N2O	Admin N2O	Admin Block Local	Place Amalgam	Sub-gingival Scaling	Net Change
NE	0	0	0	0	0	0	1	0	2	1	0	4
NV	2	2	1	2	2	1	0	0	0	0	2	12
NH	0	0	0	1	1	0	0	0	0	0	0	2
NJ	0	0	0	0	0	0	0	0	0	0	0	0
NM	0	0	0	0	4	4	0	2	1	0	0	11
NY	0	0	0	0	-1	0	0	0	0	0	0	-1
NC	0	0	0	1	2	0	0	0	0	2	0	5
ND	0	0	0	0	0	0	0	0	0	0	0	0
OH	1	1	1	1	0	0	0	0	0	0	1	5
OK	2	2	2	2	2	2	0	0	0	0	2	14
OR	0	0	0	0	0	0	2	0	0	0	0	2
PA	2	2	2	2	0	0	0	0	0	0	2	10
RI	1	1	1	1	1	2	0	0	0	-1	1	7
SC	-1	-1	-1	-2	-1	0	1	0	0	0	-1	-6
SD	0	0	2	0	1	1	3	0	0	0	0	7
TN	0	0	0	0	0	0	0	0	0	0	0	0
TX	0	0	0	0	0	0	0	1	0	0	0	1
UT	0	0	0	0	0	0	2	1	0	0	0	3
VT	0	0	0	0	0	0	1	0	1	0	0	2
VA	0	0	0	0	0	0	-1	0	0	-1	0	-2
WA	1	0	0	0	0	0	0	0	0	0	0	1
WV	0	0	0	0	1	0	0	0	0	0	0	1
WI	0	0	0	0	0	0	2	0	1	0	0	3
WY	-1	-1	0	0	0	0	0	0	-1	0	-1	-4
Mean Change	0.22	0.14	0.24	0.14	0.25	0.18	0.41	0.33	0.31	0.18	0.22	2.61
Net Change	11	7	12	7	13	9	21	17	16	9	11	115

Key:	
0	No Change
+1 to +21	Degree of Decrease in Supervision Requirements
-1 to -21	Degree of Increase in Supervision Requirements

the fundamental dental hygiene preventive services and some extended occupational tasks for each of the 50 states and the District of Columbia from 2001 to 2011. In some states, negative change occurred, suggesting that the level of supervision increased. Each score can be interpreted using the following method:[3]

- 0 - No Change
- +1 to +21 - Degree of Decrease in Supervision Requirements
- -1 to -21 - Degree of Increase in Supervision Requirements

To evaluate how much change has occurred in the level of supervision for the dental hygiene profession between the years 2001 to 2011 compared to the years 1993 to 2000, a bivariate analysis t-test was performed utilizing the OpenEpi program.[12] The greatest threat to the validity of this study includes improper measurement errors which would affect reliability. Therefore, data entry was verified twice by the author. Using an ordinal scale of supervision level (0, 1, 2, 3) for each dental hygiene task, a mean score was given for each time frame by totaling all state ordinal scale scores and dividing them by 51.

Table II: Change in Supervision Levels for Dental Hygienists by State, 2001 to 2011

State	X-Rays	Coronal Polish	Apply Fluoride	Apply Sealants	Perio. Dressings	Removal of Sutures	Monitor N2O	Admin N2O	Admin Block Local	Place Amalgam	Sub-gingival Scaling	Net Change
AL	0	0	0	0	0	0	0	0	0	-1	0	-1
AK	0	1	1	1	0	1	0	0	2	1	2	9
AZ	1	1	1	1	-1	-1	-1	-1	-1	-1	0	-2
AR	1	1	1	2	0	0	-1	-1	0	0	-1	2
CA	0	1	1	1	1	1	0	0	0	1	1	7
CO	1	0	0	0	0	0	0	0	2	0	-1	2
CT	1	1	1	1	1	2	0	0	1	0	1	9
DE	0	0	0	0	0	0	-2	-2	-2	-1	0	-7
DC	0	0	0	2	0	0	0	1	1	0	0	4
FL	2	2	1	2	2	0	0	0	0	-1	0	8
GA	0	0	0	0	0	0	0	0	0	0	0	0
HI	1	1	1	1	1	1	0	0	0	-1	1	6
ID	0	0	0	0	0	0	-2	-2	1	1	0	-2
IL	2	2	2	2	0	2	1	1	1	-1	2	14
IN	1	1	1	0	0	0	0	0	1	0	0	4
IA	1	1	1	1	1	1	0	0	0	0	1	7
KS	2	3	3	2	2	2	2	2	0	0	2	20
KY	2	2	3	3	2	2	0	1	1	0	2	18
LA	1	1	1	1	0	0	0	1	1	0	0	6
ME	0	1	1	1	-1	1	0	0	-1	1	1	4
MD	2	1	1	1	1	1	0	0	1	0	1	9
MA	1	1	1	1	1	1	0	0	1	-1	1	7
MI	1	1	1	1	1	1	1	1	1	1	1	11
MN	1	1	1	1	0	0	0	2	2	1	1	10
MS	0	0	1	0	0	0	0	0	0	0	0	1
MO	2	3	3	3	2	2	0	0	0	0	2	17
MT	1	1	1	1	0	0	0	0	-1	-1	1	3

Key:	
0	No Change
+1 to +21	Degree of Decrease in Supervision Requirements
-1 to -21	Degree of Increase in Supervision Requirements

Results

With a 95% confidence interval, the mean change in dental hygiene supervision from 2001 to 2011 was 6.57, with a standard deviation of 5.70 (p-value=0.002). The positive value of 6.57 indicates that the 11 dental hygiene tasks across the 50 states saw an average movement toward less required supervision for dental hygienists. A similar trend toward reduced average supervision requirements was observed between 1993 and 2000 (however, this trend was nominally smaller due to a shorter time frame). The mean change of dental hygiene supervision from 1993 to 2000 was 2.61,with a standard deviation of 4.36 (p-value=0.0002). The difference in 2 means between the period 1993 to 2000 and the period 2001 to 2011 is 3.96 (p-value=0.06).

Some states, such as Virginia, Kansas and Missouri, have made substantial change in supervision regulations in the past 10 years. Other states such as Alabama, Georgia, Mississippi and North Carolina have made little or no progression in changing dental hygiene regulations from 1993 to the present date. There has been an overall change in more tasks permitted for dental hygienists, in regards to supervision, over the past 10 years. Numerically, a change toward less supervision requirement occurred in 45 of the 51 jurisdic-

Table II: Change in Supervision Levels for Dental Hygienists by State, 2001 to 2011 (continued)

State	X-Rays	Coronal Polish	Apply Fluoride	Apply Sealants	Perio. Dressings	Removal of Sutures	Monitor N2O	Admin N2O	Admin Block Local	Place Amalgam	Sub-gingival Scaling	Net Change
NE	2	3	3	3	2	0	0	0	0	-1	2	14
NV	1	1	1	1	1	1	1	1	1	0	1	10
NH	0	1	1	1	0	0	1	1	1	1	1	8
NJ	1	1	1	1	0	0	1	1	1	-1	1	7
NM	1	1	1	0	0	0	0	0	1	1	0	5
NY	0	0	0	0	1	0	1	1	1	1	0	5
NC	1	1	1	0	0	1	0	0	0	-1	1	4
ND	0	0	0	0	0	0	0	0	1	1	0	2
OH	1	2	2	2	2	0	0	1	1	0	1	12
OK	2	2	2	2	2	0	0	0	0	0	2	12
OR	1	1	1	1	1	1	0	-1	0	1	1	7
PA	1	1	0	1	0	0	0	0	1	0	1	5
RI	1	1	1	1	-2	-2	0	0	1	0	1	2
SC	2	2	2	2	0	0	0	0	1	0	1	10
SD	1	1	1	1	0	0	0	1	0	0	1	6
TN	1	1	1	1	0	-1	0	1	1	0	1	6
TX	1	1	1	1	1	1	0	0	0	0	1	7
UT	0	0	0	0	0	0	0	-1	-1	0	0	-2
VT	1	1	1	1	0	0	0	0	0	-1	1	4
VA	2	3	3	3	2	2	1	1	1	0	3	21
WA	1	1	1	1	0	0	0	0	0	0	1	5
WV	2	3	3	2	0	0	0	0	1	0	2	13
WI	0	1	0	0	0	-1	0	0	0	0	1	1
WY	1	1	0	2	0	1	0	0	0	0	1	6
Mean Change	0.94	1.12	1.08	1.1	0.45	0.37	0.06	0.18	0.45	-0.02	0.84	6.57
Net Change	48	57	55	56	23	19	3	9	23	-1	43	335

Key:	
0	No Change
+1 to +21	Degree of Decrease in Supervision Requirements
-1 to -21	Degree of Increase in Supervision Requirements

tions, and a change toward more supervision requirement occurred over the past 10 years in only 5 jurisdictions. There are still some states that require direct supervision in all settings: Alabama, Georgia, Mississippi and North Carolina. There are now 35 states that allow direct access, where the dentist does not need to examine or authorize the dental hygiene services in public health settings outside of the dental office.[11] An additional 3 states do not require a dentist to examine the patient prior to dental hygiene services in public health settings outside of the dental office: Indiana, New York and South Carolina.[11]

In regards to a reduction of supervision for individual dental hygiene tasks, the largest mean changes occurred in coronal polishing (1.12), the application of sealants (1.1), the application of fluoride treatments (1.08), taking radiographs (0.094) and performing scaling and root planing (0.84). The only dental hygiene task that now requires more supervision in 2011 than in 2001 is placing an amalgam filling, with a mean score of -0.02, which is a restorative service and traditionally outside the scope of practice for dental hygienists as defined by state dental boards. With the higher number of dental hygiene graduates over the number of dental school graduates, it would seem logical to utilize these dental care providers to provide scaling and root planings, apply seal-

ants and fluoride treatments, take radiographs, and provide oral hygiene instructions, nutritional counseling and tobacco cessation counseling to the underserved American population.

Discussion

The results of this study suggest that the majority of the states are moving toward a decrease in dental hygiene supervision in order to provide oral health care in public health settings such as schools, prisons, nursing homes and private homes, for homebound individuals. The mean change between 1993 to 2000 and 2001 to 2011 may suggest that the movement is accelerating with more states adopting fewer supervision regulations at a faster rate. For the majority of states, there is a movement toward increased access to dental health care for the underserved American population.

Only 690 dental hygienists were employed in underserved settings, and the vast majority of dental hygienists, 180,240, were employed in a traditional urban setting in May 2011.[3] Therefore, the 2004 National Center for Health Workforce study's findings that show there is a positive correlation between access to dental health care and the autonomy of dental hygienists needs to be further investigated over time as more dental hygienists are allowed to practice with less dentist supervision.[3] If these findings are confirmed by further examination and studies, then expanding the dental hygiene professional practice acts would be an appropriate strategy for states seeking to expand their access to dental services.[3]

Conclusion

This study examined the difference in the mean change of required supervision levels of dental hygienists for 2 different time frames. The required supervision level is decreasing over time. There is some evidence that the pace of relaxed supervision may be accelerating, with more states adopting fewer supervision regulations at a faster rate, since the p-value was over 0.05 (p-value=0.06). It is recommended to explore these findings further to determine if the amount of difference is statistically significant.

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Catalogue of Tooth Brush Head Designs

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Abstract

Purpose: Manual toothbrushes (MTBs) and power toothbrushes (PTBs) are effective oral physiotherapy aids for plaque removal. End-rounded bristles are safer and reduce damage to oral tissues. Nylon bristles are more effective in plaque removal because the bristle is stiffer than natural bristles. In the last 10 years the number of options for MTBs and PTBs has expanded significantly and there is very little information providing a reference frame for the design characteristics of the heads. The present in vitro study characterized a variety of MTB and PTB heads to provide a reference library for other research comparisons which might be made.

Methods: Various commercial MTB and PTB heads were used to characterize the following: bristle size, shape, diameter, number of tufts, number of bristles per tuft and surface characteristics. Photographs were collected from the side, at 45 degrees and the top of each toothbrush (TB) head using a scanning electron microscope and digital camera. Images were analyzed (Soft Imaging System) for bristle features and designs. One-way ANOVA ($p \leq 0.05$) was performed to detect differences among TB types within MTB and PTB groups and between pooled values for MTB and PTB groups.

Results: There were significant differences ($p \leq 0.05$) in toothbrush bristle diameter and bristle shape. In contrast, there were no significant differences between PTB vs. MTB in regards to bristle diameter, bristle count and tuft count.

Conclusion: The results suggest that although there are wide variations in toothbrush head designs, significant differences were found only in relation to bristle diameter and shape.

Keywords: manual toothbrush, power toothbrush, toothbrush head, bristles, tufts

This study supports the NDHRA priority area, **Health Promotion/Disease Prevention:** Investigate the effectiveness of oral self-care behaviors that prevent or reduce oral diseases among all age, social and cultural groups.

Introduction

The manual toothbrush (MTB) was invented in China between 618 to 907 A.D., and was composed of hog hair for bristles.[1,2] In 1780, England resident William Addis manufactured the "first modern toothbrush," and this brush had a bone handle and holes for placement of natural hog bristles.[3] In the early 1900s, celluloid began replacing the bone handle - this change came about during World War I, when bone and hog bristles were in short supply.[3] Similarly, as a result of deficit supply, nylon bristles were introduced. Initially, nylon bristles were copies of natural bristles in length and thickness, however, they were stiffer than the natural bristles.[3] They did not have the hollow stem of natural bristle, so they did not allow water absorption. Other advantages of nylon bristles were the ability to form the bristles in various diameters and shapes, and to round the bristle ends to be gentler on gingival tissues.[3]

The first power toothbrush (PTB) was developed in Switzerland in 1939. This brush had a power cord and was introduced in the U.S. in the 1960s.[4] Contemporary PTBs were rediscovered in the 1980s, and today you can find various types of PTBs on the market that utilize varied mechanisms of action (rotational oscillation, sonic, ultrasonic) and power supplies (battery powered or rechargeable).[3,5,6] PTBs also offer an array of brush head designs.

Each brush head, whether it is a MTB or PTB, is divided into 2 parts: the toe, located at the extreme end of the head, and the heel end closest to the handle (Figure 1).[3,5,6] Toothbrush (TB) heads are composed of tufts, which are individual

Figure 1: Digital Photo of Toothbrush Heads (A: Manual Toothbrush Head; B: Power Toothbrush Head)

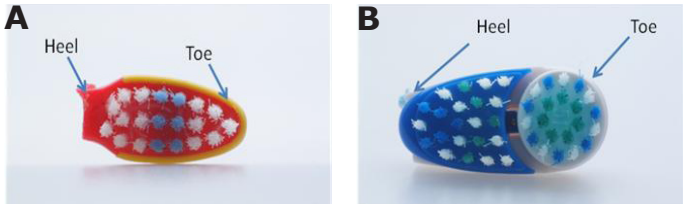
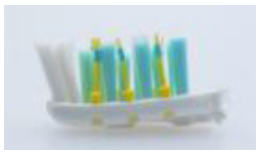
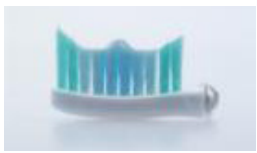
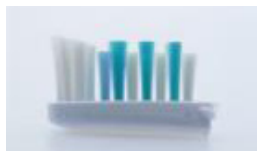


Figure 2: Various Brushing Planes for Power and Manual Toothbrush Heads

PTBs		MTBs	
			
Arm & Hammer Sonic (PTB) Bilevel, separated tufts/ rectangle		Biotene (MTB) Flat	
			
Oral-B Pulsar (PTB) Multilevel		Oral-B Stages mixed dentition (MTB) Angled	
			
Sonicare Elite Standard (PTB) Rippled		Oral-B Advantage Plus (MTB) Multilevel	
			
Oral-B Power Stages 3+ (PTB) Bilevel, round angled		Butler Gum (MTB) Rippled	

bundles of filaments secured in a hole in the TB head. Filaments within the tufts are known as bristles. Number and length of the filaments in a tuft, number of tufts, and arrangement of tufts vary with toothbrush designs.[3,5,6] A brushing plane may be flat with all filaments the same length, bi-level, multilevel, rippled or crisscrossed with tufts angled in at least 2 different directions (Figure 2).[6]

There are several studies that demonstrate that TB head design and proper brushing technique affect plaque removal.[7-15] A study conducted by Stiller et al was evaluating 3 TBs with extended, angled or flat multi-tufted bristles in regards to interproximal access.[11] They concluded the MTB with extended bristles provided an effective cleaning at interproximal areas.[11] Another study looked at orthodontic brushes and determined that the staged and v-shaped brush head designs did perform better than the planar brushes in efficacy of cleaning.[15] Rosema et al concluded from their study that the multi-leveled TB was significantly more efficacious than the flat leveled TB.[16] MTBs with CrissCross bristles that are angled in opposing directions seem to be the most effective in removal of plaque.[7,9,10] Zimmer et al study concluded that MTBs with hard bristles may remove plaque better, but may also cause more soft tissue trauma compared to brushes with softer bristles.[17] PTB head design, along with the mode of action, is to be considered with considering efficacy of plaque removal. PTBs have 5 classification groups: side to side action, counter-oscillation, rotation-oscillation, circular and ultrasonic.[18] The Cochrane review revealed some evidence that rotation- oscillation brushes reduce plaque and gingivitis more than side to side brushes in the short term.[19]

Various studies have examined TB bristles in regards to bristle end-rounding, methods for predicting the quality of nylon 612 filament for use as a bristle material,[20] filament round-ending quality in electric toothbrushes[21] and comparisons of the end-rounding of nylon bristles in commercial toothbrushes.[22-24] Studies involving end-rounding of bristles have established the need for rounding the end of the bristle to protect the tissues of the oral cavity from damage caused by tooth brushing.[24-27] The studies conducted regarding evaluation of TB bristles have either analyzed MTBs compared to other MTBs[22,28] or PTBs compared to other PTBs,[21] and no current studies have ana-

Table I: Manual Toothbrushes Utilized In Study and Features

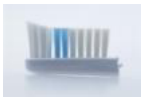
MTB Heads	Manufacturer	Type	Features
	Biotene Supersoft (BIO) (GlaxoSmithKline, USA)	Adult	Extrasoft, medium head size
	Butler Gum Technique (GBTE)	Adult	Soft bristles
	Butler Gum Summit (GS)	Adult	Soft bristles
	Butler Gum (BMTB)	Adult	Soft bristles; compact head, microtip
	Butler Gum Crayola (BCB)	Child	Soft bristles with suction cup handle
	Butler Gum Kids (BCHI)	Child	Soft bristles
	Colgate Wave (COWA) (Colgate-Palmolive Company, New York, NY)	Adult	Soft bristles; compact head
	Crest Dual Action Clean (CRDA)	Adult	Soft bristles
	Crest Complete (CRRM)	Child	Soft bristles; rippled bristles
	Oral-B Advantage Artic (OBAA)	Adult	Soft bristles, compact head
	Oral-B Advantage Glide (OBAG)	Adult	Extrasoft bristles; compact head; sensitouch
	Oral-B Advantage Plus (OBAP)	Adult	Soft bristles

lyzed or compared MTBs and PTBs to each other. The purpose of this preliminary study is to analyze a broad spectrum of commercially available MTB and PTB heads to compare characteristics known to contribute to their safety and efficacy, such as number of tufts, number of bristles per tuft, bristle diameter, bristle shape and surface characteristics of the bristles.

Methods and Materials

A total of 24 MTB and 21 PTB heads commercially available in the U.S. in 2009 were analyzed. The TBs had either soft or extra soft bristles (Tables I, II). Prior to analysis, the TB heads were removed from the handle using a Dremel 3000 series (Dremel, Racine, Ill.) with a 426 Dremel reinforced cut-off wheel. During the removal process, the TB handle was secured in a vice with the brush head face down to reduce handle residue particles getting onto the bristles. The brush heads were individually packaged in small coin sized Ziplock bags (2x3 2 MIL bags) and labeled with the name of brush, date cut and whether the head was a MTB or a PTB. Photographs were taken of each TB head and included in the tables listing the brushes used in this study (Tables I, II).

Table I: Manual Toothbrushes Utilized In Study and Features (continued)

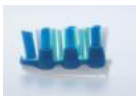
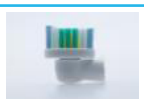
MTB Heads	Manufacturer	Type	Features
	Oral-B Advantage (OBA)	Adult	Soft bristles; compact head
	Oral-B Advantage Sensitive (OBAS)	Adult	Extrasoft bristles
	Oral-B Cross Action (OBCR)	Adult	Soft bristles; compact head
	Oral-B Indicator (OBIC)	Adult	Soft bristles; new comfort grip, fading blue bristles, compact head
	Oral-B Indicator (OBIN)	Adult	Soft bristles; compact head; indicator bristles
	Oral-B Pro-Health CrossAction (OBPH)	Adult	Soft bristles
	Oral-B Ortho (OBOR)	Child/Adult	Soft bristles
	Oral-B Stages One 4-24 months (OBS1)	Child	Cushioned head; baby soft bristles; non-slip handle
	Oral-B Stages 2-4 years (OBS2)	Child	Cushioned head; power tip, narrowhead; easy to hold handle
	Oral-B Stages Mixed Dentition (OBSM)	Child	Cushioned head; unique bristle design; varying bristle texture
	Oral-B Stages 5-7 years (OBSS)	Child	Cushioned head; power tip, cup shaped; handle stabilizer
	Oral-B Indicator Designs (OBID)	Child	Soft bristles

Digital photos were taken of each side and top of the TB head. The number of tufts per TB head was counted using the top view digital photo of each TB head as depicted in Figure 1.

The TB heads were then sputter coated with Au-Pd and inspected and documented in the scanning electron microscope (SEM) at 200x top view for bristle diameter, 15x top view for tuft counts and 40x and 200x horizontal views for surface characteristics. The SEM images were analyzed with the software Soft Imaging System GmbH (Soft Imaging System Corp., Lakewood, Colo.) to measure diameter and count bristles per tufts (Figure 3). The diameter of each bristle was measured by using the circle measurement tool. Three bristles were measured using the 200x SEM top view and averaged for the diameter of the bristles for each TB head. If a TB head had various types of bristles, then each bristle type area had a 200x SEM top view photo taken and analyzed for the various bristles diameters.

The bristles per tuft were counted by using Soft Imaging System touch count tool using the 15x SEM top view photo (Figure 3). Three tufts were counted within each 15x SEM photo, and then averaged for the typical amount of bristles per tuft.

Table II: Power Toothbrushes utilized in study and features

PTB Head	Manufacturer	Type	Features
	Arm & Hammer Spinbrush Sonic (AHSO)	Battery	Soft bristles
	Arm & Hammer Spinbrush (AHSP)	Battery	Soft bristles
	Colgate Motion (COMO) (Colgate-Palmolive Company, New York, NY)	Battery	Soft bristles; two rotational heads
	Oral-B Stages Power Ages 3+ (OB3B)*	Battery	Soft bristles; counter rotational head
	Oral-B Power Polisher (OBPD)	Rechargeable	Soft bristles, special polishing cup in center ; bristle indicators
	Oral-B (OBP)	Rechargeable	Extra Soft bristles
	Oral-B Power Tip (OBPT)	Rechargeable	Soft bristles
	Oral-B Pulsar (OBPU)	Battery	Soft bristles; compact head
	Oral-B Sonic (OBSO)	Rechargeable	Soft bristles; CrissCross Bristles
	Oral-B CrossAction Dual Clean (OBDC)	Rechargeable	Soft bristles; snap on head
	Oral-B Dual Action (OBDU)	Rechargeable	Soft bristles; Indicator bristles; Both heads move for twice the cleaning

*Children PTBs

Figure 3: SEM images (Sonicare Elite Compact PTB) indicating: A. Diameter of 3 Toothbrush Bristles; B. Bristle Count from 3 Sets of Tufts

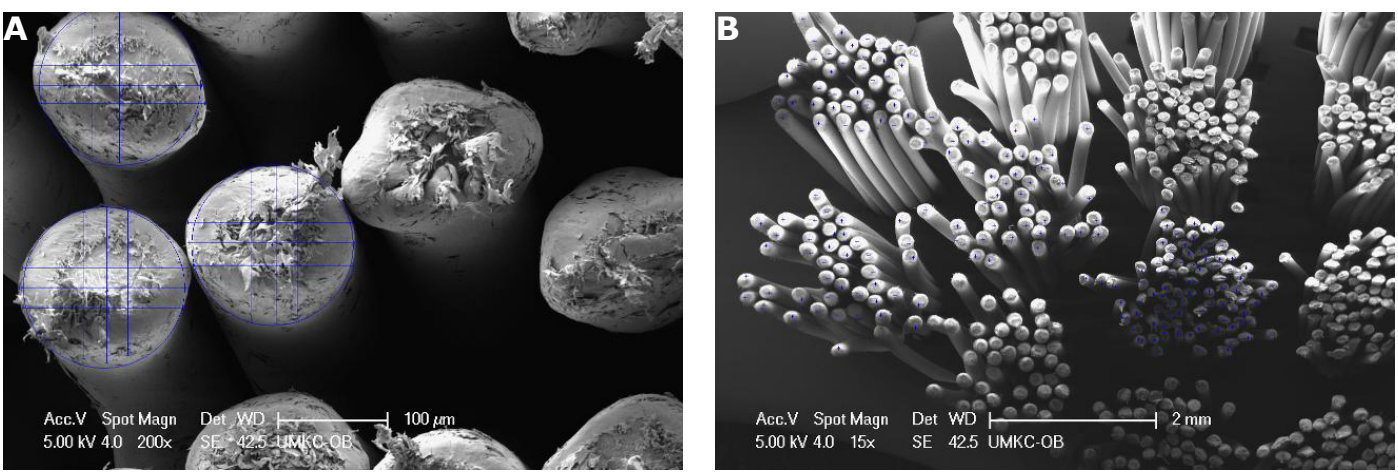
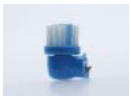


Table II: Power Toothbrushes utilized in study and features (continued)

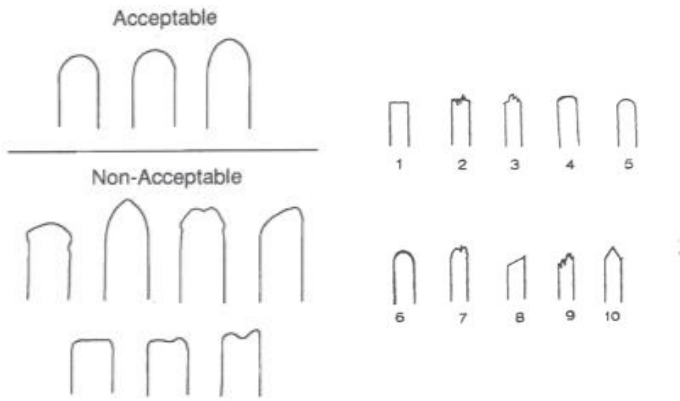
PTB Head	Manufacturer	Type	Features
	Oral-B Pulsonic (PULSE)	Rechargeable	Prosoft bristles; pivots and pulses
	Oral-B Kids 3+ (OBKP)*	Battery	Extras Soft bristles; raised row of bristles, blue indicator bristles, round head; oscillating rotation motion
	Sonicare Elite Compact (SECP)	Rechargeable	Soft Bristles ; Slim, angled neck and contour-fit bristles; rippled bristles; compact head
	Sonciare Eilte Standard (SESP)	Rechargeable	Soft Bristles; Slim,angled neck and contour-fit bristles; rippled bristles
	Sonicare Flexcare Compact (SFCP)	Rechargeable	Soft rippled bristles; indicator bristles; compact head
	Sonicare Flexcare Standard (SSFB)	Rechargeable	Soft rippled bristles; indicator bristles
	Sonicare Kid Age 4+ (SKID1)*	Rechargeable	Extrasoft bristles; compact head; rippled
	Sonicare Kid Age 7+ (SKID2)*	Rechargeable	Extrasoft bristles; rippled
	Waterpik Large (WATP1) (Fort Collins, CO)	Rechargeable	Extrasoft bristles; standard head
	Waterpik Small (WATP2)	Rechargeable	Extrasoft bristles; compact head

*Children PTBs

The surface characteristics were noted using the 40x and 200x SEM horizontal photos. When reviewing the surface characteristics, the bristle ends were analyzed for acceptable or unacceptable end-rounding using Silverstone and Featherstone scale (Figure 4).[29] The Adrians Grading Scale was used to categorize the bristle shape.[30] In addition, the bristles were also characterized as to roughness of the lateral surfaces.

Descriptive statistics for different TBs on tuft count, bristle count and bristle diameter are shown in Table III. Data analysis was performed with SAS (Statistical Analysis System, version 9.1.3; SAS Inc., Cary, NC). A 2 group t-test was used to compare the difference between MTB and PTB on bristle count, tuft count and bristle diameter. A 1-way analysis of variance (ANOVA) and Ryan-Einot-Gabriel-Welsch Q (REGWQ) multiple comparison post-hoc analysis were utilized

Figure 4: Silverstone and Featherstone Scale (A. Examples Of Acceptable And Non-Acceptable End-Rounding of Bristles;[29] B. Modified Silverstone and Featherstone Grading Scale)



Bristles 4 through 6 are acceptable, whereas 1 through 3 and 7 through 10 have an unacceptable rating.[28]

Table III: Manual and Power Toothbrush Average Tuft Count, Bristle Count and Bristle Diameter

MTB Head	Tuft Counts	Bristle Counts X±std	Bristle Diameter X±std µ	PTB Head	Tuft Counts	Bristle Counts X±std	Bristle Diameter X±std µ
Biotene Supersoft (BIO)	30	310±199	79±4µ	Arm & Hammer Spin-brush Sonic (AHSO)	23	155±115	141±5 µ
Butler Gum (BMTB)	31	38±13	178±9 µ	Arm & Hammer Spin-brush (AHSP)†	33	70±8‡	131±4 µ
Butler Gum Technique (GBTE)	30	34±10	176±10µ	Colgate Motion (COMO)	31	52±12‡	177±8 µ
Butler Gum Summit (GS)	31	45±2	113±59µ	Oral-B Power Polisher (OBPD)	16	107±20‡	141±6 µ
Butler Gum Crayola (BCB)	25	67±2	146±3 µ	Oral-B (OBP)	24	34±8	146±23 µ
Butler Gum Kids (BCHI)	19	51±1	182±4 µ	Oral-B Power Tip (OBPT)	4	69±10	157±2 µ
Colgate Wave (COWA)	35	54±3	169 ±5µ	Oral-B Pulsar (OBPU)	19	183±144	141±4µ
Crest Dual Action Clean (CRDA)*	38	82±27‡	161±48µ	Oral-B Pulsonic (PULSE)	30	52±5	329±12 µ
Crest Complete (CRRM)	25	62±13	168 ±10µ	Oral-B CrossAction Dual Clean (OBDC)†	38	90±39‡	156±7µ
Oral-B Advantage Artic (OBAA)	36	58±9	150±14µ	Oral-B Dual Action (OBDU)†	37	81±30‡	145±2µ
Oral-B Advantage Glide (OBAG)	37	81±9	154 ±5µ	Sonicare Elite Compact (SECP)	31	42±2	149 ±0µ
Oral-B Advantage Plus (OBAP)	33	61±13	146±12µ	Oral-B Stages Power Ages 3+ (OB3B)*†	30	127±53	127 ±34 µ
Oral-B Advantage (OBA)	33	52±6	193±8µ	Oral-B Kids 3+ (OBKP)	22	57±21‡	143±21 µ
Oral-B Advantage Sensitive (OBAS)	33	72±1	147±5µ	Sonciare Eilte Standard (SESP)	32	60±1	133±7 µ
Oral-B Cross Action (OBCR)	25	234±313	172±6 µ	Sonicare Flexcare Compact (SFCP)	22	67±20	172±13 µ
Oral-B Indicator (OBIC)	30	43±2	203±9 µ	Sonicare Flexcare Standard (SSFB)	32	63±25	161±2 µ
Oral-B Indicator Designs (OBID)	23	52±1	188 ±8µ	Sonicare Kid Age 4+ (SKID1)*	22	97±26	122±28 µ
Oral-B Indicator (OBIN)	30	40±1	204±6 µ	Sonicare Kid Age 7+ (SKID2)*	32	62±9	117±19µ
Oral-B Pro-Health CrossAction (OBPH)	30	72±29	172±9 µ	Waterpik Large (WATP1)	28	52±2	173±9 µ
Oral-B Ortho (OBOR)	30	46±1	202±2 µ	Waterpik Small (WATP2)	20	50±1	182±3 µ
Oral-B Stages One 4-24 months (OBS1)	32	62±1	135±5 µ				
Oral-B Stages 2-4 years (OBS2)	20	100±4	129±4 µ				
Oral-B Stages Mixed Dentition (OBSM)	34	52±4	145±7µ				
Oral-B Stages 5-7 years (OBSS)	33	62±4	149±2 µ				

to compare the diameter of TB bristles based on an unbalanced dataset. Level of significance was set at α=0.05.

Results

The average bristle diameter, average number of bristles per brush head and exact number of tufts per brush head for MTBs and PTBs are reported in Table III. There were no significant differences (p>0.05) in the mean bristle diameter, bristle count nor tuft counts between MTBs and PTBs (Table IV).

Table V reports the surface characteristics of TB heads and shapes of bristles. Oral-B Sonic (Procter & Gamble Company, Cincinnati, OH) revealed spiral bristles. Butler Gum (Sunstar Americas, Inc., Chicago, Ill.) middle section of bristles split into 4 and shredded. Crest Dual Action Clean (Procter & Gamble Company, Cincinnati, OH) has small bristles in the middle of the brush head and large bristle tips on the outside. Butler Gum Summit bristles appear spongy and some appear as an upside down cone and cut off. Oral-B Pulsar (Procter & Gamble Company, Cincinnati, OH) has a rubber bristle. Sonicare Kids PTB (Philips Electronics North America Corporation, Andover, Mass.) had a design with every other bristle on the periphery of the brush head small and all the middle section of the brush head small.

Bristle diameters, number of tufts and number of bristles among the MTB and PTB were not significantly different among types (p>0.05). For MTB, there was no significant difference (p>0.05) between flat tip with straight rims and pointed tip, but there were significant differences (p≤0.05) in diameter between round tip, flat tip with round rim and mushroom-shaped bristles. There was no significant difference in bristle diameter among different bristle shapes for PTB. Within each bristle shape, there was no significant difference in diameter between MTBs and PTBs (Table VI).

SEM of bristles of TBs that had multiple types of bristle sizes are shown in Table VII. The Arm and Hammer Spinbrushes (Church & Dwight Co., Inc., Princeton, NJ) revealed diamond shaped bristles along with the end-rounded bristles. Butler Gum toothbrush contained bristles that appear to be split into fours. Oral-B brushes had differences in terms of shape of bristles and texture. The Oral-B Pulsar had 3 types of bristles. Crest Dual Action Clean revealed texture differences and various bristle types.

Table IV: MTB versus PTB for Bristle Counts, Tuft Counts and Bristle Diameters

Variable	MTB (n=24)	PTB (n=21)
Bristle Count	76±63[a]	78±38[a]
Tuft Count	30±5[a]	26±8[a]
Bristle Diameter (um)	161±30[a]	157±43[a]

Discussion

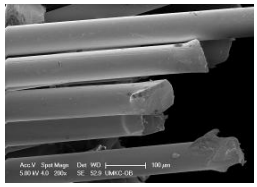
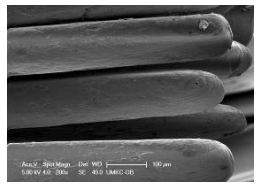
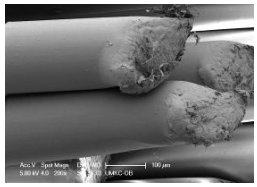
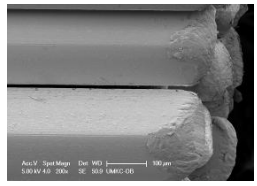
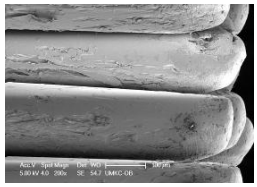
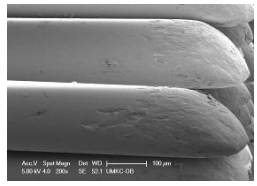
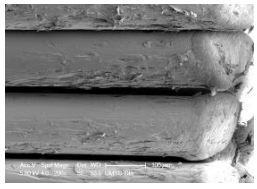
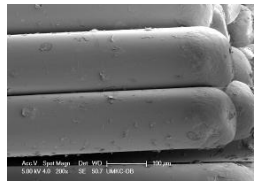
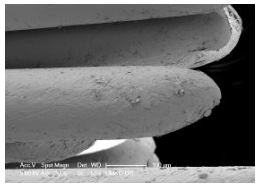
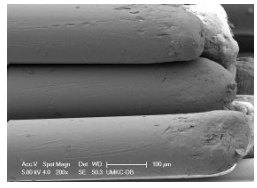
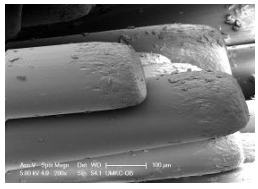
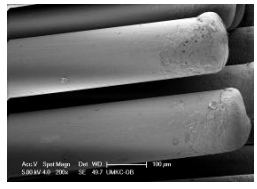
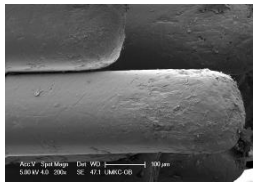
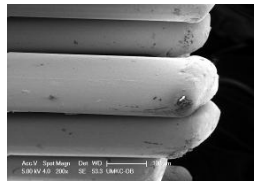
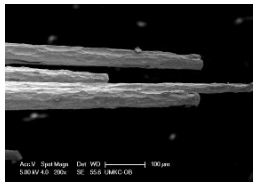
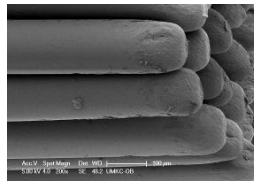
There was quite a range of bristle end shapes and numbers among the range of MTB and PTBs examined. Comments are divided into discussion of limitations of the present study, interpretation of the results, comparison of results to published information, clinical interpretation of the meaning of the results and suggestions for future research.

A limitation of the study was that only 1 TB head per type was analyzed (inter-brush variability) rather than determining "intra-type variability." This is important to utilize multiple TBs from each manufacturer to measure brush to brush variability. Often a wide variation among shapes of bristle tips exists even within an individual brush.[28] It has also been shown that the average number of "acceptable" rounded filaments differed significantly between 2 and 4, but not between 4 and 6 brushes studied per brand.[31] Studies that have compared characteristics within MTB bristles types have analyzed 30 TB heads for each brand[22,28] and a PTB study used 5 for analysis to account for intra-type variability.[21]

In the current study, brush heads were analyzed intact. Previous studies in the literature separated the bristles or tufts from the heads to be analyzed with the SEM.[32] The current study chose this path to avoid damaging or distorting the dimensions of the bristles.

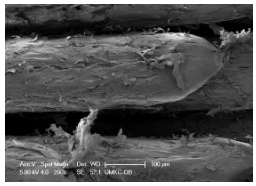
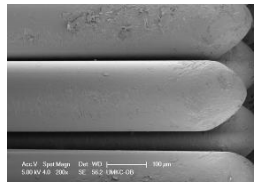
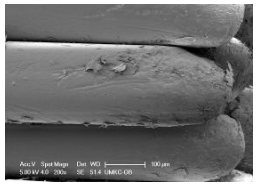
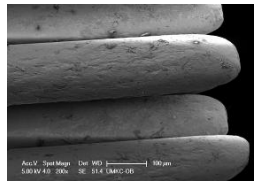
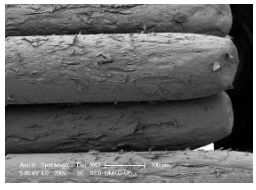
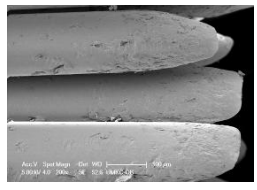
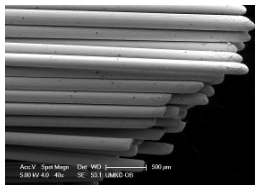
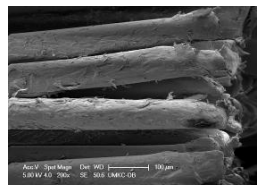
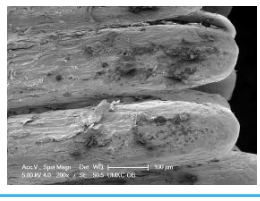
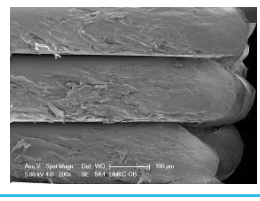
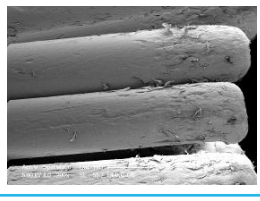
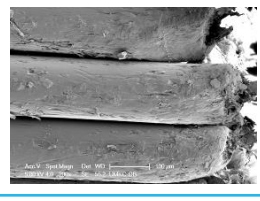
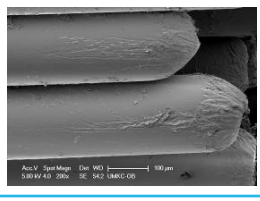
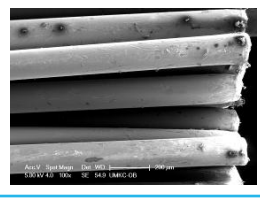
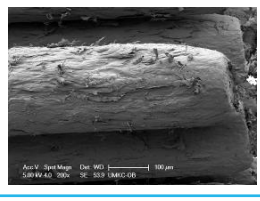
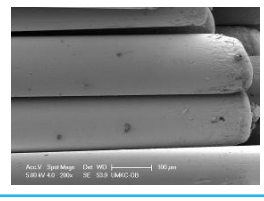
The results revealed no significance (p>0.05) between the MTB vs. PTB regarding the bristle diameter, bristle count and tuft count. However, there was a significance difference (p≤0.05) noted regarding the bristle diameters and bristle shape. The significance was found between flat tip with straight rims bristles (118μ) and round tip bristles (158μ), pointed tip shaped bristles (113μ) and round tip bristles (158μ), mushroom shaped bristles (177μ) and flat tip with straight rims bristles (118μ), and mushroom shaped bristles (177μ) and pointed tip bristles (113μ). The typical ranges for TB bristle diameter are 150μ to 400μ in diameter.[5] It appears that the TB bristles that are not the typical rounded tip has either

Table V: SEM surface characteristic and bristle shape of MTBs and PTBs

TB Name	Type	Shape	Surface Characteristic	TB Name	Type	Shape	Surface Characteristic
BIO	MTB	3		AHSP	PTB	1	
BMTB	MTB	7		AHSO	PTB	3	
BCHI	MTB	1		COMO	PTB	1	
BCB	MTB	1		OBP	PTB	2	
COWA	MTB	1		OBDC	PTB	1	
CRRM	MTB	2		OBDU	PTB	1	
CRDA	MTB	1		OBKP	PTB	1	
GS	MTB	4		OBPD	PTB	1	

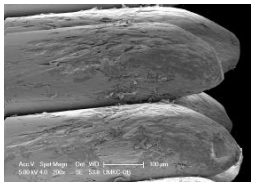
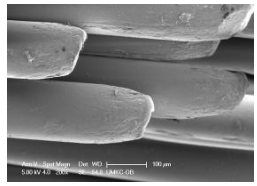
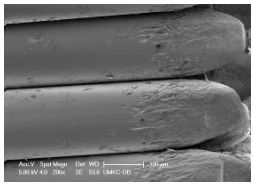
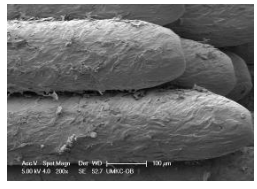
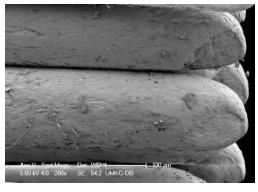
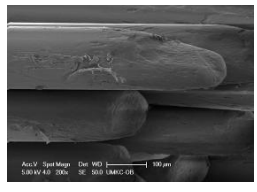
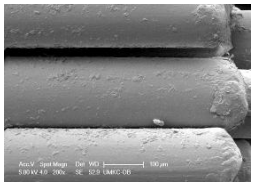
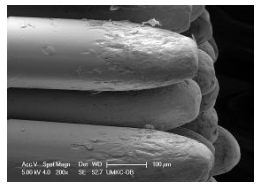
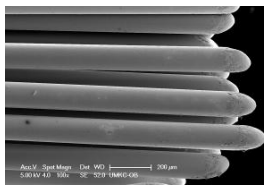
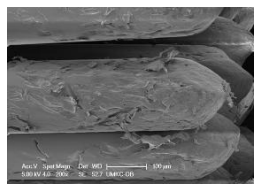
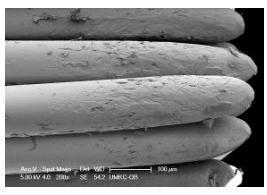
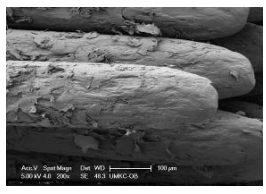
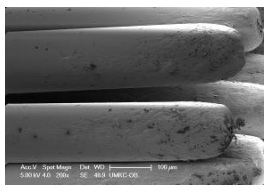
Adrians Grading Scale30 was used to determine shape: 1. round tip, 2. flat tip with rounded rims, 3. flat tip with straight rims, 4. pointed tip, 5. knife-shaped tip, 6. chisel-shaped tip, 7. mushroom-shaped

Table V: SEM surface characteristic and bristle shape of MTBs and PTBs (continued)

GBTE	MTB	7		OBPT	PTB	2	
OBA	MTB	1		OBPU	PTB	1	
OBAA	MTB	1		OBSO	PTB	1	
OBAG	MTB	1		OB3B	PTB	1	
OBAP	MTB	1		PULSE	PTB	1	
OBAS	MTB	2		SECP	PTB	2	
OBCR	MTB	1		SESP	PTB	3	
OBIC	MTB	2		SFCP	PTB	1	

Adrians Grading Scale30 was used to determine shape: 1. round tip, 2. flat tip with rounded rims, 3. flat tip with straight rims, 4. pointed tip, 5. knife-shaped tip, 6. chisel-shaped tip, 7. mushroom-shaped

Table V: SEM surface characteristic and bristle shape of MTBs and PTBs (continued)

OBIN	MTB	1		SSFB	PTB	2	
OBID	MTB	1		SKID1	PTB	1	
OBOR	MTB	1		SKID2	PTB	2	
OBPH	MTB	2		WATP1	PTB	1	
OBS1	MTB	1		WATP2	PTB	1	
OBS2	MTB	1					
OBSS	MTB	1					
OBSM	MTB	1					

Adrians Grading Scale[30] was used to determine shape: 1. round tip, 2. flat tip with rounded rims, 3. flat tip with straight rims, 4. pointed tip, 5. knife-shaped tip, 6. chisel-shaped tip, 7. mushroom-shaped

a greater diameter (mushroom shaped) or decreased diameter than normal range (flat tip with straight rim bristles or pointed tip bristles). This suggests that the shape of the bristle had an influence on the diameter of the bristle. The pointed bristles diameter and flat tip with straight rims bristles diameter were not within the typical diameters of TB bristles.

End-rounding is important due to studies that have revealed a rounded bristle causes less damage to hard and soft tissues while brushing.[32] To produce end-rounded bristles, bristle tips go through a process of grinding and polishing that is traditionally done by placing a trimmed brush against a flat, rotating grinding surface.[28] With a rippled brush containing short and long bristles, the same process would grind and polish some of the bristles while leaving others untouched.[28] Previous studies have suggested that this type of traditional end-rounding on a rippled brush may not be adequate to completely reduce oral soft tissue trauma.[33,34] A study conducted by Mulry compared a rippled TB with a traditional non-rippled TB and concluded that close to 90% of the bristles in the rippled bristle pattern design show adequate end-rounding well above the 52% observed for a flat brush due to new technology that accounted for grinding the short and long bristles of a rippled brush.[28]

Though there is evidence of the importance of end rounded TBsm,[32] inconsistent end-rounding of TB bristles was demonstrated in previous MTB studies.[28-30,35] A study regarding PTB bristles revealed when evaluating the bristle shapes that a good quality of filament tips could be found for most of the products.[21] Former studies of Oral-B[22,24,29,36-38] found some bristles were not acceptable among the tufts, where Colgate[22,29,36,37] were evaluated inconsistently, which would suggest a great variance in end-rounding quality. Butler showed a high number of not acceptable filaments in former studies[22,24,27,36,39] which were confirmed in the study by Meyer-Lueckel.[21] The first study to analyze PTB bristles concluded that most of the brands (13 out of 15) examined among the PTBs were of an acceptable quality,[21] and this study concluded the same (9 PTB out of 21 and 9 MTB out of 24).

The Adrians Grading Scale[30] and Silverstone and Featherstone scale[29] represent categories and not steps on a continuous scale. The scale that is most representative of TB designs of preference was the Adrians Grading Scale,[30] because it includes the various TB shape categories. The Silverstone and Featherstone scale assisted in determining only what is acceptable or not acceptable regarding bristle end-rounding.[29,30]

Table VI: Comparison of MTB versus PTB bristle diameter to Adrians shape scale

	Bristle Diameter (um)	
Shape Category:	MTB	PTB
1 (round tip)	164±24 (n=16)^{aA}	164±51 (n=14)^{aA}
2 (flat tip w/rounded rims)	173±23 (n=4)^{aA}	146±17 (n=5)^{aA}
3 (flat tip w/ straight rims)	79 (n=1)^{aB}	137±6 (n=2)^{aA}
4 (pointed tip)	113 (n=1)^{B}	----
5 (knife-shaped tip)	----	----
6 (chisel-shaped tip)	----	----
7 (mushroom-shaped)	177±1 (n=2)^{A}	----

Different superscripts represent significant differences at α=0.05. Small letter value between columns. Capital letter value between rows.

Although this study analyzed only 1 TB per type, further studies could evaluate a larger sample of each type to determine if there is variability in bristle diameter and shape as well as bristle and tuft count due to the manufacturing process. Other future studies could include evaluating brushes with the Adrian and Silverstone scales[29,30] before and after some time of TB use to determine what happens to the bristles over time. For example, there may be a possibility that regardless of irregular shapes at the beginning, the first change may be toward bristle rounding. After rounding, the wear on the bristles of average diameter may be reduced so that they probably last longer for the average person. In addition, one could see if the wear corresponds well to any color markers for changing brushes. Other studies could include using radically different dentifrices over time to determine how the dentifrice might affect bristle shape and end-rounding. Deterioration patterns of bristles are not known, therefore conducting a study to see if the shape of the tip remains the same over time of use and even determining if an un-rounded tip becomes round upon use or remains the same is important, since studies have determined that end-rounded tip is safer.[32]

Overall brush head design is important for both cleaning efficacy and safety.[11,13,15,17,18,40] The design needs to be considered when determining which TB to utilize or recommend. Since there were no differences in design for certain param-

Table VII: Toothbrush Heads that Included More than 1 Bristle Type

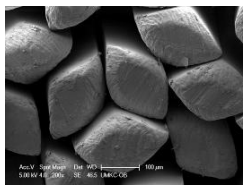
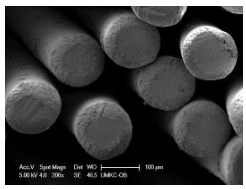
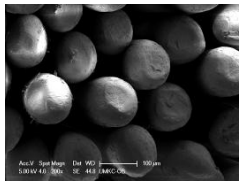
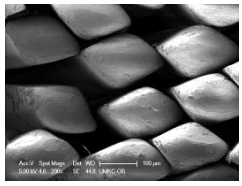
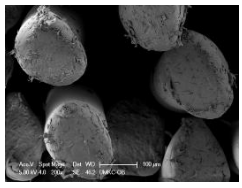
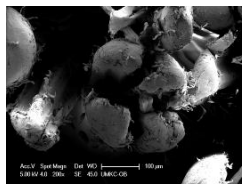
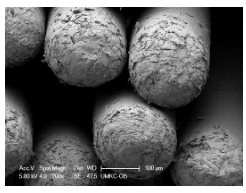
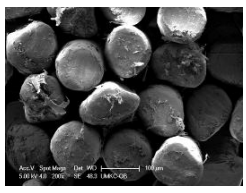
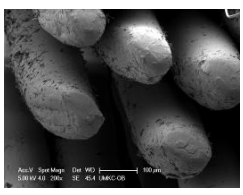
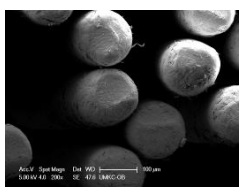
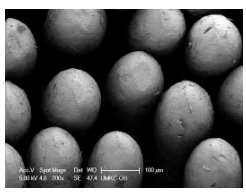
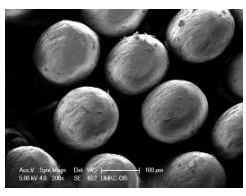
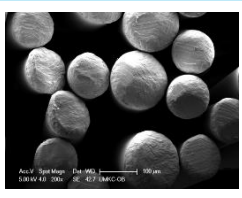
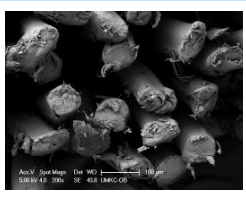
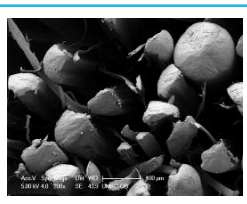
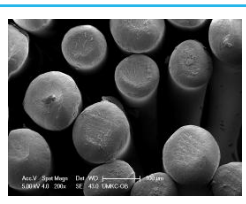
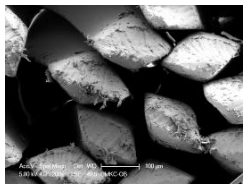
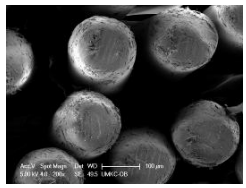
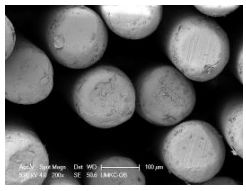
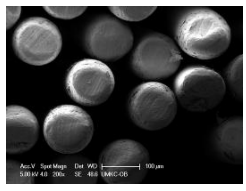
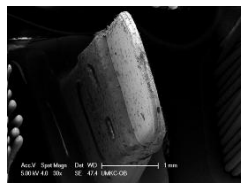
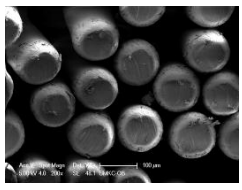
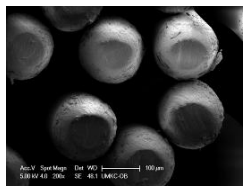
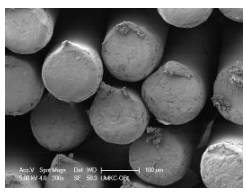
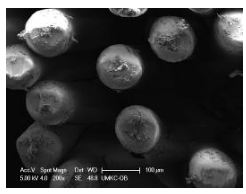
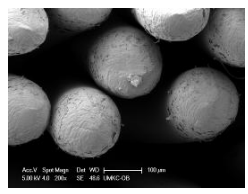
TB Brand/Type	SEM Depicting Multiple Bristle Types		
Arm & Hammer Spinbrush Sonic (AHSO) PTB			
Arm & Hammer Spinbrush (AHSP) PTB			
Butler Gum (BMTB) MTB			
Crest Dual Action Clean (CRDA) MTB			
Oral-B Advantage Plus (OBAP) MTB			
Oral-B Pulsar (OBPU) PTB			
Oral-B Stages Power Ages 3+ (OB3B) PTB			
Oral-B Kids 3+ (OBKP) PTB			

Table VII: Toothbrush Heads that Included More than 1 Bristle Type (continued)

Sonicare Elite Standard (SESP) PTB			
Sonicare Flexcare Compact (SFCP) PTB			
Sonicare Kid Age 4+ (SKID1) PTB			
Sonicare Kid Age 7+ (SKID2) PTB			

eters for the TBs analyzed in the current study, one could determine that if a new brush came out with similar design that one could predict it would have similar characteristics.

Conclusion

Although there are numerous TB head designs, based on the parameters measured in this study, there were minimal differences between the TBs that were evaluated. Within the limitations of the present investigation, the following can be concluded:

1. There was a significant difference ($p \leq 0.05$) in bristle diameters and bristle shape among the MTBs. No significant difference ($p > 0.05$) among the PTBs for bristle diameter and bristle shape.
2. No significant differences ($p > 0.05$) between MTB vs. PTB bristles count and diameters among the various manufacturers.
3. There were no significant differences ($p > 0.05$) in the tuft counts between MTB vs. PTB.

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Inter-Rater Reliability of the Mallampati Classification for Patients in a Dental Hygiene Clinic

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Abstract

Purpose: The purpose of this study was to assess the inter-rater reliability between dental hygiene students and a supervising dentist using the Mallampati classification to evaluate and classify the pharyngeal soft tissues.

Methods: A sample of 234 patients volunteered for the study. Mallampati classifications were performed by 21 dental hygiene students for patients during a 12 month period. During that same time period, the clinic dentist performed an independent assessment on the same patients. Quantitative research methods were used to evaluate the inter-rater reliability between dental hygiene students and the clinical dentist in performing the Mallampati classification. The data was analyzed using adjusted McNemar test for non-independent data, Kappa score and percentage of agreement with 95% bootstrap confidence interval.

Results: There was an agreement between the dental hygiene student and the dentist in the majority of the independent assessments with a p-value=0.498 from the adjusted McNemar test. Inter-rater agreement measured by Cohen's Kappa coefficient was 0.54 with a 95% bootstrap confidence interval of 0.42, 0.64. The percentage agreement was around 77% with a 95% confidence interval of 72%, 82%.

Conclusion: It was concluded that dental hygiene students can evaluate and classify the pharyngeal soft tissues comparable to a supervising dentist in the clinical dental hygiene setting.

Keywords: mallampati classification, obstructive sleep apnea, clinical dental hygiene education, inter-rater reliability

This study supports the NDHRA priority area, **Clinical Dental Hygiene Care:** Investigate how dental hygienists identify patients who are at–risk for oral/systemic disease.

Introduction

Obstructive sleep apnea (OSA) is a condition characterized by a partial or complete closure of the airway, resulting in repeated episodes of breathing cessation during sleep.[1] The restriction of oxygen during these episodes is known as hypoxia and can last from several seconds to several minutes in length. The repeated hypoxia episodes can lead to severe systemic consequences including hypertension, stroke, arrhythmias, cardiovascular disease or even death.[2,3] OSA is a condition that may affect up to 1 in 5 adults.[4,5] A definitive diagnosis of OSA is only obtained from polysomnography that involves an overnight stay in a sleep laboratory. The sleep study is used to identify the presence of OSA as mild, moderate or severe. Nearly 80% of all moderate to severe cases of OSA in middle age men and women are undiagnosed.[6] Dental hygiene students may be able to play an active role in the early identification of risk factors for OSA.

The role of the dental professional can begin with recognition, referral and management of sleep disorders. The Mallampati score was shown to be progressively higher in patients who exhibited more severe degrees of OSA as determined by polysomnography.[7,8] There are several intraoral traits that OSA patients exhibit including macroglossia, narrow palate, wide uvula, hypertrophy of the tonsil region and a narrow opening of the oropharynx.[9,10] The Mallampati classification is a tool used by anesthesiologists prior to surgical procedures to identify patients who may have difficulty during endotracheal intubation.[11] This scoring system uses a scale of I, II, III, IV (Figure 1) in identifying patients who may be at risk for a difficult intubation.[8] A score of I represents the greatest visibility of the posterior pharynx with the mouth open and tongue protruded, and IV shows the least visibility. Patients with a grade III or IV Mallampati classification are at greater risk of having a difficult airway for endotracheal intubation because of the limited opening of the oropharynx.[11]

Physical characteristics for OSA include obesity, male gender, age, a neck circumference greater than 17 inches for men and 16 inches for women and a retrognathic profile.[12-14] Symptoms associated with OSA include snoring, headaches, xerostomia and bruxism. Xerostomia has been identified as an oral complication due in part to the open mouth episodes experienced during the night.[2,12] Bruxism has

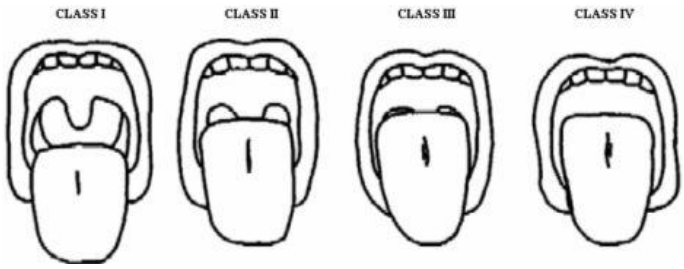
been identified in patients with OSA. The grinding of teeth, which take place during the arousal episodes, is associated with sudden arousals from the obstruction.[13] Of particular concern is the gender differences associated with risk factors for sleep apnea.[5,15] For example, men present with large tonsils a wide uvula and high tongue where as women with large tonsils and a retrognathic profile were more likely to have OSA.[9]

There are systemic and social consequences associated with OSA. The episodes of hypoxemia and arousals lead to hypertension, atherosclerosis, stroke, cardiac arrhythmias, heart failure and pulmonary hypertension.[16] Daytime symptoms include daytime sleepiness, fatigue, difficulties with concentration or memory, and depression.[2,14] Daytime sleepiness leads to an increase in accidents and loss of work production.[17,18]

There are several treatment options for OSA patients. The most common is the use of a continuous positive airway pressure (CPAP) machine. The CPAP is used during sleep to open the airway and prevent obstruction by the soft tissues in the oral cavity. Mandibular Advancement Devices (MAD) are appliances worn during sleep to reposition the mandible anteriorly to open the airway. CPAP and MAD may be used concurrently to treat OSA. In severe cases of OSA, surgery may be indicated. Surgical procedures may include reduction of soft tissue surrounding the oropharynx, orthognathic surgery and maxillomandibular advancement. However, the ultimate cure for OSA is tracheostomy.

Research shows dental professionals are receiving inadequate training to screen for sleep related disorders.[19–21] Medical and dental school curriculum includes limited hours toward the training in the identification and treatment of sleep related disorders.[21,22] Likewise, dental hygienists receive minimal training, if any, to identify the oral signs related to sleep related disorders. There are a number of methods to screen and evaluate patients for sleep disorders. Simple questionnaires that screen for daytime sleepiness and risk factors for OSA such as the Epworth Sleepiness Scale or STOP Questionnaire are available as a first line screening tool. However, there are numerous methods to assess physical characteristics related to sleep disorders.[23,24] Dental hygienists are taught to perform a very thorough oral examination on every patient and are in a unique position to identify risk factors for OSA and make appropriate referrals. Dental professionals are in an ideal position to evaluate and classify the pharyngeal soft tissues. The researchers utilized the Mallampati classification during the oral assessment to classify the pharyngeal soft tissues.

Figure 1: Mallampati Classification



There is little data to demonstrate the use of the Mallampati classification by dental hygienists in the clinical setting. The purpose of this study was to assess the inter-rater reliability between dental hygiene students and a supervising dentist using the Mallampati classification to evaluate and classify the pharyngeal soft tissues.

Methods and Materials

Twenty-one second year dental hygiene students agreed to participate in this study, which was approved by the Youngstown State University Institutional Review Board. Informed consent was obtained from the dental hygiene students and the clinic patients to participate in this study. Prior to beginning the project, a pilot study was conducted on a small sample of students to test the methods. This study was conducted in the Dental Hygiene Clinic at Youngstown State University. Data was collected during 3 semesters from May 2010 to May 2011. The dentist and dental hygiene students were trained by a licensed respiratory therapist on the proper method to determine Mallampati classification. They were shown an illustration of the 4 classifications. The therapist demonstrated the proper technique for performing this evaluation. Both the dentist and the dental hygiene students were instructed to sit the patient upright in the dental chair, and to use the dental light to look into the patients open mouth without phonation.

During the oral exam the students were given a diagram of the Mallampati classification (Figure 1) and were instructed to place a check mark next to the appropriate image that corresponded to the patients' oropharynx opening. The clinic dentist was trained by the same licensed respiratory therapist to accurately perform the same exam with the same recording criteria. The dentist conducted an independent evaluation of the patients' Mallampati classification on a separate but identical form. These forms were color-coded, numbered and labeled to differentiate between the student and dentist evaluations. Each patient was given a number identifier that was used on all forms. Both the student and dentist deposited the forms in a locked box in the clinic upon completion of the evaluation. All of the examinations were

conducted on clinic patients during clinical time as part of the intraoral and extraoral examination. There was no discussion among the students and dentist before, during or after the recording of the Mallampati classification. The data was then analyzed using the SAS statistical software.

Results

During the 1 year period of data recording, the study collected 234 independent pairs of observations from the participants, with 18 incomplete cases that were eliminated from the study. Among the records observed, 15% (36) were collected from the summer term, 46% (107) from the fall semester and 39% (91) from the spring semester. Since the critical scores to separate normal and abnormal status is between the scores of II and III, the Mallampati classification was coded as normal if the score was II or less, and coded as abnormal if the score was III or higher, for kappa statistic computation. The agreement percentage and the McNemar test were also computed based on this recoded data.

The inter-rater agreement classification table for the students and dentists from the recoded data is shown in Table I. Among all the cases recorded, 109 (46.6%) were identified as normal from both dentist and student, and 72 (30.1%) were identified as abnormal by both dentist and student. Student raters observed multiple patients which made the rating data non-independent, therefore the adjusted McNemar test using Durkalski's method was used for testing the agreement in Mallampati ratings between students and dentist, and the bootstrapping method was used for examining the correlation between ratings.[25-27] The p-value from the adjusted McNemar test is 0.498 which indicates that, statistically, there is no significant difference between the students' and dentists' ratings on patients. The Spearman's correlation coefficient is 0.54 with a 95% bootstrap confidence interval (0.50, 0.64) and p-value<0.001, which indicates significant correlation in Mallampati ratings on patients between students and the dentist. The kappa score is 0.54 with a 95% bootstrap confidence interval (0.42, 0.64), which is considered as satisfactory in the strength of agreement between students' ratings and dentists' ratings.[28,29] The percentage of agreement is around 77% with a 95% confidence interval (72%, 82%) which is a good strength of inter-rater agreement between the students and the dentist.

Table I: Classification Table for Mallampati Scores Between Students and Dentists

		Student Recorded Classification		
		Normal	Abnormal	Total
Dentist Recorded Classification	Normal	109*	29	138
	Abnormal	24	72*	96
	Total	133	101	234

*Percentage of agreement: (109 + 72)/234=77%.

Discussion

The results of this study indicate that dental hygiene students can evaluate and classify oropharyngeal tissues. The results show a 77% agreement between the dentist and the students. This indicates that students could accurately differentiate between normal and abnormal Mallampati classifications. Dental hygiene students learn to assess patients for xerostomia, bruxism, condition of the oral pharynx and the tongue. By incorporating an assessment of the oropharyngeal tissues into the oral examination, the dental hygiene student can recognize patients that may have undiagnosed OSA.

The impact OSA has on systemic, social and personal well being cannot be overestimated. Occupational accidents related to daytime sleepiness prompted the National Transportation Safety Board to issue a recommendation to screen truck drivers and bus drivers, commercial pilots, train engineers and merchant sailors for sleep apnea.[30] Early recognition and treatment of OSA has been recognized as a significant way to reduce health care utilization costs.[31] When OSA is left untreated, the risk for mortality increases.[32,33] The dental profession can begin to make an impact on undiagnosed cases of OSA.

Research has found there is a lack of information regarding the prevalence of OSA in dental and dental hygiene curricula. A study reported in the American Academy of Sleep Medicine reports that even though dental schools are including OSA in the curriculum, the number of hours is not sufficient.[21,34] Another survey of dentists' knowledge, opinion, education, resources, cooperation and clinical practice regarding OSA reports a lack of instruction in dental schools.[19]

The dental profession should be aware of risk factors and symptoms of OSA and have an opportunity to recognize, refer and treat patients.[35,36] Dental hygienists currently use risk assessments during a routine dental hygiene exam to recognize conditions and factors that predispose a patient to systemic conditions or diseases. By incorporating the Mallampati classification into the oral assessment performed by the dental hygienist a consultation with the dentist for further assessment may lead to referral to the patient's primary care physician to expedite early diagnosis and treatment of OSA.

This study has several limitations. The purpose of this study was to measure whether dental hygiene students could accurately record the Mallampati classification in the clinical dental hygiene setting. Dental hygiene students and the clinic dentist were included in this project because they were directly involved in patient contact in the dental hygiene clinic. For convenience, the clinic dentist was chosen to be the standard by which the students were measured. Repeating the study using an expert in the use of the Mallampati classification such as an anesthesiologist to compare with the student results may have resulted in a different outcome. Secondly, this study was designed so that students and the clinic dentist were provided with the same training on the use of the Mallampati classification scoring system. Students were instructed to position their patient in an upright position, tongue protruded and with no phonation to record the Mallampati classification. The dentist recorded the Mallampati classification at a convenient time during the appointment with the same patient positioning criteria. The dental hygiene students nor the dentist were observed by the researchers during the recording of the Mallampati classifications which could have led to inaccurate positioning of the patient and may explain the difference in student and dentist reporting results. Lastly, there were records omitted from the final data analysis due to student and/or dentist reporting errors.

It is important for the dental hygienist to recognize that collaboration with other health professionals can lead to expanding their role in assessment methods to aid in early identification of risk factors associated with systemic conditions. This study is an example of collaboration between respiratory therapy and dental hygiene to incorporate the use of the Mallampati classification into the oral assessment. The use of the Mallampati classification in this setting can be useful in screening for OSA. Such collaboration can lead to new approaches in preventative health care. Future research should include investigation of the expanding role of the dental professional in the recognition of risk factors associated with OSA.

Conclusion

This investigation demonstrates that dental hygiene students have the necessary skill to perform the Mallampati classification. Furthermore, results show that dental hygiene students could accurately identify patients that fell into the Mallampati classification between II and III. A classification of I or II is not associated with an airway indicating OSA but a classification of III or IV is associated with an airway indicating risk for OSA. The students' ability to accurately identify III and IV classifications as they did in this study is important in identifying OSA risk. Lastly, additional education and training is needed for dental hygiene students to increase their knowledge and recognition of risk factors for OSA and use of oral assessment methods and techniques to classify oropharyngeal tissues.

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A Survey of United States Dental Hygienists' Knowledge, Attitudes, and Practices with Infection Control Guidelines

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Abstract

Purpose: To assess knowledge, attitudes and practices of U.S. dental hygienists with infection control guidelines (ICG). Research has shown improved compliance with specific aspects of dental ICG is needed. This study supports the American Dental Hygienists' Association National Research Agenda's Occupational Health and Safety objective to investigate methods to decrease errors, risks and or hazards in health care. Data are needed to assess compliance, prevention and behavioral issues with current ICG practices.

Methods: A proportional stratified random sample (n=2,500) was recruited for an online survey. Descriptive statistics summarized demographic characteristics and knowledge, attitudes and practicess responses. Spearman's rho correlations determined relationships between knowledge, attitudes and practices responses ($p<0.05$). Dominant themes were identified from open-ended responses.

Results: A 31% response rate (n=765) was attained. Respondents agreed/strongly agreed with familiarity with ICG (86%) and believed ICG are relevant to their patients (88%). Responses indicated low compliance (rarely/never used) with handpiece sterilization (n=209, 31%), utility glove use (n=317, 47%), and pre-procedural rinsing (n=324, 48%). Significant relationships were found between ICG implementation and access to necessary supplies (rs=0.549), supervisors' expectations for using ICG (rs=0.529) and no time to use (rs=-0.537). Themes from comments indicated time is a barrier, and respondents' perceived a need for involvement of all co-workers.

Conclusion: Dental hygienists are adhering with most aspects of the ICG. High compliance with ICG among respondents in this study was associated with positive safety beliefs and practices, whereas lower compliance with ICG was associated with less positive safety beliefs and practices. A safety culture appears to be a factor in compliance with ICG.

Keywords: knowledge, attitudes, behaviors, infection control

This study supports the NDHRA priority area, **Occupational Health and Safety:** Investigate methods to decrease errors, risks and or hazards in health care and their harmful impact on patients.

Introduction

Clinical practice guidelines are evidence-based recommendations set forth by regulatory and advisory agencies to promote safety in the implementation of patient care. In 2003, the Centers for Disease Control (CDC) developed and issued the Guidelines for Infection Control in Dental Health-Care Settings.[1] Although a plan for evaluation should be included when guidelines are developed and implemented, no formal mechanism for evaluating clinical practice guidelines has been established in either the medical or dental literature.[2-3] This study was designed to assess the knowledge, attitudes and practices of U.S. dental hygienists with current (2003) CDC infection control guidelines (ICG).

Knowledge, attitudes and practices and compliance with ICG among nurses and hospital personnel has been studied extensively, and findings indicated low compliance.[4-9] Poor compliance with ICG can impact the health and safety of workers and patients.[10-12] Disease transmission has been linked to lapses in proper infection control in hospitals.[11-15] Reasons for health care workers' low compliance with ICG needs further study, and strategies to improve compliance need to be developed.[16] McCoy, et al suggested that a positive safety climate or culture including regular training, monitoring by supervisors and positive reinforcement leads to better compliance.[17]

Research agendas of the American Dental Hygienists' Association (ADHA) and the CDC include health and safety objectives.[1,18] This study supports the ADHA National Research Agenda's Occupational Health and Safety objective to investigate methods to decrease errors, risks and or hazards in health care. Data are needed to

assess dental health care workers' compliance, prevention and behavioral issues related to current ICG. Evidence suggests a need for improved compliance with some aspects of the ICG in dental settings.[3,19,20]

Most of the knowledge, attitudes and practices studies in dentistry and dental hygiene, conducted between 1995 and 2005, were related to attitudes and practices in treating patients with HIV/AIDS and compliance with specific dental procedures.[20-23] Daniel reported, based on a literature review, that oral health care providers fear of treating persons with HIV/AIDS decreased between 1986 and 1996 and concluded that the change in attitudes was possibly related to increased compliance with ICG.[23] A 1999 study by McCarthy et al found that infection control practices of Canadian dentists (n=4,107) varied widely with age and size of community. Dentists aged >60 years reported low compliance with Hepatitis B vaccination (71.8%) and handpiece sterilization (54.9%), and refusal to treat HIV patients (26.9%); however, they also had a higher compliance with hand washing. Dentists from smaller communities were more compliant with Hepatitis B vaccination and less compliant with use of ICG manuals and handwashing.[21]

Studies by King and Muzzin[20] and Wood[22] indicated that dental hygienists have adopted established ICG and are compliant with most aspects of them. However, these studies showed low compliance with pre-procedural rinsing. King and Muzzin found that, of 160 U.S. dental hygienists surveyed, 18.8% "always" or "often" and 32% "sometimes" used pre-procedural rinsing.[20] Wood reported, based on a survey of Rhode Island dental hygienists (n=171), 9% "always" and 51% "sometimes" used pre-procedural rinsing.[22] These findings indicate that, although pre-procedural rinsing may have improved between 1995 and 2005, adherence to this aspect of the ICG continued to need improvement. Wood's study also indicated low compliance for handpiece sterilization (n=171, 67% always) and utility glove use in preparing instruments for sterilization (n=110, 61% always).[22]

A 2008 study by Myers et al evaluated knowledge, attitudes and practices of general practice dentists (n=4,107) with CDC hand hygiene guidelines.[19] Results showed ≤25% of respondents reported inadequate hand hygiene practices. Findings indicated that 6% of dentists did not wash or sanitize their hands at the beginning of the clinical work day, and 11% did not wash or sanitize between patients. The majority of dentists (71%) washed their hands with soap and never used alcohol products at the start of the day; however, 51% used a combination of soap and/or alcohol hand sanitizers between patients.[19]

The purpose of this study was to assess the knowledge, attitudes and practices of dental hygienists with regard to the CDC ICG. This survey assessed 4 research questions:

1. What do dental hygienists know about CDC ICG?
2. What are the attitudes of dental hygienists regarding ICG?
3. What are the infection control behaviors used by dental hygienists?
4. Are there any relationships among knowledge, attitudes and practices data?

Methods and Materials

Research Design and Instrument

This descriptive survey was designed to determine knowledge, attitudes and practices of dental hygienists with current CDC ICG. A 41-item questionnaire was used to survey a proportional stratified random sample of dental hygienists. The questionnaire consisted of 3 parts, including 10 demographic questions and 31 knowledge, attitudes and practices items (part 1 and part 2). The questionnaire, Attitudes Regarding Infection Control Guidelines, was adapted from Larson's tool to assess dentists' barriers to adherence with hand hygiene guidelines.[24] This tool was based upon Cabana's framework, developed to assess compliance with practice guidelines and was confirmed by hypothesis testing.[25] Cabana identified 6 domains representing barriers to guideline adherence.[25] Larson established construct and content validity of the instrument.[24] Permission from Larson to use and modify that instrument was obtained by the primary investigator (PI) in this study.

Demographic questions included sex, age, degree type, years of practice and practice setting. Part 1 of the questionnaire included 20 statements (on agreement or disagreement) and 2 additional open-ended questions specific to the 2003 CDC ICG to assess knowledge, attitudes and practices of dental hygienists. The investigator modified these statements from Larson's original instrument to adapt them to the 2003 CDC ICG for dental settings. Subjects rated their knowledge, attitudes and practices behaviors in part 1 by using a 6-point Likert-type scale. Thirteen of the 20 knowledge, attitudes and practices items were positively worded, with a score of 6 indicating strong agreement. Seven items were negatively worded, with 1 indicating strong disagreement, so

these items were reverse scored for data analyses.

Part 2 included 9 statements (on percentage of time the behavior was used) that were added to Larson's original instrument based on information in the literature previously indicating low compliance with pre-procedural rinsing, utility glove use and handpiece sterilization.[20,22,23] Subjects rated frequency of their behaviors in part 2 by using a 5-point Likert-type scale with 1 indicating "never" and 5 indicating "almost always (>90% of the time)."

Three open-ended questions provided respondents with an opportunity to comment regarding factors and barriers influencing implementation of ICG or any related issues. Qualitative thematic analysis of participants' comments identified predominant themes which emerged in response to the open-ended questions.

After the instrument was redesigned for dental hygienists, the PI convened a panel of expert dental hygiene clinicians to evaluate content validity. Ten dental hygiene practitioners with over 10 years of experience each reviewed the items and provided feedback on content and clarity based on criteria provided by the PI. The evaluation criteria included length of time to complete the survey, clarity of the questions and format of the survey, and also asked for suggestions for improvement. The survey instrument was revised to enhance clarity and content validity. Approval was obtained from the Human Subjects Committee at the PI's institution. Surveys were coded with a number available only to the PI to ensure that individual identity was protected for confidentiality while also allowing a mechanism for follow up of non-responders.

Sampling

A customized master list of licensed dental hygienists was purchased from the ADHA and its marketing company (INFOCUS Marketing, Inc.). The ADHA's database included information regarding 158,000 licensed dental hygienists regarding demographics, category of work (clinical practitioner, educator, retiree or student) and mailing address. A customized list was created by INFOCUS Marketing Inc. to meet pre-established inclusion and exclusion criteria for the study. The customized list included a proportional stratified random sample of all dental hygienists who worked in clinical practice settings, included both members and non-members of ADHA, and excluded students and retired dental hygienists. INFOCUS Marketing Inc. required a minimum purchase of 2,500 names. After exclusions were applied, a percentage of dental hygienists in each of the 50 states in the U.S. were sampled according to each state's population of dental hygienists, so that each state was proportionately represented. This stratification method was utilized to contain costs and to gain a fair representation of dental hygienists in each state.

Data Collection

Postal mail addresses were the only available means of contact from the ADHA master list, so this study utilized a mixed mode survey method. The mixed method included sending a letter via bulk postal mail inviting the 2,500 subjects in the proportionate randomized sample to participate in an online survey. An Internet address was provided in the initial letter for subjects to access the online survey at a website hosted by the PI's academic department. To improve the response rate, Dillman's Tailored Design Method was used.[26] Strategies included initially sending letters via postal mail to invite all subjects to participate in an online survey, sending post cards to all subjects 1 week after the initial mailing to thank those who completed the survey and provide a gentle reminder to non-responders to complete the survey and a follow-up mailing 2 weeks later for all non-responders.

Data Analyses

Data were collected online via Survey Monkey™ and downloaded into a Microsoft Excel spreadsheet. Cronbach's alpha was used to assess internal reliability of the 6 domains originally developed by Cabana. These domains were not validated with a value of 0.70 in this population, therefore, the domains were not used to develop scales in subsequent data analyses. Statistical analysis was limited to descriptive statistics and Spearman's Rho correlations. Data were entered into statistical software (IBM SPSS release 19.0.0, copyright 2010, SPSS Inc.) for analyses. Descriptive data summarized demographic characteristics and knowledge, attitudes and practices item responses from part 1 and part 2. Spearman's rho correlations were used to determine relationships among demographics and knowledge, attitudes and practices item responses. The level of significance for all data analyses was set at <0.05.

Results

Demographics

A 31% response rate (n=765) was attained. The majority of respondents were white (95%), female (99%) and aged 42 or older (88%). Most subjects had entry-level associate degrees (68%), worked in general private practice (78%), worked in one practice setting (70%), worked more than 25 hours per

week (61%) and had practiced more than 10 years (99%). Thirty-three respondents (4%) were not employed, but were seeking employment. Alternative practice types reported (n=102, 13%) included hospital settings, community/public health settings, military, prisons and temporary agencies. Ninety-nine percent were ADHA members. Demographic data describing the sample are reported in Table I.

Results: Knowledge and Attitudes

Table II shows knowledge, attitudes and practices responses for part 1 of the survey. Four questions in part 1 assessed respondent's ratings of their knowledge of the ICG. Respondents agreed/strongly agreed that they were familiar with the ICG (n=703, 86%), the ICG was accessible (n=702, 77%) and the ICG are based on sound scientific evidence (n=689, 82%).

Fourteen items in part 1 of the survey instrument assessed attitudes about the ICG. These dental hygienists believed the ICG was relevant to patients (n=699, 88% agreed/strongly agreed), and believed that the supervisor expected use of the ICG (n=696, 86% agreed/strongly agreed). They did not believe that the ICG is cumbersome and inconvenient (n=415, 61% disagreed/strongly disagreed), or that they lacked time to use the ICG (n=534, 77% disagreed/strongly disagreed). Sixty-one percent of respondents strongly to somewhat agreed that they felt competent using alcohol-based hand products.

Results: Practices (Behaviors)

Two items in part 1 assessed infection control practice behaviors including whether the ICG had been implemented (n=696, 78% agreed/strongly agreed) and if respondents had access to necessary infection control supplies (n=698, 81% agreed/strongly agreed). Items in part 2 of the survey were also designed to assess practice behaviors (Table III). Six items assessed the percentage of time specific infection control practices were used. Responses indicating non-adherence to ICG included pre-procedural rinsing (n=324, 48% rarely/never used), slow speed handpiece sterilization after each use (n=209, 31% rarely/never used), utility glove use for handling contaminated instruments (n=317, 47% rarely/never used) and utility glove use for cleaning the treatment operatory (n=452, 66% rarely/never used). Approximately half of all respondents (n=193, 28% almost always or often and n=158, 23% sometimes) indicated use of alcohol-based hand gels for hand hygiene. Forty-six percent of respondents (n=218) believed patients prefer to see traditional hand washing.

Table I: Demographic of U.S. dental hygienists

	n	%
Age		
18-23	0	0
24-29	0	0
30-35	20	3%
36-41	67	9%
42-47	104	13%
48-53	199	26%
54-59	242	32%
>60	126	17%
Race		
White	717	95%
African American	3	0.5%
Asian	18	2%
Hispanic	8	1%
Native American	2	0.5%
Other	6	1%
Other	6	1%
Practice Setting		
One setting	527	70%
More than one setting	181	30%
Dental Hygiene Degree Entry Level		
Certificate/Associate	575	77%
Bachelor	180	23%
Highest Degree Held		
Certificate/Associate	378	50%
Bachelors	307	40%
Masters	69	9%
Doctorate	5	1%
Practice Type		
General private practice	594	78%
Solo practice (1 DDS)	136	18%
Partner (2 DDS)	95	12%
Group (3 or more DDS)	59	8%
Specialty practice	171	22%
Unemployed/seeking employment	33	4%
Other setting	102	13%
Years Practiced		
5-9	5	1%
10-14	93	12%
15-19	90	12%
20-24	100	13%
25-29	116	15%
30+	355	47%
Hours Worked Per Week		
0-8	82	11%
9-16	70	10%
17-24	143	19%
25-32	215	28%
33-40	218	29%
>41	26	3
ADHA Membership		
Membership	747	99%
Non-member	5	1%

Table II: Descriptive Statistics – Part 1 Knowledge, Attitudes and Practice Survey Items

Survey Items	n	SA	A	SWA	SWD	D	SD
Knowledge Items							
I am familiar with the ICG and its recommendation.	703	289 (41%)	315 (45%)	84 (12%)	7 (1%)	5 (1%)	3 (0)
The ICG is readily accessible if I want to refer to it.	702	243 (35%)	295 (42%)	114 (16%)	28 (4%)	16 (2%)	6 (1%)
The ICG is based on sound scientific evidence.	689	230 (33%)	336 (49%)	96 (14%)	17 (3%)	8 (1%)	2 (0)
*There are other guidelines that conflict with this one.	665	10 (2%)	40 (6%)	124 (19%)	211 (32%)	197 (29%)	83 (12%)
Attitude Items							
If we follow the recommendation of the ICG in our practice setting, it is likely that infection rates will decrease.	698	351 (50%)	270 (39%)	47 (7%)	14 (2%)	11 (1%)	5 (1%)
If I follow the recommendations of the ICG regarding hand washing, It is likely that my hands will be in worse shape (e.g. drier, more skin damage).	699	52 (7%)	122 (18%)	187 (27%)	98 (14%)	170 (24%)	70 (10%)
*The costs of the ICG outweigh the benefits.	695	88 (13%)	58 (8%)	35 (5%)	69 (10%)	218 (31%)	227 (33%)
I have confidence that the developer of the ICG is well qualified and knowledgeable about infection control.	700	216 (31%)	360 (51%)	87 (12%)	26 (4%)	3 (1%)	8 (1%)
The recommendations of the ICG are relevant to my patient population.	699	299 (43%)	315 (45%)	64 (9%)	14 (2%)	4 (1%)	3 (0)
The person I report to expects me to use the ICG.	696	306 (44%)	285 (41%)	64 (9%)	24 (3%)	10 (2%)	7 (1%)
*It is not really practical to follow the ICG recommendation.	696	8 (1%)	14 (2%)	57 (8%)	70 (10%)	251 (36%)	296 (43%)
*I do not wish to change my infection control practices, regardless of the ICG recommendations.	694	13 (2%)	19 (3%)	33 (5%)	108 (15%)	269 (39%)	252 (36%)
I feel competent using alcohol hand products (hand sanitizer gels) for routine hand hygiene.	698	95 (14%)	213 (31%)	115 (16%)	121 (17%)	103 (15%)	51 (7%)
My patients prefer to see me do a traditional hand wash.	695	131 (19%)	187 (27%)	143 (21%)	124 (18%)	85 (12%)	25 (3%)
My patients prefer seeing me performing various infection control procedures (i.e. handling instruments, surfaces, and/or barriers, cleaning/disinfecting/sterilizing).	695	168 (24%)	225 (32%)	136 (20%)	84 (12%)	68 (10%)	14 (2%)
*I don't have time to use the ICG.	690	13 (2%)	7 (1%)	44 (7%)	92 (13%)	207 (30%)	327 (47%)
If I don't use the ICG, I may be liable for malpractice.	696	256 (37%)	265 (38%)	93 (13%)	50 (7%)	19 (3%)	13 (2%)
*The ICG is cumbersome and inconvenient.	691	8 (1%)	52 (8%)	116 (17%)	100 (15%)	218 (31%)	197 (28%)
Practice/Behavior Items							
I have access to the necessary supplies and equipment to use the ICG.	698	307 (44%)	259 (37%)	71 (10%)	31 (4%)	18 (3%)	12 (2%)
I personally have implemented the recommendations of the ICG.	686	259 (38%)	274 (40%)	91 (13%)	26 (4%)	28 (4%)	8 (1%)

*=negatively worded items
Likert Scale Used: 6=Strongly Agree (SA); 5=Agree (A); 4=Somewhat Agree (SWA); 3=Somewhat Disagree (SWD); 2=Disagree (D); 1=Strongly Disagree (SD)

Table III: Descriptive Statistics – Part 2 Knowledge, Attitudes and Practice Survey Items

Practice/Behavior Questions	n	AA 5	O 4	S 3	R 2	N 1
In your work setting, what percentage of the time do you use waterless alcohol-based hand sanitizer gels for hand hygiene?	686	54 (8%)	139 (20%)	157 (23%)	195 (28%)	141 (21%)
In your work setting, what percentage of the time do you have patients use pre-procedural mouth rinses?	687	132 (19%)	67 (10%)	164 (24%)	224 (33%)	100 (14%)
In your work setting, what percentage of the time do you use heavy duty, puncture resistant utility-type gloves when handling contaminated instruments?	682	167 (24%)	102 (15%)	96 (14%)	170 (25%)	147 (22%)
In your work setting, what percentage of the time do you use heavy duty, puncture resistant utility-type gloves when cleaning the treatment operatory?	684	111 (16%)	40 (6%)	81 (12%)	193 (28%)	259 (38%)
In your work setting, what percentage of the time do you heat sterilize (autoclave) slow-speed hand pieces used for polishing?	684	306 (45%)	73 (11%)	96 (14%)	110 (16%)	99 (14%)

Likert Scale Used: 5=Almost Always (AA)=>90%; 4=Often (O)=51 to 90%; 3=Sometimes (S)=10 to 50%; 2=Rarely (R)=<10%; 1=Never (N)

Correlations

Spearman's Rho correlations were used to assess relationships between knowledge, attitudes and practices items. All data values listed in Table IV were statistically significant ($p<0.05$) and were moderate or high correlations ($rs>0.30$). Statistically significant weak correlations ($rs<0.30$) are not reported.

Significant direct relationships were found between implementation of the ICG and positive attitudes regarding: familiarity with the ICG (rs=0.537), belief in the qualifications of the ICG developer (rs=0.406), access to the ICG (rs=0.413) and infection control supplies (rs=0.549), belief in relevance of ICG to patients (rs=0.462), and belief that the person they report to expects them to use the ICG (rs=0.529). Significant direct associations also were found between the negative attitude that the ICG is not practical and negative attitudes about: the ICG being inconvenient and cumbersome to use (rs=0.540), having no time to use the ICG (rs=0.582) and not wanting to change infection control behaviors (rs=0.549). Significant inverse relationships were found between implementation of the ICG and the following knowledge, attitudes and practices items: not practical to use the ICG (rs=-0.501), no time to use the ICG (rs=0.-489), ICG are cumbersome & inconvenient to use (r2=-0.414) and not wanting to change infection control behaviors regardless of ICG (rs=-0.402).

Open-Ended Questions

Dominant themes were identified through qualitative analysis of 3 open-ended items. Themes related to factors that influenced implementation of the ICG included: patient safety/preventing disease transmission, personal safety, laws/regulations, ethical/professional responsibility and scientific evidence/research.

Dominant themes identified related to barriers to using the ICG included time, staff education and training, attitudes and cooperation of others in the office, lack of supplies, high cost of supplies, employer unwillingness to support full implementation, environmental waste issues, and a lack of understanding of the ICG.

Although no dominant themes emerged from the item asking for general comments, responses characterized challenges dental hygienists face and practice patterns. The most frequent responses indicated that utility gloves were "cumbersome," there is a lack of dental hygiene handpieces so they could not be sterilized after each use, metal cassettes are used frequently, dental hygienists fear losing their job if they "blow the whistle" on inadequate infection control practices, ICG are "overkill" and plastic barriers are "cumbersome, inconvenient and pollute the environment." Several respondents described infection control practices used in their office. Respondents expressed a need for involvement of all dental coworkers in infection control education.

Discussion

Demographic characteristics of the respondents in this study, with one exception (ADHA membership), were similar to the 2007 National ADHA profile of dental hygienists with regards to gender, race, age, type of practice setting, practice type, years practiced and entry level degree.[27] The National ADHA profile of dental hygienists, based

Table IV: Correlation Statistics Indicating Associations between Knowledge, Attitudes and Practice Items

Knowledge, Attitudes and Practice Items	Familiarity with ICG	Belief in Expertise of Developers	Access to ICG	Relevance to Patients
Familiarity with ICG	-	0.360	0.565	0.430
Belief in Expertise of ICG Developers	0.360	-	0.349	0.657
Accessibility of ICG	0.565	0.349	-	0.381
Relevance to Patients	0.430	0.657	0.381	-
Supervisor Expects Use of ICG	0.467	0.454	0.400	0.591
Not Practical to Use ICG	-0.398	-0.419	-0.332	0.498
No Time to Use ICG	-0.367	-0.343	-0.253	0.379
Cumbersome & Inconvenient to use ICG	-0.321	-0.300	-0.274	-0.324
Access to Infection Control Supplies	0.423	0.376	0.403	0.437
Do Not Wish to Change Behavior	-0.291	-0.304	-0.271	-0.369
I've Implemented the ICG	0.537	0.406	0.413	0.462

Knowledge, Attitudes and Practice Items	Supervisor Expects Use of ICG	Not Practical to Use ICG	No Time to Use ICG	Cumbersome & Inconvenient to Use ICG
Familiarity with ICG	0.467	-0.398	-0.367	-0.321
Belief in Expertise of ICG Developers	0.454	-0.419	-0.343	-0.300
Accessibility of ICG	0.400	-0.332	-0.253	-0.274
Relevance to Patients	0.591	-0.498	-0.379	-0.324
Supervisor Expects Use of ICG	-	-0.447	-0.423	-0.300
Not Practical to Use ICG	-0.447	-	0.582	0.540
No Time to Use ICG	-0.423	0.582	-	0.545
Cumbersome & Inconvenient to use ICG	-0.300	0.540	0.545	-
Access to Infection Control Supplies	0.576	-0.442	-0.484	-0.385
Do Not Wish to Change Behavior	-0.350	0.549	0.472	0.378
I've Implemented the ICG	0.529	-0.501	-0.489	-0.414

Knowledge, Attitudes and Practice Items	Access to Infection Control Supplies	Do Not Wish to Change Behavior	I've Implemented the ICG
Familiarity with ICG	0.423	-0.291	0.537
Belief in Expertise of ICG Developers	0.376	-0.304	0.406
Accessibility of ICG	0.403	-0.271	0.413
Relevance to Patients	0.437	-0.369	0.462
Supervisor Expects Use of ICG	0.576	-0.350	0.529
Not Practical to Use ICG	-0.442	0.549	-0.501
No Time to Use ICG	-0.484	0.472	-0.489
Cumbersome & Inconvenient to use ICG	-0.385	0.378	-0.414
Access to Infection Control Supplies	-	-0.376	0.549
Do Not Wish to Change Behavior	0.378	-	-0.402
I've Implemented the ICG	0.549	-0.402	-

*Values listed were all statistically significant moderate or high correlation >0.30 ($p \leq 0.05$)

on a 44% response rate, (n=5,001/11,366), was White/non-Hispanic (92%), female (99%), mean aged 44 years, with an entry level associate degree and an average of 18 years of experience working in 1 general private practice setting (72%) either solo (66%) or small group (22%). Similarly, the majority of respondents in the current study were White females, aged 42 years or older, with an entry-level associate degree and more than 10 years of experience working in 1 general private practice setting.

Dental hygienists in this study were knowledgeable about the ICG and had positive attitudes regarding the ICG. The majority of respondents believed the ICG is relevant to their patients, had access to the ICG, and believed the person they report to expected them to use the ICG. Most participants reported they did not find the ICG to be impractical, cumbersome or inconvenient to use. Results related to infection control practices indicated that most respondents had adequate supplies to use the ICG and had implemented the ICG.

Specific infection control practices that were previously identified in the literature as needing improvement indicated little change.[20,22] Dental hygienists in this study reported a high level of knowledge, access to and belief in the ICG, and reported they did not fully comply only in a few instances. Low compliance with ICG recommendations for pre-procedural rinsing, utility glove use, and handpiece sterilization were reported. These findings are similar to King and Muzzin's national survey showing that use of pre-procedural rinsing was "very low" at 18.8% (n=160)[20] and in Wood's study of Rhode Island dental hygienists indicating pre-procedural rinsing was used 51% (n=171) of the time.[22] Wood's study also indicated that 67% (n=171) always heat sterilized their hand pieces after each use and 61% (n=110) always used utility gloves which is similar to the findings for these practices in the current study. It appears that little change in these practices has occurred since 1995. Interventions targeted toward improvement of compliance of these behaviors need to be developed and implemented for all dental professionals. Interdisciplinary webinars or online learning modules may be one strategy to reach a large audience of dental healthcare workers. Dental and dental hygiene educators also need to focus on teaching these practices to improve compliance.

Daniel's reported that fear of contracting HIV or Hepatitis B decreased due to the significant changes in infection control recommendations between 1986 and 1996.[23] Dental hygienists practicing during that time, including the majority of respondents in the current study, witnessed the development and implementation of ICG due to the heightened awareness of HIV and Hepati-

Table V: Dominant Themes and Sample Comments From Open-Ended Questions

Open-ended Comments	Dominant Themes and Sample Comments
Factors Influencing Implementation of the ICG	Patient & Personal Safety/Disease transmission • "I want to protect my patients" • "I don't want to spread diseases"
	Laws/Regulations • "Being "forced" to do it"
	Ethical responsibility • "It's the right thing to do"
	Scientific evidence/research • "The experts recommend it"
Barriers to Implementing the ICG	Time • "It takes too much time to do"
	Staff education/training • "Other staff members do not get much education"
	Attitude/cooperation of others in office (changing habits) • "People are not willing to change and follow protocols, and they criticize me for doing it" • "Complacent dentists and undertrained assistants do not appreciate the value of these guidelines"
	Lack of supplies • "Dentists are cheap and skimp on supplies"
	Cost • "Supplies cost a lot"
	Unfamiliar with the ICG • "I'm not familiar with the entire guidelines"
	Employer unwillingness to change • "To get the dentist owner to place patient safety first, before the "crunch" of time (safety over time efficiency)"
	Environmental Waste • "Ridiculous amount of disposables going into the environment"

tis B. Daniels's reported that low compliance with pre-procedural rinsing, utility gloves use and handpiece sterilization may be related to lack of formal education with these procedures because they were introduced after graduation from dental hygiene school.[23] It is interesting to note that these same practice behaviors were found to be in low compliance in the current study.

Approximately half of respondents in this study reported that they believed they were somewhat to strongly competent in using alcohol hand products (hand sanitizer gels) for routine hand hygiene. This finding is consistent with findings Myers's study of general practice dentists (n=4,107) indicating 51% used hand sanitizers in combination with soap.[19]

McCoy et al suggested that a positive safety climate or culture including regular training, monitoring and positive reinforcement leads to better compliance with infection control guidelines.[17] The findings of this knowledge, attitudes and practices study indicate that most participants had implemented the ICG and also reported the presence of several factors that support a positive safety climate. These factors included supervisor/employer expectations, sufficient resources such as access to the ICG and adequate supplies and the belief that patient safety is protected by the ICG. Conversely, the respondents who believed the person they reported to did not expect them to use the ICG reported that they did not have time to use the ICG, believed it was not practical to use the ICG and felt the ICG was cumbersome and inconvenient to use indicating a less positive safety culture or climate.

Most respondents in this study worked in a general private dental practice. The practice owner most frequently is the dental hygienists' supervisor in the dental practice setting. The dentist-supervisor, or designee such as the office manager, often oversees office infection control policies and monitors costs of supplies, and is very influential in establishing the safety climate in the practice. Targeting education and/or interventions toward the individuals who foster or influence the safety culture in dental practices may be an effective way to promote positive change in the safety culture or climate to increase compliance with ICG.

Barriers reported in the open-ended questions revealed factors that might also explain low compliance reported with a few aspects of the ICG. Some of those factors included time for adequate infection control in a tight schedule, attitudes/cooperation of other staff members (dentists, dental assistants, schedulers) and disagreement about infection control practices (changing established habits), employers' unwillingness to change or provide adequate training and/or supplies, and high costs associated with full ICG implementation.

Overall, it appears that dental health care workers are aware of the importance of following ICG and are generally compliant with implementation.[19-23] These findings differ from results of studies reporting attitudes and practices of nurses or hospital personnel.[4-9] Documented cases of disease transmission linked to lapses in infection control during dental treatment are rare; whereas health care acquired infections (HAIs) are prevalent in hospital settings. Hands are the biggest culprit in cross contamination and have been identified in several studies of nurses and hospital personnel as the cause for many HAIs.[11-15]

Limitations of this study included homogeneity of respondents despite the randomization used in subject selection. Ninety-nine percent of the subjects in this study were ADHA members; therefore, results are representative of members of that professional association. In the general population of dental hygienists, approximately 23,000 (20%) of 115,000 are ADHA members.[28] King and Muzzin's study of dental hygienists indicated that ADHA members were more compliant with infection control practices as compared to non-members. They suggested that professional affiliation may impact knowledge, attitudes and practices through exposure to current research and education.[20] The high percentage of ADHA members in this sample might have influenced results indicating high rates of adherence to ICG. Non-response bias from younger dental hygienists with fewer years of experience also may have impacted results of this study; however, national data indicate the average age of the practicing dental hygienists is 44 years.

Another limitation was the low response rate, possibly related to using the mixed mode survey method. The master list from ADHA's marketing group included postal mail addresses and no email addresses. Bulk mail was used to contain costs, and incorrect addresses were not able to be tracked.

Future research should include studying the infection control knowledge, attitudes and practices of other groups of dental healthcare workers such as dental assistants, dentists, and office

managers. Assessment of reasons for continued low compliance with pre-procedural rinsing, utility gloves use, and handpiece sterilization, and targeted interventions for improvement need to be developed and evaluated.

Conclusion

Dental hygienists are knowledgeable about ICG, have implemented ICG and are compliant with most aspects of the ICG. High compliance with ICG among respondents in this study was associated with positive safety beliefs and practices; whereas lower compliance with ICG was associated with less positive safety beliefs and practices. Positive beliefs about infection control and a safety culture or climate in the work setting seem to be important in compliance with ICG and are influenced by decision makers in the practice.

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A Pilot Study Comparing the Outcome of Scaling/Root Planing With and Without Perioscope™ Technology

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Abstract

Purpose: The purpose of this study was to determine if the use of a periodontal endoscope improves periodontal outcomes of scaling/root planing when compared to scaling/root planing alone.

Methods: Thirty subjects with moderate periodontitis were recruited from the University of Minnesota School of Dentistry. Of these, 26 completed the study. A randomized split mouth design was used to evaluate periodontal outcomes at 6 to 8 weeks and 3 month intervals after sites within 2 quadrants of each subject were scaled and root planed with or without the use of the Perioscope™. Paired t-tests were used to test whether there were within-patient differences in improvement between Perioscope™ and non-Perioscope™ sites as measured by periodontal measurements (probing depth, clinical attachment level) and indices of gingival inflammation, including bleeding on probing (BOP) and gingival inflammation (GI). P-values less than 0.05 were declared to be statistically significant.

Results: Less BOP and GI were found in the Perioscope™ sites at visit 1 and visit 2. Reduction in pocket depth and clinical attachment loss was achieved for all sites but probing depth and clinical attachment level changes were found to be unrelated to the use of the Perioscope™. Mean probing depth (SD) was reduced from 5.29mm (0.4) to 3.55 mm (0.8) in the Perioscope™ sites and 5.39mm (0.5) to 3.83mm (1.2) in non-Perioscope™ sites from baseline measurements to visit 2.

Conclusion: The adjunctive use of the periodontal endoscope improved periodontal outcomes with respect to gingival inflammation and bleeding upon probing. The adjunctive use of the Perioscope™ was not found to be superior to traditional scaling and root planing with regard to pocket depth reduction and clinical attachment loss.

Keywords: periodontal treatment outcomes, periodontal endoscope, periodontal disease, periodontal technology, non-surgical periodontal therapy

This study supports the NDHRA priority area, **Clinical Dental Hygiene Care:** Assess the use of evidence-based treatment recommendations in dental hygiene practice.

Introduction

Endoscopic technology has been developed to facilitate real-time visualization of the gingival sulcus during diagnostic and therapeutic phases of periodontal care. The first generation of the periodontal endoscope, Perioscope™ (Perioscopy Inc., Oakland, Calif) was found to have technical shortcomings and a steep learning curve.[1-4] However, new technique changes and equipment modifications have improved the reliability and a number of studies have demonstrated improved efficacy for treatment of periodontal disease.[2-5,7-10]

The primary objective of scaling and root planing is to restore periodontal health by completely removing pathogenic products that induce inflammation (i.e. biofilm, calculus and endotoxin) from periodontally involved root surfaces. Calculus has been shown to contain bacterial products that induce an inflammatory response and can perpetuate periodontal infection.[11,12] Subgingival calculus is a frequent finding in patients with chronic periodontitis and it has been demonstrated that in the presence of poor oral hygiene, teeth with calculus demonstrate a higher rate of tissue attachment loss than teeth without calculus.[11,12] Therefore, the removal of bacterial plaque and calculus from root surfaces using scaling and root planing is an essential part of periodontal therapy. Although scaling and root planing are central to the treatment of most periodontal diseases, an abundance of research has demonstrated that SRP has limitations.[13-19] For example, the effectiveness of calculus removal decreases substantially with increasing pocket depth.[14,15] Root anatomy can inhibit calculus removal with an increased prevalence of residual deposits being associated with the cemento-enamel junction, line angles and furcations. The inability to visualize or accurately detect subgingival calculus with tactile

sensation also results in greater amounts of residual calculus.[16,18]

The dental endoscope was developed to facilitate visualization of the subgingival environment as an aid in diagnosis and non-surgical root debridement. Studies to date have showed that adjunctive use of the periodontal endoscope has resulted in improved visibility of deposits and calculus removal. An early study by Stambaugh et al evaluated the dental endoscope and the ability of the clinician to develop skills in using fiber optics to accurately visualize the contents of the subgingival sulcus.[1] Specified sites on 42 teeth (210 sites) were evaluated and scored with respect to root deposits and caries. The teeth were then extracted and scored by a periodontist for the same parameters (root deposits and caries) with direct magnified vision. The 2 scores were then compared. Over 95% of all root surface deposits and caries were detected with the endoscope. These results demonstrate the ability of the dental endoscope to aid the clinician in accurately viewing subgingival tissues for deposits and pathology with a high degree of accuracy. Using 15 subjects, Geisinger et al studied 50 tooth pairs.[2] Each tooth pair was randomized to receive SRP with or without the periodontal endoscope. The teeth were extracted and a stereomicroscope and digital image analysis was used to determine percent residual calculus present. Researchers concluded that the periodontal endoscope resulted in a statistically significant overall improvement in calculus removal during SRP, which was most evident in deeper probing depths.[2] In a similar companion study, Michaud et al used 30 tooth pairs and randomly assigned them to receive endoscopy-aided SRP or SRP alone.[3] The study found the use of the Perioscope™ as an adjunct to traditional SRP provided no significant improvement in calculus removal in multirooted molar teeth. One explanation for the different outcomes may be that Geisinger used only single-rooted teeth which greatly improved access, while the companion study used only molars with non-fused teeth.[3]

A limited number of studies were found to have evaluated the use of the periodontal endoscope on patients with chronic periodontitis. In a preliminary trial, Stambaugh et al studied 8 patients who had been in periodontal maintenance for 2 years but were not maintaining based on attachment loss, bleeding and inflammation.[4] Group A included all teeth in all 8 patients, group B consisted of only those sites that demonstrate 2 mm or more of attachment loss within 2 years. All patients had subgingival deposits that could not be detected tactically even when they were found with an endoscope. After instrumentation using the endoscope, the majority of sites in both groups improved with respect to gingival inflammation (GI), bleeding scores (GBI), probing depth and attachment gain.[4] Kwan treated 270 patients with moderate to advanced periodontal disease.[5] All treatment was completed in 1 visit at which time patients were given a course of systemic antibiotics. All pockets >4 mm were endoscopically debrided. Patients were seen for reevaluation and supportive treatment at 3 months and then followed every 3 months for 1 year. The results showed a reduction in probing depths for all types of teeth, particularly in posterior teeth with deep pockets. Fifty-five percent of molars with pocket depths starting at 7 to 9 mm reduced to >5 mm. Sixty-nine percent of molars with pockets ranging from 5 to 6 mm reduced to >4 mm.[5] Avradopoulos studied 6 patients and found no significant differences between SRP with and without adjunctive use of the Perioscope™ on clinical measures of plaque index, gingival index, bleeding upon probing (BOP) and clinical attachment levels when baseline measurements were compared to evaluation at one and three months post-treatment.[6]

Other investigators have examined the relationship of the subgingival tooth-borne accretions to signs of inflammation using the periodontal endoscope. Endoscopical observations by Cheeci et al found a direct relationship between BOP and presence of subgingival deposits confirming the importance of BOP as an indicator of subgingival deposits.[7] Wilson et al in 2008 and Pattison et al in 2004 found, via direct observation with the periodontal endoscope, that calculus covered with biofilm was associated with inflammation of the pocket wall to a greater degree than was biofilm alone.[9,10] Wilson, Carnio, Schenk and Myers found that histologic signs of inflammation were absent 6 months after a single course of closed subgingival scaling and root planing using the dental endoscope.[8]

Recently, Rethman and Harrel questioned why the majority of general dentists and periodontists persist in using techniques for non-surgical therapy that have remained essentially unchanged for decades in spite of new technology that promotes minimally invasive periodontal treatment.[20] To date, only a limited number of studies have examined the adjunctive use of the periodontal endoscope with SRP. To further validate the periodontal endoscope, additional clinical trials are needed to assess its benefits in improving clinical measurements of periodontal disease. The purpose of this study was to determine if the use of a periodontal endoscope improves periodontal outcomes of scaling and root planing when compared to scaling and root planing alone.

Methods and Materials

Two dental hygienist examiners underwent training and calibration in use of a dental endoscope as an aid to improve periodontal health over conventional therapy. Examiners gained knowledge and experience via Perioscope™ practice on models and patients. For calibration purposes, a convenience sample of 6 subjects with periodontitis and subgingival calculus were recruited from the University of Minnesota School of Dentistry clinics. A high percent of agreement within and between examiners was achieved for both methods. Percent inter-examiner agreement (+1) for repeated tactile measures ranged from 96.1 % to 96.7%, and 93.2% to 92.2% for repeated perioscope measures.

A convenience sample of 30 healthy adult volunteers, 18 years and older, with chronic moderate periodontitis were recruited by clinical faculty in the School of Dentistry's clinics and by using flyers posted in the School of Dentistry. The purpose of the study, the time commitment, and the risks and benefits were explained verbally to prospective subjects and written informed consent obtained. This study was approved by the University of Minnesota School of Dentistry Institutional Review Board.

Based on a 2-sided paired t-test with a 0.05 level of significance, a sample size of 30 patients was determined to be sufficient to detect a pocket depth effect size of 1.0 (mean difference=1.25 mm, standard deviation=1.25 mm) with greater than 90% power. Subjects were required to have at least 4 sites with pocket depths of 5 to 8 mm in each of 2 quadrants. Subjects were excluded if periodontal inclusion criteria were not met, if they had received prophylaxis or scaling and root planing SRP of the study teeth within 1 year prior to the study, if antibiotic premedication was required, or if they had taken antibiotics within 30 days of consent.

A randomized split mouth design was used to evaluate periodontal outcomes after sites within 2 quadrants of each subject were scaled and root planed with or without the use of the periodontal endoscope, i.e., 1 quadrant was scaled and root planed with the use of the Perioscope™ and 1 quadrant of each subject was scaled and root planed without the use of the Perioscope™. A statistical program generated a randomization table that listed the possible combination of quadrants to determine which quadrant would serve as the control or treatment quadrant. Subjects were evaluated at baseline and at 2 post-scaling and root planing visits (6 to 8 weeks, 3 months). The same examiner performed the periodontal examinations throughout the study for all subjects - attempts were made to have the same examiner perform scaling and root planning but this was not always the case. At each visit, oral health education tailored to the subjects' oral health status was provided to each subject.

Figure 1: The Tactile Calculus Index

0=absence of calculus 1=subgingival isolated flecks of calculus 2=moderate explorable detectable subgingival calculus 3=moderate to heavy ledge of subgingival calculus

(Modified from the Endoscopic Calculus Index)

Figure 2: Endoscopic Calculus Index

0=no observable calculus on root surface 1=separate flecks of calculus 2=a coalition of calculus deposits covering <50% of the visual field 3=a thick, diffuse accumulation of calculus covering >50% of the visual field

Periodontal measurements, including pocket depths, clinical attachment levels, GI (Loe and Silness, 1963) and BOP (modified sulcus bleeding index - scale 0 to 1) were taken at 6 sites before treatment and at 6 to 8 weeks and 3 month re-evaluation intervals. All probing measurements were recorded to the nearest millimeter with a manual 15 mm University of North Carolina (UNC-15) periodontal probe. Clinical attachment level (CAL) was obtained by measuring the free gingival margin to the cementoenamel junction to obtain a positive or negative number. The CAL was then calculated mathematically after the probing was completed.

Study sites in the control quadrant received ultrasonic instrumentation and instrumentation with hand curettes without the aid of the Perioscope™; treatment sites in the experimental quadrant received both ultrasonic and hand instrumentation with the aid of the Perioscope™. An ODU 11/12 explorer was used for tactile detection of calculus in both the treatment and control quadrants. In the treatment quadrant, the Endoscopic Calculus Index was used during endoscopic visualization to record the differing degrees of sub-gingival deposits (Figure 1).[9] A Tactile Calculus Index was used to determine the degree of calculus detected using tactile exploration (Figure 2). Both indices are a modification of the Greene and Vermillion index originally designed to describe supragingival biofilm. An ODU 11/12 explorer was used in both quadrants for ascertaining completion of root planing, however, the Perioscope™ was also used in the Perioscope™ quadrant for evaluation. The time allotted for both control and experimental groups depended on the

amount of sub-calculus and its subsequent removal by the clinician.

Statistical Analysis

Descriptive statistics (mean and standard deviation) were calculated for baseline measures (pocket depth, CAL, GI, BOP). For each patient, the average of the within-site changes from baseline was calculated at each follow-up for each measure. This was done separately for Perioscope™ and non-Perioscope™ sites. At each visit, paired t-tests were used to compare changes from the baseline measures between Perioscope™ and non-Perioscope™ sites. A p-value less than 0.05 was declared to be statistically significant. The same analysis was performed at both follow-up appointments. SAS V9.1.3 (SAS Institute Inc., Cary, NC) was used for the analysis.

Results

Twenty-six subjects completed the study - 7 females and 19 males. Five subjects were in the age range of 20 to -29, 3 between 30 to 39, 6 between 40 to 49, 9 in the age range of 50 to 59 and 3 over 60. There were 202 treatment study sites and 162 control study sites. At baseline, the probing depth and other clinical measures for both treatment and control sites were found to be similar (Table I). A statistically significant difference in calculus detection between the control and treatment quadrants was found (p=0.0046). Reduction in pocket depth and gain in clinical attachment was achieved at 6 to 8 weeks and at 3 months, but probing depth and gain in clinical attachment were found to be unrelated to the use of the Perioscope™. Mean probing depth (SD) was reduced from 5.29 mm (0.4) to 3.86 mm (0.6) at visit 1 and to 3.55 mm (0.8) at visit 2 in the Perioscope™ sites. In the non-Perioscope™ sites mean probing depth was reduced from 5.39 mm (0.5) to 3.91 at visit 1 and to 3.83 mm (1.2) at visit 2. No difference in mean change in BOP was observed at visit 1, 6 to 8 weeks after treatment, between the 2 groups. However, mean change in BOP from baseline to visit 2 was greater for Perioscope™ sites when compared to non-Perioscope™ sites (p=0.036), (Table III). Mean changes in the GI were also found to be greater for Perioscope™ sites when compared to non-Perioscope™ sites at visit 1 (p=0.006) and at visit 2 (p=0.0001), (Tables II, III).

Table I: Mean (SD) of Baseline Clinical Measures (n=26)

	Perioscope	Non-Periscope
PD	5.29 (0.35)	5.39 (0.53)
CEJ	1.55 (0.96)	1.50 (0.78)
CAL	3.74 (1.07)	3.88 (0.93)
GI	1.88 (0.41)	1.66 (0.40)
BOP	0.88 (0.23)	0.87 (0.31)
Calculus Indices	2.21 (0.52)	0.41 (0.66)

Table II: Change from Baseline in Measures at Visit 1

	n	Perioscope	Non-Periscope	Difference	p-value
PD	26	-1.43 (0.64)	-1.48 (0.61)	0.06 (0.71)	0.6825
CEJ	26	-0.40 (0.85)	-0.25 (0.81)	-0.15 (0.61)	0.2299
CAL	26	-1.03 (1.04)	-1.23 (0.76)	0.21 (0.88)	0.2449
GI	26	-0.80 (0.57)	-0.44 (0.59)	-0.36 (0.60)	0.0060
BOP	26	-0.26 (0.37)	-0.26 (0.38)	0.00 (0.49)	0.9988

Table III: Change from Baseline in Measures at Visit 2

	n	Perioscope	Non-Periscope	Difference	P-value
PD	26	-1.74 (0.64)	-1.56 (0.79)	-0.18 (0.67)	0.1710
CEJ	26	-0.50 (0.80)	-0.55 (0.61)	0.05 (0.65)	0.7144
CAL	26	-1.25 (0.81)	-1.01 (0.83)	-0.23 (0.81)	0.1575
GI	26	-1.08 (0.55)	-0.56 (0.60)	-0.52 (0.59)	0.0001
BOP	25	-0.45 (0.37)	-0.25 (0.41)	-0.20 (0.44)	0.0360

Discussion

Controlled studies examining the benefit of periodontal endoscopy are limited and results are mixed. However, this study and other studies using periodontal endoscopy, support previous research, not involving periodontal endoscopy, advocating complete deposit removal on root structures in order to reduce chronic gingival inflammation following periodontal treatment.

The results of this study support existing evidence that the periodontal endoscope allows the clinician to visualize subgingival root surfaces, therefore aiding in the determination of factors perpetuating chronic periodontal disease. The sites treated with the adjunctive use of the Perioscope™ were found to have a significant decrease in residual calculus

at both re-evaluation visits due to visibility of the root surface. Our findings confirm those of Checci et al, Wilson et al and Pattison et al that when BOP is present after non-surgical periodontal therapy, a higher probability of residual deposits can be assumed.[7,9,10]

Calculus has been shown to contain bacterial by-products that induce a host response and can perpetuate periodontal infection. Therefore, instrumentation should not only be aimed at biofilm removal but complete calculus removal as well. Professional periodontal maintenance and meticulous self-care will often suffice to maintain health at sites that have responded well to traditional SRP. However, areas with unresolved inflammation caused by incomplete debridement often will progress over time. Recolonization of pathogens on residual calculus occurs rapidly enough to sustain inflammation in these non-responsive sites. The results of this study support that when residual calculus is removed, resolution of inflammation and healing is more likely to occur.

Although an overall decrease in pocket depth in all sites in this study was achieved, it was not statistically significant when compared to the control sites. This result was unexpected as the investigators hypothesized that there would be improvement on all clinical parameters similar to Kwan's findings.[5] Patient populations may provide an explanation as to why this occurred. Patients in Kwan's study were patients of record and may have been more compliant with oral self-care recommendations. Patients in this study were transient and overall motivation and compliance with oral health recommendations was very low. Additionally, in Kwan's study, patients were given systemic antibiotics during the course of their treatment.

New technology and treatments that have the potential of reducing periodontal inflammation need to be investigated. More studies are needed to examine the adjunctive use of the periodontal endoscope with SRP compared to scaling alone on clinical parameters and to compare the effectiveness of calculus removal in non-surgical therapy with endoscope visualization to direct visualization during surgical access. Additional research is needed to determine if adjunctive use of the periodontal endoscope with SRP compared to SRP alone results in clinical improvement over time.

Limitations

Limitations to this study include:

- Subject selection, in that, although all subjects met the inclusion criteria, different results may have been achieved with patients with differing levels of disease
- Examiner experience with the periodontal endoscope as the different results obtained from various studies may be a reflection of operator experience

Conclusion

This study supports the current body of evidence that the periodontal endoscope allows the clinician to visualize subgingival root surfaces, therefore aiding in the determination of factors perpetuating chronic periodontal disease. A statistically significant greater decrease in gingival inflammation and bleeding upon probing at the sites treated with SRP and adjunctive use of the periodontal endoscope was achieved. Reduction in pocket depth and clinical attachment loss was also achieved however, no statistically significant differences in pocket depth reductions or clinical attachment levels were found between scaling and root planing and scaling and root planing with the adjunctive use of Perioscopy™.

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The Attitudes of Ohio Dentists and Dental Hygienists Regarding the Use of Automated External Defibrillators in the Dental Setting - A Follow-Up Study

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Abstract

Purpose: In 2004, the attitudes toward and use of automated external defibrillators (AEDs) by Ohio dental professionals were examined. While willing to use an AED, most did not have access to one. With new AED-related legislation and increased awareness of the benefits of AEDs since the initial study in 2004, the purpose of this study was to document the prevalence of and attitudes toward AED usage in the dental setting 7 years following the initial study.

Methods: A 2 page survey instrument was mailed to a random sample of 1,629 dentists and 1,801 dental hygienists in Ohio.

Results: A 24% overall response rate was achieved (36% dentists and 64% hygienists). Data were analyzed using SPSS. Results indicate 16% of respondents experienced a cardiac emergency in their practice that required contacting emergency personnel. AEDs are available in 48% of dental practices. Comparing the 2004 and 2011 data, statistically significant differences were found between the responses of dentists and dental hygienists.

Conclusion: While hygienists reported more positive attitudes toward AEDs than dentists, the majority of all respondents feel AEDs should be mandated in the dental setting. These findings suggest an increase in cardiac emergencies in Ohio dental settings, an increase in the prevalence of AEDs in Ohio dental settings and that the perceptions of dental professionals are changing in favor of the use of AEDs in the dental setting since the 2004 study.

Keywords: automated external defibrillator, sudden cardiac arrest, dental, attitudes

This study supports the NDHRA priority area, **Occupational Health and Safety:** Investigate methods to decrease errors, risks and or hazards in health care and their harmful impact on patients.

Introduction

The American Heart Association (AHA) reports that sudden cardiac arrest (SCA) is the leading cause of death in the U.S. and Canada.[1] An arrhythmia, the most common of which is ventricular fibrillation (VF), causes SCA. The only known treatment for VF is defibrillation.[2] In the mid-1990s, defibrillation was added to the AHA chain of survival.[3,4] An automated external defibrillator (AED) is a small portable device commonly used to treat VF occurring outside of hospitals.[1,3] They are commonly found in airports, sports arenas and other public venues.[5]

While any person can experience SCA, certain populations are at a greater risk, including elderly and medically-compromised individuals. Due to a longer-living population, dental practices are seeing more medically-compromised and aging patients. Due to the risk of SCA in the dental setting, many dental schools include training on AEDs as part of their emergency medical curriculum.[6] Additionally, the AHA recommends the placement of AEDs in at-risk locations, such as medical and dental offices.[7]

At-Risk Nature of the Dental Setting

Many patients experience physical stress and anxiety as a result of dental treatment, increasing the risk of SCA. Accordingly, dental professionals review and collect medical histories as part of their pre-treatment assessment to identify risk factors for potential cardiac emergencies.[8] Additionally, dental professionals are educated to screen patients to assess risk. Blood pressures and blood glucose levels are routinely taken, allowing dental professionals to monitor existing or screen for undiagnosed conditions.[9]

Following these reviews, dental procedures may be invasive, causing physical stress to the patient. In addition, the dental professional may provide various levels of conscious sedation or

administer local anesthesia and nitrous oxide.[10,11] These procedures, combined with dental patients' pain, such as abscess or tooth ache, result in the presence of physical and cardiac stressors associated with at-risk areas.[3]

Dental fear and anxiety have been documented as a concern in the dental setting.[12-14] Dental fear can range from a patient being mildly anxious to avoiding dental care altogether. Avoidance of dental care can often lead to emergency situations, increasing the patient's need for more complex treatments.[12] Anxiety can lead to physiological symptoms and cardiac stressors such as increased heart rate and blood pressure.[13,14] Research has found that even routine events, such as radiographs and the presence of dental hygiene instruments, can increase dental fear.[12,13] An observation study by Georgelin-Gurgel et al found that the sights and sounds involved with endodontic procedures increased heart rate and blood pressure in patients and recommended the need to monitor vital signs during stressful dental procedures.[13]

Basic Life Support Training in Dental Education

To prepare dental professionals to deal with SCA and other cardiac emergencies, AED training usually begins in the educational environment and continues throughout their careers. Dental students are generally trained to respond to cardiac emergencies in dental school, and many dental schools include training on AEDs as part of their emergency medical curriculum. A survey of emergency medical training in accredited U.S. dental schools documented CPR and AED training within their curriculums, however, training was neither consistent nor exhaustive in all of the schools. While over 90% of the schools stated they offered training on AEDs, not all schools included CPR training and recertification courses. Seven percent reported they do not offer CPR recertification. Moreover, 2 schools reported offering medical emergency training as an elective course instead of a requirement.[6] These findings are inconsistent with the Standards for Pre-Doctoral Dental Education, stating in standard 2–27 that "graduates must be competent in providing appropriate life support measures for medical emergencies encountered in the dental office setting."[10]

Dental hygiene education standards are more prescriptive. Standard 6–5 states that "All students, faculty and support staff involved with the direct provision of patient care must be continuously recognized/certified in basic life support procedures, including healthcare provider cardiopulmonary resuscitation with an Automated External Defibrillator (AED)."[11] The standard indicates that the student should be able to perform life support measures necessary to the delivery of quality health care. These educational standards, despite some inconsistent results in the research, further demonstrate the significance of AEDs in the dental office setting.

Dental Practice Recommendations

The American Dental Association (ADA) Council on Scientific Affairs suggested that dental offices may want to include AEDs in their medical emergency kits and that all dental professionals maintain training in basic life support (BLS).[15] The ADA provides further recommendations in Guidelines for the Use of Sedation and General Anesthesia by Dentists, stating that, during deep sedation procedures, an appropriate defibrillator must be immediately available.[16]

Despite these recommendations, practice requirements relating to BLS and AEDs continue to vary from state to state. For example, the American Dental Hygienists' Association (ADHA) reports that 45 states require CPR training as part of state continuing education requirements for dental hygienists.[17] The ADA State Government Affairs department provided a list of 35 jurisdictions, including Puerto Rico, requiring CPR training for initial licensure or as continuing education.[18] Ohio dental hygienists must be certified in health care provider CPR with AED training, while dentists have no CPR training requirement for licensure or renewal. Accordingly, it is not surprising that the Ohio state dental board does not require AEDs in dental offices.[19]

Conversely, several states now have requirements regarding AEDs in the dental setting. In 2006, Florida was one of the first states to mandate the presence of AEDs in the dental office setting as part of the minimum standard of care.[20] The Washington State Department of Health issued regulations in 2009 requiring any dental office administering anesthesia to have an AED available.[21] In 2010, Illinois required all dental offices administering anesthesia or sedation to have at least one AED on the premises at all times. All of these states also have some form of CPR certification requirement in connection with licensure of both dentists and dental hygienists.[22-25] Some states, such as Wisconsin, specifically reference AED proficiency for dentists and dental hygienists.[25]

While state legislation, professional recommendations and professional requirements have generally made CPR, AED training and the presence of AEDs standards for public care, little data currently exists to document the presence of AEDs in dental settings or the attitudes of dental professionals toward their use. A study by Kandray, Pieren and Benner in 2004 examined the attitudes and use of AEDs in the dental office setting of Ohio dentists and dental hygienists.[26] While this study found that Ohio professionals would be willing to use an AED if one were available, most dental professionals did not have one available for use.

Since the original study was conducted, the Ohio legislative environment has changed. The Ohio legislature enacted House Bill 143 into law on May 12, 2006, allowing Ohio dental hygienists to administer local anesthesia after taking a board-approved course. Additionally, the Ohio legislature passed House Bill 190 in May 2010, establishing the Public Health Oral Supervision Program, which allows dental hygienists to work under certain circumstances in the absence of the supervising dentist in alternative practice settings such as nursing homes, schools, hospitals and public institutions.[27] These changes expose dental professionals to more potential medical emergencies, including SCA. Due to these legislative changes and increased awareness of the benefits of AEDs in the 7 years following the initial study, the purpose of this study is to document the prevalence of AED usage in the dental office setting 7 years following the baseline data and to further explore the attitudes of dental professionals toward the use of AEDs in the dental setting.

Methods and Materials

Research Design

This study employed a non-experimental descriptive survey research design. The survey instrument developed for the original study was used so comparisons could be made between baseline data and data collected for this study. The 2011 survey instrument was modified from the previous exploratory study to include questions that would further examine the perceptions and attitudes of Ohio dental professionals regarding AED usage in the dental setting.

Subjects

A random sample of Ohio dentists and dental hygienists were surveyed. In order to generate the sample, lists of licensed dental professionals were obtained from the Ohio State Dental Board. The Statistical Package for the Social Sciences (SPSS) was used to derive the random sample.

A priori calculations of required sample size were computed using G-Power software version 3.0.5.[28,29] The power analysis was conducted for analysis of variance (ANOVA) using the effect size of size (f) convention 0.25.[30] The use of 7 groups in the final ANOVA analysis, a medium effect size of 0.25, an alpha of 0.05 and power of 0.95 indicated a final target sample size of 343. A minimum random sample of 1,629 dentists and 1,801 dental hygienists, for a total of 3,430 dental professionals, was surveyed to reach the target sample size (assuming a 10% response rate and reflecting the current licensing proportions).

Instrument/Data Collection

To survey dentists and registered dental hygienists on their use of and attitudes toward AEDs in the dental setting, the researcher sent an initial mailing to the random sample of licensed dentists and dental hygienists to gather the self-reported data. This study was approved by the local Social Sciences Internal Review Board at the University of Missouri – Kansas City. The initial mailing included a cover letter, a 2 page survey instrument and a postage-paid return envelope. Two weeks after the initial mailing, follow-up reminder post cards were mailed to the entire sample.

The survey instrument contained 2 parts. Part 1, comprised of questions from a survey instrument used by the investigator in 2004, included close-ended questions seeking to obtain categorical descriptive data and information regarding the presence and usage of AEDs in the dental setting (coded yes=1, no=2). Two questions were added to document the age (age coding: 18 to 30=1, 31 to 40=2, 41 to 50=3, 51 to 60=4, 61 to 70=5, 71 and older=6) of the participant and to ascertain the prevalence of CPR incidents outside the dental setting. One potentially-leading question, regarding perceived barriers, was revised from the original instrument to remove potential bias. Part 2 included questions to determine the dental professional's attitudes regarding AED usage in the dental setting. These questions were close-ended ranked questions utilizing the Likert scale (5=strongly agree, 1=strongly disagree) to measure the attitudes and beliefs. The survey instrument was developed using a systematic process to ensure validity and reliability.

Analysis

An exploratory analysis including measures of central tendencies, descriptive frequencies, t-tests, Chi-squared tests and correlations examining different group variables were completed using SPSS. Additionally, ANOVAs were completed to determine if a relationship/correlation existed between the independent and dependent variables.

Results

Comparison of 2004 and 2011 Demographics

A 24% response rate was achieved compared to 33% in 2004, with a 64% response rate for dental hygienists compared to a 59% response rate in 2004. Hygienists continue to be the majority of the respondents. Private practice was the most common practice setting (Table I). Several participants checking "other" indicated their work environment was governmental, military or correctional facilities. Most continue to indicate that they work in general dentistry (Table II). Of those who indicated they worked in "other" practice types, the most common description was orthodontics. Education was a new category of practice type added in the 2011 survey. The majority of professionals continue to report full-time employment status (Table III), defined as 30+ hours per week.

2004 and 2011 Descriptive Comparisons

A comparison of the descriptive responses from the 2004 and 2011 surveys are identified in Table IV. A new question in the 2011 survey indicated that 12% of respondents reported performing CPR outside the dental setting. While nitroglycerine use remained the same, some individuals in the 2011 survey who responded they had not administered nitroglycerin to a patient in the dental chair wrote remarks such as "Patients have taken nitro before, but I have them place it in their own mouths."

Both 2004 and 2011 respondents indicated that cost was perceived as the most significant barrier to having an AED available in the dental setting (Figure 1). Perceived lack of need was the second most selected barrier. Fewer respondents indicated lack of training was a barrier in 2011. Additionally, perceived potential liability decreased as a perceived barrier in 2011.

Significance testing was completed, including chi-square analysis and Pearson correlations, comparing the study participant responses. Significant changes (p=<0.05 or less) are shown in Table V. More respondents in 2011 indicated that their CPR certification included training for the Health Care Provider or Professional Rescuer, they had training on an AED and they had called emergency personnel for a cardiac emergency for a patient. Fewer professionals in 2011 had to perform CPR in the dental setting than in 2004. The number of respondents with an AED available increased in 2011 from those responding in 2004. More professionals indicated in 2011 that AEDs should be mandated, an AED is important in the dental setting and they would use an AED if available.

Significant differences were found between the responses of dentists and dental hygienists when comparing the 2004 and 2011 data (Table VI). Dentists were more likely to contact emergency personnel for a cardiac emergency, administer

Table I: Comparison of 2004 and 2011 Work Settings for Dentists and Hygienists

Type of Work Setting	2004	2011
Private Practice	94%	92%
Clinic	<1%	0%
Hospital	1%	1%
Public Health Setting	<1%	2%
Educational Setting	3%	3%
Other	<1%	2%

Table II: Comparison of 2004 and 2011 Practice Types for Dentists and Hygienists

Practice Type	2004	2011
General	85%	84%
Pediatric	5%	4%
Periodontal	3%	3%
Endodontic	<1%	2%
Oral Surgery	2%	1%
Education	-	2%
Other	5%	5%

Table III: Comparison of 2004 and 2011 Employment Status for Dentists and Hygienists

Employment Status	2004	2011
Full time (30+hrs/week)	71%	64%
Part time (Less than 30 hrs/week)	29%	34%
Currently Unemployed	<1%	1%
Temporary Leave	0%	<1%

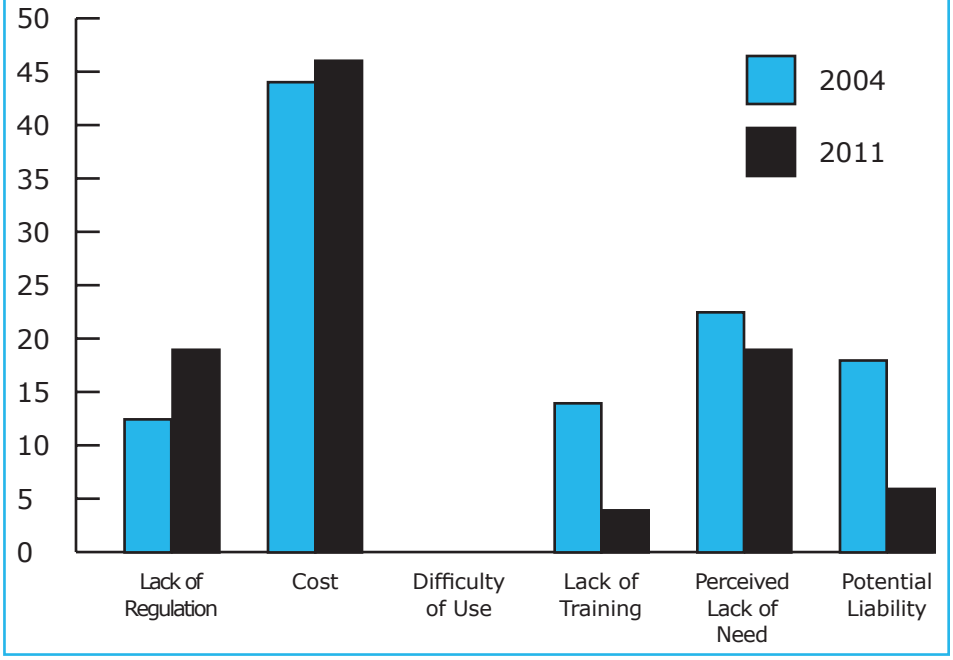
Table IV: Comparison of 2004 and 2011 Responses for Dentists and Hygienists

Question	2004	2011
Respondents' estimated time for ambulance arrival	• 50% - 3 to 5 minutes	• 48% - 3 to 5 minutes
Respondents who reported having administered nitroglycerin to a patient in the dental chair	• 6% - yes	• 6% - yes
Respondents who reported having patients who have experienced symptoms that could be indicative of a cardiac emergency	• 82% - reported at least 1 symptom • 12% - Unresponsive • 7% - Chest pain • 2% - No Pulse	• 77% - reported at least 1 symptom • 16% - Unresponsive • 10% - Chest pain • 1% - No Pulse
Respondents who reported being CPR certified	• 100% - dental hygienists • 90% - dentists	• 100% - dental hygienists • 89% - dentists
Respondents reporting AHA as source for CPR certification	• 69%	• 68%
Respondents who have used an AED in the dental setting	• 0	• <1% (3 responses)
Respondents who have performed CPR outside the dental setting (new question in 2011)	–	• 12%
Respondents who have used an AED outside the dental setting	• 2%	• 1%

nitroglycerin and perform CPR in the dental setting.

Negative correlations were noted regarding CPR certification and profession (Table VI). More hygienists reported being certified in CPR as well as being certified as a Health Care Provider or Professional Rescuer in CPR. More hygienists indicated that they had received training on AEDs. Hygienists were more likely to indicate that an AED was important in the dental setting and should be mandated.

Figure 1: Perceived Barriers to AEDs in the Dental Setting



2011 Significant Findings

Due to the significant correlations when comparing the 2004 and 2011 data, the 2011 data was further analyzed independently using Pearson correlations and ANOVA tests. Significant correlations were noted between profession and the variables reported in Table VII. Hygienists were younger than dentists. Dentists were more likely to call emergency personnel, perform CPR and administer nitroglycerin to patients. However, hygienists were more likely to report positive attitudes regarding AEDs, indicating that AEDs should be mandated and that AEDs were important in the dental setting. Dentists didn't feel as strongly as hygienists regarding mandating AEDs in the dental setting. Hygienists (M=3.91, SD=1.10) also indicated on a Likert scale that they felt they had more of a legal obligation to use an AED if needed than dentists (M=3.20, SD=1.41) (r(786)=0.272, p=<0.01).

Significant correlations were noted in the 2011 data between the following variables. Respondents with an AED available in their setting were more likely to indicate that AEDs were important (r(701)=0.315, p=<0.01) and should be man-

Table V: Significant Differences in Responses from 2004 versus 2011 for Dentists and Hygienists (p=<0.05)

Variable	2004 Study	2011 Follow-up Study
Respondents who reported having CPR Certification for the Health Care Provider or Professional Rescuer	• 81%	• 85%
Respondents who reported receiving training on AEDs	• 78%	• 96%
Respondents who reported having a patient experience a cardiac emergency in their chair and called emergency personnel	• 11%	• 16%
Respondents who performed CPR in the dental setting	• 5%	• 2%
Respondents who reported they would use an AED if needed	• 81% - Yes • 5% - No • 14% - Don't know	• 90% - Yes • <1% - No • 9% - Don't know
Respondents who had an AED available in their dental setting	• 11%	• 48%
Respondents who reported AEDs are important in the dental setting	• 69% overall	• 82% overall
Respondents who reported AEDs should be mandated in the dental setting	• 57% overall • 21% dentists • 48% hygienists	• 63% overall • 47% dentists • 72% hygienists

Table VI: 2004 and 2011 Significant Correlations - Profession

Variable	Dentist		Dental Hygienist		p–value
	M	SD	M	SD	
Experienced a cardiac emergency in their chair and called emergency personnel	1.81	0.39	1.87	0.34	<0.05
Administered nitroglycerin to a patient during a dental visit	1.89	0.31	1.97	0.19	<0.05
Performed CPR in the dental setting	1.96	0.19	1.99	0.12	<0.05
Certified in CPR	1.12	0.31	1.00	0.00	<0.01
CPR Certification for the Health Care Provider or Professional Rescuer	1.38	0.72	1.19	0.53	<0.01
Received training on AEDs	1.14	0.35	1.05	0.22	<0.01
AEDs are important in the dental setting	1.24	0.43	1.07	0.25	<0.01
AEDs should be mandated in the dental setting	1.50	0.50	1.18	0.39	<0.01

M=Mean; SD=Standard Deviation
Questions coded: yes=1; no=2

dated (r(653)=0.350, p=<0.01) in dental settings than those who did not. Professionals who were certified in CPR were also more likely to indicate that AEDs were important (r(624)=0.186, p=<0.01) and should be mandated (r(575)=0.082, p=<0.05). Those who had received training on AEDs were more likely to have an AED available (r(740)=0.140, p=<0.01), more likely to feel they were important (r(698)=0.119, p=<0.01), and more likely to feel that they should be mandated (r(650)=0.129, p=<0.01).

An ANOVA found that hygienists were more likely to be working part time than dentists. Hygienists were more likely to be unemployed or on temporary leave than dentists (F(3,785)=21.38, p=<0.01). Endodontic practices were most likely to call emergency personnel and pediatric practices were least likely (F(6,783)=4.06, p=<0.01). Oral surgery practices were most likely to administer nitroglycerin and pediatric practices were the least likely (F(6,783)=4.49, p=<0.01). Oral surgery practices followed by endodontic practices were most likely to have an unresponsive patient (F(6,779)=2.36, p=<0.05). Respondents participating in CPR outside the dental setting were most likely to be from the oral surgery practice setting, while respondents from the endo-

Table VII: 2011 Significant Pearson Correlations - Profession

Variable	Dentist		Dental Hygienist		p–value
	M	SD	M	SD	
Age range	3.73	1.25	3.03	1.09	<0.01
Experienced a cardiac emergency in their chair and called emergency personnel	1.80	0.40	1.86	0.35	<0.01
Administered nitroglycerine to a patient during a dental visit	1.89	0.31	1.96	0.20	<0.05
Received training on AEDs	1.07	0.26	1.02	0.15	<0.01
Performed CPR outside the dental setting	1.76	0.42	1.93	0.25	<0.01
AEDs should be mandated in the dental setting	1.43	0.50	1.15	0.36	<0.01
AEDs are important in the dental setting	1.20	0.40	1.05	0.22	<0.01

M=Mean; SD=Standard Deviation
Profession coded: dentist=1; dental hygienist=2
Age coded: 18 to 30=1; 31 to 40=2; 41 to 50=3; 51 to 60=4; 61 to 70=5; 71 and older=6
Other questions coded: yes=1; no=2

dontic practice settings participated the least in CPR outside the dental setting ($F(6,783)=7.03$, $p=<0.01$). All educational settings surveyed indicated they had an AED available and most oral surgery settings had an AED available. General dentistry settings were least likely to have an AED available for use ($F(6,759)=5.56$, $p=<0.01$) as illustrated in Figure 2.

Attitude questions using the Likert scale were summed to create a new variable for comparison across groups. These comparisons revealed that younger respondents had more positive attitudes regarding AEDs ($F(5,785)=5.94$, $p=<0.01$) as seen in Table VIII. However, this result may be influenced by the younger mean age of hygienists, who collectively indicated more positive attitudes. Those practicing in the oral surgery and educational practice settings had the most favorable attitudes regarding AEDs while endodontic practices had the least favorable attitudes ($F(6,784)=2.44$, $p=<0.05$).

Discussion

Results suggest that several changes have occurred since the 2004 study. AEDs appear to be becoming more prevalent in Ohio dental settings. The amount of AED training and CPR training also appears to be increasing. These changes may be due to increased awareness of the role of AEDs in BLS and the continued presence of AEDs in public locations.

Respondents were asked if they had administered nitroglycerine or performed CPR on a patient in the dental setting to ascertain the frequency of potential cardiac emergencies in the dental setting. While nitroglycerin use remained the same and CPR in the dental setting had decreased slightly, a 5% increase was noted in the number of professionals who called emergency personnel for a cardiac emergency. Also, practitioners with unresponsive patients and patients experiencing chest pains have increased since 2004. These results may suggest an increasing concern about potential cardiac emergencies in the dental setting. Due to expansions of the services offered by dental professionals, increases in dental professionals' roles outside the dental setting, and an expanding medically-compromised and geriatric patient base that has a heightened risk for SCA, the use of AEDs is becoming an increasingly-important subject for dental professionals.

Another factor is estimated response times for emergency care. Perceived response times were reported similarly in 2004 and 2011 at 3 to 5 minutes for an EMS response. However, health care provider perceptions may be optimistic regarding these response times. Previous studies have confirmed that EMS response times can vary greatly at remote and rural locations. Urban areas also suffer poor response times due to increased traffic and large buildings.[5] In many cities, the survival rate is less than 5% due to response times.[31]

In addition to documenting the prevalence of AEDs and the incidence of cardiac emergencies in the dental setting in Ohio, this study explored the attitudes of dental professionals since use and acquisition of an AED may be restricted by attitude

and perceptions. The additional attitude questions in the 2011 survey further demonstrated the differences in attitudes of dentists and dental hygienists. The more positive attitudes of dental hygienists may be explained by the increased exposure to AEDs through CPR training required for CPR certification and specific AED competency in the dental hygiene standards. However, the results suggest that the overall perceptions of both dentists and dental hygienists are becoming more positive regarding AEDs in the dental setting. Practice settings that most often had AEDs available also had the most positive attitudes regarding AEDs. This suggests that exposure to and training on AEDs may also influence attitudes.

As the new 2011 CPR guidelines reaffirm the place of an AED in the event of SCA, public awareness of the benefits of AEDs continues to increase with AED legislation diffusing into dentistry across the nation.[32] Several states, although not Ohio, enacted some form of AED legislation in the dental setting since the original study, beginning the process of integrating AEDs into dentistry. While no reported cases regarding the negligence or liability of a physician or dental office for not having an AED on the premises were identified during this review, several well-known lawsuits have been brought against Busch-Gardens, Lufthansa and United Airlines for failure to have an AED.[33] Given that health care providers, including dental professionals, are educated in emergency procedures and are aware of the benefits of AEDs, dental professionals could be held to a heightened standard of care regarding the access to emergency equipment to provide emergency care. A commentary by an attorney experienced in AED-related matters has speculated that similar legal action is imminent within the dental community.[34]

This study should be interpreted in light of several limitations. This study is subject to all limitations inherent with self-reported data, i.e. the validity and accuracy of this data must be questioned. Specifically, self-reports are potentially unreliable because participants may not always report their actual feelings and may respond as they feel they should instead of how they truly feel. The delimitation of this project is the sampling of dental professionals across Ohio; consequently, the size of the sample could also limit the extrapolation or generalization of the findings of this project to the whole dental population in Ohio. Unfortunately, the response rate was slightly lower than the previous study although the overall response was larger due to a larger sample size. Moreover, the only existing research on the use and attitudes of AEDs in the dental setting was obtained from the previous 2004 study. Little other data exists to provide contextual data. Further research on the use of AEDs in the dental setting and the attitudes of dental professionals who use them needs to be completed.

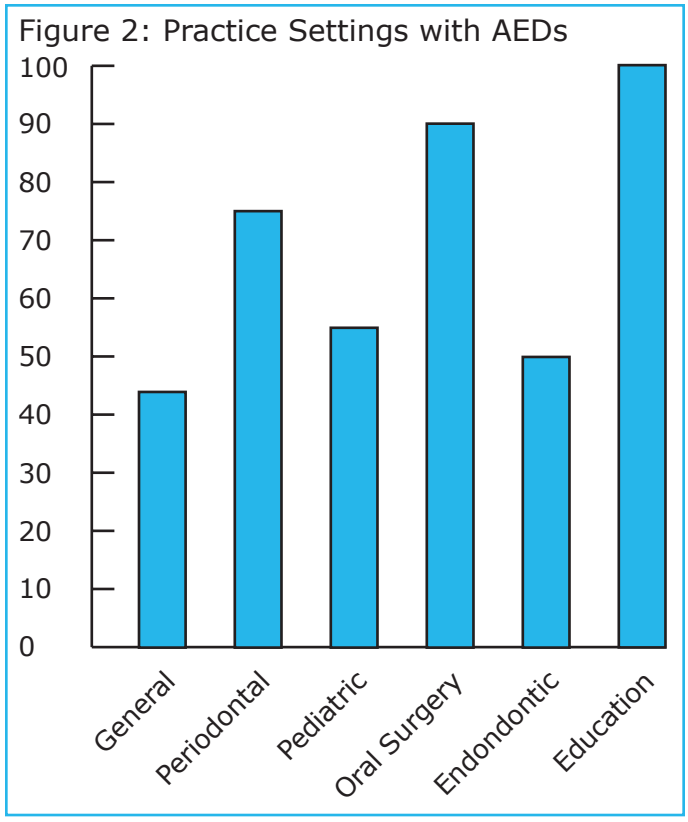


Table VIII: Age and Attitude

Age Range	Mean attitude score	Std. Deviation
18 to 30	43.85	2.15
31 to 40	43.27	3.16
41 to 50	42.91	3.63
51 to 60	42.42	4.45
61 to 70	40.91	5.34
71 and older	41.50	4.71

Age Coding: 18 to 30=1; 31 to 40=2; 41 to 50=3; 51 to 60=4; 61 to 70=5; 71 and older=6
Attitude questions: 5=strongly agree; 1=strongly disagree

Conclusion

This study of Ohio dental professionals affirms the conclusion from the 2004 study that dental professionals, including students, should be familiar with the proper protocol to follow in the event of a cardiac emergency. As public awareness of their benefits increases, AEDs are becom-

ing more common with installations at shopping centers, airports and office buildings. Having an AED on the premises, either in a dental office or dental educational setting, may soon be the standard of care for cardiac medical emergencies. As the standard of care evolves to include AEDs and legislation is passed, dental professionals should be familiar with and able to recognize and treat cardiac emergencies, including use of AEDs. Even if AEDs are not mandated, AEDs can be a critical item to have to save lives and dental settings should consider having one available.

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