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STATEMENT OF PURPOSE

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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Features

Editorial

Rebecca S. Wilder, RDH, BS, MS

The Dental Hygienist in Research: Progress over 100 Years

In 1966, an article was published in the Journal of the American Dental Hygienists' Association titled, "The Role of the Dental Hygienist in Dental Research."[1] The paper was authored by two dental hygienists with master's degrees and a dentist, all from the School of Dental Hygiene and the Division of Stomatology , School of Dental and Oral Surgery at Columbia University in New York. Although the program is no longer in existence, Columbia University was the first school to offer a Master of Science Degree in Dental Hygiene. Approximately one-third of the curriculum was devoted to research.[2] We have had many distinguished leaders in our profession who graduated from that institution. It represented the first graduate program, followed by many who recognized the importance of preparing dental hygienists for expanded roles in research and scholarship.

The article mentioned above stresses the need to prepare dental hygienists in research. "As a professional health worker, the dental hygienist has an obligation to assist the dental profession in providing the best possible care for the public. This obligation may be further fulfilled through research endeavor. The dental hygienist working in both basic and applied research may serve as either an assistant or as an administrator. What qualifies the dental hygienist for work in dental research? Her educational background which more than adequately prepares her in basic dental and clinical sciences and her license to work, under the supervisions of the dentist, directly in the mouth of the patient or subject. In addition to these qualifications, various of the following attributes will be found of considerable value: a keen imagination, excellent powers of observation, a sincere interest in the process of scientific investigation, the ability to search the literature, to design experiments, carry out the protocol, record and tabulate the data, and prepare the results (written in scientific style) for publication."

Fast forward to 2013, and you will see how far we have come in developing dental hygienists for a role in oral health research. The Journal of Dental Hygiene is full of papers that represent significant research conducted by dental hygienists who are contributing to our National Agenda for Dental Hygiene Research. In the current issue of the JDH, you will see papers representing scholarship from the U.S. and abroad. Authors are dental hygienists, dentists and physicians, dental and dental hygiene administrators and scientists with doctoral degrees. Subject areas in the current issue of the JDH represent emerging science in the areas of Bisphosphonate Associated Osteonecrosis, oral health behaviors, service learning and dental materials.

I am also pleased to see included in this issue the first published study by a dental hygienist on the topic of sleep apnea. Sleep Apnea and Sleep Medicine is an emerging area of science in dentistry. In the future, dental hygienists may play a large role in the assessment and referral of patients who test at high risk for the condition.

In 1930, Evelyn Gunnarson, DH wrote an article titled, "The Dental Hygienist, Past, Present and Future." The final paragraph includes a quote from Dr. Alfred C. Fones who said " Every dental hygienist must have her mind open to everything that is progressive." Well, our profession has seen much progress in the area of research and scholarship in the last 100 years! We must keep the progress going![3]

Sincerely,

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

References

1. Cuttita CM, McLean P, Kutscher AH. The role of the dental hygienist in dental research. I. *J Am Dent Hyg Assoc*. 1966;40(2):69-71

2. Motley WE. Dental hygiene at 75. *J Dent Hyg*. 1988;62(9):458-463.

3. Gunnarson E. The dental hygienist, past, present and future. *J Am Dent Hyg Assoc*. 1930;4(10):17-18.

Air Polishing: A Review of Current Literature

Sarah J. Graumann, RDH, BS, MDH; Michelle L. Sensat, RDH, MS; Jill L. Stoltenberg, BSDH, MA, RF

Abstract

Purpose: Routine tooth polishing continues to be an integral part of clinical practice even though the concept of selective polishing was introduced in the 1980s. This procedure assists in the removal of stains and plaque biofilm and provides a method for applying various medicaments to the teeth, such as desensitizing agents. Use of traditional polishing methods, i.e. a rubber–cup with prophylaxis paste, has been shown to remove the fluoride–rich outer layer of the enamel and cause significant loss of cementum and dentin over time. With the growing body of evidence to support alternative tooth polishing methods, dental hygiene practitioners should familiarize themselves with contemporary methods including air polishing. The purpose of this review is to provide a comprehensive overview of recent advancements in air polishing. The effect of air–powder polishing on hard and soft tissues, restorative materials, sealants, orthodontic appliances and implants, as well as health risks and contraindications to air polishing are discussed. A comprehensive computer based search made use of the following databases: CINAHL, Ovid Medline and PubMed. Articles that were not available on these sites were requested from Wilson Interlibrary.

Keywords: air polishing, air polishing devices (APD), sodium bicarbonate powder ($NaHCO_3$), glycine powder air polishing (GPAP), calcium sodium phosphosilicate ($CaNaO_6PSi$), calcium carbonate ($CaCO_3$), aluminum trihydroxide ($Al(OH)_3$)

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

Introduction

An air polisher provides an alternative method of removing supragingival extrinsic stain and deposits from the teeth. Unlike conventional mechanical polishing (handpiece with rubber–cup and prophylaxis paste) used to polish teeth, the air polisher uses a light handpiece similar to an ultrasonic scaler to generate a slurry of pressurized air, abrasive powder and water to remove plaque biofilm and stains (Figures 1, 2). Air polishing was first introduced to the dental profession in the late 1970s. The first air polishing device (APD), the Prophy Jet Marck IV™, was marketed by Dentron, Incorporated (Corpus Christi, Texas). Since that time, a variety of APDs have been developed. Previous studies have indicated that with proper use, air polishing can provide a safe, efficient and contemporary approach to plaque biofilm and stain removal.[1] The advantages of air polishing when compared to rubber–cup polishing include less time, less operator fatigue, and more efficient stain removal.[2] With evidence–based support such as this, adoption and use of the technology in practice has grown. However, most practices continue to rely on conventional polishing methods.[3]

Recent developments in air polishing necessitate an updated review of recent advancements. A literature search of air polishing was conducted to assess the scientific community's latest (1999 to 2012) recommendations for use. In this review, the effectiveness of new powders, overall effectiveness and efficiency of the technology, effects on hard and soft tissues, restorations, sealants, orthodontic appliances and implants, as well as health risks and contraindications to air polishing, will be discussed. Based on the current literature, this review will help the reader bridge information with clinical application by suggesting protocols for practice.

Powders Used in Air Polishing

Sodium bicarbonate–based powders ($NaHCO_3$) were the first powders to be used in air polishing technology. $NaHCO_3$ powders are specially processed to form a powder with a particle size of up to 250 µm.[4] Studies confirmed the safety and efficacy of the supragingival use of $NaHCO_3$ when compared to conventional scaling and rubber–cup polishing.[1] While damage to enamel was not reported, researchers and manufacturers cautioned against prolonged use on cementum, dentin and certain restorative materials such as composites.[1]

Recent developments in air polishing powders include the use of glycine, calcium sodium phosphosilicate (Sylc™; OSspray, London, UK), calcium carbonate (Prophypearls™; KaVo, Charlotte, NC) and aluminum trihydroxide (Jet–Fresh™; DENTSPLY, York,

Figure 1: Example of an Air Polishing Handpiece

CaviJet unit by DENTSPLY

Penn). Manufacturers of glycine, calcium sodium phosphosilicate and calcium carbonate claim these powders are less abrasive than traditional sodium bicarbonate–based powders. Glycine is a naturally–occurring amino acid. It is water–soluble with a non–salty taste.[4] Clinpro™ glycine powder (3M™ ESPE™, Seefeld, Germany) has been shown to have a particle size of 63 µm or less, close to 4 times smaller than the particles in $NaHCO_3$.[4–6] Pelka et al found that glycine powder produced significantly less surface damage on restorative materials than 2 $NaHCO_3$ powders (Acclean Air Preventive Powder™; Henry Schein, Lange, Germany, and Air–Flow Prophylaxis Powder™; EMS, Nylon, Switzerland).[7] As with $NaHCO_3$ air polishing, glycine has also been shown to remove plaque more efficiently than hand instruments.[8]

Historically, use of air polishing has been limited to supragingival surfaces.[1] However, in recent years, in vivo studies have demonstrated the effectiveness of glycine powder in supragingival and subgingival applications.[4,6.8–13] Petersilka et al compared the use of hand instruments and air polishing with glycine powder for subgingival plaque removal and indicated that glycine powder was superior to hand instruments in the removal of subgingival plaque in periodontal pockets of 3 to 5 mm.[8] A pronounced reduction in mean colony–forming units (CFUs) of bacteria following its use was attributed to the combination of air, pressurized water and the mildly abrasive powder, with the powder itself being the most important factor in bacterial reduction.[11]

Gingival erosions with glycine powder air polishing (GPAP) have also been investigated. When the powder nozzle was directed at a 60 to 90 degree angle to the tooth surface for 5 seconds, minor gingival erosions occurred. Petersilka et al examined the use

Figure 2: Example of the Slurry of Pressurized Air, Abrasive Powder and Water That the Air Polishing Unit Produces

CaviJet unit by DENTSPLY

of GPAP and hypothesized that GPAP may result in less gingival erosion than with hand instruments or $NaHCO_3$. All areas exhibiting gingival erosions were fully healed within 14 days following treatment.[9]

Calcium sodium phosphosilicate powder, ($CaNaO_6PSi$) (Sylc™; OSspray, London, UK) is a bioactive glass developed specifically for use with air polishing procedures. A bioactive glass is a chemical compound of naturally occurring elements which include calcium, phosphorus, silica and sodium. The manufacturer claims bioactive glass has been shown to promote the regeneration of damaged tooth surfaces creating an enamel–like layer when used in dental products and to have a more profound whitening effect as a polishing agent when compared to $NaHCO_3$.[14] Studies to date have been in vitro and not in vivo investigations. Properties associated with bioactive glass allow $CaNaO_6PSi$ to reduce dentinal hypersensitivity as well as remove plaque biofilm and stain.[15] Results from a study by Sauro et al confirmed $CaNaO_6PSi$'s ability to reduce dentin permeability by occluding the dentinal tubules when used during air polishing and conventional rubber–cup polishing procedures.[15] This mechanism of action is similar to $NaHCO_3$. Another study confirmed the ability of $CaNaO_6PSi$ to reduce dentinal hypersensitivity when compared to $NaHCO_3$. Banerjee et al found that $CaNaO_6PSi$ provided a significant benefit ($p<0.05$) 10 days following treatment whereas sensitivity increased in those subjects treated with $NaHCO_3$.[16]

Calcium carbonate ($CaCO_3$) (Prophypearls™; KaVo, Charlotte, NC) is an air polishing powder with spherically agglomerated crystals. It is hypothesized that use of this mass of uniformly shaped round crystals will minimize surface abrasion when compared to the

irregularly shaped particles found in other powders. At 45 µm, the particle size of the $CaCO_3$ powder is less than $NaHCO_3$, but similar in size to the particles in glycine.[6] While study results indicate the efficiency and effectiveness of $CaCO_3$ for stain removal, defects produced on root dentin were greater than that of $NaHCO_3$.[6] More clinical studies are needed to determine the effectiveness and abrasivity potential of $CaCO_3$.

Aluminum trihydroxide ($Al(OH)_3$) (JET–Fresh™; DENTSPLY, York, Penn) is an alternative air polishing powder for patients on sodium restricted diets.[17] Aluminum trihydroxide particles are harder but comparable in size to sodium bicarbonate.[17] Johnson et al evaluated the effects of aluminum trihydroxide on certain restorative materials, including amalgam, gold, hybrid and microfilled composites, glass ionomers and porcelain.[17] It was determined that aluminum trihydroxide should be avoided on cast restorations, luting cements, glass ionomers and resin composites.

Inorganic salts have also been investigated as air polishing agents. Petersilka et al combined non–toxic, biocompatible, water–soluble organic and inorganic salts with varying grain sizes and crystal shapes to make four novel air polishing powders.[18] Parameters included a combination of a 2 mm, 4 mm or 6 mm distance from the tooth with the powder and water setting on the APD set at low, medium or high. Mean root defects over all parameters for all 4 powders proved to be less than those produced by $NaHCO_3$. At the time of this writing, these novel powder formulations are not commercially available products.

Effectiveness and Efficiency of Use

Earlier studies on air polishing with $NaHCO_3$ based powders have demonstrated its ability to be more effective at supragingival stain removal, less fatiguing to the operator and more time efficient than conventional rubber–cup polishing.[1] These results were confirmed by a recent study which found conventional methods (rotating cups, brush cones and abrasive pastes) to be less effective and more time consuming at stain and plaque removal than modern APDs.[19] Botti et al reported that air polishing cleaned pits and fissures of teeth better and was easier to use than synthetic brushes, ensuring thorough plaque biofilm and debris removal, prior to placement of sealants.[19] In addition, this study suggested the benefits of air polishing on the overall health of the subgingival environment through its use in shallow pockets for removal of plaque biofilm. It was suggested that GPAP may replace hand instruments as well as sonic and ultrasonic scalers for subgingival plaque biofilm removal in shallow pockets.[10] GPAP has also shown a significantly greater reduction in subgingival bacteria compared to hand instrumentation ($p<0.05$).[8,10,12]

A variety of air polishing models have been introduced to the market in the last 10 years. In addition to the traditional self–contained units, handpiece units now afford clinicians with a convenient, alternative delivery model.[20] Recently, advancements in nozzle design have afforded more effective subgingival delivery.[12] Few studies have been conducted on the effectiveness of these various models.

A recent study quantified the powder emissions of APDs at different settings to evaluate the accuracy of powder emission over time depending on the powder amount in the chamber and the powder setting.[21] The 4 different air polishing units included in the study were the Air Flow® (Electo Medical Systems, London), CaviJet® (DENTSPLY, York, Penn), Air Max® (Satellec, Merignac, France) and the Prophyflex II® (KaVo, Biberach, Germany). Air Flow® and Cavi–Jet® units produced increased powder emissions with all increases in power settings. The Air Max® unit produced comparable powder emissions at low and medium settings but 5 to 12 times greater powder emissions at the high setting. The Prophyflex II® (KaVo, Biberach, Germany) unit powder setting had no significant effect on powder emission. Authors concluded that efficacy of air polishing depends on the amount of powder present in the powder chamber. Therefore, clinicians are encouraged to refill the powder chamber before each treatment session.[21] Manufacturers recommend monitoring powder levels frequently to assure adequate powder throughout a treatment procedure.[21] Air polishing models can also influence dentinal defects. An in–vitro study by Pelka et al reported that the Prophyflex3® (KaVo, Biberach, Germany) produced significantly greater defects than the EMS model ($p<0.05$) regardless of the abrasive used.[6]

Effects on Soft Tissues

In past reviews on air polishing, studies indicated some gingival bleeding and a salty taste followed use, but no significant gingival trauma within a week or 2 after treatment.[1] Recent studies have confirmed these findings.[4,8–9]

The histological examination of healthy dog gingival tissue following an application of an air abrasive jet with standard $NaHCO_3$ powder, revealed erosive changes in the keratin and epithelial cell layer. The extent of the damage correlated positively with the time of exposure.[22] Kozlovsky et al concluded that the APD should be used no more than 5 to 10 seconds per tooth surface, with overlapping strokes to minimize the extent of epithelial erosion and to pre-

vent the possibility of total exposure of the underlying connective tissue.[22] Five to 20 second intervals of air–polishing application are the working parameters used in most of the studies.[6,7,9–11,17,18,22–27] Furthermore, use of GPAP has been shown to result in less gingival erosion than hand instrumentation or $NaHCO_3$ powders when a treatment time of 5 seconds per site was used.[9] In addition, glycine–based powder is the only abrasive that has been studied for its ability to clean plaque biofilm in subgingival pockets <5 mm. In vivo studies have indicated that it is safe and caused no substantial gingival damage.[8,23]

Effects on Enamel, Cementum and Dentin

Previous literature reviews on the effects of air polishing of enamel, cementum and dentin removal by $NaHCO_3$ based powders have been reported.[1] Studies have generally found air polishing to be safe on enamel with no significant loss of enamel and less abrasive than rubber–cup polishing.[1] Studies did conclude however that caution was warranted during use on cementum and dentin to avoid loss of tooth structure and it was recommended that air polishing be limited to enamel.[1] Agger et al confirmed these findings in a recent study which used scanning electron microscopy (SEM) and laser profilometry to evaluate the abrasiveness of $NaHCO_3$ on root surfaces.[28]

Recent studies have continued to confirm the safety of air polishing with $NaHCO_3$ on enamel.[24,29,30] However, and more importantly, the reduction in abrasivity on supragingivally exposed cementum and dentin with use of the new air polishing powders.[6,18,21,25] Mean root defects using a combination of 4 different low abrasive air polishing powders on extracted teeth proved to be less than those caused by $NaHCO_3$ powder.[18] Pelka et al found the smallest root surface damage depths and volume losses with the use of GPAP compared to $NaHCO_3$ and $CaCO_3$.[6] In addition, use of the EMS delivery model produced significantly less defects in dentin when compared to the Prophyflex 3® (KaVo, Biberach, Germany).[6] Petersilka et al also studied the influence different working parameters had on root damage and determined which parameters minimized root damage.[25] They examined defect depth and volume after air polishing with conventional $NaHCO_3$. A combination of low, medium and high powder and water settings were used at 5, 10 and 20 second intervals, with a distance of 2 mm, 4 mm and 6 mm at 45 and 90 degree angles. It was determined that instrumentation time had the strongest influence on resulting defect volume compared to the powder and water settings. Distance between instrument nozzle and root surface was found negligible in this study. It was concluded that air polishing with $NaHCO_3$ may not be safe for use on exposed root surfaces.[25]

Tada et al examined the abrasiveness of glycine powder on dentin with particle diameters of 63 µm and 100 µm, respectively.[31] The larger diameter powder resulted in less damage. More research is needed to determine the cause of this finding. Most recently, Tada et al studied the effect nozzle distance had on dentinal defects during air polishing. They found that a spray distance of 6mm from the nozzle surface of the air polisher to the dentin surface using a 45 degree angle produced the shallowest defect depths. The other distances examined were 2 mm, 3 mm, 4 mm and 5 mm. In addition, glycine powder (65 µm) had produced significantly smaller depth and volume defects than $NaHCO_3$ (65 µm) and another glycine powder (25 µm). Tada et al hypothesized that the larger particle size may not have had time to reach maximum velocity when exiting the nozzle head to strike the dentin.[32]

Effects on Restorative Materials, Sealants, Orthodontic Appliances and Implants

Previous studies evaluated the effects of air polishing with $NaHCO_3$ on restorative materials and suggested caution or complete avoidance of composites and porcelain veneers.[1] Because of the differences in the studies however, Gutmann concluded that clinicians should follow manufacturers' recommendations when using air polishing on restorative materials.[1] Recent studies using new powders are limited but have indicated that during air polishing, restorative materials such as composites and porcelain veneers experience a small but noticeable material loss.[7,26,33–35] The effects of 3 types of piezoelectric ultrasonic tips were compared to air polishing with $NaHCO_3$ on restorative materials in vitro. After microscopic examination, the findings revealed that all 3 of the piezoelectric ultrasonic tips roughened the amalgam surface more than the air polished surface. The air polished amalgam surfaces did not show evidence of any macro cracks or chips, composite surfaces did not have evidence of cavities or craters, and porcelain ceramic surfaces did not have evidence of any chips or increase in pore size. The authors concluded that use of 20 psi during air polishing was more effective in reducing abrasion on restorative surfaces than 60 psi used in earlier studies.[33] Air polishing on polymer composite material with glycine powder, using 5, 10 and 30 second treatment times at a distance of 2 mm or 7 mm, showed a smoother after appearance with smaller surface defects than that of $NaHCO_3$ powder which produced large depressions on the surface.[34] Giacomelli et al found similar results on nanohybrid composite resin with glycine powder producing smaller surface defects (1 to 2 µm wide) than $NaHCO_3$ (5 to 10 µm wide).[35]

Previous studies found air polishing to be superior

to rubber cup polishing when preparing the occlusal tooth surface prior to etching for sealants. It was also found that air polishers enhanced the bond strength of sealants compared to traditional polishing, allowing for deeper penetration of the sealant resin into the enamel surface.[1] Although air polishing prior to sealing teeth was examined, the effects of air polishing on fissure sealant material was not mentioned in the literature review by Gutmann.[1] Pelka et al found that air polishing of fissure sealants generally results in substance loss, producing more surface damage with $NaHCO_3$ than GPAP.[6] This study used an angulation of 90 degrees, with a treatment time of 10 seconds, using the same APD for all teeth in the study.[7] In a similar study, Engel et al found after 5 seconds of air polishing extracted sealed teeth, $NaHCO_3$ powder led to thinner sealants and minor defects.[26] The use of the GPAP on extracted teeth sealed with the same materials, led to less sealant abrasion than with the $NaHCO_3$ powder, however, surface defects were also evident. This study concluded that once teeth have been sealed, cleaning those surfaces with air–powder polishing should be avoided.[26]

The previous review by Gutmann[1] found air polishing to be the most efficient method for stain and plaque removal around orthodontic bands, brackets and arch wires. However, a recent study found air polishing with $NaHCO_3$ caused higher frictional resistance on both metal and ceramic brackets.[27] The authors concluded that air polishing with $NaHCO_3$ should not be used in the slots of ceramic or metal brackets. SEM was used to determine differences in the effect of $NaHCO_3$ and GPAP on orthodontic appliances.[36] Marginal surface changes on arch wire and metal brackets were observed however there were no significance differences between the 2 powders. $NaHCO_3$ did however roughen plastic bracket surfaces whereas GPAP did not. Therefore, glycine proved to be the powder of choice when it came to cleaning plastic brackets.[36]

Previous studies found air polishing to be effective on implants, finding surfaces were generally smooth, plaque formations inhibited and bacteria completely removed.[1] A recent study of patients with peri–implantitis found glycine powder significantly reduced bleeding on probing 6 months after treatment when comparing it to patients who were treated with mechanical debridement using curets and chlorhexidine. Both groups had similar pocket depth reductions and clinical attachment gains 6 months after treatment.[37]

Health Concerns and Safety

The previous literature review on air polishing discussed contraindications to air polishing due to a variety of systemic medical conditions and medications.[1] These contraindications included a sodium–restricted diet, hypertension, respiratory illness, infectious disease, renal insufficiency, Addison's disease, Cushing's disease, metabolic alkalosis or medications such as mineral corticoid steroids, antidiuretics or potassium supplements.[1] More recently, products have been introduced that do not contain sodium, therefore, use of these powders is not contraindicated for conditions such as sodium–restricted diet, hypertension or renal insufficiency. Products without sodium are GPAP, $CaCO_3$ and $Al(OH)_3$. Calcium sodium phosphosilicate powder (Sylc™; OSspray, London, UK) has a very small amount of sodium mixed with the particles and no salty aftertaste. There have been no medical contraindications associated with calcium sodium phosphosilicate powder, however it is not recommended for patients with silica allergies.[14]

Very rare conditions that can arise from aerosols during air polishing include air emphysema, subcutaneous facial emphysema and pneumoparotitis. Flemmig discussed findings from Health Device Alerts that found, between 1977 and 2001, there were a total of 9 air emphysema and 3 air embolism incidents related to the use of APDs.[10] Since that time, 6 additional articles have reported similar incidents.[38–43]

Gutmann suggested following universal precautions, using high–volume evacuation instead of a saliva ejector and rinsing with an antimicrobial mouthwash before treatment to prevent any potential health risks.[1] These protocols are still recommended today. Adherence to these protocols will insure that complications related to aerosols continue to be a rare occurrence. No adverse health effects related to glycine powder, calcium sodium phosphosilicate powder or calcium carbonate were reported in the studies reviewed for this paper.

The Jet–Shield™, an aerosol reduction device, formally marketed by DENTSPLY (York, Penn), had just become available at the time of the last review on air polishing in 1998.[1]

Since that time, 1 study has evaluated the effectiveness of the Jet–Shield™. This study showed significantly fewer mean quantity of colony–forming units generated when using the Jet–Shield™, compared to not using this aerosol reduction device.[44] Use of the air polisher without this aerosol reduction device generated a greater number of colony–forming units on the operator's face mask. This study suggested that an aerosol reduction device be used during air–powder polishing.[44]

Applications for Clinical Practice and Practice Protocols

As with past reviews of the literature, this review of recent studies (1999 to 2012) of air polishing supports its use as a viable alternative to conventional polishing in today's contemporary practice. Air polishing has been found to be more effective than traditional polishing at stain and supragingival plaque biofilm removal. New, less abrasive powders are enabling the selective use of air polishing on cementum and dentin and a variety of restorative materials without concern for unnecessary damage.

Based on this review, glycine–based powders have many advantages over other abrasive powders. Present studies indicate that it creates the least defects on restorative material and tooth structures and results in the least amount of gingival erosion.[4,6–13,23,26,31,32,34–37]

Traditional rubber–cup polishing requires the clinician to make treatment decisions regarding the abrasivity of the polishing paste, amount of pressure to apply and which surfaces to polish. Air polishing has the advantage of providing the clinician with a constant pressure, thereby eliminating this variable. However, studies indicate the importance of monitoring powder levels and refilling the powder chamber prior to each treatment session for optimal results.

Aerosols are produced as a result of many procedures used in practice. While low volume evacuation may be used for limited air polishing, use of high volume evacuation (HVE) is recommended for all air polishing procedures. Standard infection control procedures, including universal precautions and use of an antimicrobial mouth rinse prior to procedures, suffice for adding this technology to the treatment appointment. Optimum angulation and distance of the air polishing nozzle to the tooth surface will avoid facial and tissue emphysemas and other gingival traumas. No other special requirements are needed to include air polishing as an option for patients.

For patients with conditions affected by aerosols or sodium intake, air polishing with $NaHCO_3$ based powders is contraindicated. However, new powders, specifically glycine–based powder, calcium carbonate, aluminum trihydroxide and calcium sodium phosphosilicate, contain little or no sodium. This alleviates the concern for use of these powders on many patients including those with sodium–restricted diets and hypertension. In addition, use of HVE or another type of aerosol reduction device such as the Jet–Shield™ (DENTSPLY, York, Penn) provides reduced risk for patients with respiratory disease. As previously stated, universal precautions and an antimicrobial mouth rinse continue to be the standard protocols for prevention of cross contamination and reduction of bacterial load in aerosols produced during air polishing.[1]

Trends and Future Research

The growing body of research related to the effective removal of subgingival plaque biofilm is a significant advancement in air polishing. Glycine–based powder may become the air–polishing powder of choice due to its low abrasiveness on gingival tissues, tooth structure, restorative materials and its potential to clean both supragingival and subgingival surfaces.[4,6–13,23,31,32,34,35,37] With additional research in this area, glycine has the potential to revolutionize the current dental hygiene recall appointment as we know it.

To use air polishing effectively, clinicians need to be trained in its proper use, the advantages and disadvantages, as well as indications and contraindications for use. Research certainly supports that patients are very accepting of this technology and prefer its use.[4,8,13,16,23]

Conclusion

This literature review has provided evidence of the usefulness of air polishing in contemporary practice. When used by a trained professional, air polishing is safe and effective.[1,8–10,23] New polishing powders, such as glycine, are less abrasive and have the potential to transform the dental hygiene recall appointment for patients with minimal periodontal involvement. The advantage of subgingival biofilm removal that is more effective and efficient than hand instrumentation will have the added benefit of cost–effective, timely delivery of supportive periodontal treatment with the potential of improved treatment outcomes.[4,8–10,12,16,23,37] Future research should continue to explore ways to reduce aerosol production, improve safety for all restorative materials and all patients, regardless of their medical condition.

Sarah J. Graumann, RDH, BS, MDH, currently works in private practice at The Gorman Center for Fine Dentistry, North Oaks, Minnesota. Michelle L. Sensat, RDH, MS, currently works in private practice at Boger Dental, Plymouth, Minnesota. Jill L. Stoltenberg, BSDH, MA, RF, is an associate professor, Division of Dental Hygiene, Department of Primary Dental Care, School of Dentistry, University of Minnesota.

References

1. Gutmann ME. Air polishing: a comprehensive review of the literature. *J Dent Hyg*. 1998;72(3):47–56.

2. Darby, ML, Walsh MM. Management of extrinsic and intrinsic stains. In: Dental Hygiene Theory and Practice. 3rd ed. Saunders; St. Louis. 2010. 511–528 p.

3. White SL, Hoffman LA. A practice survey of hygienists using an air–powder system–An investigation. *J Dent Hyg*. 1991;65:433–437.

4. Petersilka GJ. Subgingival air–polishing in the treatment of periodontal biofilm infections. *Periodontol 2000*. 2011;55(1):124–142.

5. Degrange M. Powder from sub– and supragingival plaque removal using power stream devides. 3M ESPE [Internet]. 2007 [cited 2012 March 30]. Available from: http://www.3mespe.pl/files/infotech/TPP%20Clinpro%20Prophy%20Powder.pdf

6. Pelka M, Trautmann S, Petschelt A, Lohbauer U. Influence of air–polishing devices and abrasives on root dentin–An in vitro confocal laser scanning microscope study. *Quintessence Int*. 2010;41(7):141–148.

7. Pelka MA, Altmaier K, Petschelt A, Lohbauer U. The effect of air–polishing abrasives on wear of direct restoration materials and sealants. *J Am Dent Assoc*. 2010;141(1):63–70.

8. Petersilka GJ, Steinmann D, Häberlein I, Heinecke A, Flemmig TF. Subgingival plaque removal in buccal and lingual sites using a novel low abrasive air–polishing powder. *J Clin Periodontol*. 2003;30(4):328–333.

9. Petersilka G, Faggion CM Jr, Stratmann U, et al. Effect of glycine powder air–polishing on the gingiva. *J Clin Periodontol*. 2008;35(4):324–332.

10. Flemmig TF, Hetzel M, Topoll H, Gerss J, Haeberlein I, Petersilka G. Subgingival debridement efficacy of glycine powder air polishing. *J Periodontol*. 2007;78(6):1002–1010.

11. Petersilka GJ, Tunkel J, Barakos K, Heinecke A, Häberlein I, Flemmig TF. Subgingival plaque removal at interdental sites using a low–abrasive air polishing powder. *J Periodontol*. 2003;74(3):307–311.

12. Flemmig TF, Arushanov D, Daubert D, Rothen M, Mueller G, Leroux BG. Randomized controlled trial assessing efficacy and safety of glycine powder air polishing in moderate–to–deep periodontal pockets. *J Periodontal*. 2012;83(4):444–452.

13. Wennström JL, Dahlén G, Ramberg P. Subgingival debridement of periodontal pockets by air polishing in comparison with ultrasonic instrumentation during maintenance therapy. *J Clin Periodontal*. 2011;38(9):820–827.

14. Frequently asked questions. OSSpray. Sylc™ [Internet]. [cited 2011 June 10]. Available from: http://www.osspray.com/products/Sylc/faq.aspx

15. Sauro S, Watson TF, Thompson I. Dentine desensitization induced by prophylactic and air–polishing procedures: an in vitro dentine permeability and confocal microscopy study. *J Dent*. 2010;38(5):411–422.

16. Banerjee A, Hajatdoost–Sani M, Farrell S, Thompson I. A clinical evaluation and comparison of bioactive glass and sodium bicarbonate air–polishing powders. *J Dent*. 2010;38(6):475–479.

17. Johnson WW, Barnes CM, Covey DA, Walker MP, Ross JA. The effect of a commercial aluminum airpolishing powder on dental restorative materials. *J Prosthodont*. 2004;13(3):166–172.

18. Petersilka GJ, Bell M, Häberlein I, Mehl A, Hickel R, Flemmig TF. In vitro evaluation of novel low abrasive air polishing powders. *J Clin Periodontol*. 2003;30(1):9–13.

19. Botti RH, Bossù M, Zallocco N, Vestri A, Polimeni A. Effectiveness of plaque indicators and air polishing for the sealing of pits and fissures. *Eur J Paediatr Dent*. 2010;11(1):15–18.

20. Barnes CM. An In–depth look at air polishing. *Dimensions*. 2010;8(3)32,34–36,40.

21. Petersilka GJ, Schenck U, Flemmig TF. Powder emission rates of four air polishing devices. *J Clin Periodontol*. 2002;29(8):694–698.

22. Kozlovsky A, Artzi Z, Nemcovsky CE, Hirshberg A. Effect of air–polishing devices on the gingiva: histologic study in the canine. *J Clin Periodontol*. 2005;32(4):329–334.

23. Moëne R, Décaillet F, Andersen E, Mombelli A. Subgingival plaque removal using a new air–polishing device. *J Periodontol*. 2010;81(1):79–88.

24. Ribeiro HZ, Lima JE, Vono BG, Machado MA, da Silva SM. Air polishing effect on bovine enamel and the posterior remineralizing effect of saliva. An in vitro study. *J Appl Oral Sci*. 2006;14(3):193–197.

25. Petersilka GJ, Bell M, Mehl A, Hickel R, Flemming TF. Root defects following air polishing. An in vitro study on the effects of working parameters. *J Clin Periodontol*. 2003;30(2):165–170.

26. Engel S, Jost–Brinkmann PG, Spors CK, Mohammadian S, Müller–Hartwich R. Abrasive effect of air–powder polishing on smooth surface sealants. *J Orofac Orthop*. 2009;70(5):363–370.

27. Parmagnani EA, Basting RT. Effect of sodium bicarbonate air abrasive polishing on attrition and surface micromorphology of ceramic and stainless steel brackets. *Angle Orthod*. 2012;82(2):351–362.

28. Agger MS, Hörsted–Bindslev P, Hovgaard O. Abrasiveness of an air–powder polishing System on root surfaces in vitro. *Quintessence Int*. 2001;32(5):407–411.

29. Pikdoken ML, Ozcelik C. Severe enamel abrasion due to misuse of an air polishing device. *Int J Dent Hyg*. 2006;(4):209–212.

30. Jost–Brinkmann PG. The influence of air polishers on tooth enamel. An in–vitro study. *J Orofac Orthop*. 1998;59:1–16.

31. Tada K, Kakuta K, Ogura H, Sato S. Effect of particle diameter on air polishing of dentin surfaces. *Odontology*. 2010;98(1):31–36.

32. Tada K, Wiroj S, Inatomi M, Sato S. The characterization of dentin defects produced by air polishing. *Odontology*. 2012;100(1):41–46.

33. Arabaci T, Ciçek Y, Ozgöz M, Canakçi V, Canakçi CF, Eltas A. The comparison of the effects of three types of piezoelectric ultrasonic tips and air polishing system on the filling materials: an in vitro study. *Int J Dent Hyg*. 2007;5(4):205–210.

34. Salerno M, Giacomelli L, Derchi G, Patra N, Diaspro A. Atomic force microscopy in vitro study of surface roughness and fractal character of a dental restoration composite after air–polishing. *Biomed Eng Online*. 2010;9:59.

35. Giacomelli L, Salerno M, Derchi G, Genovesi A, Paganin PP, Covani U. Effect of air polishing with glycine and bicarbonate powders on nanocomposite used in dental restorations: An in vitro study. *Int J Periodontics Restorative Dent*. 2001;31(5):e51–56.

36. Wilmes B, Vali S, Drescher D. In–vitro study of surface changes in fixed orthodontic appliances following air polishing with Clinpro Prophy and Air–Flow. *J Orofac Orthop*. 2009;70(5):371–384.

37. Sahm N, Becker J, Santel T, Schwarz F. Non–surgical treatment of peri–implantitis using an air–abrasive device or mechanical debridement and local application of chlorhexidine: a prospective, randomized, controlled clinical study. *J Clin Periodontal*. 2011;38(9):872–878.

38. Tan WK. Sudden facial swelling: subcutaneous facial emphysema secondary to use of air/water syringe during dental extraction. *Singapore Dent J*. 2000;23(1 Suppl):42–44.

39. Arai I, Aoki T, Yamazaki H, Ota Y, Kaneko A. Pneumomediastinum and subcutaneous emphysema after dental extraction detected incidentally by regular medical checkup: a case report. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2009;107(4):33–38.

40. Sekine J, Irie A, Dotsu H, Inokuchi T. Bilateral pneumothorax with extensive subcutaneous emphysema manifested during third molar surgery. A case report. *Int J Oral Maxillofac Surg*. 2000;29:355–357.

41. Uehara M, Okumura T, Asahina I. Subcutaneous cervical emphysema induced by a dental air syringe: a case report. *Int Dent*. 2007;57:28628–8.

42. Frühauf J, Weinke R, Pilger U, Kerl H, Müllegger RR. Soft tissue cervicofacial emphysema after dental treatment: report of 2 cases with emphasis on the differential diagnosis of angioedema. *Arch Dermatol*. 2005;141;1437–1440.

43. Yang SC, Chiu TH, Lin TJ, Chan HM. Subcuteanous emphysema and pneumomediastinum secondary to dental extraction: a case report and literature review. *Kaohisiumg K Med Sci*. 2006;22:641–645.

44. Muzzin K, King T, Berry C. Assessing the clinical effectiveness of an aerosol reduction device for the air polisher. *J Am Dent Assoc*. 1999;130(9):1354–1359.

The Care and Management of Bisphosphonate – Associated Osteonecrosis of the Jaw in the Patient with Multiple Myeloma: A Case Study

Melvin J. Teah, RDH, BS; Sheryl L. Ernest Syme, RDH, MS; Mark Scheper, DDS, PhD; Dianna S. Weikel, RDH, MS

Abstract

Purpose: This is a case study of a patient with multiple myeloma presenting with bisphosphonate–associated osteonecrosis of the jaw after an extraction of tooth #18 while receiving intravenous bisphosphonates. The class of drugs known as bisphosphonates is discussed. The patient's presenting signs and symptoms are reviewed. Bisphosphonate induced osteonecrosis definition, management and professional education are reviewed.

Keywords: Bisphosphonate, osteonecrosis of the jaw, zoledronic acid

This study supports the NDHRA priority area, **Clinical Dental Hygiene Care:** Investigate the links between oral and systemic health.

Introduction

As life expectancy continues to increase, so will the risk of developing a cancer such as Multiple Myeloma (MM). With many people surviving well into their seventh and eighth decades of life, it is very important to understand the unique and complex medical conditions that arise and impact oral health. MM is a hematologic malignancy that may not be well known among dental professionals, and is often characterized by an abnormal proliferation of plasma cells found in the bone marrow. Active proliferation of malignant plasma cells is a strong adverse prognostic factor in multiple myeloma.[1] The accumulation of these cells in multiple anatomical sites gives rise to the name MM. Various methods are used in diagnosing MM, such as bone marrow biopsy, fluorescent in situ hybridization, cytogenetics, electrophoresis, quantitative immunoglobulin and radiographic images of the spine, skull and long bones. According to the National Cancer Institute (NCI), MM is staged by estimating the myeloma tumor cell mass on the basis of the amount of monoclonal myeloma protein (M protein) in the serum and/or urine, along with various clinical parameters, such as hemoglobin and serum calcium concentrations, the number of lytic bone lesions, and the presence or absence of renal failure.[2] Additionally, imaging of the head/neck may be a vital step in the staging of this disease.

Annually, 4 in every 100,000 people are diagnosed with MM in the U.S.[3] Studies have shown that every race is at risk of developing MM, however, African Americans are at a higher risk. MM is more prevalent among males than females and diagnosis occurs most among adults age 65 and older. However, etiology of MM is unknown. Many factors have been associated with its etiology, such as age, gender, race, family history, radiation exposure, obesity and other plasma cell diseases.[2] The purpose of this article is to present the clinical course of a patient diagnosed with MM in 2009 who later developed oral complications secondary to the use of a bisphosphonate (BP) during the maintenance phase of his medical treatment.

Case Report

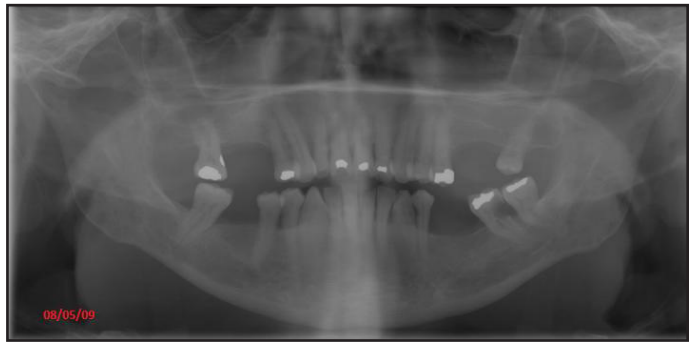
Like many patients presenting with MM, the chief complaint for this patient was severe back pain. Radiographic imaging (MRI) revealed significant bone disease with multiple compression fractures and deformity of the back. The patient attributed his pain to a fall from his motorcycle. He underwent medical intervention at a local spine center in May 2009. An MRI was performed to determine the cause of the patient's pain. Results at that time revealed no signs of MM. The pain eventually progressed and he began experiencing chest pain. He was admitted to a community hospital in June 2009, where he was diagnosed with pneumonia and a CT scan was done which revealed lytic lesions of the bone, specifically the ribs. Additional hematologic workup showed an increased total myeloma protein (M–protein) in the serum. At the time of this hospitalization, his symptoms included coughing and shortness of breath. In addition to pneumonia his MM specific diagnosis was IgA, lambda. The patient underwent 4 cycles of induction chemotherapy with his private oncologist and was referred to the Greenebaum Cancer Center

(a tertiary care facility) for evaluation of possible autologous stem cell transplant in August 2009. After 3 months of treatment his response to therapy was measured. The patient had a very good response, thus he was a candidate for autologous stem cell transplantation. On October 21, 2009, the patient was admitted to the Greenebaum Cancer Center for autologous stem cell transplant. At this time he was treated with additional chemotherapy consisting of Melphalan 200 mg/M2 followed by reinfusion of his previously harvested stem cells. The patient remained hospitalized for 14 days and was discharged as his hematologic status recovered.

Prior to initiation of autologous stem cell transplantation, the patient was evaluated by the Oral Medicine service of the Greenebaum Cancer Center in August 2009. A review of his past medical history included tobacco abuse in the form of cigarettes (1 pack per day, for 5 years), which he quit using in 1980. He is a social drinker and had occupational exposure to automobile chemicals (engine oil, transmission fluid, brake fluid, power steering fluid and engine coolant) from his years of working as an automobile mechanic. Prior to stem cell transplantation, the patient received a single infusion with zoledronic acid (Zometa®; Novartis Pharmaceuticals Corp., East Hanover, NJ). Post stem cell transplant, he has received zoledronic acid monthly for a total of 2 years of BP therapy. During this time he received an oral assessment every 3 months while undergoing care at the Greenebaum Cancer Center. Dental hygiene instrumentation was not performed during the treatment of the bisphosphonate– associated osteonecrosis of the jaw (BON) lesion.

An oral assessment, including soft and hard tissue examination, prior to autologous peripheral blood stem cell transplant was completed in August 2009 and revealed multiple missing teeth (1, 3, 14, 15, 19, 20, 21, 30 and 32) as well as multiple restorations. His dentition was in fair to poor condition and he was at a high risk for dental caries due to inadequate biofilm control, inadequate fluoride use, high fermentable carbohydrate intake and dry mouth. Professionally applied topical fluoride, in the form of gel or varnish, is recommended at 3 to 6 months intervals for patients with increased caries risk.[4] There was moderate supra and subgingival calculus present. Generalized recession also increased his risk of developing root caries. Oral care included brushing once a day with a manual toothbrush and infrequent use of floss. Probing depths revealed generalized 4 to 6 mm pocketing. His periodontal status was classified as moderate to severe, uncontrolled periodontitis with mild to moderate bleeding on probing.

Figure 1: Digital Panoramic Image at Pre–Transplant Oral Medicine Evaluation (Shows Evidence of Radiographic Caries on the Distal Root Surface of Tooth #18)



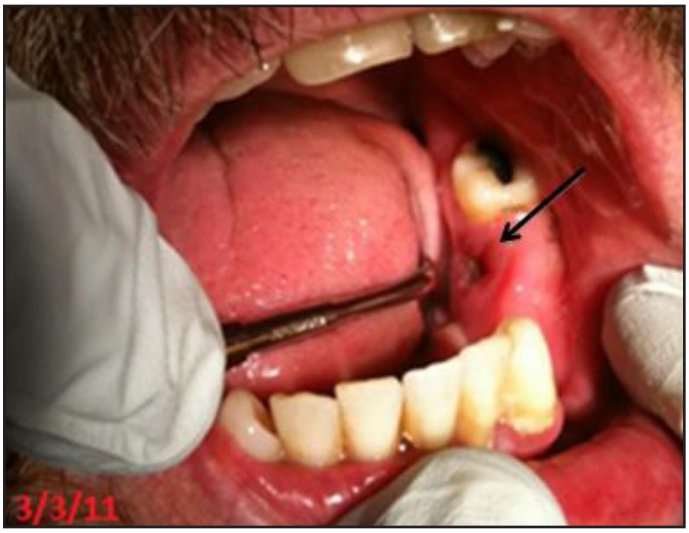
The initial panoramic radiograph exposed on August 5, 2009 revealed evidence of caries on the distal of #18 (Figure 1). Treatment options including root canal therapy or extraction were discussed with the patient. For the prevention and management of BON in patients at risk, the American Academy of Oral Medicine has developed clinical guidelines.[5] The patient was informed of the risk of developing BON post extraction. After considering the risks the patient elected extraction of #18; this was accomplished by his private dentist in September 2009, prior to stem cell transplant. Panoramic radiographs reveal the status of tooth #18 before the extraction (Figure 1) and an area of bony changes about 18 months after the extraction (Figure 2A, 2B).

During one of his routine quarterly oral evaluations on March 3, 2011, an area of exposed bone was visible in the left mandible at the extraction site of #18. The patient was asymptomatic. Antibiotic therapy was initiated. In June 2011, after 12 weeks of antibiotic therapy, including generic amoxicillin (Sandoz Inc., Princeton, NJ) 875 mg, twice daily and generic chlorhexidine oral rinse, 20 ml x30 second's, twice daily, there was no clinical improvement. The site appeared to have increased (6x9 mm) in dimension; however, the patient remained asymptomatic.

An evaluation of the site on September 27, 2011 showed that the area of BON had not healed and the buccal tissue adjacent to the exposed bone appeared enlarged. The antibiotic regimen was changed to include Augmentin® 875 mg (Sandoz Inc. Princeton, NJ) plus 500 mg metronidazole (Flagyl®; Teva Pharmaceuticals, Wales, Penn) to be taken twice daily. Prognosis for the BON lesion was guarded. The necrotic bone in this area started to separate from the mandible following re–epithelization below the bone (Figure 3A) and at 6 months (Figure 3B) shows the lesion was healing. At 7 months the necrotic bone was easily removed by

Figure 2A: Digital Panoramic Image Post Extraction of Tooth #18 (Shows Evidence of BON in the Area Where Tooth #18 Was Extracted)

Figure 2B: Clinical Photograph of BON in the Area of Tooth #18



the Greenebaum Cancer Center's attending dentist and the site was left to heal by secondary intention. A clinical photograph (Figure 3C) at 48 weeks of treatment with antibiotics and antimicrobial mouth rinse revealed resolution of BON. Antibiotics and antimicrobial mouth rinse were discontinued. Currently, the patient continues to receive Zometa infusion quarterly as part of his MM management. Following lesion resolution the patient has received routine dental care including dental hygiene instrumentation with his private dentist.

Discussion

Bone pain, broken bones, weakness, weight loss, fatigue and repeated infections may be signs and symptoms of MM.[6] Oral manifestations such as gingival hemorrhage, odontalgia, paresthesias, tooth mobility and ulcerations may also be present.[7] Referral to a dental professional for comprehensive oral evaluation is important prior to initiation of medical treatment and if oral complications develop during medical treatment.

Figure 3A: Digital Panoramic Image Post Extraction of Tooth #18 (Shows Evidence of BON After 28 Weeks of Antibiotic Therapy, With Sequestrum Developing)

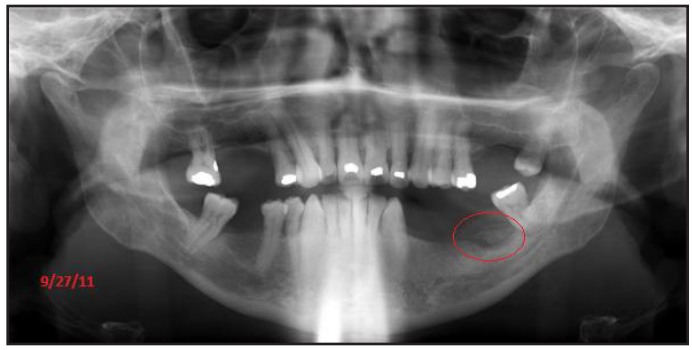


Figure 3B: Clinical Photograph of BON After 28 Weeks of Antibiotic Therapy

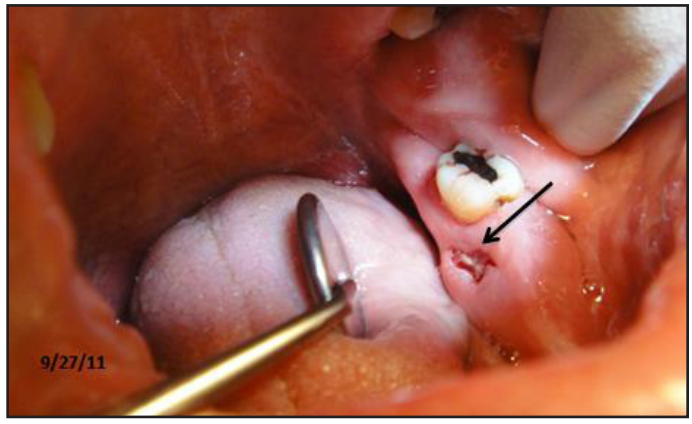
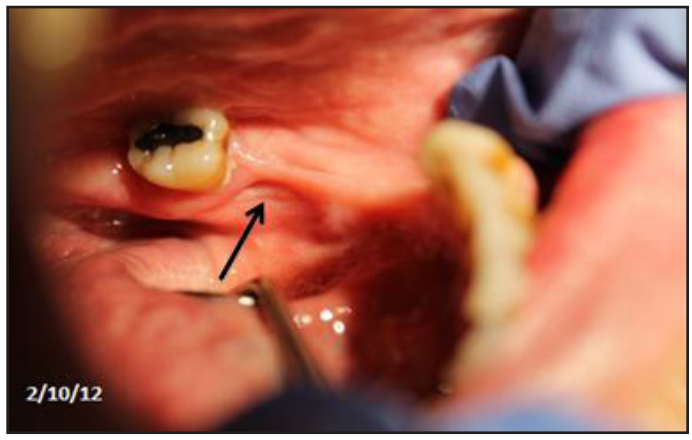


Figure 3C: Clinical Resolution of BON in the Area of Tooth #18 at 48 Weeks



People with MM are living longer which means an increased opportunity for these survivors to present as patients in private dental practices. Increasing survivorship resulting from improved management of MM is partially attributed to the development of new supportive care measures, i.e. medications. BPs are a newer class of drugs utilized in the treatment of many patients with MM and other cancers where metastatic bone disease is present. It works by pre-

venting bone osteoclastic resorption while also increasing bone density. Treatment of MM with BP may result in oral sequelae such as BON. BON is defined by the American Association of Oral and Maxillofacial Surgeons as the presence of exposed bone persisting for more than 8 weeks in the oral cavity of an individual treated with a BP with no prior history of radiation to the head or neck tissues.[8] BON closely resembles the occupational disorder historically referred to as "fossy jaw," whereby workers in match production factories were exposed to white phosphorous during the manufacturing process.[9] A retrospective study conducted by Badros et al evaluated 90 patients diagnosed with MM, and described the medical and dental characteristics of 22 of these patients who developed BON while undergoing intravenous (IV) BP therapy. The authors concluded that BON is an emerging problem in MM patients which affects older patients with myeloma who had received long–term BP therapy.[10] BP is administered either through IV or oral routes, hence creating 2 separate classes of BPs. Patients receiving IV BP are more likely to develop BON than those taking oral BP. The predicted risk of developing BON due to IV BP is 0.16 times the odds of those not receiving IV BP.[10] Table I summarizes current IV BPs in use today.

Table I: Currently approved IV BPs

Intravenous Bisphosphonates			
Brand Names	Generic Names	Manufacturers	Date Approved By FDA
Aredia	Pamidronate	Novartis	August, 1996
Zometa	zolendronic acid	Novartis	August, 2002
Reclast	zolendronic acid	Novartis	August, 2007

Oral manifestations of MM and/or its medical management can only be identified by thorough surveillance of this patient population. Two studies, 1 retrospective and 1 cross–sectional study using 2 different populations were conducted in 2 German neighboring cities with the intention of identifying the prevalence of BON in individuals with MM and comparing it with existing published data. The authors assessed the occurrence of oral manifestations among participants in both studies. They concluded that the prevalence of BON may have been underestimated to date. BON was recorded for nearly 5% (4/81) of the subjects in the retrospective study and nearly 21% (16/78) in the cross–sectional study. An oral examination of all patients in the cross–sectional portion of the study might explain the higher prevalence. Since nearly all patients with BON had an additional trigger factor (previous extraction, surgical dental procedure and the use of chemotherapy and corticosteroid). Routine oral hygiene and dental care might help to reduce BON incidence, especially prior to BP administration.[11]

The number of patients with MM that will develop BON after a period of receiving BP is unknown. Clinically, the reported incidence of BON ranges from 1.3% to 21%, with a higher frequency in the mandible than in the maxilla.[10,12–19] BON occurs in a dose and time dependent manner, with cases being more prevalent in those on IV dosing and for time periods of 10 to 59 months[10,13–17] As in this case, it is most often associated with a dental procedure or trauma, however, many are shown to occur spontaneously.[8,20] The microbial aspects of BON have focused on the uniqueness of the oral cavity where continuous host–microbe interactions take place, leaving behind bacterial smear layers and potentially inducing microenvironment acidosis.[8,20] Additionally, the jaws are a site of constant loading and unloading of the bone underlying an exquisitely thin mucosal layer producing constant bone remodeling attempts and BP accumulation.[21] These unique characteristics of the oral cavity allow for bony exposure, microbial colonial expansion, free BP release and an acidic microenvironment, all of which permit the process to increase bone necrosis, decrease bone regeneration and inhibit healing of soft tissue.[21–24]

Until recently, all of the cases of osteonecrosis of the jaw have been associated with BP therapy. However, new cases are emerging associated with anti–resorptive therapies. These drugs include Denosumab, a monoclonal antibody that selectively binds receptor activator of nuclear factor kappa–B ligand or RANKL, and Bevacizumab, a monoclonal antibody that inhibits angiogenesis through vascular endothelial growth factor (VEGF–A).[25–29] The American Dental Association recently suggested that this clinical finding be described as anti–resorptive osteonecrosis of the jaw or ARONJ, thus including both BP and non–BP drugs.[30] Although these drug–induced lesions appear clinically similar to BON lesions, their developmental mechanism is currently unknown. Further studies are necessary to fully elucidate the pathophysiology of oral lesions secondary to anti–resorptive drugs.

Anyone with poor oral habits who is taking or has taken a BP is at risk of developing BON. Recommendations to minimize the potential for BON in MM patients include maintaining good oral hygiene and frequent oral health assessment. Individuals receiving Zometa are encouraged to have a pre–treatment oral health assessment with a dentist/

dental hygienist with the goal being completion of necessary dental work prior to initiation of BP.[31,32] Dental professionals should evaluate the risk associated with chronic dental disease while providing dental treatment to individuals receiving long term BP therapy for MM. Published treatment strategies for BON depend on the stage of the lesion. Patients without evidence of necrotic bone require no treatment, however, patient education is necessary regarding future risk of developing BON. Antibacterial mouth rinse and quarterly clinical follow–up are recommended to treat asymptomatic exposed and necrotic bone without evidence of infection. Symptomatic exposed necrotic bone treatment recommendation includes antibiotic, oral antibacterial mouth rinse, anesthetics, superficial and or surgical debridement. Though there may be cases that do not respond to these treatments, the American Association of Oral Maxillofacial Surgeons and the American Academy of Oral Medicine have provided these recommendations as guidelines to be used by dental and dental hygiene professionals in the management of BON.[8,11] A multidisciplinary management approach is recommended to ensure optimum treatment and to minimize the risk of BON.

A healthy dentition and an oral cavity free of infection will help reduce the risk of BON. Once established, BON may persist for months or years and treatment is symptomatic in nature. It is important to rule out other medical and/or dental conditions when involved in the management of MM patients. Misdiagnosis may include alveolar osteitis, osteomyelitis and osteoradionecrosis, and symptoms may mimic sinusitis, gingivitis/periodontitis, periapical pathology and temporomandibular joint disorder.[33]

Conclusion

As practicing clinicians involved in oral assessment, dental hygienists are poised to identify and manage the oral health risks of MM patients undergoing systemic treatment. Providing patients with current information related to the risk/benefit of invasive dental treatment in the setting of bisphosphonate and anti–resorptive therapy is a responsibility of the dental hygienist. Collaboration with other disciplines in the treatment of the MM patient is essential in treatment planning and coordinating recommended dental care. The development of BON may lead to delays or adjustments in medical care and/or dental care, either of which may be detrimental to the patient's overall health.

Melvin J. Teah, RDH, BS, works in private practice in Baltimore. Sheryl L. Ernest Syme, RDH, MS, is an associate professor, Division of Dental Hygiene, Department of Periodontics, University of Maryland School of Dentistry, Baltimore. Mark Scheper, DDS, PhD, works in private practice in Baltimore. Dianna S. Weikel, RDH, MS, is an associate professor, Department of Oncology and Diagnostic Sciences, University of Maryland School of Dentistry and Greenebaum Cancer Center, Baltimore.

References

1. Hose D, Rème T, Hielscher T, et al. Proliferation is a central independent prognostic factor and target for personalized and risk–adapted treatment in multiple myeloma. *Haematologica*. 2011;96(1):87–95.

2. Plasma Cell Neoplasms (Including Multiple Myeloma) Treatment: Health Professional Version. National Cancer Institute [Internet]. [cited 2011 April 4]. Available from: http://www.cancer.gov/cancertopics/pdq/treatment/myeloma/Patient

3. Kyle RA. Plasma cell disorder: Hematologic Diseases. In: Goldman L, Bennett CL. Cecil Textbook of Medicine. 21st ed. Philadelphia: WB Saunders Company; 2000. p. 977–980.

4. American Dental Association Council on Scientific Affairs. Professionally applied topical fluoride: Evidence–based clinical recommendations. *J Am Dent Assoc*. 2006;137(8):1151–1159.

5. Walter C, Al–Nawas B, Frickhofen N, et al. Prevalence of bisphosphonate associated osteonecrosis of the jaws in multiple myeloma patients. *Head Face Med*. 2010;6:11.

6. What you need to know about multiple myeloma. National Cancer Institute [Internet]. [cited 2008 Nov 16]. Available from: http://www.cancer.gov/cancertopics/wyntk/myeloma

7. Vieira–Leite–Segundo A, Lima Falcão MF, Correia–Lins Filho R, Marques Soares MS, López López J, Chimenos Küstner E. Multiple Myeloma with primary manifestation in the mandible: A case report. *Med Oral Patol Oral Cir Bucal*. 2008;13(4):232–234.

8. Ruggiero SL, Dodson TB, Assael LA, et al. American Association of Oral and Maxillofacial Surgeons position paper on bisphosphonate–related osteonecrosis of the jaws––2009 update. *J Oral Maxillofac Surg*. 2009;67(5):2–12.

9. Pickett FA, American Academy of Oral Medicine. Bisphosphonate–associated osteonecrosis of the jaw: A literature review and clinical practice guidelines. *J Dent Hyg*. 2006;80(3):10.

10. Badros A, Weikel D, Salama A, et al. Osteonecrosis of the jaw in multiple myeloma patients: Clinical features and risk factors. *J Clin Oncol*. 2006:24(6):945–952.

11. Migliorati CA, Casiglia J, Epstein J, Jacobsen PL, Siegel MA, Woo SB. Managing the care of patients with bisphosphonate–associated osteonecrosis. An American Academy of Oral Medicine position paper. J *Am Dent Assoc*. 2005;136(12):1658–1668.

12. Walter C, Al–Nawas B, Grötz KA, et al. Prevalence and risk factors of bisphosphonate–associated osteonecrosis of the jaw in prostate cancer patients with advanced disease treated with zoledronate. *Eur Urol*. 2008;54(5):1066–1072.

13. Bagan JV, Jimenez Y, Murillo J, et al. Jaw osteonecrosis associated with bisphosphonates: multiple exposed areas and its relationship to teeth extractions. Study of 20 cases. *Oral Oncol*. 2006;42(3):327–329.

14. Bamias A, Kastritis E, Bamia C, et al. Osteonecrosis of the jaw in cancer after treatment with bisphosphonates: incidence and risk factors. *J Clin Oncol*. 2005;23(34):8580–8587

15. Mavrokokki T, Cheng A, Stien B, Goss A. Nature and frequency of bisphosphonate–associated osteonecrosis of the jaws in Australia. *J Oral Maxillofac Surg*. 2007;65(3):415–423

16. Woo SB, Hellstein JW, Kalmar JR: Narrative [corrected] review: bisphosphonates and osteonecrosis of the jaws. *Ann Intern Med*. 2006;144(10):753–761.

17. Aragon–Ching JB, Ning YM, Chen CC, et al. Higher incidence of osteonecrosis of the jaw (ONJ) in patients with metastatic castration resistant prostate cancer treated with anti–angiogenic agents. *Cancer Invest*. 2009;27(2):221–226.

18. Boonyapakorn T, Schirmer I, Reichart PA, Sturm I, Massenkeil G. Bisphosphonate–induced osteonecrosis of the jaws: prospective study of 80 patients with multiple myeloma and other malignancies. *Oral Oncol*. 2008;44(9):857–869.

19. Advisory Task Force on Bisphosphonate–Related Ostenonecrosis of the Jaws, American Association of Oral and Maxillofacial Surgeons. American Association of Oral and Maxillofacial Surgeons position paper on bisphosphonate–related osteonecrosis of the jaws. *J Oral Maxillofac Surg*. 2007;65(3):369–376.

20. Borrás–Blasco J, Rosique–Robles D, Giner–Marco V, Galan–Brotons A, Casterá E, Costa S. Possible delayed onset of osteonecrosis of the jaw in association with zoledronic acid. A case report. *J Clin Pharm Ther*. 2007;32(6):651–654.

21. Goffinet M, Thoulouzan M, Pradines A, et al. Zoledronic acid treatment impairs protein geranyl–geranylation for biological effects in prostatic cells. *BMC Cancer*. 2006;6:60.

22. Luckman SP, Hughes DE, Coxon FP, Graham R, Russell G, Rogers MJ. Nitrogen–containing bisphosphonates inhibit the mevalonate pathway and prevent post–translational prenylation of GTP–binding proteins, including ras. *J Bone Miner Res*. 1998;13(4):581–589

23. Sedghizadeh PP, Kumar SK, Gorur A, Schaudinn C, Shuler CF, Costerton JW. Identification of microbial biofilms in osteonecrosis of the jaws secondary to bisphosphonate therapy. *J Oral Maxillofac Surg*. 2008;66(4):767–775.

24. Weitzman R, Sauter N, Eriksen EF, et al. Critical review: updated recommendations for the prevention, diagnosis, and treatment of osteonecrosis of the jaw in cancer patients––May 2006. *Crit Rev Oncol Hematol*. 2007;62(2):148–152.

25. Taylor KH, Middlefell LS, Mizen KD. Osteonecrosis of the jaws induced by anti–RANK ligand therapy. *Br J Oral Maxillofac Surg*. 48(3):221–223.

26. Kyrgidis A, Toulis KA. Denosumab–related osteonecrosis of the jaws. *Osteoporos Int*. 2011;22(1):369–370.

27. Aghaloo TL, Felsenfeld AL, Tetradis S. Osteonecrosis of the jaw in a patient on Denosumb. *J Oral Maxillofac Surg*. 2010;68(5):959–963.

28. Migliorati CA, Covington JS 3rd. New oncology drugs and osteonecrosis of the jaw (ONJ). *J Tenn Dent Assoc*. 2009;89(4):36–38.

29. Estilo CL, Fornier M, Farooki A, Carlson D, Bohle G 3rd, Huryn JM. Osteonecrosis of the jaw related to bevacizumab. *J Clin Oncol*. 2008;26(24):4037–4038.

30. Hellstein JW, Adler RA, Edwards B, et al. Managing the care of patients receiving antiresorptive therapy for prevention and treatment of osteoporosis: executive summary of recommendations from the American Dental Association Council on Scientific Affairs. *J Am Dent Assoc*. 2011;142(11):1243–1251.

31. Ripamonti CI, Maniezzo M, Campa T, et al. Decreased occurrence of osteonecrosis of the jaw after implementation of dental preventive measures in solid tumour patients with bone metastases treated with bisphosphonates. The experience of the National Cancer Institute of Milan. *Ann Oncol*. 2009;20(1):137–145.

32. Dimopoulos MA, Kastritis E, Bamia C, et al. Reduction of osteonecrosis of the jaw (ONJ) after implementation of preventive measures in patients with multiple myeloma treated with zoledronic acid. *Ann Oncol*. 2009;20(1):117–120.

33. Khosla S, Burr D, Cauley J, et al. Bisphosphonate–Associated Osteonecrosis of the Jaw: Report of a Task Force of the American Society for Bone and Mineral Research. *J Bone Miner Res*. 2007;22(10):1479–1491.

Obstructive Sleep Apnea in Association with Periodontitis: a Case–Control Study

Nuha Ejaz Ahmad, BSDH, MSDH; Anne E. Sanders, PhD; Rose Sheats, DMD, MPH; Jennifer L. Brame, MSDH; Greg K. Essick, DDS, PhD

Abstract

Purpose: Periodontitis is associated with several cardio–metabolic disorders that are co–morbid with sleep–disordered breathing. A relationship between periodontitis and obstructive sleep apnea (OSA) is plausible, but has received little attention. This study investigated the strength of association between periodontitis and risk for OSA.

Methods: In this case–control study, cases had moderate or severe periodontitis (n=50, 32.5%) and controls had gingivitis or slight periodontitis (n=104, 67.5%). Sixty–one males (39.6%) and 93 females (60.4%) with a mean age of 61 years were sampled from the dental hygiene preventive care clinic in the School of Dentistry at the University of North Carolina at Chapel Hill between February and April 2011. Patients received a full mouth periodontal examination that included probing pocket depths and clinical attachment levels at 6 sites per tooth. The case definition for moderate or severe periodontitis was that of the American Dental Association (ADA). Risk for OSA was determined by the 4 item "STOP" OSA screening questionnaire, which assesses self–reported snoring, excessive daytime sleepiness, witnessed apnea during sleep and history of hypertension. Demographic, general health and orofacial characteristics were recorded that were considered putative predictors of either periodontitis or OSA. A multivariate binary logistic regression assessed odds of moderate or severe periodontitis according to OSA risk with adjustment for potential confounders.

Results: In all, 59 patients (38.3%) screened at high risk for OSA by providing 2 or more affirmative responses on the STOP questionnaire. Sixty percent of periodontitis cases (n=30) screened high risk of OSA compared with only 28% of controls (n=29). Cases were 4.1 times more likely (95% CI: 1.9, 11.4) to be at high risk for OSA than controls (p=0.007) after adjustment for potential confounders.

Conclusion: A significant association was observed between moderate or severe periodontitis and risk for OSA.

Keywords: obstructive sleep apnea, periodontitis, STOP questionnaire, epidemiology, human

This study supports the NDHRA priority area, **Clinical Dental Hygiene Care:** Investigate the links between oral and systemic health.

Introduction

Periodontitis results from an interaction between bacterial infection and host immunological and inflammatory responses. The disease is characterized by destruction of the tooth–supporting tissues leading to the development of periodontal pockets, alveolar bone loss and tooth mobility.[1] Epidemiologic data from NHANES 1999 to 2004 estimate the prevalence of moderate or severe periodontitis among dentate adults aged 20 to 64 years to be 9.3%, and among older adults to be 26.6%.[2]

Periodontitis is a suspected risk factor for low–birth weight and for many systemic diseases, such as cardiovascular disease, stroke, diabetes mellitus, respiratory disease, and rheumatoid arthritis.[3–9] The inflammation surrounding the teeth occurs as the immune system responds to the accumulation of bacterial plaque on the teeth and gums, and is modified by behavioral factors, systemic disease, medications and immune and hematological disorders.[10] Furthermore, the presence of systemic disorders can also affect the efficacy of periodontal therapy.[10]

The prevalence and severity of periodontitis increases with age, and is greater among male than female adults and greater in adults with low socio–economic status (SES) relative to their higher SES counterparts.[11–13] Obesity, nasal breathing difficulty, cigarette smoking and alcohol consumption are positively associated with periodontitis.[14–19]

Of most relevance to the present study are findings from a small exploratory study conducted in Australia by Gunaratnam, et al.[20] The investigators reported a significant positive relationship between polysomnography–derived apnea hypopnea index with less than 5 events/hour and periodontitis.[20] In that study, the case definition of moderate or severe periodontitis was that of the Centers for Disease Control and Prevention and the American Academy of Periodontology (CDC/AAP), which defines moderate or severe periodontitis as the presence of two or more interproximal sites with ≥4 mm clinical attachment level, not on the same tooth, or 2 or more interproximal sites with periodontal pocket depth ≥5 mm, not on the same tooth.[10] The investigators found that the prevalence of periodontitis was 77% in the study group, which was 4 times the national average for a representative sample of the adult Australian population using the same CDC/AAP periodontitis case classification. The authors suggested that because both obstructive sleep apnea (OSA) and periodontitis share an underlying inflammatory basis, a common biological pathway for the association was plausible. However, the study's findings were limited by a lack of data from a comparison group without OSA.[20]

OSA is the most common form of sleep–disordered breathing, estimated to affect 18 million individuals in the U.S,[21] Data from the Wisconsin Cohort Study indicates that the prevalence of OSA in people between the ages of 30 and 60 years was 9% to 24% for men and 4% to 9% for women.[22] Characterized by repetitive full or partial collapse of the upper airway, OSA results in periods of asphyxia, hypoxia, arousal from sleep, stimulation of the sympathetic nervous system and altered immunity.[23–25] Clinically, the condition frequently presents as habitual loud snoring, apnea witnessed by a bed partner, arousal during sleep and sleepiness and fatigue during the day.[26] As a life–threatening condition, OSA is associated with hypertension, congestive heart failure, coronary artery disease, myocardial infarction, cardiac arrhythmia, stroke, impaired glucose tolerance and type II diabetes mellitus.[27–32]

Shared risk factors for periodontitis and OSA include male sex, older age, obesity, oral breathing, cigarette smoking and alcohol consumption.[33–39] OSA is formally diagnosed during an overnight sleep study using polysomnography to grade the severity of the disorder according to the frequency of airway collapse, expressed as the apnea–hypopnea index.[40] However, screening tools exist that assess an individual's risk for OSA in various, often pre–surgical, settings.[23,41]

Given the reported high prevalence of periodontitis in patients with confirmed OSA, the current study questioned whether the prevalence of OSA was associated with the severity of periodontitis. To address this question, the risk for OSA in patients with different degrees of periodontitis severity as determined during the patients' scheduled dental visit was evaluated. The risk for OSA was assessed using the STOP questionnaire, a validated screening questionnaire.[41] Data was obtained for potentially confounding factors, such as age and gender, which are associated with increased risk for periodontitis and/or OSA.

Methods and Materials

Study Design

In this case control study, cases had moderate or severe periodontitis (case types III and IV). Dentate patients having gingivitis or slight (early) periodontitis (case types I and II) were classified as controls (Table I).

Study Population and Recruitment Procedures

Study participants were patients treated between February and April 2011 in the dental hygiene preventive care clinic at the University of North Carolina (UNC) School of Dentistry. Inclusion criteria were being dentate and aged 18 years or older. Edentulous patients and patients with healthy periodontium were excluded from participation. Potential patients were approached by the first author (hereafter referred to as the investigator) after the patients' scheduled dental cleaning was completed by the assigned dental hygiene student. Each patient was given a brief description of the study along with educational materials on OSA, after which verbal consent was obtained. The protocol was approved by the Institutional Review Board at the UNC–Chapel Hill.

Data collection

Following consent, each patient completed a sociodemographic/behavioral questionnaire while the investigator completed a clinical characteristics questionnaire. Both questionnaires were processed using Cardiff TeleForm® (version 10.5.1© 2010 Verity, Inc.), an optical scanning system that efficiently transfers penciled information to an electronic format for statistical analysis.[42] The questionnaires were designed to obtain data for this study as well as for a separate analysis of sociodemographic and clinical characteristics associated with high risk of OSA, an analysis that is not included in this publi-

Table I: Periodontal Case Type Definition

Healthy Periodontium, Type N	Gingivitis Type I	Slight* Periodontitis Type II	Moderate Periodontitis Type III	Severe Periodontitis Type IV
• No alveolar bone loss • Healthy gingiva and alveolar bone level • No bleeding • 1 to 2 mm probing depths	• No alveolar bone loss • Bleeding and/or suppuration may be present • 2 to 3 mm probing depths	• Slight attachment loss • Slight bone loss is evident, especially in alveolar crest • 3 to 4 mm probing depths	• Moderate alveolar bone and attachment loss • 5 to 6 mm probing depths	• Severe alveolar bone and attachment loss • 7+ mm probing depths
• No clinical attachment loss (CAL)	• No clinical attachment loss (CAL)	• 1 to 2 mm clinical attachment loss (CAL)	• 3 to 4 mm clinical attachment loss (CAL)	• Greater than or equal to 5 mm clinical attachment loss (CAL)
• No mobility • No furcation	• No mobility • No furcation	• No mobility • No furcation	• Mobility is possible • Furcation involvement is possible	• Mobility is possible • Furcation involvement is possible
Please Note: Periodontal classification is based on clinical and radiographic findings. Findings must be generalized in order to be classified in a higher case type. localized: <30% of sites involved generalized: >30% of sites involved				

*Note that the American Dental Association (ADA) uses the term "early" in the definition of case–type II periodontitis, where the School of Dentistry at the University of North Carolina at Chapel Hill uses the term "slight " in the definition of case–type II periodontitis

cation. No identifying data was included on either questionnaire.

Sociodemographic/Behavioral Questionnaire

The questionnaire was used to obtain information about the patient's age, gender, weight, height, education, annual household income, sleep quality (snoring, observed apnea, tiredness during the day, Epworth Sleepiness Scale,[43] teeth grinding and nasal–breathing difficulty), social habits (smoking, alcohol and sedative consumption before bedtime) and medical history (high blood pressure, diabetes mellitus, previous diagnosis with OSA or any form of sleep–disordered breathing and any previous or current treatment for OSA).

Clinical Characteristics Questionnaire

The investigator completed this questionnaire, recording relevant clinical observations, some of which were directly observed by the investigator. Other items were observations made by the dental hygiene student, confirmed by the clinical instructor and recorded in the patient's dental chart, from which the investigator extracted pertinent information. On the questionnaire, physical measurements were recorded of the patient's blood pressure (taken by the assigned dental hygiene student), body–mass index (BMI) (calculated by the investigator using the patient's self–reported weight and height) and neck circumference (measured by the investigator using a disposable tape measure). Observations of the oral soft tissue included the presence of dry mouth (as assessed by the moistness of the oral mucosa, and whether the mouth mirror easily stuck to the buccal mucosa as reported by the dental hygiene student[44]), the presence of macroglossia or large tongue (as assessed by the investigator examining the lateral and anterior borders of the tongue)[45] and the Mallampati score and tonsils grade, both of which were assessed by the investigator while the patient was in a seated position, with the head in full extension, the tongue out and with phonation.[46–48] Observations of oral hard tissue included the attrition of teeth (as measured by the investigator using the Basic Erosive Wear Examination using the highest score per sextant),[49] overjet (as measured by the dental hygiene student using a calibrated dental probe) and the morphology of the maxillary arch (as assessed by the investigator observing the shape of the hard palate).

The remaining items (approximately half) on the clinical characteristics questionnaire pertained to the patient's periodontal status. Recorded periodontal indices included the Plaque Index, Gingival Index and Bleeding Index (all of which were measured by the dental hygiene student).[50] Periodontal measurements, also assessed by the dental hygiene student using a calibrated probe, included the peri-

Table II: Percent of Periodontitis Cases According to Number of Affirmative Responses on the STOP Obstructive Sleep Apnea Screening Questionnaire

Number of affirmative responses to STOP items	Gingivitis or slight periodontitis (%)	Moderate or severe periodontitis (%)	p–value
0	77.1	22.9	0.002
1	80.0	20.0	
2	52.4	47.6	
3	46.7	53.3	
4	0.0	100.0	

odontal pocket depth (the distance from the gingival margin to the base of the pocket) and gingival recession (the distance from the cemento–enamel junction to the gingival margin). The patient's periodontal case classification, based on a detailed clinical periodontal charting with radiographic interpretation of the bone levels as prescribed by the American Dental Association, was obtained directly from the patients' chart.[51] Based primarily on the severity of attachment loss, the patient was classified into 1 of 4 categories: case type I: gingivitis, case type II: slight (early) periodontitis, case type III: moderate periodontitis or case type IV: advanced (severe) periodontitis (Table I).

Data Analysis and Statistical Methods

Using relevant patient–reported responses to the Symptom/Health Questionnaire, the patient's risk of OSA was calculated as described for the validated OSA screening instrument known as STOP questionnaire. The 4 questions assess the presence of loud snoring, frequent daytime sleepiness and tiredness, observed apnea during sleeping and high blood pressure. Responses to each question are "Yes" or "No." According to the questionnaire's scoring algorithm, affirmative responses to any 2 or more of these 4 questions denotes high risk for OSA, while affirmative responses to fewer than 2 questions denotes low risk for OSA.

Descriptive statistics summed the number of patients responding affirmatively to none, 1, 2, 3 or 4 of the STOP OSA screening items. The number and proportion of patients at high risk for OSA were calculated. Exploratory analyses were performed to describe the distribution of affirmative responses to each of the 4 STOP OSA screening items. The association between the study population's socio–demographic, behavioural and clinical characteristics and risk for OSA was tested for statistical significance using Fisher's exact test for dichotomized risk indicators and Pearson's chi–square test for categorical risk indicators. Potential covariates were limited to characteristics that have been associated with risk of periodontitis and/or OSA: gender, age, BMI, educational attainment, annual household income, cigarette smoking, alcohol/sedative consumption before bed, diabetes mellitus, impaired nasal breathing and dry mouth.

Covariates were included in multivariable binary logistic regression models if their associations in unadjusted analyses with either outcome, OSA risk or periodontitis, were significant at the $p<0.2$ level. Multivariable binary logistic regression was used to estimate the odds ratio and 95% confidence interval associating moderate/severe periodontitis with high risk for OSA with adjustment for confounding. Analyses were conducted using STATA/IC software version 12.0 (StataCorp. 2011).

Results

The study population of 154 patients comprised 50 cases (32.5%) and 104 controls (67.5%). Based on the STOP questionnaire, 38.3% of study patients were at high risk for OSA, providing affirmative responses to 2 items (27.7%), 3 items (9.7%) or all 4 items (1.2%). The likelihood of being classified a case increased with the number of affirmative responses ($p=0.002$, Table II), suggesting a crude association between OSA and periodontitis.

A higher percentage of cases than controls were at high risk for OSA for each STOP questionnaire item (Table III). Moreover, cases and controls differed significantly on the report of high blood pressure ($p=0.006$) and tiredness/sleepiness during the day ($p=0.016$). The proportion of cases was almost twice that of controls for these 2 STOP questionnaire items.

Univariate Analyses

Univariate analyses were undertaken to determine if each of 8 characteristics was associated with the risk of OSA (Table IV). A significant positive association was observed with age ($p=0.018$), self–reported diabetes mellitus ($p=0.008$) and dry mouth ($p=0.002$).

Table III: Response to Individual Items on the STOP OSA Screening Questionnaire[a] and Relationship With Periodontitis Case Status

	STOP screening questionnaire items	Response	n (%)	Moderate or severe periodontitis (%)	p–value[b]
S	Do you snore loudly?	No	124 (80.5)	29.8	0.157
		Yes	30 (19.5)	43.3	
T	Do you often feel tired, fatigued, or sleepy during the day?	No	83 (53.9)	24.1	0.016
		Yes	71 (46.1)	42.3	
O	Has anyone observed you stop breathing during your sleep?	No	132 (85.7)	31.1	0.361
		Yes	22 (14.3)	40.9	
P	Do you have or are you being treated for high blood pressure?	No	80 (51.9)	22.5	0.006
		Yes	74 (48.1)	43.2	

a – The STOP questionnaire classifies persons as high risk for OSA with affirmative responses to ≥2 STOP questions; low risk is defined as <2 affirmative responses
b – p–value tests the null hypothesis that no difference exists between response to the OSA screening question and periodontitis case status

Univariate analyses were undertaken to determine if each of the 10 characteristics was associated with moderate or severe periodontitis (Table V). Odds ratios of moderate or severe periodontitis increased with age, more prevalent among current cigarette smokers and diabetic patients.

Multivariable Analyses

A multivariate binary logistic regression was performed with case status (1=case, moderate or severe periodontitis, 0=control, gingivitis or slight periodontitis) as the dependent variable. Independent variables were those patient characteristics that met criteria based on the univariate analyses (Table VI). It was found that patients at high risk of OSA had 4.1 times greater odds (95% CI: 1.5, 11.4) of moderate or severe periodontitis than patients at low risk, after adjustment for potential confounders. Significant covariates included age, smoking and nasal–breathing difficulty. Diabetic patients had 2.7 times greater odds for having moderate or severe periodontitis, but the 95% confidence interval was equivocal (0.6, 11.4).

Discussion

The results of this study extend the finding of Gunaratnam et al that prevalence of periodontitis may be higher in patients with OSA.[20] Specifically, the present study suggests that odds of moderate or severe periodontitis were elevated 4.1–fold (95% CI: 1.5, 11.4) among patients screening high risk relative to low risk for OSA after adjustment for potential confounders. The 2 studies, however, differ in a number of ways. Gunaratnam et al studied patients who were clinically diagnosed with OSA.[20] In contrast, the current study compared periodontitis cases and controls and estimated their risks of OSA using a validated questionnaire.[41] Unlike Gunaratnam et al, it remained unknown whether the patients in the present study, in general, had OSA.[20] In both studies, periodontitis was diagnosed and classified by clinical examination. While findings of both studies suggest that the prevalence of periodontitis is greater in patients with OSA, the case control study design used in the present study provided a higher level of evidence in support of this association.

Mechanisms Underlying Association Between Periodontitis and OSA

Gunaratnam et al suggested that the increased prevalence of periodontitis in OSA patients could be due to a true association between OSA and periodontitis: OSA could act as an inflammatory mediator for periodontitis or vice versa.[20] It is also possible that an increased prevalence of mouth breathing in patients with OSA could exacerbate periodontitis and underlie the association.[20] However, in the present study, there was no association between the presence of dry mouth and periodontitis. Moreover, patients who reported more difficulty with nasal breathing (presumably favoring oral to nasal breathing) were less likely to exhibit moderate or severe periodontitis. Given that periodontitis and OSA are co–morbid with a large number of pathological conditions, it is also possible that their association is not causative but rather a reflection of their relationship to these common co–morbid conditions.[20]

Confounding variables

The multivariable analysis took into account a number of factors that have been associated with

Table IV: Relationship of study participant characteristics and high risk for obstructive sleep apnea[a]

Characteristic	n (%)	Percent with High Risk OSA	p–value
Total	154 (100.0)	38.3	
Gender			
• Female • Male	93 (60.4) 61 (39.6)	37.6 39.3	0.831
Age (years)			
• 18 to 49 • 50 to 59 • 60 to 69 • ≥70	32 (20.8) 26 (16.9) 49 (31.8) 47 (30.5)	15.6 34.6 46.9 46.8	0.018
BMI (kg/m2)[b]			
• Underweight/normal • Overweight • Obese • Missing	53 (34.4) 52 (33.8) 47 (30.5) 2 (1.3)	26.4 44.2 42.6 –	0.117
Cigarette smoking status			
• Current • Former • Never • Missing	10 (6.5) 64 (41.6) 77 (50.0) 3 (2.0)	30.0 35.9 41.6 –	0.675
Alcohol/sedatives before bed			
• Yes • No • Missing	126 (81.8) 27 (17.5) 1 (0.7)	38.1 40.7 –	0.798
Self–reported diabetes status			
• No diabetes • Diabetes	134 (87.0) 20 (13.0)	34.3 65.0	0.008
Nasal breathing status			
• No difficulty • Difficulty • Missing	138 (89.6) 15 (9.7) 1 (0.7)	39.1 33.3 –	0.661
Dry mouth			
• No dry mouth • Dry mouth	115 (74.7) 39 (25.3)	31.3 59.0	0.002

a – The STOP questionnaire classifies persons as high risk for OSA with affirmative responses to ≥2 questions; low risk is defined as <2 affirmative responses
b – World Health Organization International Classification: underweight (<18.50); normal (18.50–24.99); overweight (25.00–29.99); obese (≥30.00)

periodontitis, some of which have also been associated with sleep–disordered breathing. These are briefly discussed in the sections below in the order observed in Table VI.

Gender: Although the present study did not demonstrate a significant association between gender and the severity of periodontitis, several studies have reported that the prevalence of periodontitis is greater in males than in females.[11,12] For example, Albandar et al reported that in individuals 30 to 54 years of age, a prevalence of periodontitis was found in 34% of males but only 23% of females.[11] In individuals 55 to 90 years of age, the prevalence was 56% in males and 44% in females.[11]

Age: Age is an important risk factor for periodontitis in many studies. Both the prevalence and extent of periodontitis increase with age.[11] For example, Albanadar et al showed that 29% of persons in the aged 30 to 54 years old had periodontitis, compared with 50% aged 55 to 90 years old.[11] The present study confirmed a positive association between age and periodontitis and found that patients

Table V: Relationship of Study Participant Characteristics and the Presence of Moderate or Severe Periodontitis

Characteristic	n (%) with moderate or severe periodontitis	Odds ratio for moderate or severe periodontitis	95% CI
Total	50 (32.5)		
Gender			
• Female	27 (29.0)	Ref	–
• Male	23 (37.7)	1.48	0.75, 2.93
Age (years)			
• 18–49	6 (18.8)	Ref	–
• 50–59	4 (15.4)	0.78	0.20, 3.15
• 60–69	13 (26.5)	1.56	0.52, 4.6
• ≥70	27 (57.5)	5.85	2.02, 16.87
BMI (kg/m2)[a]			
• Underweight/normal	14 (26.4)	Ref	–
• Overweight	17 (32.7)	1.35	0.58, 3.14
• Obese	18 (38.3)	1.73	0.74, 4.04
Cigarette smoking status			
• Current	5 (50.0)	2.35	0.62, 8.90
• Former	22 (34.4)	1.23	0.60, 2.50
• Never	23 (29.9)	Ref	–
Alcohol/sedatives before bed			
• Yes	44 (34.9)	Ref	–
• No	6 (22.2)	0.53	0.20, 1.42
Self–reported diabetes status			
• No diabetes	96 (71.6)	Ref	–
• Diabetes	8 (40.0)	3.79	1.44, 10.00
Nasal breathing status			
• No difficulty	49 (35.5)	Ref	–
• Difficulty	1 (6.7)	0.13	0.02, 1.02
Dry mouth			
• No dry mouth	36 (31.3)	Ref	–
• Dry mouth	14 (35.9)	1.23	0.57, 2.64
Educational attainment			
• <College	29 (35.4)	Ref	–
• ≥College	21 (29.2)	0.75	0.38, 1.49
Annual household income (USD)			
• <50,000	28 (37.3)	Ref	–
• ≥50,000	15 (25.0)	0.56	0.26, 1.18

a – World Health Organization International Classification: underweight (<18.50), normal (18.50 to 24.99), overweight (25.00 to 29.99) and obese (≥30.00)

who were 70 years and older had 1.76 times greater odds (95% CI: 1.17–2.64) of moderate or severe periodontitis than patients who were between 18 to 49 years old.

BMI: The present study did not find a significant association between BMI and the severity of periodontitis. This stands in contrast to reported findings by other investigators.[14,15] Chaffee conducted a systematic review and meta analysis of 57 independent studies on the association between BMI and periodontitis, and identified a slight linear increase in the odds of periodontitis with increasing BMI.[14]

Cigarette smoking status: This study demonstrated a significant association between current cigarette smoking and the severity of periodontitis, where current smokers had 24.9 times greater odds

Table VI: Multivariate Binary Logistic Regression Modelling Odds of Moderate or Severe Periodontitis With 95% Confidence Interval (95% CI), (n=132)

	Odds ratio	95% CI
Male gender (ref=female)	1.78	0.64, 4.94
Age in decades[a]	1.76	1.17, 2.64
Body mass index (continuous variable)	1.06	0.96, 1.16
Current smoker (ref=never smoked)	24.68	3.19, 191.20
Former smoker (ref=never smoked)	0.72	0.24, 2.11
Alcohol/sedative before bed (ref=no alcohol/sedative)	0.72	0.19, 2.71
Diabetes (ref=no diabetes)	2.70	0.64, 11.37
Nasal breathing difficulty (ref=no difficulty)	0.09	0.01, 0.88
Dry mouth (ref=no dry mouth)	0.36	0.10, 1.39
Educational attainment ≥college (ref≤college)	0.63	0.22, 1.82
Annual household income ≥$50,000 (ref≤USD$50,000)	0.63	0.24, 1.63
High risk for obstructive sleep apnea on STOP questionnaire (ref=low risk)	4.11	1.48, 11.45
Constant	0.00	0.00, 0.18

a – Age measured in years is not substantively meaningful; hence age was rescaled in units of 10 to denote decade–sized units

(95% CI: 3.2–191.2) of having moderate or severe periodontitis than those who never smoked. The lack of precision was attributed to the small sample size. A similar finding has been observed by many previous epidemiological studies reporting smoking as a significant risk factor for periodontitis.[18,52] For example, Bergström found that smokers have 2.5 to 3.5 times greater risk of severe periodontal attachment loss than never smokers.[52]

Alcohol/Sedative use Before Bedtime: Although the current study did not find significant associations between alcohol consumption before bedtime and severity of periodontitis, several studies have suggested that alcohol consumption in general, with no restriction to bedtime, is a risk factor for oral diseases, including periodontitis, as it increases the host's susceptibility to infection.[53] The findings in the current study may not have demonstrated an association due to limiting the question to a specific time of day.

Diabetes: The present study found that patients who reported being diabetic had 2.70 times greater odds (95% CI: 0.64–11.37) of having moderate to severe periodontitis than patients who did not report being diabetic. This finding has been supported by many studies that indicate that diabetes and poor glycemic control are significant risk factors for periodontitis and vice versa.[7,54–56]

Nasal Breathing Difficulty (Mouth Breathing): The results of this study indicate that difficulty with nasal breathing favored slight periodontitis or gingivitis rather than moderate or severe periodontitis: Patients with nasal breathing difficulty had 0.09 times the odds (95% CI: 0.01–0.88) of having moderate or severe periodontitis of patients with no nasal breathing difficulty. No studies have addressed the relationship between mouth breathing and periodontitis in adults, however, a relationship has been reported in teenagers.[17]

Dry Mouth: The results of this study did not demonstrate a significant relationship between dry mouth and the severity of periodontitis. Moreover, there is little published evidence to suggest that dry mouth has a direct influence on periodontitis. This may be because saliva does not enter into the periodontal pockets where the bacterial pathogens are located.[57]

Educational attainment: Although this study did not demonstrate a significant association between educational attainment and the severity of periodontitis, a meta–analysis conducted by Boillot concluded that low educational attainment is associated with increased risk for periodontitis.[58]

SES: The results of this study did not demonstrate an association between SES and the severity of periodontitis. However, a significant association has been reported in several studies. Specifically, patients with high SES have been reported to have healthier periodontium than patients with low SES.[13]

An important strength of this study is that peri-

odontitis cases and controls were drawn from the same source population during the same time interval. All patients underwent the same measurements of periodontal health and OSA screening which were performed by the same clinicians. This enhances the principal of comparability, by ensuring less variability and a reduced risk of confounding.

Limitations of Study

This study relied on periodontal data collected by multiple examiners. However, all examiners were calibrated on the periodontal assessment and classification, and the supervising faculty confirmed the assessments before they were entered into the patients' records. Each classification was defined by precise measurements of periodontal pocket depth, clinical attachment level, mobility and/or furcation involvement and by whether these conditions were localized (<30% of the site) or generalized (≥30% of the site). This reduced the risk of case status misclassification.

The major limitation of this study is the uncertainty in the proportions of the cases and controls with and without OSA, respectively. The STOP questionnaire is a measure of risk for sleep apnea but falls short of clinical diagnosis. This questionnaire was developed for the pre–surgical assessment of patients prior to general anesthesia and administration of agents that depress respiration. Its diagnostic usefulness has been determined for patients with different severity levels of OSA based on the apnea hypopnea index. Specifically, its sensitivity and specificity with the apnea hypopnea index cutoff >5 events/hour are estimated to be 65.5% and 60%, respectively, >15 events/hour, 74.3% and 53.3%, and >30 events/hour, 79.5% and 48.6%. Though some other screening questionnaires have been shown to have higher diagnostic sensitivity, such as the STOP–BANG questionnaire,[41] the STOP questionnaire was chosen for this study because of its higher specificity. However, if misclassification of OSA status is non–differential, i.e. unrelated to periodontitis status, which is believed to be the case, then the effect of any misclassification bias is towards the null. What this means is that the odds ratio for the strength of the relationship between OSA risk and periodontitis shifts toward 1.0, making the initial estimate more conservative than it would otherwise be.

Relevance to Dental Hygienists: Patients visit the dental office more frequently than the physician's office. Moreover, dental cleaning is the most common periodically performed procedure in dentistry. One of the dental hygienists' responsibilities is to assess patients' overall well–being as well as to facilitate health promotion, disease prevention and patient education. The STOP screening questionnaire is an easy, time efficient questionnaire that, if included with the health history and periodic recall assessments, could help identify patients at high risk for a serious life–threatening condition. Moreover, the dental hygienist is optimally positioned in the dental practice to make soft tissue observations that have been associated with increased risk for OSA. By screening patients for sleep–disordered breathing, the dental hygienist supports the practice in fulfilling a greater role in the public health of the community.[21,59,60]

Conclusion

This case–control study found a positive significant association between moderate or severe periodontitis and high risk for OSA, based on the STOP questionnaire, after adjustment for potential confounders. Further investigation of this association using objective measures of OSA (polysomnography or home sleep test) is warranted. The STOP questionnaire is a simple, inexpensive screening tool could be included with the health history forms and used to identify dental patients at high risk for a life–threatening medical condition. Further investigation should include sleep study to confirm the presence or absence of OSA in patients with and without OSA. As well as to further investigate the underlying pathophysiological mechanisms of both conditions that can better explain the significant association.

Nuha Ejaz Ahmad, BSDH, MSDH, currently works at the King Saud University, College of Applied Medical Sciences, Dental Health Department, Riyadh, Saudi Arabia. At the time of this study, she was a graduate student in the Master of Science Degree Program in Dental Hygiene Education at the University of North Carolina. Anne E. Sanders, PhD, is an assistant professor, Department of Dental Ecology. Rose Sheats, DMD, MPH, is a Graduate Program Director, Department of Orthodontics. Jennifer L. Brame, RDH, MSDH, is a Clinical Assistant Professor, Department of Dental Ecology. Greg K. Essick, DDS, PhD, is a Professor, Department of Prosthodontics and Center for Neurosensory Disorders. All four are at the School of Dentistry at the University of North Carolina Chapel Hill.

References

1. Kim J, Amar S. Periodontal disease and systemic conditions: A bidirectional relationship. *Odontology*. 2006;94(1):10–21.

2. Dye BA, Tan S, Smith V, et al. Trends in oral health status: United states, 1988–1994 and 1999–2004. *Vital Health Stat 11*. 2007;(248):1–92.

3. Offenbacher S, Boggess KA, Murtha AP, et al. Progressive periodontal disease and risk of very preterm delivery. *Obstet Gynecol*. 2006;107(1):29–36.

4. Joshipura KJ, Rimm EB, Douglass CW, Trichopoulos D, Ascherio A, Willett WC. Poor oral health and coronary heart disease. *J Dent Res*. 1996;75(9):1631–1636.

5. Pradeep AR, Hadge P, Arjun Raju P, Shetty SR, Shareef K, Guruprasad CN. Periodontitis as a risk factor for cerebrovascular accident: A case–control study in the indian population. *J Periodontal Res*. 2010;45(2):223–228.

6. Mealey BL, Oates TW, American Academy of Periodontology. Diabetes mellitus and periodontal diseases. *J Periodonto*l. 2006;77(8):1289–1303.

7. Preshaw PM, Alba AL, Herrera D, et al. Periodontitis and diabetes: A two–way relationship. *Diabetologia*. 2012;55(1):21–23.

8. El Attar MM, Zaghloup MZ, Elmenoufr HS. Role of periodontitis in hospital–acquired pneumonia. *East Mediterr Health J*. 2010;16(5):563–569.

9. Scardina GA, Messina P. Microvascular periodontal alterations: A possible relationship between periodontitis and rheumatoid arthritis. *Clin Hemorheol Microcirc*. 2007;37(3):229–235.

10. Page RC, Eke PI. Case definitions for use in population–based surveillance of periodontitis. *J Periodontol*. 2007;78(7 Suppl):1387–1399.

11. Albandar JM, Brunelle JA, Kingman A. Destructive periodontal disease in adults 30 years of age and older in the united states, 1988–1994. *J Periodontol*. 1999;70(1):13–29.

12. Desvarieux M, Schwahn C, Völzke H, et al. Gender differences in the relationship between periodontal disease, tooth loss, and atherosclerosis. *Stroke*. 2004;35(9):2029–2035.

13. Chandra Shekar BR, Reddy C. Oral health status in relation to socioeconomic factors among the municipal employees of mysore city. *Indian J Dent Res*. 2011;22(3):410–418.

14. Chaffee BW, Weston SJ. Association between chronic periodontal disease and obesity: A systematic review and meta–analysis. *J Periodontol*. 2010;81(12):1708–1724.

15. Mathur LK, Manohar B, Shankarapillai R, Pandya D. Obesity and periodontitis: A clinical study. *J Indian Soc Periodontol*. 2011;15(3):240–244.

16. Al–Zahrani MS, Bissada NF, Borawskit EA. Obesity and periodontal disease in young, middle–aged, and older adults. *J Periodontol*. 2003;74(5):610–615.

17. Wagaiyu EG, Ashley FP. Mouthbreathing, lip seal and upper lip coverage and their relationship with gingival inflammation in 11–14 year–old schoolchildren. *J Clin Periodontol*. 1991;18(9):698–702.

18. Moimaz SA, Zina LG, Saliba O, Garbin CA. Smoking and periodontal disease: Clinical evidence for an association. *Oral Health Prev Dent*. 2009;7(4):369–376.

19. Amaral Cda S, Luiz RR, Leão AT. The relationship between alcohol dependence and periodontal disease. *J Periodontol*. 2008;79(6):993–998.

20. Gunaratnam K, Taylor B, Curtis B, Cistulli P. Obstructive sleep apnoea and periodontitis: A novel association? *Sleep Breath*. 2009;13(3):233–239.

21. Barsh LI. The recognition and management of sleep–breathing disorders: A mandate for dentistry. *Sleep Breath*. 2009;13(1):1–2.

22. Young T, Finn L, Peppard PE, et al. Sleep disordered breathing and mortality: Eighteen–year follow–up of the wisconsin sleep cohort. *Sleep*. 2008;31(8):1071–1078.

23. Enciso R, Clark GT. Comparing the berlin and the ARES questionnaire to identify patients with obstructive sleep apnea in a dental setting. *Sleep Breath*. 2011;15(1):83–89.

24. Bradford A, McGuire M, O'Halloran KD. Does episodic hypoxia affect upper airway dilator muscle function? implications for the pathophysiology of obstructive sleep apnoea. *Respir Physiol Neurobiol*. 2005;147(2–3):223–234.

25. Remmers JE, deGroot WJ, Sauerland EK, Anch AM. Pathogenesis of upper airway occlusion during sleep. *J Appl Physiol*. 1978;44(6):931–938.

26. Ward Flemons W, McNicholas WT. Clinical prediction of the sleep apnea syndrome. *Sleep Med Rev*. 1997;1(1):19–32.

27. Peppard PE, Young T, Palta M, Skatrud J. Prospective study of the association between sleep–disordered breathing and hypertension. *N Engl J Med*. 2000;342(19):1378–1384.

28. Shahar E, Whitney CW, Redline S, et al. Sleep–disordered breathing and cardiovascular disease: Cross–sectional results of the sleep heart health study. *Am J Respir Crit Care Med*. 2001;163(1):19–25.

29. Lee CH, Khoo SM, Chan MY, et al. Severe obstructive sleep apnea and outcomes following myocardial infarction. *J Clin Sleep Med*. 2011;7(6):616–621.

30. Mehra R, Benjamin EJ, Shahar E, et al. Association of nocturnal arrhythmias with sleep–disordered breathing: The Sleep Heart Health Study. *Am J Respir Crit Care Med*. 2006;173(8):910–916.

31. Capampangan DJ, Wellik KE, Parish JM, et al. Is obstructive sleep apnea an independent risk factor for stroke? A critically appraised topic. *Neurologist*. 2010;16(4):269–273.

32. Mahmood K, Akhter N, Eldeirawi K, et al. Prevalence of type 2 diabetes in patients with obstructive sleep apnea in a multi–ethnic sample. *J Clin Sleep Med*. 2009;5(3):215–221.

33. Kapsimalis F, Kryger MH. Gender and obstructive sleep apnea syndrome, part 1: Clinical features. *Sleep*. 2002;25(4):412–419.

34. Young T, Skatrud J, Peppard PE. Risk factors for obstructive sleep apnea in adults. *JAMA*. 2004;291(16):2013–2016.

35. Young T, Shahar E, Nieto FJ, et al. Predictors of sleep–disordered breathing in community–dwelling adults: The sleep heart health study. *Arch Intern Med*. 2002;162(8):893–900.

36. Koutsourelakis I, Vagiakis E, Roussos C, Zakynthinos S. Obstructive sleep apnoea and oral breathing in patients free of nasal obstruction. *Eur Respir J*. 2006;28(6):1222–1228.

37. Wetter DW, Young TB, Bidwell TR, Badr MS, Palta M. Smoking as a risk factor for sleep–disordered breathing. *Arch Intern Med*. 1994;154(19):2219–2224.

38. Ekici M, Ekici A, Keles H, et al. Risk factors and correlates of snoring and observed apnea. *Sleep Med*. 2008;9(3):290–296.

39. Mitler MM, Dawson A, Henriksen SJ, Sobers M, Bloom FE. Bedtime ethanol increases resistance of upper airways and produces sleep apneas in asymptomatic snorers. *Alcohol Clin Exp Res*. 1988;12(6):801–805.

40. Sleep–related breathing disorders in adults: Recommendations for syndrome definition and measurement techniques in clinical research. The report of an american academy of sleep medicine task force. *Sleep*. 1999;22(5):667–689.

41. Chung F, Yegneswaran B, Liao P, et al. STOP questionnaire: A tool to screen patients for obstructive sleep apnea. *Anesthesiology*. 2008;108(5):812–821.

42. Quan KH, Vigano A, Fainsinger RL. Evaluation of a data collection tool (TELEform) for palliative care research. *J Palliat Med*. 2003;6(3):401–408.

43. Johns MW. A new method for measuring daytime sleepiness: The epworth sleepiness scale. *Sleep*. 1991;14(6):540–545.

44. Navazesh M, ADA Council on Scientific Affairs and Division of Science. How can oral health care providers determine if patients have dry mouth? *J Am Dent Assoc*. 2003;134(5):613–620.

45. Ueyama Y, Mano T, Nishiyama A, Tsukamoto G, Shintani S, Matsumura T. Effects of surgical reduction of the tongue. *Br J Oral Maxillofac Surg*. 1999;37(6):490–495.

46. Yagi H, Nakata S, Tsuge H, et al. Morphological examination of upper airway in obstructive sleep apnea. *Auris Nasus Larynx*. 2009;36(4):444–449.

47. Friedman M, Tanyeri H, La Rosa M, et al. Clinical predictors of obstructive sleep apnea. *Laryngoscope*. 1999;109(12):1901–1907.

48. Lewis M, Keramati S, Benumof JL, Berry CC. What is the best way to determine oropharyngeal classification and mandibular space length to predict difficult laryngoscopy? *Anesthesiology*. 1994;81(1):69–75.

49. Bartlett D, Ganss C, Lussi A. Basic erosive wear examination (BEWE): A new scoring system for scientific and clinical needs. *Clin Oral Investig*. 2008;12(Suppl 1):S65–S68.

50. Wilkins EM. Indices and Scoring Methods In: Clinical Practice of the Dental Hygienist. Eighth ed. Philadelphia: Lippincott Williams and Wilkins. 1999. 298 p.

51. Risk Management Series: Diagnosing and Managing the Periodontal Patient. *J Am Dent Assoc*. 1986;12–16.

52. Bergström J. Cigarette smoking as risk factor in chronic periodontal disease. *Community Dent Oral Epidemiol*. 1989;17(5):245–247.

53. Hornecker E, Muuss T, Ehrenreich H, Mausberg RF. A pilot study on the oral conditions of severely alcohol addicted persons. *J Contemp Dent Pract*. 2003;4(2):51–59.

54. Taylor GW. Bidirectional interrelationships between diabetes and periodontal diseases: An epidemiologic perspective. *Ann Periodontol*. 2001;6(1):99–112.

55. Taylor GW, Borgnakke WS. Periodontal disease: Associations with diabetes, glycemic control and complications. *Oral Dis*. 2008;14(3):191–203.

56. Taylor GW, Burt BA, Becker MP, et al. Severe periodontitis and risk for poor glycemic control in patients with non–insulin–dependent diabetes mellitus. J Periodontol. 1996;67(Suppl 10):1085–1093.

57. Dawes C. Salivary flow patterns and the health of hard and soft oral tissues. *J Am Dent Assoc*. 2008;139(Suppl):18S–24S.

58. Boillot A, El Halabi B, Batty GD, Rangé H, Czernichow S, Bouchard P. Education as a predictor of chronic periodontitis: A systematic review with meta–analysis population–based studies. *PLoS One*. 2011;6(7):e21508.

59. Barsh LI. Responsibilities of the dental profession in the recognition and treatment of sleep breathing disorders. *Sleep Breath*. 1997;2(2):41–44.

60. Barsh LI. Dentistry's role in the recognition and treatment of sleep–breathing disorders: The need for cooperation with the medical community. *J Calif Dent Assoc*. 1998;26(8):591–598.

Comparison of the Impact of Scaler Material Composition on Polished Titanium Implant Abutment Surfaces

Hatice Hasturk, DDS, PhD; Daniel Huy Nguyen, BS; Homa Sherzai, RDH; Xiaoping Song, MD; Nikos Soukos, DDS, PhD; Felicitas B. Bidlack, PhD; Thomas E. Van Dyke, DDS, PhD

Abstract

Purpose: The purpose of this study was to compare the impact of the removal of biofilm with hand scalers of different material composition on the surface of implant abutments by assessing the surface topography and residual plaque after scaling using scanning electron microscopy (SEM).

Methods: Titanium implant analogs from 3 manufacturers (Straumann USA LLC, Andover, Maine, Nobel BioCare USA LLC, Yorba Linda, Cali, Astra Tech Implant Systems™, Dentsply, Mölndal, Sweden) were mounted in stone in plastic vials individually with authentic prosthetic abutments. Plaque samples were collected from a healthy volunteer, inoculated into growth medium and incubated with the abutments anaerobically for 1 week. A blinded, calibrated hygienist performed scaling to remove the biofilm using 6 implant scalers (in triplicate), 1 scaler for 1 abutment. The abutments were mounted on an imaging stand and processed for SEM. Images were captured in 3 randomly designated areas of interest on each abutment. Analysis of the implant polished abutment surface and plaque area measurements were performed using ImageJ image analysis software. Surface alterations were characterized by the number, length, depth and the width of the scratches observed.

Results: Glass filled resin scalers resulted in significantly more and longer scratches on all 3 abutment types compared to other scalers, while unfilled resin scalers resulted in the least surface change ($p<0.05$). Filled resin–graphite reinforced scalers, carbon fiber reinforced resin scalers and titanium scalers resulted in more superficial scratches compared to glass filled resin, as well as more scratches than unfilled resin. No statistically significant differences were found between scalers and abutments with regard to plaque removal.

Conclusion: The impact of scalers on implant abutment surfaces varies between abutment types presumably due to different surface characteristics with no apparent advantage of one abutment type over the other with regard to resistance to surface damage. Unfilled resin was found consistently to be the least damaging to abutment surfaces, although all scalers of all compositions caused detectable surface changes to polished surfaces of implant abutments.

Keywords: scaler, implant, abutment, biofilm, scanning electron microscopy

This study supports the NDHRA priority area, **Health Promotion/Disease Prevention:** Validate and test assessment instruments/strategies/mechanisms that increase health promotion and disease prevention among diverse populations.

Introduction

Long–term studies support the use of titanium implants with titanium abutments to restore edentulous areas and reinforce prostheses for partially or fully edentulous people.[1] While many implant systems have shown multiyear success rates of greater than 90% for fully edentulous patients and partially edentulous patients for both maxillary and mandibular implants,[2,3] there is lack of consensus among primary and secondary outcomes appropriate to evaluating implant outcomes such as implant survival, success or failure.[4] Recent systematic reviews[5,6] assessing the quality of randomized controlled trials (RCTs) published between 1989 and April 2011 and case series published between 2004 and 2008 reported several methodological and statistical flaws affected the reporting of these studies. Thus, it is important to use caution when interpreting the outcomes of the current studies in implant dentistry especially when long term success is being assessed.

For decades, osseointegration and the implant surface facilitating the osseointegration have been the primary goal in implant dentistry. As a results, a range of implant surfaces ranging from machined smooth to rough surfaces, are currently being used in implant dentistry.[7] Despite efforts to improve osseointegration by the modification of implant surfaces, current evidence has shown that bacterial colonization at the gingiva–implant interface can induce mucositis or periimplantitis and jeopardize the long–term success of implant rehabilitations.[8,9] This has

resulted in an emphasis on the surface of the prosthetic abutment as a means of minimizing plaque accumulation; most implant abutments now have a polished surface to eliminate roughness that may serve as a nidus for plaque formation.[10,11]

Although the soft tissue surrounding the tooth and implant resemble each other, there are inherent differences in the connective tissues.[12] There is no evidence for the presence of Sharpey's fibers between an implant or implant abutment and bone, however, a minimum width of peri–implant mucosa appears to be required to allow a stable epithelial–connective tissue attachment to form to the implant surface.[13–15] This width is analogous to the "biological width" around natural teeth as defined by Garguilo.[16] The location of the microgap between the abutment and the coronal aspect of the implant also influences the coronal height of bone contact.[17] The accumulation of pathogenic bacteria in this microgap can have an impact on the long–term success of the implant.[18] Peri–implant mucositis represents the host response of the peri–implant tissues to the bacterial challenge and it is similar to gingivitis representing the host response to the bacterial challenge in the gingiva. Although, both peri–implantitis and periodontitis lesions also have similar etiological factors and show similar clinical features,[19] critical histopathological differences regarding the extent and composition of inflammatory cell infiltration as well as the progression rate of the lesion were reported.[20] In periodontitis, a "protective" connective tissue development was shown as a self–limiting process as opposed to peri–implantitis where this process may occasionally be lacking.[21]

Although peri–implant infections may occasionally be linked to a different microbiota, including high numbers of peptostreptococci or staphylococci, the anaerobic composition of the biofilm is similar to those found in periodontitis.[22] Most importantly, despite similarities of bacterial biofilm formation on implant surfaces and on tooth surfaces, surface roughness might be an important factor influencing the biofilm formation. Mechanical and chemical interventions to disrupt the peri–implant biofilm demonstrate that microorganisms are involved in the disease process. However, there is no evidence that these factors are the origin of the development of peri–implantitis.[21,22] Nevertheless, thorough examination of implant structures at maintenance visits is essential. Changes in implant health can indicate that the implant is ailing or failing, or has failed.[23] As with the natural dentition, the removal of bacterial biofilm and calculus deposits around implants is crucial in the prevention and treatment of peri–implant diseases.[24–26] Previous studies also showed that certain pathological bacteria can induce mucositis and periimplantitis in patients receiving restorations supported with implants.[27,28] Performing professional maintenance regularly along with sufficient home care practices is necessary to maintain healthy implants. The main problem facing the dental professional, however, is removing plaque from implants without damaging the implant surface.[29,30] Previous studies have shown that bacteria attach to scratched or rough implant surfaces with greater affinity,[31,32] however, the efficacy of scaling implant surfaces to reduce inflammation caused by bacteria has been ambiguous when scratching is considered.[33] Scratches caused by scalers likely have a detrimental impact on subsequent bacterial growth due to the increased surface area for attachment.[34] Scratches and gouges are also known to impact the titanium oxide layer and alter the properties of the metal surface and possibly biocompatibility.[24]

Various scalers including plastic, graphite and titanium instruments have been specifically developed for use with implants.[29,35,36] Stainless steel instruments are contraindicated as they contaminate the titanium surface with other metal ions.[37] On the other hand, there is a concern that titanium scalers are sufficiently hard to damage the implant abutment surface, although there is limited data to support or refute this concern and titanium scalers are being widely used.[35] It is also unclear whether there is a qualitative difference between titanium, plastic and graphite scalers in plaque and calculus removal. Material strength, hardness and flexibility are issues in instrument design for subgingival instrumentation – the goal is plaque and calculus removal without abutment surface damage. Roughened implant abutment surfaces caused by different maintenance techniques have not been directly demonstrated to increase implant complications,[38] however, prevention of surface scratching will likely reduce bacterial colonization and the risk for peri–implantitis.

The purpose of the present study was to compare the impact of scalers of different material composition on the surface of three widely–used implant abutments following biofilm removal in vitro, by assessing surface topography of the abutment and presence of residual bacteria using scanning electron microscopy (SEM).

Methods and Materials

Study Materials

The 6 different scaler materials, including an amorphous unfilled resin scaler, a titanium scaler, a filled resin–graphite reinforced scaler, a prototype filled resin–carbon fiber reinforced scaler, a pro-

Table I: The Identification of Scalers Used in this Study

Scaler Names	Hu–Friedy Implacare™ scaler	Wingrove™ titanium scaler	Premier® Universal Implant scaler
Material and Scaler Type	Amorphous unfilled resin scaler; Columbia 4R/4L	Barnhart 5–6 Ti R661	Filled resin–graphite reinforced; Columbia 4R/4L
Manufacturer	Hu–Friedy Mfg, Co, Inc., Chicago	PDT Inc., Missoula, Mont.	Premier Dental, Plymouth Meeting, Penn
Unique ID	Scaler A	Scaler B	Scaler C
Scaler Names	Prototype A	Sabra scaler	Prototype B
Material and Scaler Type	Filled resin–carbon fiber reinforced scaler; a universal curette	Glass filled resin scaler; IS–1	Semi–crystalline unfilled resin scaler; Columbia 4R/4L
Manufacturer		Sabra Dental Products, Deer Park, NY	
Unique ID	Scaler D	Scaler E	Scaler F

totype universal curette, a glass filled resin scaler and a prototype semi–crystalline unfilled resin scaler provided by the sponsor were tested in this study. Detailed information on scaler names, material and scaler types and manufacturers is given in Table I. For ease of identification in the text, scalers are identified by a unique ID as listed in Table I. Fifty–four (18 per implant abutment type) titanium implant analogs and prosthetic abutments (Ti Anatomic Abutment–Straumann LLC, Esthetic Abutment–Nobel BioCare, and TiDesign–Astra Tech, Inc) were purchased from Straumann, Inc, Nobel BioCare and Astra, respectively.

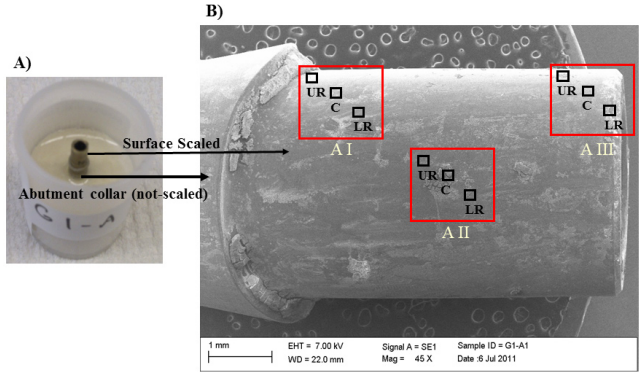
Implant–Abutment Block Preparation

Implant analogs were mounted in stone in individual sterile plastic vials (Nalgene®, Thermo Scientific, Rochester, NY) suitable for biofilm growth (Figure 1). The prosthetic abutments of each type were carefully mounted on the implant analogs. In total, 54 vials containing 3 types of implant–abutment structure (18 mounts/each) were prepared.

Biofilm Growth

Biofilm was grown on the implant abutments from the 3 manufacturers using a standard biofilm growth protocol from human plaque samples.[39] Briefly, Monday morning (baseline), subgingival plaque samples from the buccal and lingual surfaces of anterior and posterior teeth of a healthy volunteer were collected after an 18 hour non–brushing period. Permission to collect dental plaque samples with informed consent was authorized by The Forsyth Institute Institutional Review Board. The samples were placed in pre–prepared sterile culture tubes containing growth medium

Figure 1: Implant Analog–Abutment Mount Placed In Stone Model and a Representative SEM Image of an Abutment Illustrating the Areas of Interest Evaluated



Implant analogs were mounted in stone in a sterile plastic vial submerged with 10 ml growth medium for bacterial growth (see details in Methods and Materials). Images from each abutment were captured at 45X magnification. The abutment surface, "scaled surface", was studied by SEM. At the beginning of the study, the abutment collar surface as shown "non–scaled" was compared to the abutment surface to confirm surface characteristics are the same. On each abutment surface, three areas of interest were captured at 190X (depicted by red squares) and on each of these areas three regions (U=upper, C=center, and L=lower) were imaged at 1,000X and 10,000X (depicted by black squares). The images from each region were used for scratch and residual biofilm measurements.

containing pre–reduced, anaerobically sterilized (PRAS) Ringer's solution (Anaerobe System Morgan Hill, Cali). Ten ml of the medium containing dental plaque was pipetted into the vials submerging abutments, covered with aluminum foil with a loose seal and grown anaerobically for 1 week. The medium was replenished at the third and fifth day to support continuous growth.

Scaling/Instrumentation

On the seventh day of incubation, a trained and calibrated hygienist scaled the surfaces of each abutment for 60 seconds to remove all visible plaque.[34] All 6 scalers were used on each of the 3 implant types in triplicate (3 abutments/abutment type/scaler). Each scaler was used only once to ensure consistent sharpness. During scaling, vertical strokes from the bottom of the abutment to the incisal edge were made using similar force, which was standardized as part of the calibration exercise using a pressure gauge. After scaling, abutments were carefully removed from the implant blanks without touching the abutment surface and processed for scanning electron microscopy. Since the collar of the implant abutment and the abutment surface were polished to the same smoothness, as determined by SEM, the collar of the implant was left untouched and compared with the abutment surface used in this study for surface characteristics after scaling.

SEM Analysis

Immediately after instrumentation with scalers, the abutments were fixed in 4% gluteraldahyde (to fix the bacteria), followed by coating with 2% osmium tetroxide for contrast. The abutments were mounted on imaging stand (flat end pin specimen mount; Zeiss Specimen Mounts) using standard carbon adhesive tapes suitable for SEM imaging.

Each image for each abutment was captured at x45 magnification. Three randomly assigned areas of interest (same area on each abutment) were then captured at x190. The number of scratches/gouges, depth, length and the width of the scratches was measured for 3 predetermined surface areas of interest on each abutment (Figure 1). In addition, the amount of residual plaque was quantified on the surface of the abutments.

For each area of interest, 3 regions (upper, center and lower) were viewed at x1,000 and x10,000. Images from each region were evaluated for number of scratches, greatest scratch width, greatest scratch length, greatest scratch depth and amount of plaque remaining on abutment surface. Quantitative measurements were performed using ImageJ software (NIH image version 1.44, Bethesda, MD). The SEM imaging and measurements were performed by a single investigator calibrated against a gold standard.

Verification of Abutment Surface

SEM images were taken from the abutment surface and the abutment collar to verify the surface characteristics. In each implant abutment type, definitive manufacturing machine marks were apparent that were perpendicular to the direction of scaling on both the abutment and the collar. In each type of implant, the collar and abutment surface characteristics were identical.

Quantification of Scratches

Number, width, length and depth of scratches were evaluated at x1,000 and/or x10,000 magnification in the pre–designated areas of interest using ImageJ software. To quantify the number of scratches, a categorical scratch index was used: 0=none, 1=1 to 3 scratches, 2=4 to 6 scratches, 3=7 to 9 scratches, 4=10 to 20 scratches and 5=>20 scratches. Each abutment type was analyzed separately.

Scratch width was evaluated on x10,000 magnification images. Three points along the widest scratch were measured, and the average value was recorded. Length of the scratches was measured on images at x1,000 magnification. The longest scratch was measured 3 times in micrometers, and the average value was recorded for each specimen.

The depth of the scratch was determined by examining shadows, contour and contrast – the deepest scratches exhibited darker contrast and shadows. The scratch depths were graded on a scale of 1 to 4, with 1=superficial (only through plaque, metal still intact), 2=shallow, 3=moderately deep and 4=deep. Both x1,000 and x10,000 images were used to determine scratch depth.

Overall Comparison of Scalers

Different scaler types were compared in a composite index that was calculated as the mean of the scratch number, depth, width and the log10 of the scratch length for each implant type and across all implants.

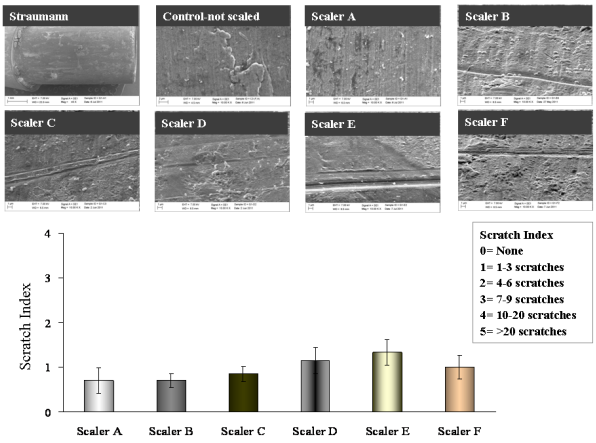
Residual Biofilm

The amount of dental plaque remaining on the abutment surface was measured at x1,000 magnification by a grading scale of 1 to 3, with 1=0 to 30%, 2=30 to 60% and 3=60 to 100%.

Intra–Examiner Calibration

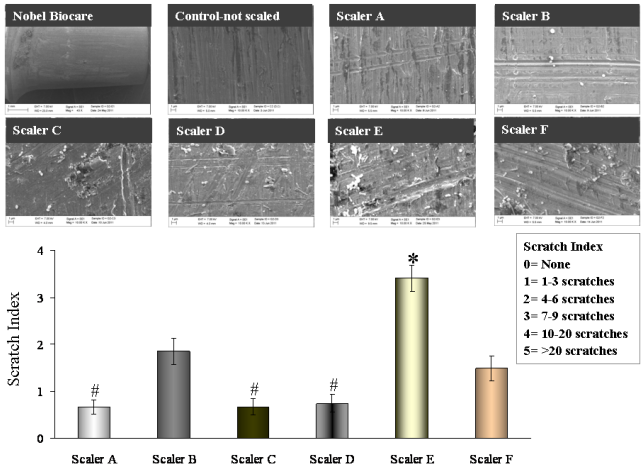
A single therapist performed the instrumentation procedures. The therapist was blinded to the material composition of the scalers and implant abutments used. Importantly, the therapist was blinded to the overall purpose of the study – she was told that it was a plaque removal study. Prior to instru-

Figure 2A: Comparison of Number of Scratches Based on a Scratch Index on Each Abutment Surface Following Scaling With All 6 Scalers Using SEM At x1,000 Magnification



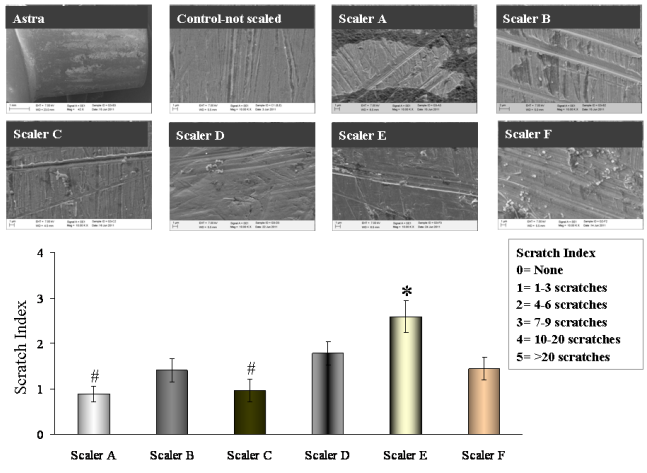
Number of scratches was counted on each Straumann abutment and averages were used for comparisons between scalers. Although the Scaler E and Scaler D resulted in the highest number of scratches, on average, all scalers caused similar scratching on Straumann implant abutments.

Figure 2B: Comparison of Number of Scratches Based on a Scratch Index on Each Abutment Surface Following Scaling With All 6 Scalers Using SEM At x1,000 Magnification



On Nobel BioCare abutment surfaces, Scaler E caused the highest number of scratches compared to all other scalers (*=p<0.05), while Scaler A, Scaler C and Scaler D resulted in significantly fewer scratches compared to Scaler E, Scaler B and Scaler F (#=p<0.05).

Figure 2C: Comparison of Number of Scratches Based on a Scratch Index on Each Abutment Surface Following Scaling With All 6 Scalers Using SEM At x1,000 Magnification



Similar to Nobel BioCare abutments, Scaler E resulted in significantly higher number of scratches on Astra abutment surfaces compared to all other scalers (*=p<0.05). Scaler A and Scaler C, although not statistically significant, were the least harmful to Astra abutment surfaces.

mentation, force applied to the instrument during scaling was standardized using a pressure–gauge. Intra–examiner calibration was calculated for percent agreement between 2 force measurements using Pearson's correlation coefficient.

Statistical Analysis

Six scalers were used on 3 different implant prosthetic abutments. Each scaler was tested on 3 individual abutments from each type of implant abutments. In total, 9 prosthetic abutments were used per scaler type. Assuming a minimum difference of 1 unit in index grading (scratch number and depth) between groups and 80% power at an alpha level of 0.05, a total of 3 scalers per scaler type used on each prosthetic abutment type (n=3) was required. Comparisons of surface scratch area, depth of surface scratches and mean area of residual bacteria were performed using repeated measures of analysis of variance (ANOVA) for within and between group comparisons using the Bonferroni post hoc test for multiple comparisons. A commercially available statistical program (SPSS) was used to analyze the data.

Results

Intra–Examiner Calibration, Instrumentation and SEM Imaging

The intra–examiner calibration for the use of standardized force was demonstrated >95% accuracy and agreement between repeated tests.

Scratch Assessments

Number of scratches: The number of scratches was compared between scalers on each abutment type using a scratch index. Scaler E resulted in the highest number of scratches on all abutment types and all surfaces; the difference was significant only

Figure 3: Evaluation of Scratch Width on Abutment Surfaces Following Scaling With All 6 Scalers Using SEM at x10,000 Magnification

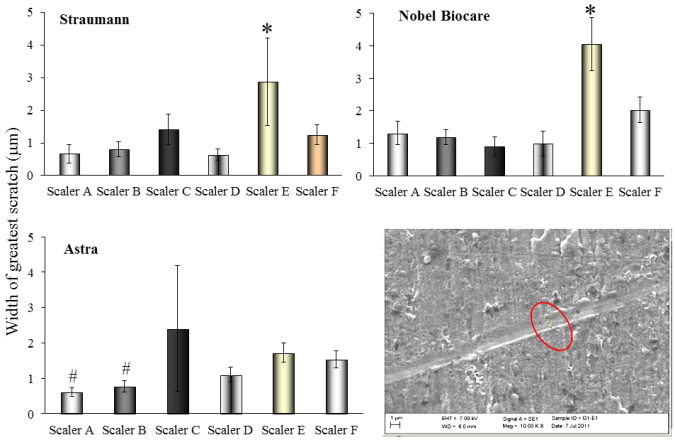
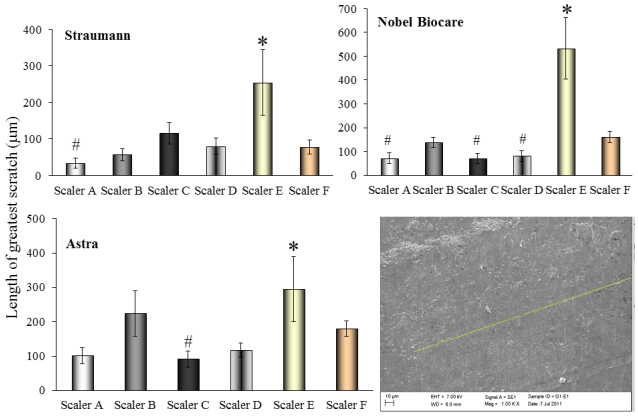


Image J was used to measure scratches at three points along the scratch (depicted by the red circle in micrograph) and the average value was recorded. Consistent with the number of the scratches, Scaler E were notable with the widest scratches observed on Straumann and Nobel BioCare abutment surfaces compared to other scalers (*=p<0.05). Scaler D, Scaler A and Scaler B on Straumann and Scaler C on Nobel BioCare abutment surfaces were the least harmful; the difference was significant only with Scaler C and on Nobel BioCare abutment surfaces (#p<0.05) compared to other scalers. Conversely, in the Astra abutment group, the widest scratches were observed on surfaces scaled with Scaler C although this observation was not consistent within the group, and the difference was not statistically significant. With regard to scratch width, Scaler A and Scaler B similarly showed the smallest scratches on the Astra abutment surfaces compared to all scalers (#p<0.05).

Figure 4: Comparison of Length of Scratches Observed Following Scaling with All 6 Scalers Using SEM at x1,000 Magnification



The longest scratch was measured three times in micrometers (depicted by yellow line on micrograph) using ImageJ and the average value was used in comparisons. Scaler E resulted in significantly longer scratches on all three abutment types (*p<0.05). Scaler B caused long scratches on Astra abutments with no significant difference. Scaler A, Scaler C and Scaler D resulted in short scratches on Nobel BioCare abutment surfaces; the difference was statistically significant compared to Scaler E and Scaler F. Scaler A was the only scaler showing statistically significant differences in scratch length on Straumann abutments (#p<0.05), while on Astra abutment surfaces, Scaler C were associated with the shortest scratches compared to Scaler E and Scaler F (#p<0.05).

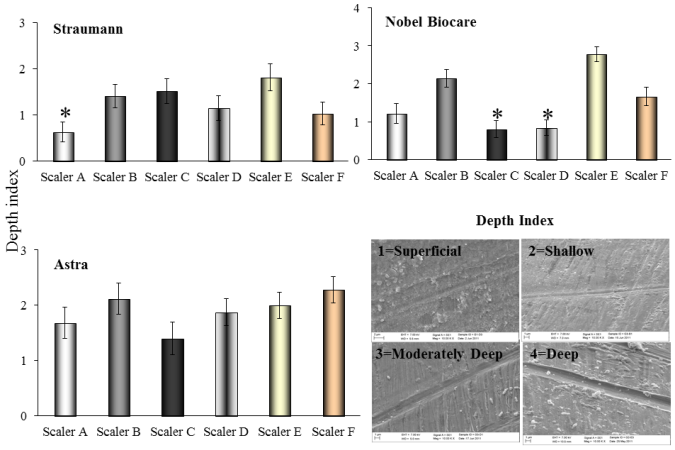
in Nobel BioCare and Astra implant abutments (Figure 2A, B and C, p<0.05) compared to other scalers. On average, all scalers caused similar scratching on Straumann implant abutments (Figure 2A), with slightly more observed on surfaces scaled with Scaler E and Scaler D. On Nobel BioCare abutment surfaces, Scaler E caused significantly higher numbers of scratches compared to all other scalers (*=p<0.05). Conversely, Scaler A, Scaler C and Scaler D resulted in significantly fewer scratches compared to Scaler E, Scaler B, and Scaler F (#=p<0.05) on Nobel BioCare abutments. Similarly, Scaler E resulted in significantly higher number of scratches on Astra abutment surfaces compared to all other scalers (*=p<0.05), whereas Scaler A and Scaler C were the least harmful to Astra abutment surfaces, although the difference was not statistically significant.

Width of Scratches: The mean scratch width was significantly higher with Scaler E on both Straumann and Nobel BioCare implant abutments compared to other scalers (Figure 3, p<0.05). Although the Scaler C appeared be associated with wider scratches, especially on Astra implant abutments, the difference was not statistically significant. Interestingly, the same scaler, Scaler C, was one of the instruments that showed the least damage (narrow scratches) on the Nobel BioCare abutment surfaces together with Scaler D, which showed a statistically significant difference compared to Scaler E and Scaler F (#p<0.05). With regard to scratch width, Scaler A were significantly less detrimental to the Astra abutment surfaces compared to all other scalers (#p<0.05).

Length of Scratches: The length of the scratches was also quantified and the averages were calculated for all scalers on each abutment surface (Figure 4). As with the width and the number of the scratches, Scaler E resulted in significantly longer scratches on all 3 abutment types (*p<0.05). On the Astra abutment surface, Scaler B also created long scratches, but the difference between other scalers was not statistically significant. On Nobel BioCare abutment surfaces, Scaler A, Scaler C and Scaler D resulted in the shortest scratches and the difference was statistically significant compared to Scaler E and Scaler F. Scaler A was the only scaler showing statistically significant differences in scratch length on Straumann abutments (#p<0.05). Similarly, Scaler C resulted in shortest scratches on the surfaces of Astra abutments compared to Scaler E and Scaler F (#p<0.05).

Depth of Scratches: A depth index was used to quantify the depth of the scratches on the scaled sur-

Figure 5: Comparison of Width of Scratches Based on a Depth Index on Each Abutment Surface Following Scaling with All 6 Scalers Using SEM at x10,000 Magnification



Scaler E caused the deepest scratches on most surfaces, but there were no statistically significant differences. On the other hand, Scaler D and Scaler C resulted in the most superficial scratches on Nobel BioCare abutments and the differences were statistically significant compared to other scalers (*p<0.05). On the Astra abutment surface, all scalers caused scratches similar in depth.

faces of each abutment type (Figure 5). Instrumentation resulted in varying degrees of scratch depth on the surface of each abutment type. Although Scaler E was found to cause the deepest scratches on most surfaces, the differences were not statistically significant. Conversely, Scaler D and Scaler C showed the most superficial scratches on Nobel BioCare abutments and the differences were statistically significant compared to other scalers (Figure 5, p<0.05). On the Astra abutment surface, all scalers caused similar scratch depth, while Scaler C showed more superficial scratches, however, the difference was not statistically significant.

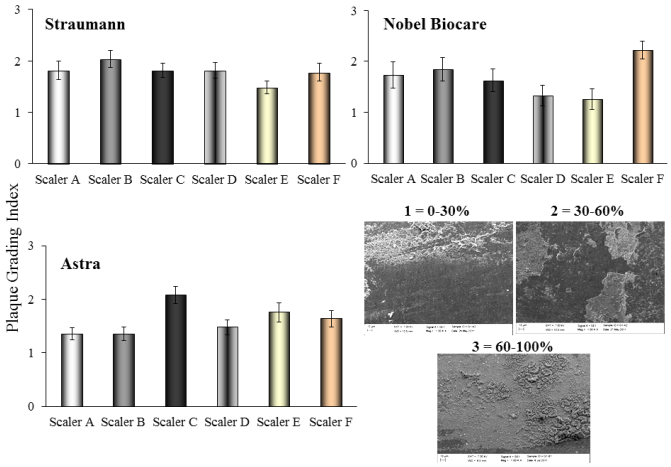
Biofilm Removal Efficiency

The efficiency of scalers in biofilm removal was tested by calculating the area covered by residual plaque in each area of interest on each implant abutment. All 3 abutment types showed similar amounts of biofilm still attached on their surfaces with no difference in efficiency of plaque removal between scalers (Figure 6).

Overall Comparison of Scalers

The composite index was able to show the overall differences between scalers when each of the assessments were evaluated for each of the abutment types (Table II). Among the 6 scalers tested, Scaler E was found to be the most detrimental scaler for all abutment types compared to all other scalers (p<0.05).

Figure 6: The Efficacy of the Scalers in Biofilm Removal from Abutment Surfaces



The area covered by residual plaque was calculated in each area of interest on each implant abutment using ImageJ software. The surfaces from all three abutment types showed similar amounts of biofilm attached on their surfaces with no difference in efficiency of plaque removal between scalers.

While none of the scalers resulted in complete biofilm removal with smooth and non–scratched abutment surfaces, Scaler A caused the least damage to the surfaces of all abutment types and this result was found statistically significant when compared to Scaler E, Scaler B and Scaler F (p<0.05).

Discussion

In this paper, implant polished abutment surface alterations caused by plaque removal with scalers in an in vitro model is reported. The experiment encompassed 6 scaler types across 3 implant types. While no major differences were seen between implant types in susceptibility to scaler caused damage, there was a significant difference between scalers in their ability to scratch the polished surfaces of implant abutments. Interestingly, while all visible plaque was removed by all scalers from all implant abutments, there was remarkable residual plaque on all surfaces examined by SEM. This finding is consistent with the findings of previous reports comparing the efficiency of hand scalers with ultrasonic and sonic scalers in plaque removal from implant surfaces.[40–43] However, it is difficult to compare the results of this study with those studies due to differences in methodology of plaque accumulation. Further, it is important to evaluate the efficiency of in vivo plaque removal of the scalers tested, in order to report the outcomes on plaque removal. This in vitro study evaluated 1 week old biofilm removal from implant surfaces that could be relevant to those clinical conditions where the peri–implant mucosal area is not cleaned daily. The present study aimed to demonstrate the in-

Table II: Overall Comparison of Composite Index for Scratch Number, Width, Length and Depth

Abutment Type	Scaler A	Scaler B	Scaler C	Scaler D	Scaler E	Scaler F
Straumann	0.88±0.43	1.17±0.51	1.46±0.49	1.21±0.52	2.10±0.67	1.29±0.41
Nobel	1.26±0.48	1.83±0.45	1.06±0.53	1.12±0.53	3.24±0.61	1.85±0.33
Astra	1.24±0.58	1.66±0.71	1.68±0.63	1.71±0.42	2.19±0.41	1.89±0.45
Overall	1.12±0.21#	1.55±0.34	1.40±0.31	1.34±0.31	2.51± 0.63 *	1.68±0.34

*Statistically significant compared to all other groups ($p<0.05$)
#Statistically significant compared to Scaler E, Scaler B and Scaler F ($p<0.05$)

fluences of the scalers on various implant surfaces rather than their efficiency in plaque removal. It is known that mechanical and chemical interventions to disrupt the peri–implant biofilm demonstrate convincingly that microorganisms are involved in the disease process and interventions have beneficial effects on the treatment of peri–implantitis.[22] However, the impact of surface roughness or residual biofilm in developing mucositis or peri–implantitis warrant more investigation.

A number of studies have been conducted to evaluate the efficiency and safety of different scaler material compositions on implants.[34,40,44–47] However, there are limited studies comparing these materials on different implant surfaces. Also, many studies evaluate the implant surface rather than the abutment, which is the clinical equivalent of treating a failing implant surface (exposed threads) rather than removing plaque from a polished abutment surface. In general, studies were conducted to test the different scalers and oral prophylaxis methods based on their influence on smooth, rough or coated and uncoated surfaces.[42,48,49] Mengel et al compared various scalers by SEM on 3 different implant and abutment surfaces including Screw–Vent implants (Dentsply), titanium plasma–coated full–screw implants (Straumann) and standard Brånemark implants (Nobel BioCare) in vitro for traces left on and substance removal from the implant/abutment surfaces.[50] The study compared titanium curettes, steel curettes, plastic curettes, rubber cups with Zircate prophy paste, the Cavitron Jet ultrasonic scaler with universal inserts and air polishing nozzles with Prophy–Jet cleaning powder, and the Densonic sonic scaler with SofTip disposable prophy tips and universal tips. The authors found that all instruments apart from the rubber cup and Cavitron Jet air polishing system left pronounced traces of the scaler material at the transition of the implant head to the titanium plasma coating of the full–screw implants.[50] The same authors conducted another in vitro study with uncoated, mechanically smoothed abutments and titanium nitride (TiN) coated abutments treated with titanium, steel and plastic curettes, a rubber cup, an ultrasonic scaler with a steel tip and an air scaler and cleaning powder. SEM was used to determine the extent of traces of instrument material, the roughness depth, and the quantity of titanium or TiN removed from the surfaces.[51] The study showed that the TiN–coated abutments displayed fewer treatment traces, less roughness depth and less surface removal after being treated with various instruments. The steel and titanium curettes and ultrasonic scaler with steel tip, however, caused the detachment of coating and greater initial roughness depth of coated implants.[51] An earlier in vitro study with titanium abutments that were treated with a metal scaler, plastic scaler, rubber cup, rubber cup with tin oxide and an air–powder abrasive reported that metal scalers roughened the titanium surface, while all other modalities tested appeared to smooth the titanium surface by removing surface debris and rounding off the sharp machined grooves present on the untreated abutment surface.[24] Commercially pure titanium and titanium–alloy abutments were used in another study comparing 5 oral hygiene methods: a gold–alloy–tipped scaler, a high–grade resin scaler, a graphite–reinforced scaler, an air–powder abrasive system and a rubber cup with tin oxide slurry to test the outcome of the scaling procedures using SEM.[49] This study introduced a standard force applied to the scalers. Interestingly, all tested hygiene methods either created significant surface alterations or left residual particles on the abutment surfaces, or both.[49]

In the present study, only hand scalers were used on 3 abutment types on smooth polished surfaces of abutments, not the implant screws. Although results of this study are parallel to some of the reported studies detailed above, in some aspects they differ. The tested scalers in the present study have unique characteristics and consisted of so called "innovative" materials (i.e., glass–reinforced or carbon–reinforced resin, etc.) and were expected to be superior or at least as

effective as the old materials, such as unfilled plastic or titanium. However, in some cases, the new materials caused more severe scratching and damage of the implant abutment surfaces tested. There was some variation noted between scaler types based upon abutment manufacturer. Notably, Scaler A, an amorphous unfilled resin scaler, was least harmful to the surface of all 3 abutment types. Our findings are consistent with an earlier in vitro study testing the impact of specific cleaning procedures on the surfaces of 3 implant types with different coatings and shapes (plasma sprayed; hydroxyapatite coated implants and smooth titanium surface screws) using SEM,[42] but this prior study evaluated implant surfaces,[48] not abutment polished surfaces, so the comparison is limited to resistance of apparent surface hardness. Among 6 different hygiene protocols measured, plastic curette, air–powder–water spray with sodium hydrocarbonate solution and chlorhexidine 0.1% solution rinse caused no or little surface damage to titanium surfaces.[42] In another study that compared the difference between smooth surfaces and rough surfaces demonstrated that smooth surfaces on titanium disks (not abutments) are more susceptible to surface alteration and non–abrasive techniques are recommended, while on the rough surfaces, abrasive systems including air–powder polishing and metal curettes were effective in preventing bacterial attachment and less harmful.[38] Overall, our findings are also consistent with an in vivo study (beagle dogs) where 6 different hygiene methods, including scaling with metal and plastic scalers, ultrasonic cleaning, air– and rubber cup–polishing and toothbrush use were tested on Bränemark abutments.[46] Plastic scalers were found to be safer on Bränemark abutment surfaces.

While this study is in vitro and reports removal of in vitro grown plaque that lacks the influence of saliva or width of peri–implant mucosa or location of micro gap, it is clear that caution should be used in the choice and use of hand instruments during maintenance visits for removing plaque from implant abutments. It would still be necessary to conduct further studies evaluating the causes of inadequate access for scaler use or the factors affecting the outcome of hygiene procedures on implant surfaces in in vivo conditions. If the goal is to maintain a smooth, polished abutment surface to discourage reformation of plaque, then the use of hand instruments that can easily cause significant scratching, such as titanium or glass filled resin, should be approached with caution.

Conclusion

Despite the new and innovative technology used in developing new materials to more efficiently and safely remove plaque and calculus from implant abutment surfaces, limitations still exist. In this study, all 6 scalers of different materials resulted in varying degrees of smooth surface alteration with obvious differences between them with regard to surface alteration on 3 different abutment types. Scaler E, a glass filled resin, resulted in significantly more and longer scratches on the abutments tested compared to all other scalers, while an amorphous unfilled resin scaler, Scaler A, showed the least surface alteration to all three abutment types with respect to number, length, width and depth of the scratches observed. Overall, the impact of different scaler materials varied slightly between implant manufacturers presumably due to different surface characteristics of the implant abutments. It may require a careful examination with appropriate dental history and radiographic evaluation to recognize the implants placed in the patient's mouth before making decisions on the prophylaxis systems to be used. Importantly, these findings do not apply to debridement of implant surfaces or the treatment of periimplantitis where rough implant surfaces and exposed thread surfaces are the target of treatment. Further investigation is required to determine the impact of various scaler compositions on rough implant surfaces.

Hatice Hasturk, DDS, PhD, is an associate member of the staff, Director of Center for Clinical and Translational Research. Daniel H. Nguyen, BS, is a research assistant. Homa Sherzai, RDH, is a research dental hygienist. Xiaoping Song, MD, is a research assistant. Nikos Soukos, DDS, PhD, is an associate member of the staff. Felicitas B. Bidlack, PhD, is an assistant member of the staff, Director of Biostructure Core Facility. Thomas E. Van Dyke, DDS, PhD, is a senior member of the staff, Vice President, Center for Clinical and Translational Research, Chair of Department of Applied Oral Sciences.

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Disclosure

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References

1. Esposito M, Murray–Curtis L, Grusovin MG, Coulthard P, Worthington HV. Interventions for replacing missing teeth: different types of dental implants. *Cochrane Database Syst Rev*. 2007;(4):CD003815.

2. Albrektsson T, Zarb G, Worthington P, Eriksson AR. The long–term efficacy of currently used dental implants: a review and proposed criteria of success. *Int J Oral Maxillofac Implants*. 1986;1(1):11–25.

3. Ozkan Y, Akoğlu B, Kulak–Ozkan Y. Five–year treatment outcomes with four types of implants in the posterior maxilla and mandible in partially edentulous patients: a retrospective study. *Int J Oral Maxillofac Implants*. 2011;26(3):639–647.

4. Needleman I, Chin S, O'Brien T, Petrie A, Donos N. Systematic review of outcome measurements and reference group(s) to evaluate and compare implant success and failure. *J Clin Periodontol*. 2012;39(Suppl 12):122–132.

5. Cairo F, Sanz I, Matesanz P, Nieri M, Pagliaro U. Quality of reporting of randomized clinical trials in implant dentistry. A systematic review on critical aspects in design, outcome assessment and clinical relevance. *J Clin Periodontol*. 2012;39(Suppl 12):81–107.

6. Vere J, Joshi R. Quality assessment of prospective case series of dental implant surgery and prosthodontics published between 2004 and 2008: a systematic review. *Int J Oral Maxillofac Implants*. 2012;27(4):865–874.

7. Esposito M, Grusovin MG, Willings M, Coulthard P, Worthington HV. The effectiveness of immediate, early, and conventional loading of dental implants: a Cochrane systematic review of randomized controlled clinical trials. *Int J Oral Maxillofac Implants*. 2007;22(6):893–904.

8. Berglundh T, Persson L, Klinge B. A systematic review of the incidence of biological and technical complications in implant dentistry reported in prospective longitudinal studies of at least 5 years. *J Clin Periodontol*. 2002;29(Suppl 3):197–212.

9. Albrektsson TIF. Consensus report of session IV. In: Lang NPK, eds. Proceedings of the First European Workshop on Periodontology. London: Quintessence. 1994. 365–369 p.

10. Esposito M, Hirsch JM, Lekholm U, Thomsen P. Biological factors contributing to failures of osseointegrated oral implants. (II). Etiopathogenesis. *Eur J Oral Sci*. 1998;106(3):721–764.

11. Teughels W, Van Assche N, Sliepen I, Quirynen M. Effect of material characteristics and/or surface topography on biofilm development. *Clin Oral Implants Res*. 2006;17(Suppl 2):68–81.

12. Berglundh T, Lindhe J, Ericsson I, Marinello CP, Liljenberg B, Thomsen P. The soft tissue barrier at implants and teeth. *Clin Oral Implants Res*. 1991;2(2):81–90.

13. Berglundh T, Lindhe J, Sterrett JD. Clinical and structural characteristics of periodontal tissues in young and old dogs. *J Clin Periodontol*. 1991;18(8):616–623.

14. Abrahamsson I, Berglundh T, Wennström J, Lindhe J. The peri–implant hard and soft tissues at different implant systems. A comparative study in the dog. *Clin Oral Implants Res*. 1996;7(3):212–219.

15. Albrektsson T, Hansson HA. An ultrastructural characterization of the interface between bone and sputtered titanium or stainless steel surfaces. *Biomaterials*. 1986;7(3):201–205.

16. Gargiulo AW, Wentz FM, Orban B. Mitotic activity of human oral epithelium exposed to 30 per cent hydrogen peroxide. *Oral Surg Oral Med Oral Pathol*. 1961;14:474–492.

17. King GN, Hermann JS, Schoolfield JD, Buser D, Cochran DL. Influence of the size of the microgap on crestal bone levels in non–submerged dental implants: a radiographic study in the canine mandible. *J Periodontol*. 2002;73(10):1111–1117.

18. Augthun M, Conrads G. Microbial findings of deep peri–implant bone defects. *Int J Oral Maxillofac Implants*. 1997;12(1):106–112.

19. Lang NP, Bosshardt DD, Lulic M. Do mucositis lesions around implants differ from gingivitis lesions around teeth? *J Clin Periodontol*. 2011;38(Suppl 11):182–187.

20. Berglundh T, Zitzmann NU, Donati M. Are peri–implantitis lesions different from periodontitis lesions? *J Clin Periodontol*. 2011;38(Suppl 11):188–202.

21. Lang NP, Berglundh T, Working Group 4 of Seventh European Workshop on Periodontology. Periimplant diseases: where are we now?––Consensus of the Seventh European Workshop on Periodontology. *J Clin Periodontol*. 2011;38(Suppl 11):178–181.

22. Mombelli A, Décaillet F. The characteristics of biofilms in peri–implant disease. *J Clin Periodontol*. 2011;38(Suppl 11):203–213.

23. Garg A. The ailing and failing implant: prevention and treatment. *Dent Implantol Update*. 2003;14(5):33–37.

24. Homiak AW, Cook PA, DeBoer J. Effect of hygiene instrumentation on titanium abutments: a scanning electron microscopy study. *J Prosthet Dent*. 1992;67(3):364–369.

25. Renvert S, Roos–Jansåker AM, Claffey N. Non–surgical treatment of peri–implant mucositis and peri–implantitis: a literature review. *J Clin Periodontol*. 2008;35(8 Suppl):305–315.

26. Roos–Jansåker AM, Renvert S, Egelberg J. Treatment of peri–implant infections: a literature review. *J Clin Periodontol*. 2003;30(6):467–485.

27. Mombelli A. Microbiology and antimicrobial therapy of peri–implantitis. *Periodontol 2000*. 2002;28:177–189.

28. George K, Zafiropoulos GG, Murat Y, Hubertus S, Nisengard RJ. Clinical and microbiological status of osseointegrated implants. *J Periodontol*. 1994;65(8):766–770.

29. Thomson–Neal D, Evans GH, Meffert RM. Effects of various prophylactic treatments on titanium, sapphire, and hydroxyapatite–coated implants: an SEM study. *Int J Periodontics Restorative Dent*. 1989;9(4):300–311.

30. Stefani LA. The care and maintenance of the dental implant patient. *J Dent Hyg*. 1988;62(9):447, 464–466.

31. Quirynen M, van Steenberghe D. Bacterial colonization of the internal part of two–stage implants. An in vivo study. *Clin Oral Implants Res*. 1993;4(3):158–161.

32. Quirynen M, Bollen CM. The influence of surface roughness and surface–free energy on supra– and subgingival plaque formation in man. A review of the literature. *J Clin Periodontol*. 1995;22(1):1–14.

33. Bain C, Green S, Bain GB, Price D. Effect of various cleaning devices on dental implants. *J Dent Res*. 1993;72(Spec. Issue):287.

34. Bain CA. An in vitro and in vivo evaluation of various implant–cleaning instruments. *Quintessence Int*. 1998;29(7):423–427.

35. Matarasso S, Quaremba G, Coraggio F, Vaia E, Cafiero C, Lang NP. Maintenance of implants: an in vitro study of titanium implant surface modifications subsequent to the application of different prophylaxis procedures. *Clin Oral Implants Res*. 1996;7(1):64–72.

36. Ewing S. Guidance evolving on cleaning dental implants. *Hygiene Tribune*. 2012;5(1).

37. Fox SC, Moriarty JD, Kusy RP. The effects of scaling a titanium implant surface with metal and plastic instruments: an in vitro study. *J Periodontol*. 1990;61(8):485–490.

38. Duarte PM, Reis AF, de Freitas PM, Ota–Tsuzuki C. Bacterial adhesion on smooth and rough titanium surfaces after treatment with different instruments. *J Periodontol*. 2009;80(11):1824–1832.

39. Fontana CR, Abernethy AD, Som S, et al. The antibacterial effect of photodynamic therapy in dental plaque–derived biofilms. *J Periodontal Res*. 2009;44(6):751–759.

40. Rühling A, Kocher T, Kreusch J, Plagmann HC. Treatment of subgingival implant surfaces with Teflon–coated sonic and ultrasonic scaler tips and various implant curettes. An in vitro study. *Clin Oral Implants Res*. 1994;5(1):19–29.

41. Sato S, Kishida M, Ito K. The comparative effect of ultrasonic scalers on titanium surfaces: an in vitro study. *J Periodontol*. 2004;75(9):1269–1273.

42. Augthun M, Tinschert J, Huber A. In vitro studies on the effect of cleaning methods on different implant surfaces. *J Periodontol*. 1998;69(8):857–864.

43. Mann M, Parmar D, Walmsley AD, Lea SC. Effect of plastic–covered ultrasonic scalers on titanium implant surfaces. *Clin Oral Implants Res*. 2012;23(1):76–82.

44. Baek SH, Shon WJ, Bae KS, Kum KY, Lee WC, Park YS. Evaluation of the safety and efficiency of novel metallic ultrasonic scaler tip on titanium surfaces. *Clin Oral Implants Res*. 2012;23(11):1269–1274.

45. Hallmon WW, Waldrop TC, Meffert RM, Wade BW. A comparative study of the effects of metallic, nonmetallic, and sonic instrumentation on titanium abutment surfaces. *Int J Oral Maxillofac Implants*. 1996;11(1):96–100.

46. Speelman JA, Collaert B, Klinge B. Evaluation of different methods to clean titanium abutments. A scanning electron microscopic study. *Clin Oral Implants Res*. 1992;3(3):120–127.

47. Rapley JW, Swan RH, Hallmon WW, Mills MP. The surface characteristics produced by various oral hygiene instruments and materials on titanium implant abutments. *Int J Oral Maxillofac Implants*. 1990;5(1):47–52.

48. Ramaglia L, di Lauro AE, Morgese F, Squillace A. Profilometric and standard error of the mean analysis of rough implant surfaces treated with different instrumentations. *Implant Dent*. 2006;15(1):77–82.

49. Bailey GM, Gardner JS, Day MH, Kovanda BJ. Implant surface alterations from a nonmetallic ultrasonic tip. *J West Soc Periodontol Periodontal Abstr*. 1998;46(3):69–73.

50. Mengel R, Buns CE, Mengel C, Flores–de–Jacoby L. An in vitro study of the treatment of implant surfaces with different instruments. *Int J Oral Maxillofac Implants*. 1998;13(1):91–96.

51. Mengel R, Meer C, Flores–de–Jacoby L. The treatment of uncoated and titanium nitride–coated abutments with different instruments. *Int J Oral Maxillofac Implants*. 2004;19(2):232–238.

Use of Recommended Communication Techniques by Maryland Dental Hygienists

Alice M. Horowitz, RDH, PhD; Joanne C. Clovis, RDH, PhD; Min Qi Wang, PhD; Dushanka V. Kleinman, DDS, MScD

Abstract

Purpose: The purpose of this study was to determine dental hygienists' use of recommended techniques to communicate science–based information for intervention and prevention of oral disease.

Methods: A 30–item survey containing 18 communication techniques representing 5 domains including 7 basic skills were mailed to a random sample of 1,258 Maryland dental hygienists to determine their use of recommended communication techniques.

Results: The response rate was 43% (n=540). Nearly all were females (98%) and 58% practiced in solo settings. About half of respondents used 6 of the 18 techniques routinely. Approximately three–quarters of respondents reported they rarely or never used 3 of the 7 basic recommended techniques. Only one basic technique (use of simple language) was used by over 90%. Respondents who had taken a communications course other than in dental hygiene school were significantly more likely to use communication techniques on a routine basis than those who had not ($p<0.01$).

Conclusion: Dental hygienists and their patients would benefit from using the recommended communication tools and techniques to address individual patient needs. To improve oral health outcomes, dental hygiene education must strengthen health literacy knowledge and communication skills in dental hygiene education programs and through continuing education courses for practicing hygienists.

Keywords: dental hygienists, recommended communication techniques, health literacy, health communication and dental health education

This study supports the NDHRA priority area, **Health Promotion/ Disease Prevention:** Assess strategies for effective communication between the dental hygienist and client.

Introduction

The oral health of Americans depends in large part on the effective transfer of research results to appropriate user groups – health providers, policy makers, other scientists and, most importantly, the public.[1,2] Dental hygienists play a critical role in educating patients about their oral health and self care.[3] The use of basic recommended communication techniques by health professionals has been shown to increase patient compliance. Thus, it is important that health care providers use recommended communication techniques to transfer or share the most current preventive information available with their patients.[4]

The challenge of providing adequate and appropriate communication in the patient–provider education process is more critical than ever as many individuals lack basic health literacy skills. According to the National Assessment of Adult Literacy (NAAL), over 36% of Americans aged 16 years and older have very limited health literacy.[5] Those at highest risk for low levels of health literacy include those who also are at greatest risk for oral health problems: the poor, minorities and people age 65 and older.[6–8] These and other factors such as being geographically remote from access to care pose enormous challenges for both patients and providers, and the array of skills required by both the individual patient and the health care provider to overcome these challenges is complex.[9]

Patient adherence to prevention and treatment regimens and patient outcomes are clearly linked to provider–patient communication.[10] Health care providers can increase oral health literacy and improve health outcomes by providing current knowledge and skills for their patients in a manner that enhances understanding and appropriate use of such information.[11–13] A lack of understanding and inappropriate or unexpected responses on the part of the patient may be misinterpreted by the health care provider as noncompliance rather than a health literacy problem that must be addressed.[14] A case in point is dental caries prevention. Dental caries can no longer be considered inevitable because measures are available to prevent or control this infectious disease. Simply put, we know how to prevent or control dental caries.[15] Yet a large portion of the public, especially those in lower income groups, are afflicted with this disease.[16,17] The gaps between

Table I: Healthy People 2020 – Topic Area: Health Communication and Health IT – Selected Objectives

HC/HIT–1: (Developmental) Improve the health literacy of the population.	
HC/HIT–1.1	Increase the proportion of persons who report their health care provider always gave them easy–to–understand instructions about what to do to take care of their illness or health condition.
HC/HIT–1.2	Increase the proportion of persons who report their health care provider always asked them to describe how they will follow the instructions.
HC/HIT–1.3	Increase the proportion of persons who report their health care providers' office always offered help in filling out a form.
HC/HIT–2: Increase the proportion of persons who report that their health care providers have satisfactory communication skills.	
HC/HIT–2.1	Increase the proportion of persons who report that their health care provider always listened carefully to them.
HC/HIT–2.2	Increase the proportion of persons who report that their health care provider always explained things so they could understand them.
HC/HIT–2.3	Increase the proportion of persons who report that their health care provider always showed respect for what they had to say.
HC/HIT–2.4	Increase the proportion of persons who report that their health care provider always spent enough time with them.
HC/HIT–3: Increase the proportion of persons who report that their health care providers always involved them in decisions about their health care as much as they wanted.	
HC/HIT–4: (Developmental) Increase the proportion of patients whose doctor recommends personalized health information resources to help them manage their health.	

how Americans' rate their children's oral health and both their own and their children's actual behavior clearly illustrate the communication challenge.[18]

Healthy People 2020 identified several objectives specifically addressing communication skills of health care providers (Table I). The first 2 main goals are particularly relevant: improve the health literacy of the population, and increase the proportion of persons reporting that their health care providers have satisfactory communication skills.[19] The related objectives are from the patient's perspective. The objectives for the first goal aim to increase the proportions of persons who report that their health care provider gave instructions they could understand and also confirmed their understanding. For the second goal, the objectives aim to increase those persons who report that their health care provider always listened carefully, explained things so they could understand, showed respect and spent enough time with them.

Essential communication skills for health care providers have been studied and reported. Skills include avoiding medical/dental jargon, using common words and paying attention to signs indicating that the patient understands, among others. Using patient–centered strategies such as being aware of the patient's state of mind and taking time to listen to the patient can increase patient understanding and compliance.[20] Other strategies that increase communication effectiveness, particularly for a low literacy audience, include using short and simple statements, listening, giving visual cues, presenting information in small increments, and asking patients to repeat instructions.[2,20]

To address some of these skills, an action plan for dentistry, Health Literacy in Dentistry Action Plan 2010–2015, was created by the American Dental Association.[21] The plan has 5 strategic goals:

1. Training and education to change perceptions of oral health
2. Advocacy to overcome barriers by replicating effective programs and proven efforts
3. Research to build the science base and accelerate science transfer
4. Dental practice to increase oral health workforce diversity, capacity and flexibility
5. Build and maintain coalitions to increase collaborations

One objective specifies that all current and future health care workers, dentists, dental hygienists, dental assistants and students of each discipline, should have education that includes the principles of effective communication and the use of plain language in practice.

The knowledge and communication approach that dental hygienists use with their patients is the key

to their patients adopting recommended oral health behaviors. The importance of dental hygienists in patient education and disease prevention is widely accepted, and evidence–based practice is supported by proponents of dental hygiene.[22,23] Yet there are few studies that investigate hygienists' knowledge, opinions and practice in these areas. Studies have shown that dental hygienists need to place greater emphasis on patient education about how individual behaviors can prevent dental caries as well as on the importance of public policy decisions on issues such as community water fluoridation. Although the hygienists' knowledge of the benefits of fluoride use and water fluoridation is relatively high, studies have shown they do not emphasize patient education on these topics, and only 32% of patients recalled being told about the benefits of fluoride.[24,25] Dental hygienists tend to use traditional health education strategies, such as conducting advising sessions or handing out pamphlets.[26] However, traditional educational methods are not always effective in changing knowledge or behavior.[27] Building a trustful relationship with patients was identified as important in the prevention and treatment of periodontal disease.[28] For the education provided by dental hygienists to be effective in influencing patient behavior, patients must be able to understand and use the information that they are given.[6,29]

Dental hygienists have a significant role in the prevention of dental diseases by preventing the onset of the disease, recognizing it at early stages and providing patient education that encourages individuals to take an active role in preventing diseases and maintaining their oral health.[24,30] Thus, there is a gap between what the evidence has shown to be effective in preventing dental caries and what the public actually understands and practices with regard to this evidence. Dental hygienists are essential communicators in bridging that gap.[1] A study to understand the use of communication techniques by dental hygienists was undertaken as part of an overall investigation to enhance oral health literacy in Maryland.

Methods and Materials

A self–administered questionnaire including items on communication techniques was used in this cross sectional descriptive study of Maryland dental hygienists. The Institutional Review Board at the University of Maryland approved the study.

In May, June and July of 2010, data was collected by a mail survey to a random sample of 1,259 dental hygienists generated from a membership list provided by the Maryland Dental Hygienists' Association (MDHA). Eighteen items on recommended communication techniques used on a routine basis were included in a 30 item questionnaire designed to also elicit the respondent's knowledge and practice pertaining to dental caries prevention. The findings in this report are limited to the questions concerning hygienists' use of communication techniques.

The items on communication were adapted from Rozier et al, and based on techniques recommended by the American Medical Association.[4,20] The 18 questions that are grouped into 5 domains are shown in Figure 1. The 7 basic techniques comprise the first 2 domains (interpersonal communication and teach back method). Respondents were asked how often they used the 18 communication techniques in a typical workweek using a Likert–type scale of 5 options: always, most of the time, occasionally, rarely and never. For each technique they were asked whether they thought the technique was effective using a yes, no or don't know response. The instrument was pilot–tested among 6 practicing dental hygienists; it was then revised and printed in a format that could be returned without an envelope. Participation in the study was voluntary and passive consent to participate was given by completing and returning the survey. Three attempts were made to reach dental hygienists and request their response.

The first mailing consisted of the full survey instrument with a cover letter signed by the president of the MDHA. Three weeks after the first mailing, a second complete mailing was sent with a modified cover letter from the president. Approximately 3 weeks after the second mailing, a postal card, also signed by the MDHA president, was mailed to remind the dental hygienist that we had not yet received the completed survey. We also asked the MDHA to send an email reminder to all dental hygienists urging them to respond to the survey as soon as possible.

Data Analysis

The outcome variable for analysis of the communication techniques was a count of the routine use of the 18 communication techniques. For the purpose of analysis, we also extracted 7 out of the 18 communication techniques as a separate outcome variable. Similar to Rozier et al, we defined routine use as use most of the time or always versus never, rarely or occasionally.[4] We also asked respondents if they had ever assessed their office or clinic facilities and procedures to determine how user–friendly it is for patients. In addition, we asked if they were interested in attending a course on communication skills.

The data was analyzed using SPSS version v18. Statistical analyses included descriptive statistics (frequencies and percentages), cross tabulation and

Figure 1: Five Domains and Items

Interpersonal communications*
• Limit number of concepts presented at a time to 2 to 3 • Ask patients whether they would like a family member or friend to accompany them in the discussion • Draw pictures or use printed illustrations • Speak slowly • Use simple language
Teach–Back Method*
• Ask patients to repeat back information or instructions • Ask patients to tell you what they will do at home to follow instructions
Patient–Friendly Materials and Aids
• Use video or DVD • Hand out printed materials • Use models or x–rays to explain
Assistance
• Underline key points on print materials • Follow–up with patients by telephone to check understanding and adherence • Read instructions out loud • Ask other office staff to follow–up with patients for post–care instructions • Write or print out instructions
Patient–Friendly Practice
• Ask patients what they can accomplish in connection with their oral hygiene • Refer patients to the Internet or other sources of information • Use a translator or interpreter when needed

*Basic Communication Techniques

chi square statistic. For the chi square test, the associations were examined between all demographic variables and the mean use of variables. Analysis of variance (ANOVA) of the selected predictor variables (demographics and the characteristics) were used as the independent variables and the dependent variable of the mean number of communication techniques used routinely. Ordinary least squares regression analysis of the selected predictor variables (demographics and practice characteristics) were used as the independent variables and the count of communication techniques routinely used in a week as the dependent variable. Because of the exploratory nature of the survey, the p–values were selected at 3 levels, $p<0.10$, $p<0.05$ and $p<0.01$.

Results

Sample Results and Characteristics

Of the 1,259 surveys sent, 579 were returned for a response rate of 46%. Of these, 540 were usable responses giving an effective response rate of 43%. Nearly all respondents were females (98%), most were White (83%), more than half practiced in a solo practice setting (58%) and about one–third were in group practices (35%). Approximately one–quarter graduated from their dental hygiene program in each of the previous 3 decades, and one–quarter graduated before 1980 (27%) (Table II). When asked what percent of their child patients had private insurance, the average response was 70%, while the average percent having Medicaid patients in their practice was 11%. The majority (66%) reported having taken a communication course other than that taught in their dental hygiene training.

Descriptive Results for Communication Techniques Used

The 18 items regarding the communication techniques regularly used are grouped into 5 domains: interpersonal communication, teach back, patient–friendly materials and aids, assistance and patient–friendly practice.[4] The percentage distribution for each of the 5 possible responses to each item is shown in Table III. The first 7 techniques included in the first 2 domains are considered to be basic skills that every health provider should use routinely. The mean response score for the routine use of each technique and domain are displayed in Figure 2.

The frequency of use varied considerably across the 18 techniques and 5 domains. Dental hygienists

Table II: Dental Hygienists' Characteristics

Characteristic	n	Percentage
Year of Graduation		
1958–1979	144	27.38
1980–1989	131	24.90
1990–1999	116	22.05
2000–2009	135	25.67
Practice Setting		
Solo Practice	306	57.84
Group Practice	189	35.30
All other	34	6.43
Occupation		
Private Practice	492	92.83
All other	38	7.17
Race/Ethnicity		
White	451	83.36
Black	34	6.28
All other	56	10.35
Gender		
Female	521	97.93
Male	11	2.07
Type of dental insurance of child patients		
Medicaid/SCHIP	464	11.0*
Private Insurance	488	70.0*
Out of Pocket	483	21.0*
Ever taken a communication course		
Yes	350	65.79
No	182	34.21

*Average percentage

reported routinely using an average of 6.95 of the 18 techniques and 3.71 of the 7 basic techniques during a typical work week. About 14% of respondents used 10 or more of the 18 techniques and 26% used 4 or more of the 7 basic techniques. Less than 5% used all 7 basic techniques. Only one basic technique (use simple language) was used routinely by nearly all respondents.

Figure 2: Percentage of Dental Hygienists Routinely Using Each Communication Technique, According to Domain

Communication Technique	Percentage
Interpersonal Communications*	52.49**
• Limit number of concepts presented at a time (2 to 3)	86.82
• Ask patients whether they would like a family member or friend to accompany them in the discussion	14.34
• Draw pictures or use printed illustrations	31.37
• Speak slowly	77.44
• Use simple language	96.99
Teach back method*	34.00**
• Ask patients to repeat back information or instructions	22.08
• Ask patients to tell you what they will do at home to follow instructions	45.95
Patient–friendly materials and aids	43.48**
• Use video or DVD	8.68
• Hand out printed materials	48.37
• Use models or x–rays to example	73.40
Assistance	23.94**
• Underline key points on print materials	23.48
• Follow–up with patients by telephone to check understanding and adherence	4.72
• Read instructions out loud	45.52
• Ask other office staff to follow–up with patients for post–care instructions	14.15
• Write or print out instructions	31.82
Patient–friendly practice	25.80**
• Ask patients what they can accomplish in connection with their oral health	30.17
• Refer patients to the internet or other sources of information	17.17
• Use a translator or interpreter when needed	30.06

*Basic communication technique
**Domain average

Table IV presents the results from the bivariate analysis of the routine use of communication techniques by provider and practice characteristics. For provider characteristics, there was a significant relationship between race and the routine use of 18 techniques ($p<0.01$). The average routine use of the 18 techniques was greater for non–White (mean=7.96) than White providers (mean=6.76). The average use of the 18 techniques was greater for dental hygienists born in foreign countries than U.S. born dental hygienists (7.78 vs. 6.95, $p<0.10$). Dental hygienists who had taken a communication course used the 18 techniques more than those who had not had a communication course (7.28 vs. 6.31, $p<0.001$). The average use of the 18 techniques was greater for those who assessed their procedures and facility to determine how user–friendly it is for patients than those who did not (7.84 vs. 6.14, $p<0.001$). Of the 5 practice characteristics variables, the only significant variable was the percent of child patients covered by Medicaid ($p<0.05$). The mean number of the 18 techniques was the highest (9.28) for dental hygienists with 26 to 50% of child patients who were insured with Medicaid.

For the use of the 7 basic techniques, the average use was higher for dental hygienists who had taken a communication course than those who had

Table III: Percent Distribution of Techniques Used Routinely by the Dental Hygienists in the Sample

Domain and Item	n	Percent Distribution					Mean Score**
		Always	Most of the Time	Occasionally	Rarely	Never	
Interpersonal Communications*							
• Limit number of concepts presented at a time (2 to 3)	516	27.52	59.30	9.69	2.71	0.75	3.10
• Ask patients whether they would like a family member or friend to accompany them in the discussion	530	4.15	10.19	31.32	28.49	25.85	1.38
• Draw pictures or use printed illustrations	526	10.65	20.72	37.64	20.53	10.46	2.01
• Speak slowly	532	21.99	55.45	18.80	3.01	0.75	2.95
• Use simple language	532	53.38	43.61	2.44	0.56	–	3.50
Teach back method*							
• Ask patients to repeat back information or instructions	530	5.09	16.98	35.09	30.94	11.89	1.72
• Ask patients to tell you what they will do at home to follow instructions	531	15.25	30.70	31.45	16.01	6.59	2.32
Patient–friendly materials and aids							
• Use video or DVD	530	3.40	5.28	13.96	18.68	58.68	0.76
• Hand out printed materials	523	16.83	31.55	40.54	8.99	2.10	2.52
• Use models or x–rays to example	530	25.66	47.74	22.08	3.21	1.32	2.93
Assistance							
• Underline key points on print materials	528	10.42	13.07	27.46	28.98	20.08	1.65
• Follow–up with patients by telephone to check understanding and adherence	530	1.51	3.21	18.49	33.21	43.58	0.85
• Read instructions out loud	525	21.14	24.38	24.98	15.81	13.71	2.23
• Ask other office staff to follow–up with patients for post–care instructions	530	4.91	9.25	23.21	33.58	29.06	1.27
• Write or print out instructions	528	10.23	21.59	41.48	17.61	9.09	2.06
Patient–friendly practice							
• Ask patients what they can accomplish in connection with their oral health	527	8.16	22.01	29.79	23.72	16.32	1.82
• Refer patients to the internet or other sources of information	530	5.09	12.08	41.32	27.92	13.58	1.67
• Use a translator or interpreter when needed	529	17.77	12.29	19.47	24.76	25.71	1.72

*Basic communication technique
**Mean score on a 5 point Likert Scale (0=never to 4=always)

not taken a communication course (3.83 vs. 3.46, $p<0.01$). Those who assessed their offices for user friendliness routinely used 7 techniques more than those who did not assess their office (4.00 vs. 3.43, $p<0.001$). Of the 5 practice characteristics variables, the only significant variable was primary occupation ($p<0.10$). The mean number of communication techniques routinely used was higher for dental hygienists who reported "other" as their primary occupation than those whose primary occupation was private practice ($p<0.10$).

Table V shows responses of hygienists' beliefs about the effectiveness of the communication techniques. Most responses were distributed between the yes and don't know categories, with relatively few selecting no. For 5 of the techniques more than half the hygienists reported they did not know whether the techniques were effective and for another 4 techniques more than one–third of dental hygienists reported they did not know if the techniques were effective.

Table VI presents the results from the multiple regression analysis with the communication techniques as the dependent variable. The results generally confirmed some of the associations that were observed in the bivariate analysis. The average number of

Table IV: Bivariate Analysis of Predictor Variables and Mean Number of Communication Techniques used Routinely

Variable	18 communication techniques (n=524)			Seven basic communication techniques (n=524)	
	Sample size (Number, %)+	Mean number of techniques used	Analysis of variance (p value)	Mean number of techniques used	Analysis of variance (p value)
Provider characteristics					
Year of graduation					
• 1958 to 1979 • 1980 to 1989 • 1990 to 1999 • 2000 to 2009	143 (27.3) 131 (25.0) 115 (22.0) 153 (25.8)	7.02 6.79 7.01 6.87	0.935	3.84 3.74 3.65 3.56	0.405
Race/Ethnicity					
• White • Black • All other	449 (84.2) 34 (6.4) 50 (9.4)	6.76 8.24 7.78	0.008***	3.68 3.68 4.02	0.272
Sex					
• Female • Male	519 (97.9) 11 (2.1)	6.91 9.18	0.024**	3.69 4.81	0.009***
Country of origin					
• U.S. • Other	492 (92.3) 41 (7.7)	6.95 7.78	0.098*	3.69 3.92	0.312
Had communications course					
• No • Yes	182 (34.3) 348 (65.7)	6.31 7.28	0.00014***	3.46 3.83	0.004***
Assessed office					
• No • Yes	279 (53.4) 244 (46.7)	6.14 7.84	0.0001***	3.43 4.00	0.0001***
Practice characteristics					
Percent of child patients with Medicaid					
• 0 to 25% • 26 to 50% • 51 to 75% • 76 to 100%	401 (87.2) 14 (3.0) 13 (2.8) 32 (7.0)	6.78 9.28 7.07 7.47	0.033**	3.63 4.42 3.46 3.93	0.128
Percent of child patients 6 months to 2 years					
• 0 to 25% • 26 to 50%	469 (98.0) 10 (2.1)	6.91 6.60	0.772	3.67 3.60	0.885
Percent of child patients 3 to 6 years					
• 0 to 25% • 26 to 50%	276 (55.5) 221 (44.5)	7.00 6.90	0.714	3.66 3.73	0.586
Primary occupation					
• Private practice • Other	490 (92.8) 38 (7.2)	6.90 7.63	0.194	3.68 4.11	0.075*
Practice setting					
• Solo practice • Group Private Practice • Other	305 (57.9) 188 (35.7) 34 (6.5)	6.93 6.90 7.38	0.737	3.67 3.70 4.08	0.264

+The sample size for each variable might not be equal to the overall sample size due to missing values
*p<0.10
**p<0.05
***p<0.01

Table V: Percentage Distribution of Participants, According to Beliefs About Effectivness of Communication Technique

Domain and Item	n	Response (percentage)		
		Yes	No	Do not know
Interpersonal Communications*				
• Limit number of concepts presented at a time (2 to 3)	409	87.0	1.5	11.5
• Ask patients whether they would like a family member or friend to accompany them in the discussion	385	52.7	4.4	42.9
• Draw pictures or use printed illustrations	393	67.9	4.1	28.0
• Speak slowly	418	83.3	1.9	14.8
• Use simple language	416	92.6	0.2	7.2
Teach back method*				
• Ask patients to repeat back information or instructions	409	54.5	5.1	40.3
• Ask patients to tell you what they will do at home to follow instructions	405	60.0	5.7	34.3
Patient–friendly materials and aids				
• Use video or DVD	364	29.1	6.9	64.0
• Hand out printed materials	398	63.3	3.8	32.9
• Use models or x–rays to example	407	91.0	1.0	8.1
Assistance				
• Underline key points on print materials	392	42.6	6.1	51.3
• Follow–up with patients by telephone to check understanding and adherence	372	33.3	7.8	58.9
• Read instructions out loud	394	57.6	5.8	36.6
• Ask other office staff to follow–up with patients for post–care instructions	377	36.6	9.0	54.4
• Write or print out instructions	401	63.8	2.2	33.9
Patient–friendly practice				
• Ask patients what they can accomplish in connection with their oral health	379	51.5	4.8	43.8
• Refer patients to the internet or other sources of information	392	37.5	4.5	57.9
• Use a translator or interpreter when needed	379	67.3	2.6	30.1

*Basic communication techniques

routinely used 18 techniques was higher for non–White compared to White, but not for the 7 basic techniques. The number of the 18 techniques and 7 basic techniques was lower for those who did not assess their procedures and facility to determine how user–friendly it is for patients than those who did. Those who had a communication course outside of their basic dental hygiene training were more likely than those who did not have such a course to routinely use either 18 techniques or 7 basic techniques ($p<0.001$).

Discussion

Routine Use of Communication Techniques

This investigation is one of the first to report dental hygienists' use of these recommended communication techniques. The routine use of communication techniques by dental hygienists varied greatly. A national survey supported by the ADA and reported by Horowitz et al using similar questions to those used in this study found that nearly 10% of dental hygienists asked patients to repeat instructions (teach back) and 31% reported they asked their patients to tell them what they would do at home to follow instructions.[31] In contrast, 22% of dental hygienists in the current study reported routine use of teach back and 46 % asked their patients to tell them what they would do at home to follow instructions.

Dental hygienists in the current study reported using an average of 6.95 of the 18 techniques and 3.71 of the 7 basic techniques. These averages are similar to dentists in a national survey which averaged 7.1 for 18 techniques and 3.1 for the 7 basic techniques.4 Most (97%) reported using simple

Table VI: Ordinary Least Squares Regression Results of Predicator Variables on Number of Communication Techniques Routinely Used in a Week

Variable	18 Communication Techniques (n=541)		Seven Basic Communication Techniques (n=541)	
	Coefficient (Standard Error)	p–value	Coefficient (Standard Error)	p–value
Year of Graduation				
• 1958–1979 vs. 2000–2009 • 1980–1989 vs. 2000–2009 • 1990–1999 vs. 2000–2009	0.15 (0.400) 0.08 (0.410) 0.13 (0.420)	0.710 0.840 0.750	0.40 (0.480) –0.10 (0.490) –0.10 (0.51)	0.400 0.840 0.840
Race/Ethnicity				
• Black vs. White • Other vs. White	1.47 (0.590) 1.02 (0.490)	0.010 0.040	–0.68 (0.710) 0.67 (0.600)	0.340 0.270
Sex				
• Female vs. Male	–2.27 (1.010)	0.020	–2.76 (1.210)	0.023**
Country of Origin				
• Other vs. U.S.	0.90 (0.540)	0.100	1.43 (0.650)	0.03**
Occupation				
• Other vs. Private Practice	0.73 (0.56)	0.190	0.43 (0.240)	0.07*
Assessed Office				
• No vs. Yes	–1.71 (0.280)	<0.0001	–0.57 (0.121)	<0.0001***
Communication course				
• No vs. Yes	–0.97 (0.300)	0.001	–1.25 (0.360)	0.001***

*p<0.10
**p<0.05
***p<0.01

language, 1 of the techniques in the interpersonal communications domain. Just a third of dental hygienists reported using teach back methods, which is recommended for universal use with patients by health literacy experts. In contrast, in the national survey of dentists nearly 20 reported using this technique.[4] Teach back methods require that the provider ask the patient to repeat back what he/she has said to determine understanding on the part of the patient.[9] In a study of health care providers practicing in federally qualified health centers, Schlichting et al found that those providers who had training in health literacy were more likely to use teach–back methods.[32]

Factors Affecting Use of Communication Techniques

Several important factors influenced the use of the 18 communication techniques. Dental hygienists who had taken a communications course other than in dental hygiene school clearly used more of the 18 communication techniques. A related factor was those who assessed their offices for user friendliness also used more of the 18 techniques than those who had not. These findings lend strong support for including communications courses as required curriculum in schools of dental hygiene and as options for continuing education by dental hygiene associations and dental hygiene programs.

The mean number of 18 techniques used by hygienists was most strongly influenced by the average percentage of Medicaid patients in their respective practice. This finding might reflect the hygienists' perception of just how much Medicaid patients need skills and understanding and thus use more communication techniques to help them understand.

For the 7 basic techniques, having had a communications course and assessing their practice for user friendliness were major factors in an increased use of communications techniques. The fact that dental hygienists who practice in "other than private practice," in other words, such as public health clinics and hospitals, also used more of the 7 basic techniques than did those in private practice is not surprising because many Medicaid and other low socio–economic status patients likely seek care in these facilities.

A patient health literacy assessment in a dental hygiene program found that a significant number of patients had marginal literacy skills indicating a need for attention to health literacy in the curriculum.[33] Although tools and techniques are available to assist health care providers, their use by dental hygienists is not known. For example, Health Literacy, Universal Precautions Toolkit has been produced by the Agency for Health Care and Quality, and dental hygienists and their patients would benefit from adapting these to their practices.[34,35] Intervention studies are needed to determine which specific adaptations are most useful in various practice settings with different patients.

Study Limitations

While the response rate (43%) was similar to other health care provider surveys and is reasonably good for a mail survey for health providers,[36] the generalizability may be limited. Selection bias is possible in that the responses of the survey participants may not reflect the views of non–responders. Providers who returned the survey were likely to be more interested in the topic than those who did not. Further, the validity of the participants' assessment of their communication also may be questioned given that direct observation could more accurately determine the type and quality of dental hygienist–patient communication. Despite these limitations, this study provides us with excellent baseline information upon which to develop and implement educational interventions and policies in Maryland.

Dental hygienists can incorporate the routine use of recommended communication techniques if they have the knowledge, understanding and skills. In undergraduate education programs it is important that dental hygiene students receive appropriate training by educators with communication expertise and that their clinical experiences include skills training and evaluation in the use of recommended communication techniques. Continuing education courses can address these gaps for practicing dental hygienists.

Conclusion

The purpose of this study was to determine the use of recommended communication techniques by Maryland dental hygienists. The results were similar to other studies that dictate a need for attention to communication skills in undergraduate curriculum and post–graduate continuing education offerings. Improved communication techniques can reduce the gaps in patient understanding and increase the likelihood of adequate and appropriate patient self–care leading to improved oral health outcomes.

Alice M. Horowitz, PhD, is a research associate professor, Department of Behavior and Community Health, School of Public Health, University of Maryland. Joanne C. Clovis, RDH, PhD, is a professor at the School of Dental Hygiene, Faculty of Dentistry, Dalhousie University, Halifax, Nova Scotia, Canada. Min Qi Wang, PhD, is a professor at the Department of Behavior and Community Health, School of Public Health, University of Maryland. Dushanka V. Kleinman, DDS, MScD, is a professor and associate dean for research at the School of Public health, University of Maryland.

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References

1. Horowitz AM. The public's oral health: The gaps between what we know and what we practice. *Adv Dent Res*. 1995;9(2):91–95.

2. Horowitz AM, Kleinman DV. Oral health literacy: the new imperative to better oral health. *Dent Clin North Am*. 2008;52(2):333–344.

3. Horowitz AM. Health education & promotion to prevent dental caries. The opportunity and responsibility of dental hygienists. *Dent Hyg (Chic)*. 1983;57(5):8–10.

4. Rozier RG, Horowitz AM, Podschun G. Dentist–patient communication techniques used in the United States The results of a national survey. *J Am Dent Assoc*. 2011;142(5):518–530.

5. Kutner M, Greenberg E, Jin Y, Paulsen C. The health literacy of America's adults: Results from the 2003 national assessment of adult literacy (NCES2006–483). National Center for Education Statistics. 2006.

6. Jones M, Lee JY, Rozier RG. Oral health literacy among adult patients seeking dental care. *J Am Dent Assoc*. 2007;138(9):1199–1208.

7. Rudd RE. Health literacy skills of US adults. *Am J Health Behav*. 2007;31(supp):8–18.

8. National Institute of Dental and Craniofacial Research, National Institute of Health, U.S. Public Health Service, Department of Health and Human Services. The invisible barrier: literacy and its relationship with oral health. A report of a workgroup sponsored by the National Institute of Dental and Craniofacial Research, National Institute of Health, U.S. Public Health Service, Department of Health and Human Services. *J Public Health Dent*. 2005;65(3):174–182.

9. Health literacy: A prescription to end confusion. nstitute of Medicine of the National Academies [Internet]. 2004 [cited 2011 November 5]. Available from: http://www.nap.edu/openbook.php?isbn=0309091179

10. Hall JA, Roter DL, Katz NR. Meta–analysis of correlates of provider behavior in medical encounters. *Med Care*. 1988;26(7):657–675.

11. Wolf MS, Wilson EA, Rapp DN, et al. Literacy and learning in health care. Pediatrics. 2009;124(Suppl 3):S275–S281.

12. Sanders LM, Shaw JS, Guez G, Baur C, Rudd R. Health literacy and child health promotion: implications for research, clinical care, and public policy. *Pediatrics*. 2009;124(Suppl 3):S306–S314.

13. Sanders LM, Federico S, Klass P, Abrams MA, Dreyer B. Literacy and child health: a systematic review. *Arch Pediatr Adolesc Med*. 2009;163(2):131–140.

14. Committee Opinion No. 491: Health Literacy. *Obstet Gynecol*. 2011;117(5):1250–1253.

15. Advancing Oral Health in America. Institute of Medicine of the National Academies [Internet]. 2011 [cited 2011 June 11] Available from: http://www.iom.edu/Reports/2011/Advancing–Oral–Health–in–america.aspx

16. Dye BA, Tan S, Smith V, et al. Trends in oral health status: United States, 1988–1994 and 1999–2004. *Vital Health Stat 11*. 2007;(248):1–92.

17. Dye BA, Thornton–Evans G. Trends in oral health by poverty status as measured by Healthy People 2010 objectives. *Public Health Rep*. 2010;125(6):817–830.

18. Oral Health Knowledge Gap Contributes to Children's Issues. Delta Dental Plans Association [Internet]. 2009 September 14 [cited 2011 May 11]. Available from: http://www.deltadental.com/Public/NewsMedia/NewsReleaseOralHealthKnowledgeGapIssues092009.jsp

19. Oral Health Objectives. 2020 Topics and Objectives. U.S. Department of Health and Human Services. 2011.

20. Schwartzberg JG, Cowett A, VanGeest J, Wolf MS. Communication techniques for patients with low health literacy: a survey of physicians, nurses, and pharmacists. *Am J Health Behav*. 2007;31(Supp 1):96–104.

21. Health Literacy in Dentistry Action Plan 2010–2015. American Dental Association [Internet]. 2009 [cited 2011 May 11]. Available from: http://ada.org/sections/professionalResources/pdfs/topics_access_health_literacy_dentistry.pdf

22. Cobban SJ, Seale LN. A collaborative approach for improving information literacy skills of dental hygiene students. *Int J Dent Hyg*. 2003;1(1):49–56.

23. Cobban SJ, Edgington EM, Clovis JB. Moving research knowledge into dental hygiene practice. *J Dent Hyg*. 2008;82(2):21.

24. McConaughy FL, Toevs SE, Lukken KM. Adult clients' recall of oral health education services received in private practice. *J Dent Hyg.* 1995;69(5):202–211.

25. Chovanec GK, Majerus GJ, Duffy MB, Bernet JK, Frazier PJ, Newell KJ. Dental hygienists' knowledge and opinions about fluorides and fluoridation. *J Public Health Dent*. 1990;50(4):227–234.

26. McConaughy FL, Lukken KM, Toevs SE. Health promotion behaviors of private practice dental hygienists. *J Dent Hyg*. 1991;65(5):222–230.

27. Weinstein P, Harrison R, Benton T. Motivating mothers to prevent caries: confirming the beneficial effect of counseling. *J Am Dent Assoc*. 2006;137(6):789–793.

28. Stenman J, Wennström JL, Abrahamsson KH. Dental hygienists' views on communicative factors and interpersonal processes in prevention and treatment of periodontal disease. *Int J Dent Hyg*. 2010;8(3):213–218.

29. Paulis M. The influence of patient education by the dental hygienist: acceptance of the fluorescence oral cancer exam. *J Dent Hyg*. 2009;83(3):134–140.

30. Ohrn K. The role of dental hygienists in oral health prevention. *Oral Health Prev Dent*. 2004;2(Suppl 1):277–281.

31. Horowitz AM, Rozier G. Communicating with Patients: A national survey of dental team members. Meeting of the American Public Health Association. Philadelphia, 2009 November 10.

32. Schlichting JA, Quinn MT, Heuer LJ, Schaefer CT, Drum ML, Chin MH. Provider percentpsions of limited health literacy in communicty health centers. *Patient Edu Couns*. 2007;69(1–3):114–120.

33. Jackson RD, Coan LL, Hughes E, Eckert GJ. Introduction of Health Literacy into the Allied Dental Curriculum: First Steps and Plans for the Future. *J Dent Educ*. 2010;74(3):318–324.

34. DeWalt DA, Callahan LF, Hawk VH, et al. Health literacy universal precautions toolkit. Agency for Healthcare Research and Quality [Internet]. 2010 [cited 2011 May 11]. Available from: http://www.ahrq.gov/professionals/quality–patient–safety/quality–resources/tools/literacy–toolkit/index.html

35. National Action Plan to Improve Health Literacy. U.S. Department of Health and Human Services, Office of Disease Prevention and Health Promotion. 2010.

36. VanGeest JB, Johnson TP, Welch VL. Methodologies for improving response rates in surveys of physicians: a systematic review. *Eval Health Prof*. 2007;30(4):303–321.

Predicting Undergraduates' Intentions to Improve Oral Health Behaviors: The Importance of Self–Identity – A Pilot Study

Alexandrina L. Dumitrescu, DDS, BSc, MSc, PhD; Carmen Duţă, BSc, PhD; Carmen Beatrice Dogaru, MD, PhD; Bogdan Manolescu, BSc, PhD

Abstract

Purpose: The purpose of this study was to explore the predictive ability of factors associated with the Theory of Planned Behavior (TPB) on oral health behaviors.

Methods: The participants of this descriptive, cross–sectional study were 179 first year medical students at the Carol Davila University of Medicine and Pharmacy that completed a questionnaire assessing TPB variables, self–identity and their current oral hygiene behaviors.

Results: Significant differences in self–identity regarding the toothbrushing behavior and reason for the dental visit were observed ($p<0.0001$). When participants were classified in 2 groups according to their levels of self–identity, significant differences were found according to their age, toothbrushing frequency, attitudes, perceived behavioral control and intention for improving oral hygiene ($p<0.0001$). Self–identity had a statistically significant positive correlation with affective attitudes, cognitive attitudes, subjective norms, perceived behavioral control and intention for improving oral hygiene. Hierarchical multiple regressions for toothbrushing frequency revealed that the TPB factors and self–identity explained 31% and 35% from the intention to improving behaviors, the coefficients for self–identity being significant. The structural equation model revealed the effect of self–identity on intention on improving oral health behaviors and the effect of past–behavior on self–identity.

Conclusion: The findings revealed the value of the extended TPB model as a predictor of intention to improve oral health behaviors. Dental educators should focus on issues of students' self–identity as a person concerned by their oral health.

Keywords: theory planned behavior; self–identity; tooth brushing; dental flossing; dental patients; self–identity

This study supports the NDHRA priority area, **Health Promotion/Disease Prevention:** Assess strategies for effective communication between the dental hygienist and client.

Introduction

According to the Theory of Planned Behavior (TPB), human behavior is guided by 3 kinds of considerations: beliefs about the likely outcomes of the behavior and the evaluations of these outcomes (behavioral beliefs), beliefs about the normative expectations of others and motivation to comply with these expectations (normative beliefs), and beliefs about the presence of factors that may facilitate or impede performance of the behavior and the perceived power of these factors (control beliefs). In their respective aggregates, behavioral beliefs produce a favorable or unfavorable attitude toward the behavior, normative beliefs result in perceived social pressure or subjective norm and control beliefs give rise to perceived behavioral control. In combination, attitude toward the behavior, subjective norm and perception of behavioral control lead to the formation of a behavioral intention. As a general rule, the more favorable the attitude and subjective norm and the greater the perceived control, the stronger should be the person's intention to perform the behavior in question.[1] Thus, in reference to Ajzen's recommendations for the development of interventions based on the TPB, the next step is to investigate the determinants of intention and their related beliefs reflecting the cognitive foundation of the targeted behavior.

Theory of planned behavior has been used successfully to provide a better understanding and explanation of a diverse range of health–related and social behaviors, including addictive behaviors (e.g., smoking, alcohol consumption and drug use), clinical and screening behaviors (e.g., health checks and cancer screening), eating and exercising behaviors (e.g., healthy diets), HIV/AIDS–related behaviors (e.g., condom use)[2–4] and oral health behaviors.[5–10] The TPB has been successfully applied to a wide range of health–related behaviors among adults and adolescents.[3,11–13]

The TPB model is a flexible model that opens to the inclusion of additional variables with aim to increase the proportion of the explained variance and to allow generalization to other research context.[14] Based on Stryker's identity theory, self–identity reflects the extent to which engaging in a behavior is important to an individual's self–concept.[15,16] Numerous studies have demonstrated the ability of self–identity to improve the predictive efficiency of the TPB.[3] Individuals who strongly identify with the role of "a person interested in his oral health" may therefore be motivated to act in accordance with their self–concept and to improve their oral health behaviors.[17,18]

The present study aimed to test an extended TPB, including self–identity, to predict young adults' intentions to engage in and subsequent engagement in improving oral hygiene behavior. It was expected that young people's level of self–identity regarding oral health would be associated with improved oral health behaviors (Hypothesis 1). It was also expected that attitude, subjective norm and perceived behavioral control (PBC) would predict intention to improve oral hygiene behavior, after taking into account the demographic factors of age, gender and past behavior, with the addition of self–identity expected to improve the prediction of intention (Hypothesis 2). Another aim of the research was to examine whether the effects of self–identity vary as a function of repeated experience of performing the relevant behavior. Specifically, it was proposed that the relationship between self–identity and intention would be strongest for people who had performed the behavior frequently in the past (Hypothesis 3).

Methods and Materials

Sample

The participants of this descriptive, correlational, cross–sectional study were 179 first year medical students at the Carol Davila University of Medicine and Pharmacy who were invited to this survey at the beginning of the 2010 to 2011 academic year. Participants' mean age was 19.68, and the sample consisted of 142 women and 37 men. In addition, the sample was homogenous in terms of ethnic background (100% Caucasians). Upon entry, all participants signed a declaration of informed consent. The study was conducted in full accordance with the declared ethical principles (World Medical Association Declaration of Helsinki, version VI, 2002).

Instruments and measures

The research data were gathered by means of a structured Romanian questionnaire. For the TPB constructs, 5 items were developed for each TPB domain based on the literature review and on Ajzen's TPB.[4] A 7–point Likert–type and semantic differential scale was used to elicit participants' responses in each of the domains. All the variables were scored consistently so that higher mean scores reflected more positive attitudes, more positive subjective norms and higher perceived behavioral control towards oral health behaviors. The overall alpha coefficient of the instrument was 0.881.

Behavioral Intention Measures

The behavioral intention measures asked participants to indicate how likely they were to engage in certain oral health behaviors on a regular basis and were measured on 7–point scales ranging from (1) extremely unlikely to (7) extremely likely. The intention items were: I will toothbrush my teeth more than twice per day, I will floss my teeth daily during the next month and I will use mouthwash daily. The Cronbach's alpha of the scale was 0.792.

Affective Attitude Toward the Behavior

Five items assessed affective associations with oral health behaviors. Each item asked participants to report how they feel when considering regular toothbrushing, flossing, mouthwashes, dental visits and scaling frequency (unpleasant/pleasant). Participants responded using 7–point scales with 1 and 7 anchored by each end of the semantic differential. The Cronbach's alpha of the scale was 0.675. The mean of the 5 items served as the measure of affective attitude.

Cognitive Attitude Toward the Behavior

Attitudes toward oral health behaviors were measured with 5 items assessing the expected value of engaging in regular oral health behaviors. Each question consisted of a semantic differential (harmful/beneficial) anchoring each end of a 7–point response scale following the prompt, "For me, performing the oral health behavior (e.g. floss my teeth daily) on a regular basis is …" The mean of the items served as an overall measure of cognitive attitudes (alpha=0.725).

Subjective Norms

One question for each behavior, measured by 7–point scales, assessed subjective norm: e.g. "Most people who are important to me would wish that I performed the oral health behavior (e.g. floss my teeth daily)" (disagree completely/agree completely). The mean of the items served as a measure of social norms (alpha=0.907).

PBC

For each behavior, PBC was assessed by 4 indicators, all measured by 7–point scales. One item made reference to how easy or difficult performance of the behavior was perceived to be: "For me is difficult to perform the oral health behavior (e.g. floss my teeth daily)" (disagree completely/agree completely). One question measured how confident the respondent was that he/she would be able to successfully perform the behavior: "If I wanted to, I would not have problems in succeeding to perform the oral health behavior (e.g. floss my teeth daily)" (disagree completely/agree completely). One item was phrased to reflect perceived control: "I have full control over performing the oral health behavior (e.g. flossing my teeth daily)" (disagree completely/agree completely). Finally, one item was of the locus of control type: "It is completely up to me whether or not I perform the oral health behavior (e.g. floss my teeth daily)" (disagree completely/agree completely). The mean of the items served as a measure of PBC (alpha=0.752).

Past Oral Hygiene Behavior

Past oral health behavior was assessed with a single item for each personal oral (home) care (e.g., frequency of tooth brushing, frequency of dental flossing, frequency of use of mouthrinse) and professional dental health care (e.g., frequency of dental visits or reasons for last dental visits): "During the last month how many times have you used dental floss?" (1=not at all, 5=every day).

Self–Identity

Two items assessed the extent to which performing the oral health behaviors is an important part of an individual's self–identity, e.g. "The oral cavity and dental health are an important part of who I am" and "I think of myself as someone who cares about his dental health," scored from 1 (no, definitely not) to 7 (yes, definitely). The mean of the items served as a measure of self–identity (coefficient alpha=0.712). A higher score indicated greater identification with the role of a person concerned by their oral health. Two levels of self–identity were defined through use of a median split.

For each construct, there were very few missing values, with 98.99%, 99.77% 99.66%, 100%, 99.57% and 100% of respondents providing responses to all items measuring affective attitude, cognitive attitude, intention, subjective norm, perceived control and self–identity, respectively. In the few cases where missing values were encountered, those who provided no response to any of the items for the various constructs were excluded from analyses. The final study group included 165 students.

Statistical Analysis

To provide an estimate of the internal consistency among items in the respective scales, Cronbach's alpha values were calculated. Discrete variables were compared with Fisher's exact test and were presented as percentages. Continuous variables were presented as mean±SD and compared with the Student t–test. Means, standard deviations and Pearson's correlations were computed between the study variables. Hierarchical multiple regression models were fit using a planned stepped approach to control for confounders and explore the relationship of predictors (attitude, social norms, perceived behavioral control and self–identity) to intention to improve oral health behaviors. Principal component analyses (with varimax rotation) supported the empirical distinction among the variables. In the performed analysis, which accounted for 72.9% of the variance, the items assessing self–identity and each of the predictors of intention outlined by the theory of planned behavior (attitude, subjective norm and perceived behavioral control) loaded on separate factors. All tests were 2–tailed. A p–value<0.05 was considered to be statistically significant. All statistical analyses were performed using SPSS 17.0 for Windows.

Structural equation modelling was used via AMOS 7.0 (SPSS, Inc.) to predict intentions to perform improve each of the behaviors. Maximum likelihood was used to estimate the parameters of the model. Model fit was determined by the following indicators: chi–squared test (non–significant or acceptable if no more than 3 times the degrees of freedom), comparative fit index (CFI) (>0.90), goodness–of–fit index (GFI) (>0.90), Tucker–Lewis index (TLI) (>0.90), Bentler Bonett normed fit index (NFI) (>0.90), standardized root mean square residual (SRMR) (<0.05) and root mean square error of approximation (RMSEA) (<0.08). Path coefficients and R2 values were also inspected to evaluate the predictive power of the model.

Results

Results are presented in several steps. First, comparisons of self–identity levels according to current oral health behaviors were performed. Also, participant characteristics stratified by self–identity level were analyzed. Second, correlations between attitude, intention, subjective norm, perceived control and intention to improve oral health behaviors were reported. Third, complex inter–relationships amongst the study variables were analyzed by hier-

Table I: Characteristics of Participants Classified According to the Self–Identity Levels

Predictors of intention to improve oral hygiene variables	Low level of Self–identity (n=85)		High level of Self–identity (n=80)		p
	M	SD	M	SD	
Toothbrushing frequency					
• Affective Attitudes	5.68	1.18	6.42	1.06	<0.0001
• Cognitive Attitudes	6.57	0.89	6.81	0.88	NS
• Subjective norms	5.85	1.76	6.13	1.87	NS
• Perceived behavioral control	5.39	0.63	5.35	0.75	NS
• Intention to improve	6.52	1.15	6.87	0.71	0.02
Flossing frequency					
• Affective Attitudes	2.98	1.61	3.85	1.81	0.002
• Cognitive Attitudes	3.57	1.88	4.62	1.95	0.001
• Subjective norms	4.47	1.88	4.96	2.24	NS
• Perceived behavioral control	4.72	1.01	5.07	0.89	0.02
• Intention to improve	3.30	2.08	4.57	2.12	<0.0001
Mouthrinse frequency					
• Affective Attitudes	3.95	1.82	4.90	1.85	0.001
• Cognitive Attitudes	4.01	1.99	5.25	1.87	<0.0001
• Subjective norms	4.76	1.90	4.91	2.29	NS
• Perceived behavioral control	4.83	0.98	5.07	1.02	NS
• Intention to improve	3.91	2.22	5.08	2.09	0.001
Dental visit frequency					
• Affective Attitudes	3.38	1.75	4.17	1.87	0.006
• Cognitive Attitudes	4.69	1.69	5.35	1.77	0.02
• Subjective norms	5.22	1.89	5.40	1.93	NS
• Perceived behavioral control	4.79	0.95	5.10	1.04	0.04
• Intention to improve	4.05	1.96	5.07	1.96	0.001
Reasons for dental visits					
• Affective Attitudes	3.01	1.66	3.56	1.75	0.04
• Cognitive Attitudes	3.77	1.87	4.48	1.98	0.029
• Subjective norms	4.47	2.02	4.97	2.12	NS
• Perceived behavioral control	4.59	0.98	5.04	1.06	0.005
• Intention to improve	3.16	1.98	4.33	2.19	<0.0001

NS: Not significant; SD: Standard Deviation

archical multiple regressions. Finally, the results of structural equation modeling of the complex inter–relationships among the study variables are reported.

Self–Identity and Oral Health Behaviors

Significant differences in self–identity regarding the toothbrushing behavior and reason for the dental visit were observed. The students who brushed their teeth more than twice a day scored significantly higher (6.55±0.74) compared with those participants who brushed their teeth once a day or less (5.64±1.46) (p=0.004). Participants who visited their dentist only when pain reported lower levels of self–identity (5.62±1.47) compared with those who visited the dentist when treatment was needed (6.35±0.87), for regular scaling (6.44±0.91) or for check–up (6.35±0.84) (p=0.01). When participants were classified in 2 groups according to their levels of self–identity, significant differences were found according to their age (19.18±1.01 vs. 20.21±4.17, p<0.05), toothbrushing frequency (p=0.005), affective attitudes, cognitive attitudes, perceived behavioral control, subjective norms and intention for improving oral hygiene (p<0.0001) (Table I). As expected, young people's level of self–identity regarding oral health was associated with improved oral health behaviors (Hypothesis 1).

Predicting intentions to improve oral health behaviors

Prior to conducting the regression analyses, correlations among the predictors were computed. Self–identity had a statistically significant positive

Table II: Means, Standard Deviations and Interscale Correlations

Study variables	M	SD	1	2	3	4	5	6	7
Toothbrushing frequency									
1. Affective Attitudes	6.04	1.18	–	–	–	–	–	–	–
2. Cognitive Attitudes	6.69	0.89	0.40**	–	–	–	–	–	–
3. Subjective norms	5.99	1.81	0.10	0.18*	–	–	–	–	–
4. Perceived behavioral control	5.37	0.69	0.03	0.26**	0.32**	–	–	–	–
5. Self–identity	6.25	1.01	0.38**	0.24**	0.22**	0.04	–	–	–
6. Past behavior	4.17	0.72	0.25**	0.28**	0.02	–0.02	0.25**	–	–
7. Intention to improve	6.69	0.97	0.31**	0.47**	0.31**	0.14	0.38**	0.23**	–
Flossing frequency									
1. Affective Attitudes	3.40	1.76	–	–	–	–	–	–	–
2. Cognitive Attitudes	4.08	1.98	0.73**	–	–	–	–	–	–
3. Subjective norms	4.70	2.07	0.27**	0.29**	–	–	–	–	–
4. Perceived behavioral control	4.89	0.97	0.36**	0.36**	0.36**	–	–	–	–
5. Self–identity	6.25	1.01	0.33**	0.31**	0.21**	0.23**	–	–	–
6. Past behavior	2.25	1.45	0.61**	0.62**	0.13	0.21**	0.15*	–	–
7. Intention to improve	3.92	2.19	0.62**	0.74**	0.34**	0.33**	0.34**	0.59**	–
Mouthrinse frequency									
1. Affective Attitudes	4.41	1.89	–	–	–	–	–	–	–
2. Cognitive Attitudes	4.61	2.03	0.73**	–	–	–	–	–	–
3. Subjective norms	4.83	2.09	0.36**	0.37**	–	–	–	–	–
4. Perceived behavioral control	4.95	1.01	0.38**	0.37**	0.38**	–	–	–	–
5. Self–identity	6.25	1.01	0.32**	0.30**	0.19*	0.12	–	–	–
6. Past behavior	2.93	1.58	0.59**	0.63**	0.18*	0.31**	0.11	–	–
7. Intention to improve	4.48	2.23	0.67**	0.80**	0.38**	0.34**	0.30**	0.64**	–
Dental visit frequency									
1. Affective Attitudes	3.76	1.85	–	–	–	–	–	–	–
2. Cognitive Attitudes	5.01	1.76	0.57**	–	–	–	–	–	–
3. Subjective norms	5.31	1.91	0.13	0.21**	–	–	–	–	–
4. Perceived behavioral control	4.94	1.01	0.21**	0.16*	0.36**	–	–	–	–
5. Self–identity	6.25	1.01	0.27**	0.21**	0.18*	0.15	–	–	–
6. Past behavior	3.14	1.27	0.41**	0.45**	0.12	0.11	0.11	–	–
7. Intention to improve	4.55	2.02	0.44**	0.59**	0.28**	0.18*	0.25**	0.36**	–
Reasons for dental visits									
1. Affective Attitudes	3.27	1.72	–	–	–	–	–	–	–
2. Cognitive Attitudes	4.12	1.95	0.54**	–	–	–	–	–	–
3. Subjective norms	4.71	2.08	0.17*	0.32**	–	–	–	–	–
4. Perceived behavioral control	4.81	1.05	0.29**	0.40**	0.39**	–	–	–	–
5. Self–identity	6.25	1.01	0.21**	0.23**	0.22**	0.21**	–	–	–
6. Past behavior	3.43	1.19	0.18*	0.15	0.11	0.15	0.14	–	–
7. Intention to improve	3.73	2.16	0.50**	0.61**	0.32**	0.39**	0.27**	0.18*	–

*p<0.05
**p<0.01

correlation with affective attitudes, cognitive attitudes, subjective norms, perceived behavioral control and intention for improving oral hygiene. The other components of the model were also significantly correlated with each other (Table II). The range of significant correlation values was found to be from 0.16 to 0.38, depending to the type of oral health behavior analyzed.

Several hierarchical multiple regression analysis predicting intention to improve each oral health behavior were conducted to determine if self–identity emerged as a significant predictor after control of the components of the TPB and past behavior (Table III). The effects of past behavior were controlled in all analyses because of consistent evidence linking past behavior to intention. For tooth brushing frequency, the step 1 variables of age, gender and

Table III: Hierarchical Multiple Regression Analysis Including Age, Gender, Past Behaviour, Attitudes, Subjective Norms, Perceived Behavioral Control and Self–Identity

Variable	B	β	R2	R2 change	F	F change	p
Prediction of intention to improve toothbrushing frequency							
Step 1			0.08	0.08	4.79	4.80	0.003
• Age • Gender • Past behavior	−0.03 0.38 0.27	−0.09 0.16 0.10					0.25 0.04 0.009
Step 2			0.31	0.23	10.16	13.08	<0.0001
• Affective Attitudes • Cognitive Attitudes • Subjective norms • Perceived behavioral control	0.09 0.40 0.13 −0.06	0.11 0.36 0.25 −0.04					0.16 0.000 0.001 0.56
Step 3			0.35	0.04	10.53	9.28	<0.0001
• Self–identity	0.21	0.22					0.003
Prediction of intention to improve flossing frequency							
Step 1			0.39	0.39	33.60	33.60	<0.0001
• Age • Gender • Past behavior	0.04 0.92 0.85	0.05 0.17 0.56					0.40 0.007 0.000
Step 2			0.61	0.22	34.24	21.49	<0.0001
• Affective Attitudes • Cognitive Attitudes • Subjective norms • Perceived behavioral control	0.12 0.53 0.13 0.03	0.10 0.48 0.12 0.01					0.20 0.000 0.02 0.83
Step 3			0.61	0.006	30.58	2.53	0.11
• Self–identity	0.19	0.08					0.11
Prediction of intention to improve mouthrinse frequency							
Step 1			0.42	0.42	37.96	37.96	<0.0001
• Age • Gender • Past behavior	0.04 0.32 0.89	0.05 0.06 0.63					0.35 0.33 0.000
Step 2			0.69	0.27	50.10	34.73	<0.0001
• Affective Attitudes • Cognitive Attitudes • Subjective norms • Perceived behavioral control	0.10 0.61 0.12 −0.03	0.08 0.56 0.11 −0.01					0.21 0.000 0.02 0.75
Step 3			0.69	0.002	43.94	0.95	0.33
• Self–identity	0.10	0.04					0.33

past behavior significantly accounted for 8% of the variance (F=4.79, p=0.003). The addition of the step 2 variables of attitude, PBC and subjective norm increased the proportion of variance to 31% (F=10.16, p<0.0001). For step 3, the addition of self–identity accounted for a further 4% of variance, with the full model accounting for 35% of the variance (F=10.53, p<0.0001). When all variables were entered into the equation, of the significant predictors, cognitive attitude had the largest beta weight, followed by subjective norm and self–identity. As predicted under Hypothesis 2, participants were most motivated to improve their oral health behavior if the behavioral role was important component of their self–identity.

Self–identity and past behavior

The last set of analyses investigated the effect of past behavior on the self–identity–intention relationship. The initial model (Figure 1) was verified using the AMOS technique. The model was modified based

Table III: Hierarchical Multiple Regression Analysis Including Age, Gender, Past Behaviour, Attitudes, Subjective Norms, Perceived Behavioral Control and Self–Identity (part II)

Variable	B	β	R2	R2 change	F	F change	p
Prediction of intention to improve dental visit frequency							
Step 1			0.16	0.16	10.33	10.33	<0.0001
• Age • Gender • Past behavior	0.04 0.90 0.54	0.07 0.18 0.34					0.34 0.01 0.000
Step 2			0.41	0.25	15.55	16.44	<0.0001
• Affective Attitudes • Cognitive Attitudes • Subjective norms • Perceived behavioral control	0.12 0.51 0.17 0.01	0.11 0.44 0.15 0.007					0.15 0.000 0.02 0.92
Step 3			0.41	0.004	13.76	1.14	0.28
• Self–identity	0.14	0.07					0.28
Prediction of intention to improve reasons for dental visits							
Step 1			0.05	0.05	3.03	3.03	0.03
• Age • Gender • Past behavior	0.05 0.60 0.31	0.07 0.11 0.17					0.32 0.15 0.02
Step 2			0.44	0.39	17.55	26.94	<0.0001
• Affective Attitudes • Cognitive Attitudes • Subjective norms • Perceived behavioral control	0.26 0.45 0.10 0.23	0.21 0.41 0.09 0.11					0.003 0.000 0.16 0.11
Step 3			0.45	0.009	15.79	2.38	0.12
• Self–identity	0.21	0.09					0.12

on an inspection of the analysis of the initial model, after which the final model was constructed (Figure 2). The structural model included paths from TPB components and improving oral health behavior intention, correlations among the TPB predictors, the effect of current oral health behaviors on intention to improve oral health behaviors (tooth brushing more than twice per day, daily flossing, daily mouth washing, visiting the dentist on a regular basis and undergoing dental scaling on a regular basis), the effect of self–identity on intention and the effect of past–behavior on self–identity.

Regarding the tooth brushing frequency, the final model fitted well with the whole sample: $\chi 2=0.53$ (df=2, p=0.76), GFI=0.99, CFI=1.00, RMSEA=0.00, TLI=1.09, NFI=0.99 and SRMR=0.009; 34.3% of the variance associated with improving toothbrushing frequency intention was accounted for by its 6 predictors. The hypothetical model was also tested separately among males and females. Goodness–of–fit statistics were significant between males and females. The model had a better fit among females ($\chi 2=0.43$ [d.f.=1, P=0.51], GFI=0.99, CFI=1.00, RMSEA=0.00, TLI=1.20, NFI=0.99 and SRMR=0.01) than among men ($\chi 2=1.37$ (df=1, p=0.24), GFI=0.98, CFI=0.99, RMSEA=0.10, TLI=0.91, NFI=0.98 and SRMR=0.05).

The hypothetical model was separately tested for all personal oral home care (e.g., frequency of tooth brushing, frequency of dental flossing, frequency of mouthwash use) and professional dental health care (e.g., frequency of dental visits or reason for last dental visit). GFI statistics were significant only for tooth brushing frequency (Table IV).

Discussion

The present study aimed to test an extended TPB, including self–identity, to predict young adults' intentions to engage in and subsequent engagement in improving oral hygiene behavior. The cognitive attitudes and subjective norms of the TPB emerged as the strongest predictors of intentions to improve oral health behaviors. In contrast with previous studies employing the TPB to examine oral health behavior,[19–25] subjective norms significantly contributed to the prediction of behavior. Strategies that aim to reduce problematic low levels of oral hygiene

Figure 1: Unifying Hypothesis to Explain Determinants of Intention to Improve Oral Health Behaviors

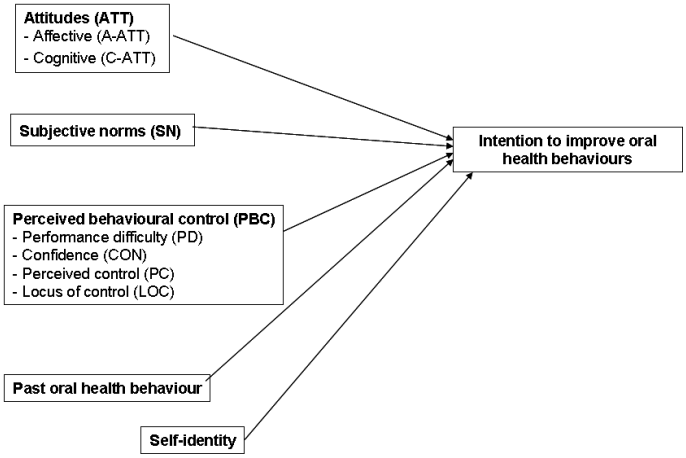
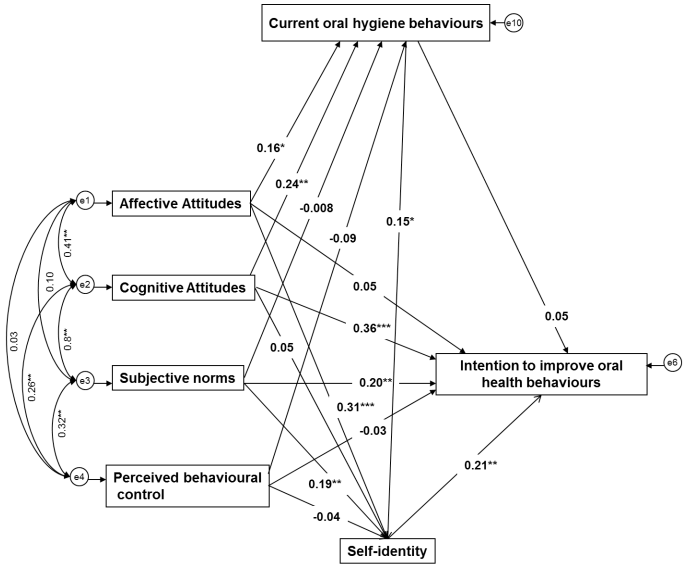


Figure 2: Structural Equations Modeling Analysis (SEMA) of Intention to Improve Oral Health Behaviors



The variance (r2) of each factor is explained by its relationships with other factors, which may interact among themselves. The strength of the relationship between two factors is indicated by the path coefficients, the significance of which is indicated by an asterisk (*:P<0.05, **:P<0.01, ***:P<0.001). Circles labeled e1–e9 indicate the measurement error of corresponding observed variables. Single–headed arrows indicate the hypothesized direction of causality, and double–headed arrows indicate nondirectional associations. Numbers adjacent to arrows represent the standardized direct effect.

could emphasize that important people in an individual's life (e.g., family, friends, coworkers) would disapprove of their missing to engage in regular hygiene (subjective norm), reinforce the negative consequences (e.g., decays, bleeding, bad breath) associated with low level use (attitudes), and encourage people to strongly embrace the identity of an oral hygiene user (e.g. flosser), endeavoring to make personal and professional oral health behaviors important to their self–concept (self–identity).

As expected, young people's level of self–identity regarding oral health was associated with improved oral health behaviors. However, the magnitude of the differences was fairly small, despite being statistical significant: a 0.9 point difference for brushing, and a 0.7 point difference for treatment, while the significant difference in age was also only 1 year. These differences could reveal a reduced utility and meaningfulness of the impact of self–identity on oral health behavior in this young study population. Younger individuals may not have a fully developed self–identity as it relates to oral hygiene. Erik Erikson's psychosocial theory revolutionized developmental thought as he was one of the first to propose a lifespan model of human development which included 8 successive psychosocial stages.[26] It appears that for many individuals, identity development is a lifelong process that extends well beyond the years of adolescence (ages 12 to 24) as identity issues continue to emerge until middle adulthood (40 to 65 years).[27] However, when participants were classified in 2 groups according to their levels of self–identity, significant differences were found according to their tooth brushing frequency, affective attitudes, cognitive attitudes, perceived behavioral control, subjective norms and intention for improving oral hygiene.

Multiple regression analysis revealed that attitude, subjective norm and PBC predict intention to improve oral hygiene behavior, after controlling for the effects of demographic factors of age, gender and past behavior. Moreover, in the present study, self–identity had a statistically significant positive correlation with affective attitudes, cognitive attitudes, subjective norms, perceived control, locus of control and intention for improving oral hygiene, and a statistically significant negative correlation with performance difficulty. However, the addition of self–identity improved the prediction of intention only regarding the tooth brushing frequency. It is argued that people's self–identities, i.e. the labels people use to describe themselves, are important determinants of behavior. Moreover, while a person's self–identity is likely to be consistent with (and mediated by) his/her attitudes, subjective norms and perceptions of control in a given area, there are situations in which self–identity may have a direct effect on behavior.[28–30]

The structural equation model revealed that the determinants of oral health self–identity are affective attitudes, social norms and past behavior.

Table IV: Goodness of Fit Test Results for Each Model Predicting Oral Health Behaviors

Model Prediction of intention to improve oral health behaviors	$\chi 2$	d.f.	P	CFI	GFI	TLI	NFI	RMSEA	SRMR
Toothbrushing frequency	0.19	1	0.661	1.00	1.00	1.10	0.99	0.00	0.008
Flossing frequency	23.14	1	<0.0001	0.94	0.96	–0.06	0.94	0.36	0.24
Mouthrinse frequency	26.05	1	<0.0001	0.94	0.96	–0.07	0.94	0.39	0.27
Dental visit frequency	7.47	1	0.006	0.97	0.98	0.40	0.97	0.19	0.11
Reasons for dental visits	14.38	1	<0.0001	0.94	0.97	–0.24	0.94	0.28	0.20

Note: Model fit was determined by the following indicators: chi–squared test (non–significant or acceptable if no more than three times the degrees of freedom), comparative fit index (CFI; >0.90), goodness–of–fit index (GFI) (GFI; >0.90), Tucker–Lewis index (TLI; >0.90), Bentler Bonett normed fit index (NFI; >0.90), standardized root mean square residual (SRMR) (SRMR; <0.05) and root mean square error of approximation (RMSEA; <0.08).

According to social identity theory, there is a continuum between personal and social identity, shifts along this continuum determine the extent to which group–related or personal characteristics influence a person's feelings and actions.[16,31] Self–identities are derived from individuals' knowledge of the roles they occupy or their memberships in particular social categories. The present study also showed that the effects of self–identity vary as a function of repeated experience of performing the relevant behavior. Charng et al reasoned that if a behavior has been performed repeatedly in the past, and thus under habitual control, then decisions to engage in it in the future should depend more on the importance of the behavior for the person's self–identity than on judgments and feelings about the behavior (attitude and perceived control) or the perceived expectations of others (subjective norm).[29] When a behavior becomes a relatively automatic response, the role of cognitive determinants of both intention and actual behavior should diminish, whereas the effect of self–identity should strengthen because repeated performance of a behavior increases both the likelihood that the behavior is an important component of the self–identity and the person's motivation to validate his or her status as a role member.[16]

This study revealed the role of self–identity only regarding tooth brushing frequency, but not in other personal or preofessional oral health behaviors. This may be due to a weaker relationship in relation to infrequently performed behaviors (e.g. flossing) than for behaviors that have been performed frequently in the recent past (e.g. tooth brushing). The latter type of behavioral roles is more likely to be internalized as a salient component of the self–concept, and hence more likely to influence behavioral intentions than less frequently performed behaviors.[16]

One limitation of the study was the limited sample population of university undergraduate students in a health professions field with a large proportion of female participants that may limit generalizability of the results. However, the hierarchical multiple regressions evaluated the effect of gender as a confounder in the present study and structural equation modeling revealed that the model was adequate in both males and females. Finally, TPB may perform differently in different socio–cultural contexts, and it is therefore important to test the applicability of the TPB in different countries and also in older populations to strengthen the cross validation and theoretical veracity of the findings.

Conclusion

The present study provided support for the application of the TPB model in the context of oral health behaviors. Self–identity as a person interested in his/her oral health had a statistically significant correlation with all components of the TPB. Moreover, participants with higher levels of self–identity reported also a better tooth brushing frequency and intention for improving oral hygiene. Thus, this added understanding of the roles that self–identity plays in the lives of young students can enhance the interactions of general practice dentists with their dental patients. Finding out if oral health identities are valid for a particular patient can help in tailoring practice in a patient–centered way and can provide the context for enabling these patients to incorporate their previous oral health behavior experience into the broader context of their dental health most effectively.

Alexandrina L. Dumitrescu, DDS, BSc, MSc, PhD, works in private practice in Bucharest, Romania. Carmen Duţă, BSc, PhD, works at the Carol Davila University of Medicine and Pharmacy, Bucharest. Carmen Beatrice Dogaru, MD, PhD, works at the Carol Davila University of Medicine and Pharmacy, Bucharest. Bogdan Manolescu, BSc, works at the University Politehnica of Bucharest.

References

1. Ajzen I. Behavioral interventions based on the theory of planned behavior. University of Massachusetts [Internet]. 2006 [cited 2013 July 26]. Available from: http://people.umass.edu/aizen/pdf/tpb.intervention.pdf

2. Conner M, Sparks P. The theory of planned behavior and health behaviors. In: Predicting health behavior. Conner M, Norman P, eds. Buckingham, England: Open University Press. 1996.

3. Armitage CJ, Conner M. Efficacy of the Theory of Planned Behavior: a meta–analytic review. *Br J Soc Psychol*. 2001;40(Pt 4):471–499.

4. Francis JJ, Eccles MP, Johnston M, et al. Constructing questionnaires based on the Theory of Planned Behavior. A manual for health services researchers. University of Newcastle [Internet]. 2004 [cited 2013 July 26]. Available from: http://pages.bangor.ac.uk/~pes004/exercise_psych/downloads/tpb_manual.pdf

5. Tedesco LA, Keffer MA, Davis EL, Christersson LA. Self–efficacy and reasoned action: Predicting oral health status and behaviour at one, three, and six month intervals. *Psy Health*. 1993;8(2–3):105–121.

6. Dumitrescu AL, Wagle M, Dogaru BC, Manolescu B. Modeling the theory of planned behavior for intention to improve oral health behaviors: the impact of attitudes, knowledge, and current behavior. *J Oral Sci*. 2011;53(3):369–377.

7. Buunk–Werkhoven YA, Burrekers SY, Jongboer A, Quant DF, van Maanen–Schakel NW. Determinants of oral hygiene behavior in the Dominican Republic. *Int Dent J*. 2011;61(6):328–333.

8. Buunk–Werkhoven YA, Dijkstra A, Bink P, van Zanten S, van der Schans CP. Determinants and promotion of oral hygiene behaviour in the Caribbean and Nepal. *Int Dent J*. 2011;61(5):267–273.

9. Defranc A, Van den Broucke S, Leroy R, et al. Measuring oral health behaviour in Flemish health care workers: an application of the theory of planned behaviour. *Community Dent Health*. 2008;25(2):107–114.

10. Luzzi L, Spencer AJ. Factors influencing the use of public dental services: an application of the Theory of Planned Behaviour. *BMC Health Serv Res*. 2008;8:93.

11. Berg C, Jonsson I, Conner M. Understanding choice of milk and bread for breakfast among Swedish children aged 11–15 years: an application of the Theory of Planned Behavior. *Appetite*. 2000;34(1):5–19.

12. O'Callaghan FV, Callan VJ, Baglioni A. Cigarette use by adolescents: attitude–behavior relationships. *Subst Use Misuse*. 1999;34(3):455–468.

13. Hutchinson MK, Wood EB. Reconceptualizing adolescent sexual risk in a parent–based expansion of the Theory of Planned Behavior. *J Nurs Scholarsh*. 2007;39(2):141–146.

14. Ajzen I. The theory of planned behavior. *Organ Behav Hum Decis Process*. 1991;50:179–211.

15. Stryker S. Identity theory: Developments and extensions. In: Yardley K, Honess T, eds. Self and identity. New York: Wiley. 1987. 89–104 pp.

16. Terry DJ, Hogg MA, White KM. The theory of planned behavior: self–identity,social identity and group norms. *Br J Soc Psychol*. 1999;38(Pt 3):225–244.

17. Åstrøm AN, Rise J. Young adults' intention to eat healthy food: extending the theory of planned behavior. *Psychol Health*. 2001;16:223–237.

18. Bradbury J, Thomason JM, Jepson NJ, et al. Perceived chewing ability and intake of fruit and vegetables. *J Dent Res*. 2008;87(8):720–725.

19. Rhodes RE, Courneya KS. Investigating Multiple Components of Attitude, Subjective Norm, and Perceived Control: An Examination of the Theory of Planned Behavior in the Exercise Domain. *Br J Soc Psychol*. 2003;42(Pt 1):129–146.

20. Rhodes RE, Courneya KS. Modelling the theory of planned behavior and past behavior. *Psychol Health Med*. 2003;8(1):57–69.

21. Rhodes RE, Macdonald HM, McKay HA. Predicting Physical Activity Intention and Behavior among Children in a Longitudinal Sample. *Soc Sci Med*. 2006;62(12):3146–3156.

22. Rhodes RE, Jones LW, Courneya KS. Extending the Theory of Planned Behavior in the Exercise Domain: A Comparison of Social Support and Subjective Norm. *Res Q Exerc Sport*. 2002;73(2):193–199.

23. Saunders RP, Motl RW, Dowda M, Dishman RK, Pate RR. Comparison of Social Variables for Understanding Physical Activity in Adolescent Girls. *Am J Health Behav*. 2004;28(5):426–436.

24. Fen YS, Sabaruddin NA. An Extended Model of Theory of Planned Behavior in Predicting Exercise Intention. *Int Business Res*. 2008;1:108–122.

25. Buunk–Werkhoven YA, Dijkstra A, van der Schans CP. Determinants of oral hygiene behavior: a study based on the theory of planned behavior. *Community Dent Oral Epidemiol*. 2011;39(3):250–259.

26. Hoare CH. Erikson on development in adulthood: New insights from the unpublished papers. New York: Oxford University Press. 2002.

27. Sokol JT. Identity Development Throughout the Lifetime: An Examination of Eriksonian Theory. *Graduate J Couns Psychol*. 2009;1(2):Article 14.

28. Biddle B, Bank B, Slavings R. Norms, preferences, identities and retention decisions. *Soc Psychol Q*. 1987;50:322–337.

29. Charng HW, Piliavin J, Callero P. Role identity and reasoned action in the prediction of repeated behavior. *Soc Psychol Q*. 1988;51:303–317.

30. Evans D, Norman P. Understanding pedestrians' road crossing decisions: an application of the theory of planned behavior. *Health Educ Res*. 1998;13(4):481–489.

31. Tajfel H, Turner JC. An integrative theory of intergroup conflict. In: Austin WG, Worchel S, eds. The social psychology of intergroup relations. Monterey, CA: Brooks–Cole. 1979. 34–47 pp.

Student Perception of Travel Service Learning Experience in Morocco

Aditi Puri, RDH, CAGS, MS, PhD, MPH candidate; Mahmoud Kaddoura, PhD, CAGS, MED, ANP/GNP; Christine Dominick, CDA, RDH, MEd

Abstract

Purpose: This study explores the perceptions of health profession students participating in academic service learning in Morocco with respect to adapting health care practices to cultural diversity.

Methods: Authors utilized semi–structured, open–ended interviews to explore the perceptions of health profession students. Nine dental hygiene and nursing students who traveled to Morocco to provide oral and general health services were interviewed. After interviews were recorded, they were transcribed verbatim to ascertain descriptive validity and to generate inductive and deductive codes that constitute the major themes of the data analysis. Thereafter, NVIVO 8© was used to rapidly determine the frequency of applied codes. The authors compared the codes and themes to establish interpretive validity. Codes and themes were initially determined independently by co–authors and applied to the data subsequently. The authors compared the applied codes to establish intra–rater reliability.

Results: International service learning experiences led to perceptions of growth as a health care provider among students. The application of knowledge and skills learned in academic programs and service learning settings were found to help in bridging the theory–practice gap. The specific experience enabled students to gain an understanding of diverse health care and cultural practices in Morocco.

Conclusion: Students perceived that the experience gained in international service learning can heighten awareness of diverse cultural and health care practices to foster professional growth of health professionals.

Keywords: service learning, culture, inter–professional healthcare, health professions and access to care

This study supports the NDHRA priority area, **Health Promotion/Disease Prevention:** Investigate how diversity among populations impacts the promotion of oral health and preventive behaviors.

Introduction

The vision of this pilot study was to understand student perceptions of service learning experience in a foreign country. The authors endeavored to collaborate with the Volunteer Morocco Organization to incorporate an oral health component in their academic service learning program. At the benefits of participating with the Volunteer Morocco, an interdisciplinary team was already established in Morocco, with supervisors who facilitated with transportation and government's rules and regulation besides offering scholarships. The members of the organization who speak languages of Morocco and know its culture accompanied the students throughout the trip.

The authors trained nursing and dental hygiene students at the Esther M. Wilkins Dental Hygiene Clinic at Massachusetts College of Pharmacy and Health Sciences–Forsyth School of Dental Hygiene. The dental hygiene school established a prevention clinic to provide oral health education and fluoride varnish to children and adults. All of the students applied this education and training in Morocco to lead oral health clinics. They also provided care to the underserved in health clinics, hospital and orphanages. Donated oral health aids, such as brushes, floss, toothpaste and fluoride varnish from dental companies were instrumental in addressing the oral health needs of the population. A minority of the participants had previous service learning experience, and few had served abroad.

The literature points to the benefits of travel service learning in terms of bridging a perceived theory–practice gap, taking advantage of inter–professional learning, meeting the needs of under–resourced communities needing improved health care, addressing ethical dilemmas associated with these communities, and aiding in professional growth.

Service Learning

Jacoby defines service learning as "a form of experiential education in which students engage in activities that address human and community needs together with structured opportunities intentionally

designed to promote student learning and development."[1] Yonder noted that integration of service learning in dental and dental hygiene education encourages graduates to work effectively with diverse populations and function dynamically in the arena of health policy.[2] Service learning is a significant national movement at all educational levels, and is particularly important in undergraduate education. It is widely recognized that connecting academics with community service through structured reflection contributes to deeper learning, is longer lasting and more applicable to new situations.[3]

In a qualitative study, the outcomes of a special needs service–learning course for dental hygiene students were evaluated. Student/faculty reflections and community coordinator feedback were employed to determine that service learning led to a deeper understanding of the subject and provided opportunities for increased awareness of professional and social issues associated with the oral care of special needs patients.[4] Lautar reviewed the literature on service learning to recommend that dental hygiene educators need to embrace the philosophy of service learning to lead its integration in the curriculum.[5] Tonkin and Quiroga noted that international service learning led to cultural integration, broadened horizons and prepared students for global citizenship.[6] Activities such as experiential and reflective learning in such settings have been found to enable students to acknowledge underling "differences" and to develop a sense of global citizenship.[7]

Interdisciplinary Collaboration

The complexity of health issues experienced by patients makes it difficult for one discipline to provide comprehensive care to individuals. The interdisciplinary learning methodology invites learners from varied disciplines to work closely together to contribute their knowledge, skills and experiences.[8] The Institute of Medicine (IOM) recommends that health professionals practice in inter–professional teams.[9] The complexity of the medical issues experienced by patients today warrants inter–professional collaboration.[10] An inter–professional health care approach can enable providers from each discipline to achieve the shared goal of augmenting a patient's health.[10] In one series of 3 articles, authors emphasized dental and medical collaboration.[11–13] Cross–disciplinary training and increased collaboration between dentistry and other health professionals can better address the needs of elderly, individuals with intellectual and developmental disabilities and other special needs.[11] This gains in significance given that a decline in the number of dental providers per capita has reduced access to dental care among disadvantaged and special needs groups. One approach suggested to alleviate this was to train medical providers to prevent diseases of the oral cavity.[13] Partnerships with medical providers can be further strengthened, by re–emphasizing the importance of general health in dental education.[12]

Cross–Cultural Awareness

An IOM study recommends integrating cross–cultural education into the training of practicing and future health care providers.[14] Service–learning opportunities to dental students in diverse communities can enrich an awareness of varied cultural influences interwoven in treatment decisions.[15] After a set of baccalaureate students enrolled in a community health nursing course with a service learning component, students perceived an increase in their cognitive, affective and practical faculties.[16] Rubin found that service learning–based models and reflective journaling in non–dental public health settings led to better cultural understanding among dental students.[17] The institution of cultural competence in the process of care is instrumental in providing optimal care.[18] In a multicultural society, cross–cultural education strategies and peer/patient interactions within curricula promote competency in providing cross–cultural care among students.[19] Dental hygiene students need to play a key role in seeking solutions to eliminate health care disparities.[20]

Access to Care in Morocco

Significant health disparities exist within the health care system in Morocco, a country with a shortage of health care professionals. The World Health Organization (WHO) has reported that in Morocco the condition of dental caries affected 72% of children under 12 years, 82.5% of adolescents 15 years old, and 97.7% of adults between 35 and 44 years.[21] Using a scale of 2.5, 2.5 to 5.0 and 5.0 or more per 1,000 population to identify the density of health workers as low, medium or high, respectively, WHO found health workers in Morocco was rated from 1.4 to 1.9 between 1996 to 2006.[22] Clearly, Morocco was found to suffer from a chronic shortage of health care workers.[22,23]

While research has pointed to the potential benefits of cross–cultural training and academic service learning in dental and dental hygiene student training, student perception is currently understudied. To explore student perceptions of inter–professional–oriented, academic service learning in a region with evident and pressing needs, the authors conducted this qualitative study. This study explores the perceptions of health profession students participating in academic service learning in Morocco with respect to culturally diverse health care practices.

Methods and Materials

This study explores the perceptions of health profession students participating in academic service learning in Morocco with respect to adapting health care practices to cultural diversity. The authors utilized semi–structured, open–ended interviews to explore the perceptions of health profession students.

Participants and Procedures

Participation in this study was open to all students in the college consortium, who were invited to participate in this project. Participation was voluntary and privately funded by the participants. Nine students, 8 female and 1 male, who agreed to participate, were recruited from 2 institutions in a Northeastern state of the U.S. The participants' age ranged between 19 and 23 years with a mean age of 21 years. Eight participants (89%) were White Caucasian and only 1 (11%) Asian. The majority of the participants are from a middle socio–economic class – they attend private college and were able to fund their trip to Morocco. The study subjects represented dental hygiene and nursing majors. Eight participants (89%) represented nursing discipline and only 1 (11%) represented dental hygiene. The subjects were recruited via email invitation, and reminders were sent to increase the response, which was 100%. All 9 participants who travelled to Morocco volunteered to participate in the study. The purposeful study sample adequately captured the heterogeneity of this group.[24,25]

The research employs a qualitative design to understand student perceptions of their academic service learning experience in Morocco. In January, 2011, approximately 2 weeks after student's return from Morocco, data was collected via a semi–structured interview protocol with open–ended questions. The questions were aimed at understanding the perceptions of students regarding access to care issues in Morocco, their view of the significance of inter–professional collaboration, and their views regarding the impact of diverse cultural and health care practices on their growth. The researchers recorded the interviews verbatim for data analysis. Each interview was 60 minutes in length, and cumulatively generated approximately 200 pages of data (average line count of 30) that was analyzed systematically. Institutional Review Board approval was obtained for this study.

Data Analysis

Several steps were implemented to ensure the validity of the study. Interviews were transcribed verbatim to assure descriptive validity. Deductive codes were derived from theories employed and literature sources, and inductive codes emerged from unanticipated themes and concepts after a careful reading of the data. Theoretical validity was ascertained by comparing themes emerging from interview data with established research noted above. Interpretative validity was determined by comparison and verification of independently determined codes and themes, prior to independent application on raw data. The authors compared codes to establish intra–rater reliability, with 95% agreement. The software NVIVO 8© was used to determine the frequency of codes rapidly.[26]

Results

The results describe major themes and subthemes found for student perceptions of the service learning experience in Morocco. Table I summarizes the results based on the interviews of 9 participants who traveled to Morocco.

Internal Motivation to Serve Underserved Countries

Motivation to serve emerged as a code during the analysis of the data. We define motivation as an internal aspiration to provide care to the underserved. Motivation inspired participants to pursue the academic service learning opportunity. One hundred percent of the participants were motivated to serve in underserved areas. Participant 5's enthusiasm was typical: "I have always believed in just giving back to the community. When I was little, [with] my father, we went to India and we did a volunteer mission in India and I helped the way I could." Similar interest was echoed by participant 2 "I went to India with my aunt's] family and I saw a lot of the poverty, and I saw [how] my uncle used to be in a health clinic, and I kind of wanted to do that work helping people." Overall, a personal motivation to serve the underprivileged in a foreign land encouraged participants to serve in Morocco.

Bridging Theory Practice Gap

A second theme that emerged during analysis focused on "bridging the theory–practice gap." This is defined as an opportunity to serve a community by applying knowledge learned. Eighty nine percent of the participants noted that the academic service learning provided a platform to apply knowledge learned in their programs. Participant 5 said:

"So we had a health clinic, we had to do blood pressure and I remember every lab, you do blood pressure and you have to listen… You have to begin an assessment for vital signs, so we were doing that in Morocco."

The experience gained in Morocco inspired 89% of the participants to apply learning to health care

Table I: Themes and Sub–themes Derived from Qualitative Analysis, with Illustrative Data

Major Themes	Subthemes
Internal motivation to serve underserved countries	
Bridging theory–practice gap	• Applied knowledge gained at school • Apply experience from academic service learning to healthcare, academics and professional life in the US
Bridging inter–cultural gaps and the urban–rural divide	• Language Barrier • Cultural shock • Adaptation to a different culture • Difference in village and city culture • Difference in US and Moroccan culture and health care
Inter–professional learning and collaboration	
Lack of access to care and ethical issues	
Professional growth as a health care provider	

practice, academics and professional life in the U.S. Participant 4 noted:

"I'll apply everything I have learned about the culture there to my healthcare. What I learned from the doctors, taking your time… being very comprehensive in your assessment. Which I know, I have learned here in class and everything, but that was the first time I have really seen it in action."

Participant discourse suggests that knowledge learned about the culture, religion and health care practices in Morocco was considered invaluable and inspired them to apply this knowledge in their home country. Their descriptions testify to a bi–directional learning experience by which the theory–practice gap is narrowed through the application of academic knowledge in experiential learning abroad (in this case Morocco), whose lessons in turn come back to inform both academic learning and health care practice at home (in the U.S.).

Bridging Inter–Cultural Gaps and the Urban–Rural Divide

A third theme emerged – participants' noted significant differences in health care practices related to differences between U.S. and Moroccan culture. Among them, they illustrated language was as a barrier. Differences between village/city life and health care practices were also noted. Despite the evident cultural differences, participants were successful in adapting to the new culture. Fifty–six percent of the participants shared perceptions of "culture shock," but it is important to note again that most of these students had not previously traveled abroad. Participant 1 describes being taken aback by elements of the Morrocan countryside:

"When we finally started the health clinic, the one into the countryside, it was shocking and a little bit hard to handle, just because of the culture shock of anywhere between, using different kind of toilet or having little kids in the clinic, run up to you and beg you for a toothbrush."

In general, significant differences were noted between city and village culture and health care practices by 67% of participants. Participant 5 lamented inequalities in resources and access to care:

"The government spends more money for healthcare in the cities… There are many people in the real villages, who live three hours from the city and don't have the car and they can't get there. So, to go to the city, it's a big thing. They only got to go once a year maybe. And there are lots of dispensaries to provide healthcare to the patients in the villages, but they are understaffed and under–stocked. The patient might need emergency care, but they can only get like primary care at the dispensary or very limited emergency care in the village and many women… they deliver their own babies in the villages. They don't have an OB doctor who can come out to the village and see them. They just don't have it and that's what they are used to."

The participants were not well versed in Arabic or French. Participant 7 expressed a universal sentiment (100% of the participants) about the difficulties presented by a language barrier:

"In terms of working with the other doctors or other professionals on like many of clinics, it was a challenge, I think at times mostly because of the language barrier, because none of us from the trip, one person spoke Arabic, but none of us were really even knew any words of Arabic or French, so that was definitely a challenge."

Seventy–eight percent of the participants noticed differences in U.S. and Moroccan health care practices. For example, participant 4 noted:

"We worked with a lot of Moroccan physicians, and pharmacists and nurses and I noticed that they all work at a very slower pace, which doesn't mean they weren't providing good care, but here as you know, it's very fast paced and rushed and everyone's stressed and tensed."

Despite the evident differences in the cultural practices 100% of the participants had managed to adapt well to the Moroccan culture. Participant 4 captures this aspect quite well:

"I felt like when I came back here, I kind of missed everything taking showers that weren't showers, there were bucket bath, my first shower back was like, now I feel adapted back to American culture, which I never thought in two weeks you would become so comfortable with a different culture that you have to adapt to your own culture."

The majority of the participants were successful in adapting to Moroccan culture despite a language barrier, a period of culture shock and evident differences in culture and health care practices.

Inter–professional Learning and Collaboration

Academic service learning provided numerous opportunities for participants to practice health care in an inter–professional environment, which appeared as another major theme in our results. The participants collaborated and learned from a variety of health care occupations (for example, from physicians, nurses, pharmacists and peers) involved in varied professions such as medical sub–disciplines (including dental hygiene, nursing, pharmacy and communications). Dental hygiene students worked in hospital settings, and nursing students provided oral care instructions and applied varnish to children and adults. These experiences were considered significant to their learning and growth by 100% of the participants. Participant 7 noted a greater appreciation for the benefits to the patient from inter–disciplinary collaboration:

"We were working with so many different professions over there that it just gave me more experience in terms that I can then apply back here when I am working with different professions. So I think having opportunity [to] interact with other departments, was [a] good experience. It made me more aware of how important it is for all departments to work together, and all disciplines were necessary for the care of the patient."

Participant 9 noted the value of inter–professional learning from a dental hygiene peer "the dental hygiene student was very helpful during the ... dental [clinics]. It was really helpful to have them show us like the techniques and explain how we're supposed to do things."

The participants noted the value of inter–professional health care practices in providing optimal care to the patients in oral and general health settings, such as oral/general health clinics and hospital.

Lack of Access to Care and Ethical Issues

In this study, all of the participants noted a lack of access to health care resources in both Moroccan cities and villages, another major theme. As mentioned above, this lack of access was far more evident and significant in the village. Participant 1 noted:

"In the village, you couldn't get to everybody. There were… men standing in front of doors to hold all of the people from trying to get in, to see doctors, and there were people who were always just demanding prescriptions… we did run out of toothbrushes and so these kids were just distraught, but that was hard… It was especially hard in the city because going to the hospital, I completely expected less…didn't think they'll have all that kind of technology, but it was so much more than that… the amount of people coming to this one hospital and for that amount of people, it was very small hospital."

Participants recognized that across the board health care resources – providers, clinics, hospital beds, etc. – were inadequate to meet the needs of the population both in the city and village.

The participants described varied instances of unethical issues observed in the Moroccan health care environment. Participants noted that health care providers could be bribed to prioritize care. As participant 7 observed:

"In the emergency room in Morocco, you were seen based on if you could slip the guard money. For example, we had a patient who was having an asthma attack and she was just kind of left there even when she fell out of her chair, she was just left on the ground. It was us who went over and picked her up."

A lack of resources created an environment ripe for ethical issues to arise. For instance, participant 7 described an instance where up to 4 babies were forced to share an isolate in the Neonatal Intensive Care Unit (NICU) and were not hooked up to appropriate monitoring/ medical devices:

"So I did a day in the NICU… they had four babies in each isolate… usually it's one baby per isolate… they didn't have ventilators for them. They had probably one cardiac machine that was like monitoring their one baby's heart rate. So they have an average of about 5 to 6 deaths per day in the NICU."

Here a lack of equipment became a matter of an infant's life or death. Ethical dilemmas such as these, as well as the aforementioned corrupt practices (such as bribery) which all lead to serious implications for health care practices in Morocco, left an indelible impression upon participants.

Professional Growth as a Health Care Provider

A substantial 78% of the participants saw the opportunity to provide inter–professional health care services under supervision in a foreign environment as a growth experience. Participant 1 explicitly commented with enthusiasm that "it was interesting and also a growth experience, you get to see different things and especially in the clinic it was really cool." Participant 6 appreciated the opportunity to lead a health clinic:

"I would never be allowed to run a clinic [in the U.S.]…. what it's really shown me is that I would love to move on with my education. I would love to go on, become a nurse practitioner or maybe surgical nurse practitioner, so I would have a broader scope for practice, it's… pushed me."

Without exception, the participants perceived their academic service learning experience as a significant factor in their growth as a health care provider. The opportunity to lead oral health clinics, observe varied medical procedures and learn new skills inspired them to pursue higher education in the future.

Discussion

Internal Motivation to Serve Underserved Countries

Internal motivation to serve the underserved population in a non–native country inspired participants to seek the Morocco service learning project. They embraced the opportunity to serve abroad despite a lack of previous service learning experience among a majority of the participants. The sources of motivation were familial influence and internal motivation. Family's engagement in community service as well as personal motivation of the participants inspired them to seek academic service learning opportunities in underserved countries.

Bridging Theory Practice Gap

The academic service learning experience provided innumerable opportunities for the students to apply learning from their academic programs. The inter–professional oral health education received at the Forsyth clinic encouraged participants to lead oral health clinics where fluoride varnish and oral health instructions were provided. Within the hospital settings participants were trained and encouraged by practitioners to provide services such as intra muscular injections, sutures, casts and assistance with deliveries. These experiences further enhanced their knowledge and skills. Upon return to U.S., the participants indicated an increased comfort with patient care and valued the clinical experiences gained in Morocco. The bi–directional learning experience bridged the theory–practice gap as the academic service learning experience provided numerous opportunities to apply knowledge and skills learned in Morocco and the U.S.

Bridging inter–cultural gaps and Inter–professional Learning

Participants experienced varied cultural differences between U.S. and Moroccan culture related to lifestyle, resources, beliefs, language, religion, health care and cultural practices. These factors contributed to cultural shock initially, but participants successfully adapted to the new culture. In fact, some of the participants immersed themselves so completely that they felt they missed the Moroccan culture and lifestyle upon return to U.S. Rubin found that service learning based models in non–dental health settings enhanced cultural understanding and community spirit among students.[17] International service learning can enable students to grow as culturally sensitive providers by increasing their understanding of diverse cultural and healthcare practices.

The Institute of Medicine (IOM) recommends health care providers to practice in inter–professional teams.[9] The complexity of the medical issues experienced by patients today warrants inter–professional collaboration.[10] The participants collaborated and learned from varied health professionals, such as nurses, pharmacists and physicians. The oral health training acquired by the nursing students at the Forsyth clinic enabled them to provide oral care to the Moroccan population. The dental hygiene student, in addition to leading oral health workshops, took the opportunity to understand the general health practices in the Moroccan hospital, health clinics and orphanage. The inter–professional practice experiences encouraged participants to value inter–professional collaboration in improving the

health of the public. Results suggest service learning experiences can prepare students to function effectively in an inter–professional health care arena.

Lack of Access to Care and Ethical Issues

The lack of access to dental care in the village became clear from the sheer number of people seeking care at the local oral health clinics organized by the Volunteer Morocco organization. The WHO reports that dental caries affect 72% of children and 97.7% of adults in Morocco.[21] Approximately 700 people arrived seeking care at the oral health clinics where students led the program. Services included providing fluoride varnish, oral health instructions and oral health aids such as brush and floss. Many were unable to access care due to a shortage of providers and oral health aids. Morocco has a chronic shortage of health care providers, as the density of health care workers was 1.4 to 1.9 from 1996 to 2006, respectively.[22,23] The city hospital's lack of providers and medical resources led to various ethical issues such as lack of medical/monitoring devices in the NICU, single NICU isolet shared by approximately 4 infants, approximately 5 to 6 deaths in the NICU and overcrowded maternity wards where suction was used to expedite deliveries. Participants raised ethical concerns when a physician in the Intensive Care Unit ignored the needs of a patient undergoing a severe asthma attack to provide care to patient with a small cut after receiving a bribe. Issues related to access to care in the underserved countries can be addressed by implementing international service learning programs such as Volunteer Morocco. These programs can not only increase access to providers and resources but also heighten cultural awareness of the providers.

Professional Growth as a Health Care Provider

Service learning is defined as a form of experiential education where in students engage in activities that address community needs along with structured opportunities aimed at promoting student learning and development,[1] The participants acquired new clinical skills and applied education and skills learned in their programs to address community needs in Morocco. These experiences not only increased their knowledge but also inspired many to pursue graduate education. The study findings indicate that international service learning in a diverse cultural environment fosters professional growth of the participating students.

The results of the study enable researchers to imply that it is feasible to award academic credit for service learning within nursing and dental hygiene programs. This can further encourage students to pursue academic service learning that results in greater understanding of diverse cultural and health care practices.

Limitations

The aim of this research was not to look through the gendered lens. The under representation of male students might be a potential limitation of the study. The researchers acknowledge that this under representation might have skewed some gender patterns. This aspect is worth exploring in future research. This is a qualitative study based in Morocco and may not be generalized. The vast majority of the participants were primarily females, White Caucasians and from a middle socio–economic class. The similarity of participants in age, ethnicity, gender, socio–economic status and educational background may constitute an additional limitation to this study. The authors acknowledge that lack of diversity in the students' characteristics could have influenced the culture lens of the participants. It is recommended that future studies could include a diverse population.

Conclusion

Student participating in the study perceived international academic service learning as effective in promoting inter–professional collaboration in diverse settings. They felt that an increase in international health care providers in the underserved countries could help resolve some of access to care issues. From student perceptions, the study identified the application of knowledge and skills learned in the academic programs and academic service learning settings was commonly perceived to be a means of bridging the gap between theory and practice. The academic service learning experience emerged as a way to heighten awareness of diverse cultural and health care practices to foster professional growth of health professions students. The opportunity for this pilot project presented itself and there was a dental hygiene need in Morocco that the authors could fulfill to emphasize cultural diversity and interdisciplinary teamwork. In the future, the authors will use the data from this pilot study to establish service learning programs locally, regionally, nationally and internationally.

Aditi Puri, RDH, CAGS, MS, PhD, MPH, is a candidate at the Mailman School of Public Health, Columbia University. Mahmoud Kaddoura, PhD, CAGS, MED, AGNP–BC, is an associate professor, MCPHS University. Christine Dominick, CDA, RDH, MEd, is a professor and the Associate Dean at the Forsyth School of Dental Hygiene Worcester, MCPHS University.

References

1. Jacoby B. Service–Learning in Higher Education: Concepts and Practices. San Francisco: Jossey–Bass. 1996.

2. Yoder KM. A framework for service–learning in dental education. *J Dent Educ*. 2006;70(2):115–123.

3. Ehrlich T. Service learning in undergraduate education: Where is it going? Carnegie Foundation for the Advancement of Teaching [Internet]. 2005 [cited 2013 July 26]. Available from: http://www.carnegiefoundation.org/perspectives/service–learning–undergraduate–education–where–it–going

4. Keselyak NT, Simmer–Beck M, Bray KK, Gadbury–Amyot CC. Evaluation of an academic service–learning course on special needs patients for dental hygiene students: A qualitative study. *J Dent Educ*. 2007;71(3):378–392.

5. Lautar CJ, Miller FY. Service–learning and dental hygiene: A literature review. *J Dent Hyg*. 2007;81(3):64.

6. Tonkin H, Quiroga D. A qualitative approach to the assessment of international service–learning. *Interdis J Study Abroad*. 2004;10:131–149.

7. Annette J. Service learning in an international context. *Interdis J Study Abroad*. 2002;8:83–93.

8. Connors K, Seifer S. Interdisciplinary Models of Service–Learning in Higher Education. National Service–Learning Clearinghouse [Internet]. 2005 [cited 2012 April 1]. Available from: http://www.servicelearning.org/instant_info/fact_sheets/he_facts/interdisciplinary

9. Committee on Quality of Health Care in America. Crossing the Quality Chasm: a New Health System for the 21st century. Institute of Medicin. 2001.

10. Lumague MM, Morgan A, Mak D, Hanna M, Kwong J, Cameron C, Zener D, Sinclair L. Interprofessional education: The student perspective. *J Interprof Care*. 2006;20(3):246–253.

11. Mouradian WE, Corbin SB. Addressing health disparities through dental–medical collaborations, part II. cross–cutting themes in the care of special populations. *J Dent Educ*. 2003;67(12):1320–1326.

12. Mouradian WE, Huebner C, DePaola D. Addressing health disparities through dental–medical collaborations, part III: Leadership for the public good. *J Dent Educ*. 2004;68(5):505–512.

13. Mouradian WE, Berg JH, Somerman MJ. Addressing disparities through dental–medical collaborations, part 1. the role of cultural competency in health disparities: Training of primary care medical practitioners in children's oral health. *J Dent Educ*. 2003;67(8):860–888.

14. Smedley BD, Stith AY, Nelson AH. Unequal Treatment: Confronting Racial and Ethnic Disparities in Health Care. Institute of Medicine. 2002

15. Formicola AJ, Stavisky J, Lewy R. Cultural competency: Dentistry and medicine learning from one another. *J Dent Educ*. 2003;67(8):869–875.

16. Amerson R. The impact of service–learning on cultural competence. *Nurs Educ Perspect*. 2010;31(1):18–22.

17. Rubin RW. Developing cultural competence and social responsibility in preclinical dental students. *J Dent Educ*. 2004;68(4):460–467.

18. Fitch P. Cultural competence and dental hygiene care delivery: Integrating cultural care into dental hygiene process of care. *J Dent Hyg*. 2004;78(1):11–21.

19. Magee KW, Darby ML, Connolly IM, Thomson E. Cultural adaptability of dental hygiene students in the United States: A pilot study. *J Dent Hyg*. 2004;78(1):22–29.

20. Access to Care Position Paper, 2001. American Dental Hygiene Association [Internet]. 2001 [cited 2012 April 6]. Available from: http://www.adha.org/resources–docs/7112_Access_to_Care_Position_Paper.pdf

21. Report on the regional meeting on strengthening oral health in primary health care. World Health Organization [Internet]. 1994 [cited 2012 April 6]. Available from: http://www.mah.se/CAPP/Country–Oral–Health–Profiles/EMRO/Morocco/Oral–Diseases/Dental–Caries/

22. WHO Statistical Information System. World Health Organization [Internet]. 2012 [cited April 6, 2012] Available from: http://www.who.int/workforcealliance/knowledge/resources/whosis/en/

23. Health Action Plan, 2008–2012: Reconciling with the citizen's health system. Kingdom of Morocco Ministry of Health. 2008.

24. Maxwell, JA. Qualitative Research Design an Interactive Approach. 2nd ed. Thousands Oaks, CA: Sage Publication. 2005.

25. Seidman I. Interviewing as Qualitative Researcher – a Guide for Researchers in Education and Social Sciences. 3rd ed. New York, NY: Teachers College Press. 1998.

26. QSR International. NVIVO 8 [Internet]. [cited 2012 April 6]. Available from: http://www.qsrinternational.com/#tab_you