THE EFFECTS OF VIBRATORY INSTRUMENTS ON DENTAL PRACTITIONER'S HANDS

An Undergraduate Research Scholars Thesis

by

SAMANTHA WRIGHT AND HADLEE HICKS

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Approved by
Faculty Research Advisors: Mikhail Umorin, Ph.D.
Leah Spittle, RDH, MS-EDHP
Chelsea Moorman, RDH, BSDH

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We, Samantha Wright and Hadlee Hicks, certify that all research compliance requirements related to this Undergraduate Research Scholars thesis have been addressed with our Faculty Research Advisors prior to the collection of any data used in this final thesis submission.

This project did not require approval from the Texas A&M University Research Compliance & Biosafety office.

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ABSTRACT

The Effects of Vibratory Instruments on Dental Practitioner's Hands

Samantha Wright and Hadlee Hicks
Caruth School of Dental Hygiene, School of Dentistry
Texas A&M University

Faculty Research Advisor: Mikhail Umorin, Ph.D.
Caruth School of Dental Hygiene, School of Dentistry
Texas A&M University

Research Faculty Advisor: Professor Leah Spittle, RDH, MS-EDHP
Caruth School of Dental Hygiene, School of Dentistry
Texas A&M University

Research Faculty Advisor: Professor Chelsea Moorman, RDH, BSDH
Caruth School of Dental Hygiene, School of Dentistry
Texas A&M University

Research supports that the use of vibratory instruments are significant occupational risk factors for developing neuromuscular and musculoskeletal disorders in dental professionals. The use of vibratory instruments can also intensify symptoms in clinicians with preexisting neuromuscular and musculoskeletal disorders. These disorders include Carpal Tunnel Syndrome, Canal of Guyon Syndrome, Rotator Cuff Tendonitis and Brachial Plexus Compression. Dentists, hygienists, and dental assistants are at risk of developing these disorders. Removing these instruments from the modern standard of health care is not an option. Vibratory instruments can have a negative impact on tactile sensitivity and nerve conduction in the ulnar, radial, and

median nerves. These conditions can lead to pain, weakness, and a decreased ability to provide optimal patient care. Stretching, ergonomics, proper positioning, and limiting the use of vibratory instrumentation can minimize this harm. Following these recommendations can delay the onset of these disorders. Future research should determine how many hours of vibratory instrumentation exposure a clinician should undergo weekly to minimize occupational harm. Dental professionals' ability to scale, polish, and perform restorative procedures will be improved as a result of a following these recommendations.

DEDICATION

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NOMENCLATURE

VPT	Vibrotactile Perception Threshold
MSD	Musculoskeletal Disorder
Hz	Hertz
NMD	Neuromuscular Disorder
NIHL	Noise-Induced Hearing Loss
RPM	Revolutions Per Minute

INTRODUCTION

Vibratory instruments have been used in dentistry since the 1950s.[1] Vibratory instruments are used by dental professionals daily, potentially for several hours. A vibratory instrument has the capacity to cause vibrations or oscillate in a way to produce a variety of effects. Vibratory instruments include Cavitrons, piezoelectric ultrasonics, sonic instrumentation, and low and high-speed handpieces. Cavitrons, piezoelectric ultrasonics, and sonic instrumentation use high frequency vibrations to produce an oscillatory motion at the tip to successfully remove plaque, biofilm, stain, and calculus from the tooth surface. Low and high-speed handpieces contain a handheld motor which can be air or electric driven that spins a cutting bur, file, or prophy cup. Low and high-speed hand pieces are used for procedures such as polishing, crown preparation, and removal of decay. Additionally, vibratory instruments are used to perform enhanced procedures such as root canals, fillings, scaling, and root planing, removing excess cement from orthodontic appliances, and recontouring bone. Historically, the first electric dental engine was invented in 1874 which had a self-contained motor and a handpiece that held a drill.[2] Needless to say, instruments producing vibrations have been around for quite some time. However, the concern to be addressed is the vast potential to cause a variety of disorders in dental practitioners due to the long term and frequent use of these instruments.

Vibratory instruments possess the ability to cause damage to the nerves of clinicians which can lead to an array of consequences. Common disorders that are associated with frequent exposure to vibratory instruments include Carpal Tunnel Syndrome, Canal of Guyon Syndrome, Rotator Cuff Tendonitis, and Medial and Lateral Brachial Plexus Compression. Carpal Tunnel Syndrome is defined as paresthesia in the median nerve distribution. Canal of Guyon Syndrome

is defined as paresthesia in the ulnar nerve distribution. Rotator Cuff Tendonitis is defined as deltoid muscle pain with overhead work and weakness when elevated. Clinicians may also report pain on resisted abduction, external or internal rotation of the shoulder, resisted elbow flexion, or pain upon active upper arm elevation. Medial brachial plexus compression is defined as radiating pain and paresthesia from the pectoral muscles with deep supra-scapular palpations. Lateral brachial plexus compression is defined as radiating pain and paresthesia from the pectoral muscles with deep sub-scapular palpations. In order to be an effective dental professional with an extensive career, it is imperative to recognize the association between the vibrations produced by these instruments and the onset of neuromuscular or musculoskeletal disorders. Not only is it necessary to shed light on the issue of vibrations and the effects, but it is also important for dental professionals to report all signs and symptoms of neuromuscular or musculoskeletal disorders. Many times, due to the lack of dental hygienists, needs of the patient, or busy schedules, provider offices are seeing 50-100 patients a day or more, depending on the size of the facility. In cases like this, the hourly use of instruments by dental staff such as ultrasonics, low-speed, or high-speed handpieces is increased.

The American Journal of Industrial Medicine conducted a cross-sectional study of 94 experienced hygienists who reported over 5 hours per week using vibratory and ultrasonic instruments.[3] This research concluded that there is a connection between the use of vibratory instruments and the onset of disorders such as Carpal Tunnel Syndrome, Canal of Guyon Syndrome, and numerous others.[3] Unfortunately, even with this data, there is no regulation or limitation to the weekly number of hours of occupational vibrations a clinician can be exposed to. Concern also comes from the concept that the amount of noise produced by these instruments can be tied to hearing loss or impairment over a period of time. Since technology within the

dental field has improved immensely, research must ensure that the safety of these instruments has been adequately proven to promote a healthy work environment. In 1957, an improved high-speed air-driven handpiece was invented by John Borden, which increased drill speed from the traditional 5,000 rpm to 300,000 rpm.[2] While it is obvious that these instruments have evolved over time, we must also address what recommendations regarding their lack of safety to clinicians have been made.

The goal of this research is not only to inform people about new therapies and potential recommendations to reduce the effects caused by vibratory instruments, but also to propose solutions to increase longevity in these careers. This review will summarize clinical problems associated with chronic vibratory instrument use, their pathophysiology, and the consequences for practitioner health and career longevity. By reflecting upon what has been proposed or implemented in the past, one can better understand what new recommendations could be made moving forward. Despite institutions and educators instructing students on the concept of vibratory instruments, there is a deficiency in the education of the harm that can be caused. By introducing the association between the amount of exposure and the long-term concerns, strategies for exposure limitations, education within programs, and ergonomic improvement are of top priority in understanding how to address this issue.

1. RELATION TO DENTAL PROFESSIONALS

Vibratory instruments are heavily relied on and benefit the dental field immensely. These essential handpieces and ultrasonic scalers aid professionals in getting the job done with efficacy and precision. The concern that comes to the forefront of vibratory instruments and their long term use is that the established data correlates the potential harm; however, there is no guideline in place to prevent or reduce the risks.[3] A study on dental hygienists who operate ultrasonic handpieces concluded that subjects who reported hand paresthesia (55.3%) are more likely to be diagnosed with Carpal Tunnel Syndrome (CTS) and possessed slower sensory nerve conduction velocity (SNCV) along the digit and palm-wrist segment of the median nerve.[3] It was also determined that the high levels of paresthesia observed among dental hygienists appeared to be attributable to several pathophysiological mechanisms, including sensory nerve demyelination at the carpal tunnel, and dysfunction of fingertip mechanoreceptors.[3] Microscopic mechanoreceptors involved in sensation lie within the Pacinian corpuscle, which is the most sensitive to skin displacement.[4] The Pacinian corpuscle is a rapidly adapting receptor that serves a purpose of aiding in vibration detection.[4] Mechanoreceptors communicate information about speed, amplitude, direction, displacement, and duration of a sensation.[5] This is a significant concern not only for current hygienists, but also for future dental professionals and students.

Vibratory instruments are used in every dental discipline and are manufactured specifically for a variety of procedures. For endodontic procedures, nickel titanium rotary instruments use flexibility, torsional strength, and elastic memory to completely remove diseased pulp tissue, microorganisms, infected dentin, as well as shape the root canal.[6] Without removing the infection completely and creating a proper shape for the gutta percha, the root canal has a

high likelihood of failure. Oscillating instruments and rotary cutting instruments with turbine and electric handpieces are used in restorative dental procedures to prepare teeth for permanent restorations, such as crowns or fillings. These instruments are designed to allow the clinician to remove decay while minimizing the removal of sound tooth structure.[7] These instruments are also used to adjust hyper occluding areas of restorations to ensure proper mastication and prevention of secondary trauma or discomfort. It is important to adjust heavy occlusal contacts as these can cause pain or sensitivity and may even lead to pulpitis. Orthodontists use high speed and low speed handpieces to remove excess cement after removing brackets from braces. This is to ensure a smooth tooth surface to prevent biofilm and stain from attaching to the tooth surface which could cause inflammation or decay over time. Oral surgeons use rotary instruments to smooth bone around extraction sites before suturing the tissue for proper healing and comfort. Ultrasonic scalers are valuable instruments in the prevention and maintenance of periodontal disease. The vibrations produced in the handpiece create an oscillating tip to mechanically remove biofilm, calculus, and endotoxins from the tooth surface.[8] These instruments were created to enhance visualization, precision, strength, convenience, and overall efficiency of the dental clinician.

Most of the instruments expel water from the working end or tip of the instruments when activated which flushes away blood, bacteria, and decay or tooth structure. Most importantly the production of water, that comes from the reservoir on the dental chair or unit, prevents pulpal irritation due to heat produced by the rotary and oscillatory instruments. Water aids in acoustic cavitation from ultrasonic scalers, which is when a liquid undergoes a rapid change in velocity creating bubbles. When in the mouth, these bubbles release a shockwave of stored kinetic energy which alters the cell walls of bacteria and detaches adherent bacteria from the tooth surface.

Acoustic microstreaming allows for these bubbles to flow in the current to reach and implode on distant bacteria. Since the power is created within the instrument itself, the clinician solely has to set the speed or power and guide the tool. This improves overall ergonomics, precision, and efficiency. These instruments have truly advanced the field of dentistry as evidenced by their wide range of applications.

Before vibratory instruments were introduced to the field of dentistry, manual instrumentation was used. This included stainless steel instruments containing a body as a handle and a pointed or rounded tip with a blade, known as a cutting edge. Dental professionals would adapt the blade to the tooth and scrape it across the tooth surface to remove biofilm and calculus.[9] Decay or infection was either scooped out and smoothed with handheld instruments or files or the tooth was just extracted. End-cutting rongeurs were used for trimming and recontouring alveolar bone and gross tissue removal. Though these tools were useful for limited procedures, they required significant time, skill, and resulted in fatigued clinicians.

The invention of handpieces, known as drills, has advanced dentistry to where it is today. It has changed the scope of practice to be able to conserve tooth structure, allowing patients to keep their teeth for a long period of time. Clinicians have become more skillful with these instruments because the piezoelectric, magnetostrictive, and handpieces provide their own strength, decreasing clinician fatigue. Before, clinicians were required to apply moderate to heavy lateral pressure to remove the structure that was being treated. The adjustable power and strength together allow the work to be done in a timely manner by allowing procedures that used to take 3 hours to now be completed in 30 minutes. Dental professionals are able to treat more patients and reach a larger population. Dentistry is no longer just treating decay or pain but preventing it. Ultrasonic scalers were initially designed to only remove supragingival deposits

but have been redeveloped to be able to clean below the gum where toothbrushes cannot reach. This can prevent disease before it happens. As discussed, these instruments are designed and marketed for their procedure enhancing abilities. However, a long-term study on the systemic effects should be addressed to ensure safety and efficacy can both be met.

In modern neuromuscular dentistry, ultra-low frequency transcutaneous electrical nerve stimulation therapy (ULF-TENS) is used to relax the muscles of the head and neck.[10] Since frequency in this case is aiding in relaxing the muscles, it is acceptable to associate that the frequency and vibrations of the dental instruments are doing the same to practitioner's hands. This low frequency neurostimulator generates a repetitive, synchronous, and bilateral stimulus that is delivered at 1.5 second intervals and a frequency of 0.66 Hz.[11] Since this stimulus is delivered at a significantly lower rate than the frequency that instruments can produce, this correlation is further established.[5] Clinicians are exposed to a higher frequency than patients receiving muscle relaxing therapy.

The near-ubiquitous use of vibratory instruments by dental professionals has brought with it an increased incidence of neurological, vascular, and joint damage to the practitioners using them. Identification of these symptoms' causes, and progression is critical to reduce their impact on dental professionals. The maximum frequency that is considered safe for continuous peripheral nerve stimulation is 30 Hz.[17] Anything above 30 Hz has not been proven to be safe. Magnetostrictive ultrasonic scalers, such as the Cavitron function at 20-40 kHz (20,000-40,000 Hz), while a piezoelectric ultrasonic scaler functions at 29-50kHz (29,000-50,000 Hz).[18] These instruments expose clinicians to over a thousand more frequency waves per minute than what is safe for the nerves. Dental handpieces range up to 7.38 kHz (7,380 Hz).[20] These high frequencies used by dental practitioners every day put them at an increased risk for neuromuscular disorders.

It is important to expand on the fact that this is not only affecting hygienists in the field of dentistry. A study examining 30 dental hygienists, 30 dentists, 30 dental technicians, and 30 nurses was conducted in regard to tactile sensitivity and performance.[10] According to this studies results, dentists experienced more peripheral neuropathy than dental hygienists due to exposure of vibrations for longer durations from using handpieces more frequently.[10] These findings should be taken into careful consideration due to the increasing trend of relying on piezoelectric scalers and Cavitrons over hand instrumentation due to advancing technology.

Other studies report Carpal Tunnel Syndrome affecting the median nerve, Canal of Guyon syndrome affecting the ulnar nerve, rotator cuff tendonitis, chronic hand paresthesia, numbness and tingling, impaired vibrotactile sensitivity, loss of upper body strength, a decline in motor performance, and sensorineural symptoms.[12] Though these injuries are thought to be from chronic vibration exposure, dental practitioners use repeated and monotonous movements of the hands and wrists, and have a high prevalence of head and neck disorders. Mercury vapor exposures from amalgam have also been related to peripheral nervous system disorders. Injuries are currently treated with medications, specifically antidepressants and anticonvulsants such as Gabapentin and Pregabalin.[13] Painkillers such as NSAIDS or Acetaminophen are often used to treat the symptoms, until repairment surgeries are necessary. However, due to the recovery process, many clinicians never return after surgery. Additionally, many insurance companies will no longer cover them to practice. It can also be difficult for the clinician to return to practice due to the inability to change their technique, habits, or instrumentation. These injuries have not been shown to resolve or improve overtime, but instead worsen. Ultrasonic and vibratory instruments are taught and highly encouraged in the education of dentistry, yet long term injuries are neither taught nor discussed due to the uncertainty of the actual cause. A study was done on a group of

first year hygiene students, all unexposed to vibratory instruments.[14] Half of the students were being studied by using vibratory instruments in the clinical setting while the control group was only using hand instruments.[14] All the students were tested and scored by a Vibratory Sensory Analyzer prior to performing the task. [14] Next, they removed 4 pieces of artificial calculus from a typodont over 45 minutes, then were re-tested and given a new Vibratory Sensory Analyzer, also known as a tactile sensitivity score. Results showed an increase in vibratory tactile sensitivity in the students exposed to the vibrations and decreased in those who were not.[14] This study is helpful to recognize that injuries are probably due to long periods of exposure over time, rather than from one time use. In contrast to hand instrumentation, vibratory instruments come with a learning curve. Students are more frequently exposed for longer periods of time while in school ranging from 2-5 years as compared to a day in private practice which estimates 78 minutes total on an average day.[15] Long periods of exposure to this level of frequency of vibrations over time increases the potential for nerve damage.

Damage induced by vibrations has been seen in the microvascular structures of the nerves and nerve fibers of clinicians fingers, arms, shoulders, and spine.[12] Vibrotactile perception thresholds have tested mechanoreceptors, sensory nerve conduction with fractionated digit palmar segments, and calibrated pinch force with force sensitive resistors.[16] Vibrotactile thresholds were measured on the hands of practicing hygienists and student hygienists by a vibrosensor and electronics to record the stimulus of the skin on fingers three, for measurement of the median nerve, and finger five, for measurement of the ulnar nerve. [16] A probe was then placed onto the fingertip and administered sinusoidal bursts of vibrations at different frequencies. [16] The clinician would signal when the stimulus was perceived and relax when it was removed. [16] Results of vibrotactile perception threshold appeared to be elevated in the experienced dental

hygienist, suggesting the amount of exposure over time causes an increased risk to injuries since tactile sensitivity was decreased in dental professionals. [16] Sensory nerve conduction velocities measured the ulnar and median nerve again, this time from distal sites in the upper extremities. [16] A Nicolet Viking Quest device was placed and measured nerve stimulation in different areas such as mid-palm, finger five, wrist and palm.[16] Nearly half of these hygienists reported frequent tingling and numbness, suggesting that the injuries are not just in the hands but continue to affect other parts of the body such as the arms and shoulders. Calibrated pinch force was also measured by gripping a manual scaler with the firmest pinch. A force sensitive resistor was placed on the second finger's glabrous pad. [16] A series of pinches were performed and randomly recorded. Several experienced dental hygienist's calibrated pinch force was beyond 30 pounds, which is attributed to mechanical limitations of the hands, arms, and shoulders.[16]

Ultimately, the concern for the future of dentistry is the risk for these conditions to occur earlier in dental professional's careers, due vibratory instrumentation being increasingly integrated into everyday routine and educational curriculum. As society moves forward with innovation, it must be of utmost importance to ensure the long-term physical effects are considered and properly addressed. Study results regarding absenteeism in professionals affected by Musculoskeletal Disorders (MSDs) prove how this problem can negatively affect several aspects of the life of professionals. [17] Therefore, it is to prevent the onset of this work-related concern. Since there is a lack of dental professionals yet more members of society receiving dental treatment, adequate safety measures must be employed to increase the working ability of health care providers.

2. EFFECTS OF INJURIES ON CAREER LONGEVITY

Although the etiology of MSDs is multifactorial, exposure to occupational risk factors significantly contributes to the onset of these disturbances.[17] As novice clinicians begin to take on private practice, it is worrisome that careers are shortened or negatively impacted due to this potentially preventable problem. Despite the fact that all dental professionals are at risk, dental hygienists may be at greater risk long term compared to dentists for developing upper extremity musculoskeletal disorders in the neck, shoulders, and lower back.[17] This is due to the long hours of periodontal work but can also be related to the type of instruments used. Dentists are more likely to use instruments that produce lower frequencies. Dental handpieces report the range of frequencies produced to be between 3,000-8,000 Hz, while ultrasonics produce frequencies between 20,000-50,000 Hz.[5] Due to this, a potential connection can be made that they are less likely to develop certain problems in comparison with hygienists. Many times, patients requiring non-surgical periodontal therapy have deep pockets and tenacious calculus. It is times like this that the Cavitron, sonic scaler, piezoelectric scaler, and polishing handpieces are used for a longer period of time. Since the exposure time would be increasing for adequate debridement, it becomes important to highlight the associated risk due to vibratory exposure.

It should be noted that those with static jobs have a higher probability of generating a disorder in the cervical spine in comparison to those involving dynamic motions.[18] Due to not only the physical, but also psychological demand of the dental field, a stressful environment is created. Stress can elicit varying effects on a person and lead to lack of motivation, depression, and career burn out. The toll that neuromuscular and musculoskeletal disorders take on the body is something that can become difficult to cope with if adequate measures are not available.

Dental professionals are called to their career in order to help others and develop superior clinical abilities. However, if the instruments that are now the standard therapy are causing harm over time, the inability to be an effective clinician can be mentally detrimental. Career burnout is characterized by mental or emotional exhaustion, negative or indifferent attitudes toward patients or co-workers, and the feeling of dissatisfaction with accomplishments.[19] If one is unable to perform up to the standards, they have established for themselves due to a disorder onset from vibratory instrumentation, it is likely they will experience some form of self-doubt.

Noise is perceived as a negative sound.[20] This could include background noise, loud instruments, or machines.[20] Meanwhile, music is perceived as a positive sound.[20] Sound can have a significant impact on systemic health in addition to being related to anxiety, phobias, worry, nervousness, and feeling uneasy.[20] This is important to us as dental professionals since it can play a significant factor in dental anxiety in patients.[20]

Healthy adults can generally hear frequencies between 20 and 20,000 hertz. The range for low frequency sounds is about 500 hertz and below. High frequency sounds range from about 2,000 hertz and above. Noise-induced hearing loss is a permanent sensorineural defect caused by occupational activity.[21] This disease may first show signs of not hearing the ringtone of a phone call, and progress to difficulty hearing low frequency sounds, such as wind, weather, and footsteps.[21] If this progresses to total hearing loss, high frequency sounds will not be able to be heard either. High frequency sounds include whistling, screaming, and squeaking. Systemically, this disease can also cause irritability, nervousness, anxiety, tinnitus, tachycardia, changes in blood pressure, headaches, loss of appetite, stomach pain, and insomnia in clinicians.[21] Ultimately, it is necessary to address that noise-induced hearing loss is an avoidable occupational disease.

While hertz measures frequency, and decibels measure intensity, the two cannot be compared. 85 decibels for 8 hours is the daily allowable noise level according to the National Institute for Occupational Safety and Health Administration.[22] Anything beyond this level is potentially hazardous.[22] Although studies have not yet consistently found the combination of various instruments being used at the same time to exceed 85 decibels, other studies have shown oral surgeons more than 5 years in the profession with hearing loss.[22] Anything beyond 4,000 hertz has not been proven to be safe for the human ear. 21 Ultrasonic scalers and the high-speed hand speed exceeds well over 4,000 hertz. If the exposure to high frequency noise is interrupted, then the hearing loss can be stopped. This suggests that the use of devices such as noise canceling headphones could protect not only clinicians, but the patients being treated as well.

A cross-sectional study was conducted in Saudi Arabia in dental cubicles at a dental college.[22] The noise of instruments and equipment was recorded during procedures of multiple specialties including periodontics, restorative dentistry, endodontics, oral surgery, and prosthodontics.[22] The minimum and maximum noise levels were recorded by a sound level meter.[22] This device is similar to the human ear in the way it responds to noise, while recording a reliable measurement.[22] The device was placed 30 centimeters from the operator's ear to record the intensity of what a clinician experiences.[22] Noise produced by ultrasonic scalers, high-vacuum suctions, low-vacuum suctions, high-speed handpieces, low-speed handpieces, an amalgamator, an apex locator, endodontic handpieces, surgical straight handpieces, a denture trimmer, and background sounds were recorded individually and in procedural combinations.[22] The sound levels were measured in 30 second increments and noted in decibels.[22]
Results showed that the amalgamator produced the maximum intensity at 79.44 decibels during restorative procedures.[22] Though none of the recorded sounds exceeded 85 decibels said to be

safe, the numbers had an average of 67.43 decibels, which is still ranked as high intensity.[22] Even the background noise of the procedures averaged 61.44.[22] Over the years, occupational noise can lead to sensorineural hearing loss.[22] Sounds in the dental office can be considered hazardous to dental professionals.[22] Exposure to harmful auditory effects over an extended period of time can have adverse effects on hearing and general health.[22] Studies should look into lowering equipment noise output aside from noise emission devices.

A similar study was conducted was conducted at the School of Dentistry, Lutheran University of Brazil over a 10-week period, 10 times a week.[21] A decibelimeter IDETEC 300 held by an operator was placed 80 centimeters from each of the 10 dental chairs.[21] It was turned on for 5 minutes before the start of clinic, at hour 1, 2, and 3 of clinic and recorded the highest intensity of noise.[21]Results concluded two recordings that exceeded the 85-decibel limit at 89.97 decibels in hour 1 during week 7 and 90.02 in hour 2 during week 9.[21]This study focused on the onset of sensi-neural hearing loss, which is why it was conducted in an educational clinic.[21] The noises during the clinic included talking, instruments, suctions, machines, music, movement, the air conditioner, and noise in surrounding operatories.[21] This school setting is similar to many dental practices where there may be more than one dentist or hygienist all using instruments and machines at the same time.

In conclusion, though the Brazilian legislation has set 85 decibels as the maximum limit to prevent noise induced hearing loss, these studies suggest that damage may be occurring before this limit is reached.[21] It should be noted that there are many different companies that make these instruments. Each company's instruments are unique, as some may produce high frequencies and have a higher intensity than others. Clinicians should be mindful of these considerations when purchasing instruments and choosing an office to work in. A simple change in arrangement of

the furniture could potentially have an effect on their hearing.[21] A future study assessing a student's hearing when starting dental school and finishing dental school would help us better understand the risk and to prevent hearing loss from exposure.[21] Dental professionals being unable to perform due to injuries from inventions that have the purpose of enhancing performance is unacceptable for the future of dentistry.

3. MEASURES PROVIDERS CAN TAKE TO DELAY ONSET OF NEUROMUSCULAR AND MUSCULOSKELETAL DISORDERS

With all things considered, it is important to address prior methods that have been suggested in order to prevent the onset of various disorders among dental personnel. Ergonomics are an important aspect of dentistry that is practiced to reduce the onset of any musculoskeletal pain. It is imperative that clinicians practice these techniques since a primary cause of musculoskeletal disorders is the work environment such as the unit chair and instrument technique.[18] The Department of Dental Hygiene and Occupational Therapy at Kangwon National University conducted a study with regards to physical therapy and ergonomic risk factors of dental hygienists.[18] Based on their ergonomic analysis, they state that the development of therapeutic exercise programs in the workspace and daily life is a crucial factor. This is because the posture of dental hygienists during scaling is highly conducive to work-related musculoskeletal disorders.[18]

When focusing on dentists specifically, a study revealed that dentists who perform procedures while sitting reported more severe low back pain in comparison to those who practice both standing and sitting.[23] Due to this finding, it may be justifiable to encourage the alternation between these two positions to help specific muscles rest while others work. Pain while sitting also has to do with the relationship between the patient position and provider. One way this can be avoided is by the provider adjusting their chair initially, then proceeding to adapt the patient's position to their ergonomic needs. A saddle chair is also an ergonomically beneficial chair, which allows the operator's knees to be under the chair while also helping to maintain a proper

lower back curve.[23] If changes are not going to be made within the design of the vibratory instrument, it is crucial that the clinician is active in other methods of prevention.

Going hand and hand with ergonomics is the recommendation of doing stretches. Stretches encouraged by Kangwon National University include finger stretches, stretching arms outward and repeatedly flexing the wrist, shoulder stretching and drawing your chin down then stretching your neck up.[18] These stretching exercises can help strengthen muscles and aid in wrist mobility. Stretching is something that can be done prior to and after performing dental work on patients in order to maximize the effect. The International Journal of Dental Hygiene published a study which reported that 25.6% of those interviewed reported stretching and inadvertently, 91.4% reported suffering from MSDs and not stretching.[17] Although individuals who do not stretch do not automatically fall to something of this nature, it is appropriate to make the connection that stretching has the potential to decrease this risk.

Research has made several suggestions with regards to reducing negative sound and promoting positive sound. This includes playing pleasant music in the waiting room, using noise canceling headphones or headphones with music, and noise absorbing furniture.[21, 22, 23]

If none of the following can be implemented in a practice, we suggest the installation of noise absorbing panels and speakers within the operatories. We also recommend that dental professionals routinely receive an audiologist evaluation. Common tests that are implemented to assess hearing loss include behavior testing in a sound booth, otoacoustic emission testing, and auditory brainstem response testing. Further research should look into setting a limit on whether a weekly exposure to high frequency sound guideline should be implemented to reduce these risks. It is necessary that precautions are taken in order to absorb these sound waves. This not only could reduce the auditory damage to dental professionals, but also patients. With these

preventable measures being supported by research, it is practical to conclude awareness should be continuously raised with regards to stretching, adequate operator positioning, and ergonomic improvement.

CONCLUSION

In summary, the creation of vibratory instruments has advanced the field of dentistry and has improved time, skill, and fatigue from strictly using hand instruments. Vibratory instruments operate at extremely high frequencies, however, have not yet been proven to be safe for use by clinicians. Many different injuries, mostly involving the median and ulnar nerves, have been reported with peripheral nerve damage from vibratory instruments being a pre-disposing factor. Noise-induced hearing loss has also been reported as an occupational issue early in dental professional's career. It is relevant to address how many dental professional's careers are becoming shortened due to these disorders and how patient interaction is negatively affected.

Though the purpose of the invention of vibratory instruments compared to hand instruments is by far outweighed, it is questionable if the risk of risk discussed outweigh the overall benefits in years to come. There should be an improvement of upper body ergonomics regarding the grasp, design, and positioning while using these instruments. Research should also further evaluate the frequencies produced. It would be appropriate to implement education in school programs about the risk these instruments pose, just as ergonomics is taught. Since using ultrasonic scalers is increasing in popularity, these instruments should be further evaluated to address if the risk of neuropathy, hearing loss or other disorders constitutes exposure limitations to be put into place. Short term used of vibratory instruments, of less than an hour, showed an increase in tactile sensitivity, while measurements of vibrotactile perceptions of practitioners with years of exposure show limited tactile sensitivity.

As the dental field becomes more dependent on vibratory instruments, mandating the use of ear protection during procedures using high frequency producing instruments should be

further evaluated. Limiting the number of hours of exposure to these instruments could potentially decrease the number of injuries in dental professionals, resulting in improved performance, quality of care, and lengthened careers. By mandating protection to be worn, there could be a decrease in hearing loss in dental professionals. Hearing loss within the dental field can lead to a disconnect between the provider and patient. It can cause educational services and questions to not be properly addressed due to communication barriers. These disorders in conjunction with hearing loss pose a well-established risk on dental professional's career longevity. A clinician must consider the correlation research makes while also implementing prevention methods. It can be concluded that these instruments should potentially be re-evaluated due to the amount of vibrations they produced.

For the future, research should be conducted to determine if specific vibratory instruments have a higher likelihood of producing a neuromuscular condition. This not only can determine which instruments we should increase precautionary use with, but also to pinpoint if any one dental professional is at more risk than another. By determining this factor, specific vibratory instruments can be further explored regarding the frequency that is being produced and overall production of products. These instruments could be improved by limiting the number of vibrations produced in the actual hand piece to less than 30 Hz or even eliminating them totally. It is also beneficial to consider limitations being put into place for time exposure in relation to instruments that produce over a set amount of hertz. If these instruments are unable to be redesigned, research could look into devices being manufactured to absorb excess vibrations. By absorbing these excess vibrations, the sound produced may also be lessened. By doing this, the vibrations on the hands of professionals would be reduced which could result in a decreased incidence of disorders. By reducing the noise that is initially produced in conjunction with the

use of headphones or sound absorbing devices, the exposure to high frequency sound would be reduced substantially.

By recognizing these concerns and issues amongst dental professionals, there is a potential for an increase in career length, a decrease in neuromuscular or musculoskeletal disorders and noise-induced hearing loss, and an improvement in the design and quality of vibratory instruments. Moving forward, it is evident that more studies are needed to improve the safety of vibratory instruments. If a longitudinal study was conducted over hygienist solely using vibratory instruments over an extended period of time, research may be able to further conclude risk factors and solutions. Also, this study could determine the effects these instruments have on the ears, as it would collect data over an extended period of time. With proper recognition of these concerns and adequate implementations, healthier providers and higher quality services for patients could be the outcome.

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