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

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EFFECTS OF FIVE DIFFERENT FINGER REST POSITIONS ON ARM MUSCLE ACTIVITY DURING SCALING BY DENTAL HYGIENE STUDENTS

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ABSTRACT

EFFECTS OF FIVE DIFFERENT FINGER REST POSITIONS ON ARM MUSCLE ACTIVITY DURING SCALING BY DENTAL HYGIENE STUDENTS

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This study was conducted to determine the effects of five different finger rest positions, (fulcrums: opposite arch, standard intra-oral, basic extra-oral, cross arch and finger on finger) on the muscle activity of four forearm muscles, (*extensor carpi radialis longus, flexor carpi ulnaris, biceps brachii* and *pronator teres*) during a simulated periodontal scaling experience. A convenience sample of 32 consenting right handed senior dental hygiene students who met inclusion criteria participated. The 32 students had no history of injuries or disabilities to the right arm, wrist, or hand. Pre-test maximum voluntary isometric contraction (MVIC) scores were obtained prior to scaling. Using a 4 x 5 counterbalanced research design, each participant used a Premier Gracey 11/12 curet to scale up to one cc of artificial calculus from the mesiobuccal surfaces of first permanent molar typodont teeth (Nos. 3, 14, 19, and 30). Five different typodonts were set up for each participant with a different fulcrum randomly assigned for use on each typodont. Each participant scaled what calculus they could in a controlled, simulated situation for up to one minute per tooth using the randomly assigned fulcrum. While scaling, participants' muscle activity was measured using surface electromyography (sEMG). Two-way ANOVA with repeated measures revealed no statistically significant interaction effect between area of the mouth scaled, muscle activity, and fulcrum used. Results revealed that following 20, one-minute scaling sessions using a hand instrument to remove artificial calculus, there was similar muscle activity generated. While scaling, forearm muscle activity was least when using the opposite arch fulcrum and most when using the cross arch fulcrum. Regardless of where scaling started more muscle activity occurred in the maxillary right quadrant and the least in the mandibular left. Based on the results, similar muscle activity is produced while scaling when using all of the five fulcrums tested in each area of the mouth. Clinicians appear to experience minimal ergonomic advantages in terms of fulcrum used and area of the mouth scaled during a simulated scaling experience. Characteristics of the patient may be more important when choosing a fulcrum than the amount of muscle activity generated.

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CHAPTER I

INTRODUCTION

In dental hygiene, a *fulcrum* is a finger rest used by a practitioner to stabilize the hand and reduce muscle stress while performing clinical procedures such as therapeutic scaling on a patient's dentition. Limited knowledge exists on what type of fulcrum(s) over long term practice would minimize forearm muscle activity and possibly reduce the incidence of cumulative trauma disorders (CTD) in dental hygienists. Researchers have been challenged to determine causes for cumulative trauma disorders in dental practitioners since the effects of these disorders threaten productivity and career longevity of the professionals affected. Several risk factors have been identified and associated with cumulative trauma disorders in dental hygienists including repetitiveness of task, posture, force, and mechanical stresses (Gerwatowski, McFall, & Stach, 1992). Researchers are continually seeking to better understand the pathophysiology of cumulative trauma disorder so that preventive strategies can be developed, taught and implemented. This study was conducted to determine differences in forearm muscle activity while using five different fulcrums when instrumenting teeth in four different quadrants of the oral cavity. Forearm muscle activity was measured by sEMG.

Statement of the Problem

This research compared the effects of five different finger fulcrums, opposite arch (OA), standard intra-oral (IO), basic extra-oral (EO), cross arch (CA) and finger on finger (FF), on the forearm muscle activity of four muscles (*extensor carpi radialis longus, flexor carpi ulnaris, biceps brachii* and *pronator teres)* during a simulated periodontal scaling experience using hand instruments. Specifically:

1. What are the comparative effects of the standard intra-oral, finger-on-finger, opposite arch, basic extra-oral and cross arch fulcrums on forearm muscle activity during hand scaling?
2. Is there an interaction between mouth quadrants scaled and the fulcrums used in the quadrants in terms of muscle activity during hand scaling?

Significance of the Problem

Dental hygiene practice is physically demanding requiring the dental hygienist to use high prehension forces, perform highly repetitive hand and wrist motions, apply heavy pressure to fulcrum fingers, and hold their wrists in awkward positions for long periods of time. The high incidence rate of musculoskeletal and CTD in dental hygienists attests to the musculoskeletal trauma experienced by dental hygienists (Werner, Hamann, Franzblau & Rodgers, 2002; Lalumandier & McPhee, 2004; Alexopoulos, 2004; Corks, 1997; Anton, Rosecrance, Merlino & Cook, 2002; and Hamann, Werner, Franzblau, Rodgers, Siew & Gruninger, 2001). Many different strategies have been promulgated to decrease the risk of CTD in dental practitioners including the use of fulcrums during instrumentation (Dong, Barr, Loomer, & Rempel, 2005; Gerwatowski et al., 1992; Michalak-Turcotte, 2000; Thornton, Stuart-Battle, Wyszynski & Wilson, 2004; Ryan, Darby, Bauman, Tolle & Naik, 2005).

In dental hygiene, using a *fulcrum* has been an advocated instrumentation technique since 1915 ("History of the Fones School of Dental Hygiene," 2005; Nield-Gehrig, 2004). However, minimal evidence exists concerning what instrument fulcrums pose the greatest protection against CTD. To date only one study has been found which compared fulcrums and hand muscle load during scaling (Dong et al., 2005; Rempel, Keir, Smutz &

Hargens, 1997a) Therefore, this study compared the effects of five different finger fulcrums (OA, IO, EO, CA, and FF) on the forearm muscle activity of four muscles, (*extensor carpi radialis longus, flexor carpi ulnaris, biceps brachii* and *pronator teres*) during a simulated periodontal scaling experience using hand instruments.

Definition of Terms

For this study, the following key terms are defined:

- **Basic extra-oral fulcrum (EO)** -An advanced fulcrumming technique stabilizing the clinician's working hand outside the patient's mouth resting on the patient's chin or cheeks. Two variations exist for this fulcrum. For the one used in this study, the clinician rests his or her knuckles against the patient's chin or cheek. The other technique involves the clinician cupping the patient's chin in the palm of his or her hand (Nield-Gehrig, 2004, pp. 513, 516).
- **Cross arch fulcrum (CA)** - An advanced fulcrumming technique in which the finger rest is established on the opposite side of an arch from the treatment area and the ring finger is rested on a tooth on the opposite side of the arch from the teeth being instrumented (Nield-Gehrig, 2004, pp. 513, 514).
- **Cumulative trauma disorder** - A musculoskeletal disorder involving injuries to the tendons, tendon sheaths, and the related bones, muscles, and nerves of the hands, wrists, elbows, arms, feet, knees, and legs; also known as repetitive strain injuries (Darby & Walsh, 2003, p. 1146).
- **Electromyography (sEMG)** - A biomedical instrument which uses electrodes taped to the skin to convey a signal from a contracting muscle. It is the electrical manifestation of the neuromuscular activation associated with a

contracting muscle (M.L. Walker, personal communication, September 22, 2005). This is the dependent variable measure of this study.

- **Finger on finger fulcrum (FF)** - An advanced fulcrumming technique in which a finger of the non-dominant hand serves as the resting point for the dominant hand while performing clinical procedures. The ring finger of the dominant hand rests on the index finger of the non-dominant hand allowing the clinician to fulcrum in line with the long axis of the tooth improving access to deep periodontal pockets (Nield-Gehrig, 2004, pp. 513, 515).
- **Fulcrum** - A finger rest used to stabilize the clinician's hand while performing clinical procedures such as therapeutic scaling on a patient's dentition. Each of the fulcrums is an independent variable in this study.
- **Muscle** - A body tissue composed of fibers or cells which contract on excitation. Body parts and organs move when the highly vascular tissue reacts. The tissue is reactive, conductive, elastic and excitable (Muscolino, 2005). Overuse of a muscle can lead to repetitive strain injury.
- **Muscle activity** - The electrical excitation of muscle fibers causing them to move, first in contraction and then in relaxation (M.L. Walker, personal communication, September 22, 2005). Amount of muscle activity considered dangerous is dependent on length in time of strain, the intensity of the strain and the specific muscle tolerance. As the dependent variable of the study, muscle activity is measured using electromyography.
- **Opposite arch fulcrum (OA)** - An advanced fulcrumming technique in which the finger rest is established on the arch opposite from the

treatment area to improve access to deep periodontal pockets. The ring finger of the dominant hand rests opposite the treatment area to facilitate parallelism to proximal root surfaces (Nield-Gehrig, 2004, pp. 513, 515).

- **Quadrant** - One quarter of an anatomic area formed by the division of the area by imaginary vertical and horizontal lines bisecting each other. The crossing of two imaginary lines on the face. The midline divides the face longitudinally and a line drawn horizontally dividing the maxillary arch from the mandibular arch intersecting with the midline yields four equal sections of a person's mouth (quadrants).
- **Scaling** - The act of removing encrusted material from a tooth surface.
  For this study, the Gracey curet 11/12 was used to scale artificial materials from artificial teeth set in a typodont, an artificial jaw fastened in a manikin head to simulate clinical conditions (Dong et al., 2005).
- **Standard intra-oral fulcrum (IO)** - Resting the pad of the ring finger of the dominant hand on a tooth near the tooth being instrumented, to stabilize the hand while performing clinical procedures (Nield-Gehrig, 2004, p. 511).
- **Typodont** - Artificial jaw containing artificial teeth fastened into a manikin in order to simulate clinical conditions. Artificial calculus deposits are simulated by various paints and materials. (Dong et al., 2005)
- ***Biceps brachii*** - Superficial fusiform muscle arising out of the scapula and inserting near the elbow. On stimulation, it can flex the forearm and arm at the shoulder joint. It turns up the palm of the hand, and moves the arm away or toward the body (Muscolino, 2005, pp. 549, 550).

- ***Extensor carpi radialis longus*** - Superficial muscle of the posterior forearm which on stimulation, serves to extend and flex the hand radially, flexes the forearm at the elbow, and works to pronate the forearm (Muscolino, 2005, pp. 604, 605).
- ***Flexor carpi ulnaris*** - Slender, superficial muscle of the forearm lying on the ulnar side of the pronator teres. When stimulated it flexes the hand at the wrist joint, flexes the forearm at the elbow joint and can radially deviate the hand at the wrist joint (Muscolino, 2005, pp. 583-585).
- ***Pronator teres*** - Superficial muscle of the forearm arising from a humeral and an ulnar head; when stimulated assists other muscles in rotating the forearm so that the palm of the hand faces downward and backward and flexes the forearm at the elbow joint (Muscolino, 2005, pp. 574, 575).

Assumptions

The following assumptions were made:

1. Dental hygiene students were trained to standardize their fulcrumming to yield consistent, accurate readings.
2. The typodont teeth provided an adequate scaling simulation for this study.
3. Limiting the actual scaling time to 20 minutes with rest periods scheduled, controlled for forearm, hand, or wrist muscle fatigue.
4. The University Physical Therapy Motion Lab's surface EMG (sEMG) system is a valid, reliable measure of real-time muscle activity and electrical activity of superficial muscles.

Limitations

Factors affecting internal and external validity follow:

1. Findings can only be generalized to other dental hygienists who are similar to those represented in this study.
2. The small sample size, 32 dental hygiene students, makes finding significant differences difficult.
3. Proper operation of the sEMG measuring instrument is essential for valid results.
4. Lack of experience by first semester senior dental hygiene students in advanced fulcrumming techniques have been problematic. This problem was minimized by providing photographs and descriptions of the fulcrums, and training and practice using the fulcrums prior to study.
5. Variations in instrument grip strength, finger placement with each advanced fulcrum, neutral wrist position, lateral pressure required for calculus removal and performance of scaling using the advanced fulcrums could have posed extraneous variables. This problem was minimized by training and practice using the fulcrums prior to the study.

Hypotheses

The following null hypotheses were tested at the .05 level:

1. There is no statistically significant *muscle activity* interaction among quadrants and type of fulcrums used (basic intra-oral, finger on finger, opposite arch, basic extra-oral, and cross arch) during hand scaling, as measured by *surface electromyography.*
2. There is no statistically significant difference in *overall muscle activity* during

hand scaling between the basic intra-oral, finger on finger, opposite arch, basic extra-oral, and cross arch fulcrums, as measured by sEMG.

3. There is no statistically significant difference in the *muscle activity* among the four quadrants, regardless of the five fulcrums used during hand scaling, as measured by sEMG.

Specific Aims/Relevance

Dental hygienists are educated to use a variety of instrument fulcrums to provide therapy, stabilize the instrument and reduce muscle stress, yet there is limited research, based on sound ergonomic theory, to support the use of these fulcrums. This present study expanded on the work by Dong et al. (2005) by assessing the effects of five different fulcrums on forearm muscle activity during a simulated periodontal scaling experience. Since minimal research has been conducted specific to what fulcrums are least traumatic to the hand, wrist and /or forearm muscles, this research contributed to clarifying the principles and theory on which the teaching of ergonomic fulcrums is based. While powered instruments have been recommended for instrumentation to reduce the CTD risk in dental hygienists, there are still many situations where clinicians must use hand instruments to provide optimal client care. Hand instrumentation necessitates the use of fulcrums for leverage and stability. This present study aimed to benefit dental hygiene educators, future clinicians and current practitioners by providing evidence-based, quantitative information revealing the comparative effects of five different fulcrums used in each quadrant of the mouth on muscle activity. Fulcrums identified to produce less muscle activity during hand scaling may be considered for use by dental hygienists when possible, as less muscle activity may equate to less risk for cumulative trauma disorders.

Working ergonomically is a continual challenge (Darby & Walsh, 2003; Drummer, 2003; and Spolarich, 2003). Results from this present study sought to contribute to knowledge of the best fulcrum(s) to use to minimize operator trauma and maximize patient care. The research also has implications for enhancing the quality of dental hygiene education. The study used kinesiological electromyography (sEMG), a valid and reliable measuring instrument, to document muscle activity/load experienced by dental hygienists (See Appendix A). Evaluative measures have determined when muscle activity increases or decreases in response to each of the fulcrums used in each quadrant of the mouth. The four superficial muscles chosen were spaced far enough apart to avoid contaminating information from neighboring muscles. Importantly, muscle cross talk was a limitation and threat to validity in the one study which specifically addressed finger rests (Dong et al., 2005).

CHAPTER II

REVIEW OF THE LITERATURE

Literature on the least stressful fulcrums used by dental hygienists to reduce/eliminate wrist injury revealed only one recent study (Dong et al., 2005). Limited knowledge exists on what types of fulcrums minimize forearm muscle activity and possibly reduce the incidence of CTD in dental hygienists over a lifetime of practice. As ergonomic research is completed in different areas of dental hygiene practice, outcomes may predict the risks leading to development of cumulative hand, wrist and forearm trauma. The literature that provided the theoretical basis for this study encompasses the study of hand/wrist and forearm injury: prevalence/incidence of upper extremity injury, causes of musculoskeletal disease/cumulative trauma injury, and significance of finger/wrist postures on cumulative trauma disorders.

Prevalence/Incidence of Upper Extremity Injury

The prevalence rate of CTS in dental hygienists is increasing. Werner et al. (2002) used nerve conduction studies and a self-administered symptom questionnaire with 305 dental hygienists to determine prevalence rates of CTS. Questions were on CTS-related symptoms and included medical history, demographic and anthropometric data, hours worked per week and weeks per year (Werner et al., 2002). Results revealed dental hygienists had prevalence rates of upper extremity inflammation twice as high as clerical workers and equal to industrial workers. Werner et al. (2002) also found that up to 25% of dental hygienists showing abnormal median nerve latency may, within ten years, develop CTS. This was the largest study to report both clinical symptoms and electrodiagnostic testing of dental hygienists (Werner et al., 2002).

Akesson, Johnsson, Bylander, Moritz and Skerfving (1999) conducted a prospective 5-year study of musculoskeletal symptoms among 90 dental personnel and 30 nurses as a control group. Fourteen participants left the study because painful musculoskeletal symptoms developed. A general Nordic questionnaire with specific questions related to symptoms in the neck and shoulders was used. In years 0 and 5, interviews and questionnaires were conducted. In year 5, a physical examination was performed. Results revealed that participants had an increased risk within the five years of the study for developing symptoms compared to the control group, especially with wrist/hand symptoms. Results from the physical examination also revealed more pain symptoms in dental personnel in the neck, shoulders, elbows, and hips compared with the control group. Dental hygienists specifically were identified to be a high-risk group for the development of musculoskeletal disorders (MSD) (Akesson et al., 1999).

Prevalence of hand problems and CTS affecting dental hygienists and to identify risk factors for both conditions was the goal of a study of 6320 army dental personnel (Lalumandier et al., 2001). Of these dental personnel, 177 were dental hygienists. Hand problems were found in 75.1% of the surveyed dental hygienists (Lalumandier et al., 2001). The researchers determined the number of years worked to be more valuable a factor in diagnosing CTS risk than the subjective term "heavy calculus patients" scaled in a given day. Results also indicted that psychosocial factors increase CTS risks on the same order as the greater number of years worked and the number of "heavy calculus" patients seen daily (Lalumandier et al., 2001).

A questionnaire survey of 490 dentists in Greece found symptoms similar to Lalumandier et al. (2001) in that dental hygienists had high incidence of hand problems as do the dental specialists described by Alexopoulos (2004). The dental specialists, orthodontists, actively seek treatment for their musculoskeletal complaints, while general dentists often reporting grossly exaggerated low back pain which is influenced by psychosocial factors. The questionnaire collected facts about musculoskeletal complaints. The researcher found it difficult to separate realistic complaints of pain from complaints about the cause of the pain (instrumentation effects). Also, in the Greek medical system, general dentists are more inclined to take a longer absence from work and seek medical care than orthodontic specialists, but if dentists practiced ergonomically, muscular discomforts might be avoided (Alexopoulos, 2004).

Another study evaluating CTS/MSD prevalence rates, used a convenience sample of 95 dental hygienists at an educational conference on ergonomics (Anton et al., 2002). Participants completed a questionnaire and were tested bilaterally with standardized nerve conduction studies at the conference which raises the threat of selection bias. The self-administered questionnaire included questions regarding demographics, work-related pain, missed work, problematic job factors, and specific hand symptoms. Findings from this study were consistent with other studies (Lalumandier et al., 2001; Akesson et al., 1999) further validating that work-related musculoskeletal symptoms are common in dental hygienists (Anton et al., 2002). Over 90% of these participants experienced at least one musculoskeletal complaint in the 12 months previous to the study (Anton et al., 2002). The researchers concluded that the accumulation of repetitive tasks embodied in all dental hygiene procedures is more critical in causing CTS than the amount of time scaling, number of years worked, or number of patients treated per day (Anton et al., 2002). This study confirmed that dental hygienists have approximately twice the CTS prevalence rate compared to the general population. Nerve conduction studies must be used to confirm CTS prevalence (Anton et al., 2002).

Dentists and dental hygienists are targeted for CTS occurrence studies because the numbers of reported cases in these professionals is increasing (Morse, Michalak-Turcotte, Atwood-Sanders, Warren, Peterson, Bruneau & Cherniack, 2003; Hamann et al., 2001; Gelberman, Hergenroeder, Hargens, Lundborg & Akeson, 1981). In a pilot study of 82 dental hygiene students, surveys were distributed to entering students, students transitioning to their second year of study and to graduating students (Morse et al., 2003). The survey included questions regarding demographics, current dental hygiene/dental-related work, other employment, use of vibrating and manual instruments and current musculoskeletal symptoms. The survey covered symptoms experienced over the past year. Participants were asked to estimate the average number of hours per week they used vibrating instruments, as well as the average number of hours per week spent using manual instruments (Morse et al., 2003). The pilot study results suggest that MSD may have rapid onset after exposure to vibrating instruments with symptoms appearing prior to graduation from a dental hygiene program. These researchers recommend larger studies examining nerve injury from using vibrating instruments and biomechanical risks from manual instrument use (Morse et al., 2003). Furthermore, dental hygiene is commanding more attention by researchers because women have smaller wrists and double to triple the incidence of CTS compared to males (Hamann et al., 2001).

Researchers worldwide have begun to document the incidence of musculoskeletal disorders, a term which includes cumulative trauma, overuse syndrome, carpal tunnel syndrome and repetitive strain injuries (Hamann et al., 2001; Stentz, Riley, Harn, Sposato, Stockstill & Harn, 1994). For example, the Swedish population study included a gender and age stratified sample of 3000 participants, surveyed for musculoskeletal complaints. Nerve conduction studies were done for those reporting symptoms. Data from this study revealed at least 1 in 5 symptomatic participants would be expected to have CTS based on clinical examination and electrophysiologic testing (Atroshi, Gummesson, Johnsson, Ornstein, Ranstam & Rosen, 1999). It is important to know the prevalence of musculoskeletal pain in the general population in order to compare occurrences specific to occupations such as dental hygiene. When researchers survey populations for CTS symptoms, they find musculoskeletal complaints as high as 80% in respondents. When researchers then test respondents, they find 20% with confirmed CTS and others who have mononeuropathy, a precursor to CTS (Atroshi et al., 1999).

Some CTS risk factors include repetitiveness of work, forceful exertions, exposure duration, exposure frequency, static posture, mechanical stress, improper posture, room temperature and tool vibration (Anton et al., 2002; Gerwatowski et al., 1992; and Atroshi et al., 1999). Supporting these findings was a study by Stentz et al. (1994) surveying all 460 registered dental hygienists in Nebraska with a response rate of 56.5% . Sixty-one percent of the respondents had experienced upper extremity altered sensations related to the physical stress of dental hygiene practice (Stentz et al., 1994). At least 90% of the respondents first noticed sensations on the average of 5.8 years since beginning professional practice (Stentz et al., 1994). This present study examined common fulcrums in dental hygiene practice and used two of the suggestions made by Stentz et al. (1994) to quantify fulcrum use, and establish a relationship between instrument use and muscle activity experienced in hand, wrist and forearm.

The CTS incidence rate climbs when a person suffers diabetes, rheumatoid arthritis, and thyroid disease which affect the integrity of blood vessels and compromise nerve tissues (Hamann et al., 2001). Astrand, Rodahl, Dahl, and Stromme (2003) have revealed a difference between the muscles of stronger and weaker individuals. Females who are less strong characteristically have good circulation of muscle blood flow, while stronger individuals may be handicapped by impaired circulation. Hamann et al. (2001) reported peripheral neuropathy in older dentists associated with exposure to heavy metals and nutritional disorders. Practitioners can minimize risks of peripheral neuropathy by choosing appropriate sized instrument handles, wearing properly fitted gloves, wearing night splints for symptomatic wrists/hands, and having a healthy lifestyle such as receiving massage and other therapies to promote circulation.

Causes of Musculoskeletal Disease/Cumulative Trauma Injury

Wrist trauma research has focused on intra-carpal canal pressure related to generating inflammation, finger postures, fingertip force, wrist positions, and muscle fiber invasions. Four arm muscles were tested in the present study relative to the finger rest positions. As described in Appendix B, two of the muscles, the *extensor carpi radialis longus* and the *flexor carpi ulnaris,* attach to the hand and contribute to it's movement. The finger to which the *extensor carpi radialis longus* is attached enables a light pinch grip. The finger to which the *flexor carpi ulnaris* is attached, is curled close to the ring finger in most fulcrums. The *biceps brachii* and the *pronator teres* both contribute to moving the forearm. These muscles were selected for this study because they reflect the force on the forearm that occurs when using a specific fulcrum during dental hygiene instrumentation. With this in mind the body of literature now shifts to research on the possible causes of cumulative trauma disorders.

Some muscles in common with this study were also studied by Bramson, Smith and Romagnoli (1998); Bystrom and Fransson-Hall (1994); Fagarasanu, Kumar and Narayyan (2004); and Dong et al. (2005). Bramson et al. (1998) evaluated muscle activity found in common dental hygiene activities, i.e., probing, flossing, scaling and polishing. Ergonomic risk factors in typical tasks performed by dental personnel were examined in two phases. Phase I involved an ergonomic risk assessment using an employee survey and videotapes of participants as they performed dental procedures. Using an Ergonomic Assessment Survey, results indicated body parts needing closer evaluation were hands, wrists, shoulder, neck, and back. Phase II, using surface goniometry and EMG, measured forces, postures and frequencies of dental hygiene work tasks compared with ergonomic guidelines. Dental hygiene tasks were chosen for Phase II by the researchers, judging these tasks to be more routine, repetitive and easier to analyze than dental tasks. Two forearm flexor muscles and two forearm extensor muscles were measured. One muscle, *extensor carpi radialis longus*, was the same used in this present study. Bramson et al. (1998) "revealed an overall medium ergonomic risk level when researching force measurements of the overall muscle activity." Researchers concluded that ergonomic risk cannot be determined without knowledge of force, frequency or duration of dental hygiene tasks (Bramson et al., 1998). Interestingly, flossing caused more muscle activity than scaling, polishing or probing.

Bystrom and Fransson-Hall (1994) measured physiologic phenomena in forearm flexor and extensor muscles using sEMG. Seven participants performed low intensity isometric handgrip exercises with altered short contraction-relaxation periods. For up to 24 hours after the exercises, these phenomena were followed: local blood flow, heart rate, blood pressure, sEMG, maximal voluntary handgrip contraction and venous concentration of potassium and lactate in both forearms of each participant. Physiologically, despite the short, light, exercise periods, muscles had not regained homeostasis and chemical balance after one hour in more than half the participants. For full recovery, 4 hours is common from light exercise; full recovery in 24 hours is common for strenuous exercises. Longer work periods than 30 continuous minutes without minor breaks might lead to accumulation of fatigue, triggering muscle injury mechanisms (Bystrom & Fransson-Hall, 1994). The researchers recommended further study of the relation between fatigue/lack of recovery and long-term occupational muscular disorders or malfunctions (Bystrom & Fransson-Hall, 1994).

Limiting muscle fatigue also was covered by Astrand et al. (2003) in reference to repeated isometric exercise. "The combination of force and frequency of repetitions determines the length of time that the exercise can be endured" (Astrand et al., 2003, 471). Scaling without hand tension and with a rhythmic pace could decrease fatigue and improve endurance. Astrand et al. (2003) reported ranges for risk levels associated with forearm blood flow to muscle fibers in term of maximum voluntary isometric contraction (MVIC). MVIC, under conscious control of the participant, is an attempt to create greatest muscle intensity involving muscular contraction against resistance in which the length of the muscle remains the same. While this present study did not measure blood flow or force, the following are ranges for risk levels associated with blood flow to muscle fibers described by Astrand et al. (2003):

- 5 to 10 percent of MVIC, all aerobic, activity can be held for extended period of time
- 20 to 30 percent of MVIC, some anaerobic processes in muscles
- 30 percent of MVIC, all anaerobic processes in muscles

Further, these anaerobic processes resulted from a shortage in blood flow to muscle fibers. At forces exceeding 30% of MVIC, blood flow decreased bringing the muscles to complete arrest at 70% of MVIC. This present study provided a one minute rest period between scaling on each typodont to allow the participant to relocate to the next trial and to minimize muscle fatigue and promote muscle recovery between trials. Dental hygiene musculature requires more study related to muscle fatigue experienced performing dental hygiene tasks.

Awkward wrist postures result in an increased load on the hand/wrist/forearm musculoskeletal structures. Nield-Gehrig (2004) recommends using alternative advanced fulcrumming techniques in order to avoid awkward wrist postures and obtain parallelism with an instrument shank or to adapt an instrument cutting edge which are required for optimal scaling. This present study is focused on five fulcrums, four of which are advanced fulcrums.

Fagarasanu et al. (2004) chose to evaluate four forearm muscles, two of which are found in this study: *extensor carpi radialis* and *flexor carpi ulnaris.* The 20 blindfolded participants sat upright, feet flat on the floor and forearm resting on a table. The electrogoniometer and sEMG electrodes were fastened to the forearm and hand. Participants were instructed to perform isometric contractions, pushing against a fixed obstacle while positioning the wrist in several positions. At the end of the exercise period, participants were to find a neutral resting position for their wrists. Forearm muscles were measured in deviated and neutral wrist positions (Fagarasanu et al., 2004). Forearm muscle measurements in relation to extreme wrist positions demonstrated that deviated postures can possibly increase risk of muscle injury, and that completing a task with the wrist in neutral zone may decrease risk (Fagarasanu et al., 2004).

Dong et al. (2005) chose four extrinsic hand muscles which were very close together and likely with sEMG, had cross-talk susceptibility confounding the results. Measuring with sEMG, hand muscle activity was lowered as a result of using finger fulcrums while scaling teeth. The 12 participants had no scaling experience so one time instruction on finger rest techniques was given. Participants were instructed to hold the instrument with a tripod grasp and to use three types of finger rest positions (no finger, one finger, and two finger) and were allowed two minutes to complete scaling for each type of finger rest position. Nail polish painted on a plastic typodont tooth (number 13) was scaled with a posterior scaler. This instrument was fitted with a pressure sensor for measuring thumb pinch force. Results reveal that use of two finger rests reduced thumb pinch force and muscle activity as compared to not using finger rests (Dong et al., 2005). In contrast to the Dong et al. (2005) study, this present study used four muscles, far enough apart, to reduce the probability of cross-talk. The comparative effects of five different finger rests on forearm muscle activity with 32 participants (not 12) were used to ensure valid and reliable research outcomes.

Significance of Finger/Wrist Postures on Cumulative Trauma Disorders

Electrodiagnostic evaluation is an electrical stimulation of nerves and muscles to establish a diagnosis of disease or injury. Electrodiagnostic studies are broadly divided into nerve conduction studies (NCS's), which measure the velocity of conduction across a nerve using surface electrodes, or electromyography (sEMG), which measures real-time muscle activity (Jarvik, Yuen & Kliot, 2004).

Muscle fatigue with overuse can cause pain, but empirical research does not link one specific cause for the group of disorders attributed to cumulative trauma. Large studies are needed to evaluate biomechanical loads, wrist positions, muscle fatigue/recovery, and force, frequency and duration of tasks related to ergonomic guidelines on forearm muscles and tendons (Dong et al., 2005; Bramson et al., 1998; Bystrom & Fransson-Hall, 1994; Fagarasanu et al., 2004; and Rempel, Serina, Klinenberg, Martin, Armstrong, Foulke & Natarajan, 1997b).

Researchers contend blood vessels and blood flow in the hand can affect carpal tunnel pressure sensitizing the median nerve. Pressure on a nerve will cause retardation of blood flow. If pressure is released, blood flow resumes. If the pressure continues, nerves suffer damage. It is speculated that a firmer grip on ultrasonic hand pieces may lessen the effects of vibration on the blood vessels (Werner et al., 2002; Gelberman et al., 1981). According to Astrand et al. (2003), stronger individuals may have impeded blood flow and be handicapped by impaired circulation "at a force that is relatively low in percentage of the maximum". In contrast, Astrand et al. (2003) explains that females have an advantage in fatigue resistance because of good muscle blood flow when the female is less strong. This leads to the assumption that the dominant female population in the dental hygiene profession may not be experiencing anaerobic blood flow. Certainly, female dental hygiene musculature requires more study related to their particular risks.

Changes in wrist position increase or decrease intracarpal canal pressures. High intracarpal canal pressures damage nerve tissue. What is not known, however, is the effects of lower intracarpal canal pressures (Gelberman, Szabo, & Mortensen, 1984). Researchers speculate that patient wrist tissues, which include epineural venules, epineural lymphatics, capillaries, nerves, and muscles, may have time to adapt to higher pressures with no damaging effects (Gelberman et al., 1981) e.g. nerve tissue rapidly recovers on surgical carpal tunnel release. Researchers have concluded that in addition to vascular insufficiency, some unknown factor also plays a significant role in the causation of CTS signs and symptoms (Stentz et al., 1994).

Many of the finger focused studies evaluated computer keyboard use and CTD risk rather than finger use during client care (Rempel et al, 1997b). Researchers are recommending that operators work with less pressure and straight fingers or the hand extended in some extreme position lends credence to the need for this present study to assist practitioners in adopting instrument fulcrums during dental hygiene practice that produce less risk for CTD. Studies appropriate for specific tasks done by dental hygienists are needed.

In summary dental practitioners are at risk for developing CTD's. Many strategies have been recommended for minimizing these risks but gaps still exist in the literature on the quantitative effects of many of these recommendations. This present study contributed to filling these gaps as it evaluated CTD risks in terms of forearm muscle activity and the use of fulcrums during hand scaling. Other practitioners and dental hygiene educators may benefit from the study outcomes in terms of how fulcrumming is taught and used in practice.

CHAPTER III

METHODS AND MATERIALS

Sample Description and Selection

Participants comprised a convenience sample of 32, 31 female and 1 male, first semester right-handed, senior dental hygiene students ranging in age from 22-44. Participants were recruited by distributing an invitational letter to second year dental hygiene students (See Appendix C). To determine whether interested participants met the inclusion and exclusion criteria, a preliminary screening questionnaire was completed (See Appendix D). Any past or present injury or disability of the working hand, wrist, forearm or shoulder excluded participants from the study. Exclusion criteria controlled for past injury which might skew the sEMG readings. Potential participants who qualified were invited to participate and given an informed consent form explaining the purpose of the study, procedures involved and the risks and benefits. Those that qualified and agreed to participate signed a written informed consent form prior to the study's initiation. Random assignment of participants to the various trials controlled for sequence effects, selection bias, investigator bias, and any unanticipated participant-relevant variable.

Research Design

The study used a counterbalanced 4 x 5 factorial design with participants acting as their own controls (See Table 1). Independent variables were the five different fulcrums (IO, EO, OA, CA and FF); dependent variables were four forearm muscles (*extensor carpi radialis longus, flexor carpi ulnaris, pronator teres* and *biceps brachii).* Given that each participant was evaluated using the five fulcrums under study, the order of fulcrums was randomized for each participant to control for sequence relevant variables. Since minimal research could be found on the effects of different finger rests used during hand scaling on muscle activity, a short term counterbalanced study was appropriate.

Table 1. 4 x 5 Counterbalanced Research Design

	sEMG pre-test	R Finger on finger fulcrum	1 minute rest	R Opposite arch fulcrum	1 minute rest	R Basic extra-oral fulcrum	1 minute rest	R Cross arch fulcrum	1 minute rest	R Standard intra-oral fulcrum
Quad. #1 tooth #3	sEMG	sEMG		sEMG		sEMG		sEMG		sEMG
Quad. #2 tooth #14	sEMG	sEMG		sEMG		sEMG		sEMG		sEMG
Quad. # 3 tooth #19	sEMG	sEMG		sEMG		sEMG		sEMG		sEMG
Quad. # 4 tooth #30	sEMG	sEMG		sEMG		sEMG		sEMG		sEMG

Procedures, Materials, and Data Collection Instruments

Dental chair-mounted typodonts equipped with an artificial face were used to simulate a client's oral cavity during scaling (See Appendix E). Teeth numbers 3, 14, 19 and 30 were coated with up to one cc of artificial calculus on the mesiobuccal surfaces. The calculus was dispensed using a six cc syringe and placed from mid-buccal to the mesiobuccal embrasure of the test teeth and covered to the height of the crown from the gingival margin. To standardize the calculus application process, a paint mask was placed over each molar before the artificial calculus was applied. Normal drying time for the artificial calculus was 48 hours.

A pilot study was conducted with two participants to test and refine the research methods. The pilot included placing the sEMG electrode sensors on the right forearm of each of the two pilot participants and collecting muscle activity data during dental hygiene instrumentation. To measure muscle activity while scaling, the skin of each participant was lightly wiped with an alcohol swab to remove dermis debris. Using the right arm and forearm of participants, surface electrodes were secured with tape over the four muscles of interest (See Appendix F). The right arm and forearm were wrapped with a light-weight bandage-type material to achieve even pressure by the electrodes on the skin and to reduce drag on the arm by the cables extending from the electrodes to the recording instrument. To ensure standardization, one physical therapy examiner conducted all of the sEMG recordings; a second physical therapy examiner timed the 20 second measurement period during each one minute of scaling. Electrodes were placed on the four test muscles and lead wires from the electrodes were taped to the participant's arm to allow mobility (See Figure 1).

Figure 1. sEMG electrode placement on four forearm muscles.

Participants performed movements planned for in the study and an examiner measured muscle activity. The pilot study was conducted to determine set up time, accuracy of readings, characteristics of the software, and data recording.

With 32 participants and 20 trials per participant, sEMG measured muscle activity on four superficial muscles independent of each other. sEMG, an electrodiagnostic test, is a valid and reliable measure of real-time muscle activity and has been used in multiple studies evaluating musculoskeletal disorders (Astrand et al., 2006; Dong et al., 2005; Atroshi et al., 1999; Bystrom & Fransson-Hall, 1994; Fagarasanu et al., 2004; and Jarvik, et al., 2004). Physical therapy consultants verified the four muscles selected for testing. sEMG muscle cross-talk susceptibility was decreased by placement of each electrode sensor directly over the middle of each of the identified muscles. Each sensor was placed at least 2 cm apart from the other according to accepted protocol (Hermens, Freriks, Disselhorst-Klug, & Rau, 2000).

A sensor was placed on the *biceps brachii* muscle as the examiner palpated the middle of the anterior belly exposed with the forearm supinated. The orientation of the sensor was parallel to the muscle fibers. Once the sensor was placed and secured by tape, the participant made a fist, flexed the forearm at the elbow joint and MVIC was tested and recorded with the examiner applying forced resistance pulling on the forearm at the wrist with the participant resisting the pull.

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

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

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

Data from the sEMG readings were collected during MVIC for each of the muscles by one physical therapy examiner. MVIC values were considered 100% activity for that muscle. The sEMG activity measured during scaling was expressed as a percentage of MVIC activity. This standard method has been re-evaluated and found to be reliable for use with surface electrodes (Burden & Bartlett, 1999; Bolgla & Uhl, 2006; Netto & Burnett, 2006). It also controls for any baseline activity/noise, because this noise would be present in both the MVIC readings and the scaling activity readings, and is thus cancelled out (Astrand et al., 2006; Burden & Bartlett, 1999; Bolgla & Uhl, 2006; Netto & Burnett, 2006; Hermens et al., 2000).

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

The electrodes are linked by coaxial cable to an amplifier that is connected to a personal computer with a DataQ data acquisition board. Lead wires from the electrodes allowed the participant to move and work. The computer program, produced by DataQ Instruments (Akron, OH), collected and analyzed the sEMG data. A sampling rate of 1000 samples per second per channel was used. The University Physical Therapy Motion Lab's sEMG system, used in this study, is a 10-channel, cabled, biological signal-acquisition system that records the electrical activity of superficial muscles using MA-110 surface electrodes with preamplifiers from Motions Lab Systems, Inc (Baton Rogue, LA, 70816). Four channels were used since the study measured only four muscles, with one muscle per channel measured by sEMG.

To ensure standardization of the participants, a 20-minute fulcrum training and practice session was conducted by the principal investigator. Appendix G lists the instructions provided to the participants. The training occurred immediately before the experiment and sEMG. To simplify the process, only supragingival scaling was used. Once the sEMG electrodes were placed comfortably on the participant's arm, sEMG measurements were recorded.

Typdodonts were prepared and set up by the principal investigator. Five different typodonts were set up for each participant with a different fulcrum (IO, EO, OA, CA and FF) randomly assigned for use on each of the typodonts. To ensure blinding, the principal investigator was blind to the order of the fulcrums. The research assistant randomized the fulcrums, signaled to the physical therapy student the beginning and ending of scaling, and completed participant paperwork. Each participant was provided with a new Premier Gracey 11/12 curet, personal protective equipment, and instructed to hand scale the mesiobuccal surfaces of the permanent first molars in each of the four quadrants (UR, UL, LL, and LR) for up to one minute using one of the assigned fulcrums per typodont.

Figure 2. Hand scaling maxillary right quadrant, with sensors in place

A standard timer was used to measure each scaling period. The protocol required each subject to scale for four minutes, rest for one minute, until all typodonts were scaled. The process continued until all 5 fulcrums were used resulting in 5 readings per typodont. Testing took approximately one hour per participant. The one minute rest between quadrants allowed sufficient time for recovery from any muscle fatigue that might occur.

Also projected was the counterbalanced design of fulcrum assignment would eliminate any systematic error that fatigue might cause. Considering the pace at which dental hygienists normally practice, the rest period was sufficient.

Validity and Reliability

Validity and reliability of this study might have been affected by the following:

- Dental hygiene students may not be calibrated in their fulcrumming techniques. This was minimized by providing written and oral instruction to each participant and allowing a supervised 5 minute practice period prior to the simulated scaling experience.
- Forearm, hand, or wrist muscle fatigue could have skewed sEMG activity. This was controlled by the short time of actual scaling (approximately 20 minutes).
- Distance between the active muscle fiber and the recording site can affect the signal received. The pilot study was conducted to ensure an acceptable signal was produced.
- The results in this study could be generalized to dental hygiene student populations similar to those tested.
- Proper operation of the sEMG is essential for valid results. Physical therapy students experienced in measuring muscle activity collected the sEMG data.

Protection of Human Subjects

The following plan for protection of human subjects was reviewed and approved by the Old Dominion University Institutional Human Subject Review Committee.

<u>Potential Risks:</u> Few expected injuries or risks to study participants exist because they are students accustomed to performing scaling using the test fulcrums. Minimal risks to

dental hygiene students included injury to the arm, wrist, hand, fingers or eyes; these risks were not anticipated. The participants wore personal protective equipment and used sterile instruments. Injuries were no greater than would be experienced as dental hygiene students in practice.

Potential Benefits: The benefits to participants included knowledge and a $25.00 payment for their participation. Participants' clinical experience was enhanced by developing awareness of the muscles and fulcrums used while scaling. Depending on the outcome, findings may benefit participants in their careers as practitioners. Results may benefit dental hygienists who are in clinical practice or who teach dental hygiene.

Consent Procedures: An informed consent form was explained, and signed by the participants (See Appendix H). The principal investigator explained the study and answered questions. Participants voluntarily consented to the study with no pressure to say yes.

Protection of Participants Rights: To maintain confidentiality, participants were issued a number; this was their identification throughout the study on data collection forms and records. All information collected from participants was kept in a locked file cabinet. Strict adherence to proper testing was under the direct supervision of qualified individuals. Data were reported in group-form only. With study completion, the data and collection forms will be kept for three years and then destroyed.

Risk-Benefit Ratio: In the interview process, participants were informed of the benefits and risks involved. The benefits of this study outweighed any risks. The dental hygiene students experienced the importance of the fulcrums they will use in their daily work as dental hygienists.

Statistical Treatment

The University Physical Therapy Motion Lab's sEMG System utilizes a Windows-based operating system for collecting MVIC for each of the muscles. Measurements were averaged using root mean squares (RMS); sEMG activity was expressed as a percentage of MVIC activity. Two-way ANOVA with repeated measures was used to analyze the data collected. This analysis is appropriate for measuring the main effects of both quadrants and fulcrums on muscle activity when randomization was used, sample size is adequate and data are ratio scaled and continuous. Descriptive statistics and linear scatter graphs were used including means, standard deviations, minimum and maximum. If interaction between quadrants and fulcrums was significant the Tukey post hoc test was run to locate significant differences. The reliability coefficient obtained through statistical analysis was 0.84 for the combined muscle activity means comparing quadrants versus fulcrums.

CHAPTER IV

RESULTS AND DISCUSSION

This study was conducted to determine the effects of different finger fulcrums on muscle activity while scaling. A convenience sample of 32 participants hand scaled four quadrants on five different typodonts as sEMG scores were recorded. Twenty sEMG recordings were made per participant; 640 total sEMG scores were obtained.

Results

Hypothesis One. The first hypothesis predicted no statistically significant interaction among quadrants of the mouth scaled (UR, UL, LL, LR) and type of fulcrums used (IO, FF, OA, EO, and CA) as measured by sEMG. Two-way ANOVA with repeated measures revealed no statistically significant interaction among quadrants and type of fulcrums used during hand scaling ($p=0.4727$) (See Table 2).

Table 2. Repeated Measures Two-Way ANOVA Test Results

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

***Significance**

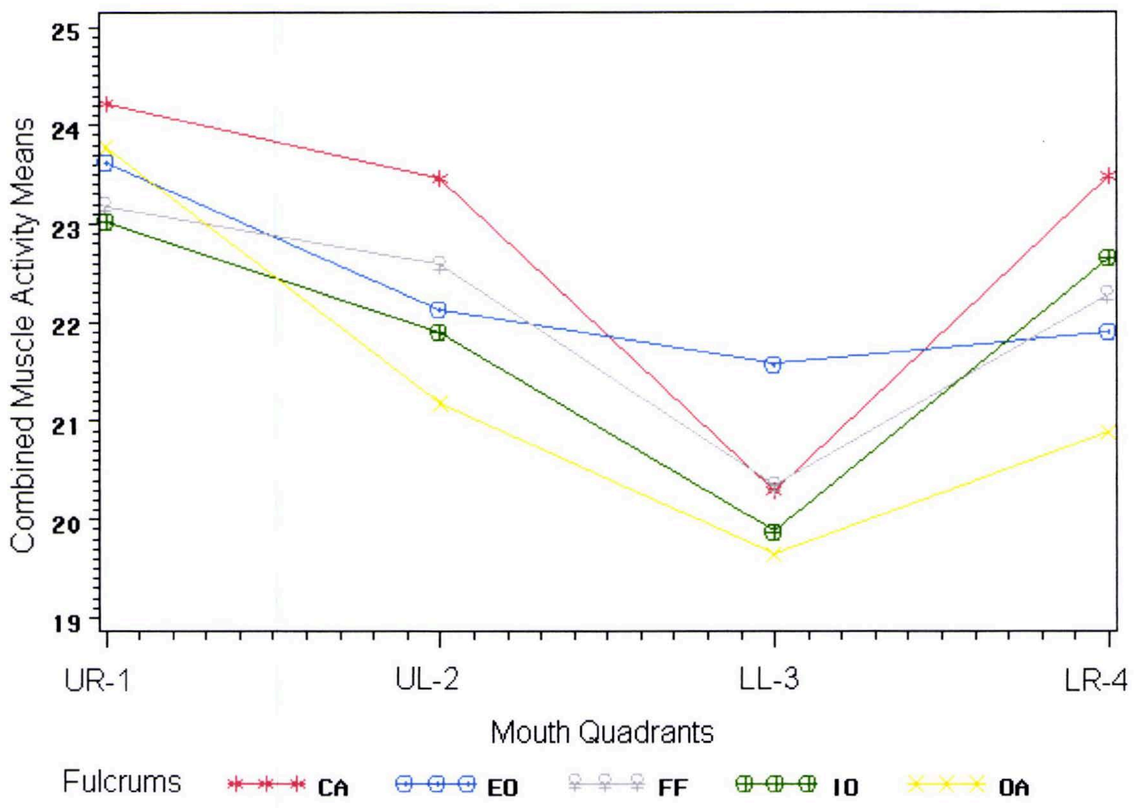
Therefore, the null hypothesis was retained.

Overall muscle activity means and standard deviations were calculated for five fulcrums in each of the four quadrants (See Table 3). Overall the population mean range is between 19.65 and 24.22. The combined muscle activity means versus the four quadrants for the five fulcrums is reflected in Figure 3; the opposite arch fulcrum had the least effect on muscle activity. Results reveal no statistically significant interaction between fulcrum and area scaled when using simulated periodontal scaling procedures.

Table 3. Muscle Activity Means and Standard Deviations Using Four Quadrants and Five Fulcrums per Quadrant.

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

Figure 3. Combined Muscle Activity Means vs. Quadrants for the Five Fulcrums.



Hypothesis Two. The second hypothesis predicted no statistically significant differences in overall muscle activity during hand scaling between the IO, FF, OA, EO, and CA fulcrums, as measured by sEMG. Two-way ANOVA with 20 repeated measures comparing the overall muscle activity for each fulcrum revealed statistically significant differences (F=2.95, df=4, p=0.0226); therefore, the null hypothesis was rejected.

Tukey's test revealed the cross arch fulcrum produced statistically significant more muscle activity when compared to the opposite arch fulcrum (p=0.0110). Muscle activity means and standard deviations were calculated for each fulcrum effect. When hand scaling, muscle activity is least using the opposite arch fulcrum and most scaling with the cross arch fulcrum. Table 4 displays participants' overall muscle activity with each of the five fulcrums. Table 5 shows greater muscle activity when participants scaled with the CA fulcrum as compared to the OA fulcrum.

Table 4. Muscle Activity Means and Standard Deviations Using Five Fulcrums.

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

Table 5. Tukey's Significance Testing Comparing Muscle Activity Between Fulcrums ("+" if p>0.05, "-" if p<0.05).

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

***Significance**

Hypothesis Three. The third hypothesis predicted no statistically significant difference in the average amount of muscle activity produced among four quadrants of the mouth, regardless of the five fulcrums used during hand scaling, as measured by sEMG. Two-way ANOVA with 20 repeated measures comparing each of the four quadrants scaled revealed statistically significant levels of muscle activity (F=20.88, df=3, p=<.0001) differences. Therefore, the null hypothesis was rejected.

Data from Tukey's test revealed that when hand scaling, regardless of fulcrum used, the maxillary right quadrant generated significantly more muscle activity when compared to the other three quadrants (p=0.0101). Further, the mandibular left quadrant consistently produced the least muscle activity when paired with the other three quadrants (p=<.0001). Muscle activity means and standard deviations were calculated for each of the four quadrants (UR, UL, LL, and LR) (See Table 6). Scaling in the UR caused the most muscle activity (Table 7). The least muscle activity occurred in hand scaling the LL quadrant. Data suggest moderate to high muscle activity in all quadrants, ranging from 19.65% MVIC to 24.22% MVIC (Bramson et al., 1998). Hand scaling in the UL or UR quadrants regardless of fulcrum used exhibited the same amount of muscle activity.

Table 6. Muscle Activity Means and Standard Deviations Using Four Quadrants of the Mouth.

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

Table 7. Tukey's Significance Testing Comparing Muscle Activity Between Quadrants

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

***Significance**

Discussion

To date no clinical data exists on the effects of advanced fulcrumming techniques on muscle activity during hand scaling. Because this study was a clinical simulation, findings are limited to the laboratory.

Hypothesis One. No significant interaction was found among quadrants, muscle activity, and type of fulcrums used when scaling in a simulated environment ($p=0.4727$). Results suggest the amount of muscle activity generated when scaling, regardless of quadrant scaled, is not affected by the use of different fulcrums. These results suggest that muscle activity generated by the dental hygienist, whether using a IO, FF, OA, EO, or CA fulcrum, is similar in all four quadrants of the mouth. Apparently, use of a different finger fulcrum does not reduce the amount of muscle activity experienced by participants during calculus removal.

Dong et al. (2005) reported that intra-oral finger rests reduced muscle activity when scaling compared to no finger rests. The EO fulcrum used in this present study can be compared to the no finger rest observed by Dong et al. (2005). Because Dong et al. (2005) had participants scale in only the maxillary left quadrant, the data obtained may not accurately represent real world scaling experiences. Extra-oral fulcrum use as reported by Dong et al. (2005) produced more muscle activity in the maxillary left quadrant than this present study. In this present study, no interaction effect occurred among quadrants and extra-oral fulcrums used while hand scaling. Differences in sample size, characteristics of participants, number of fulcrums, muscles investigated and quadrants tested, may explain the conflicting outcomes between the two studies. In addition, this present study looked at the *pronator teres and biceps brachii* muscles which were not evaluated by Dong et al. (2005). This present study found similar muscle activity regardless of fulcrum used or quadrant scaled. Further research is needed, to determine wrist and muscle activity while hand scaling and also what forearm muscles may be most appropriate for CTD risk assessment.

Hypothesis Two. Statistically significant differences were found in muscle activity when comparing the five fulcrums to each other ($p=0.0226$). However, only the cross arch fulcrum exhibited significantly higher mean muscle activity scores when compared to the opposite arch. These results might be attributed to difficulty keeping a neutral wrist position when using the cross arch fulcrum, especially in the upper right quadrant (Nield-Gehrig, 2004). Likewise the stretch of the hand across arches and the position of the wrist as it deviated from neutral might have contributed to the increased muscle activity when compared to the opposite arch. Advanced fulcrumming techniques are used selectively when another fulcrum is not effective or it is not possible to preserve fundamental scaling techniques. Cross arch fulcrums make it difficult to preserve a neutral wrist position while also achieving lower shank parallelism, access to deep pockets, appropriate muscle coordination, and calculus removal. Selecting a fulcrum should be based on its benefits and disadvantages with a particular area of the mouth.

Means were obtained for the extra-oral and finger on finger fulcrums though differences in muscle activity among those and the cross arch fulcrum are not significant. Based on the significant differences between the cross arch and opposite arch pairing, varying fulcrums while hand scaling has minimal effect on muscle activity as measured by sEMG. In general, results suggest that fulcrums used in this study produce similar amounts of muscle activity regardless of area scaled. Dental hygienists should continue to use alternative fulcrums to improve ergonomic instrumentation based on individual needs and preferences. Patient characteristics and clinical needs should drive the selection process. Larger studies are needed however, to determine the relationship between fulcrums and muscle activity while hand scaling.

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

Hypothesis Three. Statistical analysis revealed a significant difference when comparing quadrants of the mouth scaled regardless of fulcrum used ($F=20.88$, $p=<.0001$). Regardless of where calculus removal was started, more muscle activity was generated in the upper right quadrant. Results may be attributed to the angle of the wrist and forearm in the upper right being manipulated in a way that required more muscle movement and more force and effort to remove the deposits. These findings support Nield-Gehrig's (2004) belief that maxillary molar teeth are especially difficult to treat with the standard intra-oral fulcrum and often require advanced fulcrums.

Results suggest that dental hygienists may wish to start scaling in the upper right quadrant since scaling in that area, regardless of the fulcrum used, produced more muscle activity. By starting in the upper right instead of scaling this area last, fatigue may be less of an issue. Also since the study revealed that scaling in the lower left quadrant produces the least amount of muscle activity, perhaps that quadrant could be scaled when most fatigued. As fatigue becomes an issue, clinician scaling may be not as effective. Lastly, variable muscle activity might reflect improper wrist-forearm movement, incorrect finger placement, or artificial calculus being burnished during scaling.

Several unhypothesized findings were observed. Established ranges for risk levels associated with hand and wrist forces and ergonomic risk factors have been described by Bramson et al. (1998). The following are "established ranges for risk levels associated with hand and wrist forces" according to Bramson et al. (1998):

- 0 to 10 percent of MVIC, low risk
- 11 to 20 percent of MVIC, moderate risk
- 21 percent of MVIC, high risk

Maximum Voluntary Isometric Contraction scores from this present study indicate participants were within a moderate to high risk category for musculoskeletal disorders according to Bramson et al. (1998) when hand scaling regardless of fulcrum used or area of the mouth scaled. MVIC scores were within the 19.65% to 24.22% range. This data reinforces findings from others, Werner et al. (2002), Akesson et al. (1999), Lalumandier et al. (2001), Anton et al. (2002), Hamann et al. (2001) and Stentz et al. (1994), which indicate dental hygiene work results in a definite risk for musculoskeletal disorders.

While the focus of this study was on the muscle activity interaction among quadrants and type of fulcrums used during hand scaling, ancillary information by Astrand et al. (2003) is that MVIC percentages are described according to blood flow to muscle fibers and the length of time muscle contractions can occur during percentages of MVIC. This reference to blood flow is a more detailed description of muscle activity during muscle contraction which occurs, for instance, while fulcrumming during hand scaling in contrast to muscle activity recorded by sEMG. Although muscle activity risk levels have not yet been associated with the information by Astrand et al. (2003) percentages of MVIC have been linked to aerobic and anaerobic processes, "blood flow debt" in muscle fibers, fatigue resistance, impaired circulation, and muscle fiber discomfort (Astrand et al., 2003). It is commonly reported there is a female advantage "in fatigue resistance" (Astrand et al., 2003). Future research may, therefore, be needed related to female dental hygiene musculature and their particular professional risk.

Some limitations worth noting when interpreting these findings include the findings can only be generalized to the population of dental hygienists who are similar to those represented in this study. Other limitations were the use of students with less experience than licensed practitioners and the lack of subgingival scaling. Human error could have influenced the results recorded on the University Physical Therapy Motion Lab's sEMG system computer however using the same two experienced physical therapy students minimized this risk. Human error could have affected results in the scaling done by the participants for despite distribution of the directions for the study participants needed focused training on their role for the study. Using a research assistant reduced examiner bias. Randomizing and blinding the participants from the fulcrum performance order ensured validity. Also affecting muscle readings, may have been the rest some participants received when the typodonts dislodged from the manikin heads requiring a pause to re-attach the devices for appropriate performance.

CHAPTER V

SUMMARY AND CONCLUSIONS

The increased incidence of repetitive strain injuries (RSI), a part of a syndrome of carpal tunnel disorders (CTD), in the wrist, hand, or forearm is a concern for dental hygiene practitioners. Work-related pain and in some instances, disabling injury to the nerves and muscles, may shorten the lifetime practice of dental hygienists. One way dental hygiene practitioners can reduce risk and work-related injuries is using preventive strategies and making informed decisions regarding instrumentation practices and procedures. Researchers are producing studies related to instrument grasp but only one recent study focused on fulcrumming (Dong et al., 2005). According to Stentz et al. (1994) research is needed on the "biomechanical study of instrument grasps and fulcrumming profiles". Factors such as the use of finger fulcrums may impact on muscle activity when scaling and influence the ergonomic practice of dental hygiene. Minimal information can be found concerning the effects of the advanced fulcrums on muscle activity while scaling in the mouth. Specifically, the purpose of this research was to determine the effects of five different advanced fulcrumming techniques on forearm muscle activity during the removal of artificial calculus via hand scaling.

A convenience sample of 32 consenting senior dental hygiene students who qualified for this study, were enrolled. A 4 x 5 counterbalanced research design was implemented with voluntary participants who were free to withdraw at any time during the experiment. Five randomly assigned fulcrums were used, one fulcrum on each of five typodonts, while scaling artificial calculus from the mesiobuccal surfaces of first permanent molar typodont teeth (#3, 14, 19, 30) in four quadrants of the oral cavity. ANOVA with repeated measures was used to compare the sEMG readings in the five different fulcrumming positions. If significant, a follow-up Tukey's test was performed to ascertain pair-wise differences.

Data analyzed with ANOVA revealed there were no significant interaction effects among fulcrums, areas of the mouth scaled, and forearm muscle activity. The first null hypothesis was therefore retained. Comparing area scaled as well as fulcrum used, statistically significant differences in muscle activity were found thus, the other two null hypotheses were rejected. The UR quadrant resulted with statistically significant more muscle activity when compared to the UL, LL, and LR quadrants. Also statistically significant differences were found in overall muscle activity during hand scaling, but out of all of the fulcrum pairings, only two, the cross arch compared to the opposite arch fulcrum, were significant.

This research provides new information concerning fulcrums and hand scaling. Yet to be examined is whether varying the fulcrum while hand scaling reduces CTD risk. Study results have the potential to benefit dental hygiene educators, future clinicians and current practitioners although more research is needed to better clarify the effects of advanced fulcrumming techniques on muscle activity during scaling. For educators, the potential importance in these findings is that all five fulcrums investigated produce similar amounts of muscle activity and any one could be recommended based on patient and practitioner need. The evidence-based information may be used by practitioners to reduce fatigue if the practitioner considers using the opposite arch fulcrum while hand scaling if their hand is feeling stressed. Characteristics of the patient and the clinician may be more important when choosing a fulcrum than the amount of muscle activity generated.

Based on the results of this investigation in a simulated clinical setting, the following conclusions are made:

1. The amount of muscle activity generated when removing artificial calculus is similar regardless of the fulcrum used and area of the mouth scaled.
2. The cross arch fulcrum produces significantly more muscle activity when compared to the opposite arch fulcrum only.
3. Regardless of fulcrum or quadrant used while hand scaling dental hygienists are in a moderate to high risk category for musculoskeletal problems.
3. The effort required to remove artificial calculus as determined by the amount of forearm muscle activity is minimally affected by varying the fulcrum.
4. Regardless of the fulcrum used, more muscle activity is required to remove artificial calculus in the upper right quadrant that in the other quadrants.
5. Varying finger fulcrums results in minimal ergonomic advantages in terms of efforts required to remove calculus.

Given that this study was conducted on 32 first semester, right-handed senior dental hygiene students in a simulated environment, recommendations for future research are indicated:

1. Replicate this study using experienced dental hygiene clinicians instead of students.
2. Replicate this study in a real world environment using patients with calculus.
3. Determine if grip and pinch force are affected by differing fulcrums while

scaling.

4. Determine how muscle activity is affected using different scaling instruments and variation of fulcrums.
5. Replicate this study performing subgingival hand scaling.
6. Replicate this study measuring muscles in the wrist.

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

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APPENDIX A

CHARACTERISTICS OF THE sEMG SIGNAL

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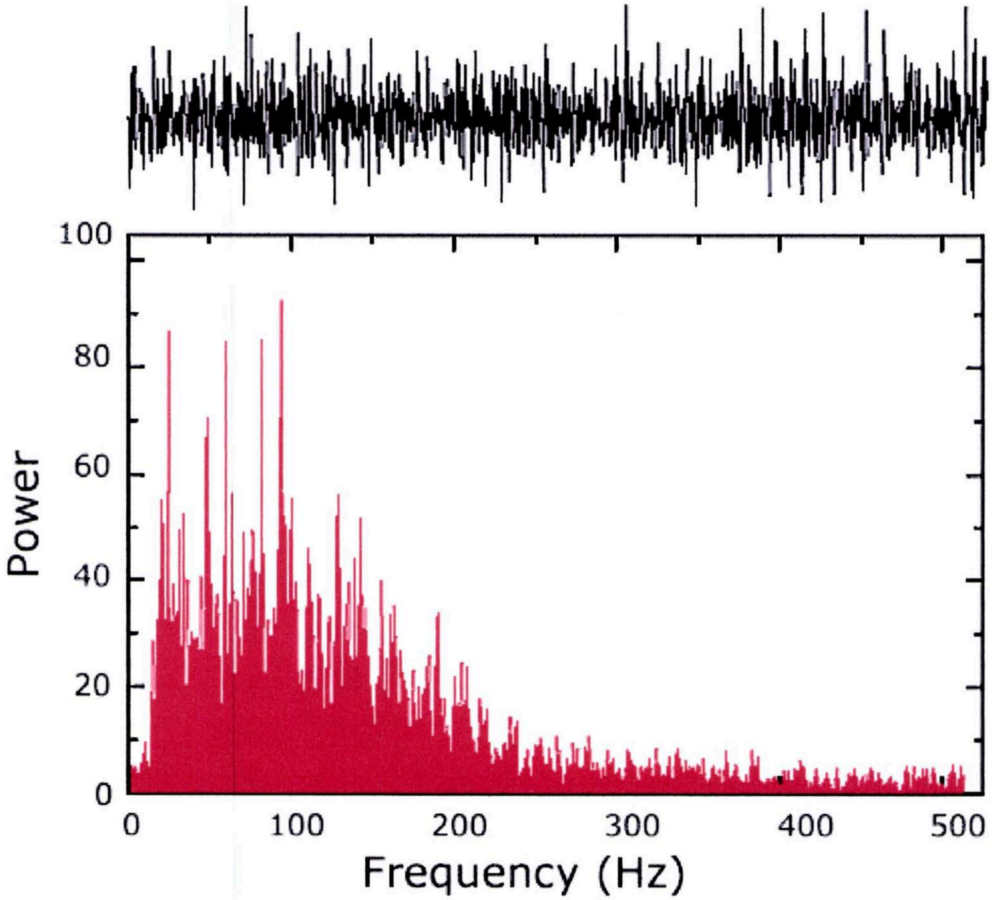
CHARACTERISTICS OF THE sEMG SIGNAL

It is well established that the amplitude of the sEMG signal is stochastic (random) in nature and can be reasonably represented by a Gausian distribution function. The amplitude of the signal can range from 0 to 10 mV (peak-to-peak) or – to 1.5 mV (rms). The usable energy of the signal is limited to the 0 to 500 Hz frequency range, with the dominant energy being in the 50-150 Hz range. Usable signals are those with energy above the electrical noise level. An example of the frequency spectrum of the sEMG signal is presented in this figure.

Figure 1: Frequency spectrum of the EMG signal detected from the Tibialis Anterior muscle during a constant force isometric contraction at 50% of voluntary maximum.



Source: De Luca (2002, page 2)

APPENDIX B

FOREARM MUSCLES TO BE TESTED

APPENDIX B

FORFEARM MUSCLES TO BE TESTED

*Muscle	**Attachments	***Actions
extensor carpi radialis longus	the humerus (the upper bone of the forearm) and the second metacarpal base (index finger) near the wrist	• extends the hand at the wrist joint • radially deviates the hand at the wrist joint • flexes the forearm at the elbow joint • pronates the forearm at the radioulnar (radius and ulna bones at the wrist) joints
flexor carpi ulnaris	medial epicondyle of the humerus and the ulna; ulnar hand on the anterior side (little finger)	• flexes the hand at the wrist joint • ulnar deviates the hand at the wrist joint • flexes the forearm at the elbow joint.
biceps brachii	has two heads, a long and short; long head attaches to the supraglenoid tubercle of the scapula; short head attaches to the coracoid process of the scapula. Those two heads are adjacent to each other. The forearm end of the muscle attachment is to the radial tuberosity (in the region of the elbow).	• flexes the forearm at the elbow joint • supinates the forearm at the radioulnar joints • flexes the arm at the shoulder joint • abducts the arm at the shoulder joint • adduct the arm at the shoulder joint.
pronator teres	3 attachments: Two are near each other at the medial epicondyle of the humerus and the	• pronates the forearm at the

	coronoid process of the ulna; other end of the muscle attaches to the lateral radius.	radioulnar joints • flexes the forearm at the elbow joint.

* forearm muscles
** attachments of these muscles
*** actions of the muscles

APPENDIX C

PARTICIPANT INVITATION LETTER

APPENDIX C

PARTICIPANT INVITATION LETTER

August 27, 2006

Dear Colleague:

As a fellow dental hygienist, I am writing to request your voluntary participation in a study on the impact of finger fulcrums on specific forearm muscles used during hand scaling. Involvement would require your participation in a 1-hour simulated clinical session during the months of September or October, 2006 at the Old Dominion University Dental Hygiene Research Center in Norfolk, Virginia. Specifically, if you participate, you will be asked to use a Gracey 11/12 curet to scale artificial calculus using five different randomly assigned fulcrums on four teeth using five different typodonts. A total of 20 teeth will be scaled at one minute intervals of time. Total time scaling the teeth will not exceed 20 minutes. Non invasive sensors will be taped to your arm and while scaling four forearm muscles will be tested and measured using electromyography. To be eligible to participate in the study, you must:

- Completed the Preliminary Screening Questionnaire
- Sign the Informed Consent Document
- Be available for the scheduled times of the study
- Be experienced with the hand instrument and fulcrums chosen for this study and
- Be a senior, first semester dental hygiene student at the School of Dental Hygiene at Old Dominion University.

Your decision to participate in this study is absolutely voluntary. I recognize that your participation may pose some inconvenience to your schedule. You will receive one twenty five dollar payment ($25.00) if you complete the study.
If you would like to participate, please call me by September 1, 2006. at 480-760-5707 or E-mail me at cherrytree@earthlink.net. Your assistance would be greatly appreciated.

Respectfully,

Lynn Tolle Principal Investigator
Mary Cosaboom/ Masters Degree Candidate
Gene W. Hirschfield School of Dental Hygiene
Old Dominion University
Norfolk, VA 23508

APPENDIX D

PARTICIPANT SCREENING QUESTIONNAIRE

APPENDIX D

PARTICIPANT SCREENING QUESTIONNAIRE

Participant Information

Name_______________________________ Assigned Number _________________

Date of Birth _________________________ Gender__________________________

Address _____________________________ Phone Number ____________________

Emergency Contact and Number

____

Inclusion Criteria/Exclusion Criteria

Year in dental hygiene program ___________

Do you have any musculoskeletal disorders or past surgeries to the arm, wrist, fingers or shoulder? Yes _____ No ______

If yes, please explain ____

Does your dental hygiene student schedule allow you at least one hour of free time to participate in this study? Yes ______ No ______

Are you right-handed? Yes ________ No _______

Meets Inclusion Criteria

Yes _______ NO ______

____

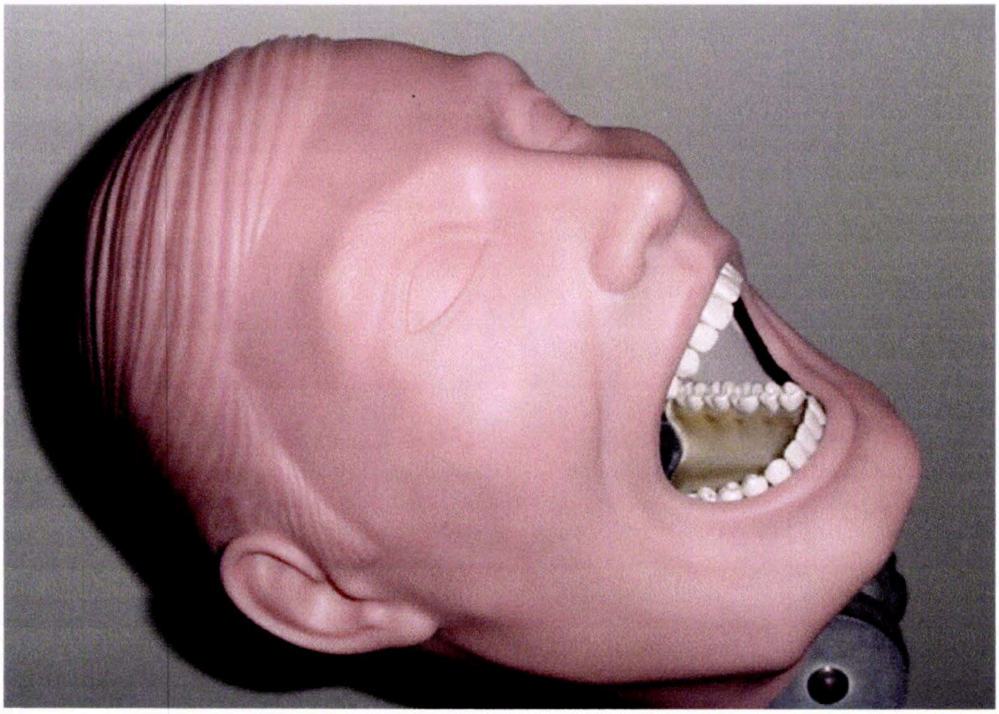
Signature of Research Assistant, Principal Investigator, or Co-Principal Investigator

APPENDIX E

CHAIR MOUNTED TYPODONT WITH ARTIFICIAL FACE

APPENDIX E

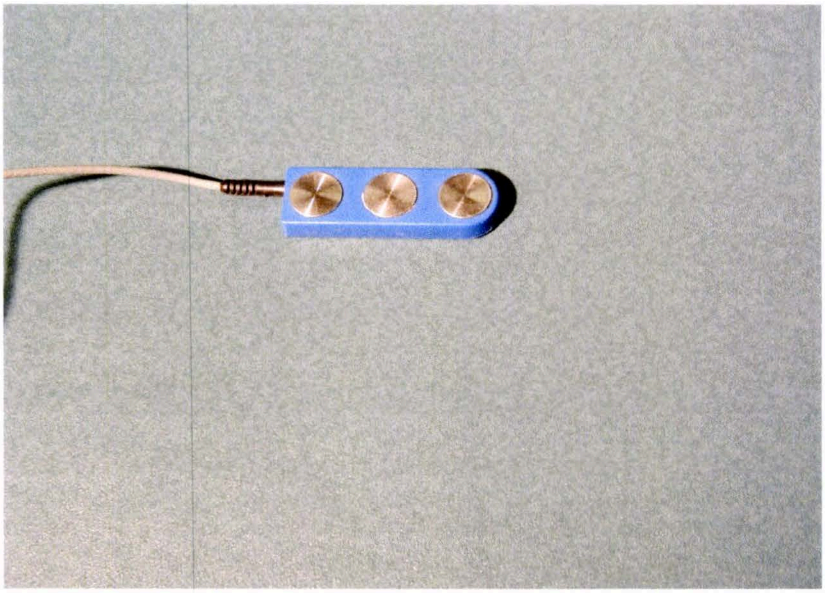
CHAIR MOUNTED TYPODONT WITH ARTIFICIAL FACE



APPENDIX F

sEMG SENSORS

sEMG Sensor



sEMG Sensor Taped to Forearm

APPENDIX G

INSTRUCTIONS FOR PARTICIPATION IN THE FINGER REST/MUSCLE ACTIVITY STUDY

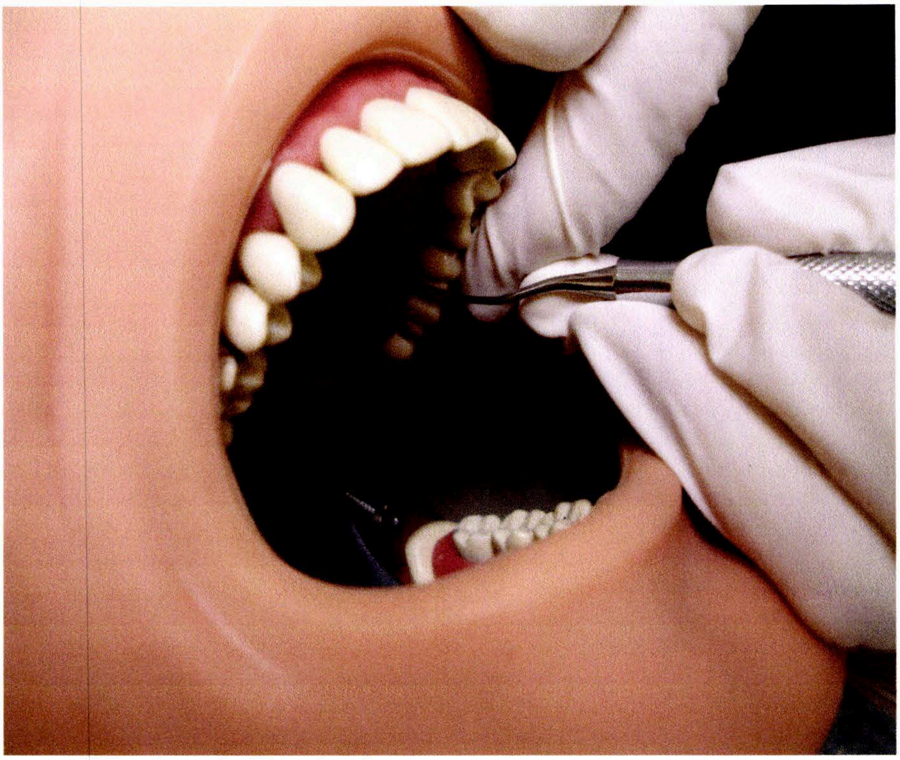
APPENDIX G

INSTRUCTIONS FOR PARTICIPATION IN THE FINGER REST/MUSCLE ACTIVITY STUDY

Inform participant that he/she will:

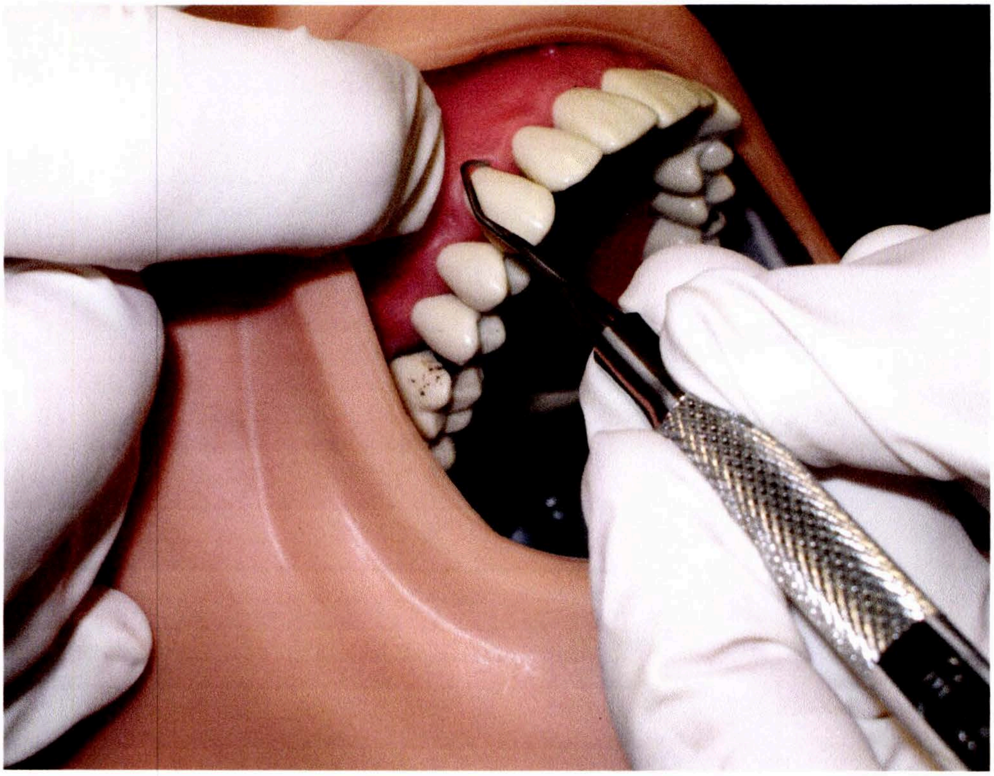
- participate in a 45 minute simulated clinical session
- receive photographs of the 5 fulcrums to be used during a 10 minute review and training session on the 5 fulcrums used and have 5 minutes to practice the fulcrums
- have up to a 5 minute warm up with the attachment of the sEMG sensors to the arm and initial readings being taken for a baseline
- be given the randomly assigned fulcrums immediately prior to participating
- wear PPE's as is done for clinic to protect against pieces of artificial calculus
- use an 11/12 Gracey curette
- be given one minute (per tooth) to scale the artificial calculus from the mesiobuccal surface of each of the four first molars in typodonts (4 minutes of scaling per fulcrum)
- have a one minute rest period between each change in fulcrums and
- be told when to begin scaling and when to stop
- have as many as five measurements taken for one fulcrum position.

Fulcrums

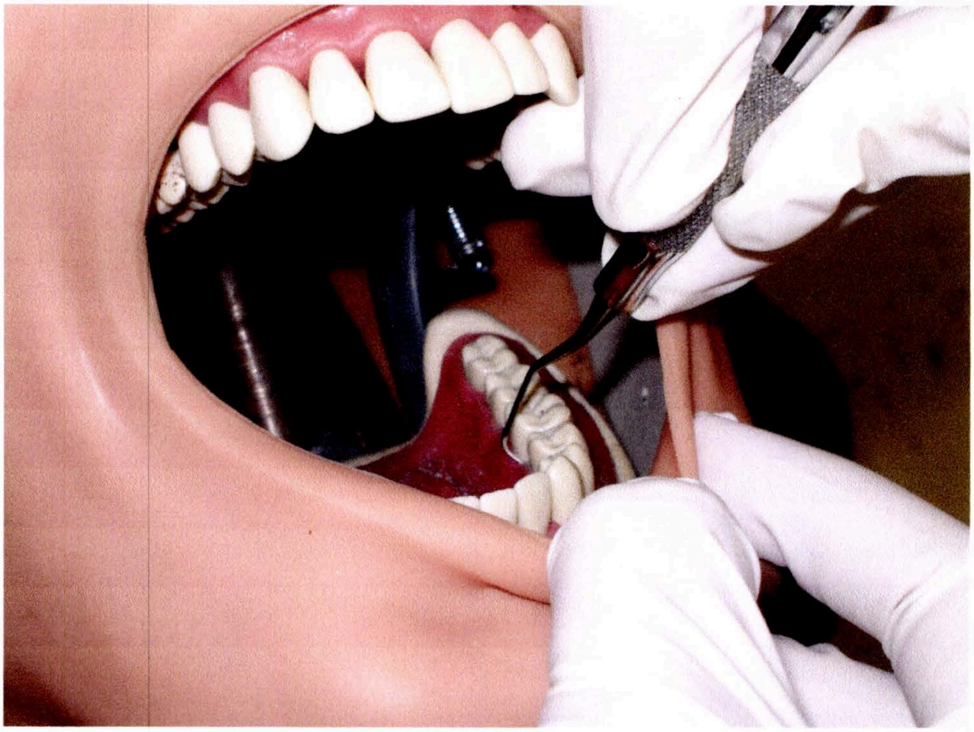


Finger on Finger Fulcrum

Standard Intra-Oral Fulcrum



Basic Extra-Oral Fulcrum



Opposite Arch Fulcrum

Cross arch Fulcrum

APPENDIX H

INFORMED CONSENT DOCUMENT

APPENDIX H

INFORMED CONSENT DOCUMENT

OLD DOMINION UNIVERSITY

PROJECT TITLE: Effects of Five Different Finger Rest Positions on Arm Muscle Activity During Scaling by Dental Hygiene Students

INTRODUCTION

The purposes of this form are to give you information that may affect your decision whether to say YES or NO to participation in this research, and to record the consent of those who say YES. Effects of Five Different Finger Rest Positions on Arm Muscle Activity during Scaling by Dental Hygiene Students in the Technology building School of Dental Hygiene, Dental Hygiene Research Center Room 1101 C.

RESEARCHERS

Susan Lynn Tolle, BSDH, MS, Professor and Director of Clinical Affairs Gene W. Hirschfeld School of Dental Hygiene at Old Dominion University, Responsible Project Investigator.
Martha L. Walker, PhD, Department Chair, School of Physical Therapy at Old Dominion University, Investigator.
Mary E. Cosaboom, BSDH, Graduate Teaching Assistant, ODU School of Dental Hygiene, Research Assistant.

DESCRIPTION OF RESEARCH STUDY

Few studies have been conducted looking into the subject of fulcrums used in dental hygiene clinical care. In dental hygiene, a fulcrum is a finger rest used by the clinician to stabilize the hand while performing clinical procedures such as therapeutic scaling and root debridement in a patient's dentition and has been an advocated instrumentation technique since 1915. Minimal evidence-based knowledge exists concerning what instrument fulcrums pose the greatest risk for cumulative trauma disorders. No studies have done what is proposed in this study, comparing the effects of five different finger fulcrums (opposite arch, standard intra-oral, basic extra-oral, cross arch, and finger on finger) on the forearm muscle activity of four muscles, (*extensor carpi radialis longus, flexor carpi ulnaris, biceps brachii* and *pronator teres)* during a simulated periodontal scaling experience using hand instruments. The fulcrums are the independent variables and the muscles are the dependent variables.

If you decide to participate, then you will join a study involving research of the effect of five finger rests (fulcrums) on four forearm muscles while hand scaling the mesiobuccal surfaces of four permanent first molars in each of four quadrants on five typodonts. You will be provided with a new Gracey 11/12 curet to use and will be instructed to remove as much of the artificial calculus as you can for up to one minute using the assigned fulcrum per typodont. A one minute rest period will occur between the scaling of each tooth in the assigned typodont. Electromyography will be used to measure the arm muscles while scaling. The skin will be lightly wiped with an alcohol swab to remove skin debris. Surface electrodes will be secured with tape over the four muscles of interest by the physical therapy examiners. You will be guided by the research assistant from one typodont to the next typodont until all 5 fulcrums have been used resulting in 20 sEMG readings per subject. You will be scaling a maximum of 20 minutes. If you say YES, then your participation will last for one hour at the ODU Dental Hygiene Research Center, Dental Hygiene Care Facility. Included in the one hour is the 15 minute training-practice period and the testing. Approximately 30 first semester senior dental hygiene students will be participating in this study.

EXCLUSIONARY CRITERIA
You should have completed the screening questionnaire. To the best of your knowledge, you should not have any past or present injury or disability of the working hand, wrist, forearm or shoulder that would keep you from participating in this study.

RISKS AND BENEFITS
RISKS: If you decide to participate in this study, then you may face a risk of hand, arm or wrist problems. A non-invasive measure (sEMG) of muscle activity will be used. As with any research there is some possibility that you may be subject to risks that have not yet been identified. These risks do not exceed those of any dental hygiene students in the School of Dental Hygiene at Old Dominion University or a dental hygienist who is practicing in a private dental office. The researcher tries to reduce these risks by using a non-invasive measuring device, providing rest between testing, and using PhD physical therapy students to achieve accurate measures in an efficient time-frame. You will be wearing personal protective equipment (masks, goggles, gloves and clinic gowns) and using sterile instruments.

BENEFITS: The main benefit to you for participating in this study is acquiring personal experience about the importance of the fulcrums you use in your daily work as a dental hygienist. Others may benefit by applying this information to their daily clinical practice. Dental hygiene educators may benefit in teaching according to the finding from this study.

COSTS AND PAYMENTS
The researchers want your decision about participating in this study to be absolutely voluntary. Your decision to participate or not participate in this study will result in no academic consequences. The researchers recognize that your participation may pose some inconvenience and costs in time. You will be awarded $25.00 upon completion of the study.

NEW INFORMATION
If the researchers find new information during this study that would reasonably change your decision about participating, then they will give it to you.

CONFIDENTIALITY
All information obtained about you in this study is strictly confidential unless disclosure is required by law. The results of this study may be used in reports, presentations and publications, but the researcher will not identify you.

WITHDRAWAL PRIVILEGE
It is OK for you to say NO. Even if you say YES now, you are free to say NO later, and walk away or withdraw from the study – at any time. Your decision will not affect your relationship with Old Dominion University, or otherwise cause a loss of benefits to which you might otherwise be entitled.

COMPENSATION FOR ILLNESS AND INJURY
If you say YES, then your consent in this document does not waive any of your legal rights. However, in the event of harm, injury, or illness arising from this study, neither Old Dominion University nor the researchers are able to give you any money, insurance coverage, free medical care, or any other compensation for such injury. In the event that you suffer injury as a result of participation in this research project, you may contact Susan Lynn Tolle at 683-5241 or Dr. David Swain the current IRB chair at 757-683-6028 at Old Dominion University, who will be glad to review the matter with you.

VOLUNTARY CONSENT
By signing this form, you are saying several things. You are saying that you have read this form or have had it read to you, that you are satisfied that you understand this form, the research study, and its risks and benefits. The researchers should have answered any questions you may

have had about the research. If you have any questions later on, then the researchers should be able to answer them:

Susan Lynn Tolle at 683-5241
Mary E. Cosaboom at 480-760-5707

If at any time you feel pressured to participate, or if you have any questions about your rights on this form, then you should call Dr. David Swain, the current IRB chair, at 757-683-6028, or the Old Dominion University Office of Research, at 757-683-3460.

And importantly, by signing below, you are telling the researcher YES, that you agree to participate in this study. The researcher should give you a copy of this form for your records.

Subject's Printed Name & Signature	**Date**

INVESTIGATOR'S STATEMENT

I certify that I have explained to this subject the nature and purpose of this research, including benefits, risks, costs, and any experimental procedures. I have described the rights and protections afforded to human subjects and have done nothing to pressure, coerce, or falsely entice this subject into participating. I am aware of my obligations under state and federal laws, and promise compliance. I have answered the subject's questions and have encouraged him/her to ask additional questions at any time during the course of this study. I have witnessed the above signature(s) on this consent form.

Investigator's Printed Name & Signature	**Date**

Approved Institutional
Review Board - ODU

FEB 1 6 2006

Expires 1 year from date
Questions: 757-683-3460

APPENDIX I

CURRICULUM VITAE

APPENDIX I

CURRICULUM VITAE
April, 2007

NAME: **MARY E. COSABOOM-FITZSIMONS, RDH, BS, MS**

ADDRESS: ᵌᶠ

EDUCATION:

Temple University 1962
Philadelphia, Pennsylvania
Graduated with High Honors
Certificate in Dental Hygiene

Northern Arizona University 1978
Flagstaff, Arizona
Bachelor of Science in Vocational-Industrial Education

Phoenix Community College/Northern Arizona University 1981
Phoenix, Arizona
Expanded Functions in Periodontal Therapy
(included 1979 license in Local Anesthesia)

Old Dominion University 2007
Norfolk, VA
MS in Dental Hygiene Education

EXPERIENCE:

Private Practice

1961	Dental Assistant (Endodontics) summer
1962 – 1975	Dental Hygienist (General Dentistry) full-time
1976 – 1989	Dental Hygienist (General Dentistry) full-time
1990 – 1992	Dental Hygienist (Periodontics) full-time
1993 – 2005	Dental Hygienist (General Practice) full-time
2005-2007	Graduate Teaching Assistant, Old Dominion University

TEACHING:

Fall 1997 – Spring 1998	Phoenix College Paradental Clinic
Fall 2005- Spring 2006	Senior Dental Hygiene Clinical Instructor
Fall 2005- Spring 2007	Graduate Teaching Assistant, Old Dominion University, Department of Dental Hygiene
Nov. 21, 2005	Applied Dental Materials, DNTH 303, "Removable Prosthodontics"
Feb. 22, 2006	Administrative Leadership and Professional Development, DNTH 516, "Consumer Driven Health Plans."
April 24-26, 2006	Senior Student Advising
April 3, 2006	Dental Hygiene Therapies and Practice, DNTH 310, "Desensitization"
October 11-18, 2006	Junior Student Advising
Fall 2006- Spring 2007	Junior Dental Hygiene Clinical Instructor
Spring 2007	Senior Dental Hygiene Clinical Instructor
February 5, 2007	Dental Hygiene Therapies and Practice, DNTH 310, "Periodontal Surgery"
February 26, 2007	Conducted Clinic Faculty Meeting
March 12-26, 2007	ODU Dental Hygiene Clinic Front Desk Manager
March 19-22, 2007	Junior Student Advising

March 26, 2007	Conducted Clinic Faculty Meeting
March 29- April 19, 2007	DNTH 418, Senior Evening Clinic Supervisor
March 19, 2007	ODU SADHA presentation, "Bright Futures for Dental Hygienists"
April 2, 2007	Dental Hygiene Therapies and Practice, DNTH 310, "Desensitization"
April 4, 2007	Dental Hygiene Therapies and Practice, DNTH 310, "Supportive Treatment Therapies"
April 18, 2007	Dental Hygiene Therapies and Practice, DNTH 310, "Periodontal Maintenance"

GRANT APPROVED:

Tolle, S.L. (PI), Walker, M. (Consultant), Cosaboom, M.E. (RA). Research completed October, 2006 and statistical analysis completed, 2007. Approved April, 2006, from the ADHA Institute for Oral health, "Effects of Five Different Finger Rest Positions on Arm Muscle Activity During Scaling by Dental Hygiene Students". $8,388.

RESEARCH COMPLETED:

Completion Certificate in Human Participant Protections Education for Research Teams

Completion Certificate in Protecting Personal Health Information in Research: Understanding the HIPAA Privacy Rule.

Clinical research for 2007 thesis, 32 participants, completed October, 2006.

Thesis, approved April 2007, "Effects of Five Different Finger Rest Positions on Arm Muscle Activity During Scaling by Dental Hygiene Students".

HONORS, AWARDS AND PRIZES:

1962 - present	Induction into Sigma Phi Alpha, Dental Hygiene Honorary Society
1962	Outstanding Clinical Dental Hygienist Award – Temple University School of Dental Hygiene, Philadelphia, Pennsylvania.
1989	Outstanding Service Award, Arizona State Dental Hygienists' Association

1991	Western Regional Board Clinical Examiner, Arizona
1992	Outstanding Service Award, Arizona State Dental Hygienists' Association
1993	Irene Newman Professional Achievement Award, American Dental Hygienists' Association
1994	RDH OF The Year for Your Outstanding Commitment to Your Patients and the Community, Arizona State Dental Hygienists' Association
1994	Distinguished Service Award, Arizona State Dental Hygienists' Association
2007	Honorable Mention, ODU Research Poster Expo, Poster titled, "Effects of Five Different Finger Rest Positions on Arm Muscle Activity During Scaling by Dental Hygiene Students"
2007	Temple University Distinguished Dental Hygiene Alumni Award

MEMBERSHIP IN PROFESSIONAL SOCIETIES:

1960 – present	American Dental Hygienists' Association (ADHA)
1962 – present	Sigma Phi Alpha Dental Hygiene Honorary Society
1962 – 1975	New Jersey Dental Hygienists' Association (NJDHA)
1975 – present	Arizona State Dental Hygienists' Association (ASDHA)
2004 – present	American Dental Education Association (ADEA)

UNIVERSITY SERVICE:

Feb. 3, 2006	Table display, Graduate Open House
Feb. 18, 2006	Clinical Instructor, National Children's Dental Access Day
Nov. 9, 2006	Conducted Public Tour of ODU Health Sciences Building
Nov. 2006	Designed ODU Wall Display of International Dental Hygiene
Feb. 10, 2007	Clinical Coordinator, National Children's Dental Access Day

PROFESSIONAL SERVICE:

1963 - 1970	Editor, NJDHA Journal
1963 – 1974	NJDHA, ADHA Alternate and Delegate
1971 – 1972	President-Elect, NJDHA

1972 – 1975	President, NJDHA
1973 – 1975	Registered Lobbyist for NJDHA
1970 – 1974	ADHA, Committee on Legislation (Chair, 1972-74)
1974 – 1975	Created and Conducted ADHA Legislative Workshops
1974	ADHA, Chair, ADA Actions Committee
1975	ADHA, Chair, ADA Minutes Review
1970 – 1976	ADHA Regional Legislative Consultant

1985 – present	ASDHA, Circulation Chair
1989 – 1991	Secretary, ASDHA
1989 – 1992	ASDHA, ADHA Alternate and Delegate
1991 – 1995	ASDHA, Chair, Annual Scientific Session
1991 – present	ASDHA, Council on Regulation and Practice

PUBLISHED ARTICLES:

Cosaboom, M. (1972). This Greater Need for Continuing Education. *Journal of the American Dental Hygienists' Association*, 46 (4).

Certificate of Attendance, July 11-14, 2005 "25th International Conference on Critical Thinking and Educational Reform" Provided by the Foundation for Critical Thinking.

Cosaboom, M. (2006). Expanding Access to Oral Care Through Affiliated Practice Dental Hygiene. *Journal of the Arizona State Dental Hygienists' Association*, Fall, 2006.

FEATURED ARTICLES:

Cosaboom, M. Expanding Access to Oral Care for Children in Arizona Through Affiliated Practice Dental Hygiene. *ACCESS*, Jan. 2007.

MANUSCRIPT IN PROGRESS:

Cosaboom, M. (2007). Community-Based Collaborations by Nurse Practitioners and Dental Hygienists. (March, 2007, under consideration for Sigma Phi Alpha Journalism Award, ADHA).

COMMUNITY SERVICE:

1970 – 1995	League of Women Voters, Program Presenter
1975 – 1982	Deputy Registrar, Voter Registration
1977 – 1984	Testimony before BLM and NFS representing Arizona Wilderness Coalition, Audubon, Sierra Club
1980	Sierra Club, Guide for the Blind in Verde River Wilderness Area