Spring 2016

The Effect of Magnification Loupes on Posture During Instrumentation by Dental Hygienists

Emily Anne Ludwig

Old Dominion University

Follow this and additional works at: http://digitalcommons.odu.edu/dentalhygiene_etds

Part of the Dental Hygiene Commons, and the Physical Therapy Commons

Recommended Citation


This Thesis is brought to you for free and open access by the Dental Hygiene at ODU Digital Commons. It has been accepted for inclusion in Dental Hygiene Theses & Dissertations by an authorized administrator of ODU Digital Commons. For more information, please contact digitalcommons@odu.edu.
THE EFFECT OF MAGNIFICATION LOUPES ON POSTURE DURING INSTRUMENTATION BY DENTAL HYGIENISTS

by

Emily Anne Ludwig
B.S.D.H., May 2014, Old Dominion University

A Thesis Submitted to the Faculty of Old Dominion University in Partial Fulfillment of the Requirements for the Degree of

MASTER OF SCIENCE
DENTAL HYGIENE
OLD DOMINION UNIVERSITY
May 2016

Approved by:

________________________
Gayle McCombs (Director)

________________________
Lynn Tolle (Member)

________________________
Daniel Russell (Member)
ABSTRACT

THE EFFECT OF MAGNIFICATION LOUPES ON POSTURE DURING INSTRUMENTATION BY DENTAL HYGIENISTS

Emily Anne Ludwig
Old Dominion University, 2016
Director: Professor Gayle McCombs

Purpose: The purpose of this study was to determine the effects of dental magnification loupes on posture during instrumentation. Methods: A convenience sample of twenty-seven right-handed dental hygienists with no history of injuries or disabilities of the head, neck, and trunk regions was enrolled. Baseline posture calibration was taken. Accelerometers were placed on four locations of the head and trunk (occipital pole of head, cervical vertebrae: C5, thoracic vertebrae: T5, lumbar vertebrae: L1) to measure changes in posture. Accelerations in three axes were recorded (anterior/posterior (AP), medial/lateral (ML), vertical (VT)). Mean accelerations of the three axes were used to compute average forward tilt (APangle) and sideways tilt (MLangle) of each sensor. For each axis, root mean square (rms) was also calculated to determine the magnitude of tremor fluctuations (i.e., APrms, MLrms and VTrms). Chair mounted typodonts with artificial calculus represented a simulated oral environment. Subjects were randomly assigned to wear loupes during the first or second half of the experiment and instructed to instrument all areas of the mouth with an ODU 11/12 explorer. An end user opinion survey was completed by participants. Results: Twenty seven participants (26 female and 1 male) completed the study. Results revealed no statistically significant differences between loupes and no loupes in the tilt angle of each sensor location in the AP or ML planes. In contrast, a statistically significant difference in mean fluctuations while wearing loupes (M=.215152, SD=.0741530) (rms) in AP at C5; t(24)=2.63, p=.015, compared to not wearing loupes (M=.261028, SD=.1379292) indicated posture fluctuations decreased while wearing loupes. APrms was only significant at C5; for ML and VT axes and sensor positions (head, C5, T5, L1) there were no statistically significant
differences in mean fluctuations (rms) between wearing loupes and not. Overall, 74% of the participants strongly agreed that magnification loupes made exploring easier and 67% of participants strongly agreed that magnification loupes improved their posture. Conclusion: While participants perceived that magnification loupes enhanced their posture, the study provided little evidence that wearing loupes leads to changes in body orientation; only to reduced postural tremors at C5 in the AP axis.
ACKNOWLEDGMENTS

I would first and foremost like to thank my thesis chair, Gayle B. McCombs, for her research expertise, guidance, support, mentorship and passion. Her wealth of knowledge in dental hygiene research and her skills in mentoring have led to the ultimate success of this research and have helped expand my knowledge related to evidence-based research. I would also like to acknowledge and thank the other members of my thesis committee, Susan Lynn Tolle and Dr. Daniel Russell. Their competence in research, time commitments and interdisciplinary knowledge/perspectives helped to develop and complete this research study.

Jessica Suedbeck, Cortney Armitano, and Joshua Lee, thank you for your time, interest, dedication and efforts as research assistants during data collection. I am also more than grateful to Dr. Daniel Russell and Cortney Armitano for providing equipment, collecting the accelerometer data, organizing it, and performing statistical analyses. This was a large undertaking and without it, this thesis would not be completed. Their commitment and expertise with data collection and statistical analysis helped to make this research successful.

I would finally like to thank my parents and Peter Milton Jr. Mom and Dad, you have given me unconditional support throughout my entire academic career. I always want to make you both proud and your love and guidance through any situation has made me successful. Peter, I cannot express my gratitude enough for your support through all of my school efforts.
TABLE OF CONTENTS

LIST OF TABLES ........................................................................................................ vi

LIST OF FIGURES ..................................................................................................... vii

Chapter

I. INTRODUCTION .................................................................................................. 1
   PROBLEM STATEMENT ............................................................................................... 3
   DEFINITION OF TERMS ............................................................................................. 3
   RESEARCH QUESTION/HYPOTHESIS ......................................................................... 4

II. REVIEW OF LITERATURE .................................................................................. 5

III. METHODS AND MATERIALS ......................................................................... 14
   RESEARCH DESIGN .................................................................................................. 14
   SAMPLE DESCRIPTION, SELECTION AND ENROLLMENT ..................................... 15
   INCLUSION CRITERIA ................................................................................................. 15
   EXCLUSION CRITERIA ............................................................................................... 15
   DATA COLLECTION ................................................................................................... 16
   PROCEDURES ............................................................................................................ 17
   TREATMENT SEQUENCE ......................................................................................... 18
   STATISTICAL ANALYSIS ......................................................................................... 18

IV. RESULTS AND DISCUSSION ............................................................................ 19

V. SUMMARY AND CONCLUSION .......................................................................... 27

REFERENCES ........................................................................................................... 28

APPENDICES
   A. FLYER ADVERTISEMENT ....................................................................................... 47
   B. PRELIMINARY PHONE SCREENING ..................................................................... 48
   C. INFORMED CONSENT ........................................................................................... 49
   D. POST OPINION SURVEY ....................................................................................... 52
   E. RANDOMIZATION CHART ..................................................................................... 57
   F. PARTICIPANT INSTRUCTIONS ............................................................................. 59

VITA .............................................................................................................................. 60


LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.  Paired Samples T-Test</td>
<td>30</td>
</tr>
<tr>
<td>II. Paired Samples Statistics</td>
<td>32</td>
</tr>
</tbody>
</table>


LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Typodont with Artificial Calculus</td>
<td>34</td>
</tr>
<tr>
<td>2. Hu-Friedy ODU 11/12 Explorer</td>
<td>35</td>
</tr>
<tr>
<td>3. Magnification Loupes with Light</td>
<td>36</td>
</tr>
<tr>
<td>4. Accelerometer Placement Guide</td>
<td>37</td>
</tr>
<tr>
<td>5. Delsys Trigno System with Triaxial Accelerometers and Computer Display</td>
<td>38</td>
</tr>
<tr>
<td>6. Neutral Body Position with Swim Cap and Head Accelerometer</td>
<td>39</td>
</tr>
<tr>
<td>7. Means and Standard Error Bars for AP Angle With and Without Loupes at the Four Sensor Locations</td>
<td>40</td>
</tr>
<tr>
<td>8. Means and Standard Error Bars for ML Angle With and Without Loupes at the Four Sensor Locations</td>
<td>41</td>
</tr>
<tr>
<td>9. Means and Standard Error Bars for Postural Fluctuations in AP axis (APrms) With and Without Loupes at the Four Sensor Locations</td>
<td>42</td>
</tr>
<tr>
<td>10. Means and Standard Error Bars for Postural Fluctuations in ML axis (MLrms) With and Without Loupes at the Four Sensor Locations</td>
<td>43</td>
</tr>
<tr>
<td>11. Means and Standard Error Bars for Postural Fluctuations in VT axis (VT rms) With and Without Loupes at the Four Sensor Locations</td>
<td>44</td>
</tr>
<tr>
<td>12. Survey Results. Question 5. Overall, do you feel that wearing magnification loupes made it easier to explore in all areas of the mouth?</td>
<td>45</td>
</tr>
<tr>
<td>13. Survey Results. Question 6. Overall, do you feel that wearing magnification loupes improved your posture during exploring in all areas of the mouth?</td>
<td>46</td>
</tr>
</tbody>
</table>
CHAPTER I
INTRODUCTION

The physical stress of clinical practice is an occupational risk factor for developing musculoskeletal disorders (MSDs) in dental hygienists. The incidence of MSDs is a well-documented concern in the dental profession and attests to the work-related trauma exerted on the practitioner. Clinicians use highly repetitive motions over extended periods of time which may cause physical stress. Additionally, dental hygiene practice may require the clinician to sit in a fixed posture position for long periods of time adding to the risk for cumulative trauma and MSDs. Researchers have been challenged with determining exact etiologies and preventive strategies for dental practitioners since MSDs threaten work productivity, income, career longevity, and the overall health of the clinician. Specific risk factors have been documented in the literature which include a limited working field, static postures, fine movements, and repetitive tasks. Various strategies such as neutral body positioning, use of magnification loupes, and improved work pacing have been suggested to minimize risk factors associated with MSDs.

The utilization of dental magnification loupes shows a great deal of promise in decreasing neck flexion and improving clarity of the work area. Loupes are promulgated to promote good posture and assist the practitioner in keeping a neutral body position. Proper body position includes a neutral state for the neck, back, shoulder, upper arm, forearm, and hands. According to Nield-Gehrig, the following ergonomic recommendations are offered to assist dental hygienists in achieving optimal posture. A neutral neck position is accomplished with a head tilt between 0 and 20 degrees. The line from the eyes to the treatment area should be as near to vertical as possible and tipping the head too far forward or tilting the head to one side should be avoided. A neutral back position is achieved by leaning forward from the hips with trunk flexion between 0 and 20 degrees, and overflexion of the spine should be avoided. A neutral torso position is
achieved when the torso is in line with the long axis of the body and leaning or twisting the torso to one side is avoided. Neutral shoulder positioning is accomplished when the shoulders are in a horizontal line with weight evenly balanced when seated. Lifting the shoulders up towards the ears, hunching the shoulders, and sitting with weight on one hip should also be avoided. Neutral upper arm position is achieved when the upper arms hang parallel to the long axis of the torso and elbows are at waist level held slightly away from the body. Greater than 20 degrees elbow abduction away from the body and elbows held above waist is a deviation from a neutral position. A neutral forearm position is achieved when the forearms are held parallel to the floor and the forearm is raised or lowered by pivoting at the elbow joint. Angling the forearm and upper arm above 60 degrees should be avoided. Neutral hand positioning is achieved when the little finger-side of the palm is slightly lower than the thumb-side of the palm and the wrist is aligned with the forearm. The thumb-side of the palm rotated down so that the palm is parallel to the floor and the hand and wrist bent up or down should be avoided.

Overall, neutral body position occurs when the three sections of the spine: cervical, thoracic, and lumbar, are aligned with the ears, shoulders, and hips.\textsuperscript{16} It is assumed that loupes provide an enhanced visual field and magnification of the oral cavity using angled telescopes which allow the clinician to sit in a neutral body position without bending forward at the neck and back.

Loupes are available in many different frame styles, differing magnification levels, and with and without lights. To ensure the best fit for ergonomically sound practice, clinicians should seek professional help when purchasing loupes. In order for loupes to fit properly, the correct working distance and appropriate declination angle must be determined.\textsuperscript{13,18}
While loupes may claim improved ergonomics with properly fitted frames and correct working distance, there is limited quantitative, evidence-based research to support this. More research is needed to examine magnification loupes and their effects on ergonomic posture.

Problem Statement

The topic of ergonomics and developing methods to decrease MSDs in dental hygienists is ongoing in current literature. Researchers are challenged with preventative strategies for MSDs. While there are several strategies that may decrease the risk of MSDs, the use of dental magnification loupes has been promoted for their ergonomic benefits; however there is limited evidence to support their use. Previous investigative studies have been limited to subjective assessments of posture while wearing loupes, therefore, more quantitative research is needed to address the ergonomic benefits of loupes.

Therefore, the purpose of this study was to assess the effect of magnification loupes on posture during a simulated full mouth exploration activity.

Definition of Terms

For the following study some key terms were defined:

Triaxial Accelerometer: This device measures acceleration along three axes and is sensitive to the acceleration due to gravity. The mean value of each axis can be used to estimate the orientation of the accelerometer axes relative to gravity. The dependent variable measure of this study.

Anterior/Posterior Angle (APangle): An approximate forward/backward tilt axis recorded by the triaxial accelerometer in relation to gravity. The dependent variable of the study.

Medial/Lateral Angle (MLangle): An approximate side to side tilt axis recorded by the triaxial accelerometer in relation to gravity. The dependent variable of the study.

RMS: Root mean square. The square root of the arithmetic mean of squares of a set of numbers. The dependent variable of the study.
Ergonomics: The science of improving and creating a safe work environment that will minimize or prevent work related injuries.

Magnification Loupes: A type of eye glass with varying magnification strengths used for the purpose of improving clinician visibility.

Duration: The amount of time it takes to complete full mouth exploration, in seconds. The dependent variable of the study.

Research Question/Hypotheses

This study intended to answer the following research question:

1. What are the effects of magnification loupes on posture in dental hygienists during full mouth exploring?
2. Is the time it takes to explore the full mouth altered with the use of magnification loupes?

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

1. There will be no statistically significant difference in posture, as measured by orientation (angle) during full mouth exploring with or without the use of magnification loupes.
2. There will be no statistically significant difference in posture, as measured by fluctuations (root mean square, rms), during full mouth exploring with or without the use of magnification loupes.
3. There will be no statistically significant difference in the time it takes to complete full mouth exploring with or without the use of magnification loupes.
CHAPTER II
REVIEW OF LITERATURE

Working ergonomically is a continual challenge for the dental hygiene practitioner. Upper extremity MSDs are common in the dental profession, with 55-63% reporting discomfort of some kind.\textsuperscript{4,19,20} Ergonomic guidelines suggest reducing awkward postures as a modification to reduce MSDs. Magnification loupes have been promoted to help reduce these awkward postures. They are fundamentally designed to enhance visual acuity, essentially assisting practitioners in staying in a neutral body position; however, limited research exists on quantitative postural measures related to the use of loupes to decrease the incidence of MSDs. Literature for this study was reviewed in the following areas: prevalence of MSDs, causes of MSDs, and significance of magnification loupes.

Prevalence

Musculoskeletal disorders have been researched extensively and identified as significant occupational health issues for dental practitioners.\textsuperscript{6} Musculoskeletal disorders are prevalent in the upper extremities such as the neck, shoulder and upper back.\textsuperscript{18,21} These disorders often lead to sick leave, reduced productivity and early retirement.

In a study of 624 Australian dental hygienists, researchers found that more than two-thirds of respondents indicated they had experienced MSDs in the neck, shoulder and lower back regions in the past 12 months.\textsuperscript{22} More than two-thirds of respondents also indicated their pain lasted more than two days. Half of those reporting MSDs stated that the pain affected their daily life. The study also showed that shoulder and lower back MSDs were significantly correlated.\textsuperscript{22}

Leggat et al conducted a survey of dentists in Queensland, Australia to determine the location of MSD symptoms, if MSDs interfered with daily activities, and whether treatment was sought.\textsuperscript{7} Two-hundred eighty five surveys were completed. Results revealed the most prevalent
MSD complaints were related to the region of the neck (57.5%), lower back (53.7%), and shoulder (53.3%). Results revealed MSDs interfered with dentist’s daily activities, most commonly at the neck (24.6%), lower back (22.1%), and shoulders (21.8%). The study also found that during the previous 12 month period over one-third of dentists had sought medical treatment, with one in ten dentists taking leave.7

Morse and colleagues conducted a study of 160 experienced dental hygienists (DH), dental hygiene students with dental assisting experience (DSA) and without (DS) to examine self-reported pain; DH (n=94), DSA (n=39) and DS (n=27).5 A 30 minute intensive upper extremity evaluation was performed by a physician specifically trained in assessing musculoskeletal symptomatology. Through self-reports of pain, aching, stiffness, spasm, inability to move the head, burning, numbness, or tingling in the neck, results revealed that 37% of DS and 43.2% of DSA reported neck symptoms, as well as 72.3% of DH. Shoulder pain was reported by 11.1% of DS, 17.9% of DSA, and 35.1% of DH. Physical examination revealed two specific neck findings: superior trapezius pain and trigger points. Data also determined that 57% of subjects who reported symptoms also had physical exam abnormalities. This study found significantly increased prevalence of reported neck pain and physical exam abnormalities related to the neck among experienced DH compared to DS and DSA. Results point to a need for ergonomic evaluation and intervention particularly focused on improving neck posture.5

Hayes et al surveyed third year dental hygiene students to investigate prevalence of MSDs.6 Using the Standardized Nordic Questionnaire, participants answered self-report questions regarding the presence of musculoskeletal pain over a twelve month period, whether the pain lasted longer than two days, and whether it affected their daily life or required medical attention. One-hundred twenty-six students completed the survey and results revealed neck pain had the highest prevalence (64.3%) over the past twelve months. Of those that experienced neck pain, 64.5%
reported the pain lasted more than two days, and 30.9% indicated they required medical treatment. Twelve month prevalence of lower back pain was also high (57.9%) with 67.1% reporting pain lasting longer than two days.  

Causes of Musculoskeletal Disorders

Work related tasks are widely considered to be the chief cause of MSDs in dental hygienists. Hayes et al. conducted a study to investigate which risk factors may help predict MSDs among Australian dental hygienists. Work habits, psychosocial factors, ergonomics education, and musculoskeletal symptoms were assessed. Six-hundred and twenty-four questionnaires were completed. Results revealed hygienists working in general private practice were more likely to report shoulder pain at an odds ratio (OR) of 1.53. Scaling tasks performed in a typical work week were also influential, with hygienists who hand-scaled reporting higher incidence of neck pain than those using ultrasonic scalers. Those using ultrasonic scalers reported shoulder pain lasting more than 2 days (OR: 3.11). Results also revealed hygienists who wore magnification loupes were less likely to have shoulder (OR: 0.46) or wrist/hand pain (OR: 0.47) than those who did not wear loupes. Hygienists who wore loupes were less likely to experience neck (OR: 0.55) or upper back pain (OR: 0.58). Those hygienists reporting neck pain were more likely to take time off from work or reduce work hours. Time off and considering changing careers were also predicted by report of lower back pain. Psychosocial factors and MSDs were also studied. Results revealed hygienists who perceived that work interfered in their home life were more likely to report MSDs. This study suggests that there are several risk factors that are predictive of MSDs including work-related and psychosocial factors.

Hayes and colleagues conducted a study of dental hygiene students to determine prevalence and predictors of MSDs over a three year period of time (2008-2010). Fifty students participated in the first year of the study, fifty-one in the second year, and forty-one in the final year. Neck
pain was the most commonly reported MSD symptom, with its prevalence rate increasing steadily from 66% to 68.3%. Lower back pain increased from 62% to 68.3% and upper back pain lasting longer than two days increased steadily from 22% to 34.1%. Related to predictors of MSDs, all students who reported feelings of stress associated with clinical requirements indicated they had experienced pain in the neck, shoulder, upper and lower back. There were no statistically significant correlations between year of study, number of clinic hours or prior experience as a dental assistant with MSDs. The study suggests that risk factors for MSDs and investigation about appropriate preventative strategies remains unclear.9

Akesson et al used electromyography and inclinometers to measure muscles of the upper back and head and neck in a group of twelve dental hygienists doing authentic work.23 The dental hygienists worked in a chair-side sitting position next to the horizontally placed patient, with knees under the backrest of the operation chair and working mainly at elbow height. Manual scalers were held by the dominant hand and the non-dominant hand held the suction or mirror. Muscle activity was recorded for work with ultrasonic devices for scaling and polishing, manual scaling with hand instruments, and all other tasks during the workday (auxiliary tasks). Results of the study showed that muscle load was generally higher during work than during breaks. During polishing and manual scaling, compared to all other tasks during the workday (auxiliary), there was an almost complete lack of muscular rest for the trapezius muscles. There was also a higher muscular load on the right trapezius muscle during manual scaling, than during ultrasonic scaling, likely due to forceful grip and repetitive forceful movements during hand scaling. Results showed that the clinicians’ heads were bent forward more than 27 degrees 50% of the time and 46 degrees 10% of the time during work compared to 7% and 29% during breaks. The head was also bent much of the time during work, exceeding 12 degrees to the left and 14 degrees to the right, compared to 7 degrees and 9 degrees during breaks. The study suggests MSDs may be related to
poor posture and work habits. Researchers suggest that more research is needed to better understand the impact of head flexion and constrained postures has on developing MSDs.\textsuperscript{23}

**Significance of Magnification Loupes**

Dental magnification loupes are commonly promoted as an aid to reduce ergonomic issues related to the neck, shoulder and back MSDs. They offer enhanced image size, reducing the need to lean in for a closer view of oral structures. Loupes have the potential to encourage neutral body positioning by allowing the clinician to sit in a more ergonomically sound position without bending forward at the neck and trunk. Research suggests that dental hygiene students may benefit from the early use of loupes prior to developing bad posture habits.\textsuperscript{11,12}

Hayes et al reported reduced prevalence of MSDs in the neck, shoulder and upper back with the use of dental magnification loupes; however, this is correlation which shows a relationship rather than quantitative data. The following studies experimentally examine the use of dental magnification loupes.\textsuperscript{1}

In a study conducted by Maggio et al, the effect of magnification loupes on psychomotor skill acquisition during a preclinical course was measured.\textsuperscript{24} Researchers used a virtual reality-based technology to assess first year dental students. One hundred sixteen students wore magnification loupes and 116 did not. Data was collected on the number of passing preparation procedures, amount of time per tooth preparation, number of times students needed computer assistance, the amount of time students needed computer assistance per procedure, and the student clinicians’ acceptance of magnification loupes. The results showed that students wearing loupes completed more passing preparations than the control group, had a faster time in completing tasks, and asked for computer assistance less frequently and for shorter periods of time. Students who wore loupes had better overall performance. Additionally, it was found that students had a high
degree of acceptance in using loupes. Researchers concluded that magnification loupes enabled new dental students to learn psychomotor dental skills more quickly and efficiently.\textsuperscript{24}

Hayes and colleagues investigated the effects of wearing loupes on MSDs of the upper extremities among dental hygienists using self-report and objective outcome measures.\textsuperscript{4} The study compared MSDs in practicing dental hygienists wearing loupes with dental hygiene students that did not wear loupes over a six-month period, using a pre and posttest design. Researchers assessed participants using the Disabilities of the Shoulder, Arm, and Hand (DASH) questionnaire at the beginning of the study, before the intervention using loupes, and again at six months. A physical assessment, measured by a physiotherapist at baseline and post-intervention, examined shoulder range of motion and scapular position. The Lennie test was used to measure normal scapular position, and an inclinometer measured total shoulder flexion and internal and external rotation. Results revealed self-report of upper extremity pain improved in the loupes group when comparing baseline to post-intervention. DASH identified a worsening of symptoms in the student group from baseline to post-intervention. Changes in scapular position were significant over time for both groups, exhibiting increased distance from the superior angle and root of the scapula to the spine, indicating use of loupes was not impacting on this outcome measure. Shoulder range of motion results were not statistically significant; while range of motion decreased in both the dental hygienists and student control groups after six months, the changes were unlikely to be clinically significant and it appears loupes had little impact on shoulder range of motion. While dental hygienists wearing loupes exhibited a significant improvement in self-reported upper extremity MSDs following intervention, there were mixed findings in terms of physical assessments, with declines in shoulder position and range of motion.\textsuperscript{4}

Using Branson’s Posture Assessment Instrument, Maillet et al conducted a study on the effect of loupes on operator posture while performing hand-scaling.\textsuperscript{11} Thirty-five first year dental
hygiene students participated in the study which used a modified version of the Posture Assessment Instrument (PAI). The modified, Posture Assessment Criteria, rated nine posture components by four raters: hips and legs (1 component), trunk (2 components), head and neck (2 components), upper arms (2 components), and shoulders (2 components). A preliminary session where participants wore only safety glasses and explored the posterior and interproximal areas of all teeth, served as a baseline for participant posture. Participants were divided into two groups: Group I wore 2.5 power magnification loupes in the first session and worked without loupes in the second session. Group II worked without loupes in the first session and wore loupes for the second session. In session one, participants were asked to demonstrate posterior scaling using Hu-Friedy 7/8, 13/14, and 15/16 working in quadrants 2 and 4. All sessions were videotaped for five minutes. In session two, the groups were switched. Four raters examined the videos of both sessions and scored each of the nine posture components three times during the five-minute video (score range of 0-45), with higher scores indicating departure from ideal posture. Results revealed overall less deviation from ideal posture when both groups wore loupes (M=10.8 without loupes compared to M=6.4 with loupes). The study was also able to demonstrate an effect of the time of introduction, comparing the improvement of students introduced to loupes in the first session (Group I) with those introduced to loupes in the second session (Group II). Group I showed a mean improvement of 5.23 compared with Group II with a mean improvement of 3.46 when introduced earlier to loupes intervention. The study concluded that early introduction of loupes is more effective in improving posture. Results showed significant improvement in posture with the use of magnification loupes with greater improvement for students using loupes early in their program.11

Branson’s Posture Assessment Instrument was used to evaluate posture in nineteen dental hygiene students by Branson and colleagues.10 Participants were randomly divided into two
groups: Group A (n=10) participated in an adjustment period of four clinical sessions wearing 2.6 magnification lenses. Group B (n=9) participated in two videotaped sessions recording posture while wearing safety glasses. Both groups completed a full mouth intraoral periodontal probing. Both groups were videotaped, then the groups were reversed. At the end of the study, participants were asked to complete a survey regarding their perception of the magnification lenses: the adjustment period, the impact on clinical skills, and the impact on posture. PAI scores could range from 10-194. Results revealed PAI scores for students wearing magnification lenses were significantly better with a mean score of 12.05 compared to 15.02 without lenses. PAI scores ranging from 10-40 are “acceptable” posture; however, lower PAI scores represent less deviation from ideal posture. Respondents reported via survey that they found magnification lenses comfortable, easy to use, and improved quality of their clinical performance. Results demonstrated a positive change in posture when students performed probing while wearing magnification loupes. Head and neck positions were noticeably improved with the use of magnification loupes. During certain parts of the video elements of movement were obscured at brief intervals, making it hard for evaluators to rate every body part necessary for the PAI.10

The literature related to magnification loupes contained several limitations and subjectivity. Hayes et al used a rater to measure scapular position and shoulder range of motion as well as self-report in the form of DASH questionnaire to explore the effect of loupes on upper extremity MSDs among dental hygienists.4 Self-report of symptoms is subjective by nature; answers related to symptoms could possibly be over or under exaggerated. A rater may also make measurement errors when assessing scapular position and range of motion. Maillet et al used the PAI to evaluate posture.11 The researchers’ method was subjective in nature because it utilized video and four separate raters to evaluate posture while wearing loupes. Participant posture can be obscured or blocked in a video, thereby providing an inaccurate recording of posture. Raters
may miss movements needed to score posture on the PAI and they may also be biased in their scoring methods, providing better scores to participants wearing loupes, as loupes are hypothesized to improve posture. Branson and colleagues used a similar PAI providing the same subjectivity issues as Maillet et al.$^{10,11}$

For these reasons, accelerometers were used to objectively quantify posture during instrumentation in this experiment. The use of accelerometers greatly reduces subjectivity, providing a quantifiable assessment of posture and possible benefits of magnification loupes.

In summary, dental professionals are at high risk for developing MSDs. Limited research is available which examines ways to reduce risks associated with these disorders. While magnification loupes hold the promise of improving posture and helping to maintain a neutral body position, empirical research is needed to determine whether magnification loupes achieve these goals. Currently, the majority of studies use descriptive measures to assess posture and very few quantitative measures of magnification loupes intervention exist. The proposed study will help fill these gaps by providing an objective measure of posture while using magnification loupes as it evaluates MSD risks associated with posture during full mouth instrumentation with and without magnification loupes.
CHAPTER III
METHODS AND MATERIALS

Research Design

The aim of this study was to assess and compare posture and postural fluctuations of participants wearing dental magnification loupes and not wearing loupes during full mouth instrumentation. Prior to study initiation, the University Institutional Review Board approved all aspects of the project. All procedures were performed in the Dental Hygiene Research Center, room #1103 at Old Dominion University, Norfolk, VA. In a simulated clinical environment, each subject explored all areas of a typodont (Columbia Dentoform Corp™, Long Island, New York R662 Model) (Figure 1) with a Hu-Friedy™ (Chicago, Illinois) ODU 11/12 explorer (Figure 2). Artificial calculus (Paradigm Dental™, Escondido, California) was applied to each typodont at varying locations. A new typodont was provided to each participant for each part of the study. Individuals were instructed to utilize their normal exploring procedures. During pilot testing, a 5 minute time frame was established which allowed sufficient time for each individual to complete full mouth exploring, as well as collect sufficient data. Participants were then randomly assigned to start treatment either wearing loupes (Figure 3) or not wearing loupes in one of two cubicles (A or B). When the participant moved to the other cubicle, they also switched whether they wore loupes or not. Subjects provided their own loupes and were instructed to only use the dental light on the unit; lights on individual loupes were not allowed. Triaxial accelerometers were placed on four areas of the body: occipital region of the head, cervical vertebrae 5 (C5), thoracic vertebrae 5 (T5) and lumbar vertebrae 1 (L1) (Figure 4). The two axes measured were approximately the anterior/posterior (AP), and medial/lateral (ML) axes.

Following the experiment, participants were asked to complete an end-user, post opinion survey. The survey consisted of demographic information and two questions related to wearing
dental magnification loupes that were scored on a Likert type scale ranging from strongly agree to strongly disagree. Question 5: Overall, do you feel that wearing magnification loupes made it easier to explore in all areas of the mouth? Question 6: Overall, do you feel that wearing magnification loupes improved your posture during exploring in all areas of the mouth?

Sample Description, Selection and Enrollment

A convenience sample of twenty-seven licensed dental hygienists, who met the inclusion criteria, were enrolled (26 female and 1 male). Participants were recruited using the internet and flyers placed throughout the campus (Appendix A). To determine whether the participants met the inclusion criteria, a preliminary phone screening was conducted (Appendix B). Participants who were right handed, currently licensed dental hygienists, owned dental magnification loupes, and were devoid of MSDs or injuries of the right wrist, forearm, shoulder, neck, upper or lower back, were invited to participate. Individuals were excluded from the study if they presented with a past or present MSD, or had a current or historical injury or disability of the right wrist, forearm, shoulder, and neck, upper or lower back. A $50.00 incentive gift card was provided at the end of the study.

Inclusion Criteria

Informed consent was obtained prior to study initiation (Appendix C). Participants included in the study were: generally healthy, adult males and females, 18 years or older, had a valid and current license to practice dental hygiene, right handed, devoid of MSDs or injury of the neck and trunk, devoid of previous surgeries of the neck and trunk, and owned magnification loupes.

Exclusion Criteria

Subjects were excluded if they were left-handed, had past or present MSDs or injury of the head, neck, upper or lower back, reported carpal tunnel syndrome, or had a recent history of
strenuous work or exercise that may have fatigued the muscles of the neck or trunk within the week prior to data collection.

Data Collection

Delsys EMGworks Software (Natick, Massachusetts) was used to collect data from each accelerometer. Prior to analysis, data was down sampled from 150 Hz to 50 Hz. Data were subsequently filtered by a second-order Butterworth low pass filter with a cutoff frequency of 20 Hz. Normal human movements range between 5-6 Hz; therefore, the low pass filter disregarded higher frequencies above 20 Hz. The accelerometers are sensitive to gravity, so that an axis directly aligned with gravity will register 1 g. If no axis is perfectly aligned with gravity (i.e., the sensor unit is tilted) basic trigonometry can be used to compute the angle of the device in the AP plane (forward or backward tilt; APangle) and ML plane (tilt towards the side; MLangle) from the mean acceleration of each axis.\textsuperscript{25,26} The average APangle and MLangle from each experimental trial was subtracted from the average APangle and MLangle of a calibration trial. These angles from the experimental trials were also used as a tilt correction so that the acceleration from the device axes could be corrected to be the computed acceleration for the real world axes of AP, ML and VT (aligned with gravity). To quantify the tremor fluctuations for each axis at each location, the root mean square (rms) was calculated from the filtered and tilt corrected data. The filtering, tilt correction procedure, and all subsequent analyses were performed using software developed in Matlab Version 7.0 (Natick, Massachusetts). Two data files were corrupted throughout this process and were not included in the sample population which resulted in a final study population of 25. Survey Monkey was used to capture participant post treatment opinions related to loupes use (Appendix D).
Procedures

Once informed consent was obtained, a baseline calibration standing posture was measured to record the natural body curvature of each individual (Figure 6), so that the angles analyzed were the deviations in the angle from the calibration posture. The accelerometers were placed on four areas of the body: occipital region of the head (head), cervical vertebrae 5 (C5), thoracic vertebrae 5 (T5) lumbar vertebrae 1 (L1), and three axes were recorded from each accelerometer: anterior-posterior (AP), medial-lateral (ML), and vertical (VT) (Figure 4 and 5). To ensure standardization, a one minute warm-up period was given to each participant to adjust to the equipment. Prior to placement of vertebra sensors, each participant’s skin was wiped with an alcohol pad and sensors were attached with double sided tape. A “swim cap” fitted with an accelerometer was used to quantify head movement. Participants were then randomly assigned to start the treatment sequence either wearing loupes or not wearing loupes in one of two cubicles (A or B) according to a randomization chart (Appendix E). When the participant switched to the other cubicle they also switched whether they wore loupes or not. For example, if participant 1 started in cubicle A wearing loupes, when they moved to cubicle B they took their loupes off. Each participant was provided with an ODU 11/12 explorer and a mirror. The researcher read an identical narration of instructions before starting each treatment sequence (Appendix F). Participants were instructed to explore all four quadrants of the typodont with artificial calculus placed throughout, using their normal technique, starting with the upper right quadrant, for up to five minutes. Participants were only permitted to use the overhead light in each dental cubicle, lights on individual loupes were not used during the experiment. All procedures were completed in one appointment, approximately 1.5 hours. After the experiment was completed, participants were asked to answer a post opinion survey on Survey Monkey.
Treatment Sequence

Screening Examination

- Preliminary phone screening
- Informed consent and enrollment

Baseline and Treatment

- Accelerometers attached and calibrated
- Randomization of loupes
- Instructions and practice
- Full mouth instrumentation with ODU 11/12 explorer starting in UR for up to five minutes
- Proceed to next cubicle unit
- Instructions and warm-up
- Full mouth instrumentation with ODU 11/12 explorer starting in UR for up to five minutes

Post Treatment

- Post opinion survey

Statistical Analysis

Separate paired samples t-tests (loupes v. no loupes) were used to assess for differences in the dependent variables: duration of trial, AP angle (forward/backward tilt relative to gravity), ML angle (side to side tilt relative to gravity), APrms, MLrms, and VTrms, for each of the four sensors (head, C5, T5, L1). Chi square was used to analyze survey question results. All statistical analyses were performed using SPSS 19 statistical software (Armonk, New York) with the hypotheses tested at a level of significance of 0.05.
CHAPTER IV
RESULTS AND DISCUSSION

This study was conducted to determine the effects of dental magnification loupes on posture. In a convenience sample of 27 practicing dental hygienists, posture was assessed using triaxial accelerometers. Based on acceleration in the three axes, the forward-backward tilt (APangle) and sideways tilt (MLangle) were computed, as well as the fluctuations/tremor in the AP, ML and VT axes. Duration of trail was also assessed.

Sample Size Analysis

Twenty seven participants were enrolled (26 female and 1 male). Participants reported various years of clinical dental hygiene practice which ranged from 1 to 5 years (n=15), 6 to 10 years (n=7), 11 to 15 years (n=3), 16 to 20 years (n=1), and 21 years and over (n=1). Twenty-seven participants completed the survey, however, data from participants #4 and #18 was not analyzed related to the dependent variables due to corrupt files, resulting in a final sample population of 25.

Results

Hypothesis one: There will be no statistically significant difference in posture, as measured by orientation (angle) during full mouth exploring with or without the use of magnification loupes.

Paired sample t-tests were performed to assess differences in AP and ML angles for each of the four sensor locations (head, C5, T5, L1) and results are illustrated in Table I. For the accelerometer at the occipital region of the head, there was no statistically significant difference at the APangle while wearing loupes (M=35.46, SD=9.86); t(24) = .385, p = .703 compared to not wearing loupes (M=35.96, SD=10.72). Results for the MLangle revealed no statistically significant difference with loupes (M=.53, SD=6.06); t(24) = .084, p = .934 compared to not
wearing loupes ($M=.59$, $SD=6.48$). The C5 accelerometer approached significance at the AP angle, but revealed no statistically significant difference in mean postural angle while wearing loupes ($M=31.54$, $SD=10.65$); $t(24) = 1.789$, $p = .086$, compared to not wearing loupes ($M=34.54$, $SD=15.33$). Additionally, there was no statistically significant difference at the ML angle at C5 while wearing loupes ($M=.78$, $SD=6.35$); $t(24) = .76$, $p = .231$, compared to not wearing loupes ($M=1.53$, $SD=6.53$). Results at the T5 accelerometer revealed no statistically significant difference at the AP angle while wearing loupes ($M=18.99$, $SD=6.28$); $t(24) = .812$, $p = .425$, compared to not wearing loupes ($M=19.52$, $SD=6.82$). Furthermore, there was no statistically significant difference at the ML angle while wearing loupes ($M=.72$, $SD=3.55$); $t(24) = .659$, $p = .516$, compared to not wearing loupes ($M=1.06$, $SD=3.95$). Finally, for the L1 accelerometer, there was no statistically significant difference at the AP angle while wearing loupes ($M=6.41$, $SD=6.25$); $t(24) = .174$, $p = .863$, compared to no loupes ($M=6.48$, $SD=6.31$) and there was also no statistically significant difference at the ML angle while wearing loupes ($M=.72$, $SD=2.73$); $t(24) = .130$, $p = .897$, compared to not wearing loupes ($M=.79$, $SD=3.53$). (Table I, Figure 7, 8). Therefore the null hypothesis was accepted.

Hypothesis two: There will be no statistically significant difference in posture, as measured by fluctuations (root mean square, rms), during full mouth exploring with or without the use of magnification loupes.

Paired sample t-tests were performed to assess for differences in rms fluctuations at AP, ML and VT for each of the four sensors (head, C5, T5, L1). Results revealed a statistically significant difference in mean postural fluctuations while wearing loupes ($M=.22$, $SD=.07$) (rms) in the AP angle at C5; $t(24) = 2.63$, $p = .015$, compared to not wearing loupes ($M=.26$, $SD=.14$), which indicated posture tremors decreased while wearing loupes (Table I, Figure 9). However, AP rms was not significant for any other sensor positions (head, T5, L1). For ML and VT axes and
sensor positions (head, C5, T5, L1) there were no statistically significant differences in mean fluctuations (rms) between wearing loupes and not (Table I, Figure 10, 11). Therefore, the null hypothesis was rejected.

Hypothesis three: There will be no statistically significant difference in the time it takes to complete full mouth exploring with or without the use of magnification loupes.

A paired sample t-test was used to assess for differences in the time it took to complete full mouth exploring with and without loupes. Results revealed there was no statistically significant difference in mean duration of trial while wearing loupes (M=262.29, SD=37.54); t(24) = 1.276, p = .214, compared to not wearing loupes (M=254.03, SD=44.50) (Table II). Therefore, the null hypothesis was accepted.

Survey Results

A post opinion, qualitative, end user survey was completed by each participant at the end of the experiment to assess overall opinion of magnification loupes. Results revealed 74% of participants strongly agreed that magnification loupes made it easier to explore, 22% agreed, and 4% were neutral. No participants disagreed or strongly disagree with this statement. Chi-square analysis revealed there was a statistically significant difference between the frequencies of the ratings, $\chi^2(2) = 21.56, p = .00$. Results demonstrated 67% of participants strongly agreed that wearing magnification loupes improved their posture, 26% agreed, and 7% were neutral. Again, no participants disagreed or strongly disagreed with this statement, and chi-square analysis revealed there was a statistically significant difference between the frequencies of the ratings, $\chi^2(2) = 14.89, p = .00$. Therefore, the majority of participants tended to strongly agree that loupes not only improved their posture, but also made exploring in all areas of the mouth easier (Figure 12, 13).
Discussion

Musculoskeletal disorders occur at a high rate in dental professionals.\textsuperscript{1-7} MSBs of upper body extremities such as the neck, shoulder and upper back are prevalent in dental hygienists.\textsuperscript{18,19} While ergonomically neutral postures help to minimize MSB causing movements, the nature of a limited working field, static postures, and fine movements places high workloads on the neck and trunk. Dental magnification loupes offer the possibility of improving ergonomic posture. They are designed to improve visual acuity and magnification of images, reducing the need to lean forward at the head, neck, and waist to get a closer view of oral structures, thereby potentially minimizing the risk of developing work related MSBs. Posture can be quantified with the use of triaxial accelerometers which measure accelerations relative to gravity in three axes: AP, ML, and VT. Using basic trigonometry, the change in tilt angle of each accelerometer can be computed in the AP (forward/backward) and ML (sideways) planes. Additionally, postural tremor fluctuations can be quantified by correcting the axis alignments and quantifying the root mean square (rms) in the AP, ML and VT axes. Research studies related to posture and dental magnification loupes typically use qualitative measures such as video and raters to assess posture. The researchers are unaware of any other study which quantitatively measured the difference in posture between wearing magnification loupes and not wearing loupes, using accelerometers. This study examined whether dental magnification loupes had an effect on posture.

Hypothesis one. Results demonstrate no statistically significant findings related to AP and ML angle which suggest that loupes had little effect on posture when performing instrumentation. The compelling results of this study lie in the angle findings at the head and neck (AP axis) with the data exhibiting adopted positions far from recommended ergonomic guidelines while wearing and not wearing loupes. Adopted positions were significantly different from their baseline neutral
body position for the head, C5 and T5 while participants were not wearing loupes. Interestingly, these deviations were very similar when participants were wearing loupes. This data suggest that with both conditions, angulation is not within neutral positioning for optimal ergonomics. According to Nield-Gehrig a neutral neck position states that the head tilt from side to side and forward to back should be between 0-20°. In both conditions, participant mean angles were well out of this range for the head and C5, creating a less than optimal neutral position. A neutral spine position occurs when trunk flexion is between 0-20°. In both conditions, T5 was very close to being out of this range.

Prevalence of neck MSDs are cited in the literature as exceptionally high especially in the dental hygiene profession, sometimes as high as 84% over a twelve month period. This discovery demonstrates that dental hygienists, despite ergonomic education and training, are not following recommendations to reduce MSDs, especially in the neck area. Furthermore, previous studies by Branson et al and Maillet et al indicate results that demonstrated a change toward improved posture with the use of magnification loupes and the results of this study cannot fully support these findings. Perhaps differences in the three can be attributed to the subjective nature of the aforementioned studies.

The angle findings may indicate loupes do not appear to affect posture, especially in the neck area as participants were far from neutral ranges whether participants wore loupes or not. These findings reveal minimal posture benefit when using magnification loupes.

Hypothesis two. Anterior/Posterior posture fluctuations (rms) were improved at C5 with the use of magnification loupes; however, postural fluctuations were not improved at the head, T5 or L1 compared to not wearing magnification loupes. While the finding in APrms at the C5 axis was statistically significant, these were very small tremors/fluctuations in posture and the important discovery lies in the angle deviations.
Hypothesis three. Results demonstrate loupes had no effect on time it took to complete full mouth exploring. This may be due to that fact that participants performed the same exploring task back to back or were using a similar technique with and without loupes while exploring. Whether or not loupes significantly improved the time it took to complete instrumentation, exploring is an important part of patient assessment and dental hygienists may sometimes perform this repetitive skill up to ten times daily. In the present study, participants were spending, on average, approximately 4 minutes exploring (262 seconds while wearing loupes and 254 seconds exploring without loupes). This data demonstrates this is roughly four minutes of exploring with the head and neck in a fixed position well out of ergonomic recommendations with and without the use of loupes.

Regardless of whether or not magnification loupes improved posture during the experiment, results of the survey show that more than half of all participants (74%) strongly agreed they felt wearing magnification loupes made it easier to explore in all areas of the mouth. More than half of all participants (67%) strongly agreed that they felt wearing magnification loupes improved their posture during exploring in all areas of the mouth. It is important to note, although 67% of participants felt magnification loupes improved their posture, the data does not support this opinion. This research expanded evidence-based knowledge concerning magnification loupes and their effect on posture. It seems the perception of loupes is that they will improve ergonomic posture; however, this quantitative study provides little evidence that wearing loupes leads to changes in body orientation; only to reduced postural tremors at C5 in the AP axis.

This study data displays that dental hygienists are far from optimal ergonomic positioning with and without the use of magnification loupes, as demonstrated by angle findings, potentially leading to MSDs. These results benefit present and future clinicians, dental hygiene educators and dental hygiene students by providing quantitative, evidence-based information regarding
magnification loupes and their postural effects. Results may assist educators when they recommend loupes purchase to dental hygiene students and clinicians when they make a decision to purchase loupes for practice. It may also assist educators in their devised methods of teaching proper ergonomic procedures.

Several limitations may have influenced the findings of this research. Participants were not allowed to use the light mounted to their dental magnification loupes during the experiment which could have revealed differences related to posture. Further research may be needed to evaluate posture while using the magnification loupes light. Dental hygienists were recruited using a convenience sample, rather than a random sample from the population. Only dental hygienists that used magnification loupes were recruited for this study, it is possible that loupes improve posture compared with individuals who do not typically use magnification loupes. This study also had a population which included only one male, further studies need to include a larger population and more males. Considering the sample size was limited to novice dental hygienists, future research should consider comparing dental hygienists with varying levels of work experience. This study assessed posture when wearing magnification loupes, further studies need to look into visual acuity, performance of dental related tasks and detection of pathology, calculus, caries, etc, while wearing magnification loupes.

The strengths of the present study lie in the experimental design. The use of quantitative assessment of posture using accelerometers reduces subjectivity. Previous research utilizes several qualitative and subjective measures to assess posture in participants such as: posture assessments instruments, videotaping and rater assessment. While Branson’s Posture Assessment Instrument is a valid and reliable tool to assess posture, it is subjective in nature with posture being measured and scored by a rater. Videotaping to assess posture also has limitations and is subjective in nature.
Participant posture may be obscured in a video therefore not providing an accurate assessment of posture.
CHAPTER V

SUMMARY AND CONCLUSION

Results revealed that with or without loupes, posture was outside of recommended ergonomic guidelines and loupes did not improve posture as evidenced by statistical findings in the AP angle, especially at the head and C5 regions. The results revealed one statistically significant difference in mean fluctuations for loupes (rms) in AP at C5 compared to no loupes (p<0.05) which indicates posture fluctuations/tremors were improved at the C5 neck area only. Duration of trial was also not significantly impacted by use of magnification loupes.

Conclusions from this study are varied. The use of magnification loupes reduced postural fluctuations in one area of the neck. The majority of the participants felt magnification loupes helped improve their posture (67%) and wearing loupes made it easier to instrument all areas of the mouth (74%); however, these perceptions do not match the quantitative measurements of this study.
REFERENCES


Table I. Paired Samples T-Tests Comparing With and Without Loupes for Each Dependent Variable

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std Error Mean</th>
<th>95% Conf. Interval of Diff. Lower</th>
<th>95% Conf. Interval of Diff. Upper</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1</td>
<td>L_duration - NL_Duration</td>
<td>8.258</td>
<td>32.353</td>
<td>6.47</td>
<td>-5.096</td>
<td>21.613</td>
<td>1.276</td>
<td>24</td>
</tr>
<tr>
<td>Pair 2</td>
<td>L_AP1ang - NL_AP1ang</td>
<td>.501</td>
<td>6.508</td>
<td>1.302</td>
<td>-2.185</td>
<td>3.188</td>
<td>.385</td>
<td>24</td>
</tr>
<tr>
<td>Pair 3</td>
<td>L_ML1ang - NL_ML1ang</td>
<td>-.059</td>
<td>3.49</td>
<td>.698</td>
<td>-1.499</td>
<td>1.382</td>
<td>-.084</td>
<td>24</td>
</tr>
<tr>
<td>Pair 4</td>
<td>L_AP1rms - NL_AP1rms</td>
<td>-.003</td>
<td>.023</td>
<td>.005</td>
<td>-.013</td>
<td>.006</td>
<td>-.766</td>
<td>24</td>
</tr>
<tr>
<td>Pair 5</td>
<td>L_ML1rms - NL_ML1rms</td>
<td>.009</td>
<td>.038</td>
<td>.008</td>
<td>-.006</td>
<td>.025</td>
<td>1.269</td>
<td>24</td>
</tr>
<tr>
<td>Pair 6</td>
<td>L_VT1rms - NL_VT1rms</td>
<td>-.002</td>
<td>.014</td>
<td>.003</td>
<td>-.008</td>
<td>.004</td>
<td>-.788</td>
<td>24</td>
</tr>
<tr>
<td>Pair 7</td>
<td>L_AP2ang - NL_AP2ang</td>
<td>3.004</td>
<td>8.394</td>
<td>1.68</td>
<td>-.461</td>
<td>6.469</td>
<td>1.789</td>
<td>24</td>
</tr>
<tr>
<td>Pair 8</td>
<td>L_ML2ang - NL_ML2ang</td>
<td>-.748</td>
<td>3.787</td>
<td>.757</td>
<td>-2.312</td>
<td>.815</td>
<td>-.988</td>
<td>24</td>
</tr>
<tr>
<td>Pair 9</td>
<td>L_AP2rms - NL_AP2rms</td>
<td>-.046</td>
<td>.087</td>
<td>.017</td>
<td>-.082</td>
<td>-.010</td>
<td>2.634</td>
<td>24</td>
</tr>
<tr>
<td>Pair 10</td>
<td>L_ML2rms - NL_ML2rms</td>
<td>.014</td>
<td>.034</td>
<td>.007</td>
<td>-.000</td>
<td>.028</td>
<td>2.040</td>
<td>24</td>
</tr>
<tr>
<td>Pair 11</td>
<td>L_VT2rms - NL_VT2rms</td>
<td>.007</td>
<td>.019</td>
<td>.004</td>
<td>-.001</td>
<td>.015</td>
<td>1.794</td>
<td>24</td>
</tr>
<tr>
<td>Pair 12</td>
<td>L_AP3ang - NL_AP3ang</td>
<td>.529</td>
<td>3.256</td>
<td>.651</td>
<td>-.815</td>
<td>1.873</td>
<td>.812</td>
<td>24</td>
</tr>
<tr>
<td>Pair 13</td>
<td>L_ML3ang - NL_ML3ang</td>
<td>-.344</td>
<td>2.611</td>
<td>.522</td>
<td>-1.422</td>
<td>.734</td>
<td>-.659</td>
<td>24</td>
</tr>
<tr>
<td>Pair 14</td>
<td>L_AP3rms - NL_AP3rms</td>
<td>-.006</td>
<td>.019</td>
<td>.004</td>
<td>-.014</td>
<td>.002</td>
<td>1.559</td>
<td>24</td>
</tr>
</tbody>
</table>
Table I. Continued

<table>
<thead>
<tr>
<th>Pair 15</th>
<th>L_ML3rms-NL_ML3rms</th>
<th>.002</th>
<th>.025</th>
<th>.005</th>
<th>-.009</th>
<th>.012</th>
<th>.317</th>
<th>24</th>
<th>.754</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 16</td>
<td>L_VT3rms-NL_VT3rms</td>
<td>-.002</td>
<td>.009</td>
<td>.002</td>
<td>-.006</td>
<td>.001</td>
<td>-1.357</td>
<td>24</td>
<td>.188</td>
</tr>
<tr>
<td>Pair 17</td>
<td>L_AP4ang-NL_AP4ang</td>
<td>.066</td>
<td>1.903</td>
<td>.380</td>
<td>-.719</td>
<td>.852</td>
<td>.174</td>
<td>24</td>
<td>.863</td>
</tr>
<tr>
<td>Pair 18</td>
<td>L_ML4ang-NL_ML4ang</td>
<td>-.067</td>
<td>2.560</td>
<td>.512</td>
<td>-1.124</td>
<td>.990</td>
<td>-.130</td>
<td>24</td>
<td>.897</td>
</tr>
<tr>
<td>Pair 19</td>
<td>L_AP4rms-NL_AP4rms</td>
<td>.001</td>
<td>.021</td>
<td>.004</td>
<td>-.008</td>
<td>.009</td>
<td>.190</td>
<td>24</td>
<td>.851</td>
</tr>
<tr>
<td>Pair 20</td>
<td>L_ML4rms-NL_ML4rms</td>
<td>-.004</td>
<td>.017</td>
<td>.003</td>
<td>-.011</td>
<td>.003</td>
<td>-1.222</td>
<td>24</td>
<td>.233</td>
</tr>
<tr>
<td>Pair 21</td>
<td>L_VT4rms-NL_VT4rms</td>
<td>-.002</td>
<td>.006</td>
<td>.006</td>
<td>-.005</td>
<td>.000</td>
<td>-1.711</td>
<td>24</td>
<td>.100</td>
</tr>
</tbody>
</table>

Duration - Duration of trial
L - Loupes
NL - No loupes
Table II. Descriptive Statistics for Each Dependent Variable Under Loupes and No Loupes Conditions

<table>
<thead>
<tr>
<th>Pair</th>
<th>Dependent Variable</th>
<th>Mean</th>
<th>N</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>L_duration</td>
<td>262.288</td>
<td>25</td>
<td>37.537</td>
<td>7.507</td>
</tr>
<tr>
<td></td>
<td>NL_Duration</td>
<td>254.030</td>
<td>25</td>
<td>44.502</td>
<td>8.900</td>
</tr>
<tr>
<td>2</td>
<td>L_AP1ang</td>
<td>-35.462</td>
<td>25</td>
<td>9.862</td>
<td>1.972</td>
</tr>
<tr>
<td></td>
<td>NL_AP1ang</td>
<td>-35.963</td>
<td>25</td>
<td>10.719</td>
<td>2.144</td>
</tr>
<tr>
<td>3</td>
<td>L_ML1ang</td>
<td>.530</td>
<td>25</td>
<td>6.068</td>
<td>1.214</td>
</tr>
<tr>
<td></td>
<td>NL_ML1ang</td>
<td>.589</td>
<td>25</td>
<td>6.478</td>
<td>1.296</td>
</tr>
<tr>
<td>4</td>
<td>L_AP1rms</td>
<td>.132</td>
<td>25</td>
<td>.048</td>
<td>.010</td>
</tr>
<tr>
<td></td>
<td>NL_AP1rms</td>
<td>.135</td>
<td>25</td>
<td>.049</td>
<td>.010</td>
</tr>
<tr>
<td>5</td>
<td>L_ML1rms</td>
<td>.197</td>
<td>25</td>
<td>.064</td>
<td>.013</td>
</tr>
<tr>
<td></td>
<td>NL_ML1rms</td>
<td>.187</td>
<td>25</td>
<td>.058</td>
<td>.012</td>
</tr>
<tr>
<td>6</td>
<td>L_VT1rms</td>
<td>.088</td>
<td>25</td>
<td>.022</td>
<td>.004</td>
</tr>
<tr>
<td></td>
<td>NL_VT1rms</td>
<td>.090</td>
<td>25</td>
<td>.025</td>
<td>.005</td>
</tr>
<tr>
<td>7</td>
<td>L_AP2ang</td>
<td>-31.537</td>
<td>25</td>
<td>10.647</td>
<td>2.129</td>
</tr>
<tr>
<td></td>
<td>NL_AP2ang</td>
<td>-34.542</td>
<td>25</td>
<td>15.330</td>
<td>3.066</td>
</tr>
<tr>
<td>8</td>
<td>L_ML2ang</td>
<td>.781</td>
<td>25</td>
<td>6.345</td>
<td>1.270</td>
</tr>
<tr>
<td></td>
<td>NL_ML2ang</td>
<td>1.529</td>
<td>25</td>
<td>6.558</td>
<td>1.312</td>
</tr>
<tr>
<td>9</td>
<td>L_AP2rms</td>
<td>.215</td>
<td>25</td>
<td>.074</td>
<td>.015</td>
</tr>
<tr>
<td></td>
<td>NL_AP2rms</td>
<td>.261</td>
<td>25</td>
<td>.138</td>
<td>.026</td>
</tr>
<tr>
<td>10</td>
<td>L_ML2rms</td>
<td>.1750</td>
<td>25</td>
<td>.058</td>
<td>.012</td>
</tr>
<tr>
<td></td>
<td>NL_ML2rms</td>
<td>.161</td>
<td>25</td>
<td>.054</td>
<td>.011</td>
</tr>
<tr>
<td>11</td>
<td>L_VT2rms</td>
<td>.117</td>
<td>25</td>
<td>.010</td>
<td>.002</td>
</tr>
<tr>
<td></td>
<td>NL_VT2rms</td>
<td>.110</td>
<td>25</td>
<td>.022</td>
<td>.004</td>
</tr>
<tr>
<td>13</td>
<td>L_ML3ang</td>
<td>.719</td>
<td>25</td>
<td>3.551</td>
<td>.710</td>
</tr>
<tr>
<td></td>
<td>NL_ML3ang</td>
<td>1.064</td>
<td>25</td>
<td>3.946</td>
<td>.789</td>
</tr>
<tr>
<td>14</td>
<td>L_AP3rms</td>
<td>.064</td>
<td>25</td>
<td>.017</td>
<td>.003</td>
</tr>
<tr>
<td></td>
<td>NL_AP3rms</td>
<td>.070</td>
<td>25</td>
<td>.020</td>
<td>.004</td>
</tr>
<tr>
<td>15</td>
<td>L_ML3rms</td>
<td>.089</td>
<td>25</td>
<td>.035</td>
<td>.007</td>
</tr>
<tr>
<td></td>
<td>NL_ML3rms</td>
<td>.087</td>
<td>25</td>
<td>.033</td>
<td>.007</td>
</tr>
</tbody>
</table>
Table II. Continued

<table>
<thead>
<tr>
<th>Pair</th>
<th>L_VT3rms</th>
<th>NL_VT3rms</th>
<th>L_AP4ang</th>
<th>NL_AP4ang</th>
<th>L_ML4ang</th>
<th>NL_ML4ang</th>
<th>L_AP4rms</th>
<th>NL_AP4rms</th>
<th>L_ML4rms</th>
<th>NL_ML4rms</th>
<th>L_VT4rms</th>
<th>VT4rms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 19</td>
<td>.052</td>
<td>25</td>
<td>.022</td>
<td>25</td>
<td>.022</td>
<td>25</td>
<td>.022</td>
<td>25</td>
<td>.022</td>
<td>25</td>
<td>.022</td>
<td>25</td>
</tr>
<tr>
<td>Pair 20</td>
<td>.069</td>
<td>25</td>
<td>.027</td>
<td>25</td>
<td>.027</td>
<td>25</td>
<td>.027</td>
<td>25</td>
<td>.027</td>
<td>25</td>
<td>.027</td>
<td>25</td>
</tr>
<tr>
<td>Pair 21</td>
<td>.024</td>
<td>25</td>
<td>.014</td>
<td>25</td>
<td>.014</td>
<td>25</td>
<td>.014</td>
<td>25</td>
<td>.014</td>
<td>25</td>
<td>.014</td>
<td>25</td>
</tr>
</tbody>
</table>

Duration - Duration of trial
L - Loupes
NL - No loupes
Figure 1. Typodont with Artificial Calculus
Figure 2. Hu-Friedy ODU 11/12 Explorer
Figure 3. Magnification Loupes with Light
Figure 4. Accelerometer Placement Guide
Figure 5. Delsys Trigno System with Triaxial Accelerometers and Computer Display
Figure 6. Neutral Body Position with Swim Cap and Head Accelerometer
Figure 7. Means and Standard Error Bars for AP Angle With and Without Loupes at the Four Sensor Locations
Figure 8. Means and Standard Error Bars for ML Angle With and Without Loupes at the Four Sensor Locations
Figure 9. Means and Standard Error Bars for Postural Fluctuations in AP axis (APrms) With and Without Loupes at the Four Sensor Locations.
Figure 10. Means and Standard Error Bars for Postural Fluctuations in ML axis (MLrms) With and Without Loupes at the Four Sensor Locations
Figure 11. Means and Standard Error Bars for Postural Fluctuations in VT axis (VTrms) With and Without Loupes at the Four Sensor Locations.
Figure 12. Survey Results. Question 5. Overall, do you feel that wearing magnification loupes made it easier to explore in all areas of the mouth?

*0%, n=0 Disagree, Strongly Disagree
Figure 13. Survey Results. Question 6. Overall, do you feel that wearing magnification loupes improved your posture during exploring in all areas of the mouth?

*0%, n=0 Disagree, Strongly Disagree
Dental Hygienists needed to participate in a research study!

Receive a $50 gift card for your participation.

If you are a registered dental hygienist, 18 and older, right handed, own magnification loupes, and have no history of musculoskeletal disorders, you could qualify!

The proposed study will examine the effects of instrument handle designs on muscles in the wrist and forearm. Additionally, the study will assess the effects of magnification loupes on posture. It requires one visit and approximately 1.5 hours of your time.

If you are interested in participating, please call 683-4719 today!

All research will be conducted at the ODU Dental Hygiene Research Center, Health Sciences Building, 47th and Hampton Blvd.
APPENDIX B

PRELIMINARY PHONE SCREENING

IRB Identifier: ________________
(To Be Assigned by the IRB)

Phone/Screening Questionnaire for Participants to Determine Inclusion/Exclusion Status

Participant Information

Name__________________________ Assigned Number ________________

Age __________________________ Gender:____________________

Inclusion Criteria/Exclusion Criteria

Do you have a history of surgery, injury or disability of your working hand, wrist, forearm, shoulder, neck, upper or lower back? Yes _____ No _____

Have you ever been diagnosed with carpel tunnel syndrome? Yes _____ No _____

Do you have any musculoskeletal disorders of the arm, wrist, fingers, shoulder, neck, upper or lower back? Yes _____ No _____

Are you left-handed? Yes____ No____

Have you overly exerted your arms, hand, neck, upper or lower back during strenuous physical activity/exercise within the last 24 hours? Yes _____ No _____

Years of experience in clinical hygiene ______________

Do you have magnification loupes? Yes________ No________

If yes, what is the magnification level? __________

What is the brand name? ____________________________

Meets Inclusion Criteria

Yes____ No____

________________________________________
Signature of Research Assistant, Principal Investigator, or Co-Principal Investigator
INFORMED CONSENT

INFORMED CONSENT DOCUMENT
OLD DOMINION UNIVERSITY

PROJECT TITLE: The Effects of Loupes and Instrument design on Posture and Muscle Activity During Instrumentation by Dental Hygienists

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. This study is called The Effects of Loupes and Instrument design on Posture and Muscle Activity During Instrumentation by Dental Hygienists and will be conducted in the Dental Hygiene Research Center, Health Sciences Building, Room 1103.

RESEARCHERS
Gayle McCombs, BSDH, MS, Professor, Gene W. Hirschfeld School of Dental Hygiene at Old Dominion University, Responsible Project Investigator.
Susan Lynn Tolle, BSDH, MS, Professor, Gene W. Hirschfeld School of Dental Hygiene at Old Dominion University, Investigator.
Daniel Russell, PhD, Assistant Professor, School of Physical Therapy at Old Dominion University, Investigator.
Martha L. Walker, PhD, Associate Professor, School of Physical Therapy at Old Dominion University, Investigator.
Emily Ludwig, BSDH, Graduate Student, Gene W. Hirschfeld School of Dental Hygiene at Old Dominion University, Investigator.
Jessica Suedbeck, BSDH, Graduate Student, Gene W. Hirschfeld School of Dental Hygiene at Old Dominion University, Investigator.

DESCRIPTION OF RESEARCH STUDY
Few studies have been conducted looking into the subject of instrument handle design and muscle activity and the effects of loupes on posture during dental hygiene clinical care. Minimal evidence-based knowledge exists concerning what instrument handle designs pose the greatest risk for musculoskeletal disorders and the effects of magnification loupes on posture.

If you decide to participate, this study will involve research measuring the effects of four (4) instrument handle designs on four (4) forearm muscles during simulated dental instrumentation (cleaning) on four (4) specific teeth in all areas of a simulated mouth (typodont). You will be randomized to a sequence of the four dental instruments and will be instructed to remove as much of the artificial calculus you can. A one minute rest period will occur between the change of instruments. Surface electromyography will be used to measure the forearm muscle activity while instrumenting. 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.

When you have completed the instrumentation process, your posture will be assessed using an accelerometer. You will be randomly assigned to one of two groups: Group A will wear loupes during the first instrumentation session and Group B will wear loupes during second session. You will progress through both sessions. You will have an accelerometer placed on your head, shoulder, upper and lower trunk to measure posture. You will then be provided with a dental instrument and instructed to instrument all areas of the mouth (supragingivally only), using your normal technique.

All procedures will be completed in one appointment, approximately 1.5 hours. To ensure standardization of the participants, a 15 minute training and practice session will be conducted immediately before the experiment begins. After the experiment is completed, you will be asked to complete a post treatment questionnaire.

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, trunk, neck or shoulder that would keep you from participating in this study.
**RISks AND BENEFITS**

**RISks:** There are no foreseeable risks involved in this study, except you may become fatigued. 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 hygienist who is practicing in a private dental office. The researcher tries to reduce these risks by using non-invasive measuring instruments, 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 instrument handle designs and loupes 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 findings from this study.

**COSTS AND PAYMENTS**

The researchers want your decision about participating in this study to be absolutely voluntary. The researchers recognize that your participation may pose some inconvenience and costs in time. You will be awarded a $50.00 Visa gift card upon completion of the study. Additionally, you will be allowed to take your instruments home with you after 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 Gayle McCombs 757-683-5150 or Dr. George Maihafer, the current IRB chair, at 757-683-4520 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:

Gayle McCombs at 683-5150
Susan Lynn Tolle at 683-5241

If at any time you feel pressured to participate, or if you have any questions about your rights or this form, then you should call Dr. George Maihafer, the current IRB chair, at 757-683-4520, 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.
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
Dear fellow Dental Hygiene Professionals,

Our names are Emily Ludwig and Jessica Suedbeck and we are currently graduate students at Old Dominion University. We are conducting research titled "The Effects of Magnification Loupes and Instrument Design on Posture and Muscle Activity During Instrumentation by Dental Hygienists."

Few studies have been conducted looking into the subject of instrument handle design and muscle activity and the effects of magnification loupes on posture during dental hygiene clinical care. Minimal evidence-based knowledge exists concerning what instrument handle designs pose the greatest risk for musculoskeletal disorders and the effects of magnification loupes on posture. This study aims to address these concerns.

This survey should take approximately 2 minutes to complete. This study has been approved by the Old Dominion University Institutional Review Board (approval #15-504).

Participation in this survey is voluntary. Results will be reported in the aggregate at the completion of the study.

Once you have answered the last item, push the "Send Survey" button and your responses will be collected.

1. If you decide to participate in the following survey click the button below.

   - [ ] I agree to participate
   - [ ] I do not agree to participate
### Demographics

2. Age
   - A. 20-29
   - B. 30-39
   - C. 40-49
   - D. Over 50

3. Gender
   - Male
   - Female

*4. How many years have you been in clinical practice?
   - A. 1-5
   - B. 6-10
   - C. 11-15
   - D. 16-20
   - E. 21 and over*
5. Overall, do you feel that wearing magnification loupes made it easier to explore in all areas of the mouth?

Strongly agree  Agree  Neutral  Disagree  Strongly disagree

6. Overall, do you feel that wearing magnification loupes improved your posture during exploring in all areas of the mouth?

Strongly agree  Agree  Neutral  Disagree  Strongly disagree
Instrument Opinion Questions

7. Please rate Instrument A on the scale below with 1 being "Not comfortable" and 5 being "Very comfortable."

<table>
<thead>
<tr>
<th></th>
<th>1 (Not Comfortable)</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5 (Very Comfortable)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter Grip</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Balance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maneuverability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

8. Please rate Instrument B on the scale below with 1 being "Not comfortable" and 5 being "Very comfortable."

<table>
<thead>
<tr>
<th></th>
<th>1 (Not Comfortable)</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5 (Very Comfortable)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter Grip</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Balance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maneuverability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

9. Please rate Instrument C on the scale below with 1 being "Not comfortable" and 5 being "Very comfortable."

<table>
<thead>
<tr>
<th></th>
<th>1 (Not Comfortable)</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5 (Very Comfortable)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter Grip</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Balance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maneuverability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
10. Please rate Instrument D on the scale below with 1 being "Not comfortable" and 5 being "Very comfortable."

<table>
<thead>
<tr>
<th></th>
<th>1 (Not Comfortable)</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5 (Very Comfortable)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter Grip</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Balance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maneuverability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

11. Overall, based on diameter grip, balance, maneuverability, and weight, which of the four instruments do you like best?

- [ ] A
- [ ] B
- [ ] C
- [ ] D

12. Overall, based on diameter grip, balance, maneuverability, and weight, which of the four instruments do you like least?

- [ ] A
- [ ] B
- [ ] C
- [ ] D
## APPENDIX E

### RANDOMIZATION CHART

<table>
<thead>
<tr>
<th>Subject</th>
<th>Loupes</th>
<th>Typodont</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Loupes No Loupes</td>
<td>B A</td>
</tr>
<tr>
<td>02</td>
<td>Loupes No Loupes</td>
<td>A B</td>
</tr>
<tr>
<td>03</td>
<td>No Loupes Loupes</td>
<td>A B</td>
</tr>
<tr>
<td>04</td>
<td>Loupes No Loupes</td>
<td>B A</td>
</tr>
<tr>
<td>05</td>
<td>Loupes No Loupes</td>
<td>B A</td>
</tr>
<tr>
<td>06</td>
<td>No Loupes Loupes</td>
<td>B A</td>
</tr>
<tr>
<td>07</td>
<td>No Loupes Loupes</td>
<td>B A</td>
</tr>
<tr>
<td>08</td>
<td>Loupes No Loupes</td>
<td>A B</td>
</tr>
<tr>
<td>09</td>
<td>Loupes No Loupes</td>
<td>A B</td>
</tr>
<tr>
<td>10</td>
<td>No Loupes Loupes</td>
<td>A B</td>
</tr>
<tr>
<td>11</td>
<td>Loupes No Loupes</td>
<td>B A</td>
</tr>
<tr>
<td>12</td>
<td>No Loupes Loupes</td>
<td>A B</td>
</tr>
<tr>
<td>13</td>
<td>No Loupes Loupes</td>
<td>B A</td>
</tr>
<tr>
<td>14</td>
<td>No Loupes Loupes</td>
<td>B A</td>
</tr>
<tr>
<td>15</td>
<td>Loupes No Loupes</td>
<td>A B</td>
</tr>
<tr>
<td>16</td>
<td>No Loupes Loupes</td>
<td>B A</td>
</tr>
<tr>
<td>17</td>
<td>Loupes No Loupes</td>
<td>B A</td>
</tr>
<tr>
<td>18</td>
<td>Loupes No Loupes</td>
<td>A B</td>
</tr>
<tr>
<td>19</td>
<td>No Loupes Loupes</td>
<td>A B</td>
</tr>
<tr>
<td>20</td>
<td>Loupes No Loupes</td>
<td>A B</td>
</tr>
<tr>
<td>21</td>
<td>Loupes No Loupes</td>
<td>B A</td>
</tr>
<tr>
<td>22</td>
<td>Loupes No Loupes</td>
<td>B A</td>
</tr>
<tr>
<td>23</td>
<td>No Loupes Loupes</td>
<td>B A</td>
</tr>
<tr>
<td></td>
<td>No Loupes</td>
<td>Loupes</td>
</tr>
<tr>
<td>---</td>
<td>-----------</td>
<td>--------</td>
</tr>
<tr>
<td>24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Loupes</td>
<td>No Loupes</td>
</tr>
</tbody>
</table>
APPENDIX F

PARTICIPANT INSTRUCTIONS

In this part of the study you will be wearing loupes and not wearing loupes. You will not be utilizing your loupes light, just the overhead light.

There will be a warm-up period before we begin and you may ask questions. You will have an ODU 11/12 explorer and a mirror.

I will be in the room, just as an observer, to facilitate data collection. Start in the UR quadrant of the typodont and explore all quadrants and surfaces of the mouth and teeth using your normal exploring technique. While exploring, if you feel calculus or get stuck or hung up on the typodont tissue, it is important to continue.

Do not stop or look up. It is important to focus on the task and refrain from asking questions or speaking with me. Stopping and looking up and/or talking could skew the data collection results.

Do you have any questions before we begin?
VITA
Emily Anne Ludwig
4608 Hampton Blvd
2011 Health Sciences Bldg
Norfolk, VA 23529

EDUCATION:
Master of Science in Dental Hygiene Expected graduation May 2016
Old Dominion University

Bachelor of Science in Dental Hygiene May 2014
Old Dominion University

EXPERIENCE:
Academic Appointments
2014-Present Graduate Teaching Assistant - Department of Dental Hygiene,
Old Dominion University, Norfolk, VA (part-time)
Responsible for assisting professors and lecturers in a lab setting.
Also responsible for performing scholarly tasks for faculty such as
literature reviews, proctoring exams, graded exams and assignments
and helping with course organization.

PUBLISHED BOOKS, MONOGRAPHS, BOOK REVIEWS, AND PAPERS
Ludwig EA, Suedbeck J. Graduate Student Learning Experience at the ADHA. Access. Jan
2016:23-25.*

PROFESSIONAL SERVICE:
2015-Present Legislative Chair position-Tidewater Dental Hygienists’ Association

2015-Present Alternate Speaker of the House-Virginia Dental Hygienists’
Association

2015-Present Governance of Tomorrow Committee Member-American Dental
Hygienists’ Association