Comparison of Tactile Discrimination Associated with Varying Weights of Explorers


Abstract: The prevalence of work-related musculoskeletal disorders in dental hygienists is significantly higher than that of the general population. The purpose of this study was to evaluate the effect of explorer weight on dental and dental hygiene students’ tactile discrimination when exploring. A randomized controlled clinical trial utilizing a dual dependent statistical design was used to collect data on a convenience sample of forty-eight (n=48) dental hygiene students beginning their senior year of their curriculum. Tactile discrimination was measured by having twenty-four experimental subjects (using a lightweight 0.4 ounce explorer) and twenty-four control subjects (using a heavier 1.0 ounce explorer) delineate the coarseness of varying textures of sandpaper in an apparatus that provided a blinded environment. Data were analyzed using SPSS. Descriptive statistics, chi square tests, and independent sample t-test were computed. Results did not display statistically significant differences between groups. Descriptive statistics illustrated that students using lightweight explorers were better able to delineate between textures. One exception to this finding was with very similar textures, where heavier explorers provided superior tactile discrimination. Overall, the weight of the explorer does not affect students’ tactile discrimination abilities.

Epidemiological literature estimates that the prevalence of work-related musculoskeletal disorders (WMSDs) in dental hygienists is significantly higher than that of the general population. Dental hygiene educators are concerned about this continuous threat. Common modifiable risk factors for development of WMSDs in dental hygienists are associated with instrumentation; forceful exertions, repetition, small diameters, flexion and extension of wrists, pinch forces, static loading of the fingers and hands, awkward hand postures, and other prehensile motions. These risk factors result in decreased circulation of blood and oxygen and increased risk of developing a WMSD. As a result, prevention of WMSDs has become a priority for the dental hygiene professionals and dental hygiene educators.

Ergonomic experts in the dental field have made recommendations for instrumentation modification and selection. These recommendations include decreasing hand forces during instrumentation by altering the instrument design and improving wrist posture. Suggested instrument variations include increasing the diameter, choosing instruments that are lightweight and balanced, padding the instruments, adapting the shape of the handle and texture, and varying the sizes of instrument handles. Most recently, Simmer-Beck et al. concluded that lightweight instruments and padded instruments required less muscle activity while pinch grasping, which may result in decreased development of WMSDs. Subgingival calculus detection and removal are difficult for both novice and experienced clinicians. Effectively accomplishing this task requires using a precision grip with the pads of the fingers to distinguish between aberrations in tooth morphology and calculus. Teaching this proficiency is arduous for both dental and dental hygiene educators due to the subjective sensations necessary for this skill being affected by individual sensory and motor nerve functions. Findings from previous studies indicate that tactile cues available at the end of finger movements provide a powerful stimulus for the control of the finger muscles. In a study that evaluated temporal synergies of hand movement and sensory cues, Santello et al. found that tactile cues influenced hand postures as the...
hand contacted objects. In a study that examined the effects of dental mirror weight, diameter, and padding on muscle activity, the muscle response to the external load (mirror handles) was different for each subject: some subjects had a decrease in muscle activity with lightweight handles, while others had an increase in muscle activity associated with lightweight handles. Previous studies are inconclusive as to what factors significantly affect tactile discrimination.

Few studies evaluate tactile discrimination in dentistry and dental hygiene. Wilkins and Nield-Gehrig, in textbooks commonly used to teach dental hygiene students, both state that hollow handles are preferred to solid handles because lighter weight handles enhance tactile sensitivity. Schoen used a relative smoothness test to evaluate tactile discrimination of experienced and inexperienced clinicians’ ability to differentiate between surface smoothness of five different dental hygiene instruments. This author concluded that there was a difference in the ability of dental hygiene clinicians to differentiate degrees of surface smoothness with different instruments.

Atilla and Kandemir evaluated the surface smoothness of cylindrical metal samples and root surfaces using a Profilometer to calibrate against standard roughness developed by the American Standards Association (ASA B46.1-1962) (ISO R468) and a periodontal probe. They concluded that decisions about the smoothness of a surface using a periodontal probe and the sense of touch were reliable for clinical use. To investigate tactile discrimination of two file-handle sleeves of endodontic hand instruments, Warren and Chandler used an endodontic simulator and determined neither endodontic device enhanced tactile discrimination. Huennekens and Daniel defined the parameters of using the ODU 11/12 explorer and surmised that it is excellent for exploring the entire dentition and detecting calculus and root surface irregularities. It can be concluded from these studies that tactile discrimination is an important consideration when selecting explorers and that basing instrument selection on ergonomic principles such as weight appears to be beneficial in the prevention of MSDs. However, no studies are published that examine how altering the weight of explorers affects tactile discrimination. It is left to the dental and dental hygiene educators to discern which instruments are effective at root surface evaluation while promoting musculoskeletal health.

The purpose of this study was to examine the effects of explorer weight on tactile discrimination using a tactile sensitivity discrimination apparatus. The following research hypothesis was examined: the weight of the ODU 11/12 explorer will produce differences in the tactile discrimination of dental hygiene students when they attempt to discern textures of sandpaper using a novel tactile sensitivity discrimination exercise.

Materials and Methods

The target population for the study was a convenience sample of forty-eight (n=48) female dental hygiene students beginning their fourth semester of a five-semester program at the University of Missouri-Kansas City School of Dentistry during the 2004-05 and 2005-06 school years. All forty-eight subjects who were targeted voluntarily chose to participate. This was a randomized controlled clinical trial utilizing a dual dependent statistical design.

A device was constructed by one of the investigators to block the view of the textured surfaces while allowing the clinician to have full use of the dominant hand holding an instrument. This allowed for blinding of subjects. Four wooden boxes, measuring 6” high, 8” wide, and 10.75” deep, were purchased from Lakeshore Learning Products (Lakeshorelearning.com Mystery Box Catalog Item RJ27) to house the textured surfaces. Each box had an open bottom and large hand openings at both ends. The hand openings were covered with soft, pliable vinyl that did not restrict hand movement.

A rectangular plate made from pressed wood board, measuring 8.5” by 11”, was designed to serve as the bottom of each box. The plates were removable, so that each box could house a variety of sandpaper pairs. Attached to each wooden plate were two wooden blocks measuring 1.5” square by 1” high. The top of each block was covered with a different grit of sandpaper. The sandpaper was glued securely to the top of each block. Each plate was assigned a number for identification purposes. Figure 1 illustrates plate #2. Sandpaper grits varied from extremely coarse (60 grit) to very fine (400). Using Schoen’s relative smoothness test as a template, ten plates each with paired abrasive strips were made for each box. Four sets of the tactile sensitivity tests were made in order to test multiple subjects at the same time. The listing of sandpaper combinations can be found in Table 1. Due to a malfunction caused by the sandpaper strip not staying attached to the wooden block, the data collected from plate 1 was not included in the data analysis because we were concerned the results...
would not be accurate. Therefore, data was collected on ten plates, but only nine plates were included in the analysis.

To obtain volunteer subjects for this study, second-year dental hygiene students were given a verbal description of the research study and an invitation to participate. Students understood participation was voluntary and that their course grade would not be affected with or without participation. Those electing to participate were required to sign a consent form prior to participation. This study was approved by the Adult Social Science Institutional Review Board at the University of Missouri-Kansas City.

Hu-Friedy Satin Steel #11/12 ODU DE Explorers (EXD11/12), weighing 1.0 oz., were chosen for the control group, and American Eagle Eaglelite Explorers 11/12 (AE EXP 11/12X), weighing 0.4 oz., were chosen for the experimental group. Both explorers were approximately the same diameter (0.5 inches) and had a similar handle texture.

Subjects were randomly assigned to be in either the control group or the experimental group prior to beginning the experiment. To simulate a situation similar to practicing on a dentoform, subjects were instructed to use a modified pen grasp to hold the assigned explorer in an ungloved hand. Each subject was instructed to use the apparatus by placing the dominant hand through the appropriate side of the box. The height of the box accommodated the use of an explorer by the subject, and the plate fit tightly so
that no slipping of the blocks occurred. Each block was designated as either “1” or “2,” and the subject could distinguish this based on the label placed on the top of the box. Subjects were instructed to fulcrum on one block at a time and explore the surface with the assigned explorer. Subjects were instructed to identify whether block #1 or #2 felt most coarse (Figure 2). No time limit was set for the subjects, but most made a selection in thirty seconds or less.

Four examiners were present to record the selection made by each subject and to reconfigure the box by changing each plate to a different test pair. The primary investigator and the study moderator instructed the examiners about how to use the apparatus, and all examiners were calibrated prior to each data collection session. The examiners asked subjects to delineate coarseness of ten varying texture plates and documented their responses. Subjects were scored by the examiners. Correctness or incorrectness was not communicated to the subject. Following the data collection, the subject responses were noted as being correct or incorrect.

Data were coded and entered into the Statistical Package of Social Science (SPSS) 13.0. Data were analyzed using SPSS by computing descriptive statistics, independent samples t-test, Pearson chi square tests, and Fisher’s exact test.

Table 1. Designations of grits on individual plates

<table>
<thead>
<tr>
<th>Plate Number</th>
<th>Grit on Block A</th>
<th>Grit on Block B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1*</td>
<td>120</td>
<td>320</td>
</tr>
<tr>
<td>2</td>
<td>60</td>
<td>120</td>
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<tr>
<td>3</td>
<td>180</td>
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<td>4</td>
<td>240</td>
<td>400</td>
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<td>10</td>
<td>400</td>
<td>80</td>
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*Plate 1 was eliminated due to equipment malfunction.

Figure 2. Exterior view of the apparatus

Subjects were instructed to use a randomly assigned explorer and identify whether block #1 or block #2 felt more coarse.
Results

Sandpaper grit is a reference to the number of abrasive particles per inch of sandpaper. Grit of 40-60 abrasive particles per inch is coarse; 80-120 abrasive particles per inch is medium; 150-180 abrasive particles per inch is fine; 220-240 abrasive particles per inch is very fine; 280-320 abrasive particles per inch is extra fine; and 360-600 abrasive particles per inch is super fine. As displayed in Table 2, results show no statistically significant differences in correctness occurred between the experimental and control groups. Descriptive statistics illustrated that subjects were better able to differentiate coarseness using the heavy explorers when textures were very similar and coarse. Subjects were better able to delineate between moderate grit differences of medium and fine textures using lightweight explorers. All subjects were able to differentiate coarseness differences of 100-160 particles per inch.

As displayed in Table 3, the number of correct answers was evenly split. All subjects were able to correctly discern between sandpaper textures in at least seven plates. Twenty-one subjects total in the experimental and control groups correctly discerned between sandpaper textures in eight plates. Nearly half the subjects (n=22) total in the experimental and control groups correctly discerned between sandpaper textures in all nine plates.

Discussion

The results of this study indicate the weight of the explorer does not influence a student clinician’s ability to differentiate degrees of surface smoothness. Tactile perception is a subjective sensation that is influenced by many variables including the sharpness of the explorer tip, wearing gloves, aberrations in root morphology, and the clinician’s experience. Several factors became apparent while completing this study. Explorer sharpness was not measured between subjects. This could have influenced the outcomes as the explorers became dull. The controlled design of this study should have made this shortcoming balanced between groups; however, that cannot be completely ascertained. Another possible shortcoming is each subject grasped the explorer handle with an ungloved hand. This allowed the investigators to replicate conditions similar to practicing on dentoforms outside of school; however, it could have heightened the sensitivity of the clinician.

The subjects used in this study were students. Using a relative smoothness test, Schoen investigated five dental hygiene instruments to be used for root surface evaluation during scaling and root planing procedures. Results demonstrated experienced clinicians scored significantly higher than students. It is hypothesized that if the investigators conducted this test on early learners or experienced dental hygienists, the outcomes may differ as clinicians move along the learning curve. It is also possible that the sandpaper plates may not duplicate the conditions found intraorally closely enough and varying weights.
provide more discrimination on variances greater than what the sandpaper plates could reproduce. The uniform texture of the sandpaper was not meant to simulate tooth enamel or calculus. The limitations of moisture, cramped space, and patient/operator positioning could not be measured in the present study.

The findings in this study are preliminary. Although dental and dental hygiene educators should not base decisions on one study, these results provide valuable information for dental and dental hygiene educators about how the new lightweight, ergonomic instruments affect student learning. This aspect of instrumentation has not been previously addressed. Decisions regarding which instruments to purchase for student kits should be based on objective, scientific data that consider musculoskeletal health and student learning.

Future studies should address the limitations of the present study and may include replicating this study using a repeated measures design to control for differences between subjects. It is also of interest to replicate this study in order to evaluate dental and dental hygiene students and dental hygienists at various stages of learning and experience and to evaluate other aspects of ergonomic recommendations such as diameter, texture, and padding to determine their impact on student learning.

**Conclusion**

The weight of explorers does not affect students’ tactile discrimination ability. Therefore, the hypothesis—the weight of the ODU 11/12 explorer will produce differences in the tactile discrimination of dental hygiene students when they attempt to discern textures of sandpaper using a novel tactile sensitivity exercise—should be rejected.

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**REFERENCES**