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A laboratory study to determine the effects of universal and rotating ultrasonic inserts on wrist movement and scaling time efficiency of dental hygienists

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Abstract: *Purpose:* The purpose of this study was to determine if differences existed in *range of wrist movements* and *scaling time efficiency* of dental hygienists using a rotating ultrasonic insert when compared with a standard universal insert. *Methods:* A convenience sample of 32 consenting experienced dental hygienists who met inclusion criteria was invited to participate. Using a cross-over research design, the 32 participants were randomly assigned to one of the two subgroups. Subgroup A ($n = 16$) used the rotating universal ultrasonic insert on a typodont, rested for 15 min and the standard universal insert on a different typodont. Subgroup B ($n = 16$) used the standard universal ultrasonic insert on a typodont, rested for 15 min and the rotating universal ultrasonic insert on a different typodont. Each participant used the rotating and standard universal ultrasonic scaling inserts to remove 2 cm^3 artificial calculus from two different typodonts for up to 15 min per insert. *Scaling time efficiency* was determined using a Modified Volpe–Manhold Calculus Index, measuring the amount of artificial calculus remaining after ultrasonic scaling. While scaling, each participant wore the WristSensor™ goniometry gloves, which determined changes in wrist movements (flexion and extension and ulnar and radial deviations), measured as a deviation from the neutral position. *Results:* A paired *t*-test ($P = 0.05$) using 30 subjects with useable data, revealed no statistically significant differences between the two different inserts in terms of *wrist movements* and *scaling time efficiency*. A multivariate analysis of variance revealed no statistically significant differences in the *percentage of* *time* dental hygienists were in high, medium or low-risk posture categories while using the rotating ultrasonic insert compared with the standard universal insert. Based on the results of this laboratory study, dental hygienists using a rotating ultrasonic insert appear to experience no ergonomic advantage in terms of wrist postures or timesavings over a standard insert.

Key words: clinical dental hygiene; cumulative trauma disorder; instrumentation

Introduction

Cumulative trauma disorders (CTDs), also known as repetitive strain injuries (RSIs), consist of a variety of musculoskeletal and nerve disorders that are related to overuse of the upper limb (1). One of the most common CTDs is carpal tunnel syndrome (CTS); however, the list also includes nerve entrapments of the ulnar and radial nerves; tendonitis of the shoulder, elbow, wrists or hand; localized muscle pain and cramping; and some vascular disorders (1). Dental hygiene practice is physically demanding requiring the dental hygienist to use high prehension forces, perform highly repetitive hand and wrist movements in a patient's mouth and hold their wrist in awkward positions for an extended period of time (2). Further, the repetitive use of handheld instruments for the removal of plaque biofilm and calculus causes extreme fatigue in the practitioner's upper extremities. The prevalence of upper extremity tendonitis and musculoskeletal disorders in dental professionals attests to the trauma exerted on clinician's hands, arms and shoulders during the process of care (1, 3–8). The physical force and repetition used in dental hygiene practice is an occupational risk factor for developing upper extremity musculoskeletal disorders in dental hygienists.

Occupational risk factors and RSI preventive strategies

Because clinical dental hygienists are at risk of developing RSI, such as CTS (3), strategies for prevention are of paramount importance. CTS occurs when the nerves innervating the hands are compressed. These nerves pass through narrow channels between the muscles and ligaments in the shoulder, arm or hand. If one of the nerves in the hand becomes compressed (normally the median nerve) impaired motor function and paresthesia along the distribution of the nerve may result (8). The occurrence of CTS can significantly impair psychomotor skill performance and clinician effectiveness (3, 7).

While the incidence of CTD in dental hygienist is well documented (1–9), few clinical studies have been conducted which measure the musculoskeletal movements and ergonomic risks involved in dental hygiene instrumentation. In 1996, under the auspices of the American Dental Association's Council on Dental Practice, a study was conducted to evaluate the ergonomic risk of tasks associated with typical dental and dental hygiene practice (9).

Dental hygienists' daily tasks evaluated included probing, scaling, polishing and flossing. The study demonstrated an overall medium ergonomic risk level when researching force measurements of the overall muscle activity in dental hygienists. Using an electrogoniometer, the researchers measured average wrist postures for flexion and extension and for ulnar and radial deviation while performing the same daily tasks. Participants wore the Greenleaf WristSensor™ goniometry gloves (Greenleaf Medical Systems, Palo Alto, CA, USA) while performing skills. Bramson *et al.* (9) determined from the literature (10–13) that:

Wrist flexion and extension greater than 45 degrees has been shown to significantly increase the likelihood of developing CTD; wrist flexion and extension below 15 degrees has been shown to decrease the likelihood of a CTD. Ulnar deviation greater than 30 degrees is typically associated with higher risk; ulnar deviations below 20 degrees decrease the incidence of CTD of the hand/wrist. Radial deviations that exceed 20 degrees increase the incidence of CTD in the hand/wrist; radial deviations that are kept below 11 degrees decrease the incidence of CTD (Table 1) (9).

The research revealed the overall average wrist movements for left and right hand flexion and extension and ulnar and radial deviation to be in the low to medium-risk categories.

Table 1. **Risk categories for developing cumulative trauma disorders based on wrist flexion, extension and ulnar and radial deviations**

	Risk level (degrees)		
Wrist posture	Lower	Medium	Higher
Flexion	0–15	16–45	46+
Extension	0–15	16–45	46+
Ulnar deviation	0–20	21–30	31+
Radial deviation	0–10	11–20	21+

From Bramson *et al.* (9, p. 177).

However, the research demonstrated that the hand or wrist had to move more than 30 times per minute while dental hygiene tasks were performed, thus indicating an ergonomic concern for RSI if dental hygiene tasks were performed more than 20 h per week (9).

Several strategies for decreasing a practitioner's risk for CTD have been promulgated.

Dong *et al.* (2) conducted a study to evaluate the effect of three different finger rest positions on hand-muscle activity and pinch force in a simulated scaling experience with 12 predental students as the subjects. Electromyography, with the application of surface electrodes on the forearms of the subjects was used to determine muscle activity. A pressure sensor attached to a hand scaling instrument determined pinch force. Each subject was provided with a manikin and a typodont with the test teeth painted with nail polish to simulate plaque and calculus. Participants scaled using each type of finger rest for 2 min and had 5-min rests between each finger position. Results revealed that finger rests during scaling reduce muscle activity and thumb pinch force when compared with not using finger rests. As a means to minimize RSI the authors concluded that clinicians would benefit from instruction in and use of finger rests.

In addition to finger rests, the following actions to enhance the ergonomics of dental hygiene practice have been suggested by Gerwatowski *et al.* (8): dental hygienist should allow adequate time for each patient, reduce the need to rush to avoid compromised hand, wrist and arm positioning and schedule patients in a predetermined sequence to avoid clusters of difficult scaling cases in a row. Further suggestions for avoiding work-related injuries through prevention include the application of ergonomic principles related to operator and patient positioning and using ergonomically designed instruments and equipment each workday (2, 8, 14, 15). Thornton *et al.* (16) stressed the need to improve ergonomic education in the academic environment as a way for future practioners' to minimize risk.

The overall goal in minimizing CTD is to reduce repetitive finger and wrist motions and avoid a tight pinching grip. One of the most prevailing recommendations for reducing CTD includes the use of powered scaling devices (8, 14–16). Due to dental professionals' high risk of developing CTD improved ultrasonic inserts have been developed. Generally, the use of an ultrasonic scaler requires a lighter grasp and less wrist motion which is necessary for preventing RSI, although the long-term effects of the vibratory exposures and the biomechanics of using ultrasonic scalers have not been determined (8, 17). Use of ultrasonic scaling instruments, however, are as effective as manual instruments for removing supragingival and subgingival plaque biofilm, and both are equally effective in reducing probing depths and bleeding scores (18–23).

Dental manufacturing companies are continually developing new technologies and instruments to address the ergonomics of scaling and root debridement and to decrease repetitive strain injuries in working dental hygienists. In 2001, an innovative ultrasonic insert was designed to rotate inside the handpiece of the ultrasonic unit, with the intention of improving ergonomics of practice as well as increasing operator ease and comfort during ultrasonic scaling. This insert design may be more ergonomic and improve the dental hygienists' periodontal debridement efficiency with less risk of RSI; however, the value of this insert in terms of wrist movements and scaling time efficiency has not been tested.

The rotating or swivel design includes a large silicone grip that measures nearly one-half inch in diameter, making this insert's finger grip 21–26% larger than other ultrasonic inserts available (23). The increase in handle size may reduce the pinch grip for the dental hygienist, which is a major ergonomic benefit (24). Because the tip swivels in the handpiece, less wrist motion may be required to debride the periodontium in comparison to a standard ultrasonic tip which is stationary in the handpiece. Additionally, less wrist movement during scaling may decrease the amount of time a practitioner needs to complete debridement and improve ergonomics of practice. Logical deductions would suggest that the rotating design should improve the dental hygienists' time efficiency and performance when using an ultrasonic scaler; however, this assumption remains untested.

The purpose of this study was to determine if a rotating ultrasonic insert reduced the number of wrist movements in dental hygienists or had an effect on scaling time efficiency when compared with a standard ultrasonic scaling tip (Fig. 1). The percentage of time participants were in high, medium or low-risk posture categories for CTS was also determined.

Materials and methods

Prior to the study's initiation, the protocol was reviewed and approved by the University's Institutional Review Board for

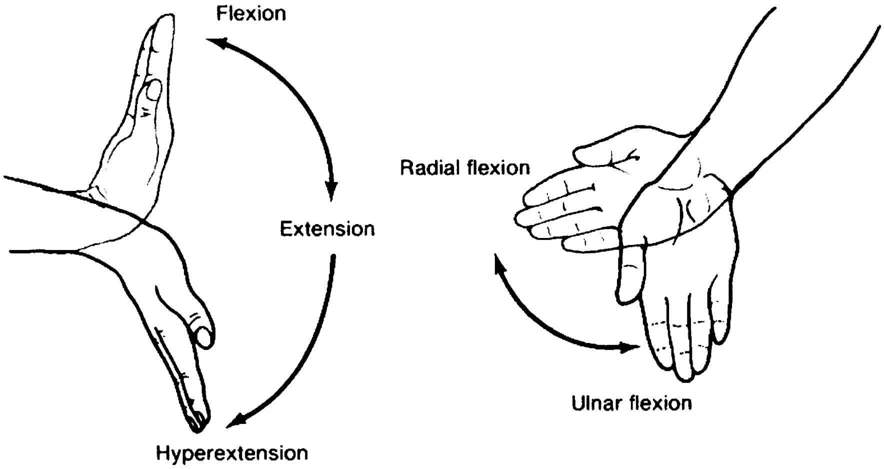

Fig 1. Wrist movements in dental hygienists.

Human Subjects. Subject inclusion criteria for the 32 participants included: right-handed dental hygienists who were actively employed for at least 30 h per week, at least 2 years working experience and experience in the use of ultrasonic scalers. The sampling selection for this study was initiated by sending a letter to all registered dental hygienists residing in the local area describing the study, the inclusion criteria and inviting all eligible hygienists to participate. Willing participants were screened to ensure eligibility, contacted by phone and based on their availability during the research time period were selected to participate. The 32 participants who were selected were randomly assigned to one of the two subgroups. Subgroup A ($n = 16$) used the rotating universal ultrasonic insert on a typodont, rested for 15 min and the standard universal insert on a different typodont in a controlled clinical simulation. Subgroup B ($n = 16$) used the standard universal ultrasonic insert on a typodont, rested for 15 min and the rotating universal ultrasonic insert on a different typodont in a controlled clinical simulation. Data from one participant per group were lost due to human error during computer back-up. The final sample size ($n = 30$) was used to analyse the data.

Procedures, materials and data collection instruments

The simulated periodontal scaling procedures involved the use of dental chair-mounted typodonts with artificial calculus. The typodonts were equipped with an artificial face to simulate a client's oral cavity during ultrasonic scaling. Using a 6 cm^3 syringe 2 cm^3 of artificial calculus paste were dispensed at the gingival margins around the facial and lingual surfaces of each tooth on the typodont in the maxillary and mandibular right quadrants, thereby controlling the application and location of the calculus and the amount of calculus scaled by each subject. The subjects in both subgroups received instruction on the use of the rotating ultrasonic insert and were allowed 10 min of supervised practice time to become familiar with the nuances of the instrument. No instruction was given on the use of the standard#10 universal tip (Hu-Friedy, Chicago, IL, USA). Following the practice session, the principal investigator calibrated both subgroups of subjects with the Greenleaf WristSensor™ goniometry gloves. To calibrate the gloves, each subject wore the glove and placed his/her right hand flat on the calibration unit and moved the wrist in accordance with defined postures (neutral, 60 degrees flexion, 60 degrees extension, 30 degrees ulnar deviation and 20 degrees radial deviation) (9). Both subgroups of hygienists' were instructed about the Greenleaf WristSensor™ goniometry gloves and were required to wear the glove throughout the entire scaling procedure.

Next, the research assistant distributed the appropriate ultrasonic insert to be used and observed the participants using the ultrasonic scalers. The subjects operated the same ultrasonic unit at a medium power setting and were timed and instructed to scale the artificial calculus from the maxillary and mandibular right quadrants for up to 15 min. Participants were requested not to remove their hand from the typodont mouth because sudden wrist movements, other than that of ultrasonic scaling, would skew the results of the study.

Each participant was asked to take a 15-min rest to control for possible fatigue before using the second ultrasonic insert. Next, the research assistant removed the ultrasonic insert from the unit and in it placed the different insert. A new typodont with artificial calculus on the two right quadrants was introduced and the research assistant again observed the dental hygienist perform the same scaling procedure with the different insert for up to 15 min. Finally, the principal investigator performed a Modified Volpe-Manhold Calculus Index Score (V-M_2) determining the amount of calculus remaining with the different insert.

To ensure optimal functioning and minimal variability, one pre-used, but calibrated ultrasonic scaling unit made by Dentsply (Dentsplay, York, PA, USA) and 32 new Hu-Friedy®#10 Universal Satin Swivel™ (30 kHz) inserts and 32 new Hu-Friedy®#10 (30 kHz) universal insert ultrasonic were used for the experiment.

The independent variable, *scaling time efficiency* of calculus removal was measured by using a Modified Volpe-Manhold Calculus Index Score (V-M) (25). The V-M was modified because every other tooth on the maxillary and mandibular right sides was scored. The principal investigator performed a modified V-M_1 (pretest) on each typodont by scoring each tooth surface (buccal and lingual) of teeth numbers 10, 16, 12, 12, 41, 43, 45, 47. This total was recorded in the subject's confidential data folder.

After the hygienists were done with each ultrasonic insert (rotating and standard insert), the principal investigator performed a post-test (V-M_2) to score the calculus remaining on the typodont in the same manner. To determine *scaling time efficiency* the formula V-M_1 minus V-M_2 divided by the time required to scale the assigned quadrants was calculated.

Electrogoniometer

The instrument used to measure *wrist movement* was an electrogoniometer, a device designed to measure range of motion angles of a joint. Since this study involved hand movements the Greenleaf WristSensor™ goniometry gloves, manufactured by Greenleaf Medical Systems, Palo Alto, CA, USA (Fig. 2) was selected as the data collection instrument. Literature from the Greenleaf WristSensor Company indicates the system is extremely accurate and reliable in bench testing (26). Jonsson and Johnson (27, 28) compared the measurement accuracy of the Greenleaf WristSensor™ goniometer system to another commercially available electrogoniometer system (Model X 65; Biometrics, Gwent UK). The two different systems were tested over a wide range of flexion/extension and radial/ulnar movements to determine measurement accuracy (28). They found the WristSensor™ system provided more accurate wrist measurements when comparing the two electrogoniometers tested (30, 31).

The Greenleaf system utilized a right-handed glove, which was worn by each subject. This glove held two sensors, which were encased in the WristSensor™ goniometry glove that was connected to a battery-operated DataRecorder (Greenleaf Medical Systems). These sensors collected *wrist movement* data (recorded in degrees) for each subject. One sensor measured ulnar and radial deviation (side to side wrist movement) and the other measured wrist extension and flexion (up and down wrist movement). The DataRecorder measured wrist position 10 times for every second of recording. Data were downloaded from the DataRecorder to a computer using the Movement Analysis System™ (MAS) software (Greenleaf Medical Systems) (29). The DataRecorder converted all raw sensor signals to angles prior to sending them to the MAS software. The MAS software stored collected data that were used to print an MAS report, which provided basic statistics on *wrist movement* including the minimum, maximum and mean angles for each sensor, plus the SD. These data were used to report the average *wrist movements* for the standard and rotating ultrasonic inserts.

The *percentage of time* spent in low, medium and high-risk categories for CTD as defined by Bramson (Table 1) were calculated from the stored collected data. This was accomplished by the researchers placing a horizontal reference line over the corresponding plot for each insert used by all subjects (9). The MAS software calculated statistics, which reported the number of times that the wrist exceeded the reference angle, the total number of seconds that the wrist spent between reference angles and the percentage of the session that the wrist spent in each risk category.

Validity and reliability

To ensure intrarater reliability and increase validity for this laboratory study, a single calibrated examiner was used to obtain all the Modified Volpe-Manhold (V-M) Calculus Index scores for all pre and post-scaling on each typodont. Before data collection the single examiner performed a test–retest V-M calculus index on 10 different typodonts over 2 days. Intrarater reliability was determined by a Pearson correlation coefficient to be 0.98 level, which is significant at the 0.01 level.

Statistical treatment

Parametric statistics were used to analyse the data. A paired *t*-test was used to evaluate average *wrist movements* and the differences in the means of the two subgroups, which accounted for final group differences. *Scaling time efficiency* was ratio scaled data and a paired *t*-test was used to evaluate differences in the amount of artificial calculus removed by each subject within the 15 allotted minutes of scaling time per insert. A multivariate analysis of variance (MANOVA) was used to determine differences in the percent of time subjects spend in low, medium and high-risk wrist posture categories.

Table 2. **Standardized (original data averages divided by the respective SDs) wrist movement mean values and SDs using the rotating and standard ultrasonic inserts**

Variable		*n*	Mean	SD	*P*-value
Radial	Rotating	28	−1.69	0.40	0.87
	Standard		−1.68	0.42	
Ulnar	Rotating	30	1.74	0.91	0.28
	Standard		1.83	0.74	
Flexion	Rotating	27	−1.37	0.22	0.87
	Standard		−1.36	0.30	
Extension	Rotating	30	1.94	0.54	0.22
	Standard		2.04	0.55	

Results

No statistically significant differences were found in the *range of wrist movements* when measuring the degree of ulnar, radial, flexion and extension required by dental hygienists when using a rotating ultrasonic scaling device to remove artificial calculus on a typodont when compared with a standard universal ultrasonic insert. The mean and SD for each subject for the two methods, that is, rotating and standard were computed for the above four variables. Standardized scores were computed by dividing each mean score by the corresponding SD. Since the SDs were zero for some of the subjects, the researchers used 28, 30, 27 and 30 subjects respectively for the variables: radial, ulnar, flexion and extension. Paired *t*-tests on these standardized scores were performed. None of the four variables showed any significant effects (Table 2). Table 3 reveals the hygienists' overall average wrist postures for the right hand ulnar and radial deviation and wrist flexion and extension. Results reveal that regardless of the tip design, participants were in a low-risk category for CTD in three out of the four wrist postures measured. A moderate risk for CTD was only found when the participants were in the extension mode.

Scaling time efficiency was measured by the amount of artificial calculus remaining after scaling with each tip for up to 15 min. The V-M overall mean score for the amount of artificial calculus applied before ultrasonic scaling (V-M prescaling) was 75.03 for the rotating tip and 76.07 for the standard tip users. Results reveal the vast majority of the participants were able to remove most of the artificial calculus with either insert within the 15-min time period indicated by the (V-M post-scaling) mean total scores of 14.33 and 19.80 for the rotating and standard inserts respectively. Only two participants were able to remove all the artificial calculus with both tips. *Scaling time efficiency* (V-M prescaling minus V-M post-scaling divided by the time required to scale the assigned quadrants) revealed a mean score of 0.07 for the rotating and 0.06 for the standard inserts. Statistical analysis using a paired *t*-test revealed no statistically significant differences ($P = 0.20$, $t = 1.31$, d.f. $= 28$) between the standard insert and the rotating ultrasonic insert in terms of mean *scaling time efficiency* (Table 4). Results indicate the participants were almost equally productive with both the rotating and standard ultrasonic inserts.

Table 4. **Scaling time efficiency mean values and SDs (*n* = 30)**

Variable	Insert	Mean	SD	*P*-value
V-M prescaling	Rotating	75.03	14.41	
	Standard	76.07	13.96	
V-M post-scaling	Rotating	14.33	11.05	
	Standard	19.80	14.54	
Scaling time efficiency	Rotating	0.07	0.02	0.20
	Standard	0.06	0.02	

V-M, Modified Volpe-Manhold Calculus Index Score.

The *percentage of time* dental hygienists were in high, medium or low-risk posture categories, was measured with the Greenleaf WristSensor™ goniometry gloves. Statistical analysis using MANOVA revealed no statistically significant difference ($P = 0.92$) between the two methods when assessing the amount of time participants wrists were in the three different risk categories for CTD as defined by Bramson *et al.* (9) (Table 5).

Discussion

To minimize risk factors for CTD mechanized instruments have been recommended for use in dental hygiene practice.

Table 3. **Hygienists' overall average wrist postures for flexion, extension, ulnar and radial deviations**

Insert type		Radial deviation	Risk	Ulnar deviation	Risk	Wrist flexion	Risk	Wrist extension	Risk
Rotating	Mean	6.32	Low	11.31	Low	6.83	Low	23.58	Medium
	n	30		30		30		30	
	SD	4.70		8.27		3.89		8.55	
Standard	Mean	6.34	Low	12.48	Low	6.92	Low	25.69	Medium
	n	30		30		30		30	
	SD	4.90		8.06		3.71		8.02	
Total	Mean	6.33	Low	11.90	Low	6.87	Low	24.63	Medium
	n	30		30		30		30	
	SD	4.77		8.12		3.77		8.29	

Table 5. **Percentage of time in risk categories (*n* = 30)**

Variable	Insert	Mean	SD
Radial high	Rotating	4.11	9.77
	Standard	3.23	11.96
Radial medium	Rotating	13.41	18.15
	Standard	11.83	15.76
Radial low	Rotating	23.61	16.85
	Standard	22.58	17.62
Ulnar high	Rotating	7.26	18.01
	Standard	8.06	16.49
Ulnar medium	Rotating	9.52	11.43
	Standard	10.94	13.40
Ulnar low	Rotating	42.10	27.62
	Standard	43.37	25.68
Flexion high	Rotating	0	0
	Standard	0.01	0.02
Flexion medium	Rotating	2.44	4.43
	Standard	1.82	2.90
Flexion low	Rotating	10.32	14.65
	Standard	8.59	8.75
Extension high	Rotating	10.06	11.73
	Standard	11.18	12.85
Extension medium	Rotating	50.52	20.46
	Standard	54.13	15.48
Extension low	Rotating	26.66	15.29
	Standard	24.28	13.51

The most recent ultrasonic technology involves the design and marketing of an innovative tip that swivels in the handpiece instead of remaining stationary. The design is believed to be more ergonomic and improve the efficiency of periodontal debridement with less risk of CTD. However, the value of this tip in terms of wrist movement and scaling time efficiency had not been tested. Given that this study was a simulation of dental hygienists performance in a clinical setting, findings are limited to the laboratory.

No statistically significant difference was found in the range of *wrist movements* when measuring the degree of radial, flexion and extension when using a rotating ultrasonic scaling insert compared with a standard universal ultrasonic insert. These results suggest the degree of *wrist movement* the dental hygienist used, whether a side by side (radial and ulnar deviations) or up and down (extension and flexion) motion, was similar for both ultrasonic inserts. Apparently, use of a rotating ultrasonic insert does not significantly reduce the range of *wrist movements* experienced by subjects during calculus removal.

When comparing the overall means of the average radial, ulnar and flexion wrist postures, regardless of which insert was used, the dental hygienists were in a low-risk posture category for CTD. These results concur with Bramson *et al.* (9) who found hygienists' overall average wrist postures for right hand radial/ulnar deviations and flexion were in the low-risk category during hand scaling. Therefore, given the results of this research and that of Bramson *et al.* (9), the dental hygienist is at low risk for developing CTD from hand scaling or using an ultrasonic instrument for radial, ulnar and flexion wrist postures. In contrast, dental hygienists' average wrist posture during extension (upward wrist movement) for both ultrasonic inserts was in a medium-risk category (24.63 degrees) (Table 3). According to Bramson *et al.* (9), wrist flexion and extension greater than 15 degrees increases the likelihood of CTD. Therefore, the dental hygienist may be at risk for CTD when extending his/her wrist during the use of an ultrasonic scaling device. Bramson *et al.* (9) reported an average medium risk for developing CTD during wrist extension when probing (19.57 degrees), hand scaling (20.01 degrees), polishing (16.80 degrees) and flossing (13.82 degrees). Findings suggest risk for CTD when using an ultrasonic (24.63 degrees) and a hand instrument (20.01 degrees), only when extending his/her wrist upward. Therefore, dental hygienists should monitor their degree of wrist extension used during clinical practice.

Similarities in *scaling time efficiency* when using both the rotating ultrasonic insert and standard universal insert were found. Specifically, no timesaving advantages were observed since the universal scaling tip used by subjects removed calculus as efficiently as a rotating ultrasonic scaling tip. Thus the amount of artificial calculus removed in the allotted time period was similar for both inserts. Findings suggest that the clinician may choose either a rotating or a standard ultrasonic insert based upon personal preference with no impact on efficiency.

Similarities were observed in the *percentage of time* dental hygienists were in high, medium or low-risk posture categories when using the rotating ultrasonic insert compared to the standard universal insert (Table 5). Therefore, the type of insert used in terms of *percentage of time* hygienists spend in low, moderate and high-risk posture categories is inconsequential (Table 5).

Regardless of the ultrasonic tip used, in the majority of time, subjects were in low-risk posture categories when measuring radial, ulnar and flexion wrist postures. However, dental hygienists spend a large portion of ultrasonic scaling time in medium extension risk postures that may lead to CTDs. Results indicate that dental hygienists are at risk of developing CTDs when using either of the inserts due to the fact that they are in the medium extension risk category for approximately 50% of the time as defined by Bramson *et al.* (9) (Table 5). Therefore, it is recommended that dental hygiene educators and researchers investigate and teach ergonomically correct ultrasonic scaling techniques to minimize the potential CTD risks from wrist extension while using an ultrasonic instrument.

Several limitations are worth noting when interpreting these findings. All subjects in this study were experienced in the use of the ultrasonics, but may not have been familiar enough with the rotating insert to use it correctly, even with supervised instruction. As a result, subjects may have erroneously used both ultrasonic inserts in the same manner, influencing the outcome. Also, the Greenleaf WristSensor™ goniometry glove may not be sensitive enough to measure small wrist movements and perhaps another electrogoniometer would better record finite differences.

Conclusions

This study provides baseline data for average *wrist movements* and *percentage of time* hygienists spend in low, moderate and high-risk categories during ultrasonic instrumentation. Further research is needed to explore how the dental hygienist deviates his/her wrist when performing clinical services during client care. Based on the laboratory findings, dental hygienists using a rotating ultrasonic insert experience no ergonomic advantage in terms of *wrist movement* or timesavings over a standard insert. Since ultrasonic scalers are used frequently in dental hygiene practice, more research should be conducted to determine the impact of ultrasonic scaler usage on dental hygienists for developing a cumulative trauma disorder. In addition, the vibratory effect of ultrasonic usage on the practitioner, as well as biomechanical stresses involved with their use should be researched. The laboratory findings of this study do not exclude the use of a rotating or standard ultrasonic insert in clinical practice; rather, emphasize the need for further research to reduce the risk of occupational related injuries to the dental hygienist's upper extremities, especially the wrist.

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