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The effect of wearing loupes on upper extremity musculoskeletal disorders among dental hygienists

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Abstract: *Objectives:* It is well established that musculoskeletal disorders (MSD) are a significant occupational health issue for dentists and hygienists. Despite this, there has been little advancement in the application of ergonomic principles in the dental profession. While the use of loupes is often promoted as an ergonomic solution, there is little published research to robustly support this claim. The aim of the present study was to investigate the effect of the use of loupes on upper extremity MSD among dental hygienists. *Methods:* The study was conducted using an exploratory pretest and post-test design, comparing musculoskeletal measures in practising dental hygienists wearing loupes with final-year dental hygiene students who did not wear loupes. Pre- and post-test measures included valid self-reported and objective outcome measures and were measured at baseline and 6 months following the intervention. Statistical analysis was conducted as a series of mixed ANOVAS with time and treatment as the independent variables. *Results:* The analysis revealed a significant interaction between time and treatment for the Disabilities of the Shoulder, Arm and Hand (DASH) scores ($P < 0.04$), indicating an improvement in symptoms for the treatment group but a reversed trend for the controls. There was also a significant mean increase in scapular position measures; however, this finding was evident in both groups, indicating that these were not a result of the intervention. *Conclusions:* Overall, this study suggests that wearing loupes appears to have both positive and negative effects on upper extremity MSD among dental hygienists. Ongoing research is required to determine the long-term effects of loupes wear, over an extended period of time.

Key words: dental hygienists; loupes; musculoskeletal disorders

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Introduction

Despite extensive research into the risk factors and modern developments in dental tools and equipment (1–3), work-related musculoskeletal disorders (MSD) are common amongst dental professionals (3, 4). Everyday workplace tasks such as finely tuned movements and exposure to vibratory instruments appear to place dental hygienists at an increased risk of MSD, as does working in a small field of vision requiring the adoption of fixed postures for extended periods (1, 5).

Upper extremity MSD is a particularly common complaint among dental hygienists, with 55–63% reporting discomfort of some kind (6, 7). The reported 12-month prevalence for shoulder pain in dental hygienists

ranges from 49.8% (8) to 68% (9), with the number of days worked and number of patients attended per day related to increasing rates (8). Pain in the wrist and hand region is also frequently reported, with between 47.5% (8) and 69.5% (10) of dental hygienists reporting MSD in a 12-month period. Increasing number of hours worked per week increases the frequency of reports of wrist/hand pain lasting longer than 2 days (11). This specific body region gains much attention, given the repetitive nature of dental hygiene work places hygienists at an increased risk for carpal tunnel syndrome (12, 13).

One of the most common treatment approaches for work-related MSD is worksite modification (14). Ergonomic suggestions include reducing awkward postures, highly repetitive movements and prolonged static positioning (14). The implementation of such modifications is difficult for a profession where scaling and debriding teeth comprise the majority of day-to-day job tasks. Researching interventions for the prevention of upper extremity MSD among dental professionals is imperative; however, there are very few studies investigating this issue. Even rarer are studies that have used clinically objective measures, such as muscle activity (15) or surface electromyography (13).

In recent years, the use of dental loupes (magnification lenses) has been promoted for its ergonomic benefits; however, there is no strong objective evidence to support their use. Previous studies have been limited to assessments of working posture (16, 17), which does not ensure that MSD is either prevented or resolved. While improved posture may be ergonomically beneficial, the movements that are made during daily workplace activities, such as the elevation, abduction and flexion of the shoulder, arm and hand (18), also have a strong bearing on the risk of MSD. Nevertheless, a recent survey examining MSD among dental hygienists reported that those wearing loupes were significantly less likely to report pain in the shoulder and wrist/hand regions than hygienists who were not wearing loupes (11). The aim of the present study was to explore the effect of wearing loupes on upper extremity MSD among dental hygienists, using both self-reported and objective outcome measures.

Methods

Ethical approval for this study was granted by The University of Newcastle Human Research and Ethics committee. The study was conducted using a pretest and post-test design to examine the effects of wearing loupes on upper extremity MSD, comparing practising dental hygienists wearing loupes with a non-equivalent control group of final-year dental hygiene students, over a period of 6 months.

Participants

Members of the Dental Hygienists Association of Australia (New South Wales Branch) were invited to participate in the study as part of the intervention group. Potential participants

were contacted by post and provided with a participant information statement, consent form and reply-paid envelope.

Final-year dental hygiene students at the University of Newcastle, Australia, were also invited to participate in the study as part of the non-equivalent control group. They were approached during a scheduled class by a staff member not involved with the research project, and given a participant information statement and consent form. They were advised of the voluntary nature of participating and assured that there would be no benefit or disadvantage to their education whether they chose to participate or not.

In order to be eligible to participate, both practising dental hygienists and students were required to have been treating patients in a clinical setting for at least 24 h per week, not currently wearing loupes, and have experienced MSD. If they had experienced any chronic MSD conditions, they were considered ineligible.

Intervention

The intervention under investigation was the use of dental loupes. All participants in the treatment group were issued Galilean flip-up style loupes, with working lengths tailored to each individual. All loupes had 2.5 \times magnification. This level was chosen as it has the greatest depth and field of vision, and greater magnifications can distort image quality (19). The convergence angle and the working angle of the magnification lenses were adjustable.

Outcome measures

Participants were required to complete a survey and physical assessment at the beginning of the study, before the intervention, and then followed up at 6 months. The Disabilities of the Shoulder, Arm and Hand (DASH) outcome measure is a validated survey (20) requiring participants to respond to 30 items assessing daily activities, function and symptoms. The physical assessment consisted of an assessor (physiotherapist) examining the shoulder range of motion (SROM), scapular position, grip strength and pinch strength using previously validated protocols (21–25). Details of these outcome measures, including their reliability, are displayed in Table 1. The assessor was blinded to the allocation of the participants.

Data analysis

Statistical analysis was performed using SPSS, version 20.0 statistical software (SPSS Inc., Chicago, IL, USA), with the primary outcome factor being changed in upper extremity pain and/or disability. The DASH outcome measure was scored according to the authors' instructions. Means and standard deviations for all measures were calculated, across treatment and time. The normality of the distribution of scores was examined using the Shapiro–Wilk test prior to analysis, whereby 2 \times 2 mixed ANOVAs were performed to reveal a significant effect at the level of $P < 0.05$.

Table 1. Description and validity of outcome measures

Measure	Description	Subjects	ICC*	Author
DASH	This questionnaire measures symptoms in the arm, shoulder and hand and the participants' ability to perform certain activities. It consists of 30 questions that require a response on a Likert-type scale	Requiring shoulder or hand/wrist treatment	0.96	Beaton <i>et al.</i> (20)
Scapula position	The Lennie test will be used to measure normal scapular resting position, as described by Sobush <i>et al.</i> (21). This test can be used an objective assessment of shoulder disorders	Healthy females	0.75–0.96	Sobush <i>et al.</i> (21)
Shoulder range of movement	An inclinometer will measure the total shoulder flexion, and internal and external rotation using the protocol as described by Green <i>et al.</i> (22). This outcome measure has been used in the evaluation of shoulder disorders	Varying degrees of pain/stiffness	0.62–0.80	Green <i>et al.</i> (22)
Grip	Participants' hand grip strength will be assessed using a hand-held dynamometer, using the protocol as described by Lindstrom-Hazel <i>et al.</i> (23), following the American Society of Hand Therapists guidelines. This test has been used as an objective measure of hand disorders	Healthy	0.94, 0.98	Peolsson <i>et al.</i> (24)
		Cervical radiculopathy	0.87, 0.97	
		Asymptomatic Carpal tunnel decompression Flexor tendon repairs	0.95 0.97 0.96	Coldham <i>et al.</i> (25)
Pinch	Participants' pinch grip will be assessed using a pinch gauge, using the protocol as described by Lindstrom-Hazel <i>et al.</i> (23), following the American Society of Hand Therapists guidelines. This measure has been used to evaluate hand disorders	Healthy	0.98	Lindstrom-Hazel <i>et al.</i> (23)

*Reliability expressed as intraclass correlation coefficients (ICC).

Results

Twelve practising dental hygienists and seventeen final-year dental hygiene students consented to participate in the study. The hygienist's age ranged from 24 to 48 years with a mean age of 31.8 (± 7.8) years, and they were working an average of 33.9 (± 8.2) clinical hours per week. The age of the students ranged from 21 to 33 years with a mean age of 25.1 (± 4.4), and they were completing an average of 28.1 (± 11.7) h of clinical activity per week. All of the practising dental hygienists were female, while only three of the dental hygiene students were male.

The means and standard deviations for the shoulder and hand measures across time and treatment are shown in Table 2. Scores for shoulder flexion, internal and external rotation were combined into a single SROM measure. Before analysis, DASH scores were transformed using a square root method after the Shapiro–Wilk test revealed the distribution of DASH scores significantly deviated from normality ($P < 0.05$). A 2×2 mixed ANOVA performed on the transformed DASH data revealed a significant interaction between time and treatment type [$F(1,27) = 4.81$, $P = 0.037$], while no main effects were significant. As indicated in Table 2, the DASH scores for the control group were lower than the treatment group, but this trend reversed following the intervention; a higher DASH score indicates a worsening of symptoms.

For scapular position measures, 2×2 mixed ANOVAS revealed a statistically significant mean increase in shoulder position, with the distance from the superior angle of the scapula to midline of 0.685 cm [$F(1,27) = 23.0$, $P < 0.01$] and a significant mean increase of 0.33 cm in the distance from the root of the scapula to midline measures [$F(1,27) = 7.81$,

$P < 0.01$]. However, the interactions between time and treatment type were not significant for any of the distance measures. This indicates that the changes across time did not differ as a function of treatment type. The 2×2 mixed ANOVAS performed on pinch and grip strength and SROM revealed no statistically significant main effects or interactions between time and treatment type.

Discussion

This study combined self-reported and objective outcome measures to investigate the effect of loupes on upper extremity MSD among dental hygienists, for what appears to be the first time. Furthermore, this is one of the only studies to investigate an intervention for MSD among dental hygienists in a real work environment. While undertaking the study in the work environment might potentially introduce confounding variables, it remains that the only tangible way to study the effect of interventions across time is to implement change in the workplace.

Overall, levels of self-reported upper extremity pain and disability improved in the loupes group when comparing baseline to post-intervention. This positive finding provides a measure of support to the proposition that using loupes may improve MSD symptoms. Moreover, the DASH identified a worsening of symptoms in the student group. Although the students do not have the same years of experience as the intervention group, their clinical hours remained constant and in excess of 24 h per week during the study. While the scores were significantly different across treatment and time, it should be noted that all means were similar to those reported in the general population (26). However, the validity of this outcome

Table 2. Self-reported and physical measures of upper extremity pain and disability

	Treatment			Control		
	<i>n</i> = 12			<i>n</i> = 17		
	Baseline mean (SD)	Post-intervention mean (SD)	Change*	Baseline mean (SD)	Post-intervention mean (SD)	Change*
Dash [†]	8.56 (9.64)	5.17 (5.29)	+ve	4.99 (6.25)	7.84 (8.73)	-ve
Distance superior angle of scapula to spine [‡] (cm)	7.91 (1.02)	8.62 (1.09)	-ve	8.28 (1.04)	8.94 (1.10)	-ve
Distance root of scapula to spine [‡] (cm)	7.28 (0.96)	7.57 (1.13)	-ve	7.23 (0.99)	7.60 (0.86)	-ve
Distance inferior angle of scapula to spine (cm)	8.54 (1.21)	8.41 (1.12)	+ve	8.28 (1.65)	8.51 (1.42)	-ve
Shoulder range of motion (degrees)	98.81 (10.26)	98.12 (8.49)	-ve	102.16 (6.96)	101.07 (5.95)	-ve
Pinch strength (kg)	7.08 (1.22)	7.67 (1.11)	+ve	7.88 (1.67)	7.71 (1.89)	-ve
Grip strength (kg)	28.58 (5.79)	29.75 (4.14)	+ve	33.12 (10.07)	34.11 (9.34)	+ve

*Change in scores from baseline to post-intervention expressed as positive (+ve) or negative (-ve).

[†]Significant difference between groups baseline and post-intervention.

[‡]Significant difference between baseline and post-intervention, but not due to treatment.

measure was previously tested among hospital patients requiring treatment for shoulder and wrist problems (20); as such, the magnitude of meaningful clinical change may be different for individuals with comparatively low levels of MSD.

Changes in scapular position were significant over time for both groups, indicating that the use of loupes was not impacting on this outcome measure. Both groups exhibited increased distance from the superior angle and root of the scapula to the spine. This indicates a more forward or protracted scapula and shoulder girdle position. It is assumed that changes in scapular resting position reflect weakness or lead to pain or dysfunction (27); more specifically, that increased protraction places undue pressure on the shoulder, thus affecting function (28). However, it is unclear how variable scapular position may be over even short periods of time (29) or, indeed whether or not changes precede pathology. It should perhaps be considered that this test may not be appropriate for measuring changes over time, in a group with low levels of MSD. Nevertheless, for the purposes of this study, scapular positioning (measuring protraction) is one of the only valid measures that are clinically examinable by palpation (28). Both the hygienists wearing loupes and student controls exhibited decreased SROM after 6 months, although this finding was not statistically significant, and the changes were unlikely to be clinically significant (<2 degrees). It appears as though wearing loupes had little impact on SROM.

The loupes group demonstrated improved pinch strength in the 6-month follow-up, while the student group's pinch strength declined. It has been previously shown that pinch strength is lower in females compared with males (30) and steadily declines with age (31). Although the statistical analysis of our results may not have revealed statistically significant findings, it is nevertheless encouraging given that loupes wearers were entirely female and older when compared with the controls. It should be considered that the use of loupes may

have required the hygienists to position their patients at a more appropriate working distance, and therefore, they were able to use their wrist and hand muscles more effectively, leading to less fatigue and symptoms. The contribution of confounding variables such as the weight and diameter of instruments used by each individual may have impacted on these results; however, it was impossible to collect data on instrument specifics within the parameters of the study design.

Grip strength measures improved in both groups over time. Overall grip strength was higher in the control group compared with the treatment group. This may have been influenced by the small number of male controls; studies have previously shown that females on average demonstrate 66% of the grip strength of their male counterparts (24). All mean scores for grip and pinch strength fall within normal range. This is consistent with previous reports from a study examining peripheral nerve dysfunction in dental hygienists, where the authors hypothesized that impairment of the median nerve perhaps was not acute enough to have impacted on muscle strength (32). Unfortunately, it is difficult to draw comparisons with other studies examining the pinch grip of dental hygienists, because other units of measurement such as kilopascals (31) or newtons (33) were recorded.

The difficulty with researching interventions for MSD lies in the fact that the exact pathophysiology or mechanisms for many conditions (including tendonitis, nerve compression and hand-arm vibration syndrome) have not been well defined (14). This is problematic when attempting to find appropriate objective measures to determine the effect of interventions for MSD. Perhaps we should consider whether prevention of MSD is possible without this knowledge. At this stage, we are relying primarily on the results from self-reported surveys and subsequent statistical analysis to give us clues about what may predict or protect dental hygienists from MSD. This being said, the importance of self-reported measures should not be

understated, especially in MSD research where the existence of subclinical or lower levels of pain may mean that physical examination and motor tests cannot observe clinically significant changes in muscle function or position of anatomical landmarks. Yet, as this method of research has its inherent limitations, it is crucial to use validated and reliable tools (34).

Study limitations

The method for selecting participants may be considered a limitation of this study. All participants volunteered to participate, and the control group was one of the convenience and therefore not equivalent or matched to the treatment group. Measurement error should always be considered when examining limitations; however, a single assessor was used for all physical assessments, and the use of reliable and validated measures helps limit potential bias. Then again, the sensitivity of the measures to detect an MSD may present a limitation, as most clinical measures are designed to assess higher levels of pain and disability and may not accurately measure lower levels of pain or disability or subclinical disorders.

Conclusions

This study suggests that wearing loupes may have both positive and negative effects in regards to upper extremity MSD. While dental hygienists wearing loupes exhibited a significant improvement in self-reported upper extremity MSD following the intervention, there were mixed findings in terms of the physical assessments, with improvements in hand strength and declines in shoulder position and range of motion. The effect of loupes on MSD should now be examined for periods longer than 6 months to determine whether the benefits of wear outweigh any negative effects. The use of validated self-reporting and clinically objective measures in future research is crucial in establishing strong clinical evidence to support the use of loupes as an intervention for MSD.

Clinical relevance

Scientific rationale for study

While loupes have been shown to improve posture during dental hygiene tasks, there is a lack of research investigating whether wearing loupes improves musculoskeletal function or pain.

Principal findings

After wearing loupes for 6 months, hygienists reported less pain in the shoulder, arm and hand. Changes in musculoskeletal function were minimal.

Practical implications

Dental hygienists considering using loupes should reflect on the mixed findings in this study and then, taking into account

their own work-related habits and health, consider whether the benefits to wearing loupes outweigh any potential negative effects.

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Author's contributions

MH, JT and DS determined the research theme. MH and PO designed the study, interpreted the results and wrote the article. AH performed analysis and provided interpretation of results. All authors were involved in the preparation of this manuscript and have approved the final manuscript.

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