

Magnification and Coaxial Illumination in Dental Hygiene Education: Experience and attitudes of clinical educators

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Abstract

Purpose: Static postural demands and precise movements involved with instrumentation, place dental professionals at high occupational risk for developing musculoskeletal disorders (MSDs). Using magnification loupes and coaxial illumination may lower the risk of developing a future MSD. The purpose of this study was to evaluate the experiences and attitudes among clinical dental hygiene educators in Ohio regarding requiring the use of magnification loupes and coaxial illumination in academic settings.

Methods: Clinical dental hygiene faculty members from the 12 dental hygiene programs in Ohio were invited to participate in a cross-sectional, electronic survey consisting of 28 items. Descriptive statistics were used to analyze the educators' experiences with magnification loupes and coaxial illumination in academic settings.

Results: Responses from 54 participants from the non-probability sample were analyzed. A majority (86%) of the respondents used magnification in their role as clinical faculty members; 94% felt that clinical faculty members and 92% felt students should be required to use magnification in academic settings. Of the 54% using coaxial illumination while caring for patients, 94% used illumination in their role as clinical faculty members. A majority of these respondents (94%) felt clinical faculty members, and students (82%) should be required to use coaxial illumination in academic settings. Improved ergonomics, increased accuracy, and efficiency were cited as the perceived rationale for mandating the use of magnification and illumination.

Conclusion: Dental hygiene faculty using magnification loupes and coaxial illumination in clinical practice and in academic settings supported requiring faculty and students to use magnification and illumination.

Keywords: magnification, loupes, coaxial illumination, ergonomics, clinical dental hygiene education, musculoskeletal disorders

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Introduction

Dental professionals are considered to be at elevated occupational risk for developing musculoskeletal disorders due to static postural demands and the precise movements involved with instrumentation.¹⁻⁵ In a survey of dental professionals, 74% of respondents reported musculoskeletal pain.³ Multiple studies have demonstrated, through the use of electromyography and photography, that dental professionals most commonly experience pain in the shoulders, neck, upper back, lower back, and wrists.^{6,7} Forward flexion of the neck and anterior carriage of the head have been identified as major sources of pain for dental hygienists in clinical practice.^{7,8} However, what is more concerning, is the pain experienced

during entry-level clinical training by dental professionals may be a precursor to the musculoskeletal disorders experienced in later in clinical practice.^{9,10}

An aspect of ergonomics involves the science of equipment design, maximizing working spaces for productivity, and minimizing operator fatigue and pain.^{11,12} Magnification loupes have been shown to provide both positive and negative aspects for clinicians.^{1,8,13,14} While more acceptable postures in students have linked to the use of loupes, additional faculty feedback was also required to achieve those postures.^{1,15} Dental hygiene students have self-reported improved postures while using indirect vision with magnification, however, there

were no significant differences in accuracy and efficiency demonstrated while using magnification.¹⁶ Despite the lack of clarity regarding the ergonomic benefits associated with the use of magnification, it has been suggested that there may be postural and clinical benefits associated with the use of coaxial illumination, or light sources aligned with the sight line.¹⁷⁻²⁰

Headlights using light-emitting diode (LED) technology provide an alternative source of illumination to the overhead dental operatory light. The use of the LED light combined with low-powered magnification (2.5X) has been shown to enhance the detection of caries in the primary dentition.²¹ Since coaxial illumination also provides shadow-free lighting in alignment to the working area, operators have reported experiencing ergonomic benefits as a result of eliminating the need for adjustments of the overhead light.^{17,19} Although ocular hazards exist with the use of LED lights, most headlight manufacturers use LED beams within the safe zone spectrum and operators are advised to use minimal settings to reduce glare while maintaining optimal visual acuity.²²

Dental hygiene educators in both clinical practice and educational settings have been shown to have a range of experiences and opinions regarding the use of magnification loupes, however, there has been an increasing trend to require dental hygiene students to use loupes. Results from a national survey of dental hygiene programs in the United States showed that only 25% of the schools mandated students to use magnification loupes and less than 10% required faculty to use magnification in 2012.²³ Five years later in 2017, results from a second national survey showed the number of dental hygiene programs mandating the use of magnification by students had increased to 44%.²⁰ However, when the additional component of coaxial illumination was considered, only 9% of the dental hygiene programs surveyed mandated the use of illumination.²⁰ In a survey of dental faculty at a single institution, the majority of dental faculty used magnification and of those, 70% used coaxial illumination concomitantly with magnification.²⁴ While the majority (91%) of the dental faculty supported students use of magnification loupes, only about three-fourths of the faculty felt that use of magnification should be required.²⁴

It has been hypothesized that the proper use of magnification and coaxial illumination can support improved ergonomic postures and a reduction of musculoskeletal strain. However, institutional requirements regarding the use of magnification and coaxial illumination by students may be influenced by the experiences and attitudes of clinical dental hygiene faculty members. Limited research exists examining the experiences and attitudes towards magnification and

coaxial illumination among dental hygiene educators who work in clinical practice and in educational settings. The purpose of this study was to evaluate dental hygiene educators' experiences towards using magnification loupes and coaxial illumination in clinical practice and in academic settings. Perceptions of dental hygiene educators in regards to the benefits of magnification and coaxial illumination in academic settings was also evaluated.

Methods

This study was deemed exempt by the Institutional Review Board of the Ohio State University. A cross-sectional survey research design, utilizing an anonymous web-based survey, was used for the study population of dental hygiene educators in the state of Ohio. There were 12 dental hygiene programs in Ohio at the time of the study, with an estimated average of 12 faculty (part-time and full-time) per program, with a minimum of one-half day of clinical teaching responsibilities per week. An estimated total of 144 dental hygiene faculty members met the inclusion criteria and were invited to participate.

Survey Instrument

The 28-item survey was self-developed to include demographic information; investigate the respondents' experience with magnification loupes and coaxial illumination; and explore dental hygiene faculty attitudes about the perceived benefits of magnification loupes and coaxial illumination to practitioners and patients. The majority of the questions required yes/no responses or Likert-style responses ranging from 1-strongly agree to 5-strongly disagree. Two questions elucidated open ended responses from participants identifying as not using magnification loupes and/or coaxial illumination.

A panel of 4 dental hygiene faculty member experts created the survey questions by patterning them after two existing surveys.^{24,25} The survey instrument was originally designed for student responses; questions were pilot tested by 30 dental hygiene students for clarity and feedback. Following revisions for clarity, the survey was modified for faculty responses by the panel of experts.

Qualtrics web-based survey software (Provo; UT, USA) was used to construct and administer the survey. An invitation e-mail was sent to the 12 dental hygiene program directors in Ohio followed by an additional e-mail instructing the program directors to forward the invitation to their dental hygiene faculty members. A reminder and separate forwarding e-mail was sent to the program director two weeks after the first notification. The survey was closed after a total elapsed running time of 28 days.

Data Analysis

Data were analyzed using SPSS Version 25 (IBM; Armonk, New York). Descriptive statistics were used to describe the dental hygiene educators' experiences with magnification loupes and coaxial illumination. Chi-square analysis and Mann Whitney U-tests were used to explore the associations between experience and attitudes with the use of magnification loupes and coaxial illumination in academic settings.

Results

Of the twelve dental hygiene programs in Ohio, eight program directors agreed to participate and forwarded the invitation to their clinical faculty. Since the total number of clinical faculty who were sent the survey was unknown, the responses represent a non-probability sample. Out of the 57 respondents who completed the survey, three were disqualified because they were either incomplete or completed by dentists. From the data of 54 respondents, 67% (n=36) worked in an associate degree program and 33% (n=18) worked in a baccalaureate program; 91% (n=49) were female and 9% (n=5) were male; the median age range was between 40-49 years (Table I).

Table I. Demographics

	Percentage and number of respondents (n=54)	
College structure	Associate degree program 66.7% (n=36)	Baccalaureate degree program 33.3% (n=18)
Gender	Female 90.7% (n=49)	Male 9.3% (n=5)
Age group	Median age group 40-49 years (n=8)	Interquartile Range 30-39 years (n=15) to 50-59 years (n=15)

The first aim of the study was to determine the current experiences of dental hygiene educators using magnification loupes and coaxial illumination in clinical practice and academic settings. Over three-fourths (80%) of the respondents used magnification loupes while delivering patient care in clinical practice, while 70% reported using loupes in their role as a clinical faculty member. Most program directors (87%) did not require clinical faculty to wear magnification loupes while overseeing students however, half of the respondents stated that students were required to purchase magnification loupes. In regards to coaxial illumination, about half (54%) reported using illumination both while

delivering patient care and in their role as a clinical faculty member. Five responses were received from the open-ended question regarding the rationale for not using magnification loupes and included: difficulty with the adjustment period/lack of proper fitting (n=3), lack of perceived need (n=1), and lack of peripheral vision (n=1). The majority (96%) of the program directors did not require clinical faculty to use coaxial illumination when overseeing students and over three quarters (78%) of the respondents stated that students were not required to use coaxial illumination. Nine open-ended responses were received regarding the rationale for not using coaxial illumination and included: difficulty with adjustment due to weight or compromised ergonomics (n=4), cost (n=2), not using loupes (n=1), no perceived need (n=1), and intent to purchase in the future (n=1). Clinical faculty experiences with magnification and illumination are shown in Table II.

The second study aim was to evaluate the attitudes of dental hygiene educators regarding the perceived benefits of magnification loupes alone in academic settings (Table III). Chi-square test of independence was calculated comparing the frequency of faculty wearing loupes while providing patient care and faculty wearing loupes while working in student clinics. A significant interaction was found ($\chi^2(1)=24.879$, $p<.001$) revealing that dental hygiene faculty who wear loupes while providing patient care were also more likely to wear loupes in the academic setting. Chi-square test of independence was calculated comparing the frequency of faculty wearing loupes while providing patient care and programs requiring students to purchase magnification loupes; no significant relationship was found ($\chi^2(1)=2.854$, $p>.05$). Chi-square test of independence was calculated comparing whether faculty wearing loupes while providing patient care and their attitude as to whether dental and dental hygiene faculty should be required to wear loupes while overseeing patient care in academic settings. A significant interaction was found ($\chi^2(1)=8.693$, $p<.01$) revealing that dental hygiene faculty who wear loupes while providing patient care were more likely to feel that dental hygiene faculty should be required to wear loupes while overseeing patient care in student clinics. Chi-square test of independence was calculated comparing the frequency of faculty wearing loupes while provide patient care and faculty wearing loupes as clinical faculty in student clinics. A significant interaction was found ($\chi^2(1)=12.306$, $p<.01$) showing that dental hygiene faculty who wear loupes while providing patient care were more likely to feel that dental hygiene students should also be required to wear loupes while providing patient care.

Table II. Faculty Experiences with Magnification Loupes and Coaxial Illumination

Question	Frequency of responses % (n)				
Do you currently use magnification loupes while providing patient care to your own patients?	Yes 79.6% (n=43)			No 20.4% (n=11)	
If yes, how often do you use the magnification loupes while providing patient care?	Always 61.1% (n=33)	Most of the time 11.1% (n=6)	Sometimes 9.3% (n=5)	No answer 18.5% (n=10)	
If yes, which best describes how you would feel if you were unable to use magnification during patient care?	I would feel as comfortable providing patient care 11.1% (n=6)	I would feel like I was compromising my ergonomics 40.7% (n=22)	I would feel unsure about providing adequate patient care 27.8% (n=15)	I would feel unable to provide care 1.9% (n=1)	
Do you wear magnification loupes while working as a clinical faculty member in the student clinic?	Yes 70.4% (n=38)			No 29.6% (n=16)	
Does your school require the students to purchase magnification loupes for patient care?	Yes 50.0% (n=27)			No 50.0% (n=27)	
Does your employer require you to wear magnification loupes while overseeing students treating patients in the student clinic?	Yes 5.6% (n=3)	No 87.0% (n=47)	No answer 7.4% (n=4)		
Do you feel that dental and dental hygiene clinical faculty members should be required to use magnification while overseeing patient care in the student clinic?	Yes 57.4% (n=31)			No 42.6% (n=23)	
Do you use a headlight (coaxial illumination) while providing patient care to your own patients?	Yes 53.7% (n=29)	No 38.9% (n=21)		No answer 7.4% (n=4)	
If yes, how often do you use a headlight while providing patient care?	Always 48.1% (n=26)	Most of the time 3.7% (n=2)	Sometimes 5.6% (n=3)	Rarely 9.3% (n=5)	No answer 33.3% (n=18)
If yes, which best describes how you would feel if you were unable to use a headlight during patient care?	I would feel as comfortable providing patient care 20.4% (n=11)	I would feel like I was compromising my ergonomics 18.5% (n=10)	I would feel unsure about providing adequate patient care	No answer 38.9% (n=21)	
Do you wear a headlight while overseeing students treating patients in the student clinic?	Yes 50.0% (n=27)	No 35.2% (n=19)	22.2% (n=12)		
Does your employer require you to wear a headlight while overseeing students treating patients in the student clinic?	Yes 0.0% (n=0)	No 96.3% (n=52)	No answer 3.7% (n=2)		
Do you feel that dental and dental hygiene clinical faculty members should be required to wear a headlight while overseeing patient care in the student clinic?	Yes 33.3% (n=18)	No 63.0% (n=34)	No answer 3.7% (n=2)		
Does your school require the students to purchase a headlight for patient care?	Yes 18.5% (n=10)	No 77.8% (n=42)	No answer 3.7% (n=2)		
Do you feel that dental and dental hygiene students should be required to wear a headlight while providing patient care?	Yes 44.4% (n=24)	No 51.9% (n=28)	No answer 3.7% (n=2)		
The use of a headlight during patient care increases the use of proper ergonomics by the practitioner.	Strongly agree 27.8% (n=15)	Agree 48.1% (n=26)	Neutral 16.7% (n=9)	Disagree 5.6% (n=3)	No answer 1.9% (n=1)

Table III. Relationships Between Magnification Loupe Experience and Attitudes

Magnification loupe experience	Do you currently use magnification loupes in clinical practice?		χ^2	<i>p</i> -value
	Yes	No		
Faculty who wore magnification loupes while working as a clinical faculty member in the student clinic	86.0%	9.1%	24.879	<.001
Schools who required students to purchase magnification loupes for patient care	55.8%	27.3%	2.854	>.05
Faculty members in dental hygiene programs should be required to wear magnification loupes while overseeing patient care in the student clinic	93.5%	60.9%	8.693	<.01
Dental hygiene students should be required to wear magnification loupes while providing patient care	92.1%	50.0%	12.306	<.001

Table IV. Relationships Between Magnification Loupe Experience and Associated Benefits

	All respondents			Faculty wearing loupes in clinical practice.		<i>p</i> -value
	<i>n</i>	Median	IQR	Yes	No	
Loupes increase the use of proper ergonomics	54	1.0	1.0-2.0	24.91 n=43	37.64 n=11	<.01
Loupes increase the accuracy of assessment and procedure	54	1.0	1.0-2.0	24.28 n=43	40.09 n=11	<.001
Loupes increase the efficiency of providing care	54	2.0	1.0-3.0	23.56 n=43	42.91 n=11	<.001

A Mann-Whitney *U*-test was used to examine faculty attitudes of whether loupes increase proper ergonomics, increase the accuracy of assessment and procedures, and increase the efficiency of providing care (Table IV). Dental hygiene faculty wearing loupes when providing patient care believe that loupes increase the use of proper ergonomics (*M* place=24.91; *U*=348.00, *p*<.01), increase the accuracy of assessment and procedures (*M* place=24.28; *U*=375.00, *p*<.01), and increase the efficiency of providing care (*M* place=23.56; *U*=406.00, *p*<.001).

The third aim was to evaluate the attitudes of dental hygiene educators regarding the perceived benefits of coaxial illumination in academic settings (Table V). Chi-square test of independence was calculated comparing the frequency of faculty using coaxial illumination while providing patient care and faculty using coaxial illumination in academic settings. A significant interaction was found ($\chi^2(2)=30.015$, *p*<.01) revealing that dental hygiene faculty

who use coaxial illumination while providing patient care were more likely to also use coaxial illumination while working in student clinics. Chi-square test of independence was calculated comparing whether faculty using coaxial illumination while providing patient care and attitudes towards whether dental hygiene faculty should be required to using coaxial illumination in academic settings. A significant interaction was found ($\chi^2(2)=17.831$, *p*<.001) showing that dental hygiene faculty who used coaxial illumination while providing patient care were more likely to feel that dental hygiene faculty members should be required to using coaxial illumination while working in student clinics. Chi-square test of independence was calculated comparing the frequency of faculty using coaxial illumination while providing patient care and attitudes regarding whether dental hygiene students should be required to use coaxial illumination while providing patient care. A significant interaction was found ($\chi^2(2)=11.077$, *p*<.01) revealing that dental hygiene faculty using coaxial illumination while providing patient care themselves are more likely to feel that dental hygiene students should be required to use coaxial illumination while providing care.

A Mann-Whitney *U* test was used to examine the attitudes of whether using coaxial illumination increases the use of proper ergonomics, increases the accuracy of assessment and procedures, and increases the efficiency of providing care among dental hygiene faculty who use coaxial illumination when providing patient care (Table VI). Dental hygiene faculty using coaxial illumination when providing patient care believe that coaxial illumination increases the use of proper ergonomics (*M* place=19.74; *U*=442.50, *p*<.01), increases the accuracy of assessment and procedure (*M* place=17.45; *U*=509.00,

$p < .001$), and increases the efficiency of providing care (M place=17.83; $U=498.00$, $p < .001$).

Discussion

Since the precursors to musculoskeletal disorders may begin early, during professional education,^{9,10} efforts must be taken to reduce the occupational risks for dental professionals during the education process. The use of magnification combined coaxial illumination has been shown in some studies to improve ergonomic postures.^{1,8,13} However, a disparity exists between the use of magnification loupes by dental professionals in clinical practice and students in educational settings.²⁵ Although a majority of dental and dental hygiene faculty utilize magnification loupes, it is estimated that less than half of dental and dental hygiene programs mandate the use of magnification loupes by students.^{20,23,24} Limited evidence exists regarding the experiences and attitudes of dental hygiene educators with respect to coaxial illumination. Understanding this critical information will help support changes in educational policies requiring the use of magnification and/or coaxial illumination by dental and dental hygiene students and potentially reduce the risks for future musculoskeletal disorders.

This study evaluated the experiences and attitudes among dental hygiene educators in Ohio regarding the use of magnification loupes and coaxial illumination. Most dental hygiene educators participating in this study, used both magnification loupes and coaxial illumination when personally delivering patient care and while overseeing students. The study data suggests that dental hygiene faculty who use loupes and coaxial illumination also believe that all clinical faculty and students should be required to use magnification and

Table V. Relationships Between Coaxial Illumination Experience and Attitudes

Coaxial illumination experience	Do you currently use coaxial illumination in clinical practice?		χ^2	p -value
	Yes	No		
Used coaxial illumination while working as a clinical faculty member in the student clinic	94.4%	6.3%	30.015	$< .001$
Felt that faculty members in dental hygiene programs should be required to use coaxial illumination while overseeing patient care in the student clinic	94.4%	32.3%	17.831	$< .001$
Felt that dental hygiene students should be required to use coaxial illumination while providing patient care	81.8%	34.6%	11.077	$< .01$

Table VI. Relationships Between Coaxial Illumination Experience and Associated Benefits

	All respondents			Faculty using coaxial illumination for patient care		p -value
	n	Median	IQR	Yes	No	
Coaxial illumination increases the use of proper ergonomics	49	2.0	1.0-2.0	19.74 n=29	32.62 n=20	$< .001$
Coaxial illumination increases the accuracy of assessment and procedure	49	1.0	1.0-2.0	17.45 n=29	35.95 n=20	$< .001$
Coaxial illumination increases the efficiency of providing care	49	2.0	1.0-3.0	17.83 n=29	35.40 n=20	$< .001$

illumination due to perceived benefits of improved ergonomic postures, increased accuracy of assessments and procedures, and improved efficiency.

The use of magnification loupes is more prevalent among dental hygiene educators when providing patient care than when overseeing students in academic settings. Of the 80% of dental hygiene educators who used loupes in this study, 82% used loupes during patient care while 70% used loupes while working with students. In a study by Thomas et al of practicing dental hygienists, 71% of respondents used loupes when providing patient care²⁵ whereas more than half of dental hygiene educators used magnification loupes in clinical teaching settings.²³ When considering dental educators, Meraner et al. found that certain dental specialties, such as periodontics, endodontics, and general restorative dentistry, were more likely to use magnification loupes than other specialties.²⁴ The higher percentage of magnification loupe users among practicing dental hygienists may be due to the majority of clinical

practitioners working in periodontal or general dentistry settings. This study also found that dental hygiene faculty who use magnification loupes when providing patient care are more likely to use magnification loupes when working as a clinical faculty member.

The use of coaxial illumination follows a similar trend with a higher prevalence among dental hygiene educators when providing patient care than when overseeing students in academic settings. Of the 54% of dental hygiene educators using coaxial illumination, 57% used illumination when delivering patient care but only half used illumination when working as a clinical faculty member. Coaxial illumination usage in this study was less than the 71% of dental educators reporting the use of coaxial illumination in conjunction with magnification loupes from one institution.²⁴ A lack of evidence exists in the literature regarding the use of coaxial illumination among practicing dental hygienists however, results from this study demonstrated that dental hygiene faculty who use coaxial illumination when providing patient care are more likely to use illumination in their role as a clinical faculty member.

Dental hygiene educators in this study perceived the benefits of improved ergonomics, increased accuracy of assessments and procedures, and increased efficiency of providing care resulted from the use of magnification loupes and coaxial illumination. In previous studies, both dental educators and practicing dental hygienists agreed that one of the benefits of using magnification loupes included improved overall quality of care.²³⁻²⁵ Despite the literature identifying improved ergonomic benefits from the use of magnification loupes,^{1,14} dental hygiene educators were more skeptical than practicing clinicians regarding the ergonomic benefits.²³⁻²⁵ However, other factors, such as the overall cost or the necessary learning curve for adjusting to loupes, may hinder the adoption of magnification among some dental hygiene educators.²³

The present study revealed that although most dental hygiene faculty utilize magnification loupes, only half of the respondents' dental hygiene programs required the use of loupes by students and only a few mandated the use of loupes by clinical faculty. In regards to coaxial illumination, a limited number of respondents indicated that their dental hygiene programs mandated students to purchase a headlight however none of the programs required clinical faculty to purchase a headlight. Further analysis showed that dental hygiene faculty using magnification loupes in clinical practice were more likely to support of the required use of loupes by students and clinical faculty. Dental hygiene faculty using coaxial illumination in clinical practice were also more supportive

of requiring the use of coaxial illumination by students and clinical faculty. Attitudes of dental hygiene educators surveyed in this study aligned with mandating student requirements for the use of magnification and coaxial illumination.

Differing views exist regarding the required use of magnification loupes by students and clinical faculty. Previous studies have shown that dental educators using magnification loupes were not entirely supportive of mandating students and clinical faculty members to use magnification loupes.^{20,24} Dental hygienists with a history of using magnification loupes in clinical practice have been shown to support the required use of loupes by students during their first year due to the perceived benefits of loupes.²⁵ Although the occasional user and non-users of magnification loupes stated the use of loupes would be beneficial when delivering patient care, most favored having the option, rather than the requirement of purchasing and using loupes while in school.²⁵ Enforcing student requirements to use magnification loupes and coaxial illumination may become problematic if the clinical faculty themselves are not compliant with the use of magnification loupes and coaxial illumination. Financial support from dental hygiene programs towards purchasing magnification and illumination may help increase their use among dental hygiene educators.

This study had several limitations. Distribution of the online survey relied on program directors to disseminate the survey to their dental hygiene faculty. Since the program directors were not asked how many faculty members were sent the online survey, the sample size could not be calculated. The survey relied on faculty self-reported data and did not ask respondents whether they worked in clinical practice. Future studies should address these limitations and include a larger number of programs. Other instruments could be used to quantitatively measure the benefits from using magnification and coaxial illumination to expand the information gained from the self-reported data in the present study,

Conclusion

Dental hygiene faculty using magnification loupes and coaxial illumination themselves, supported the requirement of clinical faculty and students to use loupes and illumination because of the perceived benefits of improved ergonomic postures, increased accuracy of assessments and procedures, and improved efficiency. However, a disparity exists regarding the use of magnification loupes and coaxial illumination among dental hygiene faculty working in clinical practice settings and academic settings, and dental hygiene students. Financial and logistic barriers should be identified and addressed prior to

mandating the use of magnification and coaxial illumination by clinical faculty and dental hygiene students.

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