Work 35 (2010) 419–429
DOI 10.3233/WOR-2010-0979
IOS Press

Review Article

Musculoskeletal disorders of the neck and shoulder in the dental professions

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Received 20 August 2008
Accepted 18 April 2009

Abstract. The prevalence of and risk factors for neck and shoulder disorders among dental practitioners (dentists, dental hygienists, and dental assistants) is reviewed. Dentists report 26–73% period prevalence of neck symptoms over the previous year, and 20–65% with shoulder symptoms. Dental hygienists report even higher rates, from 54–83% for neck and 35–76% for shoulder, and dental assistants in between (38–62% and 27–62% respectively). Symptoms begin to appear early in the career, with significant increases upon starting clinical practice. Significant social and economic consequences have been reported, including leaving the profession or reducing hours. While ergonomic improvements appear to have some positive impact, these have not been well studied, and some changes (such as the historic shift from standing to seated posture) may have moved risk from the lower back to the upper extremities. Static awkward posture, particularly those with isometric contractions of the trapezius, has been identified as a risk factor particular to these occupations. Ergonomic improvements, health promotion, and organizational interventions have been suggested as needs for reducing risk.

Keywords: Ergonomics, cumulative trauma disorders, musculoskeletal disorders, dental hygienists, dental assistants, risk factors, neck and shoulder disorders

1. Introduction

Dentists, dental hygienists, and dental assistants experience most of the risk factors typically associated with musculoskeletal disorders (MSD), including force, repetition, and awkward and (particularly) static postures. While the American Dental Association contended (in response to a proposed OSHA ergonomic standard) that ergonomic risks are fairly low in dental practice due to ergonomic equipment, flexible task scheduling, breaks between the highest risk tasks, and only moderate hand forces [8] most of the literature concludes that there remain major problems to be addressed. This article will focus on the neck and shoulder regions, which has been found to trail only back pain in reported MSDs among general dentists and specialists, and was the most prevalent MSD among dental hygienists and dental assistants in a large national US survey [17,19]. This article will analyze the prevalence of neck and shoulder musculoskeletal disorders in subsets of dental professionals (dentists, dental hygienists, and students), synthesize the risk factors known to contribute to neck and shoulder conditions, and then present strategies that may prevent or minimize the development of neck and shoulder MSDs in these dental populations. This review is meant to include all relevant studies related to neck and shoulder disorders in the dental professions rather than a systematic distillation of studies meeting a threshold of quality, and as such includes a range of methodological approaches and rigor. Table 1 provides a systematic

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assessment of the studies that were located for dental workers that included neck and shoulder symptoms to enable the reader to evaluate these variations. The table includes sample sizes, response rates, prospective vs. cross sectional, community-based vs. special population samples (such as conference participants or student classes), and notes on methods.

In addition to literature already known by the authors from prior articles and work in this area, the literature was searched using multiple databases (PubMed and Medline, Google Scholar) and search terms (including combinations of search terms for specific dental professions and musculoskeletal, MSD, neck and shoulder MSD, and ergonomics). Within databases, we followed links from articles on neck and shoulder MSD in dental workers to related articles until new articles were no longer found. Since there is a relatively modest amount of literature in this particular area, we did not have exclusion criteria for articles. We posed unique interpretations and questions based on the current literature review and developed recommendations to reduce the prevalence of MSDs in the neck and shoulder based on these findings.

1.1. Prevalence of neck and shoulder musculoskeletal disorders in dental professionals

The frequency of MSDs in the neck and shoulders has been documented in the literature (with varying consistency) among dental professionals. A 2001 review reported a range of 17–31% of general dentists and specialists with neck symptoms, and 24–28% for dental auxiliaries; the ranges for shoulder symptoms were 15–25% for dentists and 22–26% for auxiliaries, based on 11 reviewed articles [19]. An updated review (Table 1) for neck symptoms found a range of 17–73% (dentists), 54–83% (dental hygienists), and 38–62% (dental assistants). For shoulder symptoms, ranges were 20–65% (dentists), 27–76% (dental hygienists), 62% (dental assistants), and 6% for a study of dental and dental hygiene students.

While dental chairs and other dental equipment and fixtures have improved considerably in relation to adjustability and other ergonomic features, there remains a frequent need to bend and twist the neck and upper back to visualize the oral cavity (particularly if using direct visualization). The force, repetition, and static posture from the use of dental instruments can add to this load [18], in addition to tasks such as retrieving instruments, mixing materials, adjusting equipment, using high frequency vibrating tools and obtaining patient/operator positions [49].

1.2. Economic impact of neck and shoulder pain

MSDs among dental personnel have economic as well as health effects. Shugars estimated that dentists lost over $40 million (in 1987 dollars) and cancelled 1.3 million patient visits due to MSDs. Dental hygienists with MSDs reported reducing days worked, reduced speed and quality of work [19,28,35,43], and increased use of sick leave (which increased also in relation to role ambiguity and poor social and work climates) [36]. In addition, MSDs are frequent contributors to decisions to leave the dental hygiene profession. In a survey of 10,000 US hygienists, 18% of those who permanently left the profession cited work-related disability, in particular MSDs, as influential in the decision to leave; a similar U.K survey found 30% of those that left attributed it to MSDs [9,29].

This paper presents a review of the literature in relation to MSD of the neck and shoulder for dentists, dental hygienists, and dental assistants.

2. Epidemiology of neck and shoulder pain in dental professionals

High rates of occurrence of upper-extremity musculoskeletal disorders (MSDs) in dental professionals are well documented, including regional neck and shoulder pain, shoulder tendonitis, neuropathy, tension neck syndrome and trapezius myalgia [2,3,5,6,10–13,19,23, 35,41,54,57,61]. A Swedish survey found that 81% of 945 female dental workers reported an upper-extremity MSD [21], although results for neck and shoulder symptoms were not reported. Morse, in a study that included both survey and physician evaluation, found a high level of agreement between self-reported neck symptoms and the physician-diagnosed findings (83% of subjects who reported no symptoms also had normal exams, and 57% of subjects who reported symptoms also had physical exam abnormalities), although the correlation was not as strong for shoulder symptoms [30]. Overall, this suggests that surveys are reasonably valid measure of upper extremity MSDs.

2.1. Dentists

Many of the dental studies have been done outside of the U.S. A survey of 355 dentists in New South Wales found 81% reported some musculoskeletal symptoms and/or headaches in the past month, primarily in the hands and wrists, with 32% reporting neck symp-

Table 1
Neck and shoulder MSD in dental workers

				% Symptoms previous 12 Months					
Study	Country	n	Response	Neck	Shoulder	N or S	Type	Sample	Notes
Dentists									
Akesson, 1999	Sweden	30	100%	73	65	85	Prospective	Community	Female only
al Wazzan, 2001	Saudi Arabia	91	82%	64	–	–	Cross	Community	
Alexopoulos, 2004	Greece	430	88%	26	20	–	Cross	Community	
Finsen, 1998	Denmark	99	86%	54	40	62	Cross	Community	Also field study
Lalumandier,, 2001	US (Army)	1286	81%	26	21	–	Cross	Army	“Frequent” pain/sore
Leggat, 2006	Australia	285	73%	58	53	–	Cross	Community	
Marshall, 1997	Australia	355	80%	32*	8*	–	Cross	Community	In previous month
Ratzon, 2000	Israel	60	95%	38	–	–	Cross	Community	Also field study
Rucker, 2002	Brit. Columb.	421	43%	61	44	–	Cross	Recent grads	
Rundcrantz, 1990	Sweden	359	91%	54	53	–	Cross	Community	
Stockstill, 1993	U.S.	1051	98%	46*	–	–	Cross	Community	Peripheral neuropathy only
Dental Hygienists									
Akesson, 1999	Sweden	30	100%	54	68	82	Prospective	Community	Female only
al Wazzan, 2001	Saudi Arabia	12	82%	67	–	–	Cross	Community	
Anton, 2002	U.S.	109	100%	65	57	–	Cross	Conference	Work-related only
Liss, 1995	Canada	950	50%	69	50	–	Cross	Community	
Lalumandier, 2001	US (Army)	177	81%	28	26	–	Cross	Army	“Frequent” pain/sore
Morse, 2007	U.S.	94	24%	72	35	–	Cross	Community	Also Phys. Exam
Oberg, 1993	Sweden	28	100%	62	81	–	Cross	Class	
Stentz, 1994	U.S.	260	56%	39*	–	–	Cross	Community	Right shoulder only
Szeluga, 2001	U.S.	245	57%	83	76	–	Cross	Community	
Werner, 2002	U.S.	305	NA	–	13*	–	Cross	Conference	Diagnosis of shoulder tendonitis
Yee, 2005	U.S.	529	37%	75	61	–	Cross	Community	“Discomfort”
Ylipaa, 1999	Sweden	495	86%	68	72	–	Cross	Community	61% and 64% for work-related
Dental Assistants									
Akesson, 1999	Sweden	30	100%	62	62	77	Prospective	Community	Female only
al Wazzan, 2001	Saudi Arabia	72	82%	38	–	–	Cross	Community	
al Wazzan, 2001	Saudi Arabia	29	82%	62	–	–	Cross	Community	
Liss, 1995	Canada	108	50%	56	27	–	Cross	Community	
Lalumandier, 2001	US (Army)	950	81%	25	22	–	Cross	Army	“Frequent” pain/sore
Students									
Morse, 2007	U.S.	66	46%	42	20	–	Cross	Community	DH; Also Phys. Exam
Rising, 2005	U.S.	271	85%	–	–	43	Cross	4 Schools	Dental
Thornton, 2008	U.S.	590	NA	29	19	–	Cross	4 Schools	Dental
Werner, 2005	U.S.	232	43%	–	1.7*	–	Cross	3 Schools	Dental; Diagnosed shoulder tendonitis
Werner, 2005	U.S.	343	43%	–	6	16%	Cross	3 Schools	Dental & DH; Under 30 years old
Werner, 2005	U.S.	111	43%	–	3.6*	–	Cross	3 Schools	DH; Diagnosed shoulder tendonitis

toms [26]. A survey of 283 Australian dentists found 58% reporting neck symptoms (with significantly more females reporting symptoms), and 34% reporting upper back symptoms (with higher rates for older and more experienced dentists) [20]. Over one-third had sought medical treatment for the symptoms during the previous 12 months, and 91% had taken sick leave, with an average of 11.5 days of leave [20]. Symptoms were reported to interfere with daily activities in 25% of neck cases and 22% of shoulder cases [20]. A survey of 421 (43% response rate) dentists in Canada found 61% reporting neck pain and discomfort and 44% shoulder pain and discomfort; 19% reported decreased recreational activity because of the MSD [39]. A survey of 60 male dentists in Israel found 38% reporting neck symptoms in the past 12 months, 28% in the past 7 days, and 8% unable to do normal work due to the symptoms. Shoulder symptoms were 25%, 15%, and 7% respectively [37]. These studies show consistently high frequencies for neck and shoulder pain across international studies that are causing both discomfort and difficulty with functional daily activities, which

indicates a high level of severity.

A Greek study found 62% of dentists reporting MSD, 30% chronic complaints, 16% spells of absence, and 32% sought medical care [4]. A Swedish survey found 72% of dentists reported neck or shoulder pain or headaches [40]. A follow up visit of 143 dental offices found that 96 (67%) had signs of cervico-brachial disorders and discomfort [40]. In a Danish survey, just over half of surveyed dentists reported ache, pain, and discomfort in the neck, and 40% in the shoulder over the previous year, with approximately 20% reporting such pain in the previous week, with some indications that younger dentists and those that worked longer hours had more complaints [16].

Al-Wassan et al. found that 54% of a sample of 204 dental professionals in five dental offices in Saudi Arabia (dentists and dental professionals, including 12 dental hygienists) experienced neck pain. The frequency of neck pain was significantly higher ($p = 0.01$) in dentists than other dental professionals [3]. A Danish survey of 99 dentists found that 26% took no break longer than 10 min all day, 48% took 1 break, and 26% took more than 1 break [16].

In the US, a survey of 1015 dentists in Nebraska (98% response rate) found 294 (29%) with symptoms of peripheral neuropathy, with 46% of those locating the problem in the neck [46]. Overall, 16% reported constant symptoms, and 41% had symptoms while working [46]. Neck pain therefore appears to be pervasive and dentists are not taking activity breaks that could potentially reduce symptoms.

2.2. Dental hygienists and dental assistants

The reported prevalence of general musculoskeletal pain and neuropathy in dental hygienists ranges from 60% [35] to 96% [41,47], depending on the specific population studied (dental hygienists or dental hygiene assistants) and the research measures employed. The study that found an overall 96% prevalence of musculoskeletal pain amongst hygienists was from a mailed survey in Kentucky to 433 licensed dental hygienists ($n = 245$ responses) utilizing a body diagram, with the neck, shoulder, and back as the most frequent symptom locations [47]. Similarly, a written questionnaire completed by all 109 attendees at a dental hygiene continuing education conference found 93% reporting at least one job-related ache, pain, or discomfort in the previous 12 months [5].

Studies that examine only upper extremity neuropathy (generally excluding the back and sometimes neck) still show high prevalence rates. Approximately 60% of 260 practicing hygienists (56% response rate) reported symptoms related to upper extremity neuropathy alone (self-reported "altered sensations", with the most common being pain, tingling, and numbness) based on a survey of licensed dental hygienists in Nebraska; 16% indicated they had been medically diagnosed with an upper extremity neuropathy [45]. Fewer studies have examined the prevalence of MSDs in specific body regions and the specific risk factors (biomechanical and psychosocial) associated with pain in these regions. The neck/shoulder region has been reported as of concern but not studied in depth.

Prevalence rates for subjective neck pain or shoulder pain can also vary greatly depending on such factors as the response rate (those with pain may be more likely to respond which would bias estimates upward for lower response rates), the broadness or narrowness of the definition of pain and/or neuropathy used, and the time frame for recall. Szeluga found subjective neck pain prevalence rates as high as 82% (75.9% for shoulder) in a mailed survey of 433 dental hygienists in Kentucky, although only 5.4% reported missing work because of the pain [47]. Yee found 75% of 529 dental hygienist respondents (37% response rate) reporting neck discomfort over the prior 12 months, and 61% reporting shoulder discomfort in a mailed survey of licensed hygienists in two California counties [57]. In a small non-representative Swedish study of hygienists in an ergonomics class, 62% reported complaints associated with the neck and 81% with one or both shoulders during the previous 12 months [34].

Several studies have focused more on physician defined diagnoses than subjective prevalence of pain symptoms. Akesson reports that 81% of a sample of 30 dental hygienists had specific neck/shoulder findings on physical examination, and 43% were diagnosed with specific neck or shoulder MSDs including tension neck syndrome and trapezius myalgia. Werner et al. looked at shoulder tendonitis and found that 13% of a sample of 305 dental hygienists fit the clinical definition based on a physical examination [55].

Prevalence rates also depend on the type of population queried. Dental assistants perform different tasks than hygienists in many offices. Akesson found that 65% of dental assistants had general MSD pain; 35% of those fit the clinical criteria for specific MSD diagnoses. The prevalence of Tension Neck Syndrome (TNS) in dental assistants was 21.4% [2]. Clearly, wide disparities exist in the measuring and reporting of neck pain, as well as other MSDs, among dental hygienists.

These factors can impact the response to the problem, since employers may be more concerned about lost work time than simple discomfort, yet ergonomic interventions are typically more effective when implemented during the earlier phases of an MSD. Overall, however, the rates are high based on almost any definition and so response is warranted.

2.3. Dental and dental hygiene students

The data on MSDs in dental and dental hygiene students is sparse in comparison to prevalence data for dental professionals. However, there has been more recent attention given to students either as a control group or as a newly exposed group [30,31,54]. Werner found much lower rates of MSDs among dental and dental hygiene students than among a comparison group of clerical workers, finding just 6% with shoulder complaints and 16% with shoulder or neck complaints, with 1.7% of dental students and 3.6% of dental hygiene students having physician-diagnosed shoulder tendonitis [54]. However, this study only included students that were less than 30 years of age. Morse found self-reported neck symptoms were 37% for dental hygiene students, 43% for dental hygiene students who had previously been dental assistants, and 72% for experienced dental hygienists; physician-confirmed neck findings were 22% (DS), 38% (DA) and 47% (DH) respectively. Shoulder pain in the last 12 months was reported by 26.9% of respondents overall. This was significantly different for the three groups (Pearson chi-square $=$ 8.2, $p = 0.016$), with 11.1% for students, 17.9% for students/assistants, and 35.1% for experienced hygienists. Symptom frequency increased across groups for daily or constant pain, from 0% for students to 5% for student/assistants to 15% for experienced. Experienced hygienists were 2.3 times (95% CI $=$ 1.1–4.6) more likely to have some neck or shoulder findings (excluding winging) than students [30].

Although dental hygiene students generally have less cumulative duration of exposures, they gradually increase their exposures throughout their clinical training, and some studies found a corresponding increase in symptom prevalence. In a survey of 271 California dental students, over 70% of students reported chronic MSD by the third year with highest rates associated with the 3^{rd} year of school (the year reported in another study to have the most clinical hours [49]). In a study of California dental students, female students reported the neck and shoulders as the most affected regions (and also reported higher levels of pain than males), while back complaints were more common in male students [38]. The study also found that 46–50% of female students had neck or shoulder pain, and 29–58% of males; 65–85% of dental students who had previously worked in the dental field reported some type of MSD pain; and pain was related both to fatigue and to stress [38]. A new survey of 590 US dental students found similar results, with 48% reporting neck symptoms and 31% shoulder, also with highest rates in the 3rd year [49].

Morse et al., in the pilot phase for a broader study, found 46% of dental hygiene students reporting upper extremity pain (neck and shoulder), with increasing symptoms in later years of training [31], in general agreement with Thornton. In another pilot study, Barry et al. noted an increase in musculoskeletal pain and an increase in non-neutral posture for 9 students over the course of dental hygiene education, extending into the first two practicing years [7]. However, Werner et al., reported no differences by year in school [54]. Collectively, these studies indicate that dental practitioner students are not an unexposed or symptom-free population. These studies suggest that prevention programs should be introduced into dental education to prevent musculoskeletal discomfort during educational and professional years.

In sum, rates of neck and shoulder MSD are very high for all types of dental workers. A simple average of the studies reported in Table 1, using the n of each study times the prevalence rate (not adjusting for different definitions of conditions, response rates, etc.) can give a rough estimate for prevalence: an average of 41% of dentists, 66% of hygienists, 30% of assistants, and 30% of students report neck pain, and 30%, 53%, 24%, and 11% respectively for shoulder pain. While a number of these symptoms are not currently disabling, these studies also point to quite high levels of impact on chronic health, missed days and reduced income, and a significant negative overall impact on daily life.

3. Risk factors for MSD in dental professionals

In addition to the epidemiology of MSDs, the risk factors for MSDs have been investigated in order to identify and develop intervention strategies to minimize risks.

Multiple authors have noted that MSD risk factors for dental workers (and workers more generally) are multifactorial, including static and awkward postures (particularly in relation to neck and shoulder condi-

tions), repetition and force (more commonly related to hand and arm conditions), poor lighting (both intensity and positioning), improper positioning of both patient and dental worker, individual characteristics (physical conditioning, height, weight, general health, gender, age), and stress [30,41,42,49,50,52,58,60]. A thorough review of both the biomechanical and the psychosocial risk factors for MSD in dental professionals is justified in order to examine the full extent of the problem.

3.1. Biomechanical risk factors

Yamalik's extensive review of risk factors affecting dental workers noted the following specific dental tasks as risks: limited range of motion (constrained postures) resulting in isometric muscle contractions, difficulties in direct visualization (which causes awkward posture), visual demands requiring static postures, repetitive tasks for long periods including scaling and endodontic procedures, long surgical procedures, forceful clinical tasks such as scaling, and high precision and flexion for instrumentation [56]. Static postures, particularly of the trapezius muscle, have been noted as particular problems for dental workers in relation to neck and shoulder conditions, based on laboratory and other studies [16,27]. Forward head postures can lead to more chronic rounded shoulder posture, which can contribute to rotator cuff impingement and shortening of the pectoral musculature when combined with reaching for instruments [52]. One observational study of 204 workers in a range of dental occupations found 84% had neck bending while working [3].

Specific dental occupations may be at risk for different types of MSD in part due to the different types of postures inherent in each occupation [41]. In dentists, head rotation, neck flexion and the necessity of upper arm abduction for mirror usage are common risk factors for upper extremity disorders. A Swedish study of 143 site observations found that dentists with cervicobrachial disorders kept their head bent to the side and rotated to a greater extent than dentists without symptoms [40]. Risk for trapezius pain may also be heightened from holding the arm elevated for long periods, such as holding a mirror for indirect visualization [52]. Marshall found that 87% of New South Wales dentists sit when treating patients, and 65% practice 4-handed dentistry (work with an assistant) [26]. Valachi noted that general practitioners tend to be susceptible to lower back and neck injuries due to prolonged static postures, but have relatively fewer repetitive-motion injuries [52].

3.1.1. Quantifying awkward postures

Neck flexion was common in a small lab study of 8 dentists, exceeding 15 degrees for 97% of work time, and 30 degrees for 82% [16]. Upper arm abduction over 30 degrees occurred approximately 1/3 of the time, which can increase muscle pressure of the supraspinatus muscle, and there was high static muscle load in the neck and shoulder regions [16,34].

Dentists often rotate their necks to the left with side bending to the right for better visibility. Valachi notes that this is likely to strengthen the muscles on one side while weakening the opposing muscles, thus resulting in the inability to rotate the neck to the right with side bending to the left [40]. Similarly, the forward viewing posture frequently used by dental workers can lead to weakening of the stabilizer muscles of the shoulder blades, leading to rounded shoulder posture [52]. Several studies have noted an association of headaches with neck and shoulder pain [26,27,40].

A biomechanical study of 10 orthodontists (primarily students) observed characteristic postures including a forward lean, neck forward flexion between 50–95 degrees, and shoulders flexed and abducted between 0–90 degrees, combined with extensive static posture [32].

Studies of MSDs in dental hygienists have focused more on upper extremity and neck disorders than lower back injuries. Valachi suggests that the historic change in dental workers from standing posture to typically seated posture has not reduced the rate of MSD [26], but that the part of body affected has moved from the back to the neck, shoulders, and arms largely due to static postures combined with forceful, repetitive movements [52]. Dental hygienists frequently work with neck flexion over 30 degrees, with side bending or rotating, and shoulder abduction over 45 degrees [41]. In an observational study of 10 dentists and 10 dental hygienists, Marklin and Cherney found that hygienists flexed their necks at least 30 degrees 86% of the time, with shoulders abducted (elevated to the side of the trunk) at least 30 degrees for 45% and 34% of the time (left and right side respectively) [25]. These postures may be combined with high static loads and fatigue in the trapezius muscles [16,27]. Smith et al. note that dental hygiene tasks are similar to dental tasks, where high levels of flexion and rotation of the neck have also been observed [44]. Barry suggests in a small longitudinal study that there may be a change to forward-leaning posture when dental hygienists move into the working environment that may contribute to an increase in neck and shoulder pain [7]. Yee et al. suggest that amount of usage is more important than workstation

design, since they found that handedness was a clear determinant of whether dental hygienists had left or right sided pain [57]. Bramson et al. found in an videotape ergonomic analysis of 15 dental hygienists that shoulder risks averaged 4 on a 7-point scale (based on a combination of postures, force, frequency, duration, past injuries and present discomfort), and neck risks averaged the maximum of 7 [8].

Morse, in a study of dental hygienists (methods are described in Morse et al. [30]) found a clear stepwise increase in self-reported biomechanical risk factors from dental hygiene students, students who were also dental assistants, to experienced dental hygienists (see Fig. 1).

A more general review (not just dental workers) found a well-documented relationship between problems in the shoulder joint area (such as rotator cuff syndrome) and dynamic work with heavy loads, and problems in the upper shoulder and neck area with repeated or sustained exertion in awkward or static postures, even with low external loads [15]. Diagnoses such as tension neck syndrome (TNS), involving painful neck spasms and trigger points, have also been associated with this latter type of loading pattern, which is common in dental hygiene work [41].

Students may be at particular risk as they move into clinical practice due to working alone, which appears to increase postural risks; left handed students have been shown to have higher neck and shoulder MSD [48–50], with hours spent cleaning teeth marginally related [30].

In sum, postural risk factors appear to be widely present in all dental occupations and also appear to be related to neck and shoulder symptoms, and these appear to increase cumulatively as students move into practice. These are likely aggravated by repetition and force, particularly noted in dental hygienists.

3.2. Psychosocial/work practice and combined psychosocial/biomechanical risk factors

Biomechanical risk factors are not the only risk factors that must be considered when examining MSDs in the dental population; psychosocial factors have been studied both singly and in combination with biomechanical risks. Psychosocial factors include such issues as the organization of the job, job demands (number of workers seen, the hours worked), job control, style of supervision, and support amongst coworkers among others. Work-home conflicts have also been studied in relation to stress and related musculoskeletal pain.

The vast majority of 5,120 surveyed U.S. Army dentists and dental hygienists worked approximately 40 hours per week, and saw 31–50 patients a week depending on specialty [18]. A Swedish survey found that dental hygienists with MSDs were more likely to work longer hours and see more patients per day than those without MSDs [36], although another Swedish survey found MSDs decreased with more weekly work hours [58], the latter study suggesting that there may have been a “healthy worker effect”, where those with MSD decreased their work hours.

Dental hygienists and assistants may be more affected by work-family conflicts and demands, since they are primarily female, and thus, typically have more caregiver demands [60]. The extent of scaling work, work relations, smoking, dealing with uncooperative clients, and work-family overload were the major associations with neck and shoulder MSD in a sample of Swedish dental hygienists [60]. Crawford, in a qualitative focus-group study, found that dental hygienists thought that ergonomic risk factors were overlooked due to their lower status and frequent part-time status, and so responded to risks and pain more frequently through cutting hours rather than through ergonomic improvements [13]. While this may be a reasonable temporary solution for some individuals in some situations, improving ergonomics and the psycho-social environment could preserve income and the longer-term availability of skilled workers.

A Greek survey of 430 dentists explored associations between self-reported physical and psycho-social variables and symptoms (and chronic symptoms lasting over a month or with absenteeism). The strongest univariate relationships with shoulder MSD were from vibrating tools (OR = 2.9), high exertion (OR = 2.5), high need for recovery (OR = 2.0), and high job demand (OR = 1.9). For neck, the strongest were high exertion (OR = 2.4), high need for recovery (OR = 2.0), low job control (OR = 1.8), and repetitive shoulder/hand movements (OR = 1.8) [4]. Psycho-social variables mostly dropped out in multivariate associations, although long working hours are related to job demands; and low control was found to be associated with co-morbidities. The study reported that self-reported physical workload (repetitive movements, awkward working postures, prolonged sitting or standing, strenuous arm positions, arm abduction, elevated arms, and use of vibrating tools) increased the risk of shoulder MSD by an odds ratio of 2.6 [4].

Historic trends towards higher efficiency (such as increased patient visits for dental hygienists) may also have increased MSD risks [60]. In addition, there may also be relationships to personal characteristics (such

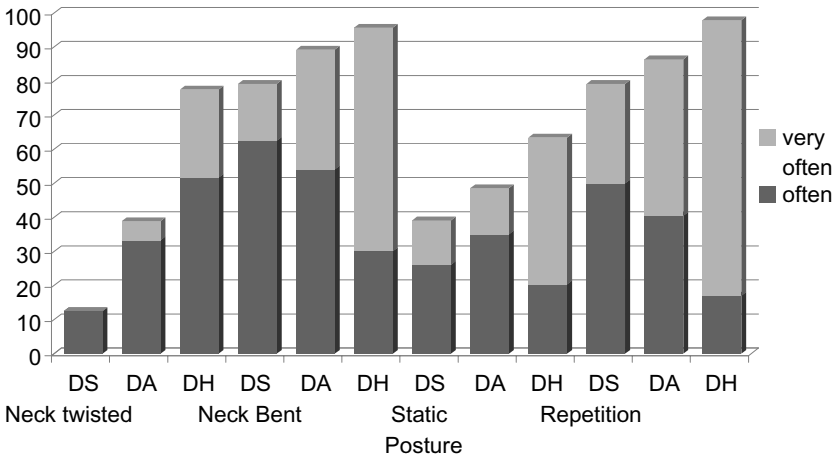

Fig. 1. Biomechanical Risk Factors for Dental Hygiene Students (DS, $n = 27$), Dental Hygiene Students who previously were Dental Assistants (DA, $n = 39$), and Experienced Dental Hygienists (DH, $n = 94$), CT, 2001 (Morse).

as height), high visual demands [44], workplace organization [13], and lack of recovery time that add to the risk of developing a musculoskeletal disorder [33,41]. A Swedish survey found that active leisure decreased the odds for upper extremity MSD, and work (including hours worked) and family overload increased the odds [60].

4. Prevention of neck and shoulder disorders in dental professionals

Several published studies have addressed recommendations for prevention for dental workers, but there have been essentially no controlled intervention studies, so recommendations have tended to derive from trying to reduce associated risk factors based on cross-sectional epidemiological studies, or small, lab based assessments of levels of risk factors. This lack of randomized controlled intervention trials was noted by Linton as a severe problem more generally (not just dental workers) for interventions on neck and back pain, including ergonomic interventions [22], with only exercise programs having sufficient study/support for clear recommendations.

Following a large US Army symptom survey and literature review, Lalumandier suggests that MSDs can be reduced through proper positioning of dental worker and patient, regular rest breaks, general good health, and exercises designed to counteract the particular risk factors for the dental occupation. Postures to avoid include head forward, rounded shoulders, and bent back. Recommendations included an (1) an adjustable ergonomic stool with lumbar support and capability to rotate, (2) dentists sitting with feet flat on floor and thighs parallel to the floor and dental assistants 4–6" higher and using a footrest on the stool, (3) patients reclined fully with mouth at the dentist's elbow height for maxillary arch tasks and lowered with a 20 degree incline (still with mouth at dentist's elbow height) for mandibular arch tasks, (4) proper lighting and indirect mirror viewing, (5) regular resting from static postures particularly for the trapezius and forearm muscles, and from repetitive motions of the forearm and hand (minimum of 6 minutes per hour and 10–15 minutes every 2–3 hours), (6) exercises during those breaks, such as relaxing the arms at the side and shaking, or moving limbs and muscles in the opposite direction of repetitive or static postures between patients (such as bending the neck backwards after prolonged forward tilt), (7) observing recommended practices for nutrition and regular leisure exercise, and (8) using shoulder blade repositioning and chin tuck exercises for neck pain [18]. Many of these recommendations are supported by other authors, but none of these recommendations were based on intervention studies, and appear to be derived primarily from application of general ergonomic practices and findings to dental practice risk factors [41,42, 51,56].

Thornton, based on a biomechanical and survey study of 590 dental students (and observation of practice areas for the 4 participating schools), recommends an adjustable stool with integrated lumbar and arm support, proper lighting (such as for maxillary treatment, having the overhead light close to the operator's line of vision), and having the patient reclining [49].

Such approaches can be developed for individual situations by evaluating individual characteristics and symptoms, postures, instrumentation, environmental, and organizational factors in relation to workplace improvements [42,51]. Qualitative responses from dental hygienists suggest ergonomic design characteristics include patient chairs able to go sufficiently low (particularly for smaller stature hygienists), adequate space in the room for moving the stool around easily, dental instruments that are sized properly for smaller hands and are lightweight, sufficient lighting, magnifying loupes available, and addressing psycho-social issues such as control over scheduling, social isolation (hygienists tend to work alone, in contrast to dental assistants), inadequate recognition and professional satisfaction [13].

Thornton recommends training on both ergonomics and stress reduction in dental schools as a prevention strategy based on a non-systematic literature review [50]. While a recent survey by the American Dental Association found that some ergonomic training was common in dental professions education (98% of dental hygiene programs reported some ergonomic training), the survey did not address the extent of the training, such as the number of contact hours. For example, there was not a separate course in ergonomics in any of the dental hygiene programs [1]. Given the magnitude of risk, further attention should be given to ensure adequate training as well as on-going assessments of practices in training, and specific attention should be given to students with previous experience as dental assistants, since risks appear to be higher, and controlled trials are urgently needed to properly assess effectiveness of interventions.

Properly selected and positioned magnification systems can help reduce forward posture, including keeping forward flexion of the neck below 20 degrees. A randomized postural assessment using four observers of 35 dental hygiene students found significantly improved posture as a result of using magnification loupes [24]. Valachi and Valachi, based on a non-systematic literature review and biomechanical and physical therapy principles, had multiple specific recommendations for dental workers, such as relaxing and stretching neck muscles, exercising, using 2X magnification, proper positioning of chair and patient, alternating sitting and standing, and using properly adjusted armrests to reduce shoulder fatigue and allow reduced force due to more stable positioning of instruments [53]. Yamalik also performed a non-systematic but comprehensive literature review to produce a set of specific recommendations, including choosing ergonomic dental instruments that are lighter weight to reduce shoulder and neck fatigue and effects from holding static postures [56]. Better dental instrument handle sizes and shapes have been shown to reduce hand force in laboratory experiments, although it is unclear if this would have effects on the neck and shoulder [14]. Based on a cross-sectional survey of 94 student and experienced hygienists, Morse recommended a prevention program of reducing both neck bending and holding arms above shoulder height (through improved dental equipment, proper client positioning, stretching, and technique training), as well as increasing supervisor support [30].

An approach that is gaining widespread support based on theoretical models and general physical therapy and ergonomic principles is “active ergonomics”, as well as combining health promotion concepts with ergonomics [58–60]. These both speak to regular movement as important in reducing the impact particularly of static postures. This includes regular movement and changing of postures over the work day, as well as integrating exercise [22], stretching (particularly in the opposite direction of static and repetitive workplace postures), yoga, and/or relaxation exercises [3]. However, Rising found no association between MSD pain and regular exercise in a survey of 271 dental students [38], and both Marshall and Rundcranz found no difference in symptoms when dentists took regular breaks [26,40].

In summary, there are multiple suggestions oriented to reducing awkward and static postures which have a sound biomechanical basis, including adjustability, better visibility, and instrument design, but there are virtually no intervention studies that objectively assess an actual positive impact. Exercise and stretching also make sense from a biomechanical standpoint, but studies have not found a strong association with lower MSD rates. Intervention studies appear to be the single most important current research need, since the risks and levels of MSD have at this point been clearly established.

5. Conclusion

Neck and shoulder pain is second only to back pain in dentistry (and may be the most common complaint for dental hygienists) and may be occurring conservatively in 1 in 4 dental professionals. It has significant social and economic consequences, including quitting the profession or significantly reducing hours. While ergonomic improvements in the dental setting have im-

proved risk factors, sit down dentistry may have unintentionally transferred muscle forces and biomechanical loads from the low back to the upper extremities, and may be exacerbated by higher productivity demands in the profession generally and psychosocial considerations including social isolation among hygienists. Symptoms appear to begin very early in careers, with higher prevalence of MSD even during educational training as clinical hours increase.

Outcome or intervention studies will be important for examining the efficacy of proposed interventions, particularly (for neck and shoulder pain) in relation to chronic effects from static awkward postures. Combining ergonomic interventions (chair redesigns, magnification and lighting, activity breaks, organizational changes, creative use of part-time or rotating work) with health promotion activities (stretching that targets the under-utilized muscles, leisure exercise, work-family conflicts) need to be designed and evaluated. Since the evidence indicates that problems begin to occur even at the start of clinical training, such interventions should be introduced at the training level, partly to reduce risks during training, but also to get new practitioners to know the benefits so they can spread the word as they move into the workforce.

Acknowledgements

This research was sponsored in part by the National Institute for Occupational Safety and Health, under Grant #: U01 OH07312. The research was also supported in part by a General Clinical Research Center grant from NIH (M01RR06192) awarded to the University of Connecticut Health Center, Farmington, CT. We would like to thank the other members of the study team who contributed to earlier parts of this work, particularly Martha Sanders, Claudia Turcotte, and Martin Cherniack.

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