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Demographic and Occupational Risk Factors of Carpal Tunnel Syndrome among Dental students in their Final Year at King Abdulaziz University, Jeddah, Saudi Arabia

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ABSTRACT

Carpal tunnel syndrome (CTS) is a common peripheral compression neuropathy that accounts for 90% of all entrapment neuropathies. Dentists typically have a higher prevalence of work-related musculoskeletal disorders including CTS. Currently, there is a lack of literature on CTS prevalence and risk factors among dentistry in Saudi Arabia. Our study was the first to examine the prevalence and the associated demographic and occupational factors of CTS among dental students. This cross-sectional study was conducted in the School of Dentistry at King Abdulaziz University. A total of 120 dental students in their final year were included. We used a validated self-administered questionnaire that included demographic data, work, medical history, and a modified Katz's hand diagram to assess the symptoms and occupational exposures. Descriptive statistics and logistic regression were applied using SPSS software version 16. The prevalence of CTS among dental students was 13.3%. It was higher in females 10% compared to male 3.3%. There was a significant relationship between the body mass index (P= 0.03) with underweight category by having a higher prevalence of CTS. The use of finger pinch grip showed an inverse association with CTS (P=0.04). Other risk factors were not significantly associated with CTS. The prevalence of CTS among dental students was higher than the general population. However, many previously identified risk factors showed no significant association with CTS adding to the controversy of the contributing risk factors of this disease among dentistry. Finger pinch grip showed inverse association which was contrary to published literature. Future studies may include exposure time for each occupational risk factor preferably in a prospective cohort.

KEYWORDS: *Prevalence; Carpal Tunnel Syndrome; Hand Diagram; Occupational; Dentistry*

INTRODUCTION

Carpal tunnel syndrome (CTS) is a common peripheral compression neuropathy that results from the entrapment of the median nerve at the wrist [1]. CTS symptoms include tingling, numbness, or pain in the areas supplied by the median nerve within the hand. The palmar surface of the index, thumb and middle finger are the main affected areas. The symptoms usually worsen at night and are exacerbated by repetitive activity [2]. There has been a significant rise during the past 20 years in the number of cases of CTS [2] and is estimated to influence 3.1% of the national population per year [3]. CTS accounts for 90% of all entrapment neuropathies [4]. The results of a study found that the lifetime prevalence of CTS among workers was 6.7% [5]. Several occupations, including the meatpacking industry [6], manufacturing industry, health professions, dentists [2], office and administrative support were associated with CTS [5].

Although the main cause of most cases of CTS is unknown, many risk factors were found to predispose to CTS [3]. In previous studies, it was found that CTS is a multi-factorial condition, which can be affected by occupational, social, and psychological risk factors [2-3]. Additionally, there was a higher prevalence of CTS among females, diabetics, rheumatoid arthritis, and thyroid disease patients [2]. For example, the prevalence of CTS among working women was 4.5%, while it was 1.9% among working men [5]. Moreover, patients with obesity were four times more likely to develop a compression of the median nerve at the wrist [2]. Several occupations such as meat and fish processing plants have recorded a prevalence of CTS in their laborers to be as high as 73.9% [7]. Other occupations have shown the following rates among their workers; dairy parlor workers was 16.6% [8], computer workers were 16.7% [9] and grocery workers was 23% [10].

In comparison with other occupations, dentists typically have a higher prevalence of work-related musculoskeletal disorders including CTS. A study based in the United States (US) found that the prevalence of CTS among dentists was 5% in 2001 [2]. Additionally, musculoskeletal pain, especially back pain, has been found to be a major health problem for dentists, affected by posture and work habits, as well as other demographic factors [11]. The outcomes of a study from New South Wales (NSW), Australia in 1997 showed that 82% reported at least one musculoskeletal symptom in the past month and 64% reported backache during the previous month [12]. On the other hand, studies have suggested that dentistry produces more stress than any other profession, mainly due to the nature and working conditions [13]. It also was suggested that mental stress causes an increase in muscle tension comparable to that caused by a physical load. The mental stress and cognitive demands such as time pressure, repetitive tasks, lack of control, high demands, and poor social support were considered psychological factors associated with the rise in muscle tension and high prevalence of musculoskeletal disorders, mostly in the upper extremities including CTS [11].

CTS is one of the most common work-related musculoskeletal system disorders and it has been associated with multiple occupational and ergonomic risk factors. Repetitive motion of the wrist, and the use of force in an uncomfortable position of the hand and wrist have been linked in higher risk of CTS [14]. Additional ergonomic factors were also associated with an increased risk of CTS such as the use of vibration tool and use of forceful grip in fixed postures of the upper extremities [14-15]. For example, in 1991 a study from the United States was conducted among ski assembly workers showed that the prevalence of CTS was 15.4% among workers with jobs with repetitive motions and only 3.1% among workers in jobs without repetitive motions [16]. The Industrial Injuries Advisory Council in the United Kingdom found that highly repetitive extension and flexion at the wrist combined with a forceful grip showed more than double fold the risk of developing CTS [17]. Moreover, a study was conducted in Finland to estimate the relationship between exposure of physical workload factors and CTS showed that workers with work tasks that demand the use of vibrating tools had two times the risk of developing carpal tunnel syndrome [18].

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The results of studies showed a high prevalence of upper extremity musculoskeletal disorders, including CTS among dentists and dental hygienists [2]. However, there is a lack of literature on CTS prevalence and risk factors among dentistry in Saudi Arabia. Moreover, there was a controversy about the association of CTS with dentistry where literature showed a significant association [19-20] while other researchers claimed no association [21]. Therefore, our study was the first to examine the prevalence of CTS among dental students at the King Abdulaziz University in Saudi Arabia as well as the study of occupational risk factors that might be associated with CTS.

METHODS AND MATERIALS

The present cross-sectional study was conducted at the King Abdulaziz University School of Dentistry, Jeddah, Saudi Arabia in 2019-2020. All dental students from the last year at the King Abdulaziz University were eligible to participate in the study. A total of 120 female and male dental students in their final year were included. This represented an 80% participation rate of the total cohort. Our only exclusion criteria were confirmed CTS prior to admission to dental school.

The study used a validated self-administered questionnaire that was combined from different surveys. The questionnaire included questions on work, ergonomic, and physical exposures [22-24]. The questionnaire was followed by a modified Katz diagram [25-27], which depends on the patient's symptoms to diagnose carpal tunnel syndrome and showed effectiveness in diagnosing CTS [25].

The self-administered questionnaire was administered as an online survey to increase the response rate during the COVID-19 pandemic. Katz diagram was separated from the online questionnaire, then the participants were asked to complete the Katz diagram at training labs, in-person classes, worksites, and over the phone under the supervision of the research team members. The questionnaire was divided into four main categories, including demographic data, work history, medical history, and symptoms of carpal tunnel syndrome. The demographic data included questions on age, gender, height, weight, marital status, dominant hand, and other social questions. The second part was about work history, which included questions on the following: the use of repetitive movement, vibrating tools, forearm rotation, wrist or hand bending or twisting, forceful grip, thumb pressing, finger pinching, and the presence of a dental assistant during a typical workday. The third section included questions about medical history such as diabetes, thyroid disease, and rheumatoid arthritis. The fourth section contained the modified Katz diagram [25-27] for the assessment of symptoms of CTS including burning or Pain, tightness or stiffness, soreness/cramping/aching, and numbness/tingling. Only the participants who experienced any of the symptoms of CTS were asked to mark the anatomical distribution in the hand diagram. Participants were classified according to their symptoms into four categories as shown in Table 1[26-27].

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Table1. Scoring criteria for hand diagrams [23]

Rating	Description of area shaded on the hand
Classic	Tingling, numbness, burning or pain in at least 2 of the digits (thumb, index and long). Symptoms in palm and dorsum of hand excluded; small finger symptoms, wrist pain or radiation proximal to the wrist allowed. • For index and long digits, must include shading between the distal tip and the proximal finger crease volarly, and include >1/2 of the middle phalanx &/or some of the distal phalanx. For thumb, must include shading in the distal phalanx volarly. • Digit may include shading dorsally from fingernail to the distal MP mark on the hand diagram. • If joint of digit (including MP) is the only area shaded and less than half of two adjacent phalanges, this may be considered arthritic complaints.
Probable	Same shading as for classic but allowed the shading to extend into the palm volarly unless it was confined to the ulnar aspect of the palm.
Possible	Tingling, numbness, burning, or pain in at least one of the digits (thumb, index and long). • May include the dorsum of the hand
Unlikely	No shading of the primary digits or shading restricted to the dorsum of the digits only.

The criteria for the diagnosis of carpal tunnel syndrome were based on the presence of tingling, numbness, burning, or pain on a modified Katz diagram. Only those with classic or probable symptoms on the hand diagrams were included in the epidemiological case definition of CTS [18].

The hand diagrams were scored by four raters, including two general practitioners and two occupational medical physicians, each hand diagram was scored independently by the first and the second authors, a discussion was done with the remaining members of the team to rectify the discrepancy of the ratings and compatible ratings were reached.

Data analysis plan:

Descriptive statistics were provided for the study populations to determine statistically significant differences for frequencies and means, the Chi-square test and t-test were used, respectively. A two-tailed p-value at the level of 0.05 was deemed significant.

To examine the predictor variables of carpal tunnel syndrome, the logistic regression model was constructed. The main model consisted of the following predictor variables: gender, dominant hand, repetitive movement, vibrating tools, forearm rotation, wrist or hand bending or twisting, forceful grip, thumb pressing, finger pinching, and the presence of a dental assistant. Also, potential confounders were added to the model including BMI and smoking. The backward regression model was used. All predictor variables were added to the model. Then, the variables that did not significantly affect the dependent measure were removed from the model one by one until the final model was reached. Statistical analyses were performed using SPSS software version 16.

Ethical consideration:

Intramural research program committee approval from King Abdulaziz University was obtained before beginning data collection. Explanations of the study aim were made in simple language that was easy to understand. All data were considered confidential and will not be used outside this study without personal approval. Researcher communication methods were provided to participants so they can seek any explanation they may desire. The participants had the right to withdraw from the study at any time. All participants will be informed of the results of the study and those with CTS were directed toward appropriate therapy resources. Participant names were coded and were kept anonymous except for the principal

investigator. Collected data were kept in a sealed and closed envelope, stored in a closed cabinet, and only authorized authors can access it for research purposes. Digital data was saved on a secure laptop for a minimum of 3 years following the data collection period.

RESULTS

A total number of 120 dental students participated in this study, 50% male and 50% female, their ages ranging from 22-29 years with a mean of 23.80 ± 1.02 years. About 93.3% of them were single. Most of the 91.7% were right-hand dominant and 17.5% currently smoke cigarettes. In addition, students' weight distribution was 9.2%, 55.8%, 25%, and 10% as underweight, normal, overweight, and obese, respectively. For the medical history section, two students reported to have hypothyroidism, one had diabetes, and one with rheumatoid arthritis (see Table 2).

Table 2. Demographic characteristics of the study group (N=120)

Characteristic	Mean (SD)
Age (years)	23.8 (1.02)
Do you use computer (Hours/week)	18.47 (20.53)
	N (%)
Gender:	
Male	60 (50)
Female	60 (50)
Marital status:	
Single	112 (93.3)
Married	6 (5)
Divorced	2 (1.7)
Dominant Hand:	
Right Hand	110 (91.7)
Left Hand	10 (8.3)
Do you currently smoke cigarettes:	
Yes	21 (17.5)
No	99 (82.5)
BMI:	
Underweight	11 (9.2)
Normal	67 (55.8)
Overweight	30 (25)
Obese	12 (10)
Medical History of diabetes:	
Yes	1 (0.8)
No	119 (99.2)
Medical History of rheumatoid arthritis:	
Yes	1 (0.8)
No	119 (99.2)
Medical History of hypothyroidism:	
Yes	2 (1.7)
No	118 (98.3)

Our study revealed that the prevalence of CTS (classic and probable) among dental students in their final year of school was 13.3%. Moreover, the prevalence was higher in females at 10% compared to males at 3.3%. Possible CTS ratings were also more common in females than in males, with 5% in males and 16.70% in females (Table 3).

Univariate regression analyses looking at the association between the epidemiological case definition of CTS with the occupational characteristics of the participants showed that repeated bending or twisting at the wrist (P=0.02), and finger pinch grip (P=0.04) were significantly associated with CTS. Other occupational risk factors did not show a significant association (Table 5).

Table 3. Distribution of the hand diagram rating results by gender* (n=120).

Hand diagram rating	Male	Female	P- value
	N (%)		
Unlikely	55 (91.7)	44 (73.3)	0.064
Possible	3 (5)	10 (16.7)	
Probable	0 (0)	1 (1.7)	
Classic	2 (3.3)	5 (8.3)	

***The epidemiological case definition of CTS includes classic and probable diagnoses which were a total of eight students (13.3%)*

Table 4 demonstrates the demographic characteristics of the participants and the epidemiological case definition of CTS (classic and probable). There was a significant relationship between the body mass index grade (P= 0.03) and the presence of CTS with the underweight category having a higher prevalence of CTS. There were no significant associations between CTS and the following variables: gender, dominant hand, currently smoking cigarettes, and medical history of diabetes, rheumatoid arthritis, or hypothyroidism.

Table 4. The demographic characteristics of the participants and the epidemiological case definition of carpal tunnel syndrome (N=120)

	Carpal tunnel syndrome		P- value
	Yes	No	
	N (%)		
Gender:			
Male	2 (25)	58 (51.8)	0.143
Female	6 (75)	54 (48.2)	
Dominant Hand:			
Right Hand	6 (75)	104 (92.9)	0.077
Left Hand	2 (25)	8 (7.1)	
Do you currently smoke cigarettes:			
Yes	1 (12.5)	20 (17.9)	0.700
No	7 (87.5)	92 (82.1)	
BMI:			
Underweight	3 (37.5)	8 (7.1)	0.035
Normal	3 (37.5)	64 (57.1)	
Overweight	1 (12.5)	29 (25.9)	
Obese	1 (12.5)	11 (9.8)	
Medical History of diabetes:			
Yes	0 (0)	1 (0.9)	0.788
No	8 (100)	111 (99.1)	
Medical History of rheumatoid arthritis:			
Yes	0 (0)	1 (0.9)	0.788
No	8 (100)	111 (99.1)	
Medical History of hypothyroidism:			
Yes	0 (0)	2 (1.8)	0.703
No	8 (100)	110 (98.2)	

Table 5. Univariate regression analysis of the epidemiological case definition of carpal tunnel syndrome and occupational characteristics of the participants (N=120)

	Carpal tunnel syndrome		Odd ratio (95%CI)	P-value*
	Yes	No		
	N (%)			
Repeated bending or twisting at the wrist			6.120 (1.271-29.470)	0.024
Yes	5 (62.5)	102 (91.1)		
No	3 (37.5)	10 (8.9)		
Operated vibrating tool			2.538 (0.463-13.917)	0.283
Yes	6 (75)	99 (88.4)		
No	2 (25)	13 (11.6)		
Twisting forearm			1.103 (0.210-5.795)	0.908
Yes	6 (75)	86 (76.8)		
No	2 (25)	26 (23.2)		
Bending or twisting hands or wrists			2.778 (0.503-15.338)	0.241
Yes	6 (75)	100 (89.3)		
No	2 (25)	12 (10.7)		
Forceful grip			0.450 (0.053-3.821)	0.464
Yes	7 (87.5)	85 (75.9)		
No	1 (12.5)	27 (24.1)		
Pressing tool			0.765 (0.147-3.983)	0.750
Yes	6 (75)	78 (69.6)		
No	2 (25)	34 (30.4)		
Finger pinch grip			4.770 (1.072-21.218)	0.040
Yes	3 (37.5)	83 (74.1)		
No	5 (62.5)	29 (25.9)		
Having dental assistant			1.000 (0.114-8.748)	1.00
Yes	1 (12.5)	14 (12.5)		
No	7 (87.5)	98 (87.5)		

**P value is from the univariate regression analysis.*

Finally, the multivariate logistic regression models showed a significant association between the epidemiological case definition of CTS and being underweight (P=0.02). Additionally, the use of finger pinch grip showed an inverse association with CTS (P=0.04). Other factors did not show significant associations including gender, dominant hand, smoking cigarettes, repeated bending or twisting the wrist, operated vibrating equipment, twisting the forearm, bending hands or wrists, forceful grip, pressing tool, and having a dental assistant during a typical workday.

Table 6. Multivariate logistic regression models showing the effect of Occupational characteristics (risk factors) on the epidemiological case definition of CTS.

Characteristic	Odd ratio (95%CI)	P- value
Gender - Male	3.358 (0.274-41.169)	0.343
Dominant Hand - Right	0.162 (0.012-2.182)	0.170
BMI - Normal		0.139
BMI - Obese	2.764 (0.154-49.570)	0.490
BMI - Overweight	1.533 (0.081-28.849)	0.775
BMI - Underweight	23.215 (1.653-326.032)	0.020
Do you currently smoke cigarettes	2.630 (0.161-43.050)	0.498
Repeated bending or twisting wrist	0.515 (0.039-6.860)	0.616
Operated vibrating tool	0.398 (0.023-6.960)	0.528
Twisting forearm	6.089 (0.298-124.259)	0.240
Bending hand or wrist	1.191 (0.063-22.431)	0.907
forceful grip	3.589 (0.210-61.318)	0.378
Pressing tool	3.292 (0.296-36.562)	0.332
Pinch grip	0.069 (0.005-0.914)	0.042
Dental assistant	0.452 (0.032-6.316)	0.555

DISCUSSION

In the current cross-sectional study, CTS as one of the occupational-related musculoskeletal disorders, we examined the prevalence of CTS and its occupational risk factors among dental students in their final year at the King Abdulaziz University School of Dentistry. In consistence with our hypothesis, the prevalence of CTS was higher among dental students 13.3% than the general population 2.7% in a study done in Sweden with 170 000 participants, the diagnosis was confirmed clinically and electrodiagnostically [28]. Additionally, our multivariate logistic regression models showed unanticipated inverse associations between pinch grip and CTS [1].

The prevalence came within the range of the previously estimated prevalence of 5-15% that was reported in different workplace studies [29-30]. A similar prevalence was reported by another cross-sectional study conducted in Michigan from 1998-2001 among 1,079 dentists which showed that 13%

were diagnosed with CTS using nerve conduction study [2]. Our study population was similar regarding exposure to occupational risk factors in clinical dentistry which demands forceful movement of the hands and wrists as well as the use of vibrating tools. A higher prevalence was found in a study conducted in the United States among 177 dental hygienists with 56% having CTS [19]. Clinical symptoms for the diagnosis of CTS were used. It was found that treating patients with heavy calculus was the most significant risk factor for dental hygienists. In addition, a cross-sectional study located in Riyadh in 2017 among 223 working dentists revealed that 30.5% had CTS-related symptoms [31]. However, the study examined the working dentists in opposed to our dental students which may account for this prevalence.

On the contrary to the published literature, our results showed an inverse association between pinch grip and CTS, this could be partially due to the small sample size which may have not accurately represented the exposure. Additionally, we were not able to study the duration spent in forceful pinch grip which has been suggested as an occupational risk factor for CTS. In other prospective multicenter studies that were conducted in the United States, 2474 participants were recruited and followed for 6.5 years. They were working in jobs with exposure to hand-intensive activities. It was found that CTS incidence was strongly correlated with the duration spent in forceful pinch or grip; the results showed those with high percent time had twice the risk of having CTS compared to those with lower percent time [1]. However, another cohort study in the United States between 2004-2006 with a total of 710 workers from various multi-task jobs evaluated physical work exposures and the incidence of CTS, it revealed that finger pinch grip was not a statistically significant risk factor [23].

BMI was considered as one of the risk factors for developing CTS, numerous literature noted that high prevalence of CTS tends to be in individuals with high BMI [32-33]. Although the causal relationship between high BMI and CTS was uncertain. This could be related to increased fat tissue in the carpal canal which would increase the compression on the median nerve [34]. Our results showed a significance by (P=0.02), (OR: 23.215), and (CI: 1.653-326.032) with 37.50% of underweight dentists having higher CTS. In this study dental students with a BMI of 18.5 and less were more likely to have CTS than those who were normal weight or obese. In alliance with a cross-sectional study that was done in Michigan, USA among 949 subjects which revealed that 65% of obese participants did not develop CTS, in contrary 20% of thin and normal participants had CTS [35].

Limitation and strength:

In future studies, it is recommended to consider the following limitations for better results. Firstly, the cross-sectional design of the study prevented us from identifying the causal relationships. Additionally, the study provides a prevalence of CTS in a single point of time. Secondly, our sample size was limited given the restrictions imposed due to the COVID-19 pandemic. However, we were able to obtain an 80% response rate from the participants. Finally, in the absence of nerve conduction studies as it was considered the gold standard confirmatory test for the diagnosis of CTS our study was constricted by the reliance on the clinical diagnosis of CTS. However, according to Anne Dale's study (27), using a hand diagram was considered a reliable tool for the diagnosis of CTS. Additionally, in another study supported by Bayes's theorem [36], the prevalence of CTS among the study participants was 71%. When the author compared the hand diagram with nerve conduction study in diagnosing CTS, the sensitivity and specificity of using hand diagram were 92%, 4%, respectively.

In contrast with most previous studies on CTS and occupational risk factors, most studies were conducted among workers, not students. According to the authors' knowledge and literature search, no previous studies have estimated the prevalence of CTS in the undergraduate population in the Middle East. The students recruited for the study were in good health and did not have co-morbid conditions, which minimizes the impact of confounders on CTS prevalence. Another important advantage of this study was that it evaluated the repetitive movements of the hand and wrist which was a risk factor for CTS as previously described in the literature [4-7-8-18-24-37].

CONCLUSION

In conclusion, our results demonstrated further evidence associating a higher prevalence of CTS among dental students than the general population. The majority of occupational risk factors in our study did not show a significant association with CTS. Finger pinch grip showed an inverse association. This was the first study that examined CTS among dental students. Furthermore, we examined previously identified risk factors of CTS and found that was not significantly associated with CTS among dental students. This indeed was an important addition to the literature as we identified that dental students were at higher risk of CTS. Additionally, we added to the controversy of the occupational risk factors of CTS. Future study designs may include exposure time for each occupational risk factor preferably in a prospective cohort rather than a cross-sectional study. Additionally, the future direction may need to expand the sample to include broader numbers of participants from different age groups, school years, and from various regions of the country.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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