

The Prevalence and Associated Risk Factors of Carpal Tunnel Syndrome among Private Dentists in Klang Valley, Malaysia: A Cross-sectional Study

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ABSTRACT

Carpal Tunnel Syndrome (CTS) is a progressive entrapment neuropathy that is commonly associated with dentists. If left untreated, permanent nerve and muscle damage may occur. The purpose of this study is to determine prevalence of CTS among private dentists in Klang Valley, Malaysia and to further identify the associated risk factors for CTS symptoms. In-person interviews of 78 subjects obtained using the convenience sampling method were carried out. The Boston Carpal Tunnel Questionnaire (BCTQ) and clinical tests of Phalen and Tinel were used to examine signs and functional impact of CTS. The overall prevalence of CTS-related symptoms is 37.2%. Using BCTQ alone, 6.4% showed mild CTS symptoms through the level of functional state scoring (FSS) while 10.3% showed mild to moderate symptoms in the scale of the severity of symptoms (SSS). There is a significant correlation between the age of dentists and CTS symptoms ($p = 0.007$). The prevalence of CTS was more common in older dentists. Increasing age and working hours per week further enhance the risk of CTS. Findings from this study will serve as a useful baseline to establish further study in Klang Valley. Future work should examine the accounts underlying these risk factors for preventive measures.

INTRODUCTION

Occupational hazard is a term used to define the risks associated with workplace environment. It includes short term physical injury and prolonged risks that may further cause occupational diseases such as cancer and musculoskeletal disorders [1]. Notably, carpal tunnel syndrome (CTS) is listed as one of occupational diseases in the European Union's list since 2003 and it is an occupational hazard to dental practitioners [2,3]. The occurrence of this syndrome is results from ischemia of the median nerve that follows vein circulatory disorder and an increase of internal canal pressure [4]. CTS is an entrapment neuropathy that presents as paresthesia, numbness and pain in the area of median nerve which includes thumb, index, middle, and lateral side of the ring finger [5]. The symptoms of CTS typically appear first at night, and then early in the morning. Other manifestations include fragility of thumb grip, clumsiness of fine finger function and a history of dropping things [6].

Generally, anything that induces an increase in the content pressure or reduction of carpal tunnel space will results in these signs and symptoms.

The prevalence of CTS has been reported to be around 3 to 6% in the general population [7,8] and while among dentists, its prevalence varies from 5 to 30.5% depending on the region and time of study [4, 6, 9, 10]. Prolonged work with highly repetitious extension and flexion of the wrist, and vigorous grip motion was shown to escalate the possibility of acquiring CTS [6]. In dental practice, occupational reasons include repetitive movements of wrist bending, repetitive pressure on palm and to use ulnar deviation of hand to hold devices forcefully. Canal cleaning movements may further compress the median nerve. Besides, ring finger is often used as fulcrum by dentists and they are positioned strenuously while doing root canal procedures, tooth extraction and movement of the wrist. These strain on fingers and repeated wrist motions will lead to the development of CTS signs [4]. Although CTS is not lethal, it may lead to irreversible median nerve damage with severe loss of hand function if

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left untreated [11]. Therefore, eliminating the pain is crucial for maintaining daily job requirements.

This study was aimed to determine the prevalence of clinical signs of CTS among private dental practitioners working in Klang Valley, Malaysia which is currently understudied. To achieve that, the Boston Carpal Tunnel Questionnaire (BCTQ) was used to examine the signs and functional impact of CTS on dentists. BCTQ was considered to be accurate in previous studies because of its superior test-retest reliability and intraclass correlation coefficients ranging from 0.8 to 0.9 [12-14]. Furthermore, BCTQ is found to be as reliable in predicting CTS as the electro-diagnostic testing according to Ortiz-Corredor, Calambas [15]. Therefore, in this study, the BCTQ from Alhusain, Almohrij [9] will be adapted. Additionally, this study also incorporated two provocative tests, namely Tinel's sign and Phalen's test for the diagnosis of CTS and to further determine its overall prevalence. Findings from this study will provide a baseline data to further establish and organize programs for CTS prevention, especially in Malaysia.

MATERIALS AND METHODS

Ethical approval

This study was approved by the Research Management Centre, MAHSA University (Ref: RMC/EC10/2020).

Sample collection and location

Upon ethical approval, a cross sectional study was conducted from October 2019 to February 2020 among private dental practitioners working in Klang Valley, Malaysia. Participants from private dental clinics located across the 15 principal cities within Klang Valley were selected using convenience sampling method. Participants were recruited based on the inclusion and exclusion criteria. Inclusion criteria: Female and male dentists operating in Klang Valley, with minimum of one year working experience are the study targets. Exclusion criteria: a) Dentists with a history of sequelae of fracture of the wrist, cervical radiculopathy, rheumatoid arthritis, pronator syndrome, thoracic outlet syndrome, previous surgical release of carpal tunnel and currently pregnant; b) first year dental officers and dental students. Using the single proportion formula, with 95% confidence level at the power of 90.8%, this study required a minimum sample size of 129 dental practitioners.

Survey tool

The BCTQ used was adapted from Alhusain, Almohrij [9] and imported into a Google Form (Mountain View, CA, US) (Supplementary File 1). The questionnaire; originally developed by Levine, Simmons [16], was used to survey dentists on the symptoms of CTS and the effects on function. The validated questionnaire composed of three parts: Demographic and health data, the level of functional state (FSS) and the scale of the severity of symptoms (SSS) in which information on demographics and health is as follows: Age, race, marital status, height, weight, regular exercise, smoking status, dental specialty, degrees apart from dentistry, years of occupation, dominant hand, patient contact time per day, pre-existing illnesses and previous CTS diagnosis. The FSS evaluates the difficulty level to carry out eight daily practical tasks such as writing, buttoning clothes, grasping a phone handle, holding a book while reading, opening bottles, carrying food baskets, household duties, and bathing and getting dressed meanwhile the SSS comprises of 11 questions pertaining to CTS symptoms on a daily basis (severity of hand pain at night, duration of pain, hand pain during the day, numbness of the hand, weakness of the hand, numbness at night and difficulty in grasping small items).

BCTQ was distributed through in-person interviews with dentists available during data collection after consent was obtained. It has been made aware to all participants of their right to abstain from participating in the study or to revoke their permission to participate without reprisal at any time. A ranking scale of 1 to 5 is used for which 1 signifies no functional difficulty or symptoms of CTS while 5 indicates an inability to perform basic activity or severe symptoms CTS. For both scales, the overall score was calculated as the items' mean. Participant(s) scoring 1.5 and above will be considered as showing symptoms of CTS.

Clinical tests

Phalen's test and Tinel's sign were conducted after the procedures were explained to the dentists, in accordance to Haghghat, Khosrawi [4]. The Phalen's test was carried out by having the hands of the dentist's positioned tangent in front of the chest with a vertical angle at the wrist for a minute. Tinel's test was done by keeping the hand of the dentists open followed by percussion of the median nerve on the forearm of the dentists. Positive Phalen's and Tinel's tests are indicated by numbness and/or discomfort in the median nerve region, showing signs suggestive of CTS.

Data analysis

Microsoft Excel (Redmond, WA, US) was used for data input and processing. Demographic and health characteristics were presented in form of frequencies and percentages. The variables analysed are gender, age (years), BMI group, marital status, habits (smoking and exercise), hand dominance, dental specialty and qualification, experience, patient contact, health condition(s) and CTS tendency. IBM SPSS Statistics 21 (Armonk, NY, US) was used to perform the chi-square test for a multivariate logistic regression model with diagnosis of CTS (Yes/No). Respondents' age (years), gender, work experience (years) and BMI status were identified as the covariates to CTS symptoms. All tests were considered statistically significant if the p-value was less than 0.05. A 95% confidence interval (CI) was used to calculate the prevalence of CTS based on BCTQ (FSS and SSS scales) and findings from Phalen's and Tinel's tests.

RESULTS

Among the respondents, a total of 100 dentists fulfilled the inclusion criteria with 78% response rate for this study. Table 1 summarized the demographic and health characteristics of respondents. The socio-demographic characteristics of the respondents show almost equal halves of participation from both gender where female dentists totaled up to 40 participants (51%) while the remaining are males (49%). In this study, the body mass index (BMI) was graded as underweight (under 18.5), normal/desirable weight (18.5 – 24.9), overweight (25 – 30), and obese (more than 30.1) according to BMI Calculator Malaysia at <https://www.calculator.com.my/bmi-calculator#.XuoTtZ4zYnU>. A normal BMI was found in more than half of the participants (59%), while 21% is overweight. "Underweight" and "obese" are in equal proportion of 10%. Out of 78 respondents, more than 93% of the participants were non-smokers. Almost all participants were right-handed (90%) with most dentists being general practitioners (71%). About 24% of participants had been working as dental practitioners with more than 20 years of experience. Less than half dentists (23%) claimed of having 8 hours or more of contact time with patients per day. Seven (9%) participants were diagnosed with CTS before, but only one respondent showed symptoms at the time of study conducted.

Figure 1 represented the total number of dentists diagnosed with CTS in relation to age, gender, years

of experience and obesity. Among the total responses collected, the highest frequency of probable CTS was found in respondents who are non-obese (N = 12/78); thus suggesting that obesity may not be a risk factor of CTS. This is followed closely by those aged 40 years or over (N = 11/78) and dental practitioners who have more than 10 years of experience (N = 10/78). Gender-wise, occurrence of probable CTS is almost in equal proportion (Mean = 7.5) between males (N = 9) and females (N = 6). A total of 19% of participants reported of having CTS symptoms, while 9% indicated that they had been diagnosed with CTS in the past. CTS prevalence was calculated to be 20.5% as per BCTQ alone.

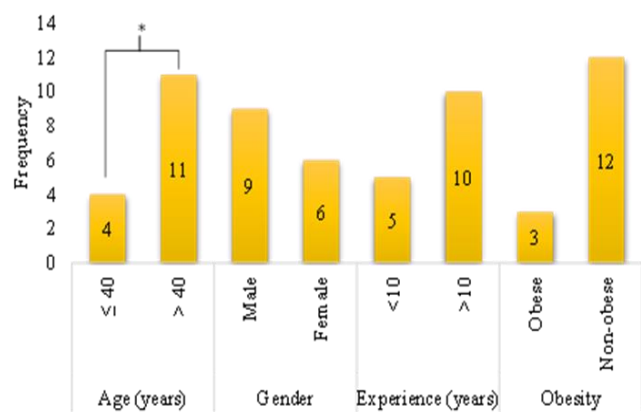


Figure 1 Total number of dentists diagnosed with carpal tunnel syndrome (CTS) in relation to age, gender, years of experience and obesity. CTS symptom classification based on response to Boston Carpal Tunnel Questionnaire. * $p < 0.05$. Abbreviation: CTS; Carpal tunnel syndrome.

Table 2 showed the multivariate logistic regression analysis of selected variables (age, gender, years of experience and respondents' BMI status) among dentists with and without CTS symptoms. Based on the data collected, it is conclusive that the age of private dental practitioners was significantly associated with probable CTS ($p = 0.007$). With increasing age, the odds of having probable CTS increases by 5.125 (95% CI 1.459-17.998) Although insignificant, the risk of having CTS symptoms was also higher by 2.667 (95% CI 1.459-17.998; $p = 0.097$) as years of practicing increasing. Our study also reflected that probable CTS is more common among the non-obese respondents (95% CI 1.459-17.998; $p = 0.166$).

Table 1 Demographic and health characteristics of respondents (n = 78)

Variables	Category	n (%)
Gender	Male	38 (48.7)
	Female	40 (51.3)
Age (years)	Up to 40	51 (65.4)
	≥ 41	27 (34.6)
Body mass index group	Underweight (< 18.5)	8 (10.3)
	Desirable weight (18.5 - 24.9)	46 (59.0)
	Overweight (25.0 - 30.0)	16 (20.5)
	Obese (30.1 or more)	8 (10.3)
Marital status	Single	35 (44.9)
	Married	43 (55.1)
Smoking	No	73 (93.6)
	Yes	5 (6.4)
Exercise	No	35 (44.9)
	Yes	43 (55.1)
Dominant hand	Right-handed	70 (89.7)
	Left-handed	8 (10.3)
Current practice in dental specialty clinic	Restorative dentistry	1 (1.3)
	Endodontic dentistry	3 (3.9)
	Prosthodontics	2 (2.6)
	Orthodontics	4 (5.1)
	Maxillofacial surgery	2 (2.6)
	General practitioner	61 (78.2)
	Others*	5 (6.4)
Occupation (years)	Up to 5	28 (35.9)
	6 – 10	18 (23.1)
	11 – 15	4 (5.1)
	16 – 20	9 (11.5)
	≥ 21	19 (24.4)
Contact time with the patients (hours/day)	Up to 8	60 (76.9)
	More than 8	18 (23.1)
Other degrees	No	65 (83.3)
	Medical Education	8 (10.3)
	Degree in Dentistry	1 (1.3)
	Other	4 (5.1)
Medical diseases or conditions	No	64 (82.1)
	Yes	14 (18.0)
Previously diagnosed with CTS	No	71 (91.0)
	Yes	7 (9.0)
CTS symptoms (From FSS & SSS)	No CTS symptoms (1 – 1.5)	72 (92.3)
	Mild symptoms (> 1.5 – 3.5)	6 (7.7)
	Severe symptoms (> 3.5 – 5)	0 (0)

*Other specialties including dental public health (2), oral physician (1), pediatric dentistry (1), and special needs dentistry (1). Abbreviation: CTS; Carpal tunnel syndrome.

Table 2 Multivariate logistic regression analysis of selected variables among dentists with and without CTS symptoms (n = 78)

Variable	Category	CTS symptoms		OR	95% CI	p-value
		Yes (15) n (%)	No (63) n (%)			
Age (years)	≤ 40	4 (8.9)	41 (91.9)	5.125	1.459, 17.998	**0.007
	> 40*	11 (33.3)	22 (66.7)			
Gender	Male*	9 (23.7)	29 (76.3)	1.759	0.559, 5.530	0.331
	Female	6 (15.0)	34 (85.0)			
Experience (years)	< 10	5 (12.2)	36 (87.8)	2.667	0.816, 8.712	0.097
	> 10*	10 (27.0)	27 (73.0)			
Obesity	Obese*	3 (37.5)	5 (62.5)	2.900	0.609, 13.807	0.166
	Non-obese	12 (17.1)	58 (82.9)			

CTS symptom classification based on response to Boston Carpal Tunnel Questionnaire. *Reference group. **A *p*-value of less than 0.05 is considered statistically significant. Abbreviations: CTS; Carpal tunnel syndrome, OR; Odds Ratio, CI; Confidence Interval.

DISCUSSION

It is important to note that CTS symptoms in dentists are more common than in the general population [9]. Therefore, recognizing the possible risk factors directing to these symptoms in dentists and to better understand the effect they pose on clinical practice is crucial just so that suitable interventional measures can be outlined and implemented to improve clinical efficiency for both dentists and their patients.

In this study, the prevalence calculated from BCTQ alone would be 20.5% while the total overall prevalence of CTS-related symptoms is 37.2%. The latter is obtained through the multiple assessments from BCTQ, Phalen and Tinel tests in which a total of 6.4% (95% CI 1.03-1.22) showed mild CTS symptoms through FSS scoring while remaining 10.3% (95% CI 1.09-1.25) showed mild to moderate symptoms in SSS. On the other hand, Phalen's test showed 21.1% positive CTS signs, while Tinel's test showed 11.3%. We have included these two clinical tests to our study in determining the prevalence as they have been implicated for the diagnosis of CTS [17]. In an extensive study conducted in Universiti Sains Malaysia (USM), Kelantan, Malaysia for estimating the prevalence of CTS; the prevalence of probable CTS among clinical dental support staff in Hospital USM (HUSM) was 38.9% (95% CI 29.0-48.9) [18]. This reveals that our present study is in trend with other studies that have been conducted in Malaysia, regardless of the state and/or city. However, the prevalence varies in different countries. For instance, a prevalence study done on Riyadh-based dentists reported of having mild or severe CTS symptoms are slightly lower (30.5%) [9]. Meanwhile in Iran, a similar study was conducted and the prevalence of clinical CTS symptoms was merely 16.7% [4]. The exact reason(s) to these

differences is uncertain however it is noted that the prevalence reported from Iran is much lower at the time of their study. It is also worth noting that the approaches used for prevalence determination vary between the studies. For instance, we have included the clinical Tinel's sign and Phalen's test which contributed to additional 16.7% to the prevalence than BCTQ (20.5%) alone. A total of nine and four independent positive Phalen's test and Tinel's sign were respectively recorded, despite no CTS symptom reported *via* BCTQ among the involved participants. Nonetheless, the Phalen's and Tinel's tests have been controversial as wide-ranging sensitivity and specificity have been reported for these tests; which could be an outcome of research bias [19-21].

Our findings revealed that gender and obesity appeared to be going against the current trend as important predictors of CTS symptoms. A total of 15% women and 24% men had CTS and chi-square showed that there was no significant difference between them (*p* > 0.05). Generally, women have smaller wrists and narrower carpal tunnel passageways. The cross-sectional area of the carpal arch normalized to the cross-sectional area of the wrist was found to be significantly smaller in females compared to men (*p* < 0.05). A study by Lakshminarayanan, Shah [22] shows that women have a smaller carpal arch relative to men with a distally reduced palmar bowing, and a narrower arch region at both tunnel stages. Their findings help to understand the increased occurrence of CTS in women as a narrower carpal arch renders the median nerve more vulnerable to neuropathy with compression. However, our present study reveals that female dentists are at lesser risk than male dentists for developing CTS symptoms, although insignificant (*p* > 0.05). This is at odds with another study, which deduced that "an equal probability to

attain CTS between genders exists when the occupational tasks are precisely similar". The authors also concluded that "the gender is not the issue, but the job is"; meaning that gender is not the contributing factor, but the nature of job (e.g. the repetitive movements) during practicing is [3]. A similar conclusion was drawn where there is no significant difference of probability of developing CTS between female and male dentists [4]. Regardless, some female-specific factors of CTS in women such as hormonal changes and pregnancy have been reported [9]. These conditions may lead to fluid retention (swelling) which affects the carpal tunnel space and further median nerve compression.

The current study also shows insignificant association between obesity and CTS. This goes against current trends where dentists with a BMI of 30 or greater were more likely to complain of CTS symptoms than normal-weight dentists. Individuals who are overweight are more predisposed to carpal tunnel syndrome because of the increased fluid deposition in the carpal tunnel tissue spaces [24]. However, in this study, results were not in trend probably due to CTS being a medical condition with multifactorial etiologies that could overlap with one another. The number of non-obese with CTS is higher in this study due to them having influenced by other risk factors such as increase in age, years of experience and gender predilection (Table 2). In addition, the studied risk factors in this study are limited as we did not include environmental factors such as habits, phone usage and *et cetera* where İnal, Demirci [25] claims that overuse of smartphones enlarges the median nerve, triggers thumb pain as well as pinch power reduction and hand functions.

There is a significant correlation between the age of dentists where 33.3% of dentists above the age of 40 versus 8.9% of dentists under the age of 40 showed CTS symptoms. The symptoms of CTS were more prevalent in people over 40 years of age ($p = 0.007$). And among dentists with 10 years or fewer experience in the career (41 dentists), 88% ($n = 36$) had no CTS symptoms, while among those who had spent more than 10 years in the dental field, 73% ($n = 27$) reported no CTS symptoms. Nevertheless, the number of years of occupation was not statistically significant. Although insignificant, our study showed observable trend that dental practitioners with more than 10 years of experience in clinical dentistry were more likely to develop CTS. This is in accordance with a study conducted in Karachi, Pakistan which deduced that dentists who have practiced for 16 to 20 years are at higher risk to

develop symptoms [26]. Hamann, Werner [10] further established that dentists diagnosed with CTS are those who have worked in the dental field for longer (27.5 vs. 21.8 years, $p < 0.001$). However, the study conducted in HUSM, Kelantan, Malaysia concluded that with increasing clinical practice and years of experience, dentists became less likely to report CTS symptoms [6]. We questioned whether religious, social and/or demographic factors play a role on the contrary findings despite similar geographical distribution as both studies were conducted in the same country. We further speculated that the presence of CTS symptoms is more closely related to the duration of time spent by dentists with their patients rather than the years of experience. For instance, dentists with more than 10 hours of patient contact per day were more likely to acquire CTS symptoms than one who just spent 4 hours per day attending patients. In fact, an earlier study delineated those dentists who worked longer hours were more likely to develop CTS symptom [10]. The study of Iranian dentists has also shown that those who worked longer hours were more prone to CTS [4].

According to the outcome of this study, it was concluded that there was a comparatively high prevalence of probable CTS among private dental practitioners practicing in Klang Valley, Malaysia and it was more common in older dentists. Increase in age and duration of work per week further enhance the risk of CTS. For future work improvement, larger controlled studies are required to further evaluate the risk factors for CTS among dentists as the findings from current study cannot be applied to Malaysia as a whole, or the region because only a small area (i.e., Klang Valley) is covered. Besides, too small a sample size; as in our study with minimum requirement of 129 respondents, may be difficult to detect meaningful correlations from the data as statistical analyses usually need a larger sample size to ensure accurate population distribution and to be considered accurate of groups of people to which the results can be generalized or transmitted. The time constraint as well as lack of access to data are limitations because this study requires us to approach dentists who are working or attending to a patient and we are often rejected because they are occupied. This is definitely a challenge, especially on the researcher's end because of time limit where it is not ideal to spend too much time waiting in a dental clinic. Further on to that, Klang Valley is in fact the region with the lowest private dental clinic-to-population ratio in Malaysia despite being the most populated [27]. Apart from that, the nature of self-reported BCTQ means that it might

be influenced by external bias. Findings can also be biased based on several factors such as work environment, number of patients, difficulty and duration of treatment as well as work stress could also implicate the results. Moreover, validation and translation of the BCTQ serves as another barrier in this study. Future research recommendation would also include detailed studies on how different specialties in dentistry are affected by CTS as well as additional correlation factors associated with CTS such as smoking, having systemic diseases and comorbidities.

CONCLUSIONS

The findings from this study serve as a useful baseline to establish further study in Klang Valley. There is an indication that CTS prevention among dental practitioners in Klang Valley is vital and early detection of CTS will ensure effective management. Therefore, future studies should explore the underlying cause(s) of the investigated risk factors and implement effective interventional and preventive training to reduce CTS risk among

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dentists. Constructive preventive approach[es] will be needed to enhance the education on ergonomic risk factors. This can be done by strengthening the curriculum about knowledge of ergonomic related endangerment in dental schools and dental training colleges. Besides, improving the awareness related to CTS would also reduce and further prevent its prevalence.

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DECLARATION OF INTEREST

None declared.

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