SCOPING REVIEW

The Role of Ergonomic Interventions to Prevent the Occurrence of Carpal Tunnel Syndrome in Dentists

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ABSTRACT

Background: Carpal tunnel syndrome (CTS) is a peripheral mononeuropathy caused by compression of the median nerve. Dentists are susceptible to CTS due to awkward static body postures and ergonomic issues with the wrist, including the use of vibrating instruments, repetitive movements, large muscle forces, and awkward postures such as flexion, extension, and ulnar and radial deviation. **Objective**: This study aimed to review various studies on ergonomic interventions to prevent CTS in dentists. **Material and Method**: This research followed PRISMA-ScR guidelines and used PCC framework (Population, Concept, and Context) for article selection process. Inclusion criteria consisted of articles with an experimental research design published between 2011 and 2021. Exclusion criteria included scoping reviews, rapid reviews, systematic reviews, gray literature, and articles that were not fully accessible. All keywords were taken from MeSH terms, and literature searches were conducted using Boolean searches on the PubMed, Wiley, and Google Scholar databases on August 17, 2021. **Result**: There were limited experimental research articles on CTS in dentists. Out of 887 articles obtained, only five were selected, with a total of 357 participants. The research subjects included general dentists, specialist dentists, and dental hygienists, both with and without CTS. **Conclusion**: Ergonomic interventions play a crucial role in preventing CTS in dentists. Clinically, these interventions are associated with improved hand function, reduced pain in the wrist/hand, and increased pinch and grip strength.

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Highlights

1. Dentists are at a higher risk of experiencing symptoms of carpal tunnel syndrome (CTS) compared to non-dental healthcare workers. This is due to repetitive movements, the use of vibrating tools, and prolonged exposure to unergonomic postures.
2. Ergonomic interventions are a key method for preventing CTS in dentists, aiming to reduce the risk of repetitive injuries that can lead to long-term disability.

BACKGROUND

Dentists often work in static postures, which require the contraction of 50% of the body's muscles to maintain stability and counteract the force of gravity. Prolonged static postures can trigger pain and injuries that may develop into musculoskeletal disorders (MSDs). The types of MSDs in dentists are generally categorized into three main groups: musculoskeletal disorders of the neck and shoulders, the upper and lower back, and the hands and wrists. The most common MSD affecting the hands and wrists is carpal tunnel syndrome (CTS) (Chopra, 2014).

Carpal tunnel syndrome (CTS) is a peripheral mononeuropathy of the upper extremities, caused by the compression of the median nerve as it passes through the carpal tunnel (Abichandani, et al., 2013; Anggayanti & Adiatmika, 2015). Symptoms of CTS are characterized by pain, paresthesia, and numbness in the thumb, index finger, middle finger, and the radial side of the ring finger, resulting from pressure on the median nerve (Annisa, et al., 2021). CTS can be triggered by repetitive movements, the use of vibrating tools, and non-ergonomic wrist positions during flexion, extension, and ulnar and radial deviation movements, particularly when these movements are sustained over long periods and exacerbated by large muscle forces (Chopra, 2014; Kumar, et al., 2020).

Dentists are at greater risk of experiencing CTS symptoms compared to non-dental healthcare workers, with older individuals and women being particularly vulnerable (Huang, et al., 2023; Ariyani, et al., 2024). In Riyadh, the prevalence of CTS among dentists is 30.5%, with female dentists having a higher risk than their male counterparts (Alhusain, et al., 2019). Research on retired dentists indicated that 56% of retirees left the profession due to musculoskeletal disorders, followed by 28% who retired due to mental and behavioral disorders. Additionally, 96% of retired dentists reported that their health had deteriorated as a result of their work (Brown, et al., 2010).

Given the high prevalence of CTS, it is crucial to address this issue by considering ergonomic challenges in the work environment, work organization, and individual factors. One effective solution is ergonomic intervention. Ergonomic interventions for CTS focus on controlling hand and wrist posture to promote ergonomic practices, reduce the risk of recurrent injuries, and prevent disability. These interventions not only protect the health of dentists but also improve their performance, enabling them to provide safe and high-quality care to patients (Das, et al, 2018; Ijaz, et al., 2022).

OBJECTIVE

The aim of this scoping review was to explore how ergonomic interventions could prevent and address the problem of CTS in dentists.

MATERIAL AND METHOD

This research was a descriptive observational study conducted through a scoping review in 2021, at a time when there were limited publications on CTS in dentists. The study used the PCC framework (Population, Concept, and Context) and PRISMA-ScR guidelines (Tricco, et al., 2018). The scoping review was conducted in three stages. First, the process of searching and identifying articles. The article search was conducted on August 17, 2021, and key terms were derived from MeSH terms. The search and identification of articles were guided by research questions that reflected the PCC framework: “How can ergonomic interventions prevent the occurrence of CTS in dentists?” The population was dentists, the concept was ergonomic interventions to prevent CTS, and the context included language and year of publication restrictions, but no geographical area restrictions. Literature searches were performed using Boolean operators such as AND, OR, and NOT across electronic databases like PubMed, Wiley, and Google Scholar (Massachusetts Institute of Technology, 2022; Ryan, 2022).

Table 1. Boolean operators in literature search.

The Boolean Sentences
The Boolean sentences used in the Pubmed and Wiley databases are: *("carpal tunnel syndrome"* **OR** *"median nerve compression"* **OR** *"musculoskeletal disorders"* **OR** *MSD)* **AND** *(ergonomic* **OR** *ergonomy* OR *"ergonomic intervention"* **OR** *"ergonomic design"* **OR** *"ergonomic training")* **AND** *(dentist* **OR** *"dental practitioner"* **OR** *"dental specialist")* **AND** *(prevent** **OR** *intervent*).* The Boolean search on Google Scholar database as follows: *(CTS* **OR** *"Carpal Tunnel Syndrome")* **AND** *(" musculoskeletal disorders"* **OR** *MSD)* **AND** *ergonomic* **AND** *dentist* **AND** *prevention* **AND** *intervention.*

The second stage was the article screening process Articles obtained from the Boolean search were entered into Microsoft Excel. An article screening process was then carried out based on the PCC framework, inclusion criteria, and exclusion criteria. The inclusion criteria for this scoping review were: (1) articles in English from the PubMed, Wiley, and Google Scholar databases; (2) articles published between 2011 and 2021; and (3) articles with experimental research designs relevant to the research questions. Exclusion criteria included: (1) articles that were not fully accessible; (2) scoping reviews; (3) rapid reviews; (4) systematic reviews; and (5) gray literature. The article screening flow is shown in Figure 1.

The third stage was the data mapping**.** From the selected articles, data mapping was carried out and entered into the data extraction table. Key findings were noted and summarized in Table 2. The data extracted from the selected articles in this scoping review included the researcher's name and year of publication, article title, research design, research area, subjects, interventions, evaluation and diagnosis methods, and research results. Qualitative synthesis was conducted based on the data extraction table.

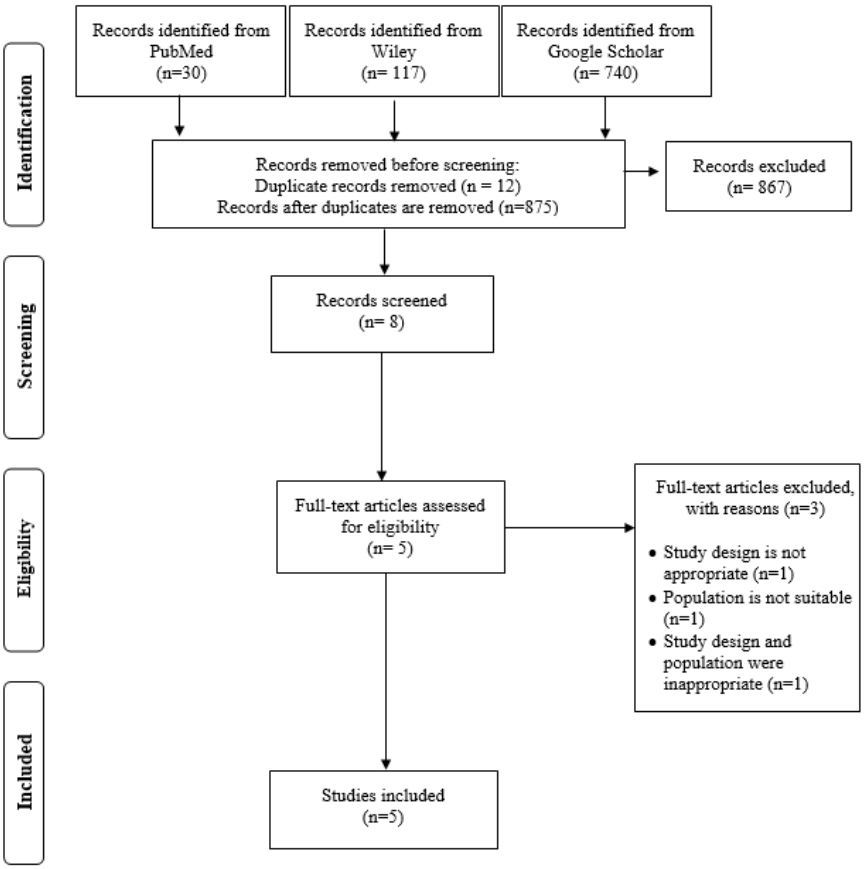

Figure 1. PRISMA-ScR flow diagram.

Table 2. Summary of ergonomic interventions studies to prevent the occurence of CTS in dentists.

No.	Author(s) and year	Article title	Study design	Country (region)	Subject	Intervention and control	Duration and follow-up	Evaluation method and diagnosis	Research results
1	Padhye, et al., (2017) doi: 10.7860/JCDR/2017/24974.9701.	Effect of Pre-Procedural Chair-Side Finger Stretches on Pinch Strength amongst Dental Cohort- A Biomechanical Study	RCT (Pilot study)	Navi Mumbai, India	Dental professionals (n=40)	Intervention group (n = 20): Subjects performed pre-procedural hand and finger stretching exercises (including finger stretching with rubber bands, tendon gliding, finger flexion and extension, thumb flexion, and finger webbing) which were repeated five times. Pinch strength was measured with a pinch meter both before and 30 minutes after the subjects performed scaling and root planing (SRP). Control group (n = 20): Subjects had their pinch strength recorded with a pinch meter both before and 30 minutes after performing the SRP.	Before and 30 minutes after the subject performed the SRP	Jamar® Hydraulic pinch gauge	The p-value for the pre- and post-SRP comparisons between the intervention and control groups showed a statistically significant difference.
2	Parmar & M.Soni, (2021) https://www.iosrjournals.org/iosr-jdms/papers/Vol20-issue4/Series-1/K2004015259.pdf	Effectiveness of Physiotherapy Intervention Along with Ergonomics among Dentists with Carpal Tunnel Syndrome: A Randomized Controlled Trial	RCT	Visnagar, Gujarat	Dentists with CTS (n=30)	Intervention group (n = 15): Subjects underwent physiotherapy and were advised to minimize repetitive or excessive wrist movements and pinch positions. They were also instructed to use instruments with round handles instead of hexagonal ones and to take a 5-minute rest every 30 minutes of work. Control group (n = 15): Subjects received the same ergonomic advice as those in the intervention group.	6 weeks	Tinel Test and Phalen Maneuver Grip Strength (kg); Numerical Pain Rating Scale (NPRS); Symptom Severity Scale (SSS); Functional Status Scale (FSS)	**FSS** improved in both groups, but the results were better in the intervention group. In the intervention group, grip strength, NPRS score, SSS, and FSS improved significantly. Specifically, hand function, pain levels, and grip strength showed notable improvements in the intervention group.
3	Rempel, et al., (2012) doi: 10.14219/jaa.archive.2012.0041.	The effects of periodontal curette handle weight and diameter on arm pain: a four-month randomized controlled trial	Randomised Controlled Trials (RCT)	San Francisco, California	Dentists (n=13) and dental hygienists (n=97)	Group 1 (n = 54): Instruments with lighter handles (14g) and a larger diameter (11mm). Group 2 (n = 56): Instruments with heavier handles (34g) and a smaller diameter (8mm).	4 months, weekly follow-up	Assessments were carried out every week for the level of pain in the right wrist/hand, elbow/forearm and shoulder for 4 months Online questionnaire with mean pain score	Mean pain scores for the wrist/hand, forearm/elbow, and shoulder were lower in subjects who used instruments with a large diameter and lighter weight. Significant changes were observed in

									shoulder pain, but no significant changes were found in wrist or elbow pain.
4	Aghilinejad, et al., (2016) http://www.ncbi.nlm.nih.gov/pubmed/28491848.	The Effect of Magnification Lenses on Reducing Musculoskeletal Discomfort among Dentists	Quasi experimental study	Tehran, Iran	Dentists (n=75)	Intervention: optical magnification loupes with 3.5x magnification	1 day (start and end of working hours)	Nordic Musculoskeletal Questionnaire (NMQ), Corlett and Bishop Scale	Significant differences were observed in the intensity of discomfort in the neck, shoulders and arms, back, elbows, forearms, and overall body. However, no significant differences were found in discomfort reduction in the hands and wrists, buttocks, thighs, knees, or feet.
5	Dehghan, et al., (2016) http://www.ncbi.nlm.nih.gov/pubmed/28491847.	The Effect of a Multifaceted Ergonomic Intervention Program on Reducing Musculoskeletal Disorders in Dentists	RCT	Tehran, Iran	Dentists (n=102)	Intervention group (n = 52): Participants received various ergonomic intervention programs, including education and training, workplace modifications, ergonomics training and surveys at the workplace, and a regular exercise program. Control group (n = 50): Only measurements were taken.	8 weeks Evaluation was carried out before, after 3 and 6 months of intervention	NMQ	The prevalence of MSDs in the neck, shoulders, arms, wrists, thighs, knees, and feet decreased in the intervention group. In contrast, the prevalence of MSDs increased in the control group.

RESULT

Search results using Boolean operators on the PubMed, Wiley, and Google Scholar databases identified 887 articles, of which 12 were excluded due to duplication. Based on the title, abstract, PCC framework, and inclusion and exclusion criteria, 867 articles were excluded, leaving 8 articles for full-text assessment. The final screening excluded 3 articles for the following reasons: one article had a research design that did not meet the inclusion criteria (Haas, et al., 2020), one article did not specify the research population (Horng, et al., 2011), and one article had a different research design with a population that did not match the inclusion criteria or PCC framework (Shivpaul, 2022). In the end, 5 experimental research articles were included in this scoping review (Rempel, et al., 2012; Aghilinejad, et al., 2016; Dehghan, et al., 2016; Padhye, et al., 2017; Parmar & M.Soni, 2021), as shown in Table 2.

The countries of origin for the included articles were Iran (n = 2), the United States (n = 1), and India (n = 2). The research subjects were general or specialist dentists, with or without CTS, who were still practicing. Each article had different inclusion criteria, such as age, gender, and weekly practice hours. The age range of the research subjects across the included articles was 18 to 45 years. One article did not report the gender of the subjects (Padhye, et al., 2017), two articles included both male and female subjects (Rempel, et al., 2012; Parmar & M.Soni, 2021), and the remaining two articles involved male subjects only (Aghilinejad, et al., 2016; Dehghan, et al., 2016).

Ergonomic interventions identified in this scoping review included interventions related to the work environment, work organization, and individual factors. Work environment interventions included the use of optical magnification loupes (Aghilinejad, et al., 2016) and instruments with larger diameters and lighter handles (Rempel, et al., 2012). Work organization interventions included ergonomic education and regular exercise programs (Dehghan, et al., 2016a). Individual interventions included finger stretching (Padhye, et al., 2017) and the implementation of a physiotherapy program (Parmar & M.Soni, 2021).

DISCUSSION

Although dentists are highly susceptible to experiencing a greater risk of CTS compared to other non-dental health workers, research on CTS in dentists remains limited. This is evidenced by a Scopus database search conducted in May 2024 using the Boolean search term "carpal tunnel syndrome," which yielded 19,610 documents. However, when focusing specifically on CTS in dentists, only 186 documents were found, indicating that research on CTS in dentists represents just 0.948% of the total documents in the Scopus database—an extremely small proportion.

A study in Navi Mumbai, India, comparatively evaluated finger muscle pinch strength before and after scaling and root planning (SRP) in subjects who stretched their fingers and those who did not. Forty dental professionals were instructed to perform SRP for 30 minutes on patients with moderate to severe calculus and signs of periodontal disease. The SRP procedure was carried out with a set of supragingival scalers and Gracey curettes #1-2 to #17-18. Pinch strength was measured before and after the SRP using a Jamar® Hydraulic pinch gauge, fixed to a table. Each subject was instructed to apply maximum voluntary pinch force for no more than 2 seconds, repeated three times, and the highest reading was recorded (Padhye, et al., 2017).

In the intervention group, five types of finger stretching were performed: stretching with rubber bands, tendon gliding, finger flexion and extension, thumb flexion, and finger webbing, each performed five times before the SRP. The results showed that the decrease in pinch strength in the intervention group was less than that in the control group. A comparison of the average pinch strength between the two groups revealed statistically significant results. In the control group, there was a significant decrease in pinch strength due to muscle fatigue. The researchers recommended conducting a longitudinal study with a larger and stratified sample size to accurately assess age-related finger muscle fatigue in dental professionals (Padhye, et al., 2017).

Pinch force plays a central role in CTS, as varying pinch forces can compress the carpal tunnel, leading to increased carpal tunnel pressure and the onset of CTS symptoms. Jobs requiring high pinch forces are common risk factors for musculoskeletal disorders (MSDs) such as CTS. Several epidemiological

studies suggest that large pinch forces are linked to the development of CTS (Jee, et al., 2015; (Li, Li, Wang, et al., 2020; Li, Li, Wu, et al., 2020).

A study in Visnagar, Gujarat, assessed the effectiveness of physiotherapy interventions coupled with ergonomic advice for dentists suffering from CTS. The intervention group received both physiotherapy and ergonomic advice, while the control group only received ergonomic advice. The ergonomic recommendations included minimizing repetitive wrist movements, avoiding or reducing pinched positions, minimizing wrist movement, using round-handled instruments instead of hexagonal ones, and resting for 5 minutes every 30 minutes of work. The results showed no significant changes in grip strength, Numerical Pain Rating Scale (NPRS), Symptom Severity Scale (SSS), or Functional Status Scale (FSS) in the control group, while the intervention group showed significant improvements in grip strength, pain reduction, and hand function. Both groups experienced some improvement in FSS, but the intervention group showed better outcomes. Researchers noted that the small sample size was a limitation of the study (Parmar & M.Soni, 2021).

A study in San Francisco, California, examined the effect of periodontal curette diameter and weight on arm pain. Subjects filled out a questionnaire online to collect demographic and work history data. Over five months, participants completed weekly surveys assessing pain in the right hand, including wrist, hand, elbow, forearm, and shoulder, using a 0-10 pain scale (0 indicating no pain, 10 indicating unbearable pain). The questionnaire also recorded the number of hours worked per week, the number of nights awakened due to numbness in the thumb, index, and middle fingers, and the number of days subjects used anti-inflammatory medication. During the first month, subjects became familiar with the online questionnaire, and data on arm pain were collected. Subjects were divided into two groups: one used an instrument made of black plastic weighing 14 g with a handle diameter of 11 mm, and the other used a steel instrument with a black coating, weighing 34 g with a handle diameter of 8 mm. The exit survey results showed that subjects using lighter instruments with larger diameter handles reported more favorable outcomes (Rempel, et al., 2012).

This finding is supported by other research in San Francisco, which also showed that lighter instruments (15 g) with larger handle diameters (10 mm and 11 mm) required less pinch force and caused less muscle load than heavier instruments with smaller handles (Dong, et al., 2005). Another study evaluating instrument design found a significant reduction in forearm muscle activity during periodontal scaling with lighter instruments and larger handle diameters. Subjects reported that light instruments with larger handles were more comfortable to use, likely because heavy instruments (23 g) with relatively large handles (11.1 mm) required greater muscle load (Suedbeck, et al., 2017). Muscles that experience excessive contractions due to heavy workloads, especially when sustained over a long period, may fatigue and cause injury to the tendons, leading to inflammation and compression of the median nerve (Occupational Health Clinics for Ontario Workers, 2016; Hulshof, et al., 2021).

An ergonomic intervention study using optical magnification loupes in Tehran, Iran, was conducted on 75 dentists with an average of 8.7 years of work experience. The optical loupes used had 3.5x magnification and were worn throughout a full work shift (7-8 hours). The results of a Musculoskeletal Disorders (MSDs) symptom examination using the Nordic Musculoskeletal Questionnaire (NMQ) showed that respondents reported symptoms across multiple body regions, with the highest percentages for the neck (92%), shoulders and arms (85.3%), back (69.3%), and lower back (94.6%). The body area discomfort scale, based on Corlett and Bishop's model, showed significant reductions in discomfort in the neck, shoulders, arms, back, elbows, forearms, and overall body ($p<0.05$) after using optical magnification loupes. However, no significant reduction in discomfort was observed in the hands, wrists, buttocks, thighs, knees, or feet ($p>0.05$). Dentists reported that the use of optical magnification loupes made their work easier (96%), more comfortable (89%), and improved working conditions (92%) (Aghilinejad, et al., 2016). Thus, optical magnification loupes can significantly reduce discomfort in various areas of the body, and their use may help maintain better posture, reducing the need for back and neck flexion.

Another study in Tehran evaluated the effect of a multifaceted ergonomics program in reducing MSDs in dentists. The intervention group received a program lasting eight weeks, consisting of ergonomics education, workplace modifications, and a routine exercise program. The prevalence of MSDs in the intervention group decreased in the neck, shoulders, arms, wrists, back, thighs, knees, and feet after three and six months, while the control group saw an increase in MSDs. The results highlighted the positive impact of the ergonomics program, with 98% of the dentists agreeing that the program provided significant benefits (Dehghan, et al., 2016).

In conclusion, a review of five ergonomic intervention studies addressing CTS in dentists highlights the importance of individual exercise programs, physiotherapy, ergonomic education, and modifications in the work environment and work organization. Stretching exercises, such as finger and wrist stretches, are essential to improve flexibility, reduce muscle stiffness, and alleviate stress. Physiotherapy programs, combined with ergonomic education, can help increase joint mobility, muscle strength, and circulation, potentially alleviating CTS symptoms. Modifications in instrument design, posture, and workspace layout are also critical in reducing hand muscle strain. The limited number of experimental studies on ergonomic interventions for CTS underscores the need for further research to better prevent and treat CTS in dental professionals (Anggraini, et al., 2024).

Strength and limitations

The strength of this scoping review lies in its exclusion of gray literature, such as proceedings, theses, annual reports, and other materials published outside of traditional sources. This ensures that the conclusions drawn are based on reliable, peer-reviewed publications. Additionally, at the time this study was conducted, no other scoping reviews focused on ergonomic interventions to prevent CTS in dentists.

A limitation of this scoping review is that it only searched for articles published in English-language journals across three databases, which may have excluded relevant studies published in other languages. Furthermore, by including research criteria without geographical limitations, the study may reflect variations in research perspectives across different countries. Another limitation is the use of differing evaluation methods across studies, which prevents direct comparisons between them.

CONCLUSION

Research on ergonomic interventions for CTS in dentists remains limited, despite the high prevalence of the condition. Based on the five studies included in this scoping review, it is evident that all types of ergonomic interventions—covering the work environment, work organization, individual factors, and their combination in the form of multifaceted interventions—can help prevent CTS in dentists. This highlights the need for further research into various aspects of CTS in dentists, as well as the development of holistic treatment approaches for CTS.

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Conflict of Interest

None.

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None.

Author Contribution

VT contributes to conception and design, analysis and interpretation of the data, drafting of the article, final approval of the article, administrative, collection and assembly of data. WA contributes to conception and design, analysis and interpretation of the data, drafting of the article, critical revision of the article for important intellectual content, final approval of the article, collection and assembly of data. APA, IS and DYR. contributes to conception and design, analysis and interpretation of the data, critical revision of the article for important intellectual content, and final approval of the article.

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