Review

THE IMPACT OF CARPAL TUNNEL SYNDROME IN DENTAL PRACTICE: A MINI-REVIEW

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ABSTRACT

The prevention of musculoskeletal disorders (MSDs) is a topical issue among dental professionals. Carpal tunnel syndrome (CTS), the most common disabling hand disorder, appears to have a high incidence in dental practitioners. This review critically examines the literature on CTS, focusing on its epidemiology, risk factors, diagnosis, and treatment. Preventive strategies and measures are also discussed to mitigate the risk of CTS among dental healthcare personnel. It is crucial for clinicians to possess a comprehensive understanding of ergonomics and to develop an acute awareness of their own body. The ability to modify inappropriate, harmful postures in order to prevent the onset of MSDs should be as fundamental as providing quality dental care.

KEYWORDS: *CTS, carpal tunnel syndrome, wrist pain, preventive measures, injury*

INTRODUCTION

Musculoskeletal disorders (MSDs) represent a significant occupational health issue in the dental profession. The prevalence of general musculoskeletal pain has been reported to range between 64% and 93%. During clinical practice, Hayes et al. found that dentists experienced the most significant prevalence of pain in the back (36.3-60.1%) and neck regions (19.8-85%), whereas for dental hygienists, the most common areas affected were the hand and wrist (60-69.5%) (1). Carpal tunnel syndrome (CTS) represents the most prevalent disabling disorder affecting the hand, and dental practice appears to be associated with an increased risk (2).

The carpal tunnel (CT) is an osteofibrous canal in the volar wrist. This structure offers attachment for the thenar and hypothenar muscles and acts as a restraint for the bowstringing of the extrinsic flexor tendons. The carpal bones and the transverse carpal ligament (or flexor retinaculum) delineate the floor (the carpal arch) and the roof of the CT space. The flexor retinaculum is about 3-4 cm wide and takes insertion into the scaphoid tuberosity, the trapezium, the pisiform, and the hook of the hamate. The CT contains 9 tendons and one nerve: the flexor pollicis longus, the four flexor digitorum superficialis, the four flexor digitorum profundus, and the median nerve (Fig. 1). As a natural consequence, any condition

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that will lead to an increase of the volume of such structures can cause compression of the median nerve. The median nerve gives sensory branches to the thumb, index, middle, and half of the ring fingers (Fig.1). Given that the palm of the hand is supplied by a sensory cutaneous branch of the median nerve, which arises proximally to the flexor retinaculum and remains superficial, this area is not affected by changes of pressure within the CT. The flexor carpi radialis tendon, and the palmaris longus tendon are other important structures that travel outside the CT but are in close contact with it (3) (Fig. 1).

This review aims to critically analyze the available scientific literature and synthesize the most reliable evidence on the epidemiology, diagnosis, and treatment of CTS. In addition, several strategies are proposed to prevent or reduce related symptomatology.

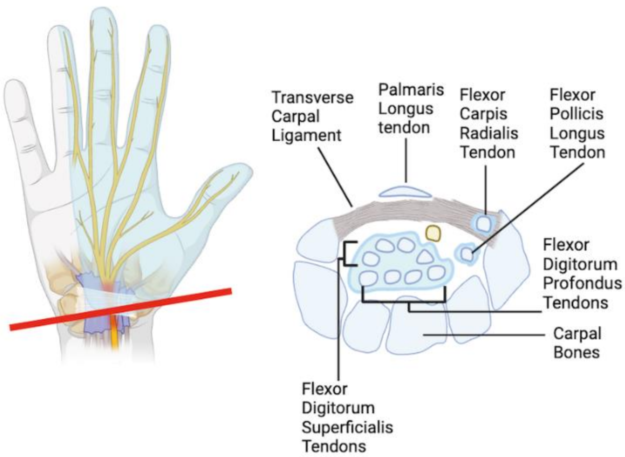

Fig. 1. *Cross section of CT area. The yellow spot represents the Median nerve responsible for the cutaneous innervation of the thumb, index, middle, and half of the ring fingers.*

MATERIALS AND METHODS

By conducting an electronic search on the MEDLINE bibliographic database (Pubmed), 202 articles with a time span from 1983 to 2024 were selected using the following algorithms: "Carpal Tunnel Syndrome" AND ("dental" OR "dentistry"). Titles and abstracts of articles were subjected to an initial selection process considering relevance, type of study, and population considered. References of selected studies were also scanned to retrieve other eligible studies.

DISCUSSION

CTS appears to be the most common peripheral mononeuropathy reported between 30 and 50 years of age (4, 5). Several studies show that approximately 3.8 % of the population complaining of pain, numbness, and tingling in their hands may have CTS(6). Such a syndrome seems to be more frequent in women than in men (7) (prevalence rate of 9.2% vs 6 %) and is associated with moderate/heavy manual work (4), such as dental practice.

The incidence of CTS and MSDs among dental healthcare personnel is relatively high. A meta-analysis conducted by Chenna et al. (8) reported that potentially 1 out of 7 dental practitioners may be affected by CTS. Although this syndrome is widely known, its etiology is not clearly defined.

Prolonged wrist flexion or extension, repetitiveness of certain movements (9), forceful executions, mechanical stress, poor posture, and vibration exposure appear to be some of the main risk factors involved in the genesis of the condition, particularly in the dental health care personnel (10). Medical risk factors include extrinsic factors, intrinsic factors, conditions that can alter the contour of the tunnel, and neuropathic factors. Extrinsic factors, such as pregnancy, menopause, obesity, renal failure, hypothyroidism, the use of oral contraceptives, or congestive heart failure, can increase the volume within CT, eliciting the syndrome. Intrinsic factors within the nerve, such as tumors or tumor-like lesions, and other extrinsic factors that can directly alter the contour of the tunnel (i.e., the aftermath of fractures of the distal radius and/or posttraumatic arthritis) represent additional causative factors that should be taken into account. Neuropathic factors, especially diabetes, also have an important role in the onset of the condition, affecting the nerves without increasing the interstitial pressure (11).

A mixture of mechanical trauma and ischemic injury to the median nerve is thought to be fundamental for the pathogenesis of CTS (12). Experimental studies have reported that neural dysfunction is directly proportional to the duration and magnitude of pressure (13). In addition, chronic compression can lead to fibrosis and adhesion of the nerve to the surrounding tissues. This condition inevitably leads to nerve traction during wrist flexion and extension, allowing the tethered median nerve test to be used as a diagnostic tool for chronic CTS (11).

Symptoms vary according to the severity of the neuropathy. A general reduction in grip strength and hand function with pain, unpleasant tingling, or numbness in the palmar aspect of the thumb, index, median, and radial aspect of the ring finger are the main symptoms reported, which tend to be worse at night. Most CTS patients report flicking the affected wrist as an effective maneuver to reduce pain and discomfort (14).

Patients may experience atypical signs of CTS, such as pain in the shoulder (15), forearm, or numbness in the third finger only (16). In a latent form, referred to as “dynamic CTS”, symptoms may be transient, and the condition is directly triggered by stressful movements (17).

In CTS, both the somatic (sensory and motor) and sympathetic fibers are affected by the compression. However, unmyelinated sympathetic fibers are thought to be more resistant to mechanical or ischemic injury than myelinated, somatic ones. This may be the possible explanation for the reported poor involvement of the sympathetic system in CTS (18).

Interestingly, in a large multicenter Italian study, patients with a more severe disease reported less severe symptoms but more important functional hand limitations than patients with mild, moderate CTS. Although it may appear contradictory, the worsening of functionality and improvement of symptoms can be explained according to the intuitive effect of the reduction in nerve fiber function (19).

The diagnosis of CTS is based on specific clinical findings and electrodiagnostic evaluation, which are necessary to distinguish it from other focal neuropathies of the upper extremities, such as cervical radiculopathy, ulnar neuropathy at the elbow, proximal median neuropathy (especially at the level of the pronator teres) and brachial plexopathy as well as Thoracic Outlet Syndrome (TOS) and Central Nervous System (CNS) disorders (multiple sclerosis, small cerebral infarction) (20, 21).

The symptom questionnaires, such as the hand diagram by Katz and Stirrat (22) or the CTS diagnostic scale adopted by Kamath and Stothard (23), based on self-reported symptoms of patients, may have high reliability. Still, their main limitation is based on the subjective component.

Based on clinical observation, since the abductor pollicis brevis is innervated by the median nerve and located superficially on the radial aspect of the thenar mass, the presence of thenar atrophy with symptoms may be sufficient to confirm the presence of moderate to severe CTS (24). Phalen’s and Tinel’s tests are the most common provocative tests used to diagnose the condition. In Phalen’s test, the patient is asked to flex the wrist and hold it in this position for 60 seconds. Pain or paraesthesia in the distribution of the median nerve represents a positive response (25) with reported sensitivity and specificity values in the range of 68% and 73%, respectively (26).

The Tinel test seems more specific than sensitive (77% vs 50%) (26). It is performed by tapping over the volar surface of the wrist; tangling or electric shocks in the area innervated by the median nerve represent the response of regenerating nerve fibers, which are more susceptible to triggers.

Similar values of sensitivity and specificity (48% vs 76%) were reported by the tethered median nerve stress test, which elicits a response hyperextending the index finger (and wrist) by pressing on the distal end with the forearm supinated (26). However, as the test assesses the presence of adhesion between the nerve and the flexor tendons, it may not be as effective in detecting the acute phases of CTS, and the general trend is to consider it more as an etiological test rather than a routine diagnostic test (26).

Other clinical signs and provocative tests have been described; however, according to Mondelli et al., none appear to be relevant on their own (27). To overcome these limitations, specific diagnostic algorithms, based on the integration of symptoms, signs, and diagnostic tests, were proposed by some authors to determine the likelihood of carpal tunnel syndrome (11).

In addition, clinical neurophysiological assessments using tests such as the vibrometry threshold, current perception, Semmes-Weinstein monofilament, tactile sensitivity, and two-point discrimination test are described in the literature. However, such diagnostic analyses generally require skill in both administration and interpretation of results (11).

Nerve Conduction Studies (NCS), in which the conduction across the nerve is assessed by surface electrodes, represent the gold standard for confirming a suspected CTS clinical condition. In addition, such exams can provide critical information on the severity of the neuropathy, on prognosis, and helpful insight to eventually assess alternate or associated diagnoses (e.g., ulnar neuropathy, cervical radiculopathy, brachial plexus lesion, or generalized polyneuropathy). On the other hand, the reported invasiveness, costs, and relatively high false-negative rate (up to 30%) of such examinations have prompted clinicians to develop more practical and less invasive evaluative methods (28-30).

Ultrasound is a useful method for assessing the median nerve cross-sectional area at various levels of the CT. Cross-sectional areas in CTS patients were shown to be significantly wider than those in healthy controls. However, due to the lack of standardization and a plethora of proposed cut-off values, wide ranges of sensitivity and specificity of such diagnostic methods have been reported (31). Since some studies have shown that non-pathological median nerve area is the same at the wrist and in the forearms (32), a direct comparison between the areas of the nerve within these structures (33) or the determination of a "swelling ratio" (34) have been proposed by some author to reduce the discrepancies. Ultrasound elastography has been shown to be an effective tool for overcoming these limitations.

Orman et al., evaluating the mean tissue strain in CTS patients, reported that it was significantly lower than in healthy controls, with the median nerve stiffer and less elastic (35). Strain elastography provided reliable cut-off strain ratios with high sensitivity and specificity values.

The same trend was found using shear wave elastography (36, 37), where an excellent accuracy in differentiating patients with and without CTS was reported in analyzing the median nerve stiffness cut-offs (37). However, these examinations do not seem to provide a clear relationship with the severity of the disease (38, 39). Despite these limitations, elastography, particularly the shear wave, has proved to be a valuable tool for diagnosing the condition and overcoming the limitations of conventional ultrasound.

Magnetic resonance imaging (MRI) can also be used in limited cases to determine the site of nerve entrapment after failed surgical procedures, for differential diagnosis in cases of vague symptoms, and to confirm the presence of space-occupying lesions (e.g., fibrolipomatous hamartoma of the median nerve (40, 41).

Treatment

Treatment of CTS is based on severity, staging of the pathology, and patient's preferences. Mild or moderate symptoms can be generally treated by non-surgical procedures such as splinting, acupuncture, steroid injections (42), vitamins B6 and B12, non-steroidal anti-inflammatory drugs (NSAIDs), ultrasound, yoga, or carpal bone mobilization (4). However, even though they can significantly relieve CTS symptoms in the short term, the durability of such beneficial effects is hardly determinable in the long term (43).

Marshall et al. reported that steroid injections produced a more significant clinical improvement in symptoms one month after the injections compared with placebo (44). However, the effects appeared to be transient, and no significant symptom relief was observed beyond one month (44). When conservative treatment fails, surgery is indicated (41). Surgical treatment is considered more effective than non-surgical treatment, especially when compared with splinting (45). With both an endoscopic or an open technique, the transverse carpal ligament is divided to increase the space and relieve pressure in the CT.

Open procedures have been shown to be effective in almost all patients (from 70 % up to 90%) with excellent long-term results (46). The endoscopic procedures, even if the technique is well performed (47), seem to have more drawbacks and a higher risk of nerve damage related to the insertion of the cannula in the CT (especially in the case of adherence) (41).

Preventive strategies

By analyzing the reported evidence, maintaining a neutral position with the forearms and wrist in a straight line is the most effective preventive measure, as it prevents increased pressure in the CT and reduces the risk of injury. The selection of larger, round-tapered, and lighter instruments with multiple accentuated angles or long terminal shanks can reduce muscle workload and pinch force (48). Rather than employing a 'one-size-fits-all' approach, the instrument design should be tailored to the operator (49). Owing to its ability to increase blood flow, inter-procedural stretching, turning the palm upward while slowly extending the elbow, is another reliable method for relieving symptoms and preventing injury (50).

CONCLUSIONS

The prevention of MSDs such as CTS is a topical issue in dentistry. Some preventive measures can be highlighted and recommended. CTS can be prevented by tailoring instruments and adopting a proper inter-procedural stretching plan. It is essential for clinicians to have a comprehensive understanding of ergonomics and develop an acute awareness of his or her own body. Being able to adjust inappropriate, harmful postures to prevent the onset of MSDs should be as fundamental as providing quality dental care.

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