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Assessment of Dental Practitioners' Pain and Evidence-Based Physical and Management Strategies: A Literature Review

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ABSTRACT

Background. Dentistry is a highly demanding profession that necessitates not only extensive theoretical knowledge but also the consistent maintenance of specific physical postures during clinical procedures. The prolonged adherence to such postures throughout a practitioner's career can lead to musculoskeletal discomfort, chronic pain, and a decline in overall quality of life. These physical and ergonomic challenges may contribute to occupational burnout, reduced job satisfaction, and, in some cases, prompt early career withdrawal. Consequently, the ergonomic demands of dental practice represent a significant factor influencing professional longevity and well-being, underscoring the need for preventive strategies and ergonomic interventions within dental education and clinical practice.

Aim. The aim of this study is to identify the most prevalent sites of musculoskeletal pain among dental professionals and to discuss evidence-based physical strategies for alleviating such discomfort, with the ultimate objective of enhancing occupational longevity and promoting sustained professional well-being in the dental workforce.

Material and methods. A systematic search of high-quality academic databases was conducted to identify peer-reviewed studies reporting statistical data and clinical management strategies related to the most prevalent musculoskeletal disorders among dental professionals. From the initial pool of literature, 56 studies - comprising randomized controlled trials, systematic reviews, and clinical studies - were selected based on their relevance, methodological rigor, and focus on dental professionals' musculoskeletal conditions and their therapeutic management.

Results. The most frequently cited musculoskeletal disorders among dental professionals include neck pain, low back pain, hip pain, shoulder pain, and forearm and wrist pain, with carpal tunnel syndrome often reported in conjunction with forearm discomfort. Management strategies vary according to the affected region. For neck pain, evidence-based recommendations emphasize manual therapy and therapeutic exercise programs, which have demonstrated efficacy in reducing pain and improving function. Low-back and hip pain are best addressed through mind-body and core-stabilizing interventions, including tai chi, yoga, and Pilates, as well as core-based or stabilization exercises, which enhance postural control and reduce mechanical stress. In the case of shoulder pain, treatment protocols suggest a combination of stretching exercises and radiofrequency ablation. Forearm pain and carpal tunnel syndrome are closely interrelated, often arising from repetitive strain; thus, a multimodal approach is recommended, incorporating orthotic support, manual therapy, and physical modalities.

Conclusions. The ergonomic challenges in dental practice are associated with the physical strain imposed by prolonged use of dental instruments and suboptimal working postures. A significant contributing factor is the insufficient foundational knowledge regarding the biomechanics of muscular and joint function. Multifaceted approach in essential to increase awareness within the dental workforce and improve well-being of dental practitioners, thereby fostering greater job satisfaction and sustainability within the dental profession.

Keywords: dentistry, pain, ergonomics, musculoskeletal, disorder, satisfaction, neck pain, low-back pain, shoulder pain, carpal tunnel syndrome, forearm pain, therapeutic exercise, manual therapy, dental education

Contents

1. Introduction

Dentistry, as a highly specialized healthcare profession, is inherently characterized by the need for precise manual dexterity, prolonged periods of static posturing, and sustained cognitive concentration during clinical procedures. These occupational demands place significant biomechanical and physiological stress on the musculoskeletal system, particularly in the cervical, lumbar, and shoulder regions. Over the past several decades, a substantial body of empirical research has consistently identified musculoskeletal disorders (MSDs) as one of the most prevalent occupational health concerns among dental professionals. These conditions, often manifesting as chronic or recurrent pain, are frequently attributed to cumulative exposure to poor ergonomic practices, restricted mobility during patient treatment, and the repetitive execution of fine motor tasks.

The consequences of such pain extend beyond physical discomfort, negatively impacting clinical performance, procedural endurance, and overall professional productivity. Moreover, these conditions are strongly associated with reduced quality of life, increased absenteeism, and early retirement from the profession. The occupational environment in dentistry - marked by limited opportunities for postural change, prolonged static loading, and high mental workload

- contributes to both physical fatigue and psychological strain, thereby exacerbating the risk of long-term health deterioration.

Given the persistent nature of these challenges, there is a pressing need to develop and evaluate evidence-based preventive and corrective strategies aimed at mitigating musculoskeletal strain. Among these, targeted physical exercise interventions - particularly those that can be integrated into daily routines, including home-based regimens - have emerged as promising non-invasive approaches. Such interventions may enhance musculoskeletal resilience, improve posture awareness, and reduce pain-related disability.

The present study seeks to critically examine the relationship between work-related MSDs in dental practitioners and the efficacy of specific physical exercise programs designed to alleviate these symptoms. By synthesizing current evidence and analyzing the impact of structured, accessible exercise regimens, this research contributes to the growing field of preventive ergonomics in dentistry, with the ultimate goal of supporting long-term occupational health, enhancing clinical performance, and promoting sustainable professional careers.

2. Materials and methods

The present study involved a comprehensive literature search and synthesis focused on ergonomics and its etiological factors, along with relevant statistical data, utilizing major academic databases: PubMed, ScienceDirect, Scopus, and Google Scholar. Key search terms were selected using the Medical Subject Headings (MeSH) tool, prioritizing those most pertinent to musculoskeletal and occupational disorders prevalent among dental professionals. Initially, the search was restricted to publications from 2020 to 2026; however, due to the limited number of relevant studies within this timeframe, the inclusion period was extended to encompass publications from 2016 onward to ensure sufficient data availability.

The selection of studies was based on methodological rigor and relevance, including clinical trials, systematic reviews, meta-analyses, cohort studies, and other high-quality evidence sources. Titles and abstracts were independently screened by the research team to identify studies directly addressing ergonomics, occupational risk factors, pathomechanisms, and behavioral determinants associated with work-related disorders in dentistry. The screening process was conducted manually, without the use of automated bibliographic screening tools, to ensure precision and consistency in study selection.

The literature collection was completed in March 2026. From an initial pool of 87 potentially relevant studies, 56 were selected for in-depth qualitative analysis based on predefined inclusion criteria related to relevance, methodological quality, English language and focus on ergonomics, occupational health, and preventive strategies in dental practice.

This review synthesizes current evidence on the behavioral, environmental, and biomechanical etiological factors contributing to common occupational disorders among dental practitioners. It further examines the underlying pathomechanisms of these conditions and evaluates non-surgical, evidence-based interventions that can be feasibly integrated into daily clinical routines to promote long-term musculoskeletal health and enhance work quality. The findings aim to inform preventive strategies and ergonomic guidelines tailored to the unique demands of dental professionals.

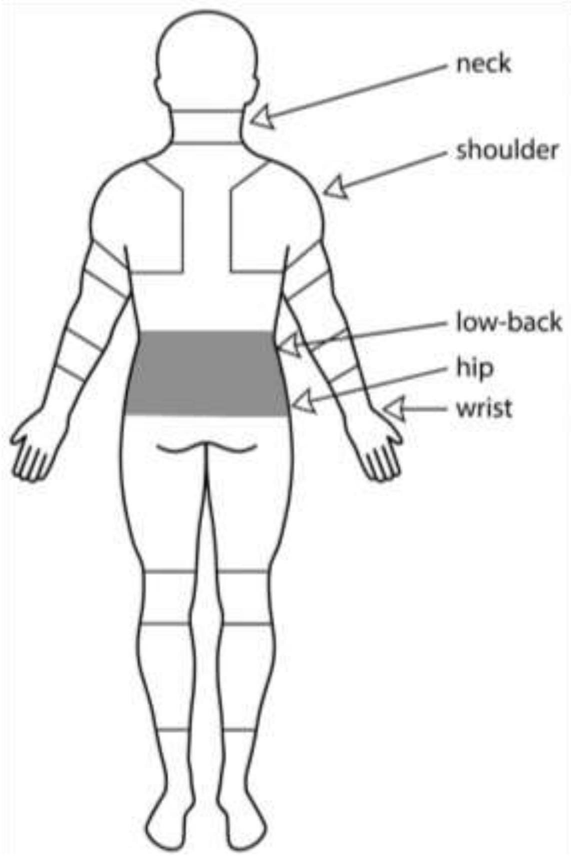
2.1. AI

AI was utilized for two specific purposes in this research. Text analysis of clinical reasoning narratives to identify linguistic patterns associated with specific logical fallacies. Assistance in refining the academic English language of the manuscript, ensuring clarity, consistency, and adherence to scientific writing standards. AI were used for additional linguistic refinement of the research manuscript, ensuring proper English grammar, style, and clarity in the presentation of results. It is important to emphasize that all AI tools were used strictly as assistive instruments under human supervision. The final interpretation of results, classification of errors, and conclusions were determined by human experts in clinical medicine and formal logic. The AI tools served primarily to enhance efficiency in data processing, pattern recognition, and linguistic refinement, rather than replacing human judgment in the analytical process.

3. Research results

3.1. Discussed sites

Among MSDs, the most frequently reported conditions include neck, low-back pain, hip pain and lateral hip pain (greater trochanteric pain syndrome). Additional commonly reported disorders encompass shoulder pain, and pain affecting the up per extremities, including the forearm and wrist. These conditions are frequently cited in the literature as prevalent musculoskeletal complaints across diverse populations. (AlOtaibi et al., 2022; Gandolfi et al., 2023; Gandolfi et al., 2021; Huang et al., 2023)



3.2. Neck pain

Neck pain (NP) is a highly prevalent MSD among dental professionals, predominantly attributable to occupational exposure and ergonomic constraints during clinical practice (AlOtaibi et al., 2022; Kawtharani et al., 2023). It is defined as musculoskeletal pain localized to the cervical spine and surrounding soft tissues, typically delineated anatomically from the occiput to the upper thoracic spine and laterally to the trapezius and shoulder girdle (Kawtharani et al., 2023). In standardized assessments, NP is often operationalized using anatomical diagrams that distinguish the cervical region from adjacent areas such as the lumbar spine, with a minimum self-reported intensity of ≥1/10 on a visual analog scale during the day required for classification (Samoladas et al., 2018). In epidemiological surveys and clinical reviews, NPs are generally described as symptoms arising in the cervical region, sometimes accompanied by clinical signs, and are differentiated from generalized upper-back pain (Cezar-Vaz et al., 2023).

The pathogenesis of NP in dentistry is multifactorial, primarily driven by biomechanical and ergonomic stressors acting upon a susceptible cervical spine. Dental practitioners routinely engage in prolonged periods of static or awkward postures - characterized by forward head flexion, lateral neck deviation, trunk rotation, elevated arm positions, and fine motor tasks within a constrained operative field. These postural demands result in sustained activation of the sternocleidomastoid and upper trapezius muscles, coupled with uneven loading of cervical joints and intervertebral discs (Cezar-Vaz et al., 2023; Samoladas et al., 2018). Repeated microtrauma, high task repetition, forceful precision grips, and inadequate workstation ergonomics contribute to cumulative tissue stress, leading to muscular fatigue, tendinopathy, ligamentous strain, and degenerative changes in the intervertebral discs. These pathological processes may manifest clinically as tension neck syndrome, cervicobrachial pain, or chronic cervicalgia. (Kawtharani et al., 2023). A key biomechanical mechanism involves prolonged cervical flexion, which impairs the function of the deep cervical flexor muscles—the primary stabilizers of the cervical spine—resulting in a compensatory shift of load to superficial muscles such as the upper trapezius. This neuromuscular imbalance reduces postural control efficiency and perpetuates pain through a cycle of altered biomechanics and increased muscle tension (Cezar-Vaz et al., 2023). Additional contributing factors include: 1. Vibration transmission from dental handpieces, particularly at high frequencies, which may induce neurovascular and osteoarticular stress despite typically short exposure durations; 2. Cold ambient temperatures, which may reduce peripheral blood flow, impair dexterity, and increase peripheral nerve sensitivity; 3. Cold ambient temperatures, which may reduce peripheral blood flow, impair dexterity, and increase peripheral nerve sensitivity (Kawtharani et al., 2023). These occupational risk factors interact with individual susceptibility variables such as sex, age, body mass index (BMI), physical fitness, and pre-existing musculoskeletal conditions. Notably, younger dentists exhibit a disproportionately high prevalence of MSDs, likely due to early and cumulative exposure during training and clinical practice. (Kawtharani et al., 2023).

A recent systematic review of 13 cross-sectional studies (2016–2020) reported a wide range in NP prevalence among dentists, from 13.02% to 84.6% (AlOtaibi et al., 2022). Individual study findings highlight significant regional variation: in Jeddah, Saudi Arabia, 84.6% of dentists reported neck, with female practitioners being 2.8 times more likely to report musculoskeletal pain than their male counterparts, and private-sector dentists exhibiting a 2.3-fold higher risk compared to those in public clinics (Meisha et al., 2019) . In India, 82% of respondents reported neck pain and 88.9% reported back pain collectively. A large-scale survey in Riyadh (n = 715) found NP in 51.9% of dental practitioners, with only 3.8% reporting routine medication use for symptom relief. In Indonesia, prevalence rates were lower but still substantial: 25.7% reported NP, 22.4% upper back pain, and 20.7% lower back pain, with 35.3% indicating symptom relief through regular physical exercise. In a Chinese hospital-based cohort, NP was reported by 83.8% of dentists; longer daily working hours were significantly associated with NP (OR = 1.43, 95% CI: 1.03–1.98), while high job demand and smoking emerged as risk factors, and regular physical activity was found to be protective. In Lebanon, the burden of MSDs is particularly high: one study reported spinal pain in 61.5% of dentists (31.6% cervical, 22.3% lumbar, 13% dorsal), with 30.6% experiencing frequent headaches; another found MSDs in 92.7% of practitioners, with NP reported by 51.5% and low back pain by 61.8% (AlOtaibi et al., 2022).

According to European Clinical Practice Guidelines (CPGs) for non-specific NP, the most effective approach to pain alleviation and functional improvement is the combination of manual therapy (MT) and therapeutic exercise, supported by moderate evidence across both acute-subacute and chronic stages of the condition (Corp et al., 2021) . This multimodal strategy demonstrates superior outcomes in pain reduction, functional restoration, and patient satisfaction compared to isolated interventions. Pharmacological interventions - such as oral analgesics (e.g., paracetamol, non-steroidal anti-inflammatory drugs [NSAIDs], and short-term opioids)—are recommended with weak evidence, primarily for short-term management during the acute phase. Topical agents may offer modest symptomatic relief but lack robust long-term efficacy. Psychological interventions and multidisciplinary care are particularly indicated for subgroups exhibiting psychosocial risk factors (e.g., catastrophizing, work-related stress) or persistent symptoms, aiming to address biopsychosocial contributors to chronicity. Among MT techniques, high-velocity, low-amplitude (HVLA) manipulation (MT1), mobilization and soft-tissue techniques (MT2), and their combinations (MT3) demonstrate moderate to strong evidence when integrated with exercise. (Hidalgo et al., 2017) These combined approaches consistently outperform either intervention alone in reducing pain, improving physical function, and enhancing patient satisfaction across short- to long-term follow-ups (Hidalgo et al., 2017). Notably, cervical mobilization applied at symptomatic levels does not confer greater clinical benefit than mobilization at asymptomatic levels, suggesting that the therapeutic effect may stem from generalized neuromuscular modulation rather than site-specific targeting. This finding supports the safety and feasibility of applying mobilization techniques at remote cervical segments, particularly in patients with contraindications to direct manipulation. Exercise-based interventions, particularly when delivered through structured referral programs, show moderate evidence of efficacy in reducing pain and improving function, with superiority over usual care and MT alone in chronic cases. In short-term randomized trials, therapeutic exercise alone has been shown to reduce disability more rapidly than MT, underscoring its role as a foundational component of rehabilitation. (Bernal-Utrera et al., 2020)

In summary, the strongest current evidence supports the integration of MT and exercise as a first-line treatment for non-specific NP. This combined approach yields clinically meaningful outcomes, including sustained pain reduction, improved physical function, and enhanced patient satisfaction, particularly in the short- to moderate-term follow-up period. The findings reinforce the need for individualized, multimodal rehabilitation strategies that prioritize patient engagement and long-term self-management.

3.2.1. MT and therapeutic exercises

MT reduces NP via neurophysiological and biomechanical effects and, when used alone or combined with exercise, yields statistically and clinically relevant improvements in pain and disability in non-specific NP. Techniques used in MT (mobilization, manipulation, soft-tissue techniques) act through several neurophysiological pathways: reduction of inflammatory biomarkers, decreased spinal excitability, reduced pain sensitivity, and modulation of cortical areas involved in pain processing, alongside sympathetic nervous system activation. (Bernal-Utrera et al., 2020; Cohen & Hooten, 2017) These central effects can rapidly down-regulate nociceptive input and contribute to hypoalgesia beyond the local treatment area. Biomechanically, joint mobilization and manipulation can improve segmental mobility, modify load distribution in cervical and upper thoracic segments, and normalize muscle recruitment patterns, especially in deep cervical flexors and extensors. Together with soft-tissue inhibition (e.g. suboccipital release), this can reduce muscle tone, improve proprioception, and restore cervical motor control, which are all disturbed in chronic, non-specific NP. (Hidalgo et al., 2017)

Therapeutic exercise targets motor control deficits and muscle imbalances in non-specific chronic NP, yielding significant improvements in disability and pain, with faster effects on function than MT alone. Primarily works through peripheral adaptations: reorganization of motor patterns, structural changes in muscle fibers, and increased strength/endurance of deep cervical flexors (e.g., longus capitis/colli) and extensors. By activating impaired deep stabilizers via cranio-cervical flexion (CCF) and progressive loading (isometric co-contraction, eccentric control), it restores proprioception, head-on-neck positioning, and postural stability, addressing key deficits in non-specific chronic NP. Central neurophysiological effects include modulation of pain processing and potential reversal of sensitization via graded exposure, reducing fear-avoidance and catastrophizing common in chronic cases. (Bernal-Utrera et al., 2020) Unlike MT's rapid hypoalgesia, exercise promotes long-term adaptations like improved neuromuscular control and endurance, potentially influencing central processes through repeated afferent input. (Cohen & Hooten, 2017)

A systematic review of 22 randomized controlled trials (n = 2,207) (Wilhelm et al., 2023) evaluated the efficacy of MT plus exercise (MT+E) compared to MT alone, exercise alone, and control in individuals with non-specific NP. In the pain domain, MT+E demonstrated statistically significant reductions in pain intensity compared to both exercise alone (MD −9.8/100, 95% CI −13.6 to −5.9) and control (MD −19.6/100, 95% CI −26.8 to −12.4). While the effect against exercise alone was statistically significant, it fell just below the commonly accepted 10-point threshold for minimal clinically important difference (MCID), suggesting that the improvement, though detectable, may not be substantial enough to be perceived as meaningful by patients. In contrast, the large effect size versus control was both statistically and clinically significant, indicating a robust benefit of combined therapy over no treatment. However, no significant difference was observed between MT+E and MT alone (MD −4.8/100), with moderate certainty evidence, suggesting that adding exercise to MT does not substantially enhance pain relief beyond MT alone in this context. Regarding disability, MT+E showed significant improvements compared to exercise alone (MD −3.3 points, 95% CI −4.9 to −1.8) and control (MD −9.0 points, 95% CI −13.5 to −4.5), though the improvement relative to exercise alone remained below the 5-point MCID, limiting its clinical interpretation. No meaningful difference was found between MT+E and MT alone. In terms of quality of life, no significant difference was observed between MT+E and exercise alone (SMD 0.02, 95% CI −0.21 to 0.18), with high certainty evidence, indicating that the addition of MT does not substantially improve health-related quality of life beyond exercise alone in the short term. In summary, while MT+E shows clear advantages over no treatment and exercise alone in reducing pain and disability, the clinical relevance of these gains—particularly in comparison to exercise alone—remains constrained by modest effect sizes. The lack of a meaningful improvement in quality of life suggests that functional and symptom relief may not translate into broader well-being improvements in this population. These findings highlight the need for individualized treatment approaches and further research to identify which subgroups benefit most from combined interventions.

3.3. Low-back and hip pain

Low-back pain (LBP) and hip pain are associated with sagittal imbalance of the spine and loss of lumbar lordosis (Gandolfi et al., 2023). Spondylosis is commonly cited as a primary etiological factor, defined as progressive degenerative changes affecting the intervertebral discs, facet joints, and adjacent bony structures (Hauser et al., 2022). LBP is anatomically defined as discomfort occurring between the inferior margin of the 12th rib and the superior margin of the iliac crest. Chronic LBP is a multifactorial condition arising from complex interactions among biological, psychological, and social factors. In addition to activation of A and C fibers, the pain experience is significantly modulated by emotional, behavioral, and cognitive influences (Hauser et al., 2022; Knezevic et al., 2021). Chronic LBP is associated with increased risk of functional disability, reduced participation in daily activities, and diminished health-related quality of life (Hauser et al., 2022; Knezevic et al., 2021). Recent survey-based research indicates that LBP accounts for 52.1% of work-related MSDs (Gandolfi et al., 2021), while another study reports a prevalence range of 48.5% to 64% in occupational populations (Gandolfi et al., 2023).

Hip pain is a clinical symptom with diverse underlying etiologies. It is most commonly associated with osteoarthritis, particularly in individuals over the age of 45 (Chamberlain, 2021). Classification of hip pain is based on anatomical location, including anterior, lateral, and posterior pain. Lateral hip pain, mostly presents greater trochanteric pain syndrome, is frequently reported among dental professionals due to prolonged standing and repetitive postural demands (Gandolfi et al., 2023). Hip pain constitutes 16.9% of all work-related musculoskeletal disorders (Gandolfi et al., 2021).

In 2023, a systematic review evaluated the efficacy of various exercise interventions for managing chronic LBP. The analysis demonstrated significant improvements in pain and function with the following modalities: Tai chi, Yoga, Pilates, Core-Based and Stabilization exercises (Li et al., 2023). These findings support the integration of targeted physical activity into multidisciplinary management strategies for chronic LBP.

3.3.1. Tai chi

Tai chi is a traditional Chinese mind-body practice that integrates physical movement, breath regulation, and mental focus. It is increasingly recognized as a therapeutic intervention for managing chronic pain conditions, particularly MSD such as chronic LBP and hip-related discomfort (Kong et al., 2016; Xu et al., 2023). The practice typically involves slow, continuous, and coordinated movements performed in an upright posture, synchronized with diaphragmatic breathing and a meditative attention to bodily sensations and movement quality. Contemporary clinical applications have adapted traditional tai chi forms into standardized, group-based programs of low to moderate intensity, typically delivered one to three times per week in 45- to 60-minute sessions. Modifications - such as reduced range of motion, use of external support (e.g., chairs or walls), or simplified movement sequences - are commonly implemented to ensure accessibility for older adults and individuals with chronic health conditions (Kong et al., 2016; Xu et al., 2023).

Several mechanisms have been proposed to explain the analgesic and functional benefits of tai chi in chronic pain. From a biomechanical and neuromuscular perspective, tai chi emphasizes postural alignment, controlled weight shifting, and integrated whole-body movement. These elements contribute to enhanced lower-limb and trunk strength, improved joint range of motion, and greater dynamic balance. Such adaptations may reduce abnormal joint loading and mechanical stress on weight-bearing structures -including the lumbar spine and hip joints - thereby attenuating movement-evoked pain and functional limitations (Xu et al., 2023). Furthermore, the slow, repetitive nature of tai chi movements may reduce excessive muscle co-contraction and stiffness, promoting more efficient motor patterns and potentially mitigating secondary pain arising from maladaptive guarding behaviors and compensatory overuse (Kong et al., 2016).

Evidence supports tai chi as a gentle, low-impact exercise intervention that can modestly reduce chronic LBP, improve physical function, and alleviate hip-related symptoms through enhanced postural control, core stability, and lower-limb biomechanics (Yang et al., 2024). In individuals with chronic or persistent LBP, tai chi-based programs have demonstrated small to moderate improvements in pain intensity and disability compared to usual care or wait-list controls. A large-scale systematic review of 10 randomized controlled trials (RCTs) involving 959 participants found that tai chi - whether used alone or as an adjunct to standard physiotherapy—reduced average pain intensity by approximately 1.3 points on a 0–10 visual analog scale (VAS) relative to control groups. This magnitude of change corresponds to a clinically meaningful improvement for approximately 50–60% of participants, although individual responses vary, with some reporting minimal or no benefit (Xu et al., 2023).

Optimal outcomes are achieved with structured, progressive tai chi programs lasting at least 8 to 12 weeks, ideally involving two or more supervised sessions per week combined with regular home practice. Common trial protocols have employed Chen-style tai chi, with session durations of 40–60 minutes, performed 2–6 times per week, resulting in total intervention doses ranging from 12 to over 160 sessions. Clinical benefits were observed after 12 weeks of three 60-minute sessions per week (36 sessions) in multiple studies. Notably, a virtual mind-body program demonstrated efficacy using a modular format: each 60-minute session incorporated six 10-minute components - energy cultivation, standing meditation, spinal flexibility training, lying meditation, core strengthening, and seated meditation - delivered twice weekly over 12 weeks (Yang et al., 2024). These findings underscore the importance of program adherence, consistency, and structured delivery in maximizing the therapeutic potential of tai chi for chronic musculoskeletal pain.

3.3.2. Yoga

Yoga is a mind-body practice rooted in ancient Indian philosophical traditions, characterized by the integration of physical postures (asanas), controlled breathing techniques (pranayama), and meditative awareness (dhyana). (Wieland et al., 2022) These components are systematically combined to enhance physical flexibility, muscular strength, body awareness, and psychophysiological relaxation. In clinical and therapeutic contexts, yoga is adapted into structured, evidence-informed programs tailored to address MSD. Specific asanas are selected and modified to target biomechanical and neuromuscular dysfunctions commonly associated with chronic pain conditions. Therapeutic yoga protocols for musculoskeletal health often incorporate sequences emphasizing key movement patterns: forward bending (e.g., Uttanasana, Paschimottanasana) to improve hamstring flexibility and spinal mobility; back extensions (e.g., Bhujangasana, Anuvittasana) to enhance spinal stability and counteract forward flexion postures; lateral stretches (e.g., Trikonasana) to promote balanced trunk mobility; and hip-opening poses (e.g., Virabhadrasana I and II, Sucirandhrasana) to address hip joint stiffness and pelvic alignment. These postures are typically performed in synchrony with rhythmic, conscious breathing (vinyasa), which enhances neuromuscular coordination, facilitates myofascial release, promotes joint space maintenance, and supports postural realignment. (Gandolfi et al., 2023; Wieland et al., 2022) The integration of breath and movement is believed to modulate the autonomic nervous system, reduce sympathetic overactivity, and enhance interoceptive awareness—mechanisms that may contribute to pain modulation and improved functional outcomes in individuals with chronic LBP and hip-related dysfunction. (Wieland et al., 2022).

A 2022 Cochrane systematic review (21 RCTs, n = 2,225 adults with chronic LBP) provides moderate- to low-certainty evidence that yoga is associated with small short-term improvements in back-specific function (standardized mean difference [SMD] 0.31–0.41 vs. non-exercise controls; minimal clinically important difference [MCID] threshold of ~5 points on the Roland-Morris Disability Questionnaire [RMDQ] unmet) and pain intensity (mean difference [MD] 4.5–11 points on a 100-point scale; below the 15-point MCID threshold), with effect sizes attenuating by 12 months (moderate certainty for function, low certainty for pain). Yoga was associated with modest improvements in physical (SMD 0.20) and mental health-related quality of life (SMD 0.20; SF-36), alongside low-certainty evidence of minimal reduction in depressive symptoms (SMD −0.19). Compared with active exercise comparators (e.g., stretching, physical therapy), yoga demonstrated no statistically significant superiority (moderate certainty; SMD ~0.08 for function, negligible differences in pain) (Wieland et al., 2022). Complementing these findings, a 2023 WHO-commissioned review (13 RCTs with low or unclear risk of bias, n = 1,362) positioned yoga within the broader context of structured exercise interventions, reporting pooled moderate-certainty effects favoring exercise over no- or sham-intervention controls (pain SMD −0.33; function SMD −0.31) in the immediate term. However, yoga-specific comparisons with usual care yielded very low-certainty null findings (MDs <10% on the scale range).

Pooled analyses indicate clinically modest yet consistent benefits across outcomes, with observed heterogeneity ($I^2 = 0$–68%) attributed to variations in intervention dosage, participant characteristics, and timing of outcome assessment (Verville et al., 2023; Wieland et al., 2022). Overall, yoga appears to confer clinically modest, consistent benefits across musculoskeletal outcomes, positioning it as a viable, evidence-informed component of multimodal rehabilitation, though not demonstrably superior to other structured exercise interventions.

3.3.3. Pilates

Pilates, originally conceptualized as "Contrology" by Joseph Pilates in the 1920s, is a mind-body exercise system characterized by a structured approach to movement that emphasizes neuromuscular control and functional movement efficiency. The method is grounded in six core principles - centring, concentration, control, precision, flow, and breathing - which collectively promote motor re-education, enhance core stability, and support improvements in postural alignment, muscular strength, flexibility, and dynamic motor control. These principles are systematically applied across mat-based or apparatus-assisted (e.g., Reformer) exercises, enabling targeted modulation of neuromuscular activation patterns and contributing to enhanced movement quality and biomechanical efficiency. (Wood et al., 2023). The therapeutic effects are primarily attributed to Pilates’ systematic emphasis on core stability, postural realignment, and precise, controlled movement execution. By enhancing trunk muscle activation, improving neuromuscular coordination, and promoting segmental spinal control, Pilates contributes to improved biomechanical function, reduced load on lumbar structures, and sustained pain relief, supporting its role as an evidence-informed, non-invasive intervention for chronic LBP management (Fernández-Rodríguez et al., 2022).

Two network meta-analyses provide robust evidence supporting the efficacy of Pilates in the management of chronic LBP. In a comprehensive analysis by Fernández-Rodríguez et al. (2023), which included 118 randomized controlled trials (RCTs; n = 9,710 participants), Pilates ranked highest in both pain relief (SUCRA = 93%) and disability reduction (SUCRA = 98%) when compared to various active interventions - including stretching, McKenzie therapy, and aerobic exercise - when all were contrasted with control conditions. Notably, Pilates demonstrated superior relative effectiveness across multiple outcome domains. A second network meta-analysis by Li et al. (2023), encompassing 75 RCTs (n = 5,254 participants), further confirmed these findings, reporting a standardized mean difference (SMD) of −1.52 (95% CI: −2.68 to −0.36) in favor of Pilates for pain reduction compared to conventional rehabilitation, and an SMD of −1.08 (95% CI: −1.89 to −0.27) for improved function relative to no intervention.

These results indicate that Pilates is a highly effective, evidence-based intervention for reducing pain and improving functional status in individuals with chronic LBP, outperforming several commonly used conservative treatments. Pilates-based exercise demonstrates clinically meaningful benefits for individuals with chronic LBP, yielding significant reductions in both pain intensity and functional disability, often outperforming or matching the efficacy of other non-pharmacological interventions.

3.3.4. Core-based and stabilization exercises

Core-based exercises and stabilization exercises target the deep core musculature to enhance spinal stability and neuromuscular control in patients with non-specific LBP (Hlaing et al., 2021; Kim & Yim, 2020; Salik Sengul et al., 2021). Core-based exercises emphasize activation of local stabilizing muscles, including the transversus abdominis (TrA), lumbar multifidus (LM), internal oblique, and gluteus maximus, to maintain lumbar-pelvic stability without excessive tissue loading. They involve isometric contractions (e.g., 7–8 seconds, 10 repetitions) in neutral spine positions (Salik Sengul et al., 2021), progressing from supine (abdominal hollowing) to dynamic positions (e.g., quadruped arm/leg raises, bridges), often using tools like pressure biofeedback for TrA activation. Core-based training retrains motor patterns, increases intra-abdominal pressure for segmental stiffness (Kim & Yim, 2020), and improves proprioception, balance, and muscle thickness changes in TrA/LM. (Hlaing et al., 2021; Salik Sengul et al., 2021) On the other hand, stabilization exercises, also termed core stability or segmental stabilization, focus on co-activation of deep core muscles (TrA, multifidus, pelvic floor) to control lumbar neutral posture during functional tasks. Protocols progress via abdominal drawing-in maneuvers, maintaining lumbar neutrality across positions (supine to Swiss ball), with 5–10 second holds repeated 10 times, emphasizing diaphragmatic breathing and limb perturbations (Salik Sengul et al., 2021). They enhance endurance (e.g., side bridge, Sorensen tests), strength (partial curl-up), motor control (unilateral stance), and function (sit-to-stand), outperforming conventional exercises in pain reduction and core stability.

Controlled Stretching Exercise (CSE) demonstrates significant pain-reducing effects compared to strengthening exercises, with superior outcomes in alleviating activity-related pain ($p < 0.008$; standardized mean difference [SMD] = 0.187) (Salik Sengul et al., 2021). In individuals with subacute non-specific LBP, CSE leads to greater reductions in pain intensity, functional disability (SMD = 0.61, $p = 0.010$), and fear of movement (SMD = 0.80, $p = 0.001$) when compared to conventional strengthening regimens (Hlaing et al., 2021). Furthermore, network meta-analyses rank CSE highly among non-pharmacological interventions for chronic LBP demonstrating substantial pain relief relative to control conditions (SMD range: -0.76 to -0.96) (Li et al., 2023).

Core-based and stabilization exercises demonstrate moderate to high evidence of clinical efficacy in managing non-specific LBP, particularly in improving spinal stability, neuromuscular control, and functional outcomes. These interventions target the activation and coordination of deep stabilizing muscles - including the TrA, LM, internal oblique, and gluteus maximus - through isometric contractions in neutral spine alignment, progressing to dynamic and functional tasks. Key mechanisms include enhanced intra-abdominal pressure generation, improved motor control, increased muscle thickness and endurance of TrA and LM, and better proprioception and postural control.

3.4. Shoulder Pain

In addition to the LBP, the hands, and upper extremities are among the most commonly reported anatomical sites affected by work-related MSDs in dental professionals (Younis et al., 2022). While dental hygienists are particularly vulnerable, dentists - including oral surgeons - are also significantly impacted. Female practitioners appear to be at a higher risk, with elevated prevalence reported in this subgroup (Cho et al., 2016). Although LBP and NP (21.3%) and shoulder pain (17.6%) were frequently cited in one study, findings from a Korean cohort revealed much higher rates, with shoulder pain (SP) reported in 72.8% and NP in 69.3% of participants. Further research indicates that SP may affect between 25% and 92.7% of dental professionals, depending on the population and assessment method (Soo et al., 2023). The shoulder is a unique joint that offers extensive range of motion. The shoulder joint relies predominantly on soft tissue structures - such as the rotator cuff musculature, joint capsule, and ligamentous restraints - for dynamic stability, as it possesses relatively limited bony congruence. This architectural design enhances range of motion and functional versatility; however, it concurrently increases susceptibility to injury due to diminished inherent bony stability. (Sidhar et al., 2024)

3.4.1. Stretching

Stretching represents a cost-effective, low-barrier primary intervention for managing SP and can be readily incorporated into routine clinical workflows or scheduled rest periods without requiring specialized equipment or professional oversight. By systematically targeting the neck, shoulder girdle, trunk, lumbar region, and distal upper limb, such protocols directly address musculotendinous structures most vulnerable to sustained postural stress and repetitive fine motor tasks common in healthcare and other precision-intensive professions - extending benefits beyond the shoulder to include potential alleviation of LBP (Kim et al., 2023). The observed increase in pain pressure thresholds (PPTs) across all assessed muscle groups following a single 30-minute stretching session indicates a rapid modulatory effect on peripheral nociceptive sensitivity, likely mediated through reduced muscle tension, enhanced local blood flow, and transient alterations in the viscoelastic properties of musculotendinous tissues. Notably, the greatest improvements in PPT were observed in muscles bearing the highest occupational load - such as the levator scapulae, upper trapezius, and rhomboids - suggesting that stretching preferentially benefits anatomical regions most at risk for work-related MSD. The finding that post-intervention PPT values restored to at least 90% of pre-work levels in many muscle groups highlights that even brief, structured stretching can effectively reverse acute nociceptive sensitization induced by a full workday. In contrast, passive rest alone failed to normalize PPTs in most muscles, underscoring the superiority of active recovery strategies over inactivity for immediate pain modulation. From an occupational health standpoint, these results support the integration of standardized stretching programs into institutional injury prevention initiatives, particularly for conditions involving neck–shoulder and periscapular pain, which are prevalent in occupations involving prolonged sitting, forward head posture, and high upper-limb demand (Kim et al., 2023). When consistently implemented during scheduled breaks, stretching may not only offer immediate symptom relief but also contribute to the long-term mitigation of cumulative tissue strain, thereby reducing the incidence and severity of work-related shoulder pain and associated functional limitations.

3.4.2. Radiofrequency ablation

Radiofrequency ablation (RFA) represents a targeted neuromodulatory intervention for the management of refractory chronic SP, supported by evidence from three systematic reviews synthesizing data from numerous clinical studies (Authors et al., 2023; Jain et al., 2024; Orhurhu et al., 2019). These reviews consistently demonstrate the efficacy of RFA, particularly when directed at the suprascapular nerve (SSN), with robust reductions in pain and improvements in physical function documented in high-quality randomized controlled trials (RCTs).

The procedure involves percutaneous insertion of a needle electrode, which delivers either conventional thermal energy (80–90°C for 90–120 seconds) or pulsed radiofrequency (PRF) fields (≤42°C, 20 ms bursts at 40–45 V) to disrupt nociceptive signaling while preserving motor function (Jain et al., 2024; Orhurhu et al., 2019). Ultrasound- or fluoroscopy-guided SSN ablation at the scapular notch is the predominant approach, typically preceded by diagnostic blockade with a ≥50% pain relief criterion to confirm neurogenic pain etiology. In select cases, adjunctive targets such as the axillary or lateral pectoral nerves may be considered. Platelet-Rich Fibrin is increasingly utilized due to its non-destructive nature, enabling repeat applications and offering comparable analgesic effects through mechanisms involving synaptic modulation and downregulation of pro-inflammatory cytokines (Jain et al., 2024).

Metric	Key Statistics	Representative Studies
Pain Relief	≥50% VAS/NRS drop in 70-81%; baseline 6.5-7.5 to 1.6-2.5 at 6-12 months	Luleci (74%, n=57, 6 mo.); Liliang (67%, n=11, VAS 7.5→2.5); Taverner(24-20% at 12 wk., n=51)
Duration	3-18 mo. (mean 6 mo.); ≤2 yr. in 10-20%	Cetingok (6 mo., n=160); Lipov (2 yr., n=3); Gabrhelik (60% at 6 mo., n=28)
Function	SPADI ↓40-55%; CMS/Oxford ↑20-40%; ROM ↑30%	Wu (SPADI 55.6→15.6/12 wk.); Sir(SPADI gains, n=31); NNT=4.4 surgery avoidance
Satisfaction/Meds	Likert 5.7-6.0; 60-82% med reduction	Gofeld (vs. lidocaine); Kane (Oxford ↑, n=12); 81.8% ↓ meds (n=11)
Comparators	Superiorto PT/lidocaine; = TENS/PBMT; inferior short-term to steroids	Eyigor(steroids faster, n=50); Wu (vs. PT, n=60)

RFA effectively alleviates shoulder pain associated with conditions such as rotator cuff tears, osteoarthritis, adhesive capsulitis, and glenohumeral arthrosis by interrupting sensory innervation from the SSN, which contributes to approximately 70% of the shoulder's sensory supply. Clinical outcomes include rapid and significant reductions in visual analog scale (VAS) and numeric rating scale (NRS) scores, with sustained pain relief observed for up to 24 months in responsive patients. Additional benefits include substantial improvements in the Shoulder Pain and Disability Index (SPADI) scores (37–55%), gains in active and passive range of motion (≥30°), and reduced reliance on opioid and non-opioid analgesics. In RCTs, RFA has demonstrated superior outcomes compared to sham procedures or physical therapy alone and has shown comparable short-term efficacy to corticosteroid injections.

While the Canadian Agency for Drugs and Technologies in Health (CADTH) acknowledges limited direct evidence specific to shoulder RFA, it notes strong parallels with the well-established efficacy of genicular RFA in large-joint osteoarthritis, suggesting potential for translational application. (Authors et al., 2023)

The safety profile of RFA is favorable, with adverse events reported in less than 5% of cases - primarily transient hematoma or sensory changes such as hypoesthesia - and no serious complications in most series. Clinical guidelines conditionally recommend SSN RFA following failure of conservative management, supported by moderate to high levels of evidence derived from large-joint denervation studies. (Authors et al., 2023)

In conclusion, suprascapular nerve-targeted RFA emerges as a safe, effective, and durable therapeutic option for chronic SP, providing meaningful pain relief and functional restoration with a favorable risk–benefit profile, particularly in patients who do not respond to non-invasive interventions such as stretching.

3.5. Forearm and wrist pain

Few studies have specifically addressed forearm pain among dentists or dental healthcare professionals, despite its recognition as an underreported site of musculoskeletal discomfort. A cross-sectional study conducted among Pakistani dental practitioners reported that forearm and elbow regions were affected in 3.4% of cases (Younis et al., 2022). Although this prevalence is comparatively lower than that of LBP (51.3%) or NP pain (21.3%) within the same cohort, the clinical significance of forearm involvement remains substantial due to the critical role of forearm function in executing precision-based dental procedures.

Quantitative assessment using PPT measurements has provided objective evidence of forearm musculoskeletal strain in dental professionals. In a controlled study involving 52 dental professionals (27 dentists and 25 dental hygienists), PPT was evaluated at multiple myofascial trigger points, including the wrist flexor group in the forearm (Kim et al., 2023). Results indicated a statistically significant decrease in PPT values in the intervention group (those performing routine dental work) over the course of a workday. Pre-work PPT values averaged 34.90 (SD 12.74) in the intervention group and 28.65 (SD 9.61) in the control group. Following a full day of clinical activity, PPT values declined significantly to 26.05 (SD 12.21) and 20.80 (SD 8.91), respectively ($P < 0.05$), representing reductions of approximately 25–27%. These findings indicate a marked increase in pain sensitivity and muscle tenderness in the forearm region, suggesting cumulative tissue stress.

Similar patterns of mechanical stress were observed in other upper extremity regions. The wrist extensor muscles exhibited a comparable reduction in PPT, decreasing from 27.93 (SD 9.12) pre-work to 19.80 (SD 7.05) post-work in the intervention group. The transverse carpal ligament region demonstrated even more pronounced changes, with PPT values declining from 47.27 (SD 14.10) to 35.95 (SD 15.32) after work - a reduction of approximately 24%. Additionally, the adductor pollicis muscle in the hand showed significant PPT reductions, from 34.84 (SD 11.79) to 24.89 (SD 7.56) (Kim et al., 2023). These interrelated changes across the forearm, wrist, and hand suggest that forearm pain is not an isolated phenomenon but rather part of a broader continuum of distal upper extremity disorders in dental professionals, driven by biomechanical and physiological interdependencies among these anatomical regions.

The etiology of forearm pain in dental practitioners is multifactorial, primarily attributed to the unique biomechanical demands of clinical practice. Dental professionals spend approximately 66% of their working time in a seated posture, with 40% of tasks performed in a forward-bent upper body posture (Howarth et al., 2016). This postural configuration necessitates sustained activation of forearm musculature to maintain precise hand and wrist positioning during intricate dental procedures. The frequent application of high-force, repetitive movements - such as instrument grasping, controlled pressure application, and prolonged static hand positioning - leads to cumulative microtrauma in the forearm flexor and extensor muscle groups.

Dental professionals are particularly susceptible to carpal tunnel syndrome (CTS), a condition directly linked to forearm biomechanics. The transverse carpal ligament, which forms the roof of the carpal tunnel, exhibited substantial PPT reductions (24–27%) following a full day of clinical work (Kim et al., 2023). Elevated intracarpal pressure due to repetitive hand movements, prolonged wrist flexion, and forceful gripping can compress the median nerve, resulting in symptoms such as paresthesia, reduced sensory perception, and radiating pain into the forearm (Kim et al., 2023)

Prolonged static postures, characteristic of dental practice, induce sustained muscle contraction, which has been shown to generate greater metabolic fatigue and mechanical stress than dynamic movements. This sustained activation leads to increased muscle stiffness and residual strain (creep) in viscoelastic tissues, contributing to tissue overloading and nociceptive sensitization (Kim et al., 2023; Younis et al., 2022).

Furthermore, the requirement to maintain elevated arm positions during procedures around the patient's oral cavity imposes additional biomechanical strain on the shoulder girdle. Compensatory muscle activation is transmitted distally through the upper limb, resulting in sustained forearm muscle contraction to stabilize the distal hand and wrist. This kinetic chain effect is particularly pronounced in dental practitioners with a stature exceeding 160 cm, who must elevate their arms excessively when working adjacent to dental unit chairs, thereby exacerbating cumulative strain across the upper extremity (Kim et al., 2023; Younis et al., 2022). Exposure to hand-arm vibration from dental handpieces and ultrasonic scalers represents an additional occupational risk factor for the development of forearm disorders. Prolonged or repeated exposure to vibration has been associated with cumulative biomechanical and physiological stress, contributing to vascular, neurological, and musculoskeletal impairments throughout the distal upper extremity, including the forearm musculature. These effects may manifest as reduced peripheral circulation, impaired nerve conduction, and increased muscle fatigue, all of which can exacerbate the risk of overuse injuries and chronic pain in dental professionals. (Maghsoudipour et al., 2021; Younis et al., 2022)

Therapy Category	Key Interventions	Symptom Relief	Functional Improvement	Electrophysiologic Changes	Evidence Strength (PEDro Score Range)
Pharmacological	Oral steroids (e.g., prednisolone); Local injections (e.g., triamcinolone, methylprednisolone)	High (up to 8 weeks for oral; >1 month for injections, delays surgery at 1 year)	Moderate (improved scores in trials)	Variable (some DML/SCV improvements, P<.001)	6-9
Physical Modalities	Ultrasound, laser, TENS, yoga	Moderate (ultrasound > laser for pain/strength)	Limited (short-term gains)	Inconclusive (no consistent NCS changes)	5-9
Manual Therapy	Self-carpal ligament stretching, Graston, ischemic compression, acupuncture	Moderate-high (numbness/tingling reduced, P=.007-.011; SSS improved Cohen's d=.69)	Moderate (pinch strength ↑, P=.007)	Minimal (no significant DL/Amp changes)	8-9
Orthotic Support	Neutral wrist splints (nocturnal/full-time)	Moderate (twice as likely symptom relief vs. extension splints)	Moderate (clinical improvements)	None reported	6-9
Combination Therapies	Splint + injection/drugs; Splint + ultrasound/TENS/neuromobilization	Moderate-high (better than single modalities in some trials)	Moderate (enhanced function)	Inconclusive (limited data)	5-8

3.6. Carpal tunnel syndrome

According to (Maghsoudipour et al., 2021), the integration of ergonomic principles into occupational health protocols is strongly advocated as a primary preventive strategy for reducing the incidence of forearm and wrist-related MSD, particularly CTS in high-risk populations. Similarly, (Khasawneh et al., 2025) underscore the critical role of ergonomic interventions and systematic risk factor control in professional dental practitioners, a cohort with elevated CTS prevalence due to repetitive upper limb tasks. These findings collectively highlight a robust consensus in the literature regarding the primacy of preventive measures in mitigating CTS burden across occupational settings.

A range of conservative management strategies have been proposed for the treatment of CTS, including pharmacological interventions, physical modalities, manual therapy, orthotic support, and combination therapies.

Oral corticosteroid therapy represents a noninvasive, accessible option for patients with mild-to-moderate CTS. Administration of oral prednisone at a dose of 20 mg daily for 10–14 days has been shown to significantly improve clinical symptoms and functional outcomes compared to placebo, with sustained benefits observed up to eight weeks (Wipperman & Goerl, 2016). Systematic reviews corroborate the short- and medium-term efficacy of oral corticosteroids, with one trial involving 36 patients demonstrating statistically significant symptom reduction in the prednisolone group relative to placebo at both post-treatment ($P = .027$) and eight-week follow-up ($P = .034$) (Jiménez Del Barrio et al., Tratamiento conservador en pacientes con síndrome del túnel carpiano con intensidad leve o moderada. Revisión sistemática./2018). Further evidence from a cohort of 109 patients revealed that both four-week and two-week prednisolone regimens led to significant improvements at post-treatment and at one-year follow-up ($P < .001$), indicating durable clinical effects (Jiménez Del Barrio et al., Tratamiento conservador en pacientes con síndrome del túnel carpiano con intensidad leve o moderada. Revisión sistemática./2018). The mechanism of action is attributed to systemic reduction of interstitial fluid pressure within the carpal tunnel, thereby alleviating median nerve compression. However, comparative evidence indicates that oral corticosteroids exhibit lower efficacy than localized injections (Jiménez Del Barrio et al., Tratamiento conservador en pacientes con síndrome del túnel carpiano con intensidad leve o moderada. Revisión sistemática./2018). Notably, NSAIDs, diuretics, and vitamin B6 supplementation have not demonstrated significant therapeutic benefit in RCTs for CTS (Wipperman & Goerl, 2016).

Local corticosteroid injection therapy has emerged as a highly effective intervention, supported by increasingly robust evidence. While early meta-analyses, such as the 2007 Cochrane review, reported symptomatic relief lasting up to one month, more recent data indicate sustained improvement for durations ranging from 10 weeks to over one year (Wipperman & Goerl, 2016). This modality has been shown to effectively delay or even obviate the need for surgical intervention. A double-blind RCT involving 111 patients compared 80 mg methylprednisolone, 40 mg methylprednisolone, and saline injections, demonstrating significantly greater symptom improvement in the methylprednisolone groups at 10 weeks, with the higher-dose group exhibiting a reduced likelihood of surgical intervention at 12 months (Wipperman & Goerl, 2016). Multiple RCTs evaluating repeated injections have reported continued symptom relief beyond 12 months, with consistent findings of reduced surgical conversion rates at one-year follow-up (Wipperman & Goerl, 2016). Nevertheless, no significant superiority has been established between specific injection techniques (e.g., ultrasound-guided vs. blind) or steroid formulations (e.g., triamcinolone acetonide, methylprednisolone acetate). Systematic reviews confirm consistent improvements in symptomatology, functional status, and patient-reported outcomes following infiltration therapy (Jiménez Del Barrio et al., Tratamiento conservador en pacientes con síndrome del túnel carpiano con intensidad leve o moderada. Revisión sistemática./2018). For instance, a study of 90 patients revealed that combined triamcinolone acetonide and procaine hydrochloride infiltration yielded superior pain reduction ($P = .002$) and sensory conduction velocity enhancement ($P = .019$) compared to monotherapy groups, with significant improvements sustained at four months ($P < .01$). Similarly, a placebo-controlled trial of 69 patients demonstrated significant improvements in functional parameters ($P < .001$), symptom severity ($P = .002$), and patient-perceived outcomes ($P < .001$) in the injection group. Another trial demonstrated that methylprednisolone acetate infiltration outperformed iontophoresis in functional improvement ($P < .005$), symptom reduction ($P < .05$), and pain alleviation ($P < .001$) at post-treatment and at both two- and eight-week follow-ups. Repeat injections may be considered at six-month intervals, although recurrence after two treatments warrants reconsideration of alternative non-surgical or surgical options (Wipperman & Goerl, 2016). Ultrasound-guided injections are increasingly recommended due to enhanced accuracy and safety, enabling real-time visualization and precise needle placement, thereby minimizing complications such as median nerve injury or tendon rupture.

Splinting is widely regarded as a first-line conservative intervention for mild-to-moderate CTS due to its simplicity, cost-effectiveness, and high tolerability (Wipperman & Goerl, 2016). A 2012 Cochrane review affirmed the superiority of nocturnal wrist splinting over placebo, although evidence remains insufficient to determine optimal splint design or comparative efficacy against other non-pharmacological modalities. Notably, neutral wrist positioning has been shown to be twice as effective in symptom relief compared to extension splints, likely due to reduced carpal tunnel pressure. Splinting is particularly indicated in reversible forms of CTS, such as those associated with pregnancy, and can be effectively combined with other therapeutic approaches. Meta-analytic evidence supports the efficacy of splinting in improving clinical parameters, with one study of 90 patients showing significant improvement across all measured outcomes except distal motor latency ($P < .001$) when compared to placebo or infiltration therapies (Jiménez Del Barrio et al., Tratamiento conservador en pacientes con síndrome del túnel carpiano con intensidad leve o moderada. Revisión sistemática./2018). The therapeutic mechanism is attributed to the reduction of intracarpal pressure, which alleviates median nerve compression (Shem et al., 2020).

Furthermore, full-time splint use has been shown to provide greater symptom relief than intermittent or nocturnal use alone.

Physical therapy interventions for CTS encompass a spectrum of modalities, though evidence quality varies significantly. Limited but promising evidence supports the use of carpal bone mobilization, therapeutic ultrasound, and nerve glide exercises (Wipperman & Goerl, 2016). Nerve glide exercises, involving passive or active hand and finger movements, are theorized to restore normal neurodynamic mobility by mitigating nerve tethering secondary to compression. Although high-quality evidence remains limited, these exercises are noted for their ease of learning, feasibility for home implementation, and compatibility with adjunctive treatments such as splinting. In contrast, therapeutic ultrasound and carpal bone mobilization require specialized training and multiple sessions (typically five times per week for 2–4 weeks), with modest evidence of efficacy. A comparative analysis indicated that therapeutic ultrasound was significantly more effective than laser therapy across all clinical parameters ($P < .001$), with greater improvements observed in both groups ($P < .001$) (Jiménez Del Barrio et al., Tratamiento conservador en pacientes con síndrome del túnel carpiano con intensidad leve o moderada. Revisión sistemática./2018).

Manual therapy techniques have also been investigated for CTS management. Manipulative therapy, involving dorsal wrist manipulation to stretch the transverse carpal ligament, is hypothesized to reduce carpal tunnel pressure (Shem et al., 2020). This technique, performed either by trained clinicians or through patient self-administered programs, has been widely documented in the literature. A landmark double-blind RCT evaluated self-myofascial stretching of the carpal ligament in 83 participants with median mononeuropathy confirmed by nerve conduction studies, randomized 1:1 to sham treatment or active stretching. Of the 36 participants who completed the study (17 sham, 19 intervention), the treatment group demonstrated statistically significant improvements in numbness ($P = .011$, Cohen’s $d = .53$), tingling ($P = .007$, Cohen’s $d = .60$), pinch strength ($P = .007$, Cohen’s $d = -.58$), and symptom severity scale ($P = .007$, Cohen’s $d = .69$). The intervention involved 30-second self-stretching sessions performed four times daily over six weeks, with high compliance rates (97% in sham, 87% in treatment group). The results suggest that self-administered myofascial stretching yields outcomes comparable to professionally delivered fascial manipulation, thereby reducing the need for specialist care. Systematic reviews further indicate that manual techniques such as ischemic compression and cupping therapy are associated with significant symptom and functional improvements (Jiménez Del Barrio et al., Tratamiento conservador en pacientes con síndrome del túnel carpiano con intensidad leve o moderada. Revisión sistemática./2018). The

Graston technique demonstrated efficacy in enhancing range of motion, though no significant effects were observed on pain, sensitivity, or electrophysiological parameters. Acupuncture has shown particular promise, with evidence supporting its effectiveness in pain reduction and functional improvement, outperforming splinting in some studies, and demonstrating improvements in distal motor latency.

The optimal integration of pharmacological and non-pharmacological treatments remains an area of ongoing research, with inconclusive evidence regarding synergistic effects. Some studies report no added benefit from combining pharmacological agents (e.g., corticosteroids) with non-pharmacological interventions such as splinting or ultrasound therapy. No significant additive effects have been demonstrated for drug-based therapies when combined with physical modalities. However, a general trend suggests that multimodal approaches - integrating pharmacological and non-pharmacological strategies - are more effective than monotherapy alone (Jiménez Del Barrio et al., Tratamiento conservador en pacientes con síndrome del túnel carpiano con intensidad leve o moderada. Revisión sistemática./2018).

3.7. Forearm

While no existing literature explicitly identifies forearm pain as being directly attributable to dental practice, evidence from related fields suggests that such discomfort may arise from ergonomic risk factors inherent in clinical dental work. (Howarth et al., 2016) have previously documented that forearm pain is frequently associated with sustained, non-neutral postures and repetitive upper-limb movements, particularly in occupations requiring prolonged manual precision. Based on these findings, it is hypothesized that dental professionals may be at increased risk for musculoskeletal discomfort in the forearm region due to the repetitive and constrained positioning of the upper extremities during procedures. This discomfort is likely to manifest primarily in the wrist and distal forearm, potentially attributable to conditions such as carpal tunnel syndrome, which is known to be exacerbated by repetitive flexion and extension motions. Furthermore, sustained activation of the forearm flexor and extensor muscle group - common during prolonged dental instrumentation - may contribute to muscular fatigue, myofascial pain, and altered neuromuscular control. Therefore, forearm pain in dental practitioners is likely a multifactorial phenomenon, stemming from both biomechanical strain and overuse-related pathologies affecting the distal upper limb.

4. Discussion

The findings of this study underscore the persistent burden of musculoskeletal disorders (MSDs) among dental professionals, with NP and LBP emerging as the most prevalent conditions, followed by hip pain, lateral hip pain. These results are consistent with recent epidemiological evidence indicating that musculoskeletal complaints are a leading cause of occupational disability and early career attrition within the dental profession (AlOtaibi et al., 2022; Gandolfi et al., 2023; Huang et al., 2023). Notably, NP was consistently reported as a primary occupational health concern, particularly among practitioners engaged in prolonged clinical procedures.

This pattern of musculoskeletal strain is closely linked to the inherently non-ergonomic nature of traditional dental practice environments. Dental professionals are routinely required to adopt sustained, static postures - such as forward head flexion, lateral neck deviation, trunk rotation, and elevated arm positions - while performing fine motor tasks within a constrained operative field (Cezar-Vaz et al., 2023; Samoladas et al., 2018). These postural demands lead to sustained activation of the sternocleidomastoid and upper trapezius muscles, resulting in uneven loading of cervical joints and intervertebral discs, and ultimately contributing to the development of chronic pain syndromes (Cezar-Vaz et al., 2023). The pathogenesis of neck pain in dentistry is thus multifactorial, driven by biomechanical stressors amplified by ergonomic inefficiencies in clinical workflow.

A critical yet underrecognized factor exacerbating this occupational risk is the limited access to an optimal field of vision during procedures. The constrained visual field, often necessitated by the use of outdated or poorly designed dental chairs and lighting systems, compels practitioners to adopt suboptimal head and neck postures to compensate for poor visibility. This not only increases the mechanical load on the cervical spine but also promotes visual fatigue and cognitive strain, which may further impair motor precision and contribute to long-term musculoskeletal strain (Kawtharani et al., 2023). Moreover, the lack of fully ergonomic instruments - including handpieces, mirrors, and retraction tools that are not adapted to the natural range of motion or hand anatomy - forces practitioners to apply excessive force or maintain awkward hand positions, further increasing the risk of cumulative trauma disorders.

Crucially, these ergonomic challenges are not acquired over time but are established early in clinical training. The current dental curriculum often introduces students to clinical procedures without adequate instruction in ergonomic principles, thereby embedding non-ergonomic postures and instrument handling techniques from the outset of their professional development (AlOtaibi et al., 2022; Samoladas et al., 2018). This early adoption of suboptimal biomechanics may become habitual, reducing the likelihood of future behavioral change and increasing the long-term risk of MSDs. As (Cezar-Vaz et al., 2023) note, the absence of structured ergonomic education during foundational clinical training may result in a "normalization" of poor posture, making it difficult to correct later in one’s career.

Beyond the well-documented risks associated with prolonged static postures and repetitive hand movements, dental professionals face additional biomechanical challenges that significantly contribute to upper extremity and ocular strain, particularly during complex procedures such as endodontic therapy and surgical tooth removal. The act of applying high forces - such as pushing a syringe piston during root canal obturation or irrigation - requires sustained, forceful grip and wrist extension, placing excessive mechanical load on the forearm flexor and extensor muscle groups. This repetitive, high-force exertion, combined with the need for precise control, increases the risk of cumulative microtrauma, contributing to the development of tendinopathies and CTS, as evidenced by significant reductions in PPT in the transverse carpal ligament and adductor pollicis muscle following a full clinical day (Kim et al., 2023). Similarly, during surgical procedures such as the removal of a broken tooth apex, practitioners are often required to maintain an inergonomic working position - such as extreme wrist flexion, ulnar deviation, or elevated arm elevation - to achieve a stable fulcrum for instruments. This suboptimal positioning compromises biomechanical efficiency, increases the risk of tendon strain, and forces compensatory muscle activation, particularly in the shoulder girdle and upper trapezius, further exacerbating musculoskeletal stress (Cezar-Vaz et al., 2023; Younis et al., 2022). Moreover, the limited field of vision during such procedures necessitates intense visual concentration, often at the expense of proper head and neck posture. This leads to eye strain and ocular discomfort, particularly when working in poorly illuminated environments or with inadequate magnification, as the eyes are forced to sustain high levels of accommodation and convergence. However, during research no single paper listing this pain was found. The combination of these factors - high-force instrument use, non-ergonomic fulcrum positioning, and visual strain - creates a synergistic risk profile for both musculoskeletal and ocular disorders. These challenges are not isolated to individual procedures but are systemic to current clinical workflows, highlighting a critical need for ergonomic redesign of instruments, improved lighting and magnification systems, and the integration of biomechanically sound techniques into dental education from the earliest stages of training. Without such interventions, the risk of early-onset, chronic occupational injuries among dental practitioners will persist, undermining both professional longevity and patient care quality.

5. Conclusions

Notably, the current clinical environment often perpetuates ergonomic risks listed in this literature review through the use of non-ergonomic instruments and equipment that fail to accommodate natural body mechanics. The lack of standardized, biomechanically optimized tools, combined with inadequate magnification and lighting systems, compounds the physical load on practitioners. Moreover, the absence of early intervention strategies in dental education means that students are frequently exposed to these risk factors before they develop the motor awareness and postural habits necessary to mitigate them, setting the stage for chronic occupational injuries.

Therefore, it is imperative that ergonomic principles be integrated into dental curricula from the very beginning of training. Early-stage education must go beyond theoretical knowledge and technical skill acquisition to include structured instruction in body mechanics, posture awareness, and the physiological consequences of poor ergonomics. This includes the implementation of regular, evidence-based physical exercise programs - such as neck and shoulder stretching, isometric strengthening, and dynamic mobility drills - within the academic schedule. These exercises should be tailored to the specific biomechanical demands of dental practice and delivered by trained physiotherapists familiar with the occupational profile of dental professionals.

Furthermore, a paradigm shift is required in the design and adoption of dental instruments and equipment. There must be enhanced collaboration between dental practitioners, biomechanical engineers, and equipment manufacturers to co-develop tools that reduce force requirements and support neutral joint positioning. Instruments should be designed with user-centered ergonomics in mind, incorporating features such as adjustable handles, balanced weight distribution, and improved grip accessibility to minimize strain on the upper limbs and spine.

The prevention of occupational MSDs in dentistry is not solely a matter of individual behavior change but a systemic challenge requiring institutional, educational, and industrial intervention. By embedding ergonomic education, proactive physical conditioning, and interdisciplinary innovation into dental training from the outset, the profession can foster a generation of practitioners who are not only technically proficient but also physically resilient.

Only through such a comprehensive, proactive approach can the dental community ensure long-term professional sustainability, improve patient care outcomes, and reduce the burden of preventable occupational injuries.

6. Disclossure

6.1. Author Contributions

Conceptualization, K.A., and P.S.; methodology, N.H., K.N. and K.A.; software, M.S.; check, K.A., M.M., J.S., P.S. and K.N.; formal analysis, D.W., J.S., K.A. and P.S.; investigation, M.M., K.K., D.W., K.O., N.H. and K.A.; resources, D.W., K.A. and P.S.; data curation, P.S., N.H. and K.K.; writing – rough preparation, J.S., P.S. and K.A.; writing – review and editing, K.A., J.S., P.S., M.M. and M.S.; visualization, M.S. and K.A.; supervision, K.A.; project administration, K.K. and P.S. All authors have read and agreed to the published version of the manuscript.

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6.5. Conflict of Interests

The authors declare no conflict of interest.

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