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The Efficacy of Various Carpel Tunnel Management Techniques in Alleviating Experimental Pain: A Controlled Clinical Trial

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***Abstract*: This study set out to directly compare the efficacy of ultrasound therapy and low level laser therapy in the management of mild to moderate idiopathic carpal tunnel syndrome (CTS). The primary aim was to evaluate and quantify the effects of these two physiotherapy interventions on pain relief, electromyographic measurements, and hand strength. The study enrolled 50 consecutive patients with confirmed CTS, totaling 90 hands, which were randomly assigned to either the ultrasound therapy group or the low level laser therapy group. Over the course of three weeks, both treatment groups underwent 15 daily sessions of their respective therapies. Assessments were conducted at three key time points: before treatment initiation, immediately post-treatment, and during a follow-up examination four weeks after the completion of therapy. The measurements encompassed various parameters, including pain assessment using a visual analogue scale, electromyographic parameters such as motor latency and action potential amplitude, and hand strength through pinch and grip strength assessments. Upon analysis, the results revealed significant differences between the two treatment modalities. The ultrasound therapy group demonstrated marked improvements across multiple outcome measures compared to the low level laser therapy group. Specifically, individuals receiving ultrasound therapy exhibited greater reductions in motor latency and increases in motor action potential amplitude. Moreover, they experienced more substantial enhancements in finger pinch strength and reported greater levels of pain relief on the visual analogue scale. Importantly, these positive outcomes were not only observed immediately after the completion of therapy but also persisted during the four-week follow-up period. This sustained efficacy underscores the potential of ultrasound therapy as a long-term treatment strategy for individuals with mild to moderate idiopathic CTS. The findings of this study suggest that ultrasound therapy may offer superior benefits compared to low level laser therapy in the management of CTS. Its ability to provide comprehensive symptom relief, improve electromyographic parameters, and enhance hand strength positions ultrasound therapy as a promising treatment option for this common condition. Nonetheless, further research is warranted to explore potential combination therapy effects and elucidate the mechanisms underlying the observed therapeutic benefits. Additionally, larger-scale studies are needed to validate the long-term effectiveness and safety of ultrasound therapy in the management of CTS.**

***Keywords*: carpel tunnel syndrome, ultrasound therapy, laser therapy, pain relief, hand strength.**

1. Introduction

Carpal tunnel syndrome (CTS) is a prevalent and disabling condition characterized by tingling, numbness, or pain in the palm side of the hands and fingers, often affecting the thumb, index, and middle fingers. These symptoms typically worsen at night, disrupting sleep and daily activities. The syndrome arises from the compression of the median nerve as it traverses the carpal tunnel—a narrow passageway formed by eight small bones called carpal bones and covered by the flexor retinaculum ligament—at the wrist. Various factors, such as direct injury, repetitive hand movements, arthritis, hormonal changes, and inflammatory conditions, can contribute to the development of CTS.

The history of CTS spans several centuries, with documented cases appearing prominently in surgical literature since the mid-19th century. However, it was during the early 20th century that the condition gained recognition in medical literature, coinciding with increased industrialization and changes in occupational activities. The term "carpal tunnel syndrome" was first coined in 1939 by Dr. George S. Phalen, who identified the pathology after working with a group of patients in the 1950s and 1960s. Since then, CTS has become one of the most commonly diagnosed nerve compression syndromes worldwide.

Epidemiological studies have provided valuable insights into the prevalence and distribution of CTS across different demographic groups. Age is a significant risk factor, with the incidence of CTS increasing with advancing age, peaking between the ages of 45 to 64 years in both men and women. Gender differences also play a notable role, with CTS being more prevalent in women, particularly those aged 50 to 59 years. Additionally, certain medical conditions and lifestyle factors, such as obesity, diabetes, pregnancy, and repetitive hand activities, have been associated with an increased risk of developing CTS.

Despite its high prevalence and impact on quality of life, CTS

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remains a challenging condition to manage effectively. While medical treatments, including pain medications, splinting, and corticosteroid injections, can provide symptomatic relief, they often fail to address the underlying causes of nerve compression. Physiotherapy interventions have emerged as an important adjunctive treatment approach, aimed at improving hand function, reducing pain, and preventing disability. These interventions may include modalities such as ultrasound, low-level laser therapy, nerve gliding exercises, and ergonomic education.

Given the multifactorial nature of CTS and its diverse clinical presentation, there is a growing need for comprehensive and interdisciplinary approaches to its management. Understanding the epidemiology, risk factors, and associated comorbidities of CTS is crucial for developing effective prevention and treatment strategies. In this context, this study aims to investigate the effectiveness of physiotherapy interventions, specifically ultrasound and low-level laser therapy, in managing mild to moderate idiopathic CTS, contributing to the evidence-based management of this common and debilitating condition.

2. Pathophysiology

The pathophysiology of CTS is typically caused by traction and compression processes working together. The key components include local edema, venous outflow blockage, persistent high pressure, and compromised intraneural microcirculation of the median nerve. The pathophysiology of nerve degeneration involves both Wallerian degeneration and retrograde degeneration. In Wallerian degeneration, the distal part of the nerve fiber undergoes simultaneous changes, including swelling and fragmentation of the axis cylinder, disintegration of the myelin sheath, and invasion of macrophages to remove debris. In retrograde degeneration, changes occur in the nerve cell body, including disintegration of Nissl granules and golgi apparatus, swelling of the cell body, and displacement of the nucleus. Regarding nerve regeneration, it begins when the endoneurial tube filled with Schwann cells remains intact, allowing axonal sprouts to pass across the site of injury. However, if the endoneural tube is interrupted, the axonal sprouts may migrate aimlessly. After successful nerve repair, regenerated axons may pass across the suture line, but they rarely enter pre-existing Schwann tubes, ultimately restoring the architecture of the nerve. Seddon's classification categorizes nerve injuries based on severity into neuropraxia, axonotmesis, and neurotmesis. Neuropraxia involves temporary disruption of nerve conduction, axonotmesis involves partial disruption with intact connective tissue, and neurotmesis involves total severance or disruption of nerve fibers, axons, myelin sheath, Schwann cells, and endoneurium. Sunderland's classification grades nerve injuries based on increasing severity, considering factors like axon transport, axon continuity, continuity of nerve fibers, perineurium, fascicles or nerve trunk, and endoneurium. Mechanisms of nerve injury include compression neuropathies, traction injuries, lacerations, cold injuries, electrical shocks, and injections, each with specific pathophysiological consequences. Clinical features of nerve injuries progress through stages characterized by pain, paraesthesia, motor weakness, and muscular atrophy, with specific signs like the "bottle sign" indicating paralysis of certain muscles.

3. Diagnosis

The diagnosis of CTS is made through the collection of medical history, physical examination (which may include CTS-specific diagnostics), and any necessary tests.

History taking:

Here's a structured approach to history-taking:

- Chief Complaint: Begin by asking the patient about their main concern or reason for seeking medical attention. This could include symptoms such as pain, numbness, weakness, or changes in sensation or motor function.
- Nature of Symptoms: Explore the specific nature of the symptoms experienced by the patient. For example, ask about the quality and location of pain, the distribution of numbness or tingling, any muscle weakness or atrophy, and any changes in sensation.
- Precipitating Factors: Determine if there were any specific events or activities that preceded the onset of symptoms. For example, ask about recent trauma, injuries, repetitive movements, exposure to cold temperatures, or any other potential triggers.
- Associated Symptoms: Inquire about any additional symptoms or related complaints. For example, ask about difficulties with hand dexterity, grip strength, coordination, or changes in sensation in other parts of the body.
- Medical History: Obtain information about any relevant medical conditions, such as diabetes, peripheral vascular disease, autoimmune disorders, or previous nerve injuries. Also, ask about any surgical procedures or treatments that may be relevant.
- Family History: Explore whether there is a family history of neurological conditions or any other relevant hereditary factors.

A. Physical Examination

During the physical examination, assess sensory functions including superficial, deep, and cortical sensations. Evaluate muscle tone, girth, length, and strength using manual muscle testing. Check range of motion for all joints individually, actively and passively. Test specific myotomes and reflexes to assess nerve function, particularly in cases of radial nerve injury where deep tendon reflexes may be reduced or absent. This comprehensive assessment provides crucial information for diagnosing and managing nerve injuries.

B. Special Tests

Tinel sign (at the wrist); During the physical examination, assess sensory functions including superficial, deep, and cortical sensations. Evaluate muscle tone, girth, length, and strength using manual muscle testing. Check range of motion for all joints individually, actively and passively. Test specific myotomes and reflexes to assess nerve function, particularly in cases of radial nerve injury where deep tendon reflexes may be reduced or absent. This comprehensive assessment provides crucial information for diagnosing and managing nerve injuries.

Fig. 1. Tinel sign's

Phalen`s (wrist flexon) test: A positive test is indicated by tingling in the thumb, index finger, middle and lateral half the ring finger caused by pressure on the median nerve [11].

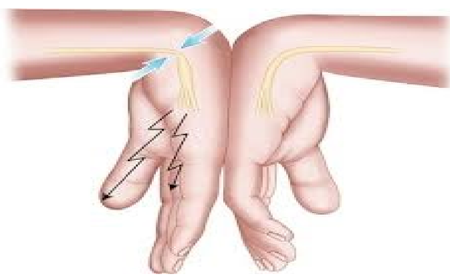

Fig. 2. Phalen's test

4. Management

A. Non-Operative Method

In the initial stage non-steroidal anti-inflammatory drugs (NSAIDS) are given. If it is unsuccessful steroids like Predinsolone for 8 days, staring 40mg for 2 days are tried. Injection-In the injection therapy, a single infusion of cortisone with splinting for 3 weeks is tried [13].

B. Physiotherapy Management

1) Conservative method

Protection: Initially, splint the wrist in a neutral position to rest it from provoking activities and minimize pressure in the carpal tunnel.

Median Nerve Mobilization: Perform specific stretches to mobilize the median nerve, progressing through different positions to alleviate symptoms without exacerbation.

Muscle Performance: Start with gentle muscle-setting exercises, then progress to strengthening and endurance exercises when symptoms are controlled. Emphasize activities to improve speed, coordination, endurance, and fine finger dexterity.

Functional Independence: Teach patients to monitor symptoms and modify activities to prevent nerve injury, particularly avoiding sustained wrist flexion, ulnar deviation, and repetitive wrist movements combined with gripping and pinching.

For surgical intervention: Open Carpal Tunnel Release (OCTR): Considered the gold standard, OCTR involves a longitudinal incision to directly visualize and release the transverse carpal ligament, providing optimal outcomes but with potential post-operative complications.

Endoscopic Carpal Tunnel Release: Involves smaller incisions and endoscopic visualization of the ligament, offering advantages such as less scarring and quicker return to function, but it may not be suitable for all patients and has technical challenges. Both surgical approaches aim to relieve pressure on the median nerve by dividing the transverse carpal ligament, with each method having its advantages and considerations.

Post-operative management of carpal tunnel syndrome focuses on relieving symptoms and promoting recovery following surgical decompression of the median nerve. Initially, maximum protection is ensured with a bulky dressing or splint, with caution exercised to avoid wrist flexion and finger flexion with the wrist flexed to prevent tendon bowstringing. Active tendon-gliding and nerve-gliding exercises are initiated to prevent adhesion formation, followed by progressive stretching, joint mobilization, and muscle performance exercises to improve strength, coordination, and dexterity. Sensory stimulation and discriminative sensory reeducation are implemented to address hypersensitivity and promote nerve recovery. Secondary prevention measures include avoiding crutches and maintaining proper sleep positions to prevent further nerve injury.

5. Prognosis

Neuropraxia, characterized by temporary nerve dysfunction without axonal damage, often leads to rapid and full recovery, particularly in areas like the forearm and wrist, with a favorable prognosis in over 90% of cases. Axonotmesis involves damage to the nerve fibers while preserving the connective tissue framework, offering a chance for recovery; however, if improvement is lacking over time, the outlook becomes grim albeit not entirely devoid of hope. Conversely, neurotmesis, where nerve continuity is entirely severed, typically precludes complete recuperation, emphasizing the critical role of nerve integrity in prognosis assessment.

6. Conclusion

Conservative treatment options include splinting the wrist in a neutral position and ultrasound therapy. Orally administered corticosteroids can be effective for short-term management (two to four weeks), but local corticosteroid injections may improve symptoms for a longer period. If symptoms are refractory to conservative measures or if nerve conduction studies show severe entrapment, open or endoscopic carpal tunnel release may be necessary Physiotherapy management is requiring in all stages of median nerve injury.

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