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Pain Intervention in Upper Extremity

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ABSTRACT

Pain in the upper extremity is a significant clinical concern, often arising from various etiologies including neurological and musculoskeletal disorders. This review focuses on contemporary pain management strategies for upper extremity conditions, emphasizing interventional approaches such as prolotherapy and ultrasound-guided injections. Prolotherapy has shown promise in treating chronic pain, particularly in conditions involving tendon and ligament injuries, by stimulating tissue regeneration and improving functional outcomes. The use of ultrasound-guided techniques for joint injections, including for conditions like epicondylitis and osteoarthritis, has also gained traction due to its precision and reduced risk of complications. This paper examines these methods, their efficacy, and the biological mechanisms underlying their therapeutic actions. Findings suggest that while these interventions provide significant pain relief and improve joint function, variability in patient response underscores the need for personalized treatment protocols. Future research should focus on long-term outcomes and further optimization of these pain management strategies in clinical settings.

Keywords: Upper extremity pain, Pain management, Prolotherapy, Ultrasound-guided injections, Chronic pain treatment.

INTRODUCTION

Discomfort is a complex sensory and emotional response to harmful stimuli, with causes ranging from acute injuries to chronic conditions. It significantly impacts daily life, disrupting routine activities, sleep, and psychological well-being. In the upper extremities, discomfort is notably prevalent, with studies indicating that up to 20% of the population is affected in some regions, including Indonesia. Effective management of upper extremity discomfort is crucial for rehabilitation, as it not only limits physical function but also impedes healing. Current interventions include pharmacological methods, targeted physical therapy, and advanced technologies like neurostimulation and regenerative therapy. This research aims to explore existing management strategies for upper extremity discomfort and develop more holistic approaches to improve patient outcomes and overall quality of life.

METHODS

Study Design

The study seems to focus on evaluating different interventions for pain management in the upper extremities, exploring both non-surgical and surgical options. It likely involves a combination of retrospective data and current clinical trial evidence to assess various therapeutic modalities.

LITERATURE REVIEW

The literature review touches on various aspects of pain management in the upper extremity, including conditions like lateral epicondylitis, arthritis, and other musculoskeletal disorders. It highlights the growing use of prolotherapy, corticosteroid injections, and other non-invasive techniques in treating these conditions. The review likely emphasizes the biological mechanisms behind musculoskeletal pain and evaluates the efficacy of different treatments through clinical trials

Inclusion and Exclusion Criteria

Inclusion Criteria:

The study would include participants with upper extremity pain, particularly those diagnosed with conditions like epicondylitis, osteoarthritis, or nerve compression syndromes.

Exclusion Criteria:

Patients with underlying systemic diseases, severe comorbidities, or conditions that could interfere with treatment outcomes might be excluded. Additionally, those who are allergic to certain therapies or materials used in treatments (e.g., corticosteroids or anesthetics) may not be eligible.

Data Extraction and Analysis

Data will be extracted from previous studies and clinical trials, focusing on the pain reduction effectiveness of different interventions. Statistical analysis will likely include a combination of descriptive and inferential techniques to compare treatment outcomes across various studies. The analysis will explore both the immediate and long-term effects of the treatments on pain relief and functional recovery in patients.

RESULTS AND DISCUSSION

Definition

The concept of pain and its treatment has evolved significantly throughout medical history. Ancient philosophers, including Aristotle, viewed pain as a passion of the soul, a concept widely accepted for about 22 centuries, while treatments remained empirical and often ineffective. Over the past century, scientific studies began to explore various theories of pain, leading to the development of therapeutic modalities. However, it wasn't until the last two decades that significant progress was made in understanding the underlying mechanisms of pain and introducing new treatment approaches. Despite these advances, much remains to be done to manage both acute and chronic pain effectively, requiring continued research, professional training, and public education[1].

Currently, the International Association for the Study of Pain (IASP) defines pain as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage," a definition widely accepted by health professionals and researchers. In recent years, however, experts have suggested a revision of this definition. In 2018, IASP formed a multinational task force to evaluate the current definition, leading to a recommendation to revise it as "an unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage," with an updated note that includes etymology[2-3].

The American Pain Society also defines pain as a discomfort that can occur anywhere in the body and is experienced by everyone at some point (American Pain Society, n.d.). It can be caused by both physical and mental factors, and it can last for varying periods. In Indonesia, the Ministry of Health defines pain similarly, noting that it is a complex human experience involving the interaction of emotional, behavioral, cognitive, and sensory physiological factors. Pain is considered a protective mechanism that alerts individuals to potential or actual tissue damage, and nociceptors (pain receptors) do not adapt to prolonged or repeated stimulation[4].

In conclusion, pain is a complex, subjective experience that involves both sensory and emotional responses to harmful stimuli. Its individual nature requires personalized management approaches. Understanding these definitions is crucial for developing effective interventions for pain, especially in managing conditions such as upper extremity pain.

Epidemiology

Epidemiology of pain, particularly in the upper extremities, provides valuable insights into its distribution, prevalence, risk factors, and related population characteristics, helping to design effective interventions. Pain is the most common healthcare complaint globally, affecting one in five adults, with one in ten diagnosed with chronic pain annually. It impacts all populations, regardless of age, gender, income, race, or geography, with major causes including cancer, arthritis, surgery, injury, and spinal issues. Pain often leads to severe consequences like depression and social issues, and for chronic pain sufferers, the average duration is seven years[5]. A study of 52 countries found significant variation in pain prevalence, with factors like gender, age, and rural residency influencing its occurrence. National factors, such as the Gini Index, population density, and gender inequality, strongly correlate with pain prevalence, but personal, local, and cultural factors also contribute. This highlights the need to prioritize pain management globally, addressing disparities in income and gender[6].

Mechanisms of Pain

Pain is a subjective experience with two main aspects: the sensation localized to a specific part of the body and the unpleasant quality with varying severity. The mechanisms of pain involve four main processes: transduction, transmission, modulation, and perception. Transduction refers to the activation of nerve endings by stimuli that damage tissues, while transmission is the process of carrying messages from the injury site to the brain. Modulation plays a role in reducing activity in the transmission system, and perception is the subjective awareness of pain.

Pain-inducing stimuli can be mechanical, thermal, or chemical. The transduction process involves the activation of primary afferent nociceptors that are sensitive to these stimuli. Chemical stimuli, such as potassium, histamine, and serotonin, can increase nociceptor sensitivity, while mechanical and thermal stimuli are typically brief.

Pain Transmission

Pain messages are transmitted through the axons of primary afferent nociceptors, carrying impulses to the spinal cord and pain transmission cells in higher centers. This process can be studied by recording the activity of nociceptor nerves, which can show the relationship between the frequency of impulses and the intensity of pain. This process is also related to the phenomenon of referred pain, where pain is felt in a location distant from the site of injury.

Pain Modulation

Modulation involves processes that inhibit pain transmission, including mechanisms in the central nervous system that reduce responses to painful stimuli. Brain stimulation-induced analgesia and opioids play an important role in pain management. This system regulates pain intensity through pathways mediated by endorphins and endogenous opioid peptides.

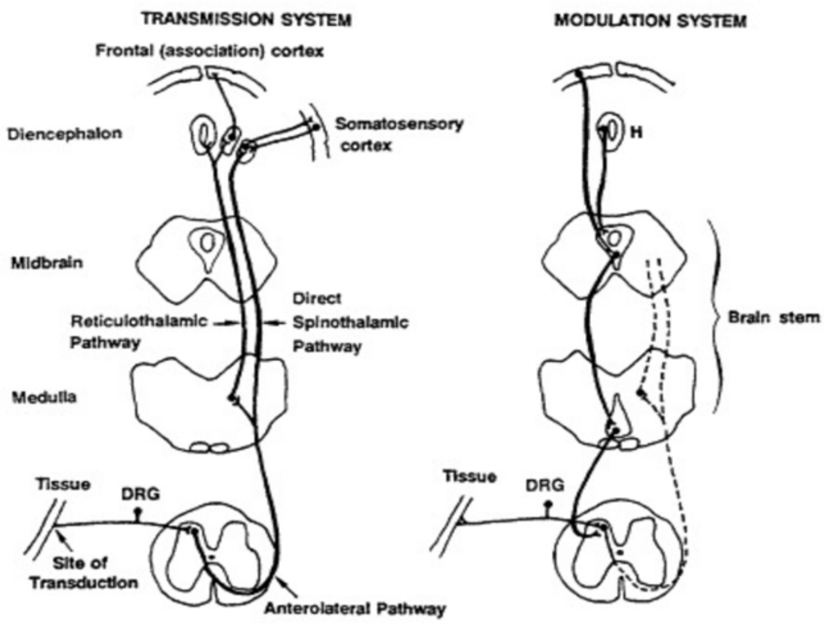

Figure 1: Outline diagram of the major neural structures relevant to pain

Physiological Processes that Enhance Pain

Sensitization is a process where the threshold of nociceptors decreases, making stimuli that would normally be innocuous become painful. Additionally, sympathetic nervous system hyperactivity can exacerbate pain, and muscle contractions associated with pain also play a role in increasing pain intensity.

Neuropathic Pain

Damage to peripheral or central nerves can lead to neuropathic pain, which is very difficult to treat. This pain often arises without physical stimulation or with minimal stimulation and is often accompanied by sensory abnormalities. Conditions such as trigeminal neuralgia and postherpetic neuralgia are common examples of neuropathic pain.

Acute vs Chronic Pain

Acute pain can evolve into chronic pain, which affects the central nervous system and alters responses to stimuli. Chronic pain is often accompanied by psychological components that worsen the pain experience. Psychological factors such as stress and anxiety can increase pain intensity, while relaxation can reduce it.

Physiological Monitoring Methods

Monitoring nociceptor activity or changes in skin temperature may provide insights into pain mechanisms. However, these methods are still limited and primarily used in research. Technologies such as thermography to monitor sympathetic function could also help evaluate pain, although their reliability still needs further testing.

Pain Classification

Pain is classified based on its origin, intensity, and duration, with somatogenic pain being localized to body tissues, nociceptive pain arising from inflammation, and neuropathic pain resulting from nervous system sensitization. Psychogenic pain, however, has no physical cause and arises from disrupted processing in the central nervous system (CNS). Acute pain, with a sudden onset, is protective, alerting individuals to potential harm and activating the autonomic nervous system, which leads to symptoms such as tachycardia, hypertension, sweating, and changes in gut motility. This type of pain can also cause anxiety and discomfort, lowering immune responses and increasing infection risk and hospital stays. Acute pain can be somatic, originating from the skin or superficial tissues, or visceral, arising from internal organs, and can sometimes be referred to distant areas due to converging sensory inputs in the CNS or sensitization of dorsal horn neurons. Chronic pain, which lasts for at least six months, often causes significant psychological changes like helplessness and depression, and persists even after the removal of the initial cause due to nervous system plasticity. Common causes of chronic pain include persistent lower back pain, cancer pain, neuralgia, causalgia, reflex sympathetic dystrophy, and myofascial pain syndrome. Rare conditions like hemiagnosia and phantom limb pain are also associated with chronic pain. Hemiagnosia, often following a stroke, causes hypersensitivity to pain in certain areas, leading to anxiety and distress, while phantom limb pain results in sensations of pain in an amputated[7-11].

Table 1: Differences Between Acute Pain and Chronic Pain

Characteristics	*Acute pain*	*Chronic pain*
Temporal features	Short history of onset and does not last longer than days or weeks	Long history with often poorly-defined onset; duration unknown
Intensity	Variable	Variable
Associated effects	If pain is severe anxiety may be prominent and sometime irritability	Depression and irritability is prominent feature
Associated pain behaviors	When pain is severe pain behaviors (e.g. moaning, rubbing and splinting) may be prominent features	Specific behavior may or may not be present. If pain is severe and for long duration specific behaviors (e.g. assuming a comfortable position) may occur
Other associated features	Features of sympathetic hyperactivity when pain is severe (e.g. tachycardia, hypertension, sweating, mydriasis)	Usually have one or more vegetative signs such as lassitude, anorexia, weight loss, insomnia, loss of libido. Sometimes these signs may be difficult to distinguish from other disease-related effects

How to Measure Pain

Pain Assessment

Pain assessment can be straightforward for acute pain, but becomes more complex for chronic pain, especially in patients with chronic or cancer-related pain. Many assessment tools have been developed for different types of pain, but due to the subjective nature of pain, evaluating pain in patients who cannot communicate well (e.g., patients with dementia) remains a challenge.

Acute Pain

For acute pain, the Visual Analog Scale (VAS) and the Numerical Rating Scale (NRS) are the most commonly used and sensitive methods for measuring pain intensity. The assessment involves pain at rest and dynamic pain (pain occurring during movement, coughing, or deep breathing). NRS is more practical and easier to understand compared to VAS. Dynamic pain is more important for reducing postoperative complications compared to pain at rest.

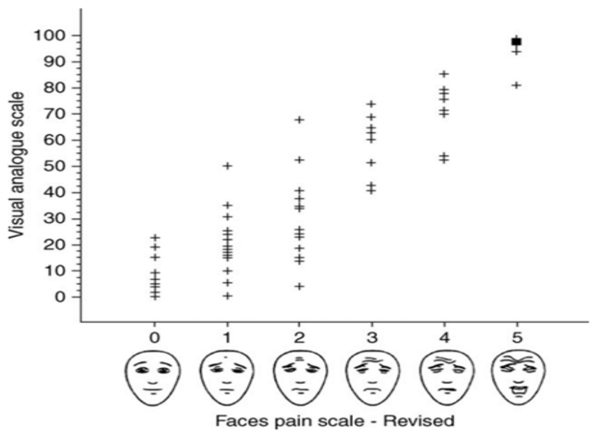

Figure 2: Facial pain scale as a way to measure pain by looking at facial expressions

Baseline Pain Assessment in Clinical Trials

Baseline pain assessment is essential in clinical trials to ensure that the effects of analgesic drugs can be accurately measured. Measuring baseline pain before treatment helps avoid misleading conclusions about the effectiveness of the drug.

Neuropathic Pain and Central Sensitization

It is important to assess for neuropathic pain or central sensitization in acute pain after surgery. Signs of central sensitization, such as mechanical allodynia, can be measured using von Frey filaments and can be suppressed by drugs like ketamine.

Chronic Pain

Chronic pain has a significant impact on a patient's physical, emotional, and social function. Assessing chronic pain requires a more comprehensive approach that includes pain history, physical examination, and diagnostic tests. Assessment tools like the Brief Pain Inventory (BPI) and McGill Pain Questionnaire are used to evaluate various aspects of chronic pain.

Pain Assessment Tools

Various tools have been developed to assess chronic and neuropathic pain. For example, the BPI assesses pain intensity and functional disruption, while the McGill Pain Questionnaire evaluates sensory, affective, and evaluative components of pain. Tools for assessing neuropathic pain include the Leeds Assessment and Neuropathic Pain Scale.

IMMPACT Recommendations

IMMPACT provides six core outcome domains to assess the effectiveness of pain treatment in clinical trials, including pain intensity, physical function, emotional function, patient satisfaction with treatment, other symptoms, and patient characteristics.

Cancer Pain Assessment

Pain assessment in cancer patients is crucial in palliative care. Tools used include BPI for assessing cancer-related pain and the Edmonton Symptom Assessment Scale for assessing various symptoms other than pain.

Pain Assessment in Patients with Communication Impairment

For patients who cannot report their pain, proxy pain assessment using pain behavior scales is essential. Scales used include the COMFORT Scale for infants and children, and the CRIES Pain Scale for neonates.

Pain in the Upper Extremities

Pain in the upper extremities can originate from two main sources: neurological and musculoskeletal etiologies. Neurological pain can arise from cervical spine pathologies, peripheral nerve compression, or neuropathies. Musculoskeletal pain can stem from issues in the shoulder or elbow.

Cervical Spine Pathology

Degenerative changes in the cervical spine, such as spondylosis, osteophytes, herniation, and ligament hypertrophy, can cause nerve compression, leading to conditions like referred pain, cervical radiculopathy, and cervical myelopathy. Pain from spondylosis arises when the intervertebral disc, innervated by sinuvertebral nerves, becomes degenerated, causing hypermobility, biomechanical disturbances, and irritation of these nerves, which results in axial pain in the neck and head without extending beyond the shoulder. Cervical radiculopathy occurs when pressure on specific nerve roots leads to pain, paresthesia, weakness, and loss of reflexes, often presenting with arm pain that is alleviated by placing the ipsilateral hand on the head. This condition can be diagnosed with tests like the Spurling test, along with imaging or electrodiagnostic studies. In more severe cases, cervical myelopathy develops when spinal cord compression causes progressive loss of function, including walking difficulty, weakness, and coordination deficits, with muscle atrophy in the hands. Diagnosis of myelopathy is typically confirmed through electromyography and MRI.

Peripheral Nerve Compression

The upper extremities contain three main nerves—median, ulnar, and radial—that are vulnerable to compression, leading to various syndromes. Carpal Tunnel Syndrome (CTS) is caused by median nerve compression at the wrist, leading to numbness in the fingers, especially at night. Anterior Interosseous Nerve Syndrome affects motor function in the hand without sensory loss. Parsonage-Turner Syndrome follows a viral infection and causes severe shoulder pain, paralysis, and muscle atrophy. Cubital Tunnel Syndrome involves ulnar nerve compression at the elbow, causing pain and weakness in the hand, while Ulnar Tunnel Syndrome affects the wrist, causing similar symptoms on the ulnar side. Lastly, Radial Neuropathy affects wrist, thumb, and finger extension, often diagnosed with electrodiagnostic tests. These conditions cause pain, weakness, and functional impairment, with diagnosis confirmed through clinical tests and imaging.

Non-compressive Peripheral Neuropathy

Peripheral neuropathy can also result from systemic diseases, involving either single or multiple nerves, leading to pain, weakness, or sensory loss in the upper extremity. Accurate history and physical exams are vital in distinguishing non-compressive neuropathies from musculoskeletal causes.

Pain from the Shoulder

Pain in the shoulder region can stem from both intrinsic pathologies within the shoulder joints, such as acromioclavicular, sternoclavicular, and glenohumeral joint issues, or from extrinsic causes like referred pain from the cervical spine. Trauma, inflammation, or osteoarthritis in the acromioclavicular and sternoclavicular joints often result in localized pain, aggravated by specific movements like forced adduction, and can be diagnosed through intra-articular anesthetic injections. Glenohumeral joint pain has a multifactorial origin, including conditions such as adhesive capsulitis, osteoarthritis, or rotator cuff tears, and diagnosis is supported by specific tests like Neer's and Hawkins' tests, as well as imaging techniques such as MRI. Additionally, scapulothoracic joint pain can overlap with cervical spine pain, with conditions like "snapping scapula" typically caused by bursitis or mechanical irritation, while scapular dyskinesis may arise from nerve palsy or other shoulder pathologies.

Pain from the Elbow

Pathological conditions affecting the elbow include lateral and medial epicondylitis, as well as osteoarthritis. Lateral Epicondylitis (Tennis Elbow) results from microtears in the extensor carpi radialis brevis muscle, causing pain on the lateral side of the elbow, especially during gripping activities. Medial Epicondylitis (Golfer's Elbow), similar in nature, affects the flexor-pronator muscles at the medial epicondyle, leading to pain during wrist flexion or resistance to pronation. Elbow Osteoarthritis involves the degeneration of cartilage in the radiocapitellar or ulnotrochlear joints, leading to pain, restricted range of motion, and in some cases, sensations of catching or locking within the joint.

Pain Interventions in the Upper Extremities

Non-surgical modalities are commonly used for various conditions in the upper extremities, including physical rehabilitation, oral medications, and injections. Corticosteroids are the most commonly used therapy due to their strong anti-inflammatory properties

Prolotherapy

Prolotherapy is a treatment technique that involves injecting sclerosing agents into affected areas to address conditions such as tendinosis and osteoarthritis. The primary agents used in this therapy, such as hypertonic dextrose, aim to stimulate an inflammatory response that encourages tissue repair. Prolotherapy is particularly beneficial for patients with conditions that do not respond to more conventional non-surgical treatments, offering a promising alternative for long-term relief.

Ultrasound-Guided Intervention Procedures

Ultrasound-guided intervention procedures have become increasingly important in the treatment of various musculoskeletal conditions. Ultrasound technology is employed to enhance the precision of injections and aspirations, making it easier to detect soft tissue abnormalities. It also provides the advantage of avoiding radiation exposure, which is a significant benefit in certain cases. Common interventions include corticosteroid injections and joint aspirations, both of which help manage conditions affecting the upper extremities.

Techniques for Various Joints

In the glenohumeral joint, ultrasound-guided corticosteroid injections and aspirations are widely used to manage conditions like adhesive capsulitis. These procedures not only offer relief from pain but also assist in diagnosing and treating joint dysfunction. Ultrasound guidance is also essential in arthrography, where it improves the accuracy and safety of the procedure.

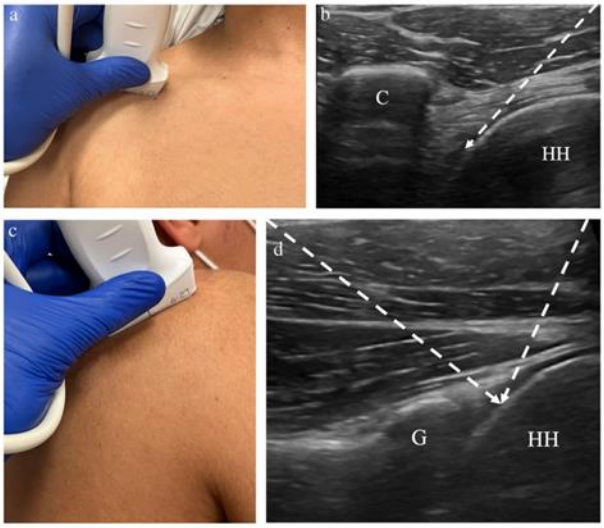

Figure 3: Glenohumeral Joint Injection Technique

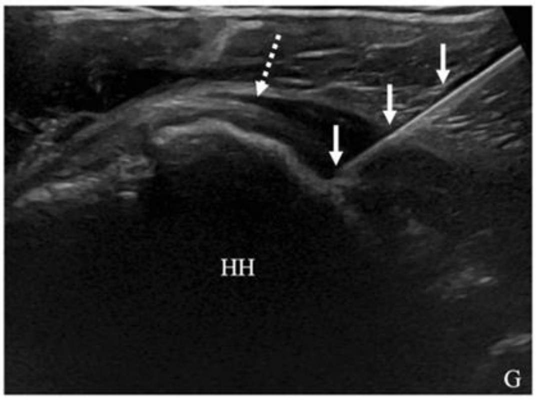

Figure 4: Ultrasound image of corticosteroid injection of the glenohumeral joint using a posterior approach

For the acromioclavicular joint, corticosteroid injections are frequently used to relieve pain caused by osteoarthritis. The incorporation of ultrasound enhances the precision of these injections, ensuring the correct placement of medication for optimal results.

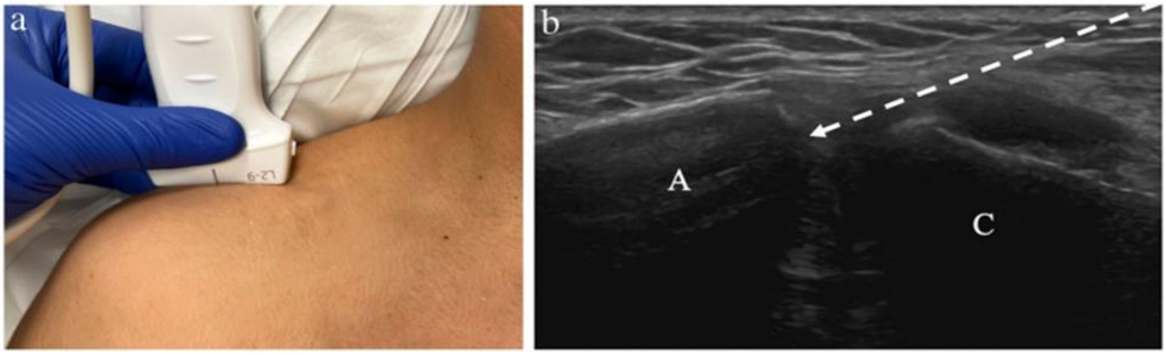

Figure 5: Acromioclavicular joint injection technique

In the case of the sternoclavicular joint, intervention procedures are less common but are utilized for conditions such as osteoarthritis and septic arthritis. Although rare, these procedures can provide much-needed relief for patients suffering from these specific joint pathologies.

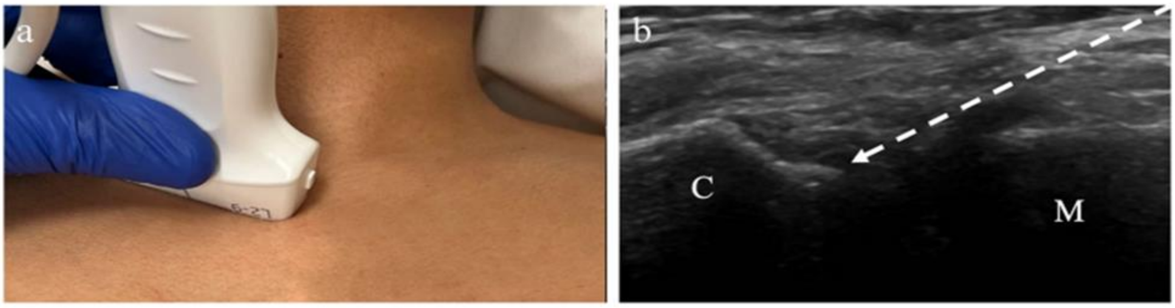

Figure 6: Sternoclavicular joint injection technique

When it comes to the elbow joint, corticosteroid injections are often employed to treat inflammatory arthritis or crystal arthropathy. These injections help reduce pain and inflammation, restoring mobility to the affected joint.

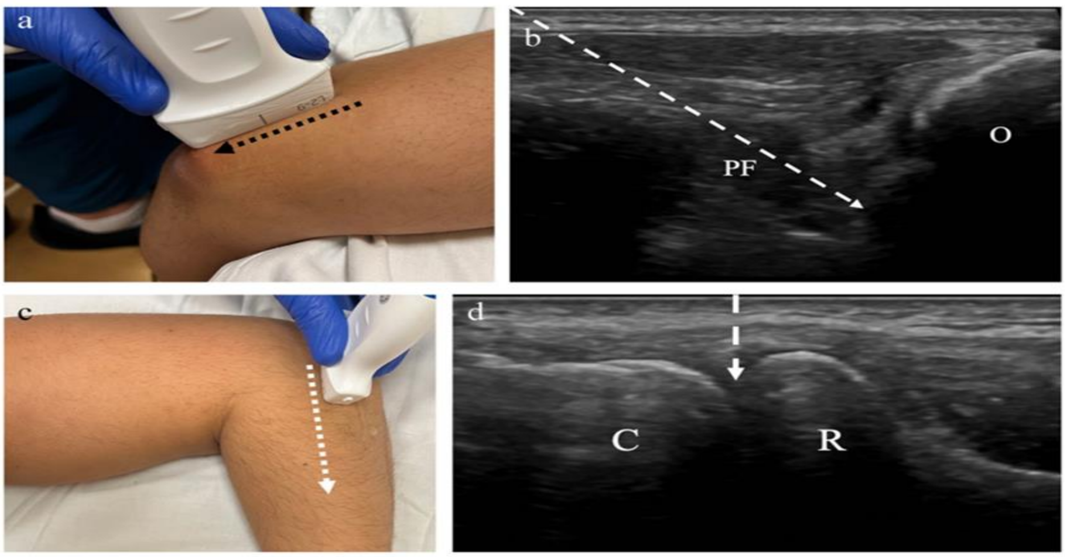

Figure 7: Elbow joint injection technique

For the wrist and hand joints, injections for osteoarthritis are common, particularly in the carpometacarpal joints of the thumb. Ultrasound guidance in these procedures ensures the accuracy of the injections, reducing the risk of complications and enhancing therapeutic outcomes.

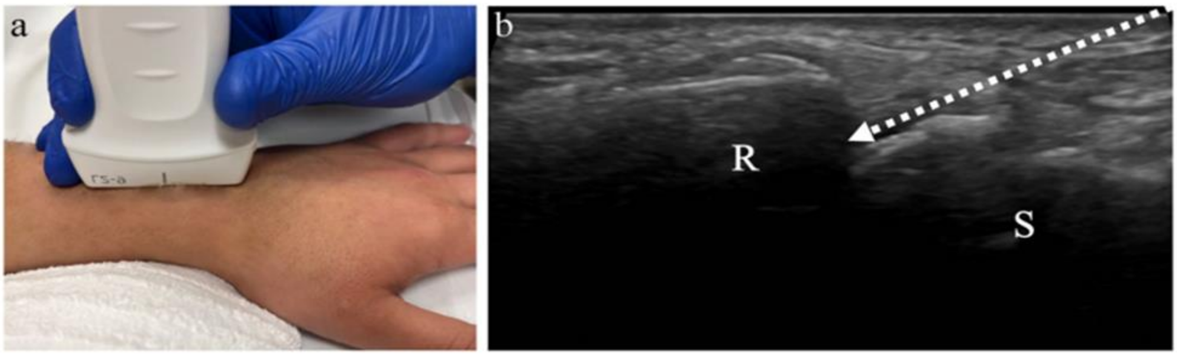

Figure 8: Radiocarpal or wrist joint injection technique

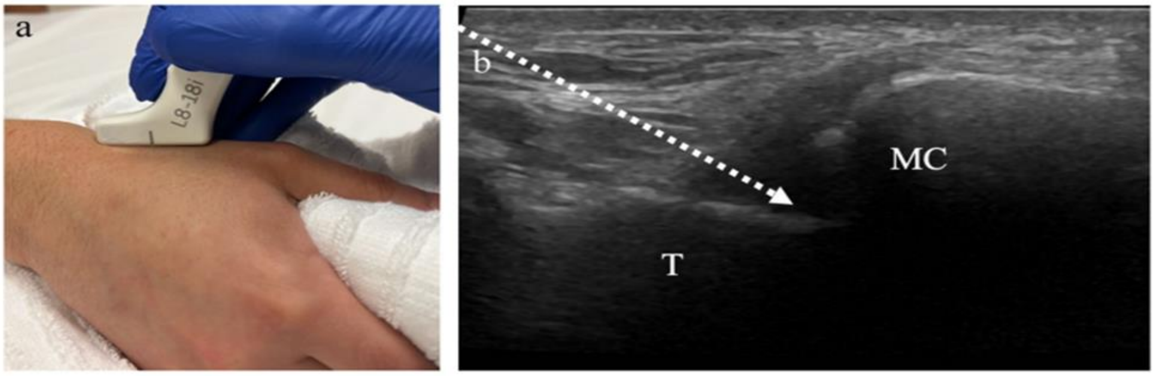

Figure 9: Thumb carpometacarpal joint injection technique

Joint	Total volume
Glenohumeral	8–12 mL
Acromioclavicular	1–2 mL
Sternoclavicular	0.5–2 mL
Elbow	3–8 mL
Wrist (radiocarpal)	2–5 mL
Small joints of hand, including thumb carpometa-carpal	0.25–1 mL

Table 2: Recommended volume to be injected into the upper extremities

Pain Complication

Persistent pain, often referred to as chronic or intractable pain, can become a disease in itself, significantly impacting both the patient and the healthcare provider[12-14]. It may lead to complications such as deconditioning, where the affected body part loses its normal function, leading to muscle atrophy, neuropathy, and, eventually, contractures. These complications can progress, causing patients to transition from using a cane to a walker or even a wheelchair. Additionally, persistent pain can lead to secondary pain in other areas due to compensatory overuse, resulting in conditions like arthropathy, myopathy, and neuropathy. Hormonal imbalances, such as adrenal exhaustion, can occur as pain activates the stress response, leading to elevated levels of catecholamines and glucocorticoids, which further exacerbate the pain and impact the cardiovascular system[15-16]. Persistent pain also leads to immune suppression, manifesting as increased vulnerability to infections and slower wound[17-18].

Neuropsychiatric issues are also common in patients with persistent pain, including insomnia, depression, cognitive deficits, and anxiety[19-20]. These complications are likely due to neuroanatomical degeneration, hormonal changes, and neurochemical depletion, often affecting areas of the brain involved in pain processing. Management of these complications remains in the early stages, but early intervention is key. Regular assessments for deconditioning, overuse injuries, and hormonal imbalances are necessary. Monitoring blood pressure and pulse can also help evaluate pain control. Furthermore, hormonal and lipid profile tests are important to identify potential issues with cortisol, pregnenolone, and testosterone levels, which can affect pain management[21]. Aggressive treatment protocols should be followed to address any emerging complications, improving the patient's overall quality of life.

Classification of Major Complications of Persistent Pain SCROLL RIGHT FOR MORE
Deconditioning "Overuse" of ancillary musculoskeletal tissue with degeneration
Decreased mobility
Obesity
Muscle atrophy
Contractures
Neuropathies
Hormonal Excess catecholamine production with hypertension and tachycardia
Glucocorticoid excess or deficiency
Hypotestosteronemia
Insulin - Lipid abnormalities
Immune suppression
Neuropsychiatric Nerve - Spinal cord degeneration
Cerebral atrophy
Depression/suicide
Insomnia
Attention deficit
Memory loss
Cognitive decline

Table 3: Classification of major complications of persistent pain

Signs and Symptoms of Glucocorticoid Abnormalities		
Glucocorticoid Excess		
Weight Gain	Menstrual Irregularity	Depression
Lethargy	Cognitive Dysfunction	Memory Loss
Osteoporosis	Paranoia/Psychosis	Back Ache
Fractures	Muscle Weakness	Hypertension
Bruising	Striae	Loss Scalp Hair
Ankle Edema	Renal Calculi	
Diabetes/Decreased Glucose Tolerance		
Glucocorticoid Deficiency		
Weakness	Fatigue/Tiredness	Salt Craving
Weight Loss	Constipation/Diarrhea	Tachycardia
Hyperpigmentation	Nausea/Vomiting/Anorexia	Anemia
Postural Dizziness	Vitiligo	Muscle/Joint Pains
Auricular Calcification	Hypokalemia	Hyponatremia
Hypotension (<110mm Hg Systolic)		

Table 4: Signs and symptoms of glucocorticoid disorders

CONCLUSION

This paper explores prolotherapy and ultrasound-guided procedures for managing pain in the upper extremities. Prolotherapy has shown effectiveness in treating chronic pain, especially in ligament and tendon injuries, by stimulating tissue regeneration, reducing pain, and improving joint function. Ultrasound-guided procedures provide precision in injecting medication, reducing complications and enhancing treatment outcomes. Both methods have their advantages and limitations, requiring clinical expertise for optimal application. Future research should focus on comparative studies to evaluate the relative effectiveness of these methods and explore new techniques to improve pain management. Overall, both approaches offer promising solutions for upper extremity pain, but a holistic approach considering patient characteristics and clinical expertise is essential for maximizing benefits.

Declaration by Authors

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Conflict of Interest: The authors declare no conflict of interest.

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