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Prospective Evaluation

Referred Pain Patterns of the Third and Fourth Dorsal Interosseous Muscles

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Background: Myofascial pain (MP) is a common disorder that can involve any skeletal muscle in the human body. There are no published reports of the referred pain patterns of the third and fourth dorsal interosseous muscles.

Objective: To investigate the referred pain patterns of the third and fouth dorsal interosseous muscles.

Study Design: Prospective evaluation.

Setting: Academic medical center.

Methods: Twenty healthy adults participated in the study. Needle placement and injection of 0.2 mL 6% hypertonic saline solution into the midpoint of the interosseous muscles were performed under ultrasonographic (US) guidance. After the injections, the participants were instructed to wait until they felt the most pain and then draw a pain diagram. This drawing was transferred to the computer for analysis.

Results: The referred pain distributions for the third dorsal interosseous muscle were as follows: the interdigital space of the third and fourth fingers, 80%; the distal phalanx of the third and fourth fingers, 45%; and the ulnar side of the palm, 55%. Three and 6 participants reported pain on the volar side of the wrist and in the fifth finger, respectively. The referred pain distributions for the fourth dorsal interosseous muscle were as follows: the interdigital space of the fourth and fifth fingers, 80%; the hypothenar area, 65%; and the distal phalanx of the fourth and fifth fingers, 60%. Seven and 3 participants also reported pain on the ulnar side of the wrist and the ulnar side of the forearm, respectively.

Limitation: This study is limited by its small sample size.

Conclusion: Referred pain patterns of the third and fourth interosseous muscles resemble the pain experienced in C7 or C8 radiculopathies or the ulnar neuropathy. Thus, identification of the third and fourth interosseous muscle trigger point should be considered when patients experience pain on the ulnar aspect of the hand and wrist.

Key words: Myofascial pain syndromes, referred pain, dorsal interosseous

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Myofascial pain (MP) is a common disorder that can involve any skeletal muscle in the human body. One of the notable features of MP is the referred pain, which is defined as pain that arises in a trigger point (TrP) but is felt at a distance, often entirely remote from its source (1). This referred pain may mislead the clinician to an inaccurate diagnosis. The importance of acknowledging MP and its referred pain patterns lies in the fact that they produce symptoms very similar to other disorders, such as angina pectoris (pectoralis major), C6 radiculopathy (pectoralis minor), appendicitis (lower rectus

abdominis), or epicondylitis (wrist extensor) (1).

Through the pioneering works of Simons et al and Kang et al (1-4), over 300 referred pain patterns of 181 different skeletal muscles, including those of the head and hand intrinsic muscles, have been described and documented. Although the referred pain patterns of most forearm and hand muscles have been described, there are no published reports of the referred pain patterns of the third and fourth dorsal interosseous (DI) muscles.

The DIs are bipennate muscles, each arising from the adjacent sides of 2 metacarpal bones and attaching to the bases of the proximal phalanges and the dorsal digital expansions (5). Their main function is to abduct the other fingers from the center of the middle finger, but they also participate in the flexion of the proximal phalanges and the extension of the middle and distal phalanges. Thus, they are susceptible to overload stress, which may lead to MP.

Hypertonic saline injection has been widely accepted as an adequate method of inducing MP with a similar quality and intensity as clinical myalgia (6-8). The objective of this study was to use this approach to determine the referred pain patterns of the third and fourth DI muscles and to recognize MP of the third and fourth DIs as a possible cause of pain in the wrist and hand areas.

Methods

Participants

A total of 20 healthy adults with no history of neck or arm pain, upper limb paresthesia, cervical radiculopathy, or physical findings suggestive of MP in the shoulder or upper limb regions participated in the study. The participants consisted of 10 men and 10 women with an average age of 27.9 years (range, 22 – 37 years). All participants provided written informed consent to participate in the study, which was approved by the institutional review board.

Muscle Pain Induction

Hypertonic saline was injected into the muscle to experimentally induce pain that could mimic the pain of myofascial TrP. In all participants, induction of muscle pain was performed bilaterally. The injection on the third DI was performed on the left hand and the injection on the fourth DI was performed on the right hand. To prevent habituation, the injection on the right hand was performed a week following that on the left hand. The participant was laid in the supine position with arms to the side and with full pronation of the forearm. The midpoint between the third and fourth metacarpal bones on the left hand and between the fourth and fifth metacarpal bones on the right hand was marked, and ultrasonographic (US) guidance was employed to confirm accurate needle placement and injection into the DI muscles. We used a 5 – 12 MHz linear transducer (Philips Ultrasound, USA). Following skin sterilization, the US probe, with a sterile cover, was placed on the dorsum of the hand to visualize the DI muscles in a transverse plane (Fig. 1). After identifying the DI muscles on sonography, the needle was carefully

Fig. 1. *Injections of 0.2 mL of 6% hypertonic saline into the dorsal interosseous (third and fourth) muscles were done with US guidance.*

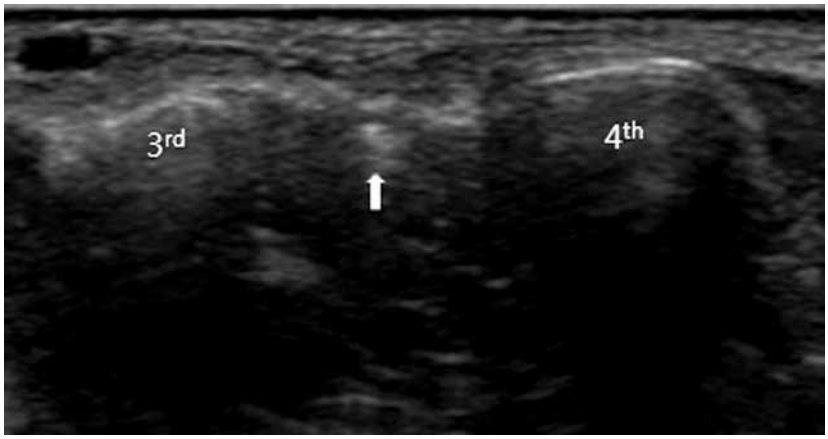

Fig. 2. The needle was inserted, aiming for the midpoint of the dorsal interosseous muscle, until the needle tip appeared on the US monitor. After confirmation of accurate needle tip location (arrow), 0.2 mL of 6% hypertonic saline solution was slowly injected into the muscle to induce pain. 3rd, third metacarpal bone; 4th, fourth metacarpal bone.

inserted, aiming for the midpoint of the DI muscles, until the needle tip appeared on the US monitor (Fig. 2). After US confirmation of accurate needle placement, 0.2 mL of 6% hypertonic saline solution was slowly injected into the muscle to induce pain. For hemostasis, gentle manual pressure was applied for 10 seconds after the needle was removed.

Pain Drawing and Analysis

After the hypertonic saline injection, the participants were instructed to wait until they felt the most pain and then draw the areas where they experienced pain in a pain diagram (Fig. 3). Pain areas were differentially depicted according to the intensity of the pain. Areas of more intense pain were shaded darker than less painful areas; however, the intensity of pain was not considered in the subsequent analyses. The injected hand was kept on a level surface during the drawing process to prevent any possible effect of gravity on the injected solution.

The participants' pain drawings in the pain diagrams were transferred manually into the hand template on a computer screen by a single researcher (TWC). In order to characterize the common areas of pain referral, the 20 computerized pain drawings were then overlapped with 10% opacity. This analysis was performed for each DI muscle.

Results

Twenty healthy adults (10 men, 10 women) were enrolled in this study. The mean age was 27.9 years (range, 22 – 37 years).

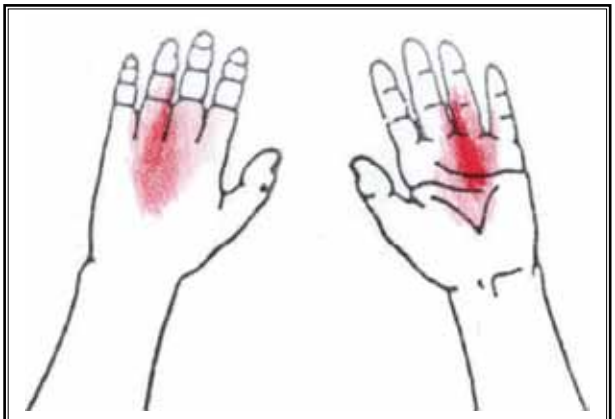

Fig. 3. *Pain drawing of a participant after the injection of hypertonic saline into the third dorsal interosseous muscle.*

Several referred pain locations were observed after the intramuscular injection of hypertonic saline into the third DI muscle. The most common location of pain referral was seen in the interdigital space of the third and fourth fingers, along the palmar and dorsal sides of hands (16 of 20 arms, 80%). Nine of 20 arms (45%) reported pain on the distal phalanx of the third and fourth fingers. In a third of the participants (7 of 20 arms, 35%), the referred pain was extended to the interdigital space of the fourth and fifth fingers. Three participants reported pain on the ulnar side of the wrist and one participant reported pain on the radial side of the forearm (Fig. 4).

Fig. 4. Pain referral patterns after the injection of hypertonic saline into the third dorsal interosseous muscle, which were obtained by the overlapping 20 computerized pain drawings. Common areas of pain were shaded in a darker color.
Left = dorsal side of the left hand, Right = palmar side of the left hand

Fig. 5. Pain referral patterns after the injection of hypertonic saline into the fourth dorsal interosseous muscle, which were obtained by the overlapping of 20 computerized pain drawings. Common areas of pain were shaded in a darker color.
Left = dorsal side of the right hand, Right = palmar side of the right hand

After the intramuscular injection of hypertonic saline into the fourth DI muscle, the most common pain referral location was seen in the interdigital space of the fourth and fifth fingers (16 of 20 arms, 80%). Twelve of 20 arms (60%) reported pain on the distal phalanx of the fifth finger and 13 of 20 arms (65%) reported pain on the hypothenar area. Seven participants described pain on the ulnar side of the wrist and one participant reported pain on the medial epicondyle area (Fig. 5).

In all participants, pain onset began shortly after the needle was removed from the injection site and pain intensity increased with manual compression. All participants described the pain as deep, aching, or throbbing in character, at both the site of injection and the referred areas. There was no complaint of an electric shock-like sensation, other paresthesia, or involuntary muscle contraction, which indicate nerve irritation during the injection. Pain gradually subsided within minutes after the injection and there were no adverse side effects in any of the participants.

Discussion

The DI muscles are deep-lying muscles that originate from the adjacent surfaces of 2 metacarpal bones. The first DI muscle usually has a strong insertion on the radial side of the base of the proximal phalanx of the index finger and little or no attachment to the extensor expansions. The second and third DI muscles are attached in part to the base of the proximal phalanx of the middle finger on its radial and ulnar sides, but also have strong connections to the extensor expansion. The fourth DI muscle arises from the fourth and fifth metacarpal bones and inserts into both the proximal phalanx and the extensor expansion (9). Although the main action of DI muscles is to abduct fingers, they are also active during the extension of the interphalangeal joints when the metacarpophalangeal joints are flexed (9). The DI muscles are involved in the various actions of a hand; as such, they are susceptible to overload stress during daily activities, and are also potential sources of hand and wrist pain. However, the actions of DI muscles differ slightly in some parts. During the pincer grasp, the first and second DI muscles may be more active than the third and fourth DI muscles; however, during the power grasp, the third and fourth DI muscles, which are located on the medial side of the hand, are more stressed than the first and second DI muscles. Therefore, the referred pain patterns of the third and fourth DI muscles might be quite different from those of the first and second DI muscles. However, there is no docu-

mented report about the referred pain patterns originating from a potential TrP in the third and fourth DI muscles, while those of the first and second DI muscles are already described by previous study (1). Repetitive activities leading to overload stress of skeletal muscles are known to be the main causative factors in the development of MP (1,10). Thus, identification of muscle pain patterns for each individual muscle is crucial for accurate diagnosis and effective treatment.

In our previous study, 0.3 mL of hypertonic saline was used for induction of muscle pain in the pronator quadratus muscle (2). However, in this study we injected 0.2 mL of hypertonic saline because of the relatively small size of the DI muscles and also to prevent the possible leakage of hypertonic saline to adjacent structures. The referred pain location may vary significantly depending on the site of hypertonic saline injection into the muscle; therefore, accurate needle placement was confirmed by US guidance.

The results of this study revealed the pain referral patterns of the third and fourth DI muscles. In the case of the third DI muscle, pain was mainly distributed on both the palmar and dorsal sides of the third and fourth fingers, spreading to the fifth finger and the ulnar side of the wrist. The most intense pain was described as located on the interdigital space of the third and fourth fingers. The referred pain patterns were similar to the C7 and C8 dermatomes, as well as the ulnar and dorsal ulnar cutaneous nerve territories.

In the case of the fourth DI muscle, the most intense pain was noted on the interdigital space of the fourth and fifth fingers. Referred pain extended along the palmar and dorsal aspects of the fourth and fifth fingers, the hypothenar area, and the ulnar side of the wrist. These areas also overlap with the C8 dermatome, as well as the ulnar and dorsal ulnar cutaneous nerve territories.

The mechanism of referred pain is still largely unknown and there is no reasonable theory to completely explain it. Previously, a number of studies suggested the peripheral and central sensitization theories as mechanisms of referred pain generation (11-14). Another study proposed the pre-local hyper-excitability theory, which suggested a peripheral sensitization with an additional central modulation (15). However, the discrepancies between experimental pain models and clinical studies including chronic patients have been reported (11,16). Previous experimental pain model studies have shown that the experimental pain usually refers distally, while the referred pain is more frequently induced at the tendon and tendon-bone junction sites (8,17). When considering the fact that referred pain from muscular TrPs tends to be closely related to the muscle's bony attachments, it is quite obvious that the pain referral patterns of TrPs in the third and fourth DI muscles follow the direction of the DI muscles distally and their tendinous insertions.

The referral pain patterns described may assist in diagnosing MP of the third and fourth DI muscles in the case of pain symptoms in the C7 and C8 dermatomes or the ulnar nerve territory that are unaccompanied by motor involvement. Moreover, the referred pain pattern on the ulnar side of the wrist should be kept in mind for the differential diagnosis of triangular fibrocartilage complex injury and arthritis. However, it is important to acknowledge that the pain referral patterns of a myofascial TrP are not exclusive to a single muscle and that TrPs in different muscles may have similar referral patterns. For example, the pain referral areas similar to those of the third DI muscle can be found in the flexor digitorum superficialis and profundus, the flexor carpi ulnaris, the extensor carpi ulnaris, and even in the extensor digitorum muscles. Moreover, the pain referral areas similar to those of the fourth DI muscle can be found in the same muscles as above (1). Thus, all possibilities must be considered before a conclusive diagnosis is made.

Compared to the other studies, the current study does have some strengths. In contrast to previous studies (2,3) that used electromyography to guide the needle placement, the authors used US guidance to confirm accurate needle placement. Also, unlike previous studies (2,3), which relied upon a single researcher's analysis to determine the pattern of pain referral, this study attempted the overlapping of all pain drawings to characterize the common areas of pain referral.

There are limitations in this study. First, the sample size was relatively small to evaluate more significant pain referral patterns. Second, we did not assess the intensity of the referred pain induced by the experiment. Third, age range was small, and older participants were not included. Finally, injection into an actual TrP of a DI muscle could not be confirmed, as the characteristic twitch response was not elicited in the pain-free participants.

Conclusion

The current study showed the referred pain patterns of the third and fourth DI muscles. The referred pain patterns resemble the pain experienced in C7 or

C8 radiculopathies and ulnar neuropathy, as well as the pain in conditions of triangular fibrocartilage complex injury and arthritis. Thus, the identification of TrP in the third and fourth DI muscles should be considered in pain of the ulnar aspect of the hand and wrist, especially when no other neurologic abnormalities or inflammatory conditions are present.

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Declaration of Interest statement

There are no conflicts of interest.

All authors have read and approved this paper.

All authors contributed in design of this study, acquisition of data, analysis, subscribing article, and revising it.

Dr. Choi and Dr. Kang designed the study protocol.

Dr. Park and Dr. Lee had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Dr. Choi managed the literature searches and summaries of previous related works and wrote the first draft of the manuscript.

Dr. Kang provided revision for intellectual content and final approval of the manuscript.

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