Physical Medicine and Rehabilitation Treatment for Post-Traumatic Myositis Ossificans: A Case Report and Short Literature Review

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Abstract: **Background:** Myositis Ossificans (MO) is a benign bone formation in a extra-skeletal location. The most common subtype of MO, the post-traumatic, usually develops after a traumatic event. Patients usually present with pain and joint stiffness. The aim of treatments are to decrease pain and joint stiffness. **Objectives** : The aim of this case report was to document the physical medicine and rehabilitation (PM&R) treatment of a patient who had post-traumatic myositis ossificans. **Case Presentation:** A 62-years-old man developed MO as a result of a chronic traumatic injury. He was suffering from weakness in motion of the hip joint, and felt severe pain (VAS=7-8) since 1 year ago. History of falls recognized 2 years ago. The patient could not stand and walk. A radiograph showed MO. The patient received PM&R treatment once in a week for 6 months, consisted of infra-red, transcutaneous electrical nerve stimulation, range of motion, and strengthening exercise. **Result:** After 6 months of treatment, patient felt the pain decreased (VAS=3-4). Patient could stand and walk with walker. A radiograph was no changed. **Conclusions:** This case report demonstrated the benefit of PM&R treatment in eliminating pain and joint stiffness of post-traumatic myositis ossificans, although radiographic imaging no changed.

1 INTRODUCTION

Myositis ossificans count as a benign, mature lamellar bone formation within skeletal muscle or other extra-skeletal soft tissue locations, and most of the case are self-limiting (Savvidou et al, 2021). The subtype of Post traumatic myositis ossificans (PTMO) occurs in 60 - 75% of all cases as a result of a single direct blunt trauma or repeated micro- injuries, although in 40% cases the patient have no history of trauma (Herdiansyah et al, 2017). Predilection are anterior and posterior muscle groups in thigh and arm, but some cases have been reported in the neck, hand, calf, shoulder, thorax, and abdomen (Zietkiewicz, 2014). Usual symptoms consist of pain, localized tenderness, swelling, as well as palpable mass with decreased range of motion, and its responsible for considerable morbidity (Schultzel et al, 2014).

Diagnosis of PTMO could be obtained from clinical history, physical examination, radiographic and other imaging, but regularly overlooked and some difficulties might occur. Myositis ossificans in early stage without a considerable amount of calcification and ossification could mimic other pathologic condition, leads to false negative radiological findings or misdiagnosis such as osteosarcoma, soft tissue sarcoma (Wang et al, 2018). Clinical suspicion is necessary as complaints are nonspesific including pain, swelling and may differ based on location and its phase. Diagnosis is predominantly by radiograph imaging. Treatment of myositis ossificans is conservative, as the disease is self-limitting and self-resolving. Non steroid anti- inflammatory drugs and physical medicine and

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rehabilitation treatment are pillar of the treatment in order to reduce swelling and increase range of motion in the affected area. Therapy protocol were medication, along with physical medicine and rehabilitation which aimed to decrease severe pain, improve in range of motion. Surgical approach might necessary in persistent pain or occurance of secondary complications (Bhatia et al, 2021).

The aim of this case report was to document the physical medicine and rehabilitation treatment of a patient who had post-traumatic myositis ossificans.

2 CASE PRESENTATION

2.1 Clinical History

A 62-year-old Indonesian man was referred to the Department of Physical Medicine and Rehabilitation, UNS Hospital Surakarta with chief complaint of pain and weakness in hip joint. The patient was currently complaining pain in the left groin since 1 years ago. The pain is intermittent and severe occurs 2-3 times a day. The pain got worsen when the patient sat for too long and decreased when the patient rest. History of falls recognized 2 years ago. Denied complaints of fever and significant weight loss.

Anamnesis revealed that the patient fell from the roof with a height of ± 3 meters in a sitting position, arround 2 years ago. Right after, the patient undergo a traditional massage on the left groin at home for 1 year. Complaints of pain in the left groin did not improve, the patient went to the Department Orthopaedic, UNS Hospital and was given oral medication, then consulted to Department Physical Medicine and Rehabilitation.

On examination, patient felt severe pain on left hip joint (VAS=7-8). Palpation revealed there was a tenderness in the left hip joint area and the antero-mid of the left rectus femoris. Due to severe pain, the patient was difficult to move his left leg and his hip joint range of motion couldn't be assesed. Manual muscle testing was difficult to evaluate. The patient could not stand and walk with this condition.

2.2 Imaging

Radiograph examination showed Myositis Ossificans which was marked by ossification around the neck of the left femur, in soft tissue. Completely, radiograph imaging shows good bone structure and trabeculation, the articular surfaces are smooth, no soft tissue swelling seen, no discontinuity in pelvic bones, and bilateral femoral heads are seen in the acetabular fossa. The sacroiliac and hip joints bilaterally were not widened or narrowed. The Shenton line and Skinner line bilaterally were good and symmetrical (Figure 1).

Figure 1: Radiograph imaging before treatment.

2.3 Conservative Treatment

The therapy protocol were oral medication and physical medicine and rehabilitation treatment which aimed to decreased severe pain, improve in range of motion, so the patient could stand and walk again. Patient had given oral analgetic from Orthopaedic Departement. In Physical Medicine and Rehabilitation Department, patient had given infra-red, transcutaneous electrical nerve stimulation (TENS), range of motion (ROM) and strengthening exercise once in a week. The patient was already treated with infra-red prior to exercise, conventional TENS was added to treatment regimen. Infra-red had given in left hip joint and the anterior thigh within 20 minutes, based on the heat sensation tolerated by the patient. A symmetrical biphasic waveform was selected, with a rate of 50 Hz, an amplitude between the sensory and motor thresholds, had given in left hip joint area and the anterior thigh within 20 minutes. ROM exercise had given for maintenance mobility of left hip joint (flexion, extension, abduction and adduction), and performed within 20-30 minutes. Manual strenghtening exercise, isometric mode, had given for within 20-30 minutes.

2.4 Result

After 6 months of treatment, patient felt the pain decreased (VAS=3-4). Palpation examination revealed there was a slight tenderness in the left hip joint area and the antero-mid of the left rectus femoris. Range of motion of left hip flexor were 0-

30^0 (active) and 0-60^0 (passive), extensor 0-5^0 (active) and 0-full (passive), abductor 0-20^0 (active) and 0-10^0 (passive), adductor 0-10^0 (active) and 0-full (passive). Manual muscle testing of left hip was 3-. Patient could stand and walk with walker (Figure 2).

Figure 2: Patient could stand and walk with walker after treatment.

Meanwhile the radiograph imaging showed no changed (Figure 3).

Figure 3: Radiograph imaging after treatment.

3 DISCUSSION

Myositis ossificans consist of several subtypes, include: a) Post-traumatic, known as focal or proliferative myositis, the most common subtypes occured in 75% cases; b) Non-traumatic, associated with infections, paraplegia, poliomyelitis, and burn; and c) Progressive, or fibrodysplasia ossifcans progressive as a hereditary, autosomal dominant condition resulting from mutation activity of bone-morphogenetic protein signalling (Li et al, 2016; Savvidou et al, 2021). Studies stated that males are more commonly affected, with 50% of the patient present within the second and third decades of life (Saad et al, 2021). Elderly patient are less affected occured arround 12% cases in 50-70 years old patient, compared to the adolescents or young-adult with high mobility and athletically active (Olvi and Santini-Araujo, 2015). In this case, we presented a case of post-traumatic myositis ossificans in a 65 years old man, with a history of trauma arround two years ago. Patient felt discomfort, pain, and decreased range of motion in his left hip area. Myositis ossificans becomes clinically suspected when a strain, contusion, and pain are unresponsive to conservative care and pain increasing along with progressive loss of range of motion (Torrance and Degraauw, 2011).

The pathophysiology of post-traumatic myositis ossificans is not fully understood. Hypothesis behind the ossification could be proliferation of mesodermal tissues as a reaction to trauma (Gupta et al, 2020). Other studies stated that inappropriate differentiation of fibroblast into osteogenic cells contributed to its process (Mavrogenis et al, 2011; Walczak et al, 2015). Local stem cell's dysregulation in response to tissue injury followed by subsequent inflammation leads to heterotopic bone formation. Skeletal muscle injury induces a local inflammatory cycle, realising pro-inflammatory cytokines thereby bone morphogenetic proteins-2 (BMP-2) and transforming growth factor (TGF) which act on vascular endothelial cells of skeletal muscle (Walczak et al, 2015). These cytokines then stimulates endothelial-mesencymal transition, and differentiate into chondorcytes or osteoblast upon exposure to an inflammatory environment. Chondrocytes then differentiate to cartilage, and undergo endochondral bone formation in extraskeleteal tissue so does the osteoblasts (Medici and Olsen, 2012; Walczak et al, 2015).

Development of PTMO obtained through radiographic imaging, clinical sign and symptoms, and histopathological stages. Stages commonly described as: early, intermediate, and mature. Early stages occurs in the first four weeks following the trauma, as a inflammatory cascade that procedes ossification and calcification are often not present in radiograph imaging (Glodblum et al, 2013). Decreased in range of motion, erythema, pain, and swelling shows in early lesion in hours or days after the injury (Olvi and Santini-Araujo, 2015). As in this case, patient immediately feels pain right after the injury. Pain commonly results of the lesion causing mechanical irritation of surrounding structure, includes joint or tendon (Walczak et al, 2015). Calcification seen in radiograph imaging as the lesion

matures through an intermediate stages in four to eight weeks (Walczak et al, 2015; Gupta et al, 2020). Mature lesions characterized by marked peripheral bone formation, attached to the cortex continues over the following months (Walczak et al, 2015). In this case, radiograph imaging was taken 2 years after history of trauma, and calcification shown in left femur area.

Conservative treatment including nonsteroidal anti-inflammatory drugs and physical therapy may be sufficient for recovery (Walczak et al, 2015; Al-Qattan, 2017). Treatment known as the "West Point Flexion Protocol" established as a three-phase treatment, consist of: 1) movement restriction; 2) recovery of motion; 3) functional rehabilitation . First phase minimalize the hemorrhage, includes rest, ice, elevation, and Buck's traction and isometric exercise in 24 - 48 hours after the injury but depends on how severe the contusion occurs. Early treatment of muscle injuries with the aim of controlling the development of the hematoma and maintaining function with the ultimate goal of reducing the chance for the development of MO. The second, focuses on achieving full extension, then flexion as tolerated combined with heat and promoting comfort for the patient[17]. The last phase, consists of resistance training combined with non-contact sports (Miller et al, 2006).

During the first 15 days after injury, the lesion is vulnerable to further trauma and, therefore, excessive activity, vigorous stretching and massage should be avoided to limit bleeding (Miller et al, 2006). But in this case, patient had a traditional massage for a year. No proper medical treatment was taken right after the trauma, until patient couldn't walk in duration of two years. Although PTMO also counted as self-limiting, but inapropriate treatment could worsen the condition as in this case the patient had a traditional massage at home for a year. If MO develops further despite prevention, gradual restoration of flexibility and strength with minimal pain will be the goal of rehabilitation (Miller et al, 2006; Torrance and Degraauw, 2011, Kopacz-Dósa et al, 2021).

3.1 Pharmacological Therapy

Several therapies can be given to MO both as prophylaxis and postoperative adjunct therapy. Indomethacin (NSAID) is used to further inhibit new bone formation (Bulthel et al, 2016). Recommended doses of indomethacin vary from 75 - 100mg/day for 7 - 14 days (Bai et al, 2023), other stated 23 - 50mg as a prophylaxis 2 - 3 times daily for 7 - 11 days along with proton pump inhibitor (Miller et al, 2006). NSAID inhibit the COX cycle and reduce inflammatory responses.

Colchicine has been found to reduce MO after total hip arthroplasty through inhibition of tissue mineralization, cell proliferation, and so does the heterotopic ossification (Kopacz-Dósa et al, 2021). Several studies suggest that the prophylactic use of indomethacin and etidronate (ethane 1 – hydroxyl – 1, 1 – bisphosphoric acid or EHDP) may be beneficial in reducing postoperative ectopic calcification. EHDP is more effective in the initial period of treatment, with a gradual decline in its effectiveness later in life (Lungu, 2021).

3.2 Physical Medicine and Rehabilitation Treatment

Rehabilitation in patients with myositis ossificans goals to restore the flexibility, strength, and proprioception to avoiding maladaptive compensatory patterns during the rehabilitation phase. Flexibility exercises should be performed with static stretching or contraction-relaxation techniques to avoid further muscle injury (Miller et al, 2006). The weakened muscles by MO and all other muscles by agonist action are the target of strengthening programs. Proper care should be taken, to prevent overstrained muscles and further muscle impairment. In this case, patient undergo a traditional massage which may overstrained the muscles. During the first 15 days after trauma the lesions are vulnurable to further trauma, therefore patient should avoid excessive activity, forceful stretching, and massage to limit the bleeding. Crutches could help to rest the affected area and minimize hematoma formation (Torrance and Degraauw, 2011).

Muscle activation exercises should progress from those that require the least effort to the maximum effort (concentric, isometric, eccentric, plyometric). Active ROM and resistive strengthening exercises are important to improve and restore the fuction, mainly in more severe lesions. Proprioception exercises should be started as early as possible in the recovery phase, since MO itself has the possibility to damage several elements of intramuscular nerves which play a role in muscle tone causing disturbances in muscle activation. During the initial phase of rehabilitation, the main emphasis is on restoring capsular mobility and movement of the accessory joints through joint mobilization techniques (Miller et al, 2006).

Electrical stimulation widely used in therapeutic and prophylactic modality in physiotherapy practice to stimulate joint mobility, along with analgesic and anti-inflammatory effects, thereby prevent regression or prevent heterotopic ossification (Zotz and de Paula, 2015). The most common cause of heterotopic ossification due to trauma is myositis ossificans. Administration of

electric voltage can provide analgesia, muscle contraction, increased local circulation, fluid drainage, muscle tightening or relaxation, increased regeneration, and tissue healing so that the use of electrical stimulation is expected to be useful for curing pain and ROM disorders in MO (Starkey, 2015; Zotz and de Paula, 2015). Among the various forms of electrical stimulation applications, there are two types of therapy that plays role in assisting recovery of individual kinetic function, producing postoperative analgesia and muscle contractions to prevent atrophy. Transcutaneous electrical nerve stimulation (TENS) is used as an additional method of analgesia in postoperative patients (Reves et al, 2004; Zotz and de Paula, 2015) meanwhile Functional electrical stimulation (FES) provide healing time and prevent muscle atrophy in the spinal cord (Durigan et al, 2005; Zotz and de Paula, 2015).

TENS is one of the main electrical stimulation therapies used in acute and chronic pain conditions, which works on several mechanism. TENS is able to stimulate thick and myelinated sensory nerves (A-fiber), which in turn blocks the thin fiber (C-fiber) pain modulation impulses and closes the gate of pain signals at the level of the application site to the spinal cord (Zuim et al, 2006; Patil et al, 2016). Pain relieved effect from TENS results as it stimulation of endogenous release of morphine-like substance which have analgesic properties by reducing calcium deposition in muscle tissue (Zotz and de Paula, 2015; Patil et al, 2016). This also able to help the regression process of the ongoing inflammatory process (Zotz and de Paula, 2015). Another mechanism is that TENS causes light and rhythmic muscle contractions, which increase local circulation of blood and lymph nodes by this mechanism reducing interstitial edema and accumulation of harmful tissue metabolites (Zuim et al, 2006; Patil et al, 2016). In one study, high-frequency TENS with a pulse duration of 100 ms significantly reduced inflammation and pain in animals. TENS with frequency modulated stimulation of 98.27 ± 0.05 Hz showed an inhibitory effect on heterotopic bone. TENS is a viable treatment option for HO (Zotz and de Paula, 2015; Patil et al, 2016).

Infrared radiation had given to this patient, and studies shows a promising complementary treatment for a wide range of musculoskeletal conditions in reducing the pain (Tsagkaris et al, 2022). The potential clinical and physiological effects depend on the composition of the tissues and the proportions of biomolecules present in the body fluids. At the cellular level, the interaction between IR and living tissue can change the cell membrane potential due to heat by increasing intracellular Ca2+ levels. This occurs due to increased membrane permeability to Ca2+ and increased release of Ca2+ from the endoplasmic reticulum in response to reactive oxygen species (ROS) generated due to exposure of cells to radiation (Golovynska et al, 2021). At the tissue level infrared radiation reduced oxidative stress a`nd vasodilation, due to increased levels of Nitric Oxide (NO) as an endogenous antioxidant that counteracts ROS production. Simultaneously, it can stimulate growth factor production and deposition of extracellular matrix which promotes tissue repair (Golovynska et al, 2021). Infrared radiation improves the blood circulation in injuries and accelerate wound healing, reduce muscle spasms and increase the conduction velocity of sensory nerves, and potentially reduce endorphins modulated pain (Lee et al, 2019).

4 CONCLUSIONS

This case report demonstrated the benefit of physical medicine and rehabilitation treatment in eliminating pain and joint stiffness of post-traumatic myositis ossificans, although radiographic imaging no changed.

REFERENCES

Al-Qattan, M.M., Al-Fahdil, L., Al-Shammari, H.M., Joarder, A.I., 2017. Management of myositis ossificans of the hand: a case report and a review of the literature. *The Journal of Hand Surgery*. Jul 1;42(7):576-e1.

Bai, Q., Zou, X., Yang, G., Fan, Y., Wang, W., Zhang, B., Chang, X., 2023. Painful and restricted hip due to myositis ossificans circumscripta of the pectineus muscle after pelvic fracture: a case report. *Medicine*. Apr 4;102(17).

Bultheel, M., Kirby, J.H., Viljoen, J.T., Viviers, P.L., 2016. An atypical presentation of myositis ossificans. *South African Journal of Sports Medicine*. 28(1):33-4.

Bhatia, A., Vidad, A.R., Mehra, D., Shah, H., Ogunjemilusi, O., 2021. Multifocal post-traumatic myositis ossificans circumscripta in a young male following a motor vehicle accident: a review of imaging and clinical presentation. *Cureus*. Apr 6;13(4).

Durigan, J.L.Q., Cancelliero, K.M., Polacow, M.L.O., Silva, C.A., Guirro, R.R.J., 2005. Modelos de desuso muscular e estimulac¸ãoelétrica neuromuscular: aspectos pertinentes à reabilitac¸ãofisioterapêutica. *Fisioterapia em Movimento*. 18: 53–62

Goldblum, J.R., Weiss, S.W., Folpe, A.L., 2013. *Enzinger and Weiss's Soft Tissue Tumors E-book.* Elsevier Health Sciences. Oct 11.

Golovynska, I., Golovynskyi, S., Stepanov, Y.V., Stepanova, L.I., Qu, J., Ohulchanskyy, T.Y., 2021. Red and near-infrared light evokes Ca2+ influx, endoplasmic reticulum release and membrane depolarization in neurons and cancer cells. *Journal of*

Photochemistry and Photobiology B: Biology. Jan 1;214:112088.

Gupta, S., Kawde, P., Kekatpure, A., Karmore, S., Rathi, R., 2020. Myositis ossificans traumatica of the wrist in elderly: a description of an unusual case. *Indian Journal of Forensic Medicine & Toxicology*. Oct 29;14(4):6905-7.

Herdiansyah, D., Prabowo, T., Goesasi, R.Z., 2017. The difference on pain and range of motion after high-intensity laser therapy on myositis ossificans of the right deltoid muscle: a case report. *Indonesian Journal of Physical Medicine and Rehabilitation*. Jun 1;6(01):42-6.

Kopacz-Dósa, B., Vulturar, R., Vele, P., Damian, L., 2021. Myositis ossificans: a short review. *Health, Sports & Rehabilitation Medicine*. Oct 1;22(4).

Lee, D., Seo, Y., Kim, Y.W., Kim, S., Bae, H., Choi, J., Lim, I., Bang, H., Kim, J.H., Ko, J.H., 2019. Far-infrared radiation stimulates platelet-derived growth factor mediated skeletal muscle cell migration through extracellular matrix-integrin signaling. *The Korean Journal of Physiology & Pharmacology*. Mar 1;23(2):141-50.

Li, W.T., Horng, S.Y., Chien, H.F., 2016. Abdominis rectus intramuscular myositis ossificans. *Formosan Journal of Surgery*. Feb 1;49(1):20-6.

Lungu, S.G., 2011. Case report-myositis ossificans: two case presentations. *Medical Journal of Zambia*. 38(2):25-31.

Mavrogenis, A.F., Soucacos, P.N., Papagelopoulos, P.J., 2011. Heterotopic ossification revisited. *Orthopedics*. Mar 11;34(3).

Medici, D., Olsen, B.R., 2012. The role of endothelial-mesenchymal transition in heterotopic ossification. *Journal of Bone and Mineral Research*. Aug;27(8):1619-22.

Miller, A.E., Davis, B.A., Beckley, O.A., 2006. Bilateral and recurrent myositis ossificans in an athlete: a case report and review of treatment options. *Archives of Physical Medicine and Rehabilitation*. Feb 1;87(2):286-90.

Olvi, L.G., Santini-Araujo, E., 2015. Myositis ossificans. tumors and tumor-like lesions of bone: for surgical pathologists. *Orthopedic Surgeons and Radiologists*. 777-92.

Patil, S., Iyengar, A.R., Kotni, R.M., Subash, B.V., Joshi, R.K., 2016. Evaluation of efficacy of ultrasonography in the assessment of transcutaneous electrical nerve stimulation in subjects with myositis and myofascial pain. *The Korean Journal of Pain*. Jan 31;29(1):12-7.

Reeves, J.L., Graff-Radford, S.B., Shipman, D. The effects of transcutaneous electrical nerve stimulation on experimental pain and sympathetic nervous system response. *Pain Medicine Journal*. 5: 150–161, doi: 10.1111/pme.2004.5.issue-2.

Saad, A., Azzopardi, C., Patel, A., Davies, A.M., Botchu, R., 2021. Myositis ossificans revisited–the largest reported case series. *Journal of Clinical Orthopaedics and Trauma*. Jun 1;17:123-7.

Savvidou, O., Papakonstantinou, O., Lakiotaki, E., Melissaridou, D., Korkolopoulou, P., Papagelopoulos, P.J., 2021. Post-traumatic myositis ossificans: a benign lesion that simulates malignant bone and soft tissue tumours. *EFORT open reviews*. Jul 8;6(7):572-83.

Schultzel, M.M., Johnson, M.H., Rosenthal, H.G., 2014. Bilateral deltoid myositis ossificans in a weightlifter using anabolic steroids. *Orthopedics*. Sep 1;37(9):e844-7.

Starkey, C., 2015. Recursos Terapêuticos em Fisioterapia.1st edn.São Paulo: Manole

Torrance, D.A., Degraauw, C., 2011. Treatment of post-traumatic myositis ossificans of the anterior thigh with extracorporeal shock wave therapy. *The Journal of the Canadian Chiropractic Association*. Dec;55(4):240.

Tsagkaris, C., Papazoglou, A.S., Eleftheriades, A., Tsakopoulos, S., Alexiou, A., Găman, M.A., Moysidis, D.V., 2022. Infrared radiation in the management of musculoskeletal conditions and chronic pain: a systematic review. *European Journal of Investigation in Health, Psychology and Education*. Mar 14;12(3):334-43.

Walczak, B.E., Johnson, C.N., Howe, B.M., 2015. Myositis ossificans. *Journal of the American Academy of Orthopaedic Surgeons*. Oct 1;23(10):612-22.

Wang, H., Nie, P., Li, Y., Hou, F., Dong, C., Huang, Y., Hao, D., 2018. MRI findings of early myositis ossificans without calcification or ossification. *BioMed Research International*. Sep 3;2018

Zietkiewicz, J.M., 2014. Post-traumatic myositis ossificans. *SA Journal of Radiology*. 18(2).

Zotz, T.G., de Paula, J.B., 2015. Influence of transcutaneous electrical stimulation on heterotopic ossification: an experimental study in Wistar rats. *Brazilian Journal of Medical and Biological Research*. Aug 18;48:1055-62.

Zuim, P.R., Garcia, A.R., Turcio, K.H., Hamata, M.M., 2006. Evaluation of microcurrent electrical nerve stimulation (MENS) effectiveness on muscle pain in temporomandibular disorders patients. *Journal of Applied Oral Science*. 14:61–66. PMID: 19089032.