Myositis Ossificans Traumatica of the Temporal Muscle: a Case Report and Literature Review Emphasizing Radiographic Features on Computed Tomography and Magnetic Resonance Imaging

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ABSTRACT

Objectives: Heterotopic bone formation within a muscle is designated as ‘myositis ossificans’, and it is associated with multiple aetiologies, such as trauma, genetic predisposition, post-infection, or undetermined causes. When the disease develops as a result of a trauma, the myositis ossificans is classified as ‘myositis ossificans traumatica’. In this case report, a case of myositis ossificans traumatica is described, emphasizing its imaging features. Additionally, a literature review of the imaging features of myositis ossificans is discussed.

Material and Methods: A 60-year old male patient presented with restricted mouth opening and pain during mastication. Multislice computed tomography and magnetic resonance imaging examinations were conducted. Case reports in the literature of myositis ossificans were searched databases from August 1984 until April 2019 using the keyword ‘masticatory muscles’ combined with ‘myositis’; ‘inflammatory myositis’; infectious myositis’; ‘inflammatory muscle diseases’; ‘focal myositis’ and ‘proliferative myositis’. Data was summarised and evaluated according to a critical appraisal checklist for case reports.

Results: Multislice computed tomography demonstrated an ectopic hyperdense area arising from the coronoid bone and within the temporal muscle. Magnetic resonance imaging demonstrated the same area with a hypointense signal. In the literature review, 53 myositis ossificans cases were identified, and 12 cases affecting the temporal muscle were found.

Conclusions: The main imaging feature of myositis ossificans is the presence of a radiopaque, hyperdense or hypointense mass in the affected muscle, which is seen on multislice computed tomography and magnetic resonance imaging, respectively. The final diagnosis is through histopathological examination, although imaging can suggest the most likely diagnosis.

Keywords: diagnostic imaging; magnetic resonance imaging; myositis ossificans, oral pathology, temporal muscle; tomography.

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INTRODUCTION

Heterotopic bone formation within a muscle is designated as ‘myositis ossificans’ (MO) [1], and it is associated with multiple aetiologies, such as trauma, genetic predisposition [1], post-infection [2], or even undetermined causes [3]. When the disease develops as a result of a trauma, the MO is classified as ‘myositis ossificans traumatica’ (MOT), which is also known as focal or proliferative myositis. MOT is frequently reported as an orthopaedic outcome of chronic trauma to muscles, and it is rarely found in craniofacial sites, such as the temporal bone [1]. Focal MO in the head and neck often occurs in a defined muscle group [4]; when the disorder predominantly affects the temporal muscle, it is known as ‘MOT of temporalis’.

MOT affecting the temporal muscle is infrequent [3,5-14], and it is unusual to have MOT affecting the temporal muscle exclusively [15-23]. Trismus is one of the chief complaints reported in MO and MOT of temporalis [4,15-18,20,21], although swelling with or without pain can be present [19,23].

The differential diagnosis of MO, due to its radiographic features of radiopaque areas with ill-defined or infiltrative borders, primarily includes malignancies, such as sarcomas or chondrosarcomas, although other conditions may be considered, such as osteomas, osteochondromas, haemangiomas, or nodular fasciitis [24]. Hence, dentists should be aware of this unusual condition in order to determine a definitive diagnosis.

Thus, the objective of this report is to describe imaging features of a MOT of temporalis case, considering its characteristics in multislice computed tomography (MCT) and magnetic resonance imaging (MRI). Additionally, English language case reports of MO in different databases were reviewed, summarised and qualitatively assessed in order to allow for an overview of the main imaging features of MO in the literature.

CASE DESCRIPTION AND RESULTS

An African descendant, 60-year old male patient was referred to the Maxillofacial Surgery service (Campo Limpio Hospital, São Paulo, Brazil) due to restricted mouth opening and pain during mastication. The patient noticed the symptoms ten years before the consultation. The extraoral examination showed pain with palpation of the bilateral masticatory muscles, mainly in the temporal region, and limited mouth opening. Intraoral examination did not reveal any associated abnormalities. The patient mentioned a history of a previous cranio-facial trauma with a fracture in the frontal bone followed by trismus, but no other concomitant systemic disease.

The patient initially underwent a MCT and MRI to identify possible causes of his complaints. In the MCT examination, an ectopic hyperdense area was observed with density similar to bone tissue, as demonstrated in Figure 1. In the coronal slice (Figure 1A), a bone protuberance arising from the frontal bone was noted; the sagittal slice (Figure 1B) demonstrated the same bone protuberance arising from the frontal bone and mandible coronoid process, which was the likely aetiology of the restricted mouth opening. Axial slices (Figure 1C) showed...
the radiopaque mass involved in the temporal muscle area. Figure 2 demonstrates a three-dimensional view of the ectopic bone formation.

MRI showed a hypointense area arising from the coronoid bone, suggesting the presence of the calcification observed in the MCT. The MRI is demonstrated in Figure 3.

Initially, these imaging findings suggested that possible diagnoses included malignant or benign neoplasms. The patient was referred to surgical treatment with full removal of the calcified areas and coronoidectomy. Histopathologic examination of the tissue removed confirmed the diagnosis of myositis ossificans traumatica in the temporal muscle.

Literature review search

The selection of MO case reports was performed using PubMed, Embase (Excerpta Medical Database), Cochrane Central Register of Controlled Trials, Scopus, Web of Science, and Google Scholar databases. These databases were searched for English language publications from August 1984 until April 2019. Original articles and literature reviews were excluded; only human cases affecting masticatory muscles were included in the review.

The keywords (considering Medical Subject Heading terms) applied were: “myositis” AND “masticatory muscles”; “inflammatory myopathy” AND “masticatory muscles”; “inflammatory myositis” AND “masticatory muscles”; “infectious myositis” AND “masticatory muscles”; “inflammatory muscle diseases” AND “masticatory muscles”; “focal myositis” AND “masticatory muscles”; “proliferative myositis” AND “masticatory muscles”, exhibited in the flow chart in Figure 4. The reports that were not available on the selected databases, as well as the library of São Paulo University, and the São Paulo University collaborative library service, were requested from the authors. In the cases with a lack of response by the authors, the case reports were excluded from the review. The search results and summarised data, mainly regarding MO imaging features, are available in Table 1.

The literature search found 53 English language articles reporting cases of MO [1-12,15,16,18-57], in which ten cases were bilateral [3,9,12,33,34,47,50]. MO Temporalis was reported in 12 cases [12,15,16,18,21,23,28-30,54], in which one case was bilateral [12]. The medial pterygoid muscles were the most affected muscle [1,3,5,8,26,27,32,35,38,39,42-46,48,51,55]. The summarised data regarding the muscles involved are available in Figure 5.

Figure 2. Three-dimensional view of the case. Ectopic bone formation is evinced by the arrow.

Figure 3. Magnetic resonance imaging examination. The hypointense area arising from coronoid bone. T2-weighted images, sagittal slices.
### Table 1A. Summarized data of the literature search. Authors, year of the publication, country, aetiology of the case reported, side involved, imaging examinations requested and imaging examinations main findings

| Author                      | Year | Country | Gender age | Aetiology                      | Side and area involved                          | Imaging examinations† | Imaging features‡ |
|-----------------------------|------|---------|------------|--------------------------------|------------------------------------------------|-----------------------|-------------------|
| Hanisch et al. [17]         | 2018 | Germany | Male 28    | Inflammation/infection        | Right, medial pterygoid muscles                 | CT                    | Calcification      |
| Jiang et al. [2]            | 2015 | China   | Male 51    | Trauma                        | Right, medial and lateral pterygoid muscles     | PR, CT                | PR (panoramic radiograph); chronic peritapical lesions; CT: heterotopic bone formation; MRI: normal anatomic structures |
| Jayade et al. [3]           | 2014 | India   | Female 25  | Not determined                 | Bilateral, medial and lateral pterygoid muscles | CT, MRI               | CT: heterotopic bone formation and specks of calcification; MRI: ossification and hypertrophy in the muscle |
| Ratansi et al. [4]          | 2017 | UK      | Female 41  | Not determined                 | Right, temporal region (infratemporal fossa and masticatory spaces) | CT, MRI, PET          | CT: soft tissue lesion; MRI: “plaque-like tissue”; PET: low grade uptake in the infratemporal fossa and masticator spaces |
| Reddy et al. [5]            | 2014 | India   | Male 21    | Trauma                        | Left, temporal and medial pterygoid muscles     | CT, MRI               | CT: calcified masses within temporal muscle; MRI: hemotoma-like lesion within temporal muscle |
| Nomoto et al. [6]           | 2012 | Japan   | Male 39    | Not determined                 | Left and right, masseter, temporal, pterygoid and frontal muscles | PR, CT                | PR: calcification in the buccal muscles bilaterally; CT: hyperdense areas (calcifications) within temporal, lateral pterygoid, frontal and masseter muscles |
| Goði et al. [7]             | 2011 | India   | Male 21    | Not determined                 | Right, temporal and lateral pterygoid muscles   | CT                    | CT: Calculifications involving masticatory muscles and fascia; a thick oosseous bridge was observed in the region of the inferior head of the right lateral pterygoid muscle |
| Comer and Duffy [8]         | 2009 | USA     | Female 18  | Trauma (exodontia)            | Right, medial pterygoid and temporal muscles    | CT                    | Impressive calcification of the right and medial pterygoid muscles |
| Yano et al. [9]             | 2005 | Japan   | Male 34    | Trauma                        | Musater (bilateral) and temporal muscles (left) | PR, CT                | PR: calcification in the gales and scalp; CT: high density calcification within bilateral masseter muscles |
| St-Hilarie et al. [10]      | 2004 | USA     | Female 68  | Trauma (anaesthesia)          | Left, masseter, pterygoid and temporalis muscles | PR, CT, CT            | PR: no pathological findings; CT: calcification and inflammation within the temporal and pterygoid muscle |
| Spinaezz et al. [11]        | 1998 | USA     | Male 55    | Muscule stress                | Left, lateral pterygoid                         | PR, CT, MRI           | PR: coronoid hypotrophy; CT: coronoid hypotrophy, spotty diffuse a calcification in the temporal muscle nearby the coronoid process; MRI: intrareticular adhesion or partial bony ankylosis |
| Myoken et al. [12]          | 1998 | Japan   | Male 55    | Trauma                        | Bilateral, temporal muscle                      | CT                    | Bilateral radiaopacity within temporal muscle |
| Guarda-Nardini et al. [16]  | 2011 | Italy   | Male 50    | Trauma                        | Right, temporal muscle                          | CT                    | Osceous neoformation in the area of the temporal muscle |
| Manzano et al. [18]         | 2007 | Spain   | Male 51    | Trauma                        | Right, temporal muscles                         | PR, CT                | PR: (orthopantomography) bone density opacity in the region of right coronoid process; CT: bone density mass in the region of temporal fossa, that fused the right temporal bone with its correspondent coronoid process |
| Uematsu et al. [19]         | 2005 | Japan   | Female 38  | Not determined                 | Left, temporal muscle                           | CT, MRI               | CT: high density mass in the subcutaneous tissue (no apparent calcification); MRI: osseous area in the temporal muscle in T1-weighted images, heterogeneous mass in the temporal muscle |
| Saka et al. [20]            | 2002 | Germany | Male 33    | Trauma                        | Left, temporal muscle                           | PR, CT, MRI, USG       | PR: no pathological findings; CT and MRI: not described; USG: heterogeneous echogenic mass in the temporal muscle |
| Mevio et al. [21]           | 2001 | Italy   | Female 55  | Trauma                        | Right, temporal muscle                          | CT                    | Area of osification within the right temporal muscle |
| Lello and Makek [22]        | 1996 | Switz.  | Male 34    | Trauma (accident)             | Left, masseter muscle                           | CT                    | Peripheral hydrosen mass with a hypodense central area |
| Wiesnedfeld et al. [23]     | 1985 | England | Female 10  | Repetitive infection          | Right, temporal muscle                          | PR, CT                | PR: calcification; CT: calcification with involvement of temporal muscle |
| Fiti-Trepat et al. [24]     | 2016 | Spain   | Female 49  | Related to the third molar    | Left, masseter muscle                           | PR, CT                | PR: (orthopantomography) and CT: well-defined calcification |
| Cavalheiro et al. [25]      | 2019 | Brazil  | Male 71    | Trauma (gunshot)              | Left, temporal, musater and mimetic muscles     | CT                    | Amorphous ossified formations, in a cortical/medullar pattern |
| Karrabi and Emecki [26]     | 2018 | Turkey  | Female 30  | Trauma (third molar extraction)| Right, medial pterygoid muscles                 | CT, MRI               | CT: irregular heterotopic calcification; MRI: temporomandibular joint; no abnormal findings |
| Onishi et al. [27]          | 2018 | Japan   | Male 27    | Inflammation/infection        | Left, masseter, temporal, pterygoid medial and lateral muscles | CT, MRI, USG (dippler) | CT: swelling in the masticatory muscles without calcification; MRI: diffusely enlarged contrast-enhanced masticatory muscles appearing hyperintense on T1; USG: normal caroid, temporal and maxillary arteries |
| Becker et al. [28]          | 2016 | Brazil  | Male 17    | Trauma (fracture)             | Right, temporal muscle                          | CT                    | Cortical thickening and peristomial reaction of the coronoid process; soft tissue volume increase |
| Danuan et al. [29]          | 2016 | Romania | Female 22  | Not determined                 | Right, temporal muscle                          | US                    | Enlarged of the muscle involved |
| Wang et al. [30]            | 2016 | China   | Female 49  | Trauma (fall accident)        | Right, temporal muscle                          | CT                    | Expanding hydrosen mass (heterotopic bone formation) |
| Dürmürkel et al. [31]       | 2015 | Turkey  | Female 64  | Trauma                        | Left, masseter muscle                           | PR, CT                | PR (panoramic radiograph) ovoid masses; CT: small rounded radioluscent areas with central calcifications, within the muscle |
| Ferras et al. [32]          | 2015 | USA     | Female 50  | Infection (abcess)            | Right, medial pterygoid muscles                 | CT                    | Heterotopic ossification with mature bone replacing |

†Considering only preoperative imaging examinations, according to the author’s description.

‡Considering exclusively authors description.

*Systematic literature review with a description of the case report.

PR = Plain radiograph; CTBC = cone-beam computed tomography; CT = computed tomography; MRI = magnetic resonance imaging; USG = ultrasound examination; PET = positron emission tomographic scan; HU = Hounsfield unit.
| Author          | Year | Country | Gender | Age | Aetiology                                      | Side and area involved | Imaging examinations | Imaging features                                      |
|-----------------|------|---------|--------|-----|-----------------------------------------------|------------------------|---------------------|-------------------------------------------------------|
| Kang et al. [33] | 2015 | Korea   | Female | 80  | Trauma                                        | Case 1: left, lateral pterygoid muscle; Case 2, 3, and 4: bilateral, pterygoid muscle | PR, CT, MRI         | Case 1: PR: no alterations; CT: swelling and loss of fat plane; Case 2, 3, and 4: PR: no alterations (no CT performed); MRI: hyperintense T2 signal |
| Mashiko et al. [34] | 2015 | Japan   | Male   | 36  | Trauma                                        | Bilateral, masseter    | CT                  | CT: calcified mass                                     |
| Torres et al. [35] | 2015 | Brazil  | Female | 36  | Not determined                                | Right, medial pterygoid muscle | PR, CT, MRI        | PR (panoramic radiograph): calcification in mandibular ramus and pterygoid process; CT: fusion of medial pterygoid muscle to the pterygoid plates; MRI: calcified mass |
| Ahmad et al. [36] | 2014 | Nepal   | Male   | 30  | Trauma                                        | Left, masseter muscle  | CT                  | Irregularly outlined hyperdense lesion with dense corticated rim |
| Almeida et al. [37] | 2014 | USA/Brazil | Female | 20 | Trauma                                        | Not determined         | CT                  | Calcification of the pterygoid muscle                  |
| Boffano et al. [38] | 2014 | Italy   | Female | 37  | Not determined                                | Left, medial pterygoid muscle | PR, CT              | PR (panoramic radiograph): radiopaque calcified region; CT: irregular heterotopic calcification |
| Kamalapur et al. [39] | 2014 | India   | Female | 20 | Not determined                                | Right, temporal, lateral and medial pterygoid muscles | CT, MRI             | CT: High attenuation mass (1200 - 1400 HU); MRI: Hypointense mass on T1 |
| Spuzia et al. [40] | 2014 | Italy   | Male   | 30  | Trauma (multiple fractures)                   | Left, lateral pterygoid muscle | CT                  | CT: significant calcification of the muscle.           |
| Pionibino et al. [41] | 2013 | Italy   | Female | 62  | Not determined                                | Right, masseter muscle | PR, CT              | PR (orthopantomography): radiopaque area in the maxilla; CT: grossly round mass with heterogeneous density |
| Choudhary et al. [42] | 2012 | India   | Male   | 31  | Trauma                                        | Left, medial pterygoid muscle | CT, PR, CT          | PR (mandible lateral oblique): radiopaque mass; CT: calcification of the muscle |
| Thangavelu et al. [43] | 2001 | India   | Female | 36  | Trauma (traumatic extraction)                 | Left, medial pterygoid muscle | PR, CT              | PR (panoramic radiograph): elongated left coronoid and radiopaque structures; CT: irregular ossified mass with multiple foci of central noncalcified regions of low attenuation, surrounded by a peripheral ring of high density, consistent with mature bone |
| Ramieri et al. [44] | 2010 | Italy   | Male   | 64  | Not determined                                | Right, medial pterygoid muscle | CT, MRI             | CT: bone formation within the muscle; MRI: complete lock of the temporomandibular joint |
| Trautmann et al. [45] | 2010 | Brazil  | Male   | 33  | Trauma (after mandibular block anaesthesia)   | Left, medial pterygoid muscle | CT                  | Complete calcification of the muscle                   |
| Bansal et al. [46] | 2009 | India   | Female | 20  | Trauma (dento-alveolar trauma followed by extractions of all teeth) | Right, buccinator and medial pterygoid muscles | PR, CT              | PR (orthopantomography) and CT: calcified mass         |
| Kruse et al. [47] | 2009 | Switzerland | Female | 35 | After intubation and chemotherapy             | Bilateral, masseter muscle | PR, CT              | PR (panoramic radiograph): amorphous calcification within the soft tissue; CT: bilateral diffuse calcification |
| Rattan et al. [48] | 2008 | India   | Male   | 45  | Injection of absolute alcohol for trigeminal neuralgia | Left, medial pterygoid muscles | PR, CT              | PR (orthopantomography): diffuse opacity; CT: irregular ossified mass |
| Aoki et al. [49] | 2002 | Japan   | Male   | 44  | Trauma (on the face)                          | Left, masseter and lateral pterygoid muscles | CT, MRI, PET        | CT: muscle calcification; MRI: calcified lesions; PET: spot centered around the masseter muscle |
| Kim et al. [50] | 2002 | USA     | Female | 30  | Trauma (anaesthesia)                          | Bilateral, lateral pterygoid muscle | PR, CT, MRI         | PR (panoramic radiograph): calcified region; CT: high attenuation within the lateral pterygoid plate; MRI: no temporomandibular joint abnormalities |
| Takahashi and Sato [51] | 1999 | Japan   | Female | 71  | Idiopathic (incidental found)                 | Left, medial pterygoid muscle | PR, CT              | PR (panoramic radiograph): heterotopic calcification; CT: round masses |
| Geist et al. [52] | 1998 | USA     | Male   | 44  | Trauma (fracture)                             | Left, masseter muscle  | PR, CT              | PR (panoramic radiograph and Reverse Towne’s): bone mass in the region of the muscle; CT: radiopacity |
| Steiner et al. [53] | 1997 | USA     | Male   | 40  | Trauma (fracture)                             | Not determined         | Right, temporal muscle | MRI: T2-weighted images showed increased signal intensity within the muscle; T1-weighted images showed muscle enlargement |
| Naumann et al. [54] | 1993 | Germany | Male   | 19  | Not determined                                | Left, masseter muscle  | PR, CT,C/CT         | PR (panoramic radiograph): radiopaque mass; CT: calcified persistal hematoma within the muscle; MRI: calcified mass |
| Parkash et al. [55] | 1992 | India   | Male   | 28  | Not determined                                | Left, medial pterygoid muscle | PR, CT              | CT: ossifying lesion, fusion between lateral pterygoid plate and medial surface of mandibular ramus |
| Fujiwara et al. [56] | 1987 | Japan   | Male   | 63  | Not determined                                | Right, buccinator muscle | PR, CT              | PR: no changes; CT: soft tissue mass without bone destruction |
| Arima et al. [57] | 1984 | Japan   | Male   | 25  | Trauma in the chest which resulted in cheek swelling | Left, masseter muscle  | PR                  | PR: irregular radiopaque mass                          |

*Considering only preoperative imaging examinations, according to the author’s description.
*Considering exclusively authors description.
PR = plain radiograph; CTBC = cone-beam computed tomography; CT = computed tomography; MRI = magnetic resonance imaging; USG = ultrasound examination; PET = positron emission tomographic scan; HU = Hounsfield unit.
Figure 4. Flow chart of the literature search strategy.

Figure 5. Summarized data pertaining to myositis ossificans most affected muscles.
CT examinations were performed in all cases except three [11,29,57]. Ultrasonography (USG) was performed in two cases [20,27,29] and positron emission tomographic scans (PET) were used in two cases [4,49]. The qualitative assessment of the case reports included in the literature review is presented in Table 2. The case reports were evaluated according to “The Joanna Briggs Institute (2017)” critical appraisal checklist for case reports [58]. The checklist consists of 8 questions. Checklist items were marked as “yes, no, unclear or not applicable”. The question number 7 of the checklist was marked as “not applicable” for all the articles cited in this review as this question regards to a new condition or drug treatment [58].

Considering diagnostic imaging features qualitative evaluation (question 4: diagnostic methods), only one article was classified as “no” due to the fact that, despite of mentioning the imaging examinations applied, no description of the examinations was available, only USG [29]. Histopathology features of MOT were predominantly described as a novel formation of bone and osteoid tissue within the muscle fibers, [2] with the presence of inflammatory infiltrate, degenerative tissue and necrotic muscle fibres [4]. Only in 12 publications the histopathology examination were not proper described [15,16,21,26,29,33,36,40,45,47,50,53].

DISCUSSION

Cranial MO imaging may resemble malignant neoplasms due to imaging findings, which include the appearance of an ill-defined radiopaque mass, often related to reported symptomatology, such as trismus, pain, and oedema, especially when the pathological process is associated with the masticatory muscles. Furthermore, its rapid growth, followed by significant pain and joint mobility restriction [15] leads to concern among patients and professionals. The heterotopic bone formation inherent to MO is also present in malignant neoplasms, such as osteosarcomas [23], and MO is defined as the formation of a non-neoplastic, mature, lamellar bone in the extraskeletal soft tissue. MO is usually observed in larger muscles and rarely in masticatory muscles [15]. According to the literature, 25% of cases of MO have an unknown aetiology [8] although MO can be a result of persistent inflammation or trauma [15]. In a few cases, the cause of MO was determined to be from dental origin, such as trauma during dental extraction surgery [8,26,35,43,46], repetitive infection in the third molar [24], dentoalveolar abscess [32], after a mandibular nerve block [10,45,50], intubation [47], or injection of absolute alcohol for trigeminal neuralgia [48]. In the case presented in this report, the cause of MO was traumatic.

It is rare that MO develops on both sides of the face [3,9,12,33,34,47,50], which requires multiple interventions. Conventional radiographs are often requested as the first imaging examination to investigate patient symptomatology. For craniofacial MO, the conventional examination is a panoramic radiograph [15,18,20,23,24], which provides a dimensional observation of the radiopaque mass near the region affected [15,38,41]. Further imaging examinations, including MCT and MRI are needed to determine the extension of the radiopaque mass and the muscles involved in the heterotopic bone formation. However, in early development of MO, no pathological alterations can be observed by plain radiographs [10,56].

In MCT, the extension and the limits of the radiopaque mass observed in conventional radiographs can be fully determined, although the adjacent soft tissue compromised cannot be entirely evaluated. In the literature, imaging findings are often described as hyperdense areas related to the muscles involved, designated as calcifications [1,5-10,12,15,18,19,21,23,24,37] or heterotopic bone neoformation [3,16,26,32,38,41]. Other imaging findings were also reported, such as a hypodense central area within the hyperdense area [22], coronoid process hypertrophy [11] or coronoid process fusion with the temporal bone [18], diffuse [47] or irregular calcification [48] within the involved muscle, as well as coronoid process cortical thickening and periosteal reaction [28], and complete calcification of the muscle [45]. The absence of any calcification on CT was reported in two cases, which showed oedema in a diffuse area of the masticatory muscles [27] or no alterations [33]. Hounsfield values of the hyperdense area related to MO ranged from 1200 to 1400. In the case presented in this report, the hyperdense area noticed on CT also showed heterotopic bone formation, with a bone protuberance arising from the temporal bone within the temporal muscle. On MRI, which is the imaging examination that provides the most accurate soft tissue evaluation, the imaging findings described are: partial bone ankylosis [11] an isointense area in the muscle involved on T1-weighted images [19], hyperintense areas on T2-weighted images [33], and haematoma-like findings within the muscle [5]. In the present report, a hypointense area was noted arising from coronoid bone, within the temporal bone.

http://www.ejomr.org/JOMR/archives/2019/4/e5/v10n4e5ht.htm
Table 2. Risk of bias assessment according to “The Joanna Briggs Institute (2017)” critical appraisal checklist for case reports [58]

| Author              | 1. Were patient's demographic characteristics clearly described? | 2. Was the patient's history clearly described and presented as a timeline? | 3. Was the current clinical condition of the patient on presentation clearly described? | 4. Were diagnostic tests or methods and the results clearly described? | 5. Was the intervention(s) or treatment procedure(s) clearly described? | 6. Was the post-intervention clinical condition clearly described? | 7. Were the adverse events or unanticipated events identified and described? | 8. Does the case report provide takeaway lessons |
|---------------------|---------------------------------------------------------------|--------------------------------------------------------------------------|--------------------------------------------------------------------------|--------------------------------------------------------------------------|--------------------------------------------------------------------------|--------------------------------------------------------------------------|--------------------------------------------------------------------------|--------------------------------------------------------------------------|
| Hanisch et al. [1]  | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | No                                                                      | Yes                                                                      |
| Jiang et al. [2]    | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | No                                                                      | Yes                                                                      |
| Jayade et al. [3]   | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Ratani et al. [4]   | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | No                                                                      | Yes                                                                      |
| Reddy et al. [5]    | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Nemoto et al. [6]   | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | No                                                                      | Yes                                                                      |
| Godhi et al. [7]    | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Conner and Duffy. [8] | Yes                                                        | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Yase et al. [9]     | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| St-Hilarie et al. [10] | Yes                                                         | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Spinazzee et al. [11] | Yes                                                        | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Myokon et al. [12]  | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Giraudo-Nardini et al. [16] | Yes                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Manzano et al. [18] | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Lenteza et al. [19] | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Saka et al. [20]    | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | No                                                                      | Yes                                                                      |
| Meyo et al. [21]    | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Lehto and Mark. [22] | Yes                                                         | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Woonse Thiel et al. [23] | Yes                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Fite-Trepap et al. [24] | Yes                                                        | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Civalheiro et al. [25] | Yes                                                        | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Karras et al. [26]  | No                                                            | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Oinsh et al. [27]   | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Becker et al. [28]  | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Domtien et al. [29] | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Wang et al. [30]    | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Dermiul et al. [31] | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Ferrer et al. [32]  | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | No*                                                                      | Yes                                                                      |
| Kang et al. [33]    | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Mian et al. [34]    | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Torres et al. [35]  | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Ahmad et al. [36]   | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Almeda et al. [37]  | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Boffano et al. [38] | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Kamalpur et al. [39] | Yes                                                         | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Spina et al. [40]   | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Piombino et al. [41] | Yes                                                         | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Choudhary et al. [42] | Yes                                                        | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Thangavolu et al. [43] | Yes                                                       | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Ramsier et al. [44] | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Trachtman et al. [45] | Yes                                                        | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Bansal et al. [46]  | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Kraus et al. [47]   | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Rattan et al. [48]  | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | No                                                                      | Yes                                                                      |
| Aoki et al. [49]    | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Kim et al. [50]     | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Takahashi and Sato [51] | Yes                                                        | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | No                                                                      | Yes                                                                      |
| Geist et al. [52]   | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Steiner et al. [53] | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | No                                                                      | Yes                                                                      |
| Naumann et al. [54] | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Parkash et al. [55] | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Rugiwa et al. [56]  | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |
| Arima et al. [57]   | Yes                                                          | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      | Yes                                                                      |

*The focus of this article was ultrasound examination only.

†The myositis ossificans case was reported as a clinical challenge.

NA = not applicable.
Ultrasound examination was not usually requested; however, an USG can show the muscle enlargement [29] and muscle alterations as a heterogeneous echogenic area [20]. PET examinations, used as a complementary tool to CT and MRI, can show low-grade uptake [4] and spots in the muscle affected by MO [49].

Besides malignant neoplasms, the differential diagnosis of MO may include pathological processes such as nodular fasciitis, haemangiomas with multiple phleboliths [31] and benign neoplasms, such as osteomas [24]. While considering these hypotheses, some imaging features should be noted. For instance, osteomas are well-defined radiopaque lesions, in contrast to MO, which often exhibit ill-defined or diffuse borders [11,26,36,38,43,47,48,57], although some reports of MO did show round and well defined areas [24,31,41,51]. Nodular fasciitis, although of a similar aetiology to MO, does not appear as radiopaque masses [15]. Haemangiomas with multiple phleboliths can be excluded due to the main imaging feature of phleboliths, which usually include a radiopaque core with the appearance of concentric rings, also called ‘laminations’ [59,60]. However there is a case of MO in the masseter muscle which had imaging features similar to phleboliths [31]. When considering malignant neoplasms, despite the fact that calcifications can be noted, the destruction or invasion of adjacent structures or tissues is often observed, which is not seen in MO cases.

Other differential diagnoses should be considered when a case of MOT is under investigation, such as fibrous ankylosis in the temporal joint [11], and fibrodysplasia ossificans progressive [61], or progressive myositis ossificans, due to limited mouth opening and pain with mastication. However, these two pathologies have differences when compared to MO or even to MOT. Fibrous ankylosis in the temporal joint has its own imaging features, which include the anatomical alteration of the temporal joint and mandible head [61]. Fibrodysplasia ossificans progressive is a genetic disorder that may affect the patient in the childhood or in adult life and is recognised by two clinical features: progressive formation of extraskeletal bone and malformation of the great toes [61]. Progressive myositis ossificans is also a genetic disorder associated with several skeletal malformations, sexual disorders and deafness [21].

Finally, MO treatment usually includes surgical intervention, with the resection of the ossified mass [3,7,10,18] and eventually coronoidectomy [5,6,8,9,15,16,28], mainly if it affects temporal muscles, as in MOT of temporalis. The limitation of the present case report and literature review was the impossibility to evaluate all the case reports available in the literature during the period of the time selected in the methodology due to the lack of response by some authors.

CONCLUSIONS

In conclusion, the main imaging feature of myositis ossificans is the presence of a radiopaque (on plain radiographs), hyperdense (on computed tomographic examination) or hypointense (on magnetic resonance imaging) mass in the affected muscle, which is demonstrated particularly well by computed tomography and magnetic resonance imaging. The final diagnosis is through histopathological examination, although imaging examinations can direct the most likely diagnosis.

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