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 Limpo 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

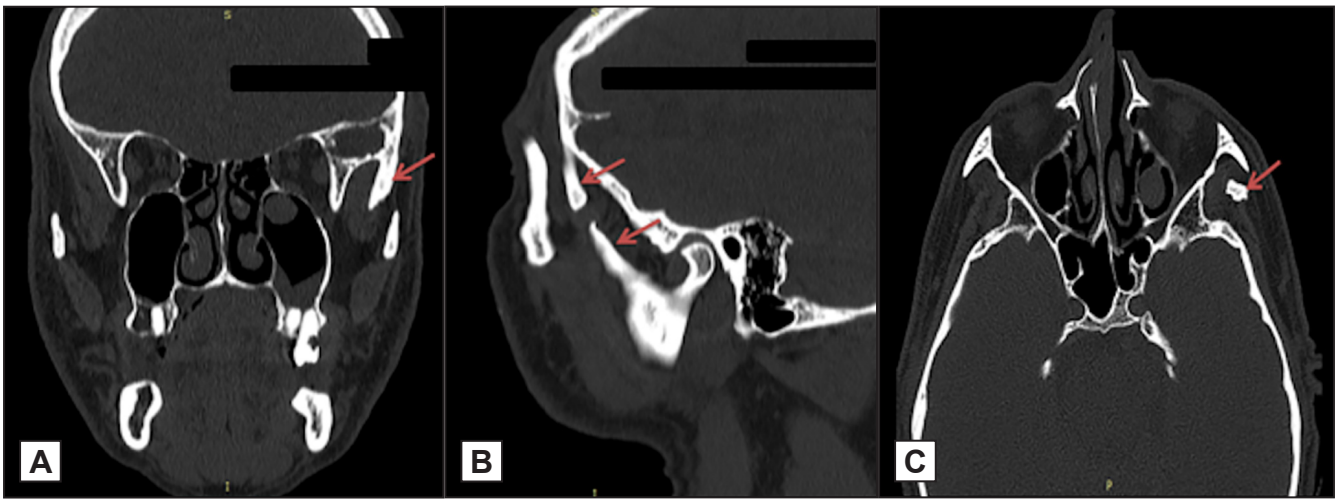

Figure 1. Initial multislice computed tomography of the case.
A = in frontal slice, a bone protuberance arising from the temporal bone, left size; B = sagittal slice, in which the protuberance can be observed both arising from frontal bone and coronoid process; C = in axial slice, a hyperdense area in the temporal muscle area, designated by the arrow in the pictures.

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 colaborative 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.

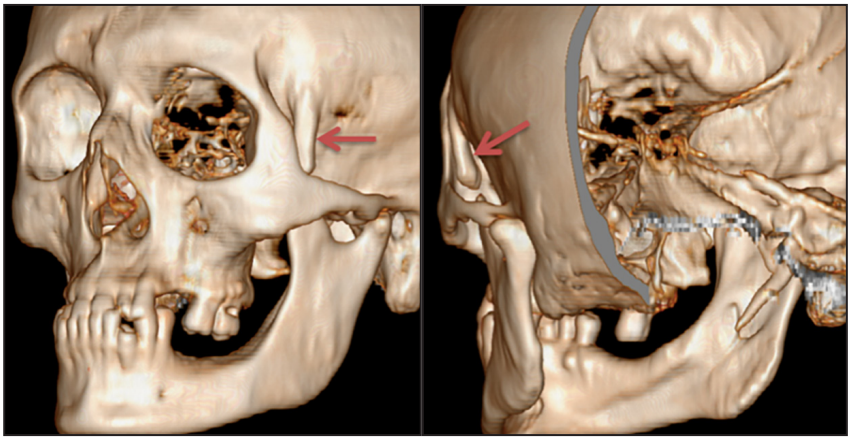

Figure 2. Three-dimensional view of the case. Ectopic bone formation is evinced by the arrow.

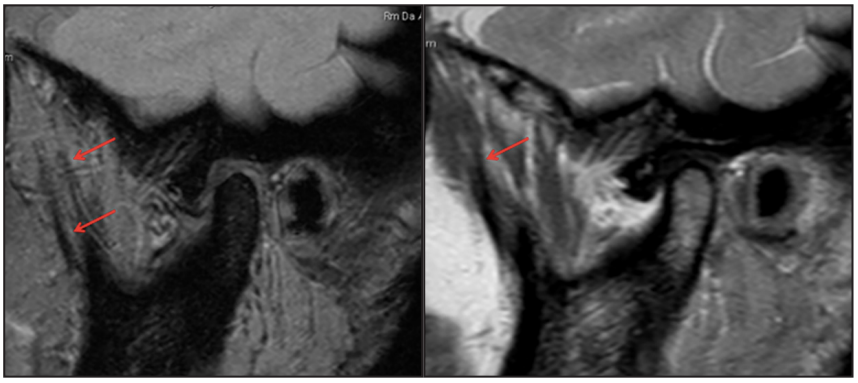

Figure 3. Magnetic resonance imaging examination. The hypointense area arising from coronoid bone. T2-weighted images, sagittal slices.

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[a]	Imaging features[b]
Hanisch et al. [1][c]	2018	Germany	Male 28	Inflammation/infection	Right, medial pterygoid muscles	CT	Calcification
Jiang et al. [2]	2015	China	Female 42	Inflammation/infection	Right, medial and lateral pterygoid muscles	PR, CT	PR (panoramic radiograph): chronic periapical 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 hyperostosis in the muscle
Ratansi et al. [4]	2017	UK	Female 41	Not determined	Right, temporal region (infratemporal fossa and masticatory spaces)	CTBC, MRI, PET	CTBC: 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: hematoma-like lesion within temporal muscle
Nemoto et al. [6]	2012	Japan	Male 39	Trauma	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
Godhi et al. [7]	2011	India	Male 21	Not determined	Right, temporal and lateral pterygoid muscles	CT	Calcifications involving masticatory muscles and fascia; a thick osseous bridge was observed in the region of the inferior head of the right lateral pterygoid muscle
Conner 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	Masseter (bilateral) and temporal muscles (left)	PR, CT	PR: calcification in the galea 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	PR: no pathological findings; CT: calcification and inflammation within the temporal and pterygoid muscle
Spinazze et al. [11]	1998	USA	Male 55	Muscule stress	Left, lateral pterygoid	PR, CT, MRI	PR: coronoid hypertrophy; CT: coronoid hypertrophy, spotty diffuse a calcification in the temporal muscle nearby the coronoid process; MRI: intraarticular adhesion or partial bony ankylosis
Myoken et al. [12]	1998	Japan	Male 55	Trauma	Bilateral, temporal muscle	CT	Bilateral radiopacity within temporal muscle
Guarda-Nardini et al. [16]	2011	Italy	Male 50	Trauma	Right, temporal muscle	CT	Osseous neoformation in the area of the temporal muscle
Manzano et al. [18]	2007	Spain	Male 51	Trauma	Right, temporal muscles	PR, CT	PR: (ortopantomography) bone density opacity in the region of right coronoid process; CT: bone density mass in the region of temporal fossa, that fussed 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: isointense 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 ossification within the right temporal muscle
Lello and Makek [22]	1986	Switz.	Male 34	Trauma (accident)	Left, masseter muscle	CT	Peripheral hyperdense mass with a hypodense central area
Wiesenfeld et al. [23]	1985	England	Female 10	Not determined	Right, temporal muscle	PR, CT	PR: calcification; CT: calcification with involvement of temporal muscle
Fité-Trepat et al, [24]	2016	Spain	Female 49	Repetitive infection 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, masseter and mimetic muscles	CT	Amorphous ossified formations, in a cortical/medullar pattern
Karaali and Emeki [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 (doppler)	CT: swelling in the masticatory muscles without calcification; MRI: diffusely enlarged contrast-enhanced masticatory muscles appearing hyperintense on T1; USG: normal carotid, temporal and maxillary arteries
Becker et al. [28]	2016	Brazil	Male 17	Trauma (fracture)	Right, temporal muscle	CT	Cortical thickening and periosteal reaction of the coronoid process; soft tissue volume increase
Damian 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 hyperdense mass (heterotopic bone formation)
Dermirkol et al. [31]	2015	Turkey	Female 64	Trauma	Left, masseter muscle	PR, CT	PR (panoramic radiograph) ovoid masses; CT: small rounded radiolucent areas with central calcifications, within the muscle
Ferra et al. [32]	2015	USA	Female 50	Infection (abscess)	Right, medial pterygoid muscles	CT	Heterotopic ossification with mature bone replacing.

[a]Considering only preoperative imaging examinations, according to the author's description.
[b]Considering exclusively authors description.
[c]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.

Table 1B. 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[a]	Imaging features[b]
Kang et al. [33]	2015	Korea	Case 1: female 80; Case 2: female 25; Case 3: female 49; Case 4: female 19	Case 1: trauma; Cases 2,3 and 4: not determined	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	Inflammation/ infection (post-exodontia)	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	Not determined	Left, lateral pterygoid muscle	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	Left, temporal, lateral and medial pterygoid muscles	CT, MRI	CT: High attenuation mass (1200 - 1400 HU); MRI: Hypointense mass on T1
Spinzia et al. [40]	2014	Italy	Male 30	Trauma (multiple fractures)	Left, lateral pterygoid muscle	CT	CT: significant calcification of the muscle.
Piombino 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	PR, CT	PR (mandible lateral oblique): radiopaque mass; CT: calcification of the muscle
Thangavelu et al. [43]	2011	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	Inflammation (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 (ortopantomography) and CT: calcified mass
Kruse et al. [47]	2009	Switzerland	Female 35	After intubation and chemotheraphy	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 (blow 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	Idiophatic (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/ female 15	Trauma (fracture)/ trauma (shotgun)	Left, masseter/ left, masseter muscle	PR, CT/CT	PR (panoramic radiograph): radiopaque mass; CT: calcified periosteal hematoma within the muscle/CT: calcified mass
Naumann et al. [54]	1993	Germany	Male 19	Not determined	Right, temporal muscle	MRI	T2-weighted images showed increased signal intensity within the muscle; T1-weighted images showed muscle enlarged
Parkash et al. [55]	1992	India	Male 28	Not determined	Left, medial pterygoid muscle	PR, CT	PR (panoramic radiograph): obliteration of the temporomandibular joint space and fan-shaped calcified mass; 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

[a]Considering only preoperative imaging examinations, according to the author's description.
[b]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.

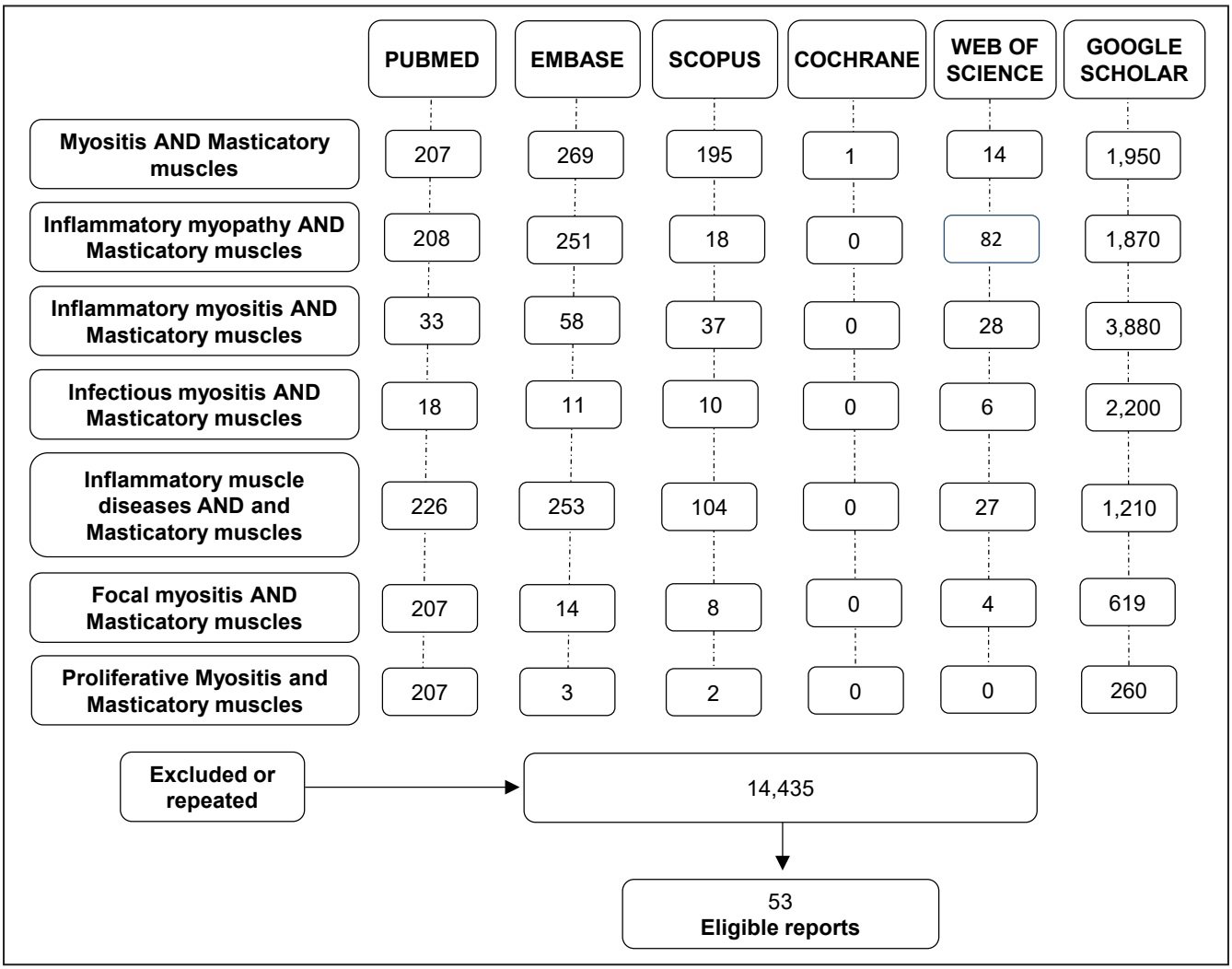

Figure 4. Flow chart of the literature search strategy.

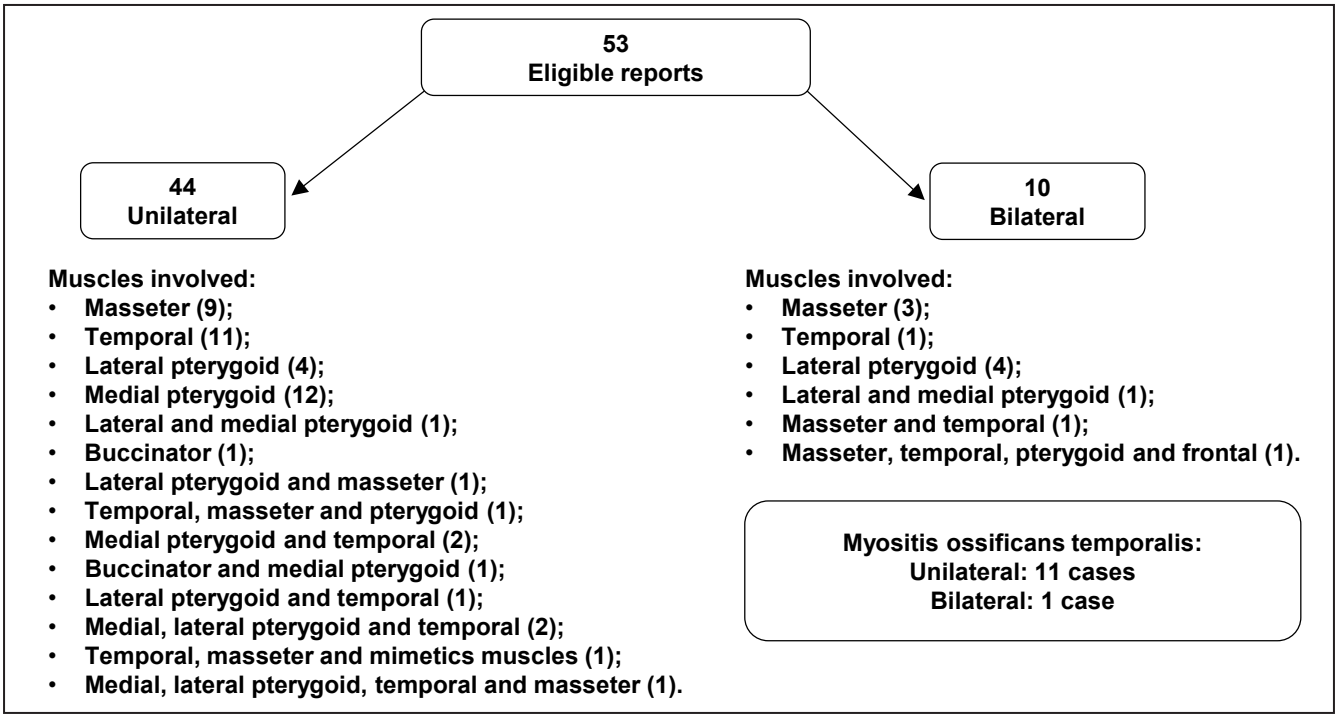

Figure 5. Summarized data pertaining to myositis ossificans most affected muscles.

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 exhibited 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 requested 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.

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	NA	Yes
Jiang et al. [2]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Jayade et al. [3]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Ratansi et al. [4]	Yes	Yes	Yes	Yes	No	No	NA	Yes
Reddy et al. [5]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Nemoto et al. [6]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Godhi et al. [7]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Conner and Duffy. [8]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Yano et al. [9]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
St-Hilarie et al. [10]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Spinazze et al. [11]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Myoken et al. [12]	Yes	Yes	Yes	Yes	Yes	No	NA	Yes
Guarda-Nardini et al. [16]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Manzano et al. [18]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Uematsu et al. [19]	Yes	Yes	Yes	Yes	No	No	NA	No
Saka et al. [20]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Mevio et al. [21]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Lello and Makek [22]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Wiesenfeld et al. [23]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Fité-Trepat et al, [24]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Cavalheiro et al. [25]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Karaali and Emeki. [26]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Onishi et al. [27]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Becker et al. [28]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Damian et al. [29]	Yes	Yes	Yes	No[a]	Yes	Yes	NA	Yes
Wang et al. [30]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Dermirkol et al. [31]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Ferra et al. [32]	Yes	Yes	Yes	Yes	Yes	No[b]	NA	Yes
Kang et al[33]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Mashiko et al. [34]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Torres et al. [35]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Ahmad et al. [36]	Yes	Yes	Yes	Yes	Yes	No	NA	Yes
Almeida et al. [37]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Boffano et al. [38]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Kamalapur et al. [39]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Spinzia et al. [40]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Piombino et al. [41]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Choudhary et al. [42]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Thangavelu et al. [43]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Ramieri et al. [44]	Yes	Yes	Yes	Yes	Yes	No	NA	Yes
Trautmann et al. [45]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Bansal et al. [46]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Kruse et al. [47]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Rattan et al. [48]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Aoki et al. [49]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Kim et al. [50]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Takahashi and Sato [51]	Yes	Yes	Yes	Yes	Yes	No	NA	Yes
Geist et al. [52]	Yes	Yes	Yes	Yes	Yes	No	NA	Yes
Steiner et al. [53]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Naumann et al. [54]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Parkash et al. [55]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Fujiwara et al. [56]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes
Arima et al. [57]	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes

[a]The focus of this article was ultrasound examination only.
[b]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 exhibits 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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