



## POST TRAUMATIC MYOSITIS OSSIFICANS : SONOGRAPHIC FINDINGS

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**POST TRAUMATIC MYOSITIS OSSIFICANS : SONOGRAPHIC FINDINGS**

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Review

Sonographic findings of myositis ossificans

**Purpose:** The US appearance of Post – traumatic myositis ossificans (PTMO) is not well established, because only few cases have been described. Aim of this paper is to report the US features of PMTO in a quite large cohort of patients.

**Methods:** Fifteen patients with histological diagnosis of PTMO were enrolled. The following US parameters were evaluated: mass; calcification; Power Doppler signal; relationship with contiguous structures.

**Results:** Five patients (33.3 %) were diagnosed as early and ten (66.6 %) as mature PTMO. As common characteristics of both early and mature PTMO, US examination showed an oval hypoechoic mass, without infiltrative borders, located in muscle belly. In the early phases, a center of less echogenicity was observed, associated with an outer sheet – like hyperechoic peripheral rim, while, in mature phase, the peripheral calcification was more reflective and distal acoustic shadowing was observed.

**Conclusions:** US is highly sensitive in the detection of PTMO and it can be used for serial evaluation. It can provide indicative features in the differential diagnosis between PTMO and malignant soft tissue tumors.

**Keywords:** Myositis ossificans, Ultrasound, Soft tissue calcification, musculoskeletal system

## Sonographic findings of myositis ossificans

### 1. Introduction

Myositis Ossificans is a benign condition of heterotopic non – neoplastic bone or cartilage formation in / or adjacent to a muscle and in proximity to a bone [1, 2].

Four different clinical entities have been described : a) Myositis ossificans post – traumatica (PTMO); b) fibrodysplasia ossificans progressiva (FOP); c) myositis ossificans associated with paraplegia and d) myositis ossificans circumscripta [3].

Among these entities, PTMO is the most common, including 60 – 75 % of all cases, and may occur after a single direct blow or repeated minor traumas, although no history of trauma is observed in approximately 40 % of patients [2, 4].

Thigh and arm are the commonest locations [5], even if some cases have been reported in hand, neck, calf, shoulder, thorax and abdomen [6 – 10]. Pain, oedema, swelling as well as palpable mass with associated decreased range of motion are usually complained by the patients [5].

Microscopically, degeneration and necrosis of the damaged muscle are seen first; afterwards the proliferation of mesenchymal cells, mineralisation and bone formation are observed.

From a clinical and radiologic point of view, the differential diagnosis includes hematoma, abscess, focal rhabdomyolysis, and malignant primary or secondary soft tissue tumors [11].

The imaging techniques, used to confirm PTMO, are a) conventional radiography (RX), b) bone scintigraphy, c) computed tomography (CT), d) magnetic resonance (MR) and e) ultrasonography (US) [2].

Among these imaging modalities, US is the most suitable, because easy to perform, low cost and safe for the patient.

However, the US features of PTMO are not well established : actually, there are very few case

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reports in literature [6, 7, 12] and in most of them the diagnosis has not been confirmed by histopathology.

The aim of this paper is therefore to report the US features of PMTO in the early and mature stages, confirmed by histological examinations, in a relatively large sample of patients.

**2. Material and methods**

Fifteen patients (8 M : 7 F, mean age 31.2; SD 18,60 years, range from 12 to 65 years) referred to our Department, were retrospectively enrolled (from November 2006 to April 2009).

In these patients, PTMO was suspected on the basis of history, symptoms, physical examination and US.

US evaluation was performed using a multi – frequency (5 – 12 MHz) linear array transducer (Acuson, Siemens Medical Solution, Germany).

Lesions were evaluated according to a standard protocol, using multiplanar scans; Power Doppler (PD) as well as tissue harmonic imaging was used.

The following parameters were evaluated:

- 1) Mass (appearance, echogenicity, margins and dimension);
- 2) Calcification (position, appearance, distal shadowing and dimension);
- 3) PD signal;
- 4) Relationship with contiguous structures (muscle, bone, vessels and nerves).

A semiquantitative grading system was used to evaluate the neovascularization inside the area of the lesion interested by PD signal. According to this system grade (0) is no Doppler

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activity; (1+), one or two tiny colour foci; (2++), up to 50 % colour in the region of interest; (3+++), 50 – 90 % colour in the region of interest; (4++++), 90 – 100 % colour in the region of interest [13].

PTMO diagnosis was then confirmed by histopathology, performed at the same time on specimens obtained by means of real – time US guided needle biopsy.

This procedure was carried out not only for diagnosis confirmation but also for clinical purposes (possible surgical planning). Prior to biopsy, a written informed consent was obtained from the patient.

Biopsies were done under local anesthesia and performed in sterile conditions. The needle pathway was decided on the basis of safe access route (according to the orthopaedic surgeon), avoidance of vessels and nerves (vital structures), skin to lesion distance, and also the expected definite treatment plans to avoid any possible intercompartmental contamination or seeding [14].

Under real – time US monitoring, a 13 – 14 Gauge (150 mm) Tru – Cut needle was guided inside the lesions and a tissue sample was obtained.

In total, at least 4 – 5 specimens were collected from the central, intermediate and peripheral layers of the lesion in order to better differentiate early from mature PTMO at histopathological examination.

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3. Results

All the patients complained pain, local heat and swelling with decreased range of motion of the compartment affected. A palpable mass, in general harder in mature PTMO, was found in 7 cases (46,6 %).

In 10 patients (66,6 %) the lesion occurred in the thigh (8 right and 2 left), while in 5 cases (4 right and 1 left) it occurred in the arm.

A single direct blow was reported in 73,3 % patients while in the remaining 26,7 % of patients no history of trauma was reported.

The time elapsed between the injury and the US evaluation, although without significant statistical difference, was quite longer for mature PTMO ( $32.5 \pm 17.6$  days vs  $17.5 \pm 3.54$  days in early PTMO). This wide range of values is probably due to the characteristics of the trauma and individual reactivity.

The longest and transverse mean diameters were  $5.5 \pm 1.7$  cm (range from 9.2 to 3 cm) and  $3.4 \pm 0.9$  cm (range from 5.3 to 1.6 cm) respectively (Tab. 1).

Mature PTMO was observed in 10 patients and early PTMO in 5. The hystopathological criteria for early PTMO were evidence of degeneration and necrosis of the damaged muscle, fibroblasts proliferation, whereas those for mature PTMO were presence of ground substance, mineralisation and bone like tissue (Fig. 1).

As common characteristics of both early and mature PTMO, US examination showed, in all cases, an oval shaped homogenous hypoechoic soft tissue mass when scanned along its long axis and rounded on transverse sonograms. Mass borders appeared regular and not infiltrative. In all the patients, the mass was located in the muscle belly, which appeared thickened; muscle fibers were not interrupted.

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The other structures adjacent to PTMO were preserved; in particular, no connections with the bone, nerves and vessels were reported.

In the early phases of PTMO, a center of less echogenicity was observed in all cases, associated with an outer sheet – like hyperechoic, not well defined, peripheral rim in three. No clear zonal demarcation or calcification was present (Fig. 2).

In the mature phases, with the increasing ossification, the peripheral rim – like calcification was more reflective with a distal acoustic shadowing in all cases. However, in three patients, the superficial calcified wall did not completely obscure the deep boundary and few internal calcific deposits were seen (Fig. 3).

Only in the early PTMO, vascularization was observed and was classified as 1+ (two cases), 2++ (two cases) (Fig. 4) and 3+++ (one case). In none of mature PTMO cases, PD signal was present (Tab. 2).

No complications (bleeding, nerves injuries, etc) apart from pain in the biopsy site were complained by the patients.



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4. Discussion

The present study, performed on fifteen cases of PTMO, confirmed by histopathological examinations, shows that some US features (homogenous hypoechoic mass, well defined and regular borders) are common both to the early and mature stages of the disease.

The early phase is characterized by a center of less echogenicity associated with an outer hyperechoic area consistent with lamellar bone, without a clear calcification. These separate zones of varying echogenicity correspond pathologically to an outer muscular layer, an inner layer of immature osteoid and mature peripheral lamellar bone, and an innermost layer of proliferating fibroblasts, necrosis, and hemorrhage.

In the mature phase, a peripheral rim – like calcification is observed and few internal calcific deposits may be seen (presence of ground substance, mature lamellar bone, with a minor immature component of osteoid on histopathological examination).

Obviously, several intermediate stages may be visualized.

Vascularization, evaluated with a semiquantitative method [13], is mainly observed in the early phase, while it progressively disappears as the lesion progresses to more mature stages.

Our results are in agreement with other authors [2, 15 – 19], both for the early phase and the mature one. In particular Okayama et al. [16] described, in a case of recurrent PTMO, the presence of an echogenic area, representing a soft tissue mass, with a center of less echogenicity inside and no evidence of calcification.

The diagnosis of PTMO, besides clinical history and physical examination, is based on different imaging techniques (RX, CT, bone scintigraphy, MRI and US) [2, 20, 21].

RX is often carried out as a first examination when a PTMO is suspected, but the findings are not specific, ranging from initially normal to the appearance of a soft tissue mass with faint

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periosteal new bone formation, within 1 to 2 weeks post injury [2]. Therefore, conventional radiography does not allow a clear visualization of PTMO in its early stages.

After 3 to 4 weeks, when mineralization of the osteoid occurs, and after months, when the deposition of dense bone is observed, the diagnosis may be suspected, but unconclusively [2].

It may be used to determine the size, density, and anatomical location only of calcified lesions and it may also be helpful in differentiating PTMO from osteosarcoma, since it reveals the peripheral calcification and the absence of invasion of surrounding tissue, that are characteristic of PTMO.

Bone scintigraphy with Tc 99 phosphate cannot distinguish the location of the lesion within tissue planes or provide precise information on the size and area of demarcation [22].

Furthermore, the increased uptake is non specific and musculoskeletal tumours and infection cannot be ruled out, as they may show similar uptake on the 3 – phases bone scintigraphy, as seen in early PTMO [22, 23]. Therefore, this technique is not appropriate in the diagnosis of PTMO.

CT is useful only in the diagnosis of mature PTMO as it best demonstrates the typical zonal pattern of ossification [2] and clearly locates the lesion prior to surgical excision.

The MRI appearances of PTMO are variable and depend on the maturity of the lesion [24]. It is the most sensitive technique for identifying small, early lesions, but may be not specific. An important limitation is its relative inability to detect soft – tissue calcification [2].

It must be added that the above mentioned imaging techniques are expensive, invasive and often require sedation, especially in children [25]. Another disadvantage is represented by the possible occurrence of allergic reaction to the contrast medium (in cases of bone scintigraphy and MRI). Therefore, these modalities are unsuitable for a serial visualization of developing lesions.

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Compared to the above mentioned techniques, US evaluation has several advantages.

In early stages, US is highly sensitive in the detection of calcific deposits in soft tissues (i.e. prior to the development of the ossification) [16] and it can be used for serial evaluation until mature calcified lesions are observed.

US also provides indicative features (in terms of echotexture, vascularization, margin, involvement of surrounding tissues, etc) to distinguish between PTMO and malignant soft tissue, even if, in some cases, further imaging modalities are needed and histopathological diagnosis from specimens obtained by excision is mandatory.

Moreover, the angulation of the US transducer can show the presence of a soft tissue plane between the calcification and the adjacent bony cortex or surrounding tissues, thus providing further features of benignity.

A careful and correct diagnosis of PTMO is important to decide for surgery. Indeed, surgery is indicated when vascularisation is completely absent and there is a total reflection of the US beam from the outer zone. Moreover, US can be used to guide the surgical excision, because it marks very well its anatomical extension.

The surgical excision is suitable when disabling pain and functional impairment are present. On the other hand, it must be considered that only mature PTMO must be removed, because the recurrence is more likely to occur if a lesion is removed when it is metabolically active (presence of Power Doppler signal).

Some strenghts and limitations of this study must be acknowledged. Compared to other papers, in which only few patients were evaluated and histological examination was not carried out, our study evaluated a quite large sample of PTMO, confirmed by histopathology.

At this regard, it must be underlined that a firm diagnosis can be obtained only by histopathological examination of the mass after excision; however, in our cases, we think that

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reliable conclusions may be drawn, because several specimens were obtained from the different layers of the lesions under US control.

Other limitations are represented by the retrospective nature of this study and by the fact that other soft tissue masses have not been included in the comparison with PTMO; in addition, the patients were evaluated only once and were not followed up.

In conclusion, in our opinion, US can be considered as a useful tool in the PTMO evaluation because easy to perform, low – cost and safe for patients, especially for children.

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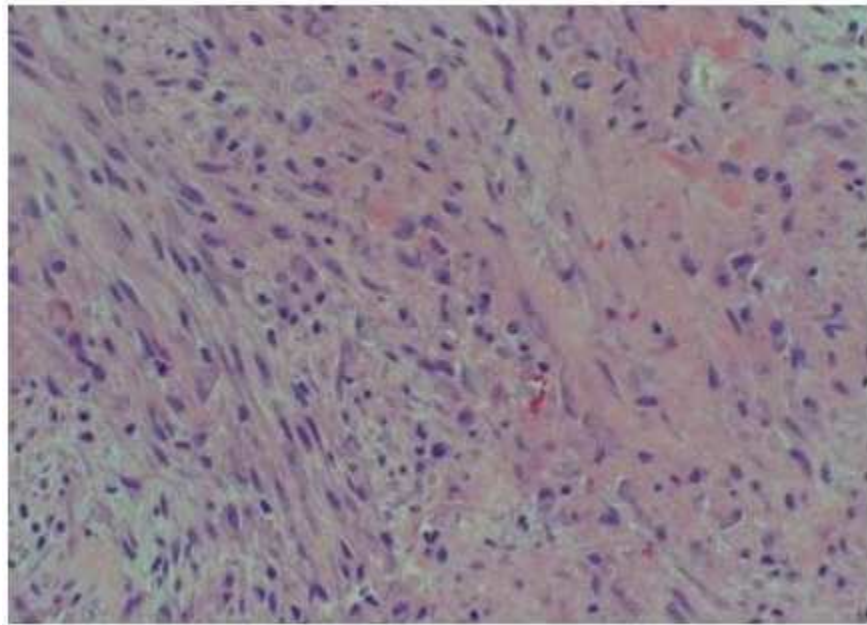


Figure 1a). Packed and damaged muscle fibers (20x);  
116x86mm (96 x 96 DPI)



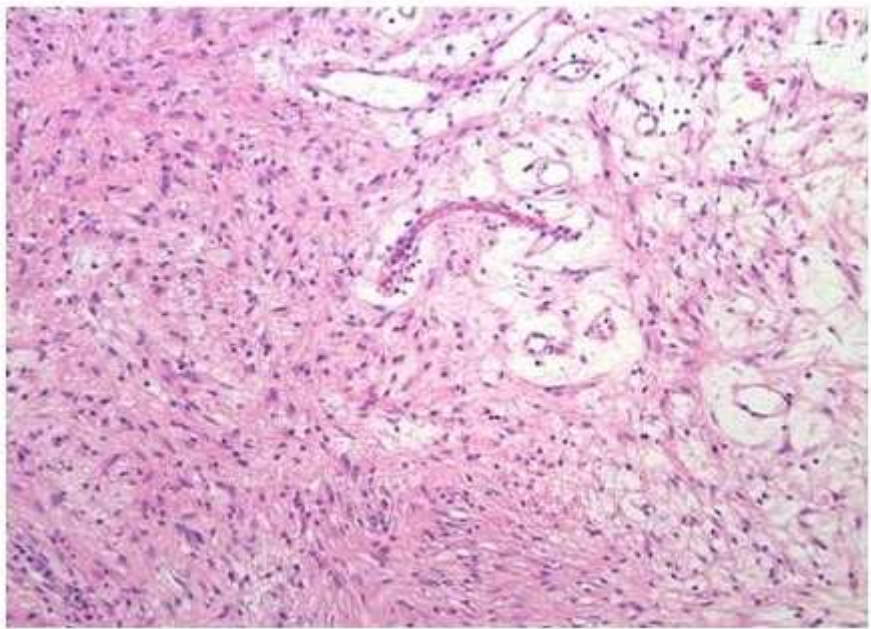


Figure 1b). Fibroblast proliferation with storiform pattern, scattered clusters of chronic inflammatory cells (10x)  
115x85mm (96 x 96 DPI)

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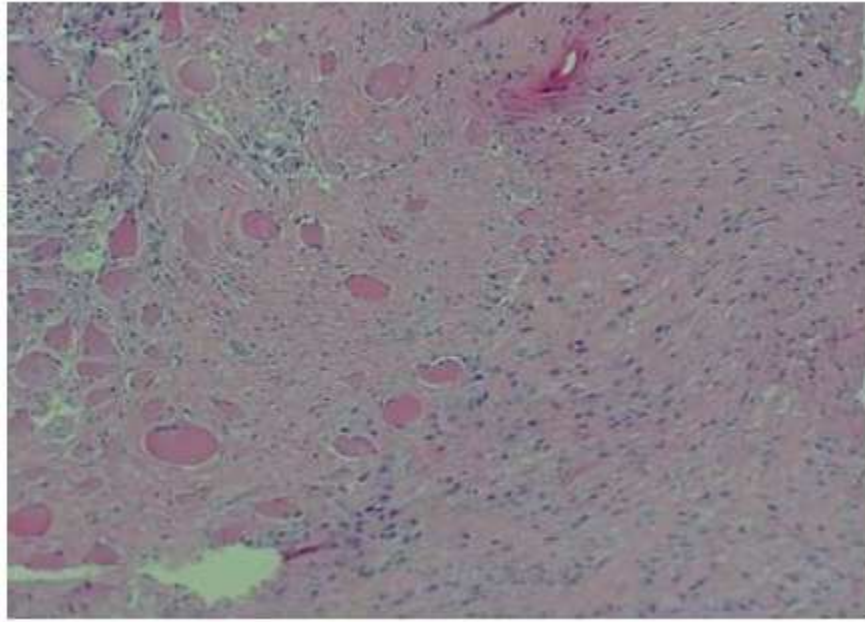


Figure 1c: Outer zone. Proliferation of mesenchymal cells and presence of ground substance (20x);  
116x85mm (96 x 96 DPI)

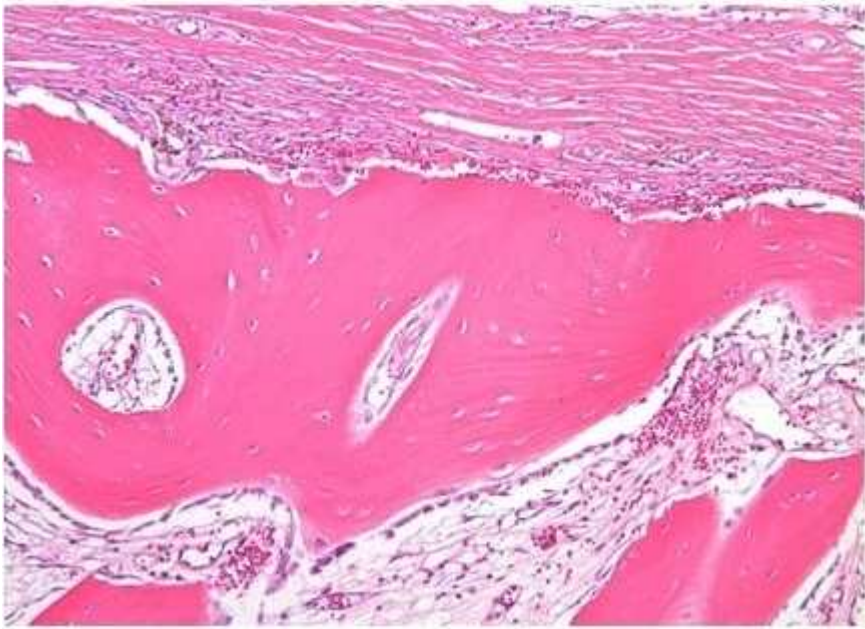


Figure 1d). Mineralisation and bone like tissue formation (20x)  
115x84mm (96 x 96 DPI)

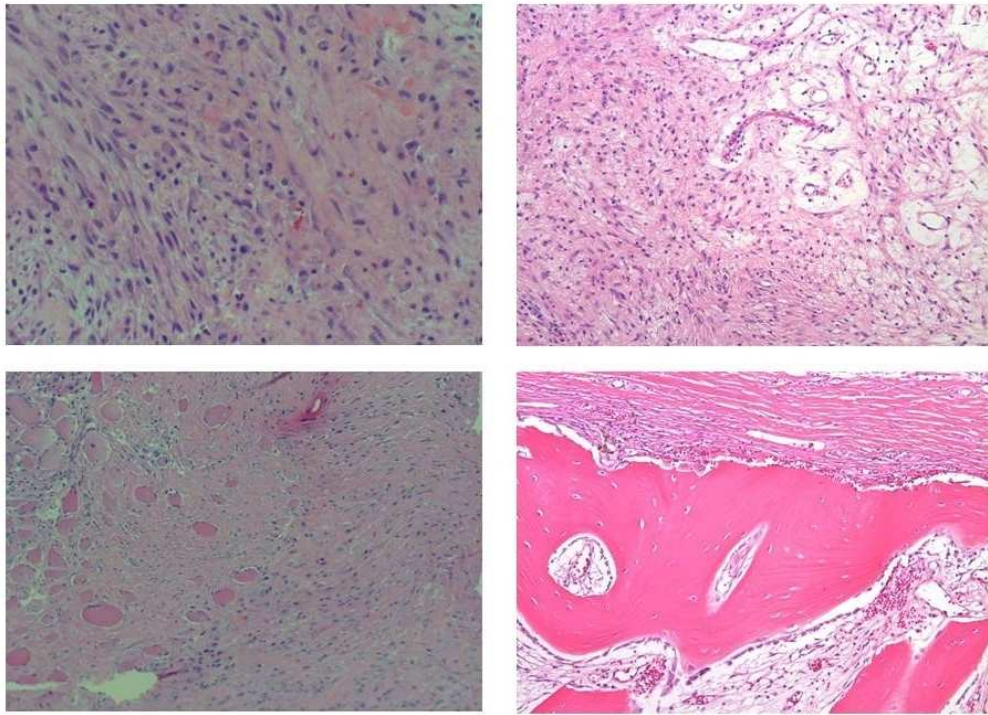


Figure 1: PTMO histological examination in different stages (haematoxylin – eosin stain).  
Central zone. 1a). Packed and damaged muscle fibers (20x); 1b). Fibroblast proliferation with storiform pattern, scattered clusters of chronic inflammatory cells (10x)  
Outer zone. 1c). Proliferation of mesenchymal cells and presence of ground substance (20x); 1d). Mineralisation and bone like tissue formation (20x).  
239x176mm (96 x 96 DPI)



Figure 2a). Sonograms of right thigh : note the muscle thickening and swelling (transverse scan).  
No regular, but indistinct borders are seen.  
81x80mm (96 x 96 DPI)





Figure 2b). A rounded, hypoechoic mass between the calipers, with well defined borders, is seen (transverse scan). No calcification are observed. M = Muscle  
90x79mm (96 x 96 DPI)

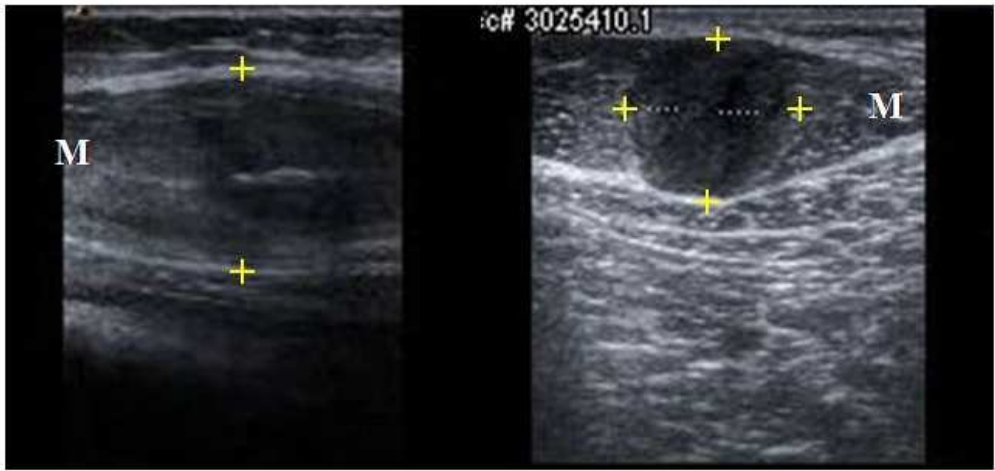


Figure 2 : Early PTMO.  
2a). Sonograms of right thigh : note the muscle thickening and swelling (transverse scan). No regular, but indistinct borders are seen.  
2b). A rounded, hypoechoic mass between the calipers, with well defined borders, is seen (transverse scan). No calcification are observed. M = Muscle  
170x85mm (96 x 96 DPI)

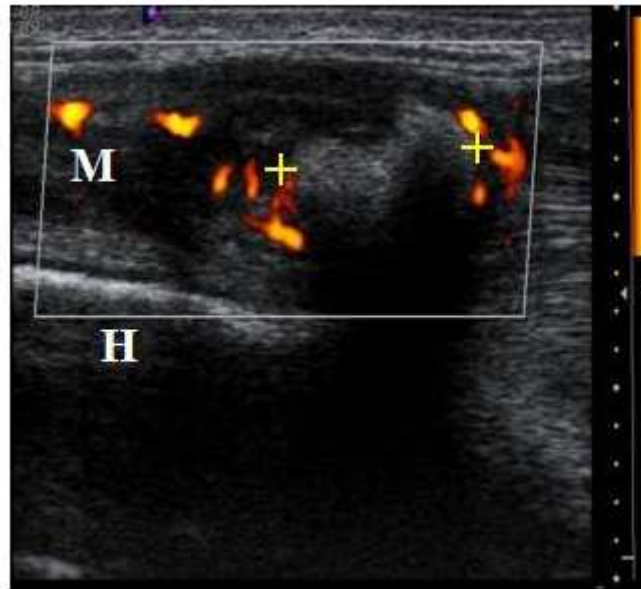


Figure 3 : Early PTMO of triceps brachii.

Note the calcification (calipers) into the thickened muscular belly (longitudinal scan). Power Doppler signal is present (moderate). In all the cases, the surrounding tissue are not involved. M = Muscle;

H = Humerus

87x81mm (96 x 96 DPI)



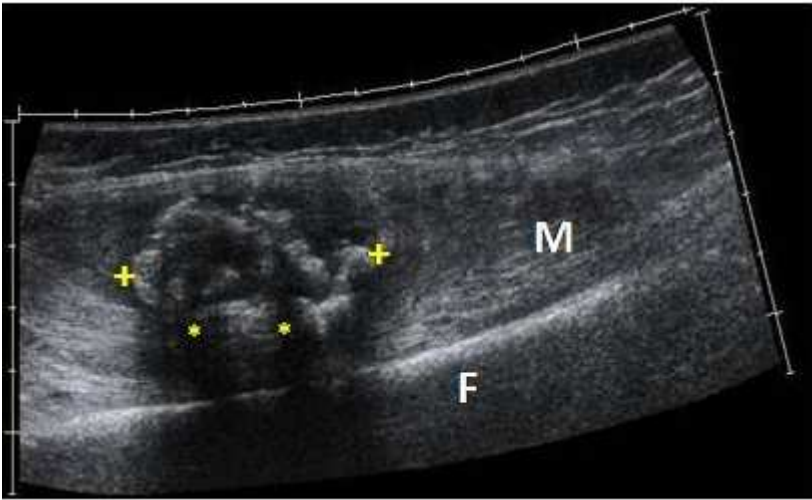


Figure 4a). Scattered calcifications (calipers) which do not completely obscure the deep boundary;  
few internal calcific deposits are also seen.  
107x66mm (96 x 96 DPI)

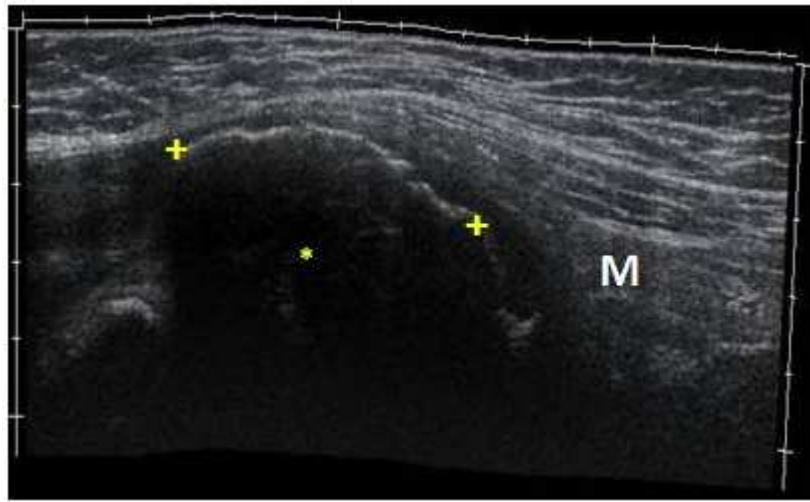


Figure 4b). Note the calcification (calipers) and its distal shadowing (\*).  
108x67mm (96 x 96 DPI)



Figure 4c). The femoral cortex is interrupted. In these cases, the mass was located in the muscle belly, which appeared thickened. M = Muscle; F = Femoral shaft  
107x65mm (96 x 96 DPI)

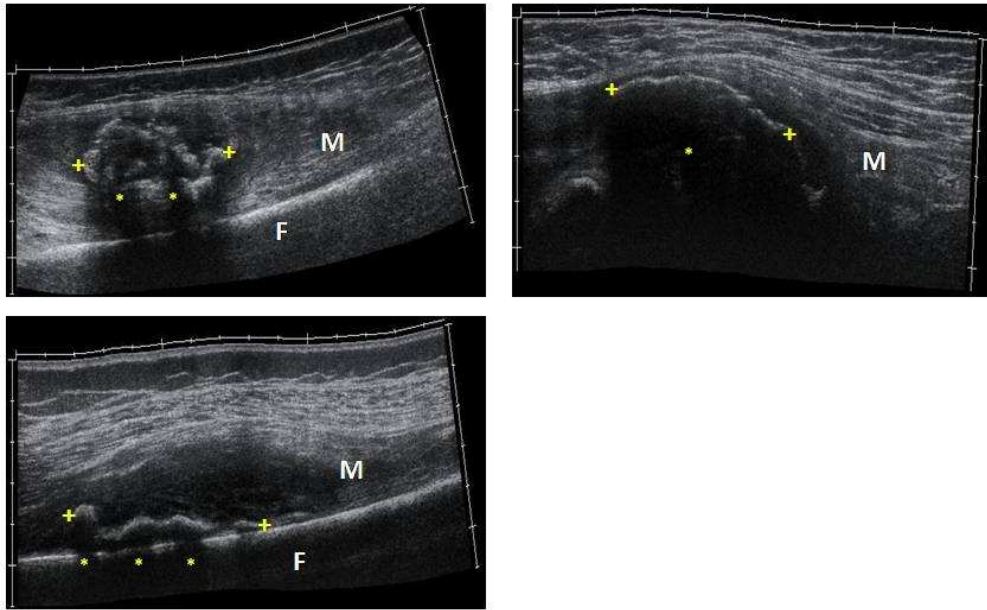


Figure 4 : Mature PTMO. Longitudinal scan of right thigh of three different cases.  
4a). Scattered calcifications (calipers) which do not completely obscure the deep boundary; few internal calcific deposits are also seen.  
4b). Note the calcification (calipers) and its distal shadowing (\*).  
4c). The femoral cortex is interrupted. In these cases, the mass was located in the muscle belly, which appeared thickened. M = Muscle; F = Femoral shaft  
222x139mm (96 x 96 DPI)

Sonographic findings of myositis ossificans

**Figure 1:** PTMO histological examination in different stages (haematoxylin – eosin stain).

*Central zone.* **1a).** Packed and damaged muscle fibers (20x); **1b).** Fibroblast proliferation with storiform pattern, scattered clusters of chronic inflammatory cells (10x)

*Outer zone.* **1c).** Proliferation of mesenchymal cells and presence of ground substance (20x); **1d).** Mineralisation and bone like tissue formation (20x).

## Sonographic findings of myositis ossificans

**Figure 2 :** Early PTMO.

**2a).** Sonograms of right thigh : note the muscle thickening and swelling (transverse scan).

No regular, but indistinct borders are seen.

**2b).** A rounded, hypoechoic mass between the calipers, with well defined borders, is seen (transverse scan). No calcification are observed. **M** = Muscle

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**Figure 3 :** Early PTMO of triceps brachii.

Note the calcification (calipers) into the thickened muscular belly (longitudinal scan). Power Doppler signal is present (moderate). In all the cases, the surrounding tissue are not involved.

**M** = Muscle; **H** = Humerus

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## Sonographic findings of myositis ossificans

**Figure 4** : Mature PTMO. Longitudinal scan of right thigh of three different cases.

**4a).** Scattered calcifications (calipers) which do not completely obscure the deep boundary; few internal calcific deposits are also seen.

**4b).** Note the calcification (calipers) and its distal shadowing (\*).

**4c).** The femoral cortex is interrupted. In these cases, the mass was located in the muscle belly, which appeared thickened. **M** = Muscle; **F** = Femoral shaft



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**Table 1 :** Demography and characteristics of PTMO lesion.

Symptoms are reported in terms of pain, tenderness, swelling, decreased Range of Motion.

Case	Gender	Age	Location	Symptoms	Injury	Time lapse (days)	Mean diameters (Longest – Transverse; cm)	Histopathological results
1	M	59	Right thigh	Mild	Not traumatic	20	6 x 3	Early
2	M	15	Right arm	Moderate	Traumatic	20	5 x 2.3	Early
3	M	13	Right thigh	Moderate	Traumatic	15	9.2 x 5.3	Early
4	M	28	Right thigh	Marked	Traumatic	15	3.8 x 3	Early
5	M	53	Right thigh	Mild	Traumatic	15	5.3 x 4.2	Early
6	M	16	Right arm	Moderate	Traumatic	20	5.6 x 4.2	Mature
7	F	16	Left arm	Moderate	Traumatic	30	4.5 x 2.8	Mature
8	F	30	Left thigh	Mild	Not traumatic	45	3.7 x 2.9	Mature
9	M	17	Right thigh	Marked	Traumatic	20	7.6 x 3.4	Mature
10	F	25	Right thigh	Mild	Traumatic	30	5.3 x 4.2	Mature
11	F	12	Right thigh	Moderate	Traumatic	45	5.7 x 4.7	Mature
12	F	36	Right thigh	Marked	Not traumatic	30	5.2 x 3.6	Mature
13	M	65	Right arm	Marked	Not traumatic	30	8.6 x 3.8	Mature
14	F	58	Left thigh	Moderate	Traumatic	30	4.5 x 2.9	Mature
15	F	25	Right arm	Moderate	Traumatic	45	3 x 1.6	Mature

## Sonographic findings of myositis ossificans

**Table 2 :** PTMO US appearance and histopathological features

	EARLY	MATURE
<b>Mass</b>	Oval (on longitudinal sonograms) – rounded (on transverse sonograms), homogenous, hypoechoic mass, well defined, with regular borders	
<b>Calcification</b>	Outer sheet – like hyperechoic, not well defined, peripheral rim	Reflective peripheral rim – like calcification reflective; distal acoustic shadowing
<b>Vascularization</b>	Present	Absent
<b>Other structures</b> (bone, muscle, nerve, vessel)	No infiltration; muscle fibers not interrupted; muscle belly thickened	
<b>Histopathology</b>	Degeneration / necrosis of the damaged muscle; fibroblasts proliferation	Presence of ground substance; mineralization; bone like tissue

Sonographic findings of myositis ossificans

**Purpose:** The US appearance of Post – traumatic myositis ossificans (PTMO) is not well established, because only few cases have been described. **The** aim of this paper is to report the US features of PMTO in a quite large cohort of patients.

**Methods:** Fifteen patients with histological diagnosis of PTMO were enrolled. The following US parameters were evaluated: mass; calcification; Power Doppler signal; relationship with contiguous structures.

**Results:** Five patients (33.3 %) were diagnosed as early **PTMO** and ten (66.6 %) as mature PTMO.

As common characteristics of both early and mature PTMO, US examination showed an oval hypoechoic mass, without infiltrative borders, located in muscle belly.

In the early phases, a center of less echogenicity was observed, associated with an outer sheet – like hyperechoic peripheral rim, while, in mature phase, the peripheral calcification was more reflective and distal acoustic shadowing was observed.

**Conclusions:** US is highly sensitive in the detection of PTMO and it can be used for serial evaluation. It can provide indicative features in the differential diagnosis between PTMO and malignant soft tissue tumors.

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1. Introduction

Myositis Ossificans is a benign condition of heterotopic non – neoplastic bone or cartilage formation in / or adjacent to a muscle and in proximity to a bone [1, 2].

Four different clinical entities have been described : a) Myositis ossificans post – traumatica (PTMO); b) fibrodysplasia ossificans progressiva (FOP); c) myositis ossificans associated with paraplegia and d) myositis ossificans circumscripta [3].

Among these entities, PTMO is the most common, comprising including 60 – 75 % of all cases, and may occur after a single direct blow or repeated minor traumas, although no history of trauma is observed in approximately 40 % of patients [2, 4].

Thigh and arm are the commonest locations [5], even if some cases have been reported in the hand, neck, calf, shoulder, thorax and abdomen [6 – 10]. Pain, oedema, swelling as well as palpable mass with associated decreased range of motion are usually complained by the patients [5].

Microscopically, degeneration and necrosis of the damaged muscle are seen first; afterwards the proliferation of mesenchymal cells, mineralisation and bone formation are observed.

From a clinical and radiologic point of view, the differential diagnosis includes hematoma, abscess, focal rhabdomyolysis, and malignant primary or secondary soft tissue tumors [11].

The imaging techniques, used to confirm PTMO, are a) conventional radiography (RX), b) bone scintigraphy, c) computed tomography (CT), d) magnetic resonance (MR) and e) ultrasonography (US) [2].

Among these imaging modalities, US is the more most suitable, because easy to perform, low cost and safe for the patient.

However, the US features of PTMO are not well established : actually, there are very few case

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reports in the literature [6, 7, 12] and in most of them the diagnosis has not been confirmed by histopathology.

The aim of this paper is therefore to report the US features of PMTO in the early and mature stages, confirmed by histological examinations, in a relatively large sample of patients.

## 2. Material and methods

Fifteen patients (8 M : 7 F, mean age 31.2; SD 18,60 years, range from 12 to 65 years) referred to our Department, were retrospectively enrolled (from November 2006 to April 2009).

In all these patients, PTMO was suspected on the basis of history, symptoms, physical examination and US.

US evaluation was performed using a multi – frequency (5 – 12 MHz) linear array transducer (Acuson, Siemens Medical Solution, Germany).

Lesions were evaluated according to a standard protocol, utilizing using multiplanar scans; Power Doppler (PD) as well as tissue harmonic imaging was used.

The following parameters were evaluated:

- 1) Mass (appearance, echogenicity, margins and dimension);
- 2) Calcification (position, appearance, distal shadowing and dimension);
- 3) PD signal;
- 4) Relationship with contiguous structures (muscle, bone, vessels and nerves).

A semiquantitative grading system was used to evaluate the neovascularization inside the area of the lesion interested by PD signal. According to this system grade (0) is no Doppler

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activity; (1+), one or two tiny colour foci; (2++), up to 50 % colour ~~inside~~ in the region of interest; (3+++), 50 – 90 % colour ~~inside~~ in the region of interest; (4++++), 90 – 100 % colour ~~inside~~ in the region of interest [13].

PTMO diagnosis was then confirmed by histopathology, performed at the same time on specimens obtained by means of real – time US guided needle biopsy.

This procedure was carried out not only for diagnosis confirmation but also for clinical purposes (possible surgical planning). Prior ~~the~~ to biopsy, a written informed consent was obtained from the patient.

Biopsies were done under local anesthesia and performed in sterile conditions. The needle pathway was decided on the basis of safe access route (according to the orthopaedic surgeon), avoidance of vessels and nerves (vital structures), skin to lesion distance, and also the expected definite treatment plans to avoid any possible intercompartmental contamination or seeding [14].

Under real – time US monitoring, a 13 – 14 Gauge (150 mm) Tru – Cut needle was guided inside the lesions and a tissue sample was obtained.

In total, at least 4 – 5 specimens were collected from the central, intermediate and peripheral layers of the lesion in order to better differentiate early from mature PTMO at histopathological examination.

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### 3. Results

All the patients complained pain, local heat and swelling with decreased range of motion of the compartment affected. A palpable mass, in general ~~more hard~~ harder in mature PTMO, was found in 7 cases (46,6 %).

In 10 patients (66,6 %) the lesion occurred in the thigh (8 right and 2 left), while in 5 cases (4 right and 1 left) ~~were observed~~ it occurred in the arm.

A single direct blow was reported in 73,3 % patients while in the remaining 26,7 % of patients no history of trauma was reported.

The time elapsed between the injury and the US evaluation, although without significant statistical difference, was quite longer for mature PTMO ( $32.5 \pm 17.6$  days *vs*  $17.5 \pm 3.54$  days in early PTMO). This wide range of values is probably due to the characteristics of the trauma and the individual reactivity.

The longest and transverse mean diameters were  $5.5 \pm 1.7$  cm (range from 9.2 to 3 cm) and  $3.4 \pm 0.9$  cm (range from 5.3 to 1.6 cm) respectively (Tab. 1).

Mature PTMO was observed in 10 patients and early PTMO in 5. The hystopathological criteria for early PTMO were evidence of degeneration and necrosis of the damaged muscle, fibroblasts proliferation, whereas those for mature PTMO were presence of ground substance, mineralisation and bone like tissue (Fig. 1).

As common characteristics of both early and mature PTMO, US examination showed, in all cases, an oval shaped homogenous hypoechoic soft tissue mass when scanned along its long axis and rounded on transverse sonograms. Mass borders appeared regular and not infiltrative.

In all the patients, the mass was located in the muscle belly, which appeared thickened; muscle fibers were ~~hypoechoic but~~ not interrupted.



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The other structures adjacent to PTMO were preserved; in particular, no connections with the bone, nerves and vessels were reported.

In the early phases of PTMO, a center of less echogenicity was observed in all cases, associated with an outer sheet – like hyperechoic, not well defined, peripheral rim in three. No clear zonal demarcation or calcification was ~~not~~ present ~~in all~~ (Fig. 2).

In the mature phases, with the increasing ossification, the peripheral rim – like calcification was more reflective with a distal acoustic shadowing in all cases ~~was observed~~. However, in three patients, the superficial calcified wall ~~does~~ did not completely obscure the deep boundary and few internal calcific deposits were seen (Fig. 3).

Only in the early PTMO, vascularization was observed and was classified as 1+ (two cases), 2++ (two cases) (Fig. 4) and 3+++ (one case). In none of mature PTMO cases, PD signal was present (Tab. 2).

No complications (bleeding, nerves injuries, etc) apart from pain in the biopsy site were complained by the patients.

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### 4. Discussion

The present study, performed on fifteen cases of PTMO, confirmed by histopathological examinations, shows that some US features (homogenous hypoechoic mass, well defined and regular borders) are common both to the early and mature stages of the disease.

The early phase is characterized by a center of less echogenicity associated with an outer hyperechoic area consistent with lamellar bone, without a clear calcification. These separate zones of varying echogenicity correspond pathologically to an outer muscular layer, an inner layer of immature osteoid and mature peripheral lamellar bone, and an innermost layer of proliferating fibroblasts, necrosis, and hemorrhage.

In the mature phase, a peripheral rim – like calcification is observed and few internal calcific deposits may be seen (presence of ground substance, mature lamellar bone, with a minor immature component of osteoid on histopathological examination).

Obviously, several intermediate stages may be visualized.

Vascularization, evaluated with a semiquantitative method [13], is mainly observed in the early phase, while it progressively disappears as the lesion progresses to more mature stages.

Our results are in agreement with other authors [2, 15 – 19], ~~who, in the early phase, described three separate zones of varying echogenicity (the “zone phenomenon”)~~ both for the early phase and the mature one. In particular Okayama et al. [16] described, in a case of recurrent PTMO, the presence of an echogenic area, representing a soft tissue mass, with a center of less echogenicity inside and no evidence of calcification.

~~Also, the US features, relative to the mature phase, are similar to those reported in the literature.~~

The diagnosis of PTMO, besides clinical history and physical examination, is based on

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different imaging techniques (RX, CT, bone scintigraphy, MRI and US) [2, 20, 21].

RX is often carried out as a first examination imaging modalities when a PTMO is suspected, but the findings are not specific, ranging from initially normal to the appearance of a soft tissue mass with faint periosteal new bone formation, within 1 to 2 weeks post injury [2]. Therefore, conventional radiography does not allow a clear visualization of PTMO in its early stages.

After 3 to 4 weeks, when mineralization of the osteoid occurs, and after months, when the deposition of dense bone is observed, the diagnosis may be suspected, but unconclusively [2]. It may be used to determine the size, density, and anatomical location only of calcified lesions and it may also be helpful in differentiating PTMO from osteosarcoma, since it reveals the peripheral calcification and the absence of invasion of surrounding tissue, that are characteristic of PTMO.

Bone scintigraphy with Tc 99 phosphate cannot distinguish the location of the lesion within tissue planes or provide precise information on the size and area of demarcation [22]. Furthermore, the increased uptake is non specific and musculoskeletal tumours and infection cannot be ruled out, as they may show similar uptake on the 3 – phases bone scintigraphy, as seen in early PTMO [22, 23]. Therefore, this technique is not appropriate indicated in the diagnosis of PTMO.

CT is useful only in the diagnosis of mature PTMO as it best demonstrates the typical zonal pattern of ossification [2] and clearly locates the lesion prior to surgical excision.

The MRI appearances of PTMO are variable and depend on the maturity of the lesion [24]. It is the most sensitive technique for identifying small, early lesions, but may be not specific. An important limitation is its relative inability to detect soft – tissue calcification [2].

It must be added that the above mentioned imaging techniques are expensive, invasive and

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often require sedation, especially in children [25]. ~~Another~~ disadvantage is represented by the possible ~~occurrence~~ ~~evenience~~ of allergic ~~reaction~~ ~~response~~ to the contrast medium (in cases of bone scintigraphy and MRI). Therefore, these modalities are unsuitable for a serial visualization of developing lesions.

~~In comparison~~ Compared to the above mentioned techniques, US evaluation has several advantages.

In early stages, US is highly sensitive in the detection of calcific deposits in soft tissues (i.e. prior to ~~the~~ development of the ossification) [16] and it can be used for serial evaluation until mature calcified lesions are observed.

~~In addition~~ US ~~could~~ also provides indicative features (in terms of echotexture, vascularization, margin, involvement of surrounding tissues, etc) to distinguish between PTMO and malignant soft tissue, even if, in some cases, further imaging modalities are needed and histopathological diagnosis from specimens obtained by excision is mandatory.

Moreover, the angulation of the US transducer can show the presence of a soft tissue plane between the calcification and the adjacent bony cortex or surrounding tissues, thus providing further features of benignity.

A careful and correct diagnosis of PTMO is important to decide for surgery. Indeed, surgery is indicated when vascularisation is completely absent and there is a total reflection of the US beam from the outer zone. Moreover, US can be used to guide the surgical excision, because it marks very well its anatomical extension.

~~Finally, when~~ The surgical excision is ~~indicated due to~~ suitable when disabling pain and functional impairment are present ~~it must be considered that~~. On the other hand, only mature PTMO must be removed, because the recurrence is more likely to occur if a lesion is removed when it is metabolically active (presence of Power Doppler signal).

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Some strenght and limitations of this study must be acknowledged. Compared to other papers, in which only few patients were evaluated and histological examination was not carried out, our study evaluated a quite large sample of PTMO, confirmed by histopathology.

At this regard, it must be underlined that a firm diagnosis can be obtained only by histopathological examination of the mass after excision; however, in our cases, we think that reliable conclusions may be drawn, because several specimens were obtained from the different layers of the lesions under US control.

Other limitations are represented by the retrospective nature of this study and by the fact that other soft tissue masses have not been included in the comparison with PTMO; in addition, the patients were evaluated only once and were not followed up.

In conclusion, in our opinion, US can be considered as a useful tool in the PTMO evaluation because easy to perform, low – cost and safe for patients, especially in for children.

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**Figure 1:** PTMO histological examination in different stages (haematoxylin – eosin stain).

*Central zone :* ~~(a) In the right side of the picture,~~ 1a). Packed and damaged muscle fibers ~~can be seen~~ (20x); 1b). Fibroblast proliferation with storiform pattern, scattered clusters of chronic inflammatory cells ~~are evident~~ (10x);

*Outer zone :* ~~(c)~~ 1c). Proliferation of mesenchymal cells and presence of ground substance (20x); ~~(d)~~ 1d). Mineralisation and bone like tissue formation (20x).

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**Figure 2 :** Early PTMO.

**2a), Sonograms** of right thigh : ~~(a)~~ note the muscle ~~hypoechoic~~ thickening and swelling (transverse scan). No regular, but indistinct borders are seen.

**2b), ~~(b)~~** A rounded, hypoechoic mass between the calipers, with well defined borders, is seen (transverse scan). No calcification are observed. **M** = Muscle

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**Figure 3 :** Early PTMO of triceps brachii.

Note the ~~nebular~~ calcification (calipers) into the thickened muscular belly (longitudinal scan). Power Doppler signal is present (moderate). In all the cases, the surrounding tissue are not involved. **M** = Muscle; **H** = Humerus

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**Figure 4** : Mature PTMO. Longitudinal scan of right thigh of three different cases.

~~(a)~~ **4a**). Scattered calcifications (calipers) which, ~~however,~~ do not completely obscure the deep boundary; few internal calcific deposits are also seen.

~~(b), (c)~~ **4b**). Note the ~~peripheral rim-like~~ calcification (calipers) and its distal shadowing (\*).

~~(c) note that the underlying femoral shaft is not involved and~~ **4c**). The femoral cortex is interrupted. In these cases, the mass was located in the muscle belly, which appeared thickened. ~~Muscle fibers were hypoechoic but not interrupted.~~ **M** = Muscle; **F** = Femoral shaft