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● *Original Contribution*

SHOCK WAVES IN THE TREATMENT OF POST-TRAUMATIC MYOSITIS OSSIFICANS

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Abstract—Myositis ossificans (MO) is a fairly common evolution in sports activity and can be due to direct trauma or to repeated micro-injuries. The traditional therapeutic approach relies on a variety of treatments, such as physical therapy but evidence of their proven clinical efficacy is lacking. The latest therapeutic option is surgical removal but this is a demolitive procedure and is frequently associated with a significant loss of functional integrity. There are few articles in literature about the treatment of post-traumatic MO, and none on extracorporeal shock wave therapy (ESWT). We illustrate a case series of 24 sportsmen treated with three sessions of electro-hydraulic shockwave therapy and an associated rehabilitation program. Only a partial reduction of the ossification was observed in the X-ray images but all the patients showed signs of functional improvement immediately after therapy. Two months after the therapy, a normal range of motion and no signs of weakness were observed. Three months after treatment, 87.5% of patients resumed regular sports activities. (E-mail: angelanotarnicola@yahoo.it) **© 2010 World Federation for Ultrasound in Medicine & Biology.**

Key Words: **Myositis ossificans, Shock wave therapy, Muscle injury, Stiffness.**

INTRODUCTION

Muscle contusion injuries commonly occur in contact sports, potentially causing considerable morbidity in athletes. Contusions are the second most common cause of disability in athletes, the most common causes being muscular tears and strain. Myositis ossificans traumatica (MO) occurs after blunt trauma to muscle tissue. Although the mechanism of bone formation in the muscle is unclear, there are incidences ranging from 9% to 20% of this process in athletes who have sustained a direct blow from a body part of an opponent, most often the knee (Danchik et al. 1993). The most common site of occurrence is the anterior thigh and the process develops subsequent to the formation of an intramuscular hematoma (Miller et al. 2006). Patients experience tenderness and swelling at the site of injury and their symptoms are generally unresponsive to 1 week of rest. In the acute phase, treatment consists of immobilization of the muscle in tension, ice and elevation. Pharmacologic interventions such as indomethacin and other nonsteroidal anti-inflammatory drugs (NSAIDs) may also be employed. Surgery is usually considered in patients who suffer persistent continued pain, limited motion or a deterioration of function, after 4 to 6 months from the trauma (Spencer and Missen 1989; Giombini et al. 2003).

The aim of these clinical studies is to assess the efficacy of extracorporeal shock wave therapy (ESWT) in the treatment of MO. Shockwave treatment was initially employed for lithotripsy of kidney stones but has since been extended to the treatment of calcified tendons and pseudoarthrosis. The rationale for adoption of this treatment is the cavitation effect that has a mechanical action inducing bleeding as well as a biologic action stimulating tissue repair (Tu et al. 2007).

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MATHERIALS AND METHODS

This prospective clinical study was approved by the Local Ethics Committee and observed the Declaration of Helsinki ethical principles for medical research involving human subjects.

Twenty-four patients (all male, mean age 25.54 years, range 18–58 years), with post-traumatic MO, diagnosed on the basis of the clinical history, physical examination, X-rays and MRI, were treated. All patients freely signed an informed consent statement to take part in the study. They were treated with ESWT and physiotherapy. A control group was absent.

The inclusion criteria were:

- a diagnosis of MO, with ossification of more than 1 cm in length, as evaluated by X-ray;
- age between 18 and 60 years;
- elite or sub-elite athletes;
- painful symptoms and functional limitation lasting 1.5 months or more;
- no heart pacemaker use;
- absence of systemic inflammatory or neoplastic disease;
- no use of anticoagulants.

Before the injury all actively participated in various sports: soccer ($n = 12$), skiing ($n = 3$), motorcycling ($n = 2$), cycling ($n = 1$), mountain-bike ($n = 1$), basketball ($n = 1$), swimming ($n = 1$), athletics ($n = 1$), karate ($n = 1$) and skating ($n = 1$). MO were reported in specific muscles of the lower extremities (quadriceps, $n = 10$; vastus medialis, quadriceps and rectus femoris muscles, $n = 3$; quadriceps and rectus femoris muscles, $n = 1$; biceps femoris, $n = 1$; adductors, $n = 2$; quadricepts femoris, vastus lateralis and rectus femoris, $n = 3$; vastus lateralis, $n = 1$; sural triceps, $n = 1$; adductors and biceps femoralis, $n = 1$), or upper extremity (biceps brachialis, $n = 1$). MO had been caused by sports trauma: muscle contusion (in 12 patients), bone fractures (in 4 patients), torn muscles (in 2 patients), wounds (in 2 patients) and soft tissue cutting (in 4 patients) (Table 1).

The trauma was associated with a large haematoma. In the following weeks, pain and difficulties in mobilizing the limb still persisted and the stiffness started to stabilize, resulting in a progressive range of motion (ROM) reduction. A few weeks after the trauma, radiographic analysis and MRI were performed and the diagnosis of MO was made.

In the immediate post-traumatic phase, the patients were treated with rest, local application of ice and the administration of aspirin or indomethacin. At the same time, the subjects underwent local ultrasound therapy and physiotherapy every day, usually exercises of passive manual mobilization and stretching but no particular improvements were observed. In the following weeks, a marked muscle tenderness associated with reduced ROM persisted. Subsequently, the subjects underwent further daily physiotherapy with manual and mechanical passive mobilization. Continuous passive motion (CPM) was associated with stretching exercises but yielded no appreciable results.

The surgical treatment option was excluded because of the mass involvement and diffusion inside the muscle: in fact, surgical removal would have significantly jeopardized the muscle function of these young athletes.

In view of the poor results of physiotherapy and the limits to surgical intervention, we administered shock wave treatment after an average of 4 ± 2.09 months (range 1.5–14 months) from the trauma.

The ESWT was generated by two electro-hydraulic systems, Evotron or Ossatron (Milano, Italy) OSA 140 by HMT srl, in according with the guidelines of the International Society of Medical Shock Waves Therapy (ISMST) (Thiele 2009). The skin region was put in direct contact with the shock waves generation tube, after applying ultrasound gel. Using an X-ray image in scale 1:1, we outlined the area of ossification on the skin region and administered 100 impulses per cm^2 of ossification, every 2 weeks for three sessions. The shock waves (SW) were performed without anaesthesia. We chose to apply medium power so the pain was well tolerated (range from 0.13 to 0.23 mJ/mm2, mean 0.15 ± 0.02 mJ/mm2), on the basis of the energy flux density (EFD) used in the treatment of calcified tendons (Moretti et al. 2005).

After the first session, the patients started a rehabilitation program consisting of one daily session 6 days a week. The rehabilitation program included passive and active mobilization performed by a therapist, passive mobilization with CPM using a mechanical device (kinetic), bending being increased from 0° to a value set on the basis of the pain threshold. In addition, stretching and proprioceptive exercises were proposed for a total duration of about 80 min with a physiotherapy program quite similar to the one performed in the first months following the trauma. From the third week of treatment, isometric exercises for muscular reinforcement were introduced in the program; then, starting from the fifth week, exercises for muscular reinforcement with isotonic devices in closed and open kinetic chain were performed, too. From the seventh week onwards, the physiotherapy frequency was reduced to three sessions a week, while eccentric exercise, at first with natural load and then with overload, was introduced. From the third month onwards, technical training on the pitch, even with ball exercises, was resumed (Miller et al. 2006).

Evaluations were made before treatment and 1, 2, 3, 6 and 12 months after treatment. These evaluations were always performed by the same examiner and consisted of:

Table 1. This table shows the anamnesis, the side and the type of injury of the 24 cases affected by MO

Patient (male)	Age (years)	Months after the trauma	Trauma	Sport	Side of trauma	Muscle	Articulation
1	16	1,5	Contusion	Soccer	Right thigh	Quadriceps femoris	Knee
2	49	2	Contusion	Cycling	Right thigh	Quadriceps femoris	Knee
3	15	3	Contusion	Basket	Left thigh	Quadriceps femoris	Knee
4	27	14	Contusion	Soccer	Right thigh	Quadriceps femoris	Knee
5	18	9	Bone fracture	Soccer	Left thigh	Vastus lateralis	Knee
6	26	2	Contusion	Soccer	Right thigh	Quadriceps femoris	Knee
7	58	4	Wound	Motorcycle	Left thigh	Quadriceps femoris	Knee
8	21	5	Wound	Athletic	Left thigh	Biceps femoris	Hip
9	17	4	Bone fracture	Soccer	Left thigh	Quadriceps femoris, vastus lateralis and rectus femoris	Knee
10	25	1,5	Cutting	Ski	Right thigh	Adductors	Hip
11	22	3	Contusion	Karate	Right thigh	Quadriceps femoris and rectus femoris	Knee
12	23	3	Contusion	Soccer	Left thigh	Quadriceps femoris, vastus medialis and rectus femoris	Knee
13	27	2	Contusion	Ski	Left thigh	Quadriceps femoris, vastus medialis and rectus femoris	Knee
14	17	8	Bone fracture	Soccer	Left thigh	Quadriceps femoris, vastus medialis and rectus femoris	Knee
15	35	4	Tear	Swimming	Right thigh	Adductors	Knee
16	28	2	Cutting	Skating	Left thigh	Sural triceps	Ankle
17	27	3	Contusion	Motorcycle	Right thigh	Quadriceps femoris, vastus lateralis and rectus femoris	Hip
18	31	2	Cutting	Mountain bike	Right thigh	Adductors and biceps femoris	Hip
19	35	4	Tear	Ski	Left arm	Biceps brachialis	Elbow
20	29	3	Bone fracture	Soccer	Left thigh	Quadriceps femoris, vastus lateralis and rectus femoris	Knee
21	22	5	Contusion	Soccer	Right thigh	Quadriceps femoris	Knee
22	18	3	Contusion	Soccer	Right thigh	Quadriceps femoris	Knee
23	26	2	Contusion	Soccer	Right thigh	Quadriceps femoris	Knee
24	25	7	Cutting	Soccer	Left thigh	Quadriceps femoris	Knee
Mean	26.54	4.04	–	–	–	–	–
DS	10.1	2.9	–	–	–	–	–

MO = myositis ossificans.

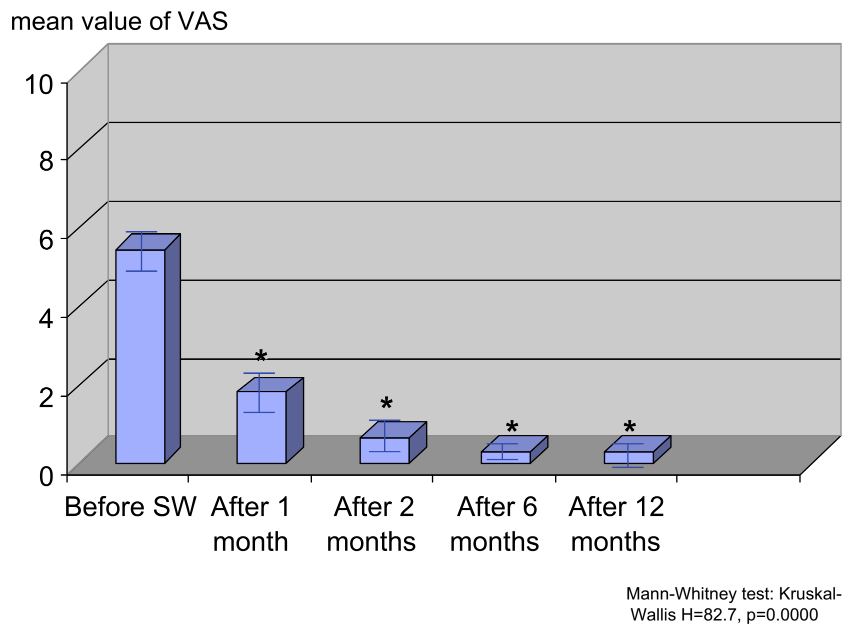

Fig. 1. Values of visual analog scale (VAS)(0-10) before shock waves (SW) and during the follow-up of the study. At 1, 2, 3, 6 and 12 months after the SW the decrease of VAS is significant statistically (ANOVA F = 118.3; p = 0.000).

- the visual analog scale (VAS) of pain on which patients assigned a number between 0 (absence of pain) to 10 (most severe);
- Fischer's algometer to quantify painful pressure on the muscle area affected by MO and expressed as Kg/cm^2 (Fisher 1987);
- assessment of the range of motion (ROM) articulation deficit of the functional insertion of the injured muscle;
- X-rays of the ossification;
- the weeks taken to return to the sport-specific training, to the sport-specific activity and to competitive activity.

Collected data were loaded into a database and analysed with the statistical software Epi-Info 3.3 (public domain software-CDC Atlanta, GA, USA; WHO Ginevra, Swaziland). The nonparametric Mann-Whitney test was applied to compare the subsequent variables (VAS,

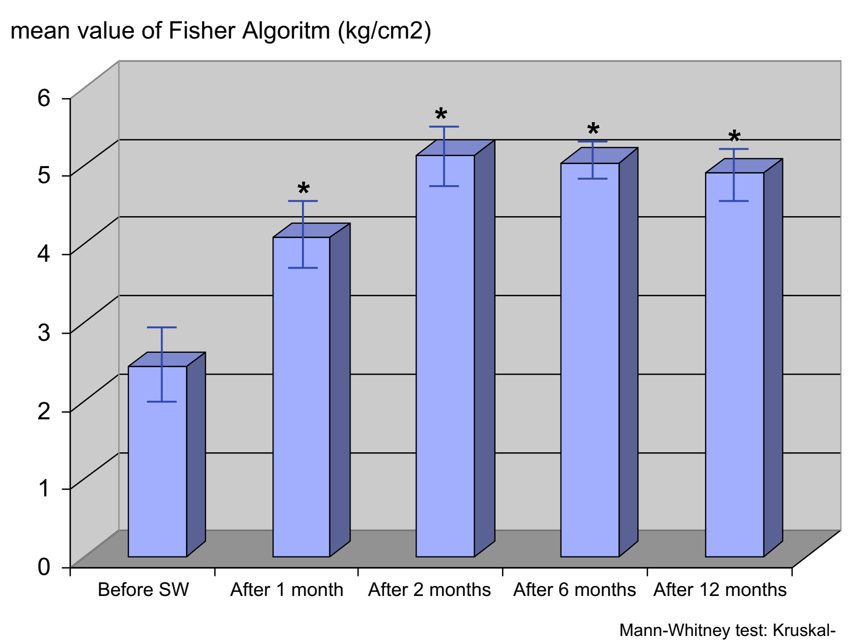

Fig. 2. Values of Fisher algorithm (Kg/cm2) before SW and during the follow-up of the study. At 1, 2, 3, 6 and 12 months after the shock waves (SW), the decrease of Fisher algorithm is statistically significant (ANOVA F = 78.9; p = 0.000).

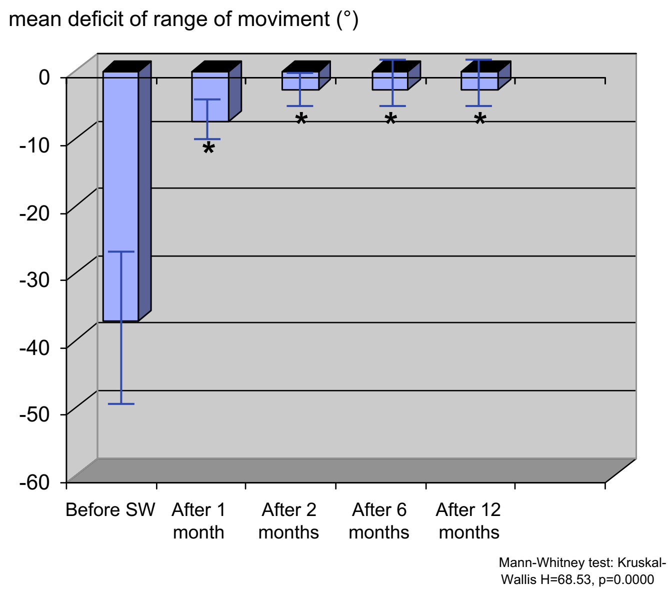

Fig. 3. Values of range of motion (ROM) (degrees of motion) before shock waves (SW) and during the follow-up of the study. At 1, 2, 3, 6 and 12 months after the SW the improvement of ROM is significant statistically (ANOVA F = 38.58; $p = 0.000$).

Fischer's algometer and ROM);besides, the Student's *t*-test was used to compare the dimension of ossification area on radiography (RX) images. All data were expressed as mean ± SD and median. A *p* value less than 0.05 was regarded as significant.

RESULTS

All 24 patients completed the study protocol. We administered a cumulative average of 3833 ± 1362 impulses in everyone during three sessions to each patient. The EFD ranged from 0.13 to 0.23 mJ/mm2 (mean 0.15 ± 0.02 mJ/mm2) and we applied a frequency of 4.0 Hz. We registered a significant progressive decrease in the intensity of pain measured using the VAS scale and Fischer's algometer and an improvement of the ROM in all the patients (Figs. 1, 2 and 3). We obtained a complete clinical and functional resolution in 21 of the 24 patients, with a return to sport-specific training after 7.17 ± 3.05 weeks, to sport-specific activity after 11.32 ± 4.06 weeks and to competitive activity after 13.05 ± 4.17 weeks. Except for three patients, all had made a complete return to the previous sport activity within the 12 months of the follow-up (Table 2). However, the X-ray images showed only a partial reduction of the ossification area in all the patients. Before the SW, the ossification area was 38.33 ± 13.63 cm^2 (median 40 cm^2) (range 15–80 cm^2), vs. 35.54 cm^2 ± 12.09 (range 15–70 cm^2) at 12 months (*t*-test, T-statistic = 0.75, $p = 0.05$) (Figs. 4, 5, 6, 7, 8 and 9).

Before the ESWT, the ROM deficit was -37.1° ± 22.5° (median –30°), the VAS was 5.4 ± 1.2 (median 5) and the Fischer algometer score was 2.6 ± 1 Kg/cm^2 (median 2.5 Kg/cm^2).

After the end of SW therapy, the ROM (Mann-Whitney test: Kruskal-Wallis H = 68.53, $p = 0.0000$), the

Table 2. The table presents the time for the return to sport activity after the SW treatment in each of the 24 patients

	Return to sport (weeks)		
Patient	Return to sport-specific training	Return to sport-specific activity	Complete return to previous agonistic activity
1	12	No return	No return
2	6	10	12
3	6	10	12
4	6	14	16
5	10	10	12
6	6	10	12
8	7	11	14
9	12	14	16
10	4	16	18
11	6	8	19
12	6	10	12
13	6	10	12
14	No return	10	12
15	6	No return	No return
16	6	10	12
17	6	8	10
18	4	8	10
19	4	8	10
20	16	8	10
21	6	24	28
22	6	10	12
23	6	10	12
24	12	20	No return
Mean*	7.17	11.32	13.5
SD*	3.05	4.06	4.17

SW = shock wave.
*excluding the patients who had not improved.

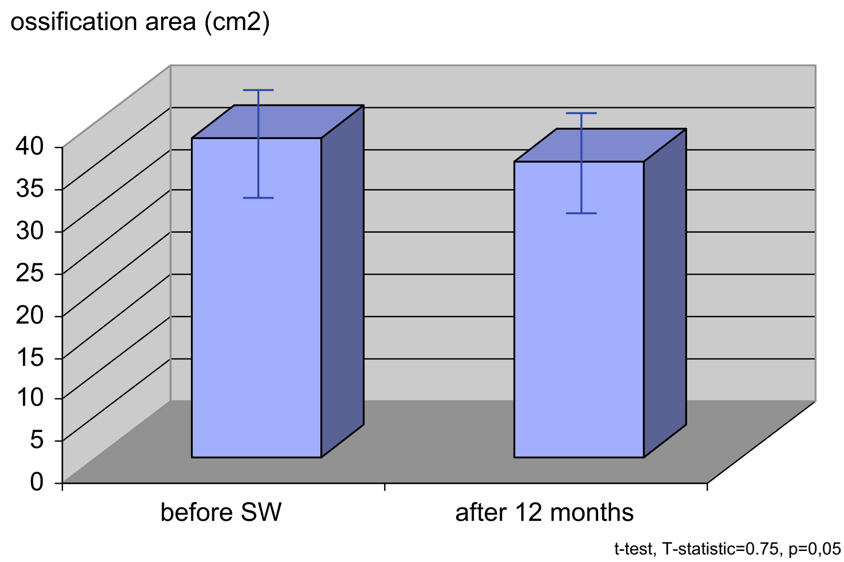

Fig. 4. Values of area of ossification before shock waves (SW) and during the follow-up of the study. At 1, 2, 3, 6 and 12 months after the SW the decrease of the ossification is not statistically significant.

VAS (Mann-Whitney test: Kruskal-Wallis $H = 82.7$, $p = 0.0000$) and the Fischer algometer score (Mann-Whitney test: Kruskal-Wallis $H = 823.88$, $p = 0.0000$) showed statistical significant improvements. In fact, at the first month the ROM deficit decreased to $-6.7° \pm 8.5°$ (median $-5°$), the VAS decreased to 1.6 ± 1.2 (median 1) and the Fischer algometer score improved to 4.4 ± 0.9 Kg/cm^2 (median 4 Kg/cm^2).

Two months after ESWT the improvement had continued: the ROM deficit was $-2.5° \pm 6.6°$ (median 0°), the VAS was 0.6 ± 0.9 (median 0°) and the Fischer algometer score 5.5 ± 0.8 Kg/cm^2 (median 6 Kg/cm^2).

Six months after ESWT the ROM deficit was $-2.75° \pm 7.2°$ (median 0°), the VAS was 0.2 ± 0.6 (median 0°) and the Fischer algometer score was 5.8 ± 0.5 (median 6 Kg/cm^2).

Finally, 12 months after ESWT the ROM deficit was $-2.75° \pm 7.2°$ (median 0°), the VAS was 0.23 ± 0.7 (median 0) and the Fischer algometer score was 5.9 ± 0.4 (median 6 Kg/cm^2).

DISCUSSION

Myositis ossificans traumatica is defined as a non-neoplastic proliferation of cartilage and bone in an area of muscle that has been exposed to trauma. The pathogenesis of MO formation is largely unknown. It has been hypothesized that rapidly proliferating mesenchymal cells ultimately differentiate into bone-forming cells and osteoblasts in the presence of localized tissue anoxia, producing ectopic bone and cartilage. In addition, muscle damage leads to prostaglandin synthesis, which attracts inflammatory cells to the site of injury, fostering the formation of heterotopic bone (Aro et al. 1991). Ackerman described (1958) three zones in the lesion:

- central zone: extremely varied cells and atypical mitotic figures;
- middle zone: orientated osteoid tissue;
- outer zone: well-formed bone.

The symptoms include persistent pain in the traumatized zone and increased by flexion, local tenderness and stiffness, in association with a ROM reduction, affecting the corresponding joint. This functional reduction significantly impedes sports activity, especially in high level athletes (Booth and Westers 1989). Evidence of post-traumatic stiffness appears at a very early stage, after a few weeks, with abnormal bone formation in the soft tissue (Sodl et al. 2008). The initial damage is followed by soft tissue swelling, which grows within 1 to 2 months into a solid, painful mass. The MO radiographic frame shows floccular calcified density in the soft tissues 2 to 6 weeks from the disease onset; within 6 to 8 weeks the calcification becomes sharply circumscribed and ossifications tend to adhere to the periosteum (Wang et al. 1999). Magnetic resonance imaging (MRI) can be used in the acute stage to define the localization of the muscular lesion; however, interpretation of the tissue frame evolution in the subsequent phase proves more difficult (Shirkhoda et al. 1995).

Rehabilitation of patients with MO should include restoration of flexibility, strength and proprioception. The traditional therapeutic approach relies on a variety of treatments such as physical therapies, ranging from therapeutic ultrasound to local hyperthermia (Giombini et al. 2007) or roentgen therapy (Ciambellotti and Ripamonti 1984), medication, ranging from systemic NSAIDs

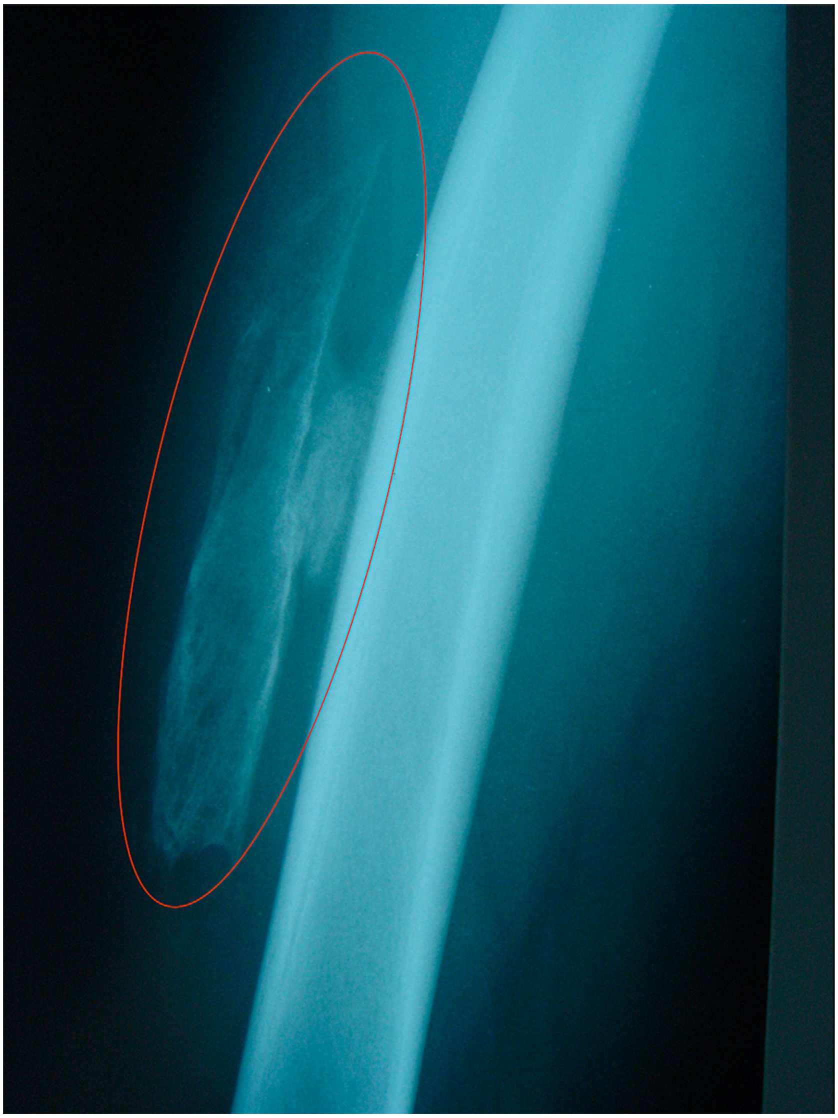

Fig. 5. Patient 1: before shock waves (SW), the radiograph of the femur reveals a bone formation anteriorly.

to local iontophoresis, as well as local injection of different drugs (mesotherapy) (Wieder 1992; Jarvinen et al. 2005, 2007). According to a review by Haran for the Cochrane Systematic Review, there is insufficient evidence to recommend the use of disodium etidronate or other pharmacologic treatments for MO (Haran et al. 2004). A technique of manual rupture, diacutaneous fibrolysis, of the muscular calcifications has also been proposed by Colombo and Ekman (1978). The latest therapeutic option is surgical removal of the anatomical part affected by MO (Benetos et al. 2006). The decision to operate is often due to a serious functional deterioration reducing the sports performance, related to a considerable ROM limitation and to the presence of severe pain. The subsequent return to sports activities will depend on the athlete demonstrating nearly full limb strength and coordination.

Shock waves are defined as a sequence of single sonic pulses characterized by high peak pressure (100 MPa), a fast pressure rise ($<$10 ns) and short duration (10 μs). Since 1996, scientific research has started to focus on the use of extracorporeal shock wave therapy (ESWT) in the treatment of muscle-tendon pathologies (Rompe et al. 1996). In 2000 and then in 2001, the Food and Drug Administration granted approval for the use of this method in the treatment of heel spur (Wang et al. 2006) and calcific shoulder tendonitis (Sems et al. 2006). Many authors have reported that the effect of stimulation with ESWT leads, at the tissue level, to the development of mending phenomena in association with neovascular angiogenesis, which is associated to an increase of RNA-synthetase and to a rebalancing of intracellular homeostasis, coupled with an increase of nitric oxide (Wang et al. 2003; Thiel 2001).

Fig. 6. Patient 1: before shock waves (SW), the magnetic resonance (MR) scan shows the myositis ossificans in the quadriceps muscle.

We performed an extensive literature review, including an Internet search with Google.com and MEDLINE searches from 1970 to 2009. We used the terms: ossification and myositis ossificans. Articles in English, German, French and Italian were selected. There were 4277 articles of a general kind referring to the different ossification types and to the different therapies proposed and 301 articles related to MO; only 46 of these specifically refer to MO in sports. Finally, we found no articles related to ESWT applied to MO.

On the strength of our positive experience of the application of ESWT to treat calcified tendonitis, we were encouraged to use this therapy in the treatment of MO. Further support to this therapeutic hypothesis was offered by the good results described by some authors in the use of ESWT for heterotopic ossification treatment (Vannini et al. 2000). We were principally supported by the rationale that SW are able to break up calcifications in tendon disease (Jakobeit et al. 2002). Therefore, we expected to obtain similar results in the administration for MO, whereas in fact we observed only a partial reduction of the ossification area. However, we elicited a substantial improvement of the pain and of the functional ROM in the treated segment. This discovery led us to consider why SW could disaggregate the calcification in tendinopathy but not the ossification in MO. Codman suggested that the calcified tendon is the result of a sequence of degeneration, necrosis and calcification (Uhthoff 1975). Following investigators described calcifying tendinopathy as calcium deposits in necrotic collagen tissue (Tashjian et al. 2009). Therefore, the application of shockwave therapy in calcified tendon induces an increased pressure within the

Fig. 7. Patient 1: 3 months after shockwaves (SW), the radiography (RX) shows the minimal reduction of the ossification area.

therapeutic focus, causing fragmentation and cavitation inside the amorphic calcifications, leading to disorganisation and disintegration of these deposits (Loew et al. 1999). This effect does not occur when there is lamellar bone organized in osteons in the target zone because there is too little space to generate cavitation (Russo et al. 2000). Indeed, SW do not induce fractures in cortical bone (Pauwels et al. 2004). Therefore, we hypothesized that this might be the reason why SW could not produce a complete disaggregation of ossifications in muscle tissue.

Nevertheless, during our study we appreciated the clinical recovery of the patients. This could be explained

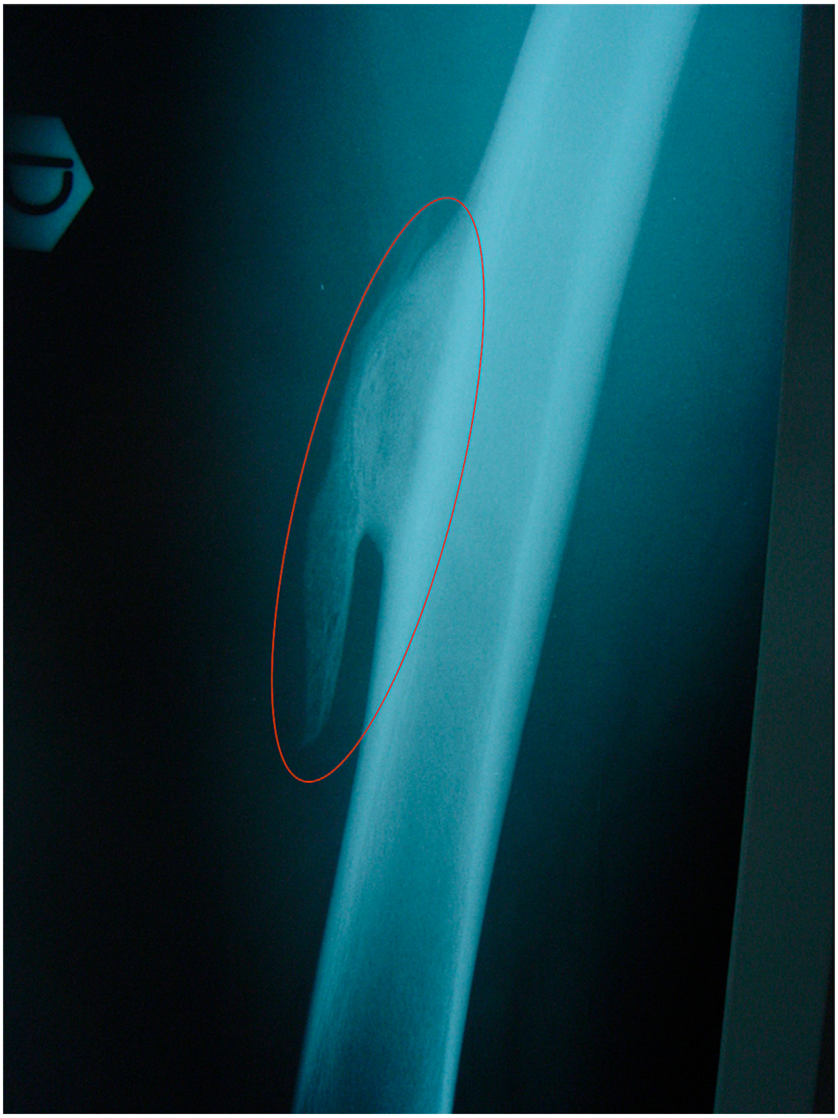

Fig. 8. Patient 1: at RX image the ossification has partially disintegrated 12 months after extracorporeal shock wave therapy (ESWT).

on the basis of some previous studies that have investigated the effects of SW on muscle. They argued that SW induce softening of the myogelosis and a significant alleviation of pain in hypertonic diseases (Kirkali et al. 1995; Kraus et al. 1999; Manganotti and Amelio 2005); a direct effect of shock waves on muscles is considered in accordance with the documented therapeutic effects seen on tendon and bone: neo-angiogenesis that induces a washing-out of catabolic products, the synthesised NO that produces anti-inflammatory effects and the release of growth factors that activates cellular repair processes (Wang et al. 2008). Moreover, it has been demonstrated that muscle spasm is reduced in the muscle tissue and the contractile capacity is increased thanks to metabolic modulations at the mitochondrial level. These modulations are useful in MO, where the weakness and swelling are caused by the considerable oedema and the catabolic loss of muscle protein locally and around the injury site (Ackerman 1958).

Similar results are shown in the application of SW in the treatment of avascular necrosis of the bone (AVN). Some clinical studies have investigated the effects principally on AVN of the hip and they found a significant improvement in pain and in functionality without substantial changes of lesion on radiograph and MRI (Wang et al. 2005, 2008). Therefore, these articles suggest that extracorporeal shock wave treatment may reorganize pathologic memory traces, thus, giving cause to real and permanent pain relief (Wess 2008).

In our experience, already after 1 month from the end of the ESWT, patients had less pain and a statistically significant functional recovery. These results persisted

Fig. 9. Patient 1: the magnetic resonance (MR) scan shows the reduction of MO 12 months after extracorporeal shock wave therapy (ESWT).

and further improved over the 1-year follow-up term. After an average of 13 weeks, 87.5% of the patients were able to resume competitive sports activities. We observed, as other authors had previously reported using other physiotherapy schedules, that ESWT does not induce a significant reduction of the ossification (Bernard et al. 2002; Parikh et al. 2002). Nevertheless, our clinical findings support the application of ESWT in MO, demonstrating that even in absence of the total disgregation of the ossification, the treatment improved the trophism of the damaged muscle tissue.

The results of the current clinical experience reveal that at first the administration of physiotherapy alone has been unsuccessful and only when the shock waves were associated, the management of MO became efficacy: the injury tissue benefited from the SW for the biologic stimulus and from the physiotherapy for the physical one.

However, our experience is a preliminary case study. As mentioned before, it has the limitation of the absence of a control group. At present, we propose to continue this study with the adoption of a randomization into two groups to compare the effects of the cooperation of ESWT and physiotherapy vs. only physiotherapy. It seems to be necessary for classification of ESWT as evidence-based medicine. The administration of few sessions of middle energy SW promises to improve the results of existing standards management of MO. Besides, it should be interesting to value the efficacy of ESWT in the earlier stage of MO, when the fully ossified is not jet made up.

In conclusion, the current literature indicates that shock waves offer an interesting therapeutic opportunity for restoring the physiologic conditions of muscle-tendon extensibility. MO is not an uncommon sequela of sports injuries. It is most likely to occur after contusions or strains and is often of major clinical consequence if not treated appropriately. In the treatment of MO, we suggest associating ESWT to traditional rehabilitation methods. ESWT is noninvasive, inexpensive and without side-effects and could be a viable alternative to surgery. Further experimental studies are needed to verify the effects of SW treatment on the tissues in this disease.

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