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Intravenous bisphosphonates and vitamin D in the treatment of bone marrow oedema in professional athletes

Maciej J.K. Simon [a,1], Florian Barvencik [a,1], Moritz Luttke [b], Michael Amling [a], Hans-Wilhelm Mueller-Wohlfahrt [c], Peter Ueblacker [a,c,*]

[a] Department of Osteology and Biomechanics, University Medical Center Hamburg-Eppendorf, Martinistr. 52, 20246 Hamburg, Germany
[b] Private Practice for Radiology and Nuclear Medicine, Burgstrasse 7, 80331 Munich, Germany
[c] MW Center for Orthopedics and Sports Medicine, Munich and Football Club FC Bayern Munich, Dienerstrasse 12, 80331 Munich, Germany

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ABSTRACT

Introduction: The goal of this retrospective study was to evaluate the safety and efficacy of ibandronate for bone marrow oedema (BMO) syndrome and stress fracture cases, and to demonstrate an additional field of therapeutic importance—the high-performance athlete.
Patients and methods: This retrospective study included twenty-five high-performance athletes. Sixty per cent of the athletes were European soccer players and 40.0% other high-class international athletes (3 women and 22 men with an average age of 25.0 ± 4.2), with BMO of the lower trunk or extremity diagnosed by magnetic resonance imaging (MRI). The treatment regimen consisted of high-dose vitamin D supplementation and intravenous ibandronate therapy.
Results: The time between the onset of pain and proper diagnosis of BMO was 106.3 ± 104.1 days. Excellent pain reduction (pain at rest and under strain) and improved mobility was reported within the first two weeks after the first ibandronate administration by sixteen patients (64%). The time from first treatment until return to competition (RTC) was on average 102.6 ± 65.2 days in total. If the time from onset of pain until diagnosis was within 40 days, the RTC was significantly reduced ($p \leq 0.05$) to almost 50% (63.8 ± 48.1 days) when compared to the athletes with later diagnosis (124.4 ± 63.2 days).
Conclusions: The here-applied therapy regimen of intravenous BPs application and vitamin D supplementation in BMO syndrome has a beneficial effect for high-performance athletes. An early diagnosis and rapid treatment start can reduce the RTC significantly. An optimal bone metabolism with sufficient daily calcium and vitamin D intake is crucial and should not only be strived for the professional but also for the recreational athlete.

Introduction

Bone marrow oedema (BMO) is defined as an increase of interstitial fluid in an affected bone.[1] Among athletes and military recruits, BMO and stress fractures are a very common problem and diagnosis.[2–4] It can cause pain and disable the person to move and particularly in athletes to participate in sports practices or competitions.[5,6] It can be diagnosed on MR-images in patients with joint and bone pain. Predominantly, the lower extremity joints are affected and its occurrence is often in young and middle-aged patients.[5,7–11] The initially taken radiograph appears normal or rather non-diagnostic in the early phase, but is essential to exclude fractures, osteoarthritis or other degenerative changes. The earliest changes can be detected with MR-images, but this diagnostic step is often postponed, due to unspecific symptoms, which are compromising the quality of life, and furthermore because the BMO syndrome is not commonly known. But with advanced imaging technology and greater magnetic resonance imaging (MRI)-widespread an early diagnosis is achievable. Though with BMO syndrome being often a transient and self-limiting disorder an early diagnosis is important, in particular for high-performance athletes. However, development of an osteo-necrosis on a basis of a BMO is possible, but there is not yet a good consensus on this topic.[12,13] Though histological analyses of 80 cases demonstrated a correlation between these two disorders.[14] The treatment options range from conservative regimens with

* Corresponding author at: Department of Osteology and Biomechanics, University Medical Center Hamburg-Eppendorf, Lottestr. 59, 22529 Hamburg, Germany. Tel.: +49 40 7410 56083; fax: +49 40 7410 58010.
E-mail addresses: ma.simon@uke.de (Maciej J.K. Simon), fbarvencik@uke.de (F. Barvencik), g.luttke@radiologie-muenchen.de (M. Luttke), amling@uke.de (M. Amling), info@mw-oc.de (H.-W. Mueller-Wohlfahrt), peter.ueblacker@gmx.net (P. Ueblacker).
[1] M.J.K.S. and F.B. contributed equally to this article and therefore share first authorship.

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weight-bearing, analgesic medication, pharmacologic therapy, physiotherapy to surgical interventions.[5,7–10,12,15,16] However, looking at the current patient collective of high-performance athletes a quick return to full exercise and competition fitness, and halt of the progression to osteonecrosis is wanted.

BMO can occur at different sites, mostly in the hip and lower extremity, and has been described under several synonyms, e.g. transient (bone) marrow oedema, transient osteoporosis or avascular osteonecrosis.[5,10,17,18] According to Meizer et al., the knee was most BMO affected region (48.1%) followed by the talus (18.3%), femur (17.3%) and other locations (16.3%), respectively.[5] BMO is an unspecific finding in the MRI, which can eventually progress to osteonecrosis as seen in 50% of symptomatic hip cases where a focal necrosis was identified and surrounded by BMO.[13] The complex aetiology of osteonecrosis (ON) is at present unclear.[19] The deterioration stages of the affected bone and cartilage are defined by radiographs and/or MR-images.[11]

BMO syndrome shows an increased bone turnover as previously described.[15] This is often due to the fact that BMO are additionally accompanied by stress fractures.[17] Stress fractures are very common in athletes and military recruits, 2.9% in Finnish military recruits and 5.9% in female Navy recruits within the first 8 weeks of service.[20–23] This is often due to intensive exercises, abrupt increase in intensity, and too little and too short regeneration times.[24] Additionally, other studies have shown with therapeutic regimens and images that BMO syndrome and stress fractures differ from avascular osteonecrosis.[5,7,9,14] This is important for treatment strategies, often surgical with e.g. core decompression in avascular ON or a conservative management for BMO and stress fracture cases. Therefore, antiresorptive drugs like bisphosphonates (BPs) are useful pharmacological agents in increased bone turnover as detected in BMO and stress fracture cases.[6,18,25]

BPs have shown since many decades a positive effect on bone metabolism. They inhibit osteoclasts and herewith reduce bone resorption.[26,27] BPs have been effectively used to treat local bone metabolism disorders as seen in ON or localised transient osteoporosis,[11,15,28] furthermore their positive influence in treatment of BMO and stress fractures has been demonstrated.[6,10,11,18,29] This was recently demonstrated by Bartl et al. where 93% of patients receiving ibandronate had returned after 3 months to normal daily activities compared to only 20% of the control group, the rest was still on strong pain medication and using walking aids.[11]

Here, a special group of high-performance athletes showing symptomatic clinical patterns and radiographical signs of BMO and their non-operative treatment regimens and outcomes is presented. All of the athletes were refrained from sports performance due to the symptomatic BMO. The goal of this retrospective study was to evaluate the safety and efficacy of ibandronate for BMO syndrome and stress fracture cases, and to demonstrate an additional field of therapeutic importance—the high-performance athlete.

Patients and methods

This retrospective study was conducted from January 2010 until December 2012. Twenty-five high-performance athletes (3 women and 22 men with an average age of 25.0 ± 4.2) with BMO of the lower trunk or extremity diagnosed by magnetic resonance imaging (MRI) were included in this study. After taking a detailed medical history, specifically excluding any trauma (only atraumatic cases were included), and physical examination, all patients without radiographic images were sent to the radiologic department and had a high-resolution MRI scan (limited field of view, 1.5 or 3.0 T, use of surface coils) of the region of interest (ROI). Informed consent including off-label use of intravenous bisphosphonate was obtained from all patients and the 3 premenopausal women were required to use contraception, since the potential risks for humans during pregnancy are unknown. Additionally, all patients were subjected to laboratory analysis of bone metabolism. None of the patients had any recent traumas, operations or any history of ON in the ROI. The patients complained about pain in the ROI due to which they were limited in or prevented from their sports and could not continue to exercise.

Treatment regimen

All patients underwent a standardised treatment plan that similarly was previously described.[10] All vitamin D deficiencies were corrected with a high-dose vitamin D oral therapy (20.000 IU Dekristol; mibe GmbH Arzneimittel, Brehna, Germany) (treatment goal: >30 μg/l). Patients with a balanced vitamin D serum level received the first intravenous administration of 3 mg ibandronate (Bonviva® 3 mg i.v., Roche Pharma Schweiz AG, Basel, Switzerland) after excluding contraindications like hypocalcaemia, severe chronic kidney disease, pregnancy and any previous osteonecrosis of the jaw. In addition to the weekly vitamin D supplementation, calcicare D3 (calcium 600 mg, 400 IU vitamin D; Orion Pharma GmbH, Hamburg, Germany) was given daily to the patients for the first six weeks to minimise the risk of hypocalcaemia. Dental status, no current on-going invasive dental procedures and history of tumours before initializing BP therapy were questioned to assess the risk of osteonecrosis of the jaw (ONJ). Additionally, pain-controlled partial weight bearing (if possible) was immediately advised to the athletes for a minimum of four weeks with possible individual adaption according to the healing process, in order to minimise stress of the affected site. Anticoagulation was prescribed until full weight bearing. After the initial phase, the athletes were instructed to start an individual training program. Following primary radiographic imaging for diagnostic purposes, a follow-up MRI examination was particularly performed in cases of suspected aggravation or a delayed healing process.

If after the first BP application no clinical improvement was detected and follow-up MRI scans showed no BMO reduction, a second or third administration of 3 mg of ibandronate was administered after 4–6 weeks to the preceding one. With positive progression in individual training, athletes were gradually reintegrated into the regular training program. The athletes informed our institution regarding return dates to full practice and competition level.

Statistical analysis

Statistical analysis was performed using the unpaired Student's *t*-test. Levels of significance were defined as significant when $p \leq 0.05$.

Results

BMO was diagnosed in all cases and in five cases (20%) a stress fracture was additionally identified in the ROI by MRI scans. Of the 25 athletes, sixty per cent were European first and a handful second and third league soccer players, and 40% other high-class international athletes contending at international competitions (Table 1). The five track and field athletes compete at International Athletics Championships and Games. Both skiers participate in International Ski Federation (FIS) Alpine Ski World Championships. Basketball players are competing at National First League level. The treated tennis player plays at top level on the World Tennis Association (WTA) Tour. The average body mass index (BMI) was 22.7 ± 2.0 kg/m^2.

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Table 1
General information of athletes and treatments.

Sport discipline	Level	Sex	Age group	Location of BMO	Onset of pain until diagnosis (days)	Therapy	RTC (days)
Soccer	2	m	20–29	Lumbar spine	77	1 × 3 mg	55
Track and field, high jump	1	m	20–29	Lumbar spine	96	1 × 3 mg	84
Soccer	1	m	20–29	Lumbar spine + sacrum	213	1 × 3 mg	51
Tennis	1	f	20–29	sacrum	168	2 × 3 mg	98
Soccer	1	m	20–29	Pubic symphysis R + L	21	2 × 3 mg	89
Soccer	1	m	20–29	Pubic symphysis, R + L	7	2 × 3 mg	89
Soccer	1	m	20–29	Pubic symphysis, L	11	1 × 3 mg	55
Soccer	2	m	20–29	Pubic symphysis, R	71	1 × 3 mg	54
Soccer	2	m	20–29	Pubic symphysis, R	73	3 × 3 mg	141
Track and field, long distance	1	f	30–39	Pubic symphysis, R	88	1 × 3 mg	193
Soccer	2	m	20–29	Pubic symphysis, R	108	2 × 3 mg	193
Soccer	2	m	20–29	Pubic symphysis, R	176	2 × 3 mg	162
Track and field, decathlon	1	m	20–29	Pubic symphysis, R	344	3 × 3 mg	188
Soccer	1	m	20–29	Knee, L	9	1 × 3 mg	31
Basketball	1	m	30–39	Knee, L	31	1 × 3 mg	18
Ski, alpine	1	m	20–29	Knee, R	8	1 × 3 mg	9
Ski, alpine	1	m	30–39	Knee, R	36	1 × 3 mg	134
Soccer	1	m	20–29	Knee, R	319	2 × 3 mg	163
Track and field, pole vault	1	f	20–29	Talocrural region, L	48	1 × 3 mg	213
Basketball	1	m	20–29	Talocrural region, L	216	1 × 3 mg	82
Soccer	1	m	20–29	Talocrural region, R	53	1 × 3 mg	21
Soccer	1	m	20–29	Calcaneus, L	164	1 × 3 mg	98
Soccer	1	m	30–39	Calcaneus, L	345	2 × 3 mg	194
Soccer	1	m	20–29	Midfoot, L	3	1 × 3 mg	21
Track and field, sprint	1	m	30–39	Midfoot, L	9	1 × 3 mg	129

Basic information about the athletes (sports discipline, level of competition, sex [m(ale) or f(emale)], age in years), the location of bone marrow oedema (BMO), type of treatment regimen (ibandronate in mg) and time periods from onset of pain until diagnosis as well as from first treatment (ibandronate infusion) until return to full training/competition (RTC) in days. Grouped by injury location. Level 1 = professional athlete participating at highest level according to the sports discipline. Level 2 = professional athletes and junior athletes participating at second highest level. Age groups: 20–29-year-old and 30–39-year-old athletes.

Mean follow-up time for the athletes was 395 ± 269.7 days. The time between the onset of pain and proper diagnosis was 106.3 ± 104.1 days (Fig. 1). Clinical examinations revealed in most cases pain on palpation, limited function of the adjacent muscles, limited ROM (range of motion) of affected joints, in some patients additionally a limping gait. After establishing the diagnosis the average time to start of the treatment regimen was 16.3 ± 10.1 days.

Initially average vitamin D values were 30.8 ± 7.8 ng/ml. However 60% of the patients were vitamin D deficient. Eleven patients (44%) showed a vitamin D insufficiency (20–31 ng/ml) and four patients (16%) had a vitamin D deficiency (less than 20 ng/ml). High-dose vitamin D supplementation was started and very well tolerated. Vitamin D check up at the last visit prior returning to competition showed an average of 40.1 ± 3.1 ng/ml. Calcium and phosphate parameters averaged at 2.49 ± 0.11 mmol/l and 3.33 ± 0.87 mg/dl, respectively. The further analysis of bone metabolism parameters (alkaline phosphatase (ALP), parathyroid hormone (PTH) and creatinine) showed normal serum values in all cases. Only two cases experienced minor side effects of intravenous ibandronate application, the rest tolerated the treatment protocol well. Both of the cases with "acute phase reaction" had flu-like symptoms including mild arthralgias and myalgias for a maximum of 4 days and recovered thereafter quickly. Both had only received once 3 mg of ibandronate intravenously. No hypocalcaemia was observed.

Sixteen athletes (64%) reported pain reduction (at rest and under strain) and improved mobility in the first two weeks after the first ibandronate administration. Pain at rest and under strain was the parameters questioned at the initial visit and for all the follow-up visits to monitor improvement. Nine athletes (~ 36%) did not report significant pain improvement under strain; however, the pain at rest had vanished after the first administration. These nine athletes received a second and two of these a third ibandronate injection (Table 1).

Return to competition time (RTC) is the time period from first BP treatment until return to full training/competition (sports). RTC was averaged to be 102.6 ± 65.2 days in total. For the group receiving only one ibandronate infusion the RTC was 78 ± 61.7 days, and 141.1 ± 47.7 and 164.5 ± 33.2 days for the athletes with two infusions and three injections, respectively. All athletes returned to full sportive activity on their pre-injury level. If the time from onset of pain until diagnosis was within 40 days, the RTC was significantly reduced to almost 50% (63.8 ± 48.1 days) when compared to the

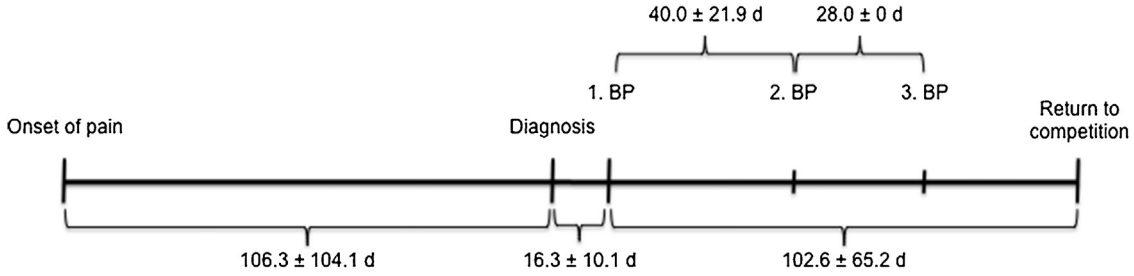

Fig. 1. Treatment timeline. Timeline with key points for the current study with average times (±standard deviation) in days. Onset of pain until diagnosis presents as the longest time period with 103.6 days. Time for the first bisphosphonate (BP) infusion after diagnosis was averaged around 16.3 days. Average times until further BP infusions (second and third BP) are demonstrated. Athletes returned to full training or competition (RTC) in total after 102.6 days from first BP infusion.

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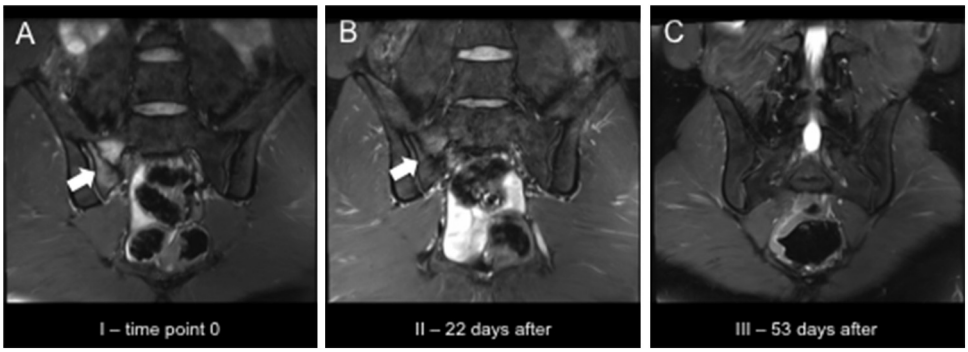

Fig. 2. Bone marrow oedema of the os sacrum. MR-imaging of a 25-year-old high-professional female tennis player playing at the highest international level demonstrates a bone marrow oedema with a stress fracture of the right os sacrum. The athlete was unable to train and started complaining about pain after a sudden jump on her right leg 168 days before first visit in our centre. The first T2-weighted image (a frontal plane) reveals a fracture line as well as an intense adjacent bone marrow oedema within the os sacrum (arrow). Follow-up MRI 22 days later (B) after high dose vitamin D and bisphosphonate treatment show already a significant decrease of the oedema and reduced fracture line (arrow). Consecutive MR-imaging one month later (C; the athlete was meanwhile pain-free) reveals an almost complete resorption of the oedema. The fracture line is not detectable anymore. The athlete was back to full unrestricted tennis training (RTC) within 98 days after correct diagnosis and beginning of adequate treatment.

athletes receiving later diagnosis (124.4 ± 63.2 days) ($p \leq 0.05$). The complete time from onset of pain, diagnosis and treatment until return to full training/competition was for the entire collective a total of 225.2 ± 179.4 days.

The following MRI scans show the pre-treatment and follow-up situation of BMO in three different locations (Figs. 2–4). A BMO with a stress fracture (dense line) of the sacrum can be identified on the MRI in the frontal plane (Fig. 2). A significant reduction of the BMO over time can be observed (Fig. 2A–C). BMO and the improved situation in the follow-up of the os pubic are shown (Fig. 3A). The follow-up image was taken at a different institute and in a different sequence (Fig. 3 A, STIR and B, PD tse fs), however the sensitivity of the oedemas is equal and therefore the images are comparable. Another usual BMO location is the calcaneus as demonstrated in the MRI of another athlete (Fig. 4A). Follow-up scan reveals a complete regression of the BMO (Fig. 4B).

Discussion

This current study demonstrates that painful and mobility limiting BMO, in some cases combined with stress fractures, in high-performance athletes can be treated successfully by intravenous applied ibandronate and high-dose vitamin D supplementation. The BMO caused pain in the athletes and hence limited the ability to participate in training or competition.

The proper diagnosis of BMO syndrome with or without a stress fracture is of uttermost importance as it is differently treated to a muscle injury, a torn ligament or a traumatic fracture.[30,31] BMO and osteonecrosis cases and their treatment with a bisphosphonate have been previously described.[10,11,32] BPs have demonstrated a positive influence on the bone metabolism in animal experiments as well as in local bone disorders.[10,18,26,27] Baier et al. compared the effects of intravenous ibandronate application versus prostacyclin infusions.[32] They showed that both drugs effectively reduced BMO in the knee and foot in 20 cases. Numerous side effects, like headaches, flush-like symptoms or a facial rash, can be observed in the prostacyclin treatment.[5,33] Additionally, a smaller patient compliance rate can be expected for prostacyclin administration compared to ibandronate. Ibandronate is given in a single injection approximately once a month in an outpatient set-up compared to five consecutive days of infusion for prostacyclin, usually on an inpatient basis with close monitoring like EKG, etc.[5,7,32] Osteonecrosis of the jaw is known to be a major side effect, if administered frequently, but this can be significantly reduced with a proper dental hygiene and its occurrence is low in non-malignant cases.[34,35] Flu-like symptoms are known to be a common side effect in BP treatment as is hypocalcaemia. Hypocalcaemia prophylaxis was done with vitamin D and calcium supplementation in the current study. Another antiresorptive therapy option could be denosumab. This human monoclonal

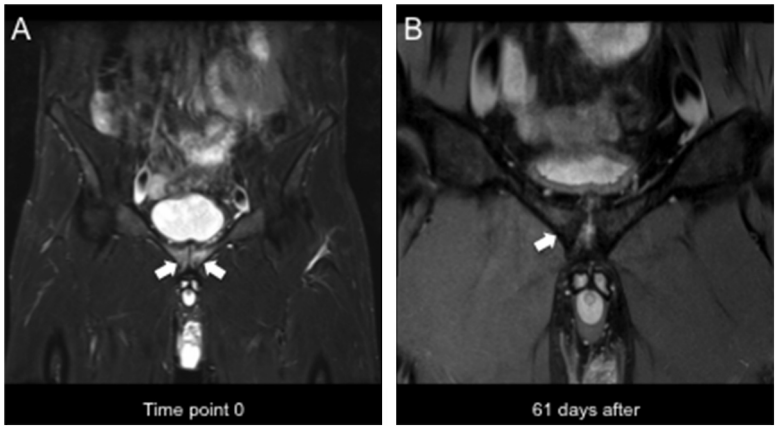

Fig. 3. Case of a bone marrow oedema in os pubis. Twenty-three-years old soccer player reported at first visit about recurrent pubic pain since more than five months preventing him from full training. No trauma was detectable. MRI shows an intense BMO of the os pubis, accentuated on the right side, in the frontal plane (arrows). Follow-up imaging after high dose vitamin D and bisphosphonate treatment reveals a significant decrease of the oedema correlative with a significant decrease of pain (right side still visible marked by with an arrow). The RTC was recorded after 89 days.

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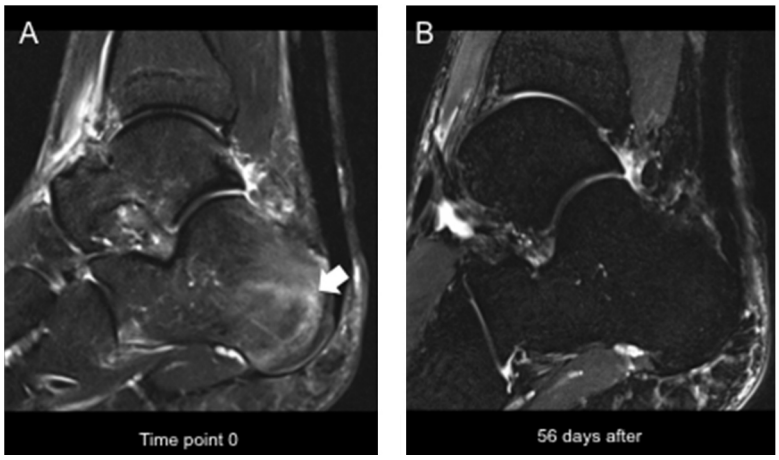

Fig. 4. Athlete with a bone marrow oedema of the calcaneus. Case of a 33-year-old first league soccer player complaining about pain on the left hindfoot for already 345 days preventing the athlete from full training. MRI at first visit demonstrates an intense BMO of the posterior calcaneus as well as an Achilles tendinopathy (arrow). Follow-up imaging shows a decrease of the BMO after high dose vitamin D and bisphosphonate treatment combined with a significant reduction of pain (Please note: MRI was performed in two different external facilities. Thus, sequences are slightly different, but still comparable.). RTC was recorded at 194 days, indicating that late diagnosis and delayed treatment lead to a long absence time.

antibody inhibits the action of receptor activator of nuclear factor-κB ligand (RANKL), which lowers bone resorption.[36] However, to our knowledge there are no published results from clinical investigations that used denosumab in cases of BMO. Further treatment options for BMO can be the core decompression, which is an operative procedure.[33] The indication for this operation is done very cautiously in the early stages of a BMO. Core decompression is one of the treatment options that is often used, but an operation bears the risk of an infection, even when it is very small. An additional treatment option is the conservative treatment method with initial partial weight bearing with analgesics and stepwise rehabilitation.[37] This treatment regimen is usually not accepted by an athlete or an individual needing a short healing process because of missed training sessions or important games/events in his/her career.

Vitamin D supplementation is known to reduce the number of fracture incidences by 21%.[23,38] Stress reactions and fractures are commonly seen in military recruits and athletes around the world.[3,16,21,22,25] One major factor is that exercise is increased in most cases too rapidly or regeneration times are too short.[23] Additionally, vitamin D deficiency is a major contributor to stress reactions, also seen in elderly patients.[10,22,39,40] This factor is reduced with a proper supplementation in this present investigation and vitamin D also enhances athletic performance.[23,38,41]

Treatment of high-performance athletes is a special challenge: Professional athletes require rapid return to high-class sports competition level and not only daily activities as seen in previous studies with stress reactions of the bone.[10,11] A significantly reduced RTC is for this group a major goal.[20] Returning to sports or competition in this study means that the athletes can fully exercise without any restrictions and are able to compete again. However, this does not mean that the athlete participated in the next event, as it might be some time away, and this also excludes the situation of a coach deciding not to use the player for e.g. tactical purposes. Thus, RTC was defined as the time from treatment to full, unrestricted training. The RTC was nearly halved in athletes with early diagnosis (within 40 days) and rapidly initiated treatment as to those with later diagnosis as shown in this study. The reason for major delays in treatment initiation with intravenous bisphosphonates was the postponed presentation of the athletes at our institution, as many of the international athletes initially visited their doctors in their home countries and were then referred to our institution.

The MRI scans at our institution were taken with the highest level of sensitivity. Some athletes presented with current but externally taken MR-images. This can cause for the inexperienced observer in cases with externally obtained MRI scans with a lower sensitivity a misreading of the current situation in the follow-up scans. But with this information and experience the interpretation of MRI scans can be properly executed. Generally, there was a significant reduction or even complete regression of BMO detected after ibandronate administration in the follow-ups. However, the oedema intensity and/or expansion size on the MRI scans is not the solitary grading factor of treatment success since BMO signal in MRI can persist over a longer time period when patients are already pain free and able to perform in full athletic activity. It rather is the athletes' complaint or pain description as well as clinical findings such as normal findings on palpation, ROM of affected joints, normal status of the adjacent muscles and others. However, the athlete needs to be reprimanded to follow a slow reintegration process (including rehabilitation and medical check-ups) towards full practice/competition level as healing bone requires time and too early strain increase can disturb bone healing processes severely. Moreover, BMO can be asymptomatic and accidentally found in MRI scans. These do not need to be treated with intravenous bisphosphonates or a decrease in physical activity. However, these athletes should be closely monitored for any signs and symptoms of BMO. Moreover, serum levels of bone parameters should be checked and a basic vitamin d and calcium supplementation is recommended.

A stress fracture is defined by a fracture line found in radiologic images. Stress fractures can be differentiated into a fatigue- or insufficiency-related fracture, which is dependable on the bone structure and its durability.[3,42] A BMO is a diagnosis made usually by a MRI scan, which demonstrates an increase of fluid accumulation in the affected area of the bone, which can be symptomatic and have a self-remission but also can progress into an ON.[7] In some cases, a fracture line can be seen on MRI T1-weighted sequences, however in general MRI scans are excellent and radiation-free procedures to early identify stress reactions of the bone.[43] Computer tomography (CT) is best to identify structural changes to the bone, such as stress fractures, but has a high radiation exposure and therefore should only be performed in questionable cases.[44,45]

There are limitations to this study. First it is a retrospective study. Secondly, the lack of a control group does not allow proper

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comparison of RTC of athletes treated with BPs versus the natural course of the disease. However, the here-analysed group is a special and unique cohort of high-performance athletes. These international athletes rely on their health and a quick return to competition and complete fitness. Therefore, BPs were given to all high-performance athletes, as previously described in a case-series with significant improvement,[6] with the aim to stop the painful and possibly increasing BMO and/or destructive development of an ON, and return the athlete quicker to competition fitness. Furthermore, this current investigation focused on the RTC, on the significant reduction of pathological findings in the MRI and the effectiveness and safety of ibandronate application. Pain-controlled full weight-bearing strategy was followed to achieve good functional results and to minimise demineralisation of bone. This was strongly appreciated by the athletes and enhanced patient compliance. The "off-label" use of BPs for localised bone disorders is justifiable by previously mentioned studies.[10,11,28] The concept that BPs stop the localised bone turnover with osteoclast inhibition prevents further structural bone reactions as seen in cases of osteonecrosis or other stress reactions of the bone.[10,26,28] Additionally, in some cases the proper diagnosis was not achieved until the patient arrived at our clinic causing a delay in treatment and hence compromising the rapid positive treatment outcome. This study presents multiple BMO locations and is not limited to a single or two specific areas. This can be a limitation. However, the purpose of this treatment study was to demonstrate bisphosphonate efficacy in BMO and therefore a broad spectrum of BMO locations is of benefit to the clinician since BMO can appear in numerous bones.

The results of this retrospective study with such a unique collective suggest that the here-applied therapy regimen of intravenous BPs application and high-dose vitamin D supplementation in BMO syndrome has a beneficial effect for high-performance athletes. An early diagnosis and rapid treatment start can reduce the RTC immensely. Furthermore, knowledge of the faster improvement of clinical findings and a postponed reduction of the oedemas on the MR-images should not compromise the return to competition. An optimal bone metabolism with sufficient daily calcium and vitamin D intake should be strived for not only for the professional but also for the recreational athlete.

Conclusions

BP treatment of BMO in the lower trunk and lower extremity of high-performance athletes is associated with a great improvement of clinical symptoms, bringing the athletes back to full sportive performance. Reduced RTC is feasible if proper diagnosis is made quickly. A complete or partial resolution of BMO in MRI after BP is usually observed but delayed. This study shows that i.v. administration of ibandronate and vitamin D supplementation benefits the high-performance athlete with BMO. Further prospective, randomised and controlled trials are needed to confirm this beneficial and RTC reducing effect of intravenous BP therapy.

Conflict of interest

The authors state that there is no conflict of interest.

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