Chirurgia Narządów Ruchu i Ortopedia Polska
ISSN 0009-479X www.polishorthopaedics.pl

Recent advances on diagnosis and treatment of osteoid osteoma

Najnowsze doniesienia w diagnostyce i leczeniu kostniaka kostnawego

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REVIEW

Chir. Narzadow Ruchu Ortop. Pol., 2022; 87(1) 25-31

DOI: 10.31139/chnriop.2022.87.1.5

Received: 17.03.2022
Accepted: 29.03.2022
Published: 31.03.2022

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Abstract

Osteoid osteoma (OO) is a benign bony lesion with a characteristic radiologic feature of x-ray focus (nidus). The most common symptom indicating diagnosis is strong nocturnal pain that eases with nonsteroidal anti-inflammatory drugs (NSAID). Computed tomography (CT) is a method of choice for diagnosing and localizing the tumor. Osteoid osteoma can regress spontaneously, thus conservative treatment is one of the methods of choice. In the past open resection surgery had been a standard management of osteoid osteoma until radiofrequency ablation (RFA) was discovered in the early 1990s. Nowadays, there are a few minimally invasive treatment techniques that are used. CT-guided radiofrequency ablation is considered a gold standard technique these days. Many cases occur with late diagnosis, and delayed treatment despite of characteristic symptoms. Therefore, it is crucial to be familiar with the clinical features of osteoid osteoma, proper diagnostic patterns, and treatment schemes.

Key words: osteoid osteoma, radiofrequency ablation, CT-guided procedure, thermal ablation, cryoablation, laser ablation, microwave ablation, Magnetic Resonance-guided Focused Ultrasound (MRgFUS).

Streszczenie

Kostniak kostnawy jest nowotworem łagodnym o charakterystycznym ognisku (nidus) w badaniach radiologicznych. Najczęstszym objawem prowadzącym do jego rozpoznania jest silny, nocny ból, reagujący na niesteroidowe leki przeciwzapalne. Tomografia komputerowa jest metodą z wyboru w diagnostyce i lokalizacji zmiany. Kostniak kostnawy może wygoić się samoistnie, toteż leczenie zachowawcze jest jedną z metod postępowania. Resekcja otwarta była standardowym leczeniem kostniaka kostnawego do czasu wprowadzenia termoablacji prądem wysokiej częstotliwości (RFA) na początku lat 90. XX wieku. Obecnie istnieje kilka metod leczenia małoinwazyjnego. RFA pod kontrolą tomografii komputerowej jest aktualnie uważana za złoty standard terapeutyczny leczenia kostniaka kostnawego. W wielu przypadkach występuje znaczne opóźnienie pomiędzy początkiem charakterystycznych objawów a postawieniem prawidłowej diagnozy i skutecznym wyleczeniem. W związku z tym istotna jest znajomość obrazu klinicznego, prawidłowy dobór metod diagnostycznych i leczniczych.

Słowa kluczowe: kostniak kostnawy, ablacja częstotliwością radiową, nawigacja tomografią komputerową, termoablacja, krioablacja, ablacja laserowa, ablacja mikrofalowa, MRgFUS.

Introduction

Osteoid osteoma is the third most frequent benign bony tumor. Its frequency is 11% amongst benign bone tumors, and 3% in all primary bony tumors. The most common affected localization is the lower extremity, especially femur and tibia bones. Men are 3 times more affected than women [1,2]. The average onset is between 5 and 25 years of age [3,4].

Osteoid osteoma is a benign bony lesion with the appearance of intensified nocturnal pain. A characteristic feature of osteoid osteoma is that using NSAID drugs and aspirin shows positive results in alleviating pain [1]. Pain during the night disturbs patients' sleeping patterns and by that decreases their quality of life [5,6]. Symptoms are frequently mistaken for a kind of trauma in the affected area [7]. Some cases of osteoid osteoma are presented with atypical localization and abnormal results of imagining studies, which can lead to misdiagnosis [8].

Pain during the night cannot occur or in some cases, it occurs in a location outside of the lesion [4].

The article is an overview of the latest reports on diagnostic methods and presents the advantages and relative disadvantages of both invasive and non-invasive techniques in the treatment of osteoid osteoma.

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Presentation and diagnosis

Osteoid osteoma in microscopic examination shows a focus(nidus) build-up with osteoid tissue, surrounded with reactive sclerotic bone with elements of inflammation [9]. Usually, nidus does not exceed 1cm in diameter. In CT and x-ray examination it gives a characteristic picture of hypodense focus surrounded with elliptically shaped thickened cortical layer. In some cases, reactive sclerosis of bone and the thickening of the cortical layer might be very thick and dense and cover nidus, so it is not detectable [10]. The mineralization factor of nidus grows with time from the first onset of pain and probably with the age of the tumor. According to Touraine's study, the focuses of tumors localized in the shaft of long bones are characterized by lower mineralization levels regardless of its localization concerning the cortical layer [11]. It is believed that nidus is responsible for the occurrence of pain, which can be explained by the fact that after the excision of the tumor, the pain disappears [1].

The cortical type of osteoid osteoma is the most common, with approximately 75% of all occurrences. Medullary type is usually atypically localized with around 20% of cases, subperiosteal type is barely 5% [8]. There has been a hypothesis proposed in the study by Kayser et al. that many osteoid osteoma was probably in first place localized in the subperiosteal area, with bone transformation into the subperiosteal area and intraosseous erosion migrating to the inside of the bone [12]. Osteoid osteoma is typically localized is in the shaft of long bones, especially the femur and tibia [13].

The first step of diagnosis is usually a standard x-ray image. Evaluation might be difficult because of varied, irregular bony shapes and shades overlapping each other [7] (Fig. 1).

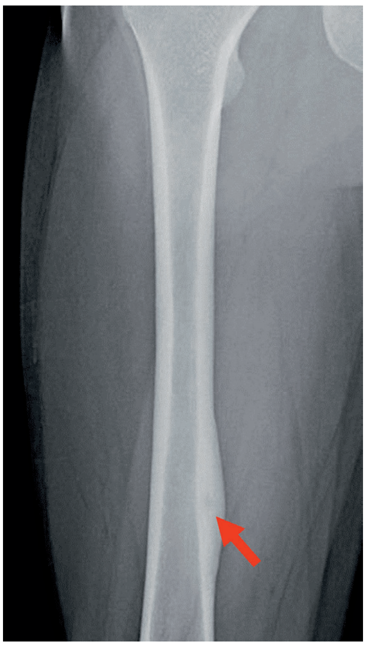

Fig. 1. Osteoid osteoma of femur in x-ray.

CT scan is a method of choice for obtaining a diagnosis and localizing the tumor [2,10] (Fig. 2,3). Extensive edema of bone marrow, changes in soft tissue, and close localization to joints might disturb the diagnosis of osteoid osteoma with MRI technique [14]. According to Davies et al., study use of MRI can lead to misdiagnosis. Some features can be easily misinterpreted, and osteoid osteoma might be hard to identify [15] (Fig. 4).

Zampa et al., on the other hand, present in their study that dynamic MRI enhances the visibility of tumor's focus and allows a confident diagnosis of osteoid osteoma placed in atypical localizations. Dynamic MRI significantly increased the conspicuity of nidus in comparison with not enhanced MRI [16].

As stated in the study by Teixeira et al., MRI perfusion has sensitivity and specificity above 90% of diagnosing recurrence of osteoid osteoma. Patients with successful treatment were observed with no or delayed enhancement of contrast in dynamic MRI. Cases of failed treatment were demonstrated with early and rapid enhancement [17].

Fig. 2. Osteoid osteoma of talus in CT.

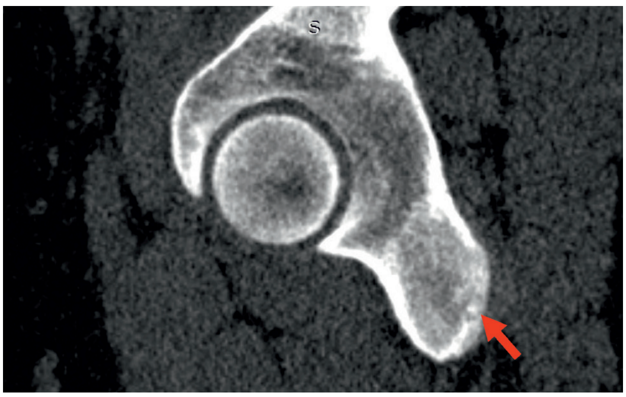

Fig. 3. Osteoid osteoma of the sciatic tumor in CT.

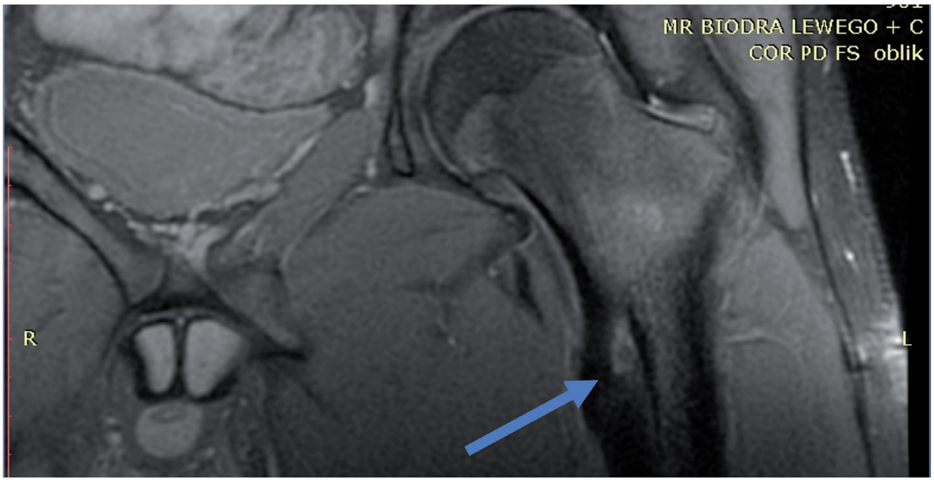

Fig. 4. Osteoid osteoma of lesser trochanter of the femur in MRI.

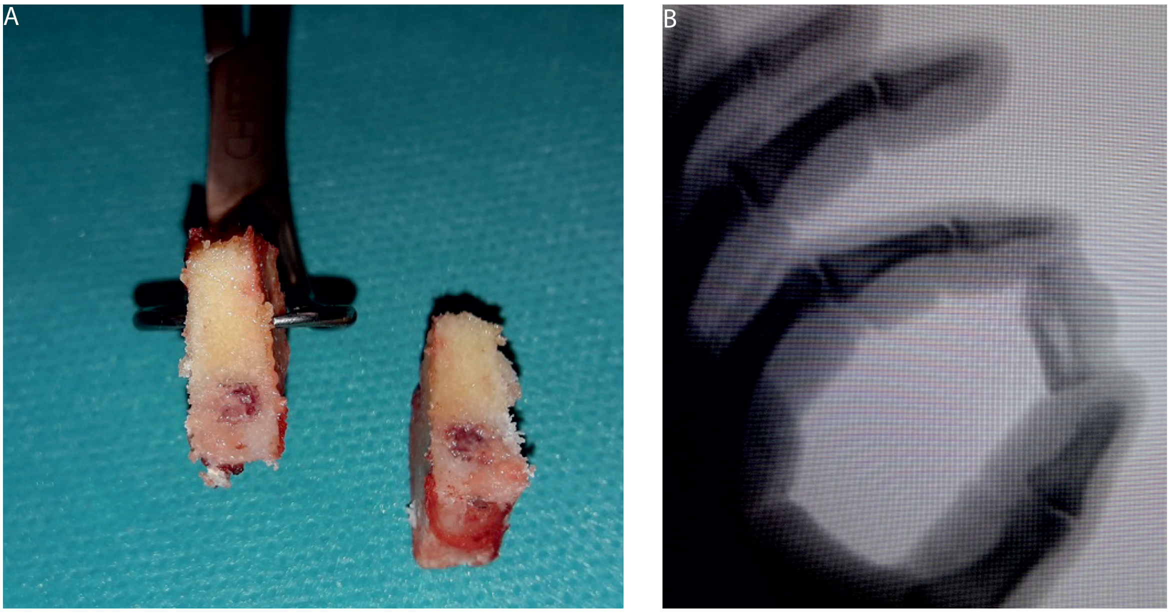

Fig. 5A-B. Fragmentary biopsy of osteoid osteoma.

Confirmation of diagnosis of osteoid osteoma may be done with bone scintigraphy that uses technetium-99 as the active agent. The sensitivity of the method according to sources is even 100%. It is a method of differentiation of osteoid osteoma with chronic inflammation of bones and bone marrow, Brodie abscess, and tumor metastases [1,2,14].

Taking a biopsy before performing minimally invasive procedures of treating osteoid osteoma tends to be controversial because of the high variability of histopathological results independent of needle size [18,19].

In the study by Becce et al., 67.5% of biopsy results were ambiguous [18]. Hoffman et al. confirmed diagnoses in 48% of taken biopsies. Those studies prove that taking a biopsy before starting treatment is not obligatory since there is a high number of false-negative results in clinical and radiological unambiguous cases of osteoid osteoma [18,20] (Fig. 5A-B).

Conservative treatment

When localization of an osteoid osteoma tumor is difficult to access with surgical and minimally invasive methods, conservative treatment should be considered [21]. The approximate time needed to reduce pain with conservative treatment is 6 to 15 years. It can be reduced with long-term NSAID treatment down to 2-3 years [21,22]. According to the study of Aiba et al., 45 % of examined patients were cured with conservative treatment. Time of effective conservative treatment with patients using NSAID, and not using it was approximately the same [23]. It is believed that the analgesic effect of rofecoxib, a COX-2 selective inhibitor, is better than conventional nonsteroidal anti-inflammatory drugs in the conservative treatment of osteoid osteoma [24].

Surgical treatment

For many years, surgery was a standard method of treatment of osteoid osteoma. With time, minimally invasive techniques like radiofrequency ablation, cryoablation, or laser ablation replaced regular surgery mainly due to their smaller invasiveness. In the past years, surgical treatment was used in the case of ineffective results of conservative treatment [25]. Surgical methods include en-bloc excision, curettage, and arthroscopic procedure in the case of intraarticular localization of the lesion [26]. The effectiveness of arthroscopic treatment is estimated at around 90% [26,27]. In the study of Sluga et al., the ratio of recurrence after curettage was 12%, and after en-block excision – 4,5% [26,28]. Postoperative fractures occurred in 3% of patients after the curettage of the lesion, and 4,5% after the surgical en-bloc excision of OO [28]. In the case of increased risk of postoperative fractures with a higher loss of cortical layer and weakening of a bone after tumor excision, prophylactic internal fixation is sometimes indicated [25] (Fig. 6). Besides fractures, other side effects of surgical treatment of osteoid osteoma are hematoma and infections. In addition, prolonged hospitalization due to surgical treatment requires the patient to not overload the operated extremity and can lead to an extended time of returning to performing physical activities [29].

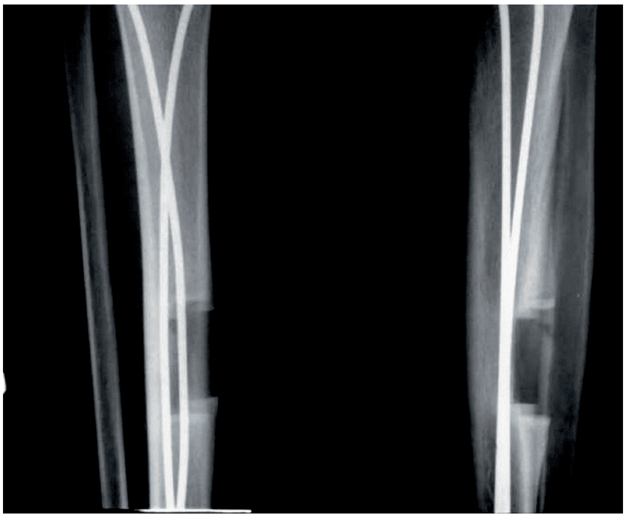

Fig. 6. Prophylactic stabilisation of tibia after surgical excision of osteoid osteoma.

Minimally invasive treatment

Computed tomography-guided radiofrequency ablation (CT-RFA)

CT-RFA is a method based on an ablation mechanism with the production of heat. Percutaneous drill with the formation of a canal enables the placement of an ablation electrode (Fig. 7,8). The flow of alternating current heats the area at the distal end of the electrode. There is no consensus regarding temperature or time used in the ablation method. Usually, it is 90 Celsius degrees in 4-6 minutes. Certain authors prefer the use of increasing temperature while performing thermoablation due to predictable less extensive tissue carbonization [30]. In the study of Neumann et al., the temperature of 95-100°C was used for 1-2 minutes. Within five years following this treatment, 97% of patients have made full recovery [31]. Two cycles of ablation, lasting for 6 minutes, each with a temperature of 90°C, were used in the study of Abboud et al. In between cycles, the ablation electrode was cooled down to 40°C. Clinical success was achieved in 100% of cases [32]. Osteoid osteoma of vertebrae, studied by Albasinni et al. was gradually warmed up to 90°C for 15 minutes. Primary clinical success was observed in 93.4%, whereas secondary in 96.3% of studied patients [33].

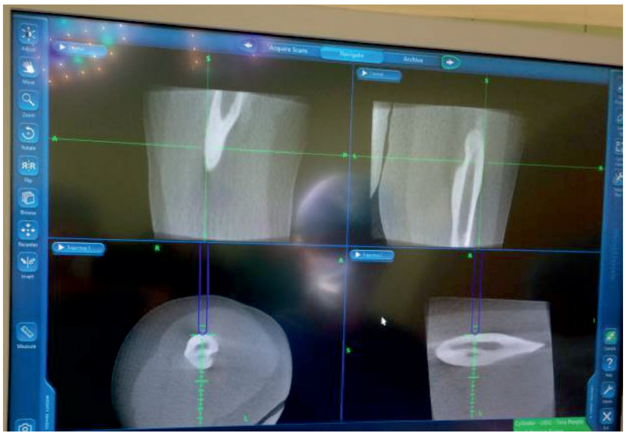

Fig. 7. 3D navigation image during canal drilling.

Fig. 8. Moment of electrode insertion during termoablation with 3D navigation.

Particular steps of surgery are performed with the use of computed tomography [3,5,34]. The use of a three-dimensional (3D) fluoroscopy navigational system is an alternative option. It allows precise multi-dimensional localization of a tumor, especially about complex anatomical structures like scapula or pelvis. Moreover, fluoroscopic 3D navigation allows imaging in real-time, which can lead to improvement of the method and decrease the risk of improper placement of the ablation electrode [35] (Fig. 9).

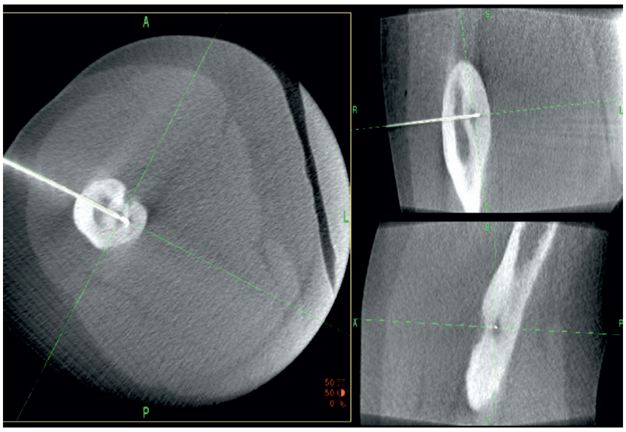

Fig. 9. Confirmation of electrode location during termoablation with 3D navigation.

The type of used anesthesia is a contentious issue. Some authors claim that epidural, spinal, or general anesthesias can be used [34]. It is believed that local anesthesia might not be a sufficient pain control method used during the surgery [3, 5]. As stated in a study by Rosenthal et al., percutaneous procedures under local anesthesia were considered a failure because of the occurrence of pain [36].

CT-RFA method of treatment of osteoid osteoma is considered a gold standard and preferred over surgical methods due to its safety, effectiveness, and rate of success [3, 37, 38]. Clinical success is rated at 95-100%. The rate of relapse is close to 5% [34]. There are not many studies that point out factors responsible for the therapeutic failure of the method [39]. Researchers believe that to avoid the relapse in patients with a tumor that cannot be removed, CT-RFA should be performed with the ablative electrode inserted a few times in various positions [40,41]. In the study by Rimondi et al., a lower percentage of relapse was observed in the case of using ablation methods with 90-93 Celsius degree with time prolonged to 15 minutes in comparison with short 4-minute ablations [42].

Interstitial laser ablation (ILA)

ILA is a minimally invasive method of treatment of osteoid osteoma, it involves the transmission of light via optical fiber and converting it into heat energy in the location of the tumor. Because ILA is considered to be painful, it is performed under general or regional anesthesia [43-45]. For the precise localization of the tumor and the successful orientation of the needle, it is navigated with intraoperative CT guidance [43]. The advantages in comparison with CT-RFA are no need for the placement of a neutral electrode on the patient's body, no artificial electric flow in the patient's body, no interaction with a pacemaker or implantable cardioverter or metal elements in the patient's body, and low costs of optic fiber [44]. Success rate counts between 94-100% [3]. Side effects after the procedure may involve sympathetic dystrophy of the wrist when the tumor is located in its region, skin burns caused by moveable optical fiber, patellar ligament enthesopathy in treatment of patellar osteoid osteoma, hematoma, tendinitis, infections [3,43,44,46].

Microwave ablation (MWA)

MWA is rather a new method of treatment of OO [3]. Even though CT-RFA is a gold standard, MWA is gaining popularity [47]. The therapeutical success of this method ranges between 92-100% [48-50]. MWA generates an electromagnetic field in which polar molecules like water, are moveable. It leads to an increased level of kinetic energy which is converted to heat. Microwave energy is transmitted to tissue via an interstitial antenna. The advantages of MWA are the resistance of microwaves to the high impedance of tissue (bones are characterized with high impedance value) and the possibility of deeper penetration of tissue compared to CT-RFA [51]. Amongst side effects, we list local numbness, soft tissue infections, weakness of treated spot, skin burn, and damage of nerves [3,49,50].

Cryoablation

In comparison with other percutaneous methods of treatment of osteoid osteoma, cryoablation is focused on freezing the tumor tissue. Thanks to that effect, the cryoablation procedure does not provoke as much pain as other noninvasive techniques, and it can be performed with local anesthesia or weak sedation with the patient staying conscious [52,53]. In some cases, general anesthesia may be required. Cryoablation methods do not produce heat, thus there is a lower risk of breaking the joint capsule, articular cartilage, or dura mater of the spinal cord [52].

Cryoablation, like other percutaneous procedures, is performed with intraoperative CT guidance [3]. Because of that, it is easier to localize the tumor, precisely insert the needle, and control the formation of an "ice ball" in the area of the tumor [52].

According to certain sources, the final therapeutic success of cryoablation amounts to 90,5%-96% [53-55]. Side effects noticed in some studies were as listed: skin burns, tissue edema, temporary pain, weakening of the operated area, occurrence of skin blisters, numbness [52, 54,55].

Noninvasive treatment

Magnetic resonance guided focused ultrasound (MRg FUS)

MRgFUS is an innovative method of treating OO [3]. In comparison to other methods, it is a noninvasive one [3, 56-58]. The procedure is done under the control of an MRI scan. It shows precise localization of the tumor and enables choosing a perfect path for ultrasound beam administration. MRgFUS emits heat within the tumor. The Temperature of the osteoid osteoma tumor and its surrounding is measured with MRI [56]. The procedure of

MRgFUS is performed under general anesthesia, analgosedation, local nerve block, or spinal anesthesia [56,57].

Despite being a non-invasive method which is a big advantage, it has some limitations. Some of the criteria that exclude the usage of MRgFUS are the localization of a tumor within cranium or vertebrae, close localization of tumor <1cm from skin, neurovascular bundles, intestine, epiphyseal plate, infection, chronic cardiovascular diseases, neurological disease, hematologic disease, nephrological disease, scars or dental implants on the way of the ultrasound beam [57]. Moreover, the MRgFUS method is proportionally expensive and limited with the availability of MRI [58]. The clinical success of this technique rates between 87 and 100% [3].

Summary

Recommended technique in the diagnosis of osteoid osteoma is imaging with CT. The final diagnosis is given with the occurrence of clinical and radiologic features. In the case of minimally invasive methods, a biopsy is not needed. Conservative and surgical treatments are rarely used. There are a few ablation techniques, amongst which the most commonly used one is CT-guided radiofrequency ablation. It features almost 100% of effectiveness.

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