



MEETING REPORT

Workshop of European task force on medication-related osteonecrosis of the jaw—Current challenges

Morten Schiodt^{1,2}  | Sven Otto³ | Stefano Fedele⁴  | Alberto Bedogni⁵  |
 Ourania Nicolatou-Galitis⁶  | Roman Guggenberger⁷ | Bente Brokstad Herlofson^{8,9} |
 Oliver Ristow¹⁰ | Thomas Kofod¹

¹Department of Oral & Maxillofacial Surgery, Copenhagen University Hospital, Copenhagen, Denmark

²Department of Clinical Epidemiology, Aarhus University Hospital, Aarhus, Denmark

³Department of Oral and Maxillofacial Surgery, Ludwig-Maximilians University Munich, München, Germany

⁴UCL Eastman Dental Institute and NIHR UCLH Biomedical Research Centre, University College London, London, UK

⁵Department of Neuroscience-DNS, Regional Center for Prevention, Diagnosis and Treatment of Medication and Radiation-related Bone Diseases of the Head and Neck, University of Padova, Padova, Italy

⁶Clinic of Hospital Dentistry, National & Kapodistrian University of Athens, Athens, Greece

⁷Diagnostic and Interventional Radiology, University Hospital Zurich, Zurich, Switzerland

⁸Department of Oral Surgery and Oral Medicine, Faculty of Dentistry, University of Oslo, Oslo, Norway

⁹Division for Head, Neck, and Reconstructive Surgery, Department of Otorhinolaryngology, Unit of Oral and Maxillofacial Surgery, Oslo University Hospital, Oslo, Norway

¹⁰Department of Oral and Maxillofacial Surgery, University of Heidelberg, Heidelberg, Germany

Correspondence

Morten Schiodt, Department of Oral & Maxillofacial Surgery, Copenhagen University Hospital, Copenhagen, Denmark.

Email: mschioedt@hotmail.com

Funding information

Amgen

1 | INTRODUCTION

MRONJ is a potentially serious complication of anti-resorptive (AR) treatment in patients with skeletal metastases due to various cancers as well as osteoporosis (Campisi et al., 2014). MRONJ may also develop in anti-resorptive-naïve individuals exposed to a variety of anti-angiogenic agents (Mohamed, Nielsen, & Schiodt, 2018; Nicolatou-Galitis, Kouri, et al., 2019; Pimolbutr, Porter, & Fedele, 2018). MRONJ may lead to a reduced quality of life due to jaw bone infections, chronic pain, tooth loss, impaired function, and disfigurement.

Since the first report by Marx, 2003 (Marx, 2003), the number of cases and relevant publications has increased significantly (M.

Schiodt, PubMed Search 26.6.2019, unpublished). Despite significant progress in our knowledge of the disease, there remain a number of controversial aspects that are of high relevance to researchers, clinicians, and not least patients. The European Task Force on MRONJ comprises of a multidisciplinary group of European clinical investigators with a special interest in the diagnosis and management of MRONJ and a track record of relevant research and publications, who considered the current controversies on MRONJ a reason for academic concern, a potential threat to patients, and a limitation for better research. The group met up in two separate workshops in order to (a) highlight some of the most controversial aspects of current knowledge on MRONJ and (b) provide an expert opinion-based

The workshop group members are all engaged in MRONJ treatment and research and account for a total of 159 publications (including some shared publications). In the following, the number of published papers on MRONJ for each author is listed in brackets.

Morten Schiodt (21), Sven Otto (40), Stefano Fedele (16), Alberto Bedogni (26), Ourania Nicolatou-Galitis (16), Roman Guggenberger (3), Bente Brokstad Herlofson (19), Oliver Ristow (17), Thomas Kofod (1).

This is an open access article under the terms of the Creative Commons Attribution License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.

© 2019 The Authors. *Oral Diseases* published by John Wiley & Sons Ltd.

consensus on these topics with a view to help clinicians making informed decisions on patient's care and inspire future investigators to design better clinical studies. The Group agreed to focus upon three highly controversial aspects of MRONJ: (a) definition and classification, (b) risk factors, and (c) management/treatment of MRONJ.

2 | CONTROVERSIES ON DEFINITION AND CLASSIFICATION

The consensus papers by Ruggiero et al. representing the American Association of Oral and Maxillofacial Surgeons (AAOMS) (Advisory Task Force on Bisphosphonate-Related Osteonecrosis of the Jaws AAOMS, 2007; S. L. Ruggiero et al., 2014; Ruggiero et al., 2009) have been instrumental in the process of establishing an understanding and acceptance of a widely used definition and classification of MRONJ. The most recent version of the AAOMS consensus (2014) includes (a) the MRONJ case definition as the presence of exposed jaw bone or bone that can be probed through an intraoral or extraoral fistula(e) for at least 8 weeks in a patient receiving anti-resorptive and/or anti-angiogenic therapy who had not received radiotherapy to the head and neck, and (b) a disease classification into 4 clinical stages (stage 0-3). The most notable change introduced in the 2014 AAOMS consensus was the modified MRONJ definition so to include patients presenting with an intraoral or extraoral fistula(e). This important amendment was inspired by a number of reports highlighting that a sub-group of patients can in fact present with MRONJ disease characterized by the absence of exposed bone on visual inspection (so-called non-exposed MRONJ, including the presence of an intraoral fistula, mandibular fracture, dentally unexplained pain, and swelling, among other manifestations), and therefore, they would not fulfill the case definition of MRONJ as suggested by the initial version of the AAOMS consensus (2007) (Ascani, Campisi, & Junquera Gutierrez, 2014; Bedogni, Fusco, Agrillo, & Campisi, 2012; Fedele et al., 2015; S. Patel et al., 2012; Schiodt, Reibel, Oturai, & Kofod, 2014; Yarom, Fedele, Lazarovici, & Elad, 2010).

The background was the obviously different interpretations of the term "bone exposure" by different author groups and adjudicators in clinical and epidemiological studies. Some authors regarded bone that can be probed through a fistula as exposed and diagnosed MRONJ in the respective cases, while other authors did not include those patients.

The 2009 update of the AAOMS consensus papers (Ruggiero et al., 2009) partially addressed this issue as they added the new classification stage (stage 0) to include patients presenting with the non-exposed variant of MRONJ. However, the MRONJ case definition remained paradoxically unchanged, therefore preventing non-exposed MRONJ cases to be formally diagnosed, especially in clinical trials and epidemiological studies (Fedele et al., 2015).

Although the 2014 update of the AAOMS consensus represents a notable improvement, patients presenting with non-exposed MRONJ without fistulas (e.g., dentally unexplained pain, mobile teeth not due to periodontitis, numbness of the lip, mandibular fracture) continue

to remain excluded from MRONJ case definition (Fedele et al., 2015) (Table 1 and 2). There is therefore an urgent need for expanding the case definition of MRONJ so to encompass the other manifestations of non-exposed MRONJ and ensure that these patients can (a) be formally diagnosed and treated, and (b) be included in clinical and epidemiological studies. The Group appreciated that this might be a difficult task as an accurate case definition should ensure the exclusion of etiopathologically different disorders presenting with similar clinical manifestations, which include plaque-related gingivitis/periodontitis, dental and periapical disease, benign fibro-osseous lesion of the jawbones, chronic sclerosing osteomyelitis, infectious osteomyelitis, primary jawbone malignancy, metastatic disease, and TMJ disorders (Fedele et al., 2015; Patel et al., 2012; Ruggiero et al., 2014; Schiodt et al., 2014). Excluding these conditions as well as describing the MRONJ lesions requires imaging. The value of imaging is described later under controversies on management/treatment. Some authors have suggested that that up to one-quarter of MRONJ patients can present with the non-exposed variant (Fedele et al., 2015). Although this proportion is expected to be somewhat reduced after the inclusion of fistula in the definition (2014 AAOMS paper), efforts should be made to improve and expand case definition so to capture diagnosis in these patients including those with non-exposed MRONJ without fistulas.

The Group also suggested that the requirement of 8-week observation of potential MRONJ manifestation to fit the case definition may no longer be necessary. About one third to half of the affected individuals currently develop MRONJ without a history of dental extraction or other trauma (Otto, Pautke, Van den Wyngaert, Niepel, & Schiodt, 2018), and differential diagnosis with other dental and jawbone disease can be achieved without having to wait for 8 weeks (Bedogni et al., 2012).

TABLE 1 Staging of MRONJ. After (Ruggiero et al., 2014)

MRONJ ^a Staging
At-risk category No apparent necrotic bone in patients who have been treated with either oral or IV bisphosphonates
Stage 0 No clinical evidence of necrotic bone, but non-specific clinical findings, radiographic changes, and symptoms
Stage 1 Exposed and necrotic bone, or fistulae that probe to bone, in patients who are asymptomatic and have no evidence of infection
Stage 2 Exposed and necrotic bone, or fistulae that probe to bone, associated with infection as evidenced by pain and erythema in the region of the exposed bone with or without purulent drainage
Stage 3 Exposed and necrotic bone or a fistula that probes to bone in patients with pain, infection, and one or more of the following: exposed and necrotic bone extending beyond the region of alveolar bone (i.e., inferior border and ramus in the mandible, maxillary sinus, and zygoma in the maxilla), resulting in pathologic fracture, extraoral fistula, oral antral/oral-nasal communication, or osteolysis extending to the inferior border of the mandible of sinus floor

^aExposed or probable bone in the maxillofacial region without resolution for >8 weeks in patients treated with an anti-resorptive and/or an anti-angiogenic agent who have not received radiation therapy to the jaws.

3 | CONTROVERSIES ON RISK FACTORS

According to the literature, tooth extraction, infection, type and dosage of AR, and duration of treatment are considered to be risk factors.

Approximately half to two-thirds of MRONJ cases are reported to develop following a tooth extraction (Otto et al., 2018). Dental extraction was reported as a main risk factor in 73% of the cases of ONJ (Nicolatou-Galitis et al., 2011), and historically, these cases have been identified as a non-healing extraction socket (Bedogni et al., 2012). Accordingly, the vast majority of recommendations on dental treatment of patients on anti-resorptive or anti-angiogenic therapy have included advice against dental extractions as a mean to resolve dental infection (Khan et al., 2008; Khosla et al., 2007; Matsuo et al., 2014; Ruggiero et al., 2014; Yoneda et al., 2010).

However, a growing body of evidence suggests that dental infection, rather than dental extraction per se, might represent the main local risk factor for MRONJ (Otto et al., 2015; Panya et al., 2017; Saia et al., 2010). For example, a 2011 case-control study with three dental practice-based research networks in the United States found that the likelihood of developing osteonecrosis was higher (almost double) in patients with a history of suppuration compared to those with a history of dental extractions (OR 11.9 vs. 6.6) (Barasch et al., 2011). It is also increasingly reported that dental extractions in patients exposed to anti-resorptive therapy usually do not translate into MRONJ development, when tooth extraction is performed using alveolectomy and primary surgical mucosal closure (Heufelder et al., 2014; Otto et al., 2015). Thus, surgical intervention per se should not be overemphasized as the main risk factor for MRONJ development. Similarly, it has been suggested that infection around the implants (peri-implantitis) represents a notable risk factor for MRONJ development (Giovannacci et al., 2016; Troeltzsch et al., 2016). This is also in line with the high success rate after surgery on the jawbone to cure MRONJ lesions (see later).

TABLE 2 Mismatch between the 2014 AAOMS case definition criteria (Ruggiero et al., 2014) and clinical manifestations of MRONJ (modified from Fedele et al. (2015))

Clinical manifestations	Included in the AAOMS definition
Exposed MRONJ	
Frank bone exposure	Yes
Non-exposed MRONJ	
Sinus/Fistula tract ^a	Yes
Bone pain ^a	No
Bone swelling ^a	No
Gingival swelling ^a	No
Tooth mobility ^a	No
Mandibular fracture ^a	No
Maxillary sinus Pain ^a	No
Lower lip numbness/dysaesthesia ^a	No

^aNot caused by dental or other jawbone diseases, which should be ruled out with clinical and radiological investigations before suspecting MRONJ diagnosis.

The Group suggested that dental infection might currently be a more common and relevant risk factor for MRONJ compared to extraction and that a notable proportion of MRONJ cases believed to have been triggered by dental extraction in fact represent cases of non-exposed MRONJ that had already developed because of dental/periodontal infection before the actual extraction took place. Recent studies have reported the presence of histologically proven alveolar necrotic bone associated with dental/periodontal infection at the time of the extraction of teeth (Nicolatou-Galitis et al., 2015; Nicolatou-Galitis, Schiødt, et al., 2019). Similarly, animal studies have reported that MRONJ can develop to areas of periodontal infection in the absence of dental extraction surgery (Nowicki et al., 2019; Otto et al., 2017). Although evidence remains not robust and further well-designed clinical trials are needed, the Group suggested that patients on anti-resorptive therapy should not be declined dental extractions for the treatment of recurrent dental/periodontal infections that cannot be resolved or have failed to resolve with restorative treatment, as the persistence of the infection per se represents a notable risk factor for MRONJ development. The group recommended that when needed, tooth extractions should be performed with raising a muco-periosteal flap, alveolectomy, smoothing of bone edges, mobilization of the flap, and primary tension-free closure of the alveolus with tight suturing.

The Group also highlighted the importance of appropriate stratification of the risk of MRONJ development based on the type, dose, and administration route of anti-resorptive medication. There is robust evidence that drug-related factors associated with an increased risk of MRONJ development include nitrogen-containing structure, cumulative high dose, use in cancer setting, and intravenous administration (Abt, 2017; Malden & Lopes, 2012; Ruggiero et al., 2014; Vahtsevanos et al., 2009). However, it should be emphasized that intravenous administration of bisphosphonate per se should not be automatically considered an indicator of the high risk of MRONJ development. For example, some osteoporosis patients receive yearly intravenous bisphosphonates; however, because the cumulative dosage remains low, their risk of developing MRONJ is also low. Furthermore, a low dose, usually quarterly or half-yearly, of prophylactic intravenous bisphosphonates has been recently introduced in the management of breast cancer patients without metastases (adjuvant therapy), and this has been reported to be associated with notably lower risk of MRONJ development (Patel et al., 2018; Rugani et al., 2014). The Group suggested that, in order to optimize risk assessment and management of patients on anti-resorptive therapy, it is important to highlight to all clinicians and, in particular in the dental setting, that the risk of MRONJ development is mostly associated with high cumulative dosage of nitrogen-containing bisphosphonates. (Fung et al., 2017; Ruggiero et al., 2014).

4 | CONTROVERSIES ON MANAGEMENT/TREATMENT

Expert opinion-based recommendations for the management of MRONJ are included in the AAOMS position papers (Advisory Task Force on Bisphosphonate-Related Osteonecrosis of the Jaws

AAOMS, 2007; Ruggiero et al., 2009, 2014). The Group highlighted that AAOMS treatment recommendations, which are based on a clinically driven staging system, may fail to reflect the actual bone extension of MRONJ disease, with the risk of assigning patients to “inappropriate” treatments (Bedogni et al., 2014).

Accordingly, some authors advocated the adoption of treatments based also on the radiological aspects of MRONJ disease (Campisi et al., 2014) in order to pick up early signs of disease or base therapeutic decisions on accurate assessment of disease extent. However, there remains no consensus on the efficacy of different radiological imaging modalities (e.g., CT, MRI, or nuclear imaging) in assessing, with high accuracy, the “true” MRONJ disease extent. (Bisdas et al., 2008; Devlin et al., 2018). A number of studies have compared specific imaging modalities and found inconsistent results in terms of overestimation/underestimation of the extension of MRONJ (Guggenberger et al., 2013; Stockmann et al., 2010).

The group advised that clinicians should be careful in adopting treatment recommendations that are solely based on clinical assessment of MRONJ patients, and that further imaging studies are needed in order to study the extension of necrotic bone disease in MRONJ patients.

The group also highlighted the current controversy on surgical management of MRONJ patients. The AAOMS recommendations suggest generally non-surgical treatment for stages 1 and 2, and performing surgical debridement/resection of necrotic bone only for stage 3 MRONJ patients (Advisory Task Force on Bisphosphonate-Related Osteonecrosis of the Jaws AAOMS, 2007; Salvatore L. Ruggiero et al., 2009; Ruggiero et al., 2014).

However, there is an increasing body of evidence suggesting that surgical removal of necrotic bone might be curative in patients with all MRONJ stages (Aljohani et al., 2019; Otto et al., 2018; Ristow et al., 2018), where cure is defined as long-term resolution of symptoms and complete mucosal closure (absence of residual bone exposure). Other studies have documented high success rate of surgical treatment compared to non-surgical treatment (Aljohani et al., 2019; Hauer et al., 2019; Yamada et al., 2018).

A recent study also suggests that non-surgical therapy might lead to progression of MRONJ disease. Ristow et al. (2019) described a longitudinal study of 92 patients with stage 1 MRONJ who were initially treated by using a standardized conservative (non-surgical) protocol consisting of antimicrobial mouth rinsing and gel application (with chlorhexidine). The authors reported that only 8 patients (8.7%) showed complete mucosal healing and resolutions of symptoms whereas the remaining 84 (91.3%) had persistent exposed jaw bone at the end of the observation period (15.6 months). Among these 84 patients, 67 (80%) showed progression of their MRONJ disease (upshift in AAOMS stage from 1 to 2 or 3), which eventually led to extensive bone and/or tooth loss in 28 cases (Ristow et al., 2019). The group highlighted that, although well-designed comparative trials are required, there is increasing evidence suggesting that surgical removal of the necrotic bone might provide long-lasting benefits to MRONJ patients in terms of resolving symptoms, obtaining mucosal healing, and preventing further progression of necrotic bone disease. With this growing

body of evidence, a number of clinicians have shifted their therapeutic approach from conservative (non-surgical) to upfront surgical treatment.

5 | RECOMMENDATIONS

Based on the discussion points summarized above, the group has produced a number of consensus key statements and recommendations so to inform clinicians and advice researchers, as a first step of reaching solutions.

5.1 | Key statements and recommendations relevant to definition and classifications of MRONJ

- Current widely adopted definition does not identify all patients affected by MRONJ
- The current description of stage 0 is controversial, does not fulfill the definition of the disease, and may be misleading and difficult to interpret.
- Stage 0 of the AAOMS classification is a diagnostic challenge, as there are overlaps with dental and non-dental diseases. Stage 0 may ultimately need confirmation by imaging and/or histopathology.
- Cases of non-exposed MRONJ without fistula should be included in the definition, possibly in terms of suspected or probable MRONJ after ruling out other dental and non-dental disease. The only ultimate proof of non-exposed MRONJ might be the histopathologic confirmation of necrotic bone. Decision on biopsy should be taken on an individual basis.
- The definition criterion of 8-week bone exposure/probing of bone does not apply to all cases and may delay diagnosis and consequently treatment.
- The role of imaging in the definition and classification of MRONJ needs further refinement. Imaging may aid in diagnosis (especially for non-exposed cases) and help determining disease extension and planning treatment.
- Present classification/staging does not adequately capture the extension and severity of MRONJ lesions. This may potentially affect treatment and prognosis.

5.2 | Key statements and recommendations relevant to risk factors for MRONJ

- Tooth extraction does not automatically translate into an increased risk of developing MRONJ, as certain surgical procedures notably reduce the risk.
- The reported high risk of developing MRONJ after tooth extraction might be related to an underlying pre-existing dental/periodontal infection rather than to the surgery per se.
- The risk of developing MRONJ is not related to the way of

administration as single factor; an accurate risk assessment should include an evaluation of the cumulative dosage and duration of anti-resorptive treatment. Typically, high-dose anti-resorptive therapy given to cancer patients with metastases is associated with higher risk of MRONJ development as compared to low-dose therapy given to osteoporosis patients.

5.3 | Key statements and recommendations relevant to management/treatment of MRONJ

- Because there is no accurate staging system reflecting the extension of MRONJ bone disease, it is problematic, and possibly misleading, to inform treatment recommendations on the basis of currently available staging systems.
- The term “conservative treatment” is used inconsistently in the literature and might include a number of different interventions ranging from topical antimicrobial mouthwashes to removal of superficial loose sequestra.
- The group recommends using the terms non-surgical versus surgical treatment.
- Recent literature suggests that non-surgical treatment may lead to disease progression.
- Surgical treatment is superior to non-surgical management in promoting long-term mucosal healing as well as absence of symptoms or radiological signs indicative of bone necrosis.
- If the aim of treatment is reduction of symptoms (pain) and control of infection, non-surgical treatment may be a valid management option. This seems particularly appropriate in frail elderly patients and in end-of-life oncology palliative setting.
- Early surgical intervention on localized disease may prevent progression and the need for subsequent extensive surgery (consider to treat surgically and early).

6 | GENERAL SUMMARY

The Group has highlighted a number of controversial aspects of current knowledge and practice relevant to MRONJ, which have the potential to affect clinical management of patients as well as research. The Groups suggest that key statement and recommendations presented in this paper might represent a useful tool so to stimulate a proactive discussion and inspire new and better-designed research, as first step to reach a consensus and improve the management of patients with MRONJ.

ACKNOWLEDGEMENTS

The workshops were supported by a donation from Amgen. All authors have received a fee for their contributions. The assistance from research nurse Line Eriksen in preparing the manuscript is highly acknowledged.

CONFLICT OF INTEREST

No conflict of interest.

AUTHOR CONTRIBUTIONS

Each author has participated in the workshops and has actively contributed to the creative process of establishing the paper. The first author has also been responsible for heading the editing and the revision process.

ORCID

Morten Schiodt  <https://orcid.org/0000-0001-9154-3956>

Stefano Fedele  <https://orcid.org/0000-0001-9006-9412>

Alberto Bedogni  <https://orcid.org/0000-0003-4742-4508>

Ourania Nicolatou-Galitis  <https://orcid.org/0000-0001-9036-6329>

REFERENCES

- Abt, E. (2017). The risk of medication-related osteonecrosis of the jaw after dental extraction is higher for patients on intravenous as compared with oral antiresorptive drugs. *Journal of Evidence Based Dental Practice*, 17(2), 105–106. <https://doi.org/10.1016/j.jebdp.2017.03.007>
- Advisory Task Force on Bisphosphonate-Related Osteonecrosis of the Jaws AAOMS (2007). American association of oral and maxillofacial surgeons position paper on bisphosphonate-related osteonecrosis of the jaws. *Journal of Oral and Maxillofacial Surgery*, 65(3), 369–376. <https://doi.org/10.1016/j.joms.2006.11.003>
- Aljohani, S., Troeltzsch, M., Hafner, S., Kaeppler, G., Mast, G., & Otto, S. (2019). Surgical treatment of medication-related osteonecrosis of the upper jaw: Case series. *Oral Diseases*, 25(2), 497–507. <https://doi.org/10.1111/odi.12992>
- Ascani, G., Campisi, G., & Junquera Gutierrez, L. M. (2014). Current controversies in classification, management, and prevention of bisphosphonate-related osteonecrosis of the jaw. *International Journal of Dentistry*, 2014, 565743. <https://doi.org/10.1155/2014/565743>
- Barasch, A., Cunha-Cruz, J., Curro, F. A., Hujoel, P., Sung, A. H., Vena, D...Group, C. C (2011). Risk factors for osteonecrosis of the jaws: A case-control study from the CONDOR dental PBRN. *Journal of Dental Research*, 90(4), 439–444. <https://doi.org/10.1177/0022034510397196>
- Bedogni, A., Fedele, S., Bedogni, G., Scoletta, M., Favia, G., Colella, G., ... Campisi, G. (2014). Staging of osteonecrosis of the jaw requires computed tomography for accurate definition of the extent of bony disease. *British Journal of Oral and Maxillofacial Surgery*, 52(7), 603–608. <https://doi.org/10.1016/j.bjoms.2014.04.009>
- Bedogni, A., Fusco, V., Agrillo, A., & Campisi, G. (2012). Learning from experience. Proposal of a refined definition and staging system for bisphosphonate-related osteonecrosis of the jaw (BRONJ). *Oral Diseases*, 18(6), 621–623. <https://doi.org/10.1111/j.1601-0825.2012.01903.x>
- Bisdas, S., Chambron Pinho, N., Smolarz, A., Sader, R., Vogl, T. J., & Mack, M. G. (2008). Bisphosphonate-induced osteonecrosis of the jaws: CT and MRI spectrum of findings in 32 patients. *Clinical Radiology*, 63(1), 71–77. <https://doi.org/10.1016/j.crad.2007.04.023>
- Campisi, G., Fedele, S., Fusco, V., Pizzo, G., Di Fede, O., & Bedogni, A. (2014). Epidemiology, clinical manifestations, risk reduction and

- treatment strategies of jaw osteonecrosis in cancer patients exposed to antiresorptive agents. *Future Oncology*, 10(2), 257–275. <https://doi.org/10.2217/fon.13.211>
- Devlin, H., Greenwall-Cohen, J., Benton, J., Goodwin, T. L., Littlewood, A., & Horner, K. (2018). Detecting the earliest radiological signs of bisphosphonate-related osteonecrosis. *British Dental Journal*, 224(1), 26–31. <https://doi.org/10.1038/sj.bdj.2017.1001>
- Fedele, S., Bedogni, G., Scoletta, M., Favia, G., Colella, G., Agrillo, A., ... Bedogni, A. (2015). Up to a quarter of patients with osteonecrosis of the jaw associated with antiresorptive agents remain undiagnosed. *British Journal of Oral and Maxillofacial Surgery*, 53(1), 13–17. <https://doi.org/10.1016/j.bjoms.2014.09.001>
- Fung, P., Bedogni, G., Bedogni, A., Petrie, A., Porter, S., Campisi, G., ... Fedele, S. (2017). Time to onset of bisphosphonate-related osteonecrosis of the jaws: A multicentre retrospective cohort study. *Oral Diseases*, 23(4), 477–483. <https://doi.org/10.1111/odi.12632>
- Giovannacci, I., Meleti, M., Manfredi, M., Mortellaro, C., Greco Lucchina, A., Bonanini, M., & Vescevi, P. (2016). Medication-related osteonecrosis of the jaw around dental implants: Implant surgery-triggered or implant presence-triggered osteonecrosis? *Journal of Craniofacial Surgery*, 27(3), 697–701. <https://doi.org/10.1097/SCS.00000000000002564>
- Guggenberger, R., Fischer, D. R., Metzler, P., Andreisek, G., Nanz, D., Jacobsen, C., & Schmid, D. T. (2013). Bisphosphonate-induced osteonecrosis of the jaw: Comparison of disease extent on contrast-enhanced MR imaging, [18F] fluoride PET/CT, and conebeam CT imaging. *AJNR American Journal of Neuroradiology*, 34(6), 1242–1247. <https://doi.org/10.3174/ajnr.A3355>
- Hauer, L., Jambura, J., Hrusak, D., Chalupova, M., Posta, P., Rusnak, S., & Vyskocil, V. (2019). Surgical therapy for medication-related osteonecrosis of the jaw in osteoporotic patients treated with antiresorptive agents. *Biomedical Papers of the Medical Faculty of the University Palacký, Olomouc, Czechoslovakia*, [Epub ahead of print]. <https://doi.org/10.5507/bp.2018.081>
- Heufelder, M. J., Hendricks, J., Remmerbach, T., Frerich, B., Hemprich, A., & Wilde, F. (2014). Principles of oral surgery for prevention of bisphosphonate-related osteonecrosis of the jaw. *Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology*, 117(6), e429–435. <https://doi.org/10.1016/j.oooo.2012.08.442>
- Khan, A. A., Sándor, G. K., Dore, E., Morrison, A. D., Alsahli, M., Amin, F., ... Glorieux, F. H. (2008). Canadian consensus practice guidelines for bisphosphonate associated osteonecrosis of the jaw. *The Journal of Rheumatology*, 35(7), 1391–1397.
- Khosla, S., Burr, D., Cauley, J., Dempster, D. W., Ebeling, P. R., Felsenberg, D., ... Shane, E. (2007). Bisphosphonate-associated osteonecrosis of the jaw: Report of a task force of the American Society for Bone and Mineral Research. *Journal of Bone and Mineral Research*, 22(10), 1479–1491. <https://doi.org/10.1359/jbmr.0707onj>
- Malden, N., & Lopes, V. (2012). An epidemiological study of alendronate-related osteonecrosis of the jaws. A case series from the south-east of Scotland with attention given to case definition and prevalence. *Journal of Bone and Mineral Metabolism*, 30(2), 171–182. <https://doi.org/10.1007/s00774-011-0299-z>
- Marx, R. E. (2003). Pamidronate (Aredia) and zoledronate (Zometa) induced avascular necrosis of the jaws: A growing epidemic. *Journal of Oral and Maxillofacial Surgery*, 61(9), 1115–1117. [https://doi.org/10.1016/s0278-2391\(03\)00720-1](https://doi.org/10.1016/s0278-2391(03)00720-1)
- Matsuo, A., Hamada, H., Kaise, H., Chikazu, D., Yamada, K., & Kohno, N. (2014). Characteristics of the early stages of intravenous bisphosphonate-related osteonecrosis of the jaw in patients with breast cancer. *Acta Odontologica Scandinavica*, 72(8), 656–663. <https://doi.org/10.3109/00016357.2014.887772>
- Mohamed, H. A. M., Nielsen, C. E. N., & Schiodt, M. (2018). Medication related osteonecrosis of the jaws associated with targeted therapy as monotherapy and in combination with antiresorptives. A report of 7 cases from the Copenhagen Cohort. *Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology*, 125(2), 157–163. <https://doi.org/10.1016/j.oooo.2017.10.010>
- Nicolatou-Galitis, O., Kouri, M., Papadopoulou, E., Vardas, E., Galiti, D., Epstein, J. B....Group, M. B. S (2019). Osteonecrosis of the jaw related to non-antiresorptive medications: A systematic review. *Supportive Care in Cancer*, 27(2), 383–394. <https://doi.org/10.1007/s00520-018-4501-x>
- Nicolatou-Galitis, O., Papadopoulou, E., Sarri, T., Boziari, P., Karayianni, A., Kyrtsionis, M.-C., ... Migliorati, C. A. (2011). Osteonecrosis of the jaw in oncology patients treated with bisphosphonates: Prospective experience of a dental oncology referral center. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontics*, 112(2), 195–202. <https://doi.org/10.1016/j.tripleo.2011.02.037>
- Nicolatou-Galitis, O., Razis, E., Galiti, D., Galitis, E., Labropoulos, S., Tsimpidakis, A., ... Migliorati, C. (2015). Periodontal disease preceding osteonecrosis of the jaw (ONJ) in cancer patients receiving antiresorptives alone or combined with targeted therapies: Report of 5 cases and literature review. *Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology*, 120(6), 699–706. <https://doi.org/10.1016/j.oooo.2015.08.007>
- Nicolatou-Galitis, O., Schiødt, M., Mendes, R. A., Ripamonti, C., Hope, S., Drudge-Coates, L., ... Van den Wyngaert, T. (2019). Medication-related osteonecrosis of the jaw: Definition and best practice for prevention, diagnosis, and treatment. *Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology*, 127(2), 117–135. <https://doi.org/10.1016/j.oooo.2018.09.008>
- Nowicki, B., Nehrbass, D., Arens, D., Stadelmann, V. A., Zeiter, S., Otto, S., ... Stoddart, M. J. (2019). Medication-related osteonecrosis of the jaw in a minipig model: Parameters for developing a macroscopic, radiological, and microscopic grading scheme. *Journal of Cranio-Maxillo-Facial Surgery*, 47(7), 1162–1169. <https://doi.org/10.1016/j.jcms.2019.03.002>
- Otto, S., Pautke, C., Martin Jurado, O., Nehrbass, D., Stoddart, M. J., Ehrenfeld, M., & Zeiter, S. (2017). Further development of the MRONJ minipig large animal model. *Journal of Cranio-Maxillo-Facial Surgery*, 45(9), 1503–1514. <https://doi.org/10.1016/j.jcms.2017.07.002>
- Otto, S., Pautke, C., Van den Wyngaert, T., Niepel, D., & Schiødt, M. (2018). Medication-related osteonecrosis of the jaw: Prevention, diagnosis and management in patients with cancer and bone metastases. *Cancer Treatment Reviews*, 69, 177–187. <https://doi.org/10.1016/j.ctrv.2018.06.007>
- Otto, S., Tröltzsch, M., Jambrovic, V., Panya, S., Probst, F., Ristow, O., ... Pautke, C. (2015). Tooth extraction in patients receiving oral or intravenous bisphosphonate administration: A trigger for BRONJ development? *Journal of Cranio-Maxillo-Facial Surgery*, 43(6), 847–854. <https://doi.org/10.1016/j.jcms.2015.03.039>
- Panya, S., Fliefel, R., Probst, F., Troltsch, M., Ehrenfeld, M., Schubert, S., & Otto, S. (2017). Role of microbiological culture and polymerase chain reaction (PCR) of actinomycetes in medication-related osteonecrosis of the jaw (MRONJ). *Journal of Cranio-Maxillo-Facial Surgery*, 45(3), 357–363. <https://doi.org/10.1016/j.jcms.2017.01.006>
- Patel, S., Choyee, S., Uyanne, J., Nguyen, A. L., Lee, P., Sedghizadeh, P. P., ... Le, A. D. (2012). Non-exposed bisphosphonate-related osteonecrosis of the jaw: A critical assessment of current definition, staging, and treatment guidelines. *Oral Diseases*, 18(7), 625–632. <https://doi.org/10.1111/j.1601-0825.2012.01911.x>
- Patel, V., Mansi, J., Ghosh, S., Kwok, J., Burke, M., Reilly, D., ... Chia, K. (2018). MRONJ risk of adjuvant bisphosphonates in early stage breast cancer. *British Dental Journal*, 224(2), 74–79. <https://doi.org/10.1038/sj.bdj.2017.1039>
- Pimolbutr, K., Porter, S., & Fedele, S. (2018). Osteonecrosis of the jaw associated with antiangiogenics in antiresorptive-naïve patient: A comprehensive review of the literature. *BioMed Research International*, 2018, 1–14. <https://doi.org/10.1155/2018/8071579>

- Ristow, O., Rückschloß, T., Bodem, J., Berger, M., Bodem, E., Kargus, S., ... Freudlsperger, C. (2018). Double-layer closure techniques after bone surgery of medication-related osteonecrosis of the jaw—A single center cohort study. *Journal of Cranio-Maxillo-Facial Surgery*, 46(5), 815–824. <https://doi.org/10.1016/j.jcms.2018.03.005>
- Ristow, O., Rückschloß, T., Müller, M., Berger, M., Kargus, S., Pautke, C., ... Freudlsperger, C. (2019). Is the conservative non-surgical management of medication-related osteonecrosis of the jaw an appropriate treatment option for early stages? A long-term single-center cohort study. *Journal of Cranio-Maxillo-Facial Surgery*, 47(3), 491–499. <https://doi.org/10.1016/j.jcms.2018.12.014>
- Rugani, P., Luschin, G., Jakse, N., Kirnbauer, B., Lang, U., & Acham, S. (2014). Prevalence of bisphosphonate-associated osteonecrosis of the jaw after intravenous zoledronate infusions in patients with early breast cancer. *Clinical Oral Investigations*, 18(2), 401–407. <https://doi.org/10.1007/s00784-013-1012-5>
- Ruggiero, S. L., Dodson, T. B., Assael, L. A., Landesberg, R., Marx, R. E., & Mehrotra, B. (2009). American association of oral and maxillofacial surgeons position paper on bisphosphonate-related osteonecrosis of the jaw—2009 update. *Australian Endodontic Journal*, 35, 119–130.
- Ruggiero, S. L., Dodson, T. B., Fantasia, J., Goodday, R., Aghaloo, T., Mehrotra, B., ... Surgeons, A. A. o. O. a. M. (2014). American Association of Oral and Maxillofacial Surgeons position paper on medication-related osteonecrosis of the jaw—2014 update. *Journal of Oral and Maxillofacial Surgery*, 72(10), 1938–1956. <https://doi.org/10.1016/j.joms.2014.04.031>
- Saia, G., Blandamura, S., Bettini, G., Tronchet, A., Totola, A., Bedogni, G., ... Bedogni, A. (2010). Occurrence of bisphosphonate-related osteonecrosis of the jaw after surgical tooth extraction. *Journal of Oral and Maxillofacial Surgery*, 68(4), 797–804. <https://doi.org/10.1016/j.joms.2009.10.026>
- Schiodt, M., Reibel, J., Oturai, P., & Kofod, T. (2014). Comparison of non-exposed and exposed bisphosphonate-induced osteonecrosis of the jaws: A retrospective analysis from the Copenhagen cohort and a proposal for an updated classification system. *Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology*, 117(2), 204–213. <https://doi.org/10.1016/j.oooo.2013.10.010>
- Stockmann, P., Hinkmann, F. M., Lell, M. M., Fenner, M., Vairaktaris, E., Neukam, F. W., & Nkenke, E. (2010). Panoramic radiograph, computed tomography or magnetic resonance imaging. Which imaging technique should be preferred in bisphosphonate-associated osteonecrosis of the jaw? A prospective clinical study. *Clinical Oral Investigations*, 14(3), 311–317. <https://doi.org/10.1007/s00784-009-0293-1>
- Troeltzsch, M., Cagna, D., Stähler, P., Probst, F., Kaepler, G., Troeltzsch, M., ... Otto, S. (2016). Clinical features of peri-implant medication-related osteonecrosis of the jaw: Is there an association to peri-implantitis? *Journal of Cranio-Maxillo-Facial Surgery*, 44(12), 1945–1951. <https://doi.org/10.1016/j.jcms.2016.09.018>
- Vahtsevanos, K., Kyrgidis, A., Verrou, E., Katodritou, E., Triaridis, S., Andreadis, C. G., ... Antoniadis, K. (2009). Longitudinal cohort study of risk factors in cancer patients of bisphosphonate-related osteonecrosis of the jaw. *Journal of Clinical Oncology*, 27(32), 5356–5362. <https://doi.org/10.1200/JCO.2009.21.9584>
- Yamada, S.-I., Kurita, H., Kondo, E., Suzuki, S., Nishimaki, F., Yoshimura, N., ... Kamata, T. (2018). Treatment outcomes and prognostic factors of medication-related osteonecrosis of the jaw: A case- and literature-based review. *Clinical Oral Investigations*, 23(8), 3203–3211.
- Yarom, N., Fedele, S., Lazarovici, T. S., & Elad, S. (2010). Is exposure of the jawbone mandatory for establishing the diagnosis of bisphosphonate-related osteonecrosis of the jaw? *Journal of Oral and Maxillofacial Surgery*, 68(3), 705. <https://doi.org/10.1016/j.joms.2009.07.086>
- Yoneda, T., Hagino, H., Sugimoto, T., Ohta, H., Takahashi, S., Soen, S., ... Urade, M. (2010). Bisphosphonate-related osteonecrosis of the jaw: Position paper from the Allied Task Force Committee of Japanese Society for Bone and Mineral Research, Japan Osteoporosis Society, Japanese Society of Periodontology, Japanese Society for Oral and Maxillofacial Radiology, and Japanese Society of Oral and Maxillofacial Surgeons. *Journal of Bone and Mineral Metabolism*, 28(4), 365–383. <https://doi.org/10.1007/s00774-010-0162-7>

How to cite this article: Schiodt M, Otto S, Fedele S, et al. Workshop of European task force on medication-related osteonecrosis of the jaw—Current challenges. *Oral Dis*. 2019;25:1815–1821. <https://doi.org/10.1111/odi.13160>