

American Association of Oral and Maxillofacial Surgeons' Position Paper on Medication-Related Osteonecrosis of the Jaws—2022 Update



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Strategies for management of patients with, or at risk for, medication-related osteonecrosis of the jaws (MRONJ) – formerly referred to as bisphosphonate-related osteonecrosis of the jaws (BRONJ)—were set forth in the American Association of Oral and Maxillofacial Surgeons (AAOMS) position papers in 2007, 2009 and 2014. The position papers were developed by a committee appointed by the AAOMS Board of Trustees and comprising clinicians with extensive experience in caring for these patients, as well as clinical and basic science researchers. The knowledge base and experience in addressing MRONJ continues to evolve and expand, necessitating modifications and refinements to the previous position papers. Three members of the AAOMS Committee on Oral, Head, and Neck Oncologic and Reconstructive Surgery (COH-NORS) and three authors of the 2014 position paper were appointed to serve as a working group to analyze the current literature and revise the guidance as indicated to reflect current knowledge in this field. This update contains revisions to diagnosis and management strategies and highlights the current research status. AAOMS maintains that it is vitally important for this information to be disseminated to other relevant healthcare professionals and organizations.

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Medications prescribed for dental and medical conditions have potential side effects that warrant a **risk-benefit discussion**. Where therapeutic margins are

wide and complications are readily corrected, decisions are implemented in a straightforward fashion. Where therapeutic margins are wide but

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complications are significant, deciding to proceed with pharmacologic treatment becomes more challenging. In most cases of MRONJ, local therapies can be successful. The fact that more complex treatment is required for a few patients should not impact decision-making for all other patients with osteonecrosis of the jaws. The medications associated with MRONJ have proved to be safe and effective in clinical trials and postmarketing analyses for most patients and should continue as a mainstay therapy when indicated. Communicating the risks of MRONJ to patients and providers is critical to ensure appropriate medical management for the primary disease.

Undoubtedly, risk profiles may change as new medications come to market. In addition, our understanding of disease pathophysiology, risk modifiers, and treatment strategies will continue to evolve. It is of the utmost importance that clinicians base their patient treatment decisions on currently available scientific evidence.

Strategies for management of patients at risk for or with MRONJ were set forth in American Association of Oral and Maxillofacial Surgeons (AAOMS) Position Papers in 2007,¹ 2009,² and 2014.³ These position papers were developed by a committee appointed by the AAOMS Board of Trustees and comprised of clinicians with extensive experience in caring for these patients, as well as clinical and basic science researchers. The knowledge base and experience in addressing MRONJ continues to evolve and expand, necessitating modifications and refinements to the previously published position papers. A working group comprised of three members of the AAOMS Committee on Oral, Head, and Neck Oncologic and Reconstructive Surgery (COH-NORS) and three authors of the 2014 paper convened remotely in the fall of 2020 to appraise the current literature and revise the guidelines as indicated to reflect the current knowledge in this field. This update contains revisions to the pathogenesis and management strategies and highlights the current research status. AAOMS maintains it is vitally important for this information to be disseminated to other relevant healthcare professionals and organizations.

Purpose

The purpose of this position paper is to provide updates regarding:

1. Risk estimates for developing MRONJ.
2. Comparisons of the risks and benefits of medications related to osteonecrosis of the jaw in order to facilitate medical decision-making for the treating physician, dentist, dental specialist, and patient with the establishment of algorithms.

3. Guidance to clinicians regarding:
 - a. The differential diagnosis of MRONJ in patients with a history of exposure to antiresorptive medications.
 - b. MRONJ prevention measures and management strategies for patients with MRONJ based on the disease stage.

Medications

Bisphosphonates (BPs) are antiresorptive medications that are effective in managing cancer-related conditions, including hypercalcemia of malignancy, spinal cord compression, and pathologic fractures (skeletal-related events [SREs]) associated with bone metastases in the context of solid tumors (such as breast, prostate, and lung cancers) and multiple myeloma.⁴⁻¹³ While the potential for BPs to improve cancer-specific survival remains controversial, these medications have had a significant positive effect on the quality of life for patients with advanced cancer involving the skeleton and reducing or preventing skeletal-related events.

Bisphosphonates also are used for the prevention of osteoporosis-related fractures (fragility fractures) in patients with osteoporosis and osteopenia.¹⁴⁻¹⁶ BPs administered orally—including alendronate (Fosamax®), risedronate (Actonel®) or parenterally (zoledronic acid [Reclast®]), and ibandronate (Boniva®)—can result in a significant reduction in vertebral and nonvertebral fractures for patients with osteoporosis.¹⁷⁻²⁰

Bisphosphonate therapy also is indicated for other metabolic bone diseases such as Paget's disease of bone and osteogenesis imperfecta.²¹⁻²³ However, clinical trials have not demonstrated the efficacy of bisphosphonate therapy in the management of fibrous dysplasia.²⁴

Denosumab (DMB), a receptor activator of nuclear factor kappa-B ligand (RANK-L), is an antiresorptive agent that exists as a fully humanized antibody against RANK ligand and inhibits osteoclast function and associated bone resorption. When denosumab (Prolia®) is administered subcutaneously every 6 months, there is a significant reduction in the risk of vertebral, nonvertebral, and hip fractures in osteoporotic patients.²⁵⁻²⁸ Denosumab (Xgeva®) also is effective in reducing SREs related to metastatic bone disease from solid tumors when administered monthly.²⁹⁻³¹

RANK ligand inhibitors also have proven efficacy in the treatment of giant cell tumors of bone and fibrous dysplasia.³²⁻³⁶ In contrast to BPs, RANK-L inhibitors do not bind to bone, and their effects on bone remodeling are mostly diminished within 6 months of treatment cessation.

Romosozumab is a new monoclonal antibody used for fracture prevention in osteoporotic women. Romosozumab, administered subcutaneously, works via the Wnt pathway by binding to and inhibiting sclerostin, resulting in increased bone formation and decreased bone resorption.³⁷

MRONJ Case Definition

MRONJ should be distinguished from other forms of osteonecrosis (ONJ) conditions and identified by history and clinical exam. The clinical criteria required to establish a diagnosis of MRONJ have remained unchanged from the previous position paper.³

The case definition of MRONJ includes all the following elements:

1. Current or previous treatment with antiresorptive therapy alone or in combination with immune modulators or antiangiogenic medications.
2. Exposed bone or bone that can be probed through an intraoral or extraoral fistula(e) in the maxillofacial region that has persisted for more than 8 weeks.
3. No history of radiation therapy to the jaws or metastatic disease to the jaws.

Staging

A staging system for MRONJ was introduced in the 2009 AAOMS position paper and then modified in the 2014 position paper to characterize more accurately all aspects of the clinical presentation of MRONJ. Since these modifications, the AAOMS staging system has continued to be a straightforward and relevant system to properly stratify these patients. It has been adopted by several professional societies and research organizations. The staging system facilitates the creation of rational treatment guidelines and guides data collection to assess the prognosis and outcomes for MRONJ patients. While AAOMS recognizes that different classification systems are being used by other organizations,³⁸ the Association considers the AAOMS system to be a useful and widely implemented assessment tool guiding clinicians involved in the care of MRONJ patients.

AAOMS remains concerned that over-emphasizing **variable radiographic features** often attributed to MRONJ may overestimate the true disease frequency by including **false positives** in the numerator (eg, cases with radiographic findings suggestive of MRONJ), but these patients do not fit the criteria for the diagnosis of MRONJ.

In the **orthopedic literature**, the usefulness of a **Stage 0 category** has been established for staging **avascular necrosis (AVN) of the femoral head** when there is a suspicion of AVN in a patient at risk, but the diagnostic information is not conclusive.³⁹

AAOMS believes the **Stage 0 category for MRONJ is analogous in principle** and does account for the wide-ranging **radiographic presentation of MRONJ that exists prior to overt bone exposure**. Therefore, AAOMS has decided to maintain the current classification system with no modifications.

PATIENTS AT-RISK

No apparent necrotic bone in asymptomatic patients who have been treated with IV or oral antiresorptive therapy.

STAGE 0 (NONEXPOSED BONE VARIANT)

Patients with no clinical evidence of necrotic bone but who present with nonspecific symptoms or clinical *and* radiographic findings, such as:

Symptoms

- Odontalgia not explained by an odontogenic cause.
- Dull, aching bone pain in the jaw, which may radiate to the temporomandibular joint region.
- Sinus pain, which may be associated with inflammation and thickening of the maxillary sinus wall.
- Altered neurosensory function.

Clinical Findings

- Loosening of teeth not explained by chronic periodontal disease.
- Intraoral or extraoral swelling.

Radiographic Findings

- Alveolar bone loss or resorption not attributable to chronic periodontal disease.
- Changes to trabecular pattern sclerotic bone and no new bone in extraction sockets.
- Regions of osteosclerosis involving the alveolar bone and/or the surrounding basilar bone.
- Thickening/ obscuring of periodontal ligament (thickening of the lamina dura, sclerosis, and decreased size of the periodontal ligament space).

⁴⁰

These nonspecific findings, which characterize this variant of MRONJ without bone exposure, may occur in patients with a prior history of Stage 1, 2, or 3 disease who have been healed and have no clinical evidence of exposed bone. Progression to Stage 1 disease has been reported in up to 50 percent of patients with Stage 0 disease⁴¹ and, therefore, AAOMS deems it prudent to consider Stage 0 disease as a potential precursor to MRONJ.

STAGE 1

Exposed and necrotic bone or fistula that probes to the bone in patients who are asymptomatic and have no evidence of infection/inflammation. These patients also may present with radiographic findings mentioned for Stage 0 that are localized to the alveolar bone region.

STAGE 2

Exposed and necrotic bone, or fistula that probes to the bone, with evidence of infection/inflammation. These patients are symptomatic. These patients also may present with radiographic findings mentioned for Stage 0 localized to the alveolar bone region.

STAGE 3

Exposed and necrotic bone or fistulae that probes to the bone, with evidence of infection, and one or more of the following:

- Exposed necrotic bone extending beyond the region of alveolar bone (ie, inferior border and ramus in the mandible, maxillary sinus, and zygoma in the maxilla)
- Pathologic fracture.
- Extraoral fistula.
- Oral antral/oral-nasal communication.
- Osteolysis extending to the inferior border of the mandible or sinus floor.

CAUSALITY

It is important to understand that patients at risk for or with established MRONJ also can present with other common clinical conditions not to be confused with MRONJ. Commonly misdiagnosed conditions may include but are not limited to alveolar osteitis, sinusitis, gingivitis/periodontitis, caries, periapical pathology, odontalgia, atypical neuralgias, fibro-osseous lesions, sarcoma, chronic sclerosing osteomyelitis, and temporomandibular joint (TMJ) disorders. It also is important to remember that delayed healing, exposed bone or sequestra (ie, osteonecrosis [ONJ]), can occur in patients not exposed to antiresorptive agents.⁴²

Proving causality of any medication-related complication is challenging from an epidemiologic perspective. It is well-known that MRONJ is a rare entity, multifactorial in nature, and patients with the same clinical presentation exist who have not been exposed to an antiresorptive medication. Studies have reported

jaw necrosis in antiresorptive naïve patients in which necrosis was linked to bacterial, viral, or fungal infections, trauma, smoking, steroids, immunocompromised host, autoimmune diseases, diabetes, and chemotherapy.⁴³⁻⁵⁷ Furthermore, patient populations, such as those with osteogenesis imperfecta have been treated with antiresorptive agents without reports of MRONJ.⁵⁸ Many patients receiving medications associated with MRONJ have other comorbidities, which are likely exacerbating or contributing factors. In combination, these confounding variables make incidence and prevalence difficult to estimate.

Clinical trials, while being the gold standard for efficacy and safety data, are seldom powered to demonstrate uncommon events. Prior to the discovery of MRONJ, large randomized prospective trials of BPs with up to 10 years of patient data did not reveal any jaw bone necrosis as a complication.^{17,59} More recently, the HORIZON Pivotal Fracture trial tested 3,889 randomized patients given annual zoledronic acid versus placebo for 3 years; one patient developed MRONJ in the intervention group and one in the placebo group.¹⁸ Extension of this trial for up to 6 years resulted in one additional MRONJ patient in the treatment group.⁶⁰ Extension to 9 years resulted in no additional confirmed cases of MRONJ.⁶¹

Definitive causality, taken as a whole, remains a difficult task to prove in general, let alone in individual patients presenting with clinical symptoms. Clinicians should be aware of these facts in decisions regarding treatment recommendations.

PATHOPHYSIOLOGY

Since the AAOMS position paper in 2014, significant knowledge has been gained regarding MRONJ pathophysiology from both clinical and particularly preclinical animal studies. It should be noted that animal studies have a number of limitations, are most often using supratherapeutic doses and likely do not truly mirror the clinical environment. That said, they are critical in understanding disease mechanisms and can serve as one reference point to evidence-based clinical decision-making.

Much debate persists among clinicians and researchers, contributing to the various treatment protocols utilized for patients today.⁶²⁻⁶⁵ Disease specificity unique to the jaws has focused leading hypotheses to include bone remodeling inhibition, inflammation or infection, angiogenesis inhibition, innate or acquired immune dysfunction, as well as genetic predisposition.^{3,65} Both animal and human studies suggest that an antiresorptive medication, coupled with inflammation or infection, is necessary and

sufficient to induce MRONJ. However, as more knowledge is gained on the subject, it is becoming increasingly apparent that MRONJ is multifactorial, and it is likely that multiple hypotheses can explain the overall pathophysiology of this disease.^{3,65}

Bone Remodeling Inhibition

The definition of MRONJ includes oral or parenteral administration of antiresorptive medications, such that bone remodeling suppression is a central hypothesis in its pathophysiology. Antiresorptive medications, including BPs and denosumab (DMB), have direct effects on osteoclast formation, differentiation, or function. In osteoporosis, BPs are a first-line therapy to decrease bone remodeling, increase bone mineral density, and decrease vertebral and long bone fractures.^{66,67} BPs, in higher doses, also are utilized in primary bone malignancy and bone metastases to decrease SREs, including hypercalcemia of malignancy, reduce severe bone pain, and improve quality of life.⁶⁸⁻⁷² Although DMB has only been approved for use since 2010, its use has increased significantly for both osteoporosis and malignancy in the last decade. Prevalence of MRONJ with DMB users is at least as high as BP users, likely due to its increased potency to inhibit bone resorption.^{30,73-75} This is supported in the jaws as animal studies demonstrate absent osteoclasts around the alveolar bone of DMB-treated mice.⁷⁶ Human bone specimens also show an increased number of nonfunctional osteoclasts surrounding necrotic bone in BP-treated patients,⁷⁷ further reinforcing bone remodeling inhibition as a leading hypothesis in MRONJ pathophysiology. With the appearance of MRONJ in DMB-treated patients, it becomes increasingly apparent that the underlying pathophysiology involves dysfunctional osteoclasts.

Animal studies evaluating withdrawal of BPs or DMB further highlight the importance of bone remodeling in MRONJ prevention and resolution. Rodents with established ONJ failed to resolve when antiresorptive were withdrawn. However, discontinuing DMB, but not BPs, prior to tooth extraction successfully prevented MRONJ development in rats.^{78,79} Moreover, parathyroid hormone, which acts directly on osteoblasts to induce bone formation and indirectly increases osteoclastic bone resorption and overall remodeling, has been shown to prevent MRONJ and improve extraction socket healing in rodents and preliminarily in patients.⁸⁰⁻⁸² This observation provides further support for the central role of osteoclast inhibition in MRONJ pathogenesis.

Inflammation or Infection

Although most studies report tooth extraction as the major inciting event for MRONJ development, it is clear that most extracted teeth had pre-existing peri-

odontal or periapical disease.^{3,64,83,84} From this patient information, animal models of inflammation or infection were developed to replicate clinical, radiographic, and histologic features of MRONJ.⁸⁵⁻⁸⁸ Presence of inflammatory cytokines, specifically at the site of MRONJ, also support the strong role of inflammation.⁸⁹ As evidence of increased systemic inflammation and its contribution to MRONJ development, mice with experimentally induced rheumatoid arthritis demonstrated more severe MRONJ with increased oral bone exposure, more pronounced radiographic features, intense local inflammatory infiltrate, and larger areas of histologic necrosis.⁹⁰ Further support for the inflammatory etiology showed that removal of the inflammatory nidus in ligature-induced periodontitis ameliorated MRONJ development in mice, demonstrating reduced inflammation and prevention of disease progression.⁹¹ Moreover, transplantation of peripheral blood mononuclear cells with anti-inflammatory properties reduced MRONJ prevalence by improving soft-tissue healing, decreasing inflammatory polymorphonuclear cells and inflammatory marker expression, as well as enhancing vascularity.⁹² These preclinical findings confirm the irrefutable role of inflammation or infection in MRONJ disease prevalence, severity and resolution.

The presence of bacteria on the exposed necrotic bone also contributes to disease severity, where pain and signs of infection define Stage 2 MRONJ.^{3,93,94} This is not surprising since poor oral hygiene and biofilm presence are associated with MRONJ development,^{95,96} and oral health maintenance and dental prophylaxis before initiating antiresorptive therapy can decrease MRONJ prevalence.^{97,98} Importantly, clinical treatment protocols to reduce the biofilm and eradicate infection have emerged as important alternatives to debridement and resection in patients who may not be ideal surgical candidates.⁶³

Angiogenesis Inhibition

Osteonecrosis is traditionally defined as avascular necrosis or aseptic necrosis, most commonly characterized as osteocyte death after decreased blood flow to the femoral head.⁹⁹ However, MRONJ is defined as necrotic bone in the maxillofacial region after exposure to either antiresorptive or antiangiogenic medications.³ BPs such as zoledronic acid directly inhibit angiogenesis in vitro and in vivo¹⁰⁰⁻¹⁰³ and animal models demonstrate decreased vascularity in sites of MRONJ and decreased microvessel numbers during early stages of bone healing.¹⁰⁴ In addition, angiogenesis normally seen during extraction socket healing is inhibited by BPs, and both BPs and DMB have been shown to decrease arterial area, venous area, and overall vascularity of periodontal tissues during

early and late MRONJ development.^{105,106} Importantly, antiangiogenic medications, such as VEGF inhibitors, tyrosine kinase receptor inhibitors, and immunomodulatory drugs,¹⁰⁷⁻¹⁰⁹ can be associated with MRONJ. Moreover, patients with multiple myeloma receiving both antiresorptive and antiangiogenic medications, as shown in several studies,¹¹⁰⁻¹¹⁴ have a higher MRONJ prevalence. Important aspects of MRONJ treatment include determining disease margins, which can be challenging as microvascular mucosal abnormalities can be seen adjacent to frank MRONJ lesions.¹¹⁵ It is important to note that the incidence of MRONJ in patients on antiangiogenics is much lower than those taking antiresorptive medications.

Innate or Acquired Immune Dysfunction

Although animal studies confirm that an antiresorptive medication—coupled with inflammation or infection—is necessary and sufficient to produce MRONJ, not all patients with dental infections develop the disease. It is well-known that patients with medical comorbidities such as diabetes or rheumatoid arthritis or immunocompromised states are at significantly higher risk for MRONJ with or without exposure to antiresorptive agents.^{3,64,114,116} Patients with metastatic or primary bone malignancies have a compromised immune system.¹¹⁷ This also has been confirmed with animal studies, where chemotherapy, steroids, and disease-modifying antirheumatic drugs (DMARDs), combined with antiangiogenic medications and an antiresorptive, increase MRONJ severity or prevalence.¹¹⁸⁻¹²⁰ Moreover, higher rates of MRONJ occur in patients with multiple myeloma who receive multiple chemotherapeutic agents.^{110,121}

Replenishing the area of nonhealing MRONJ lesions with mesenchymal stem cells (MSCs) to overcome immune dysfunction is a potential area of therapeutic interest, especially in patients who are immunocompromised. A recent study showed altered numbers and patterns of T-cells in human and rat MRONJ necrotic bone samples as compared to healthy patients and non-MRONJ sites.¹²² Preclinical studies also demonstrate healing or prevention of MRONJ lesions after systemic infusion with adipose or bone marrow-derived MSCs.¹²³⁻¹²⁵

Genetic Factors

In the 2014 paper, the authors identified several reports describing single-nucleotide polymorphisms (SNPs) that were associated with the development of MRONJ. Most of these SNPs were located within regions of the gene associated with either bone turnover, collagen formation, or certain metabolic bone diseases. Indeed, increasing evidence is available to support the role of SNPs with MRONJ.^{126,127} Specific

links to sirtuin-1 (SIRT1), a bone remodeling regulator that promotes bone formation, may be protective against MRONJ if upregulated.¹²⁸ SIRT1 also is involved in both reduction of inflammation and induction of angiogenesis, suggesting a role in several of the leading MRONJ hypotheses.¹²⁸ Other genes also have been reported to increase MRONJ risk through their role in angiogenesis, bone remodeling, and immune responses, including PPAR gamma, CYP2C8, and many others.¹²⁹ Collectively, these studies suggest that MRONJ is a multifactorial disease and that genetic factors may play a role in its development.¹³⁰ Overall, however, current studies document either a weak or no association between genetic factors measured and risk for MRONJ.¹³¹ To determine predisposition, studies with larger sample sizes should be performed, with genetic risks confirmed in both BPs and DMB-treated patients who have breast or prostate cancer metastases, multiple myeloma, or osteoporosis.

Risk Factors for MRONJ

MEDICATION-RELATED RISK FACTORS

To estimate the risk for medications associated with MRONJ, the primary parameter to be considered is the therapeutic indication for treatment (eg, malignancy or osteoporosis/osteopenia). The data suggest that antiresorptive medications (ie, BPs and DMB) are associated with an increased risk for developing MRONJ. The risk of MRONJ is considerably higher in the malignancy group (<5%) than in the osteoporosis group (<0.05%). Current data are insufficient to identify other medications as risk factors for developing MRONJ.

MRONJ risk among cancer patients

For estimating the risk for MRONJ among patients exposed to a medication, the risk for MRONJ in patients *not exposed* to antiresorptive medications must be estimated (Table 1). The risk for MRONJ among cancer patients enrolled in clinical trials and assigned to *placebo* groups ranges from 0 percent to 0.7 percent.¹³²⁻¹³⁸

- Among cancer patients exposed to zoledronate, the cumulative risk of MRONJ clusters in the low single digits, <5 percent, and ranges from 0 percent to 18 percent.^{113,132,133,137-144} The wide variation in estimates may be explained by the varying durations of follow-up, one to 10 years, reported in the various studies. The risk of MRONJ among cancer patients exposed to zoledronate ranges between 2-10 times higher than cancer patients treated with placebo.
- Among cancer patients exposed to DMB, the risk of MRONJ ranges from 0 percent to 6.9 percent, with most studies reporting rates <5

Table 1. MRONJ DISEASE FREQUENCY GROUPED BY INDICATIONS FOR TREATMENT VERSUS MEDICATION*

Indications for Treatment	Medication					Study Design
	Placebo	Zoledronate	Oral BPs	Denosumab	Romosozumab	
Malignancy						
Coleman (2020) ¹³⁸	0.2% (2,218)*			5% (2,241)		RCT [†]
O'Carrigan et al, (2017) ¹³⁷	0.7% (6,788)			0.4% (6,788)		Systematic review
O'Carrigan et al, (2017) ¹³⁷	0% (3,060)	1% (3,078)				Systematic review
Macherey et al, (2017) ¹³⁶	0.7% (818)	1.5% (808)				Systematic review
Gnant et al, (2015) ²⁴⁷	0% (903)	0% (900)				RCT
Coleman et al, (2014) ¹³³	0% (1,679)	1.7% (1,681)				RCT
Valachis et al, (2013) ¹³²	0% (3,039)	0.52% (4,774)				Systemic review
Boquete-Castro et al, (2016) ¹³⁵	0.1%	1.14%		1.7%		Systematic review
Coleman (2020) ¹³⁸	0.2% (2,218)			5.4% (2,214)		RCT
Gnant et al, (2015) ²⁴⁷	0% (1,709)			0% (1,711)		RCT
Raje et al, (2018) ¹¹³		2.8% (82)		4.1% (850)		RCT
Himmelstein (2017) ¹⁴⁰		1.5% (1,822)				RCT
Henry (2014) ¹⁴¹		1.1% (786)		0.8% (792)		RCT
Yang et al, (2019) ²⁴⁸		2% (8,525)				Systematic review
Peddi et al, (2013) ¹⁴²		1.3% (2,846)		1.8% (2,885)		Systematic review
Ng et al, (2021) ¹⁴⁵		1.6-4% [‡] 3.8-18% [§]		1.9% [‡] 6.9% [§]		Systematic review
Wang et al, (2014) ¹⁴⁴		1.4% (1,013)		2% (1,020)		Systematic review
Osteoporosis						
Papapoulos et al, (2012) ²⁶	0% (3,383)			0.04% (4,549)		RCT
Grbic et al, (2010) ¹⁵⁰	0.02% (4,945)	0.02% (5,864)				Systematic review
Cosman et al, (2016) ¹⁵¹	0% (3,322)				0.03% (3,321)	RCT
Saag et al, (2017) ³⁷			0.05% (2,047)		0.05% (2,046)	RCT
Bone et al, (2017) ¹⁵³				0.3% (2,343) 10-yr f/u		RCT
Hallmer et al, (2018) ⁷⁵			0.043%			Population study (50,000)
Nonmalignant bone disease						
Chawla et al, (2019) ¹⁵⁶				5% (532)		Prospective case series
Rutkowski ¹⁵⁵				0.7% (138)		Retrospective case series

* Sample size in parentheses

† Randomized clinical trial.

‡ <2 years of follow-up.

§ >2 years of follow-up.

percent.^{113,134,135,138,141,142,144,145} The risk for MRONJ among cancer patients exposed to DMB is comparable to the risk of MRONJ in cancer patients exposed to zoledronate.^{135,141,142,144,145}

Since the 2014 update, investigators have implicated numerous families of medications as risk factors for MRONJ.¹⁴⁶⁻¹⁴⁹ These medications include tyrosine kinase inhibitors (TKIs) such as sunitinib, monoclonal antibodies (bevacizumab), fusion proteins (afibercept), mTOR inhibitors (everolimus), radiopharmaceuticals (radium 223), selective estrogen receptor modulators (raloxifene), and immunosuppressants (methotrexate and corticosteroids).

When compared to antiresorptive medications, the level of evidence supporting other medication families as risk factors for MRONJ is level 5 (eg, isolated case reports or mini-case series [<5 cases]).¹⁴⁶⁻¹⁴⁹ Given that the poly-pharmaceutical management of cancer patients combined with the fact that cancer and immunosuppression are risk factors for MRONJ without exposure to antiresorptive agents, AAOMS believes that identifying a single medication as being the etiologic agent for MRONJ seems unlikely in case reports or mini-case series. Further controlled prospective studies will be required to measure the risk of MRONJ associated with non-antiresorptive agents.

MRONJ Risk Among Osteoporosis Patients

Most dentists and oral and maxillofacial surgeons evaluate patients in their practices exposed to antiresorptive therapy for management of osteoporosis (Table 1).

a. Risk for MRONJ among osteoporotic patients exposed to BPs.

The risk of MRONJ among study subjects assigned to placebo groups enrolled in osteoporosis clinical trials ranged from 0 percent to 0.02 percent.^{26,150,151} Among study subjects treated with BPs, the risk of MRONJ is 0.02 percent to 0.05 percent.^{37,75,152} Among patients exposed to IV zoledronate, the risk for MRONJ is estimated to be $\leq 0.02\%$ (≤ 2 per 10,000). For patients exposed to oral bisphosphonates, MRONJ risk is estimated to be $\leq 0.05\%$ (≤ 5 per 10,000).

b. MRONJ risk among osteoporotic patients exposed to RANK-L inhibitors.

After 10 years of follow-up, among patients exposed to DMB, the risk for MRONJ was reported to be 0.3 percent, almost an order of magnitude higher than for BPs.¹⁵³

c. The risk for MRONJ when exposed to romosozumab (0.03 percent to 0.05 percent) is comparable to alendronate (0.05 percent).^{37,151} In the placebo group, there were no cases of MRONJ.¹⁵¹ It will be important to continue to monitor romosozumab to assess its role as a risk factor for MRONJ.

The risk for MRONJ among osteoporosis patients treated with BPs ranges from 0.02 percent to 0.05 percent and overlaps the risk for MRONJ of patients enrolled in placebo groups (0 percent to 0.02 percent). The risk for MRONJ among patients treated with denosumab, however, has a larger range—from 0.04 percent to 0.3 percent. As such, additional research will be needed to better estimate the risk of MRONJ among patients receiving denosumab. The risk of MRONJ for patients exposed to romosozumab (0.03 percent to 0.05 percent) more closely aligns with the risk associated with BPs.^{37,151} However, given its recent introduction as a therapeutic agent, additional research will be needed to refine its association and risk estimate for MRONJ.

Based on this current review of data, the risk of developing MRONJ among osteoporotic patients exposed to BPs, DMB, and romosozumab is low. The occurrence of cases seen is best explained by a rare event among a large number of patients, 5.1 million over the age of 55, exposed to these drugs.¹⁵⁴

MRONJ Risk Among Patients with Nonmalignant Bone Disease

a. AAOMS identified two studies where DMB was used to manage aggressive giant cell tumors of bone.^{155,156} The risk of developing MRONJ in the two studies was broad and ranged from 0.7 percent to 5 percent. This is comparable to the risks of developing MRONJ in subjects treated with DMB for malignancies (range = 0 percent to 6.9 percent). Additional studies will be needed to confirm the risk estimate for MRONJ among patients with nonmalignant bone disease treated with antiresorptives.

b. There are very limited data describing the occurrence of MRONJ in the pediatric population for osteogenesis imperfecta and other conditions. In a systematic review estimating the risk of MRONJ among children with osteogenesis imperfecta, there were no cases of MRONJ identified in a sample of 486 subjects treated for 4.5 to 6.8 years.¹⁵⁷ In a different systematic review that estimated the risk for MRONJ among those under the age of 24 for several conditions treated using BPs, no cases of MRONJ were reported.¹⁵⁸

The overall quality of the studies included in both systematic reviews was limited by small sample sizes or lack of MRONJ-related risk factors.

Duration of Medication Therapy as a Risk Factor for MRONJ

Regardless of indications for therapy, the *duration of antiresorptive therapy* is a risk factor for developing MRONJ. Among cancer patients exposed to zoledronate or DMB (n = 5,723), the risk of developing MRONJ was, respectively, 0.5 percent and 0.8 percent at 1 year, 1.0 percent and 1.8 percent at 2 years, and 1.3 percent and 1.8 percent at 3 years.¹⁴¹ In a study by Saad et al, the investigators combined three-blinded phase three trials and found similar results, including a plateau after 2 years for patients exposed to DMB.⁵ In a more recent systematic review by Ng et al, the risk of MRONJ among cancer patients treated with zoledronate, was 1.6 percent to 4 percent after 2 years of treatment and 3.8 percent to 18 percent with more than 2 years of treatment.¹⁴⁵ Likewise, for DMB, the risks for developing MRONJ were 1.9 percent and 6.9 percent with <24 months and >24 months of exposure, respectively.¹⁴⁵

For patients receiving bisphosphonate therapy to manage osteoporosis, data regarding duration are mixed. Early on, the prevalence of MRONJ was reported as increasing over time from near 0 percent at baseline to 0.21 percent after four or more years of BP exposure based on retrospective analysis.^{152,159} More recent data from a large prospective, randomized placebo controlled trial demonstrate no significant increase in MRONJ in patients treated for up to 9 years.^{18,60,61} In addition, there are no postmarketing data or general clinical experience to support an MRONJ prevalence of 0.21 percent in any osteoporosis-treated group. Therefore, while duration may be a risk factor, the overall risk remains low.

LOCAL FACTORS

Dentoalveolar Operations

Dentoalveolar operations are the most common identifiable predisposing factor for developing MRONJ. Several studies report that among patients with MRONJ, tooth extraction is cited as a predisposing event ranging from 62 percent to 82 percent.^{5,75,160} While this information is important, it is not what most patients or clinicians want to know. Most providers and patients want an answer to the following clinical question: "Among patients exposed to antiresorptive medications, what is the risk for developing MRONJ following tooth extraction (or other dentoalveolar procedures such as implant placement or periodontal procedures)?" Cur-

rent estimates for the risk of MRONJ among osteoporotic patients exposed to BPs following tooth extraction range from 0 percent to 0.15 percent.^{161,162} For osteoporotic patients exposed to DMB, the risk for MRONJ following tooth extraction was 1 percent.¹⁶³

For cancer patients exposed to BPs, the risk of developing MRONJ after tooth extraction ranges from 1.6 percent to 14.8 percent.¹⁶⁴⁻¹⁶⁶ In a small case series, n = 61 subjects having 102 extractions, the risk for MRONJ after tooth extraction was 13.1 percent.¹⁶⁷ In a systematic review by Gaudin et al, the risk for MRONJ after tooth extraction (n = 564) was estimated to be 3.2 percent.¹⁶² While the estimates for developing MRONJ in high-risk patients undergoing tooth extraction vary, they cluster between 1 percent and 5 percent, similar to estimates of osteoradionecrosis following tooth extraction in irradiated patients.

The risk of developing MRONJ among patients who have been exposed to antiresorptive medications for other dentoalveolar operations such as dental implant placement and endodontic or periodontal procedures is unknown.¹⁶⁸ The risk for MRONJ after implant placement among patients treated with DMB has been reported to be 0.5 percent.¹⁶³ Absent better data, AAOMS cautions the use of these procedures in cancer patients exposed to antiresorptive therapies and recommends osteoporosis patients be informed of potential risks, albeit low, including development of MRONJ, early and late implant failure all of which have been described in case reports and clinical trials.

Anatomic Factors

Limited new information regarding anatomic risk factors for MRONJ is available. MRONJ is more likely to appear in the mandible (75 percent) than the maxilla (25 percent) but can appear in both jaws (4.5 percent).^{5,75} Denture use was associated with an increased risk for MRONJ among cancer patients exposed to zoledronate (OR = 4.9; 95 percent CI = 1.2 to 20.1).¹⁶⁹ In a study by Vahtsevanos et al, a sample of 1,621 cancer patients treated with intravenous zoledronate, ibandronate or pamidronate, there was a two-fold increased risk for MRONJ among denture wearers.¹⁷⁰

Concomitant Oral Disease

Pre-existing inflammatory dental disease such as periodontal disease or periapical pathology is cited as a risk factor.^{75,168} Among cancer patients with MRONJ, the pre-existing inflammatory dental disease was a risk factor among 50 percent of the cases.^{5,165}

Given that a common treatment of inflammatory dental disease is tooth extraction, pre-existing dental disease may confound the relationship between tooth

extraction and risk for MRONJ. Tooth extraction may expose MRONJ as opposed to being the precipitating event. It would be valuable to see an estimate of the association between tooth extraction and MRONJ adjusted for pre-existing inflammatory dental disease.

After tooth extraction and periodontal disease, the next most common risk factor is reported as “spontaneous” MRONJ with no identifiable dental risk factor.¹⁶⁸

DEMOGRAPHIC AND SYSTEMIC FACTORS AND OTHER MEDICATIONS

Age and sex are variably reported as risk factors for MRONJ.^{5,165,169-171} The higher prevalence of MRONJ in the female population is likely a reflection of the underlying disease for which the agents are being prescribed (eg, osteoporosis, breast cancer).

As noted previously, those under the age of 24 treated with antiresorptives for benign bone diseases have not demonstrated any risk for MRONJ even after an extended duration of therapy. The overall quality of the studies included even in systematic reviews is based on small sample sizes and the lack of other MRONJ-related risk factors. The risk of developing MRONJ in the pediatric population requires continued surveillance.

Corticosteroids are associated with an increased risk for MRONJ.^{5,168,171} There are concerns that corticosteroids increase the risk for MRONJ when given in conjunction with antiresorptive agents.

Comorbid conditions are inconsistently reported to be associated with an increased risk for MRONJ, including anemia (hemoglobin < 10 g/dL) and diabetes.^{5,171} Cancer type also is variably reported as a risk factor.^{170,172}

Tobacco use is variably reported as a risk factor for MRONJ. In a case-control study, tobacco use approached statistical significance as a risk factor for MRONJ in cancer patients (OR = 3.0; 95 percent CI = 0.8 to 10.4).¹⁶⁹ In a more recent case-controlled study, tobacco use was not associated with ONJ in a sample of cancer patients exposed to zoledronate.¹⁷¹ Vahtsevanos did not report an association between tobacco use and MRONJ.¹⁷⁰

In brief, after chemotherapy and corticosteroid exposure, the next most reported comorbidity is “no comorbidity.”¹⁶⁸

In summary, the current literature reaffirms that the risk of MRONJ is significantly greater in cancer patients receiving antiresorptive therapy compared to patients receiving antiresorptive therapy for osteoporosis. Moreover, the risk of MRONJ in osteoporosis patients receiving antiresorptive therapy continues to be very low regardless of drug type (BPs, DMB, romoszumab) or dosing schedule.

Management Strategies

TREATMENT GOALS

The major goals of treatment for patients at risk of developing or who have established MRONJ are:

- Prevention of MRONJ (see section [MRONJ risk among cancer patients](#) below).
- Prioritization and support of continued oncologic treatment in patients receiving antiresorptive therapy alone or in combination with immune modulators or antiangiogenic medications:
 - Oncology patients benefit from the therapeutic effect of antiresorptive therapy by controlling bone pain and reducing the incidence of other SREs.
- Prioritization and support of continued bone health and the prevention of fragility fractures
 - Patients with osteoporosis, osteopenia, and other metabolic bone diseases benefit from antiresorptive therapy by significantly reducing the risk of fragility fractures and other skeletal-related events.
- Preservation of quality of life through:
 - Patient education and reassurance.
 - Control of pain.
 - Control of secondary infection.
 - Prevention of extension of lesion and development of new areas of necrosis.

PREVENTION OF MRONJ

Numerous studies demonstrate potentially modifiable factors for reducing the risk of MRONJ, including performing high-risk surgical procedures prior to initiating therapy,^{95,173-175} using preoperative and postoperative antibiotics and antimicrobial mouth rinses,^{174,176-180} primarily closing extractions sites,¹⁷⁶⁻¹⁷⁸ and maintaining good oral hygiene.^{95,166,176,177,181} Maximizing overall patient health is always indicated, such as smoking cessation and diabetes optimization. Although no individual strategy nor collection of strategies eliminates all MRONJ risks, these preventive procedures are recommended.

The prevention of MRONJ begins with the realization that patients receiving antiresorptive therapies may have altered osseous wound-healing capacity, which may also be a risk for developing MRONJ. Similar to other common preventive strategies in medicine and dentistry, healthcare providers need to recognize the importance of coordinated dental care and pretreatment management in minimizing the risk of MRONJ. This requires a continuous effort to educate patients, dentists, and medical professionals

about the real risks associated with these therapies and clinical prevention paradigms that can mitigate MRONJ development.

AAOMS re-emphasizes the importance of a multidisciplinary approach to the treatment of patients who are receiving antiresorptive therapies. This may also apply to other immune modulators or targeted therapies taken alone or in combination with antiresorptives. This approach includes consultation with an appropriate dental professional when it is determined a patient would benefit from these therapies.

Optimization of Oral Health

The 2014 AAOMS position paper identified valid prophylactic treatment strategies that reduce the incidence of MRONJ. The efficacies of these strategies remain validated by subsequent studies that demonstrate the importance of pretreatment dental screening and regimented dental surveillance. There is a robust level of support for early screening and initiation of appropriate dental care prior to the initiation of antiresorptive therapy.^{38,182-186}

These preventive management strategies not only decrease the risk for MRONJ but accrue the benefits that all patients enjoy with optimum oral health.¹⁸⁶⁻¹⁹³

In a prospective study of prostate cancer patients with bone metastasis, instituting a more regimented dental health surveillance system resulted in a 2.5-fold reduction in relative risk compared to symptomatically driven dental treatment.¹⁸⁶ In a systematic review aimed at identifying prevention strategies associated with tooth extractions in patients at risk for MRONJ, no randomized clinical trials were reported.¹⁹⁴ However, there are many animal studies that demonstrate that periodontal or periapical inflammation plays a key role in creating a local environment that supports the development of bone necrosis in the context of systemic antiresorptive therapy.^{85,91,195,196}

Treatment planning for patients at risk of developing MRONJ should include a thorough examination of the oral cavity and a radiographic assessment when indicated. It is important to identify both acute infection and sites of potential infection to prevent future sequelae that could be exacerbated once drug therapies begin. Considerations during the clinical and radiographic assessment include patient motivation, patient education regarding dental care, fluoride application, chlorhexidine rinses, tooth mobility, periodontal disease, presence of root fragments, caries, periapical pathology, edentulism, and denture stability.¹⁹⁷

An additional benefit of early dental consultation, when the use of antiresorptive therapy is being considered, is that the patient is informed of the risk associated with these drug therapies and the risk incurred by not undergoing recommended

dental preventive measures before consenting to treatment.

Cessation of At-Risk Medication Therapy (Drug Holiday) Prior to Tooth Extraction or Other Procedures that Involve Osseous Injury (eg, Dental Implant Placement, Periodontal or Apical Endodontic Treatment)

The clinical practice of antiresorptive drug holidays to mitigate MRONJ risk in patients undergoing dentoalveolar surgery was controversial at the time of the previous AAOMS position paper in 2014 and remained the case in 2021. While the practice of a drug holiday has been accepted and recommended by several international professional societies,^{3,38,182,183,198} the evidence to support or refute such positions remains inconclusive. The difficulty in establishing or refuting the efficacy of drug holidays is due to the rarity of MRONJ in these patient populations. Therefore, since few events are reported, randomized-controlled trials provide insufficient data to create sound treatment protocols. In a 2020 systematic review that studied the efficacy of antiresorptive drug holiday in preventing MRONJ, a variety of papers were identified with differing conclusions suggesting that a high level of evidence for supporting or refuting the use of a holiday is missing.¹⁹⁹

The historical use of a drug holiday was intended to decrease the prevalence of MRONJ subsequent to the performance of high-risk surgical procedures. The concern regarding this practice is the loss of efficacy of antiresorptive therapy with the development of SREs and fragility fractures. Among others, factors for consideration may include disease-related risk (cancer vs osteoporosis), drug-dosing frequency, duration of therapy, comorbidities, other medications (especially chemotherapy, steroids, or antiangiogenics), degree of underlying infection/inflammation, and extent of surgery to be performed.

Of note, the working group was unable to reach a consensus regarding a recommendation on drug holidays and was evenly split between offering drug holidays to patients on a case-by-case basis using prior recommendations and those who never recommend drug holidays, believing that the risks of potential deleterious effects of suspending antiresorptive therapy may outweigh a benefit.

A special concern should be considered for suspending RANKL inhibitors in osteoporosis patients. Several studies have demonstrated a rebound increase in bone resorption following the discontinuation of DMB, resulting in an increased risk of multilevel vertebral fractures.²⁰⁰⁻²⁰² If DMB is to be suspended, the timing and duration of the holiday should be optimized in order to minimize this risk. The planned dentoalveolar surgery can be completed 3-4 months following the last dose of

Table 2. MRONJ PREVENTION STRATEGIES

Pretherapy (Nonmalignant Disease)	<ul style="list-style-type: none"> • Educate patient about the potential risks associated with long-term ART.* • Optimization of dental health can occur concurrent with ART.
Pretherapy (malignant disease)	<ul style="list-style-type: none"> • Educate patients about the higher risk of MRONJ and the importance of regimented dental care. • Optimization of the dental health <i>prior</i> to the initiation of ART if systemic conditions permit (extraction of nonrestorable teeth or teeth with a poor prognosis).
During antiresorptive therapy (nonmalignant disease)	<ul style="list-style-type: none"> • No alteration of operative plan for most patients. • Considerations include drug schedule, duration of therapy, comorbidities, other medications (especially chemotherapy, steroids, or antiangiogenics), degree of underlying infection/inflammation, and extent of surgery to be performed. Drug holidays are controversial. • BTM[†] are not a useful tool to assess MRONJ risk.
During antiresorptive therapy/targeted therapies (malignant disease)	<ul style="list-style-type: none"> • Educate patients about the higher MRONJ risk in the setting of malignant disease. • Educate the patient about the importance of regimented dental care and prevention. • Avoid dentoalveolar surgery if possible. • Consider root retention techniques to avoid extractions. • Dental implants are contraindicated. • Drug holidays are controversial.

* Antiresorptive therapies.

† Bone turnover markers (CTX).

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DMB when the level of osteoclast inhibition is waning. It can then be reinstituted 6-8 weeks postsurgery. This management strategy minimizes the length of the drug holiday while maintaining a favorable environment for bone healing.

Bone Turnover Markers. Since the 2014 AAOMS position paper, there has been a shift away from bone turnover markers. No biomarkers are validated for clinical decision-making, and continued research and prospective studies are required before these markers can be considered efficacious tools in estimating MRONJ risk.

Other Biomarkers

Biomarkers related to angiogenesis, VEGF activity, endocrine function, and PTH have more recently been described.²⁰³⁻²⁰⁵ These markers remain at an exploratory stage and are not yet validated for clinical decision-making.

PREVENTION STRATEGIES

Patients scheduled to initiate antiresorptive treatment for cancer therapy

The treatment objective for this group of patients is to minimize the risk of developing MRONJ (Table 2). Although a small percentage of patients receiving antiresorptives develop osteonecrosis of the jaw spontaneously, the majority of affected patients experience

this complication following dentoalveolar surgery.^{5,112,165,206,207} Therefore, *if systemic conditions permit*, initiation of antiresorptive therapy should be delayed until dental health is optimized.^{173,208} This decision must be made in conjunction with the treating physician and dentist and other specialists involved in the care of the patient. There is widespread consensus that optimizing dental health prior to initiating therapy is efficacious and of paramount importance.^{38,185,186,209} Medical oncologists should educate their patients about the importance of dental health and the efficacy of prophylactic dental treatment in the prevention of MRONJ. Similar to patients who are to receive radiation therapy, optimizing the dental health in patients receiving antiresorptives or other therapies that can compromise bone healing is essential. The pretreatment evaluation of dental health must extend beyond a review of systems and include a physical and radiographic exam. Therefore, a comprehensive dental examination performed by a dental health professional would be a prudent approach for all patients prior to receiving antiresorptive therapy for malignant disease. This level of dental health assessment is most appropriately performed by a dental health professional.

The importance of minimizing the burden of dental infection and inflammation prior to dentoalveolar surgery in this cohort of patients with an elevated MRONJ risk cannot be over-emphasized. Nonrestorable teeth

and those with a poor prognosis should be extracted. Other necessary elective dentoalveolar surgery also should be completed at this time. It remains advisable that antiresorptive therapy should be delayed, *if systemic conditions permit*, until the surgical site(s) have mucosalized or until there is adequate osseous healing. Dental prophylaxis, caries control, conservative restorative dentistry, and nonoperative endodontic therapy are critical to maintaining functionally sound teeth. This level of care must be continued on a frequent and indefinite basis.¹⁸⁵

The posterior lingual plate region is a common site for trauma and mucosal irritation in denture wearers.^{5,75,170} Therefore, patients with full or partial dentures should be examined for areas of mucosal trauma, especially along the lingual flange region. It also is critical that patients be educated as to the importance of dental hygiene and regular dental evaluations, and specifically instructed to report any pain, swelling, or exposed bone.

Patients scheduled to initiate antiresorptive treatment for osteoporosis

Patients who are scheduled to receive antiresorptive therapy for the prevention of fragility fractures assume a significantly lower risk of MRONJ. Therefore, the urgency and the timing of optimizing the dental health are not as crucial. However, at the initiation of treatment, it would be prudent to educate patients regarding the potential risks of MRONJ. The importance of optimizing dental health throughout this treatment period and beyond cannot be underestimated.

It is not uncommon for patients to seek the consultation of an oral and maxillofacial surgeon in guiding their decision about starting or continuing antiresorptive therapy. In this scenario, the consulting oral and maxillofacial surgeon should use this opportunity to place the risks and benefits into the proper perspective. More specifically, patients should be reminded of the benefits associated with antiresorptive therapies in preventing fragility fractures and an acknowledgment of the rare occurrence of MRONJ.

The initial enthusiasm and attention associated with the discovery of MRONJ have had unintended consequences. When initially described, a “class effect” was observed, suggesting that MRONJ rates for patients receiving oncologic doses of BPs and those receiving osteoporotic doses of BPs were similar. A plateau and a decline in the use of BPs for osteoporosis was noted in 2006 and is hypothesized to be associated with various safety concerns, such as MRONJ. Patients are becoming increasingly more reluctant to begin or comply with their antiresorptive therapy. Current evidence also confirms an increase in fragility fractures with significant associ-

ated morbidity. As one salient example, hip fracture rates in the United States declined each year from 2002 to 2012 and then plateaued at levels higher than projected for 2013 to 2015, attributable to an “osteoporosis treatment gap.”²¹⁰ Hip fracture carries significant morbidity, with only 40 percent to 60 percent of individuals recovering their prefracture level of mobility and ability to perform instrumental activities of daily living.²¹¹ These data are representative of a true health crisis. The documented risk for developing MRONJ is low; however, the patient-perceived risk is not. As such, patients are unwilling to start or continue antiresorptive medical therapy. Patients are irrationally denying themselves the tangible therapeutic benefit of antiresorptive therapy to minimize the risk of fragility fractures in order to prevent a minuscule risk of developing MRONJ.

It is clear the benefit of fracture prevention outweighs the risk of MRONJ development in osteoporotic patients.²¹² This benefit is even more favorable in the cancer population where bone-stabilizing medications significantly improve quality of life, and it is detrimental when antiresorptives are withheld due to MRONJ safety concerns.

Asymptomatic patients receiving antiresorptive therapies for cancer

Maintaining good oral hygiene and dental care is of paramount importance in preventing dental disease that may require eventual extractions or other dentoalveolar surgery. Procedures that involve direct osseous injury should be avoided if possible. If a dentoalveolar surgical procedure is unavoidable (eg, fractured tooth, advanced periodontal disease), patients should be informed of the associated risks. The benefit of a drug holiday remains unsubstantiated in this setting. Nonrestorable teeth may be treated by removal of the crowns and endodontic treatment of the remaining roots.²¹³ Teeth may be extracted if necessary. Placement of dental implants should be avoided in the oncology patient receiving parenteral antiresorptive therapy or antiangiogenic medications. Case series and systematic reviews have reported necrosis associated with antiresorptive therapy and implant placement.^{194,214-216}

Asymptomatic patients receiving antiresorptive therapy for osteoporosis

Since the 2014 position paper, epidemiologic data regarding the risk of MRONJ in patients receiving antiresorptive therapy for osteoporosis remain limited due to the lack of sound prospective studies with sufficient power. Nevertheless, the risk for developing MRONJ is between 0.02 percent and 0.04 percent for BPs and 0.3 percent for DMB. (see

Table 1). Sound recommendations based on strong clinical research design are still lacking for patients taking oral BPs.

In general, elective dentoalveolar surgery does not appear to be contraindicated in this group. Risk assessment for the development of MRONJ in these patients includes the above-stated data and the discussion above related to drug holidays.

The placement of dental implants in the context of antiresorptive therapy for osteoporosis continues to be an area of research interest. Several systematic reviews have acknowledged the lack of quality data and randomized clinical trials. Some studies have recommended caution, especially with a longer duration of therapy or steroid use.^{194,216} For example, in their systematic review, Granate et al,²¹⁶ identified several studies that reported an elevated MRONJ risk associated with implants placed in the posterior jaw if the duration of bisphosphonate therapy exceeded 3 years and if the patients were receiving systemic corticosteroids. In contrast to these studies, systematic reviews by Gelazius et al, and Stavropoulos et al, reported no increase in risk.^{214,217} A recent retrospective propensity-matched cohort study of 44,900 patients reported a decreased risk of ONJ in osteoporosis patients receiving implants compared to matched controls who did not have implants. Of note, 9,738 patients had a history of BP use, and the results for implants was in contrast to risk increase for patients who underwent tooth extraction.²¹⁸

Reports of implant-related (MRONJ) necrosis can be divided into the early (implant surgery-triggered) or late (implant presence-triggered) category.^{215,219,220} In these reviews, the majority of the implant-related necrosis were not related to the initial implant surgery but occurred late (>12 months) and often at sites where implants were placed prior to the initiation of bisphosphonate therapy. The common presentation was an en bloc failure, where the osseointegration of the implants is maintained within the sequestrum.^{220,221} This has been recognized as a separate pattern of failure that is distinct from the common peri-implantitis failure and considered by some to be pathognomonic of MRONJ. Although there are no prospective studies or systematic reviews pertaining to implant-related necrosis associated with RANKL inhibitors or other targeted therapies, AAOMS considers this to have a similar level of risk.

In summary, robust data do not exist, and available data are conflicting. Therefore, AAOMS suggests that if dental implants are placed, informed consent should be provided to include the low risk of MRONJ, as well as early and late implant failure. These patients should be placed on a regular long-term recall schedule.

Treatment Strategies

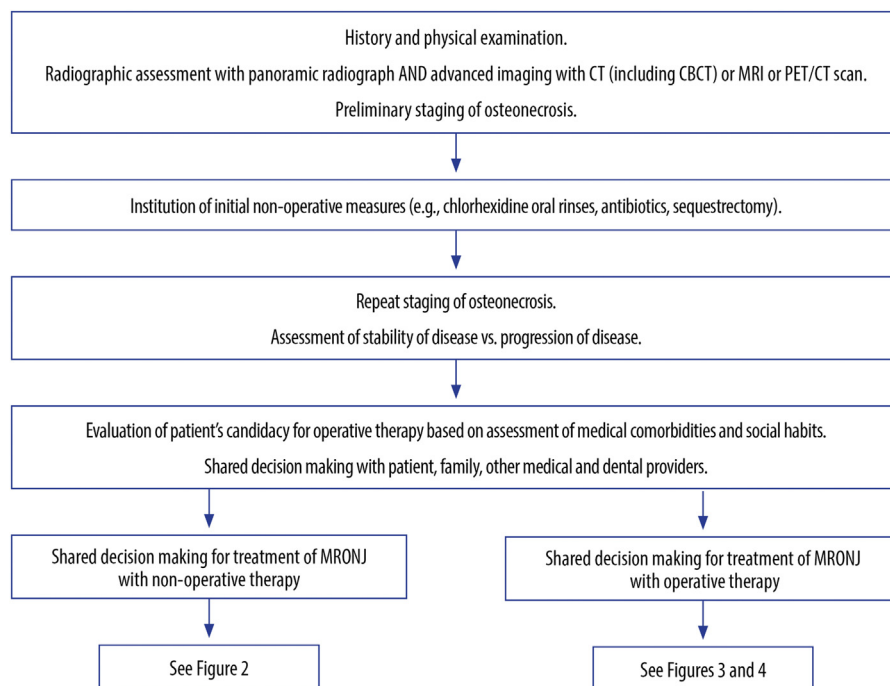
AAOMS has developed a series of treatment algorithms to streamline the evaluation (Fig 1) and management strategies (Figs 2-4) for patients with MRONJ. These strategies are based on a current review of nonoperative and operative therapies and their associated outcomes. Emphasis is placed on both nonoperative and operative management being acceptable for all stages of disease based on surgical judgment and patient factors in a shared decision-making model.

Nonoperative therapy

The efficacy of nonoperative therapies in the management of MRONJ is documented in the literature and provides a useful adjunct to the spectrum of management strategies that also include operative treatment (Fig 2). Nonoperative strategies can be useful in all stages, especially where significant comorbidities preclude operative treatment. They may also result in stabilization of disease or cure in earlier stages. The goal of both operative and nonoperative therapies remains the same: curative therapy and quality-of-life improvement. Nonoperative therapy heavily focuses on patient education, reassurance, control of pain, and control of secondary infection to allow for sequestration of the exposed, necrotic bone.^{3,63}

Decisions on operative versus nonoperative therapy should be patient-specific and tailored to individual needs. The risk versus benefit ratio (including quality of life with their current symptomology), ability to perform good wound care to prevent infection and disease spread, morbidity from a major surgical procedure, as well as oral function or dental rehabilitation after marginal or segmental resection should be considered. Radiographic imaging is of utmost importance in the evaluation of MRONJ lesions. Three-dimensional imaging can identify forming or fully formed sequestra and potentially decrease the invasiveness of a surgical procedure. Maintenance of maxillary or mandibular integrity is desirable, as the reconstruction of surgical defects in this population can be challenging.^{63,222}

Stage 1 patients can be managed with chlorhexidine wound care and improved oral hygiene to remove the biofilm from the necrotic bone surface.⁶³ Surgery may not be indicated in the absence of disease progression, with patient adequate quality of life.^{63,223} Stage 2 patients may struggle with local wound care and may require antibiotics for symptom control. Those patients who remain refractory to nonoperative treatment or those patients who cannot maintain adequate hygiene may benefit from operative therapy. In the presence of developing or established bony

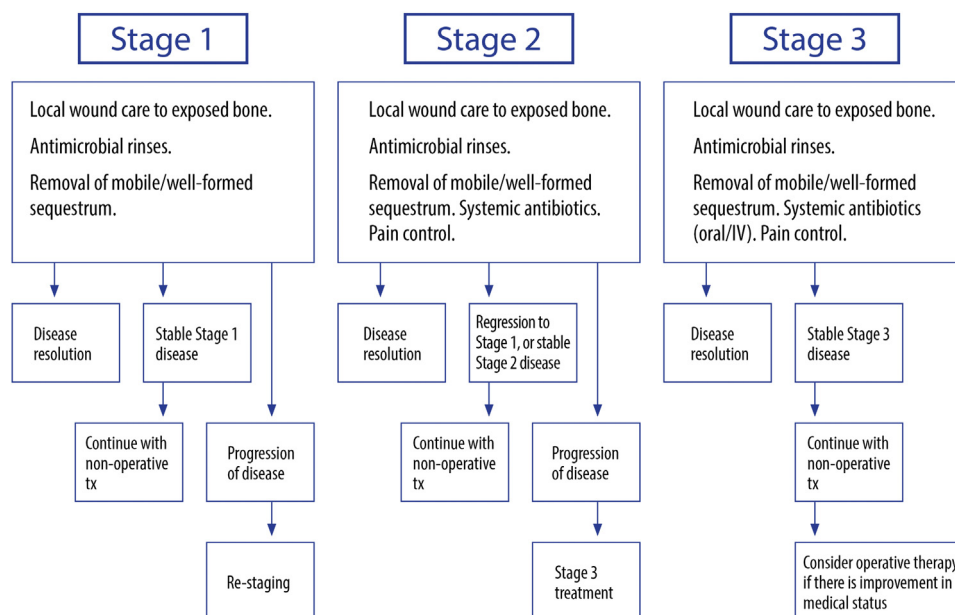
**FIGURE 1.** Initial evaluation.

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sequestra, nonoperative therapy may be indicated to allow for ultimate sequestrectomy. Exfoliation of the exposed, necrotic bone will often result in disease resolution.^{63,224,225} Therefore, for those patients with

Stage 2 or 3 diseases who are poor surgical candidates, nonoperative therapies may be indicated (Fig 2).

There is little evidence to suggest that the use of adjunctive therapies, such as hyperbaric oxygen or

**FIGURE 2.** Non-operative therapies.

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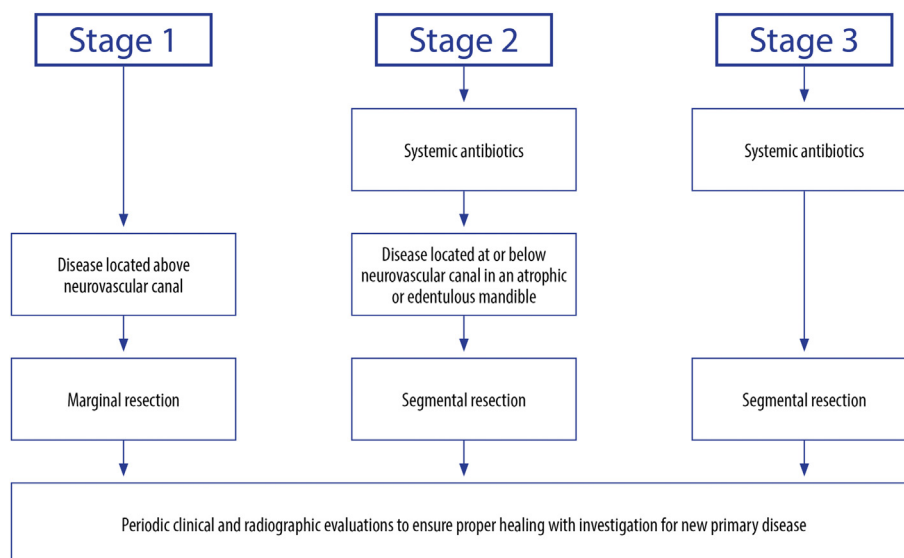


FIGURE 3. Operative therapies for mandibular disease.

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ozone therapy, can lead to MRONJ resolution. Larger studies and controlled trials have yet to demonstrate the efficacy of the aforementioned treatments.²²⁶⁻²²⁹ Therefore, these therapies should not be recommended as a mainstay of treatment at this time.

The use of vitamin E and pentoxifylline as an adjunct to standard MRONJ therapies have been reported only in case studies. A randomized, prospective, placebo-controlled trial of vitamin E and pentoxifylline is underway and will provide additional information about

this treatment modality. Teriparatide, one of the few anabolic agents used for the treatment of osteoporosis, also has shown promise as an adjunct for the treatment of MRONJ in osteoporotic patients.²³⁰

Operative therapy

While nonoperative therapy continues to be a treatment option for MRONJ, operative therapy is increasingly reported as a viable option with high success rates for all stages of the disease (Figs 3 and 4).

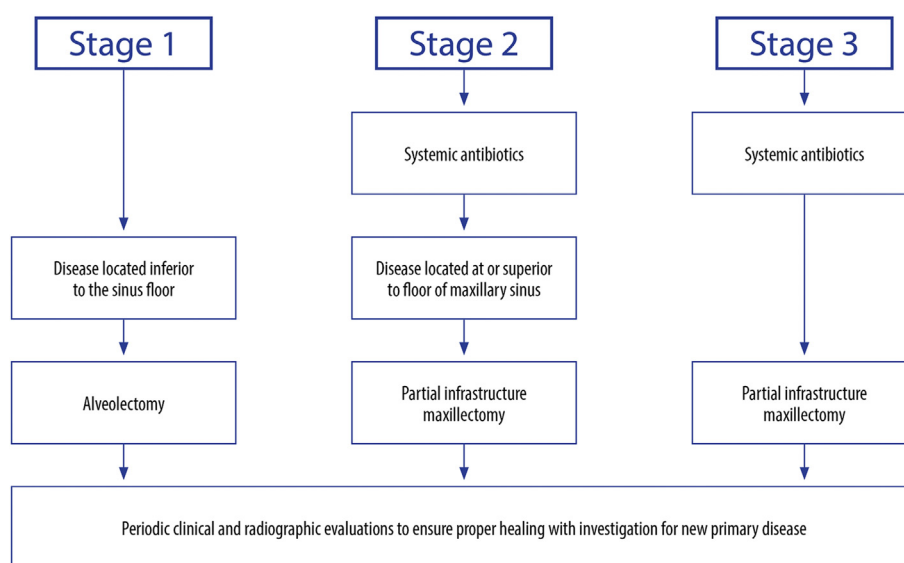


FIGURE 4. Operative therapies for maxillary disease.

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Numerous reports have identified high success rates associated with resection of MRONJ lesions.²³¹⁻²³⁷ Importantly, one must consider that MRONJ may progress over time, albeit in an unpredictable manner.²³⁸ Furthermore, adopting a nonoperative approach to MRONJ does not uniformly result in sequestration of the exposed necrotic bone with disease resolution.²³⁹ Thus, operative intervention should be explored and presented as a treatment option in an attempt to reduce the progression of disease with the recognition that early surgical intervention can predict beneficial patient outcomes.²⁴⁰

Segmental or marginal resection of the mandible and partial maxillectomy are effective methods to control MRONJ.^{231-238,241} This approach can be applied to patients with all stages of MRONJ, including Stage 1 disease.¹⁶⁹ These resections require margins beyond the borders of the necrotic bone to an area of vital, bleeding bone. Additional reports have identified success when surgical resection of MRONJ was performed by experienced surgeons.^{242,243} Consistent with surgical principles, control of comorbid conditions is paramount in managing MRONJ.²⁴¹ Physiologically compromised patients, such as those with an increasing burden of distant metastatic disease, may not respond favorably to resection of their osteonecrotic jaw, and may occasionally develop refractory disease.²⁴¹ Finally, surgical resection for MRONJ in patients with metastatic cancer may identify metastases in the jaw specimen, albeit in a minority of patients.⁶²

Active clinical and radiographic surveillance is critical in the nonoperative management of patients with Stage 1, 2, and 3 diseases to monitor for signs of disease progression. In patients who demonstrate the failure of nonoperative therapy, early operative intervention is recommended. In patients with a progressive clinical or radiographic disease or more advanced disease at presentation, surgical resection of MRONJ should be performed without first instituting prolonged nonoperative measures. MRONJ represents a complex wound whereby operative therapy can be performed in a timely fashion.^{241,244} Although controversy between operative and nonoperative therapies exist, operative treatment of patients has demonstrated maintenance of mucosal coverage, improved quality of life, and expedient resumption of antiresorptive therapy for all stages of MRONJ disease.²⁴⁵ The benefit of drug holidays for the operative intervention of MRONJ has not been substantiated.

Future Research

AAOMS realizes that MRONJ is a complex disease process with a multifactorial etiology for which

many questions remain unanswered. Continued pre-clinical and clinical data are required, especially in the form of prospective studies. Continued research efforts and the outcomes that result should be considered the foundation upon which recommendations are developed that will guide patients and providers. While the data supporting the conclusion that antiresorptives represent genuine risk factors are robust, this is not the case for other classifications of medications (eg, antiangiogenics, corticosteroids, immune modulators). Published studies have reported a relationship of certain dosing practices (eg, transition from BPs to DMB) or a synergistic effect between antiresorptive medications and antiangiogenic medication with a risk of MRONJ. These associations, however, are based on case reports and small case series. It also has been hypothesized that the total exposure to an antiresorptive medication is a risk factor for developing MRONJ. However, this has been difficult to demonstrate, possibly as a result of not having a good measure of exposure other than years of treatment. Similar to the cancer risk associated with tobacco use (eg, pack/years), the antiresorptive exposure risk MRONJ may be better defined as a cumulative dose load (eg, mg equivalent of BP/years of exposure) that would account for risk associated with different medications and dosing schedules over time. Dose-reduction protocols and individualized strategies for antiresorptive therapy in long-term cancer survivors with a metastatic bone disease are being explored. It remains to be determined if these protocols will reduce the risk of MRONJ in this patient cohort.²⁴⁶ AAOMS acknowledges the challenge of elucidating potential risks associated with non-antiresorptive therapies, alone or in combination with antiresorptive medications, and therefore considers it imperative that research efforts continue in the form of prospective studies.

A review of the current literature also failed to provide sound data in the form of randomized, controlled trials that would establish the effectiveness of biomarkers and drug holidays or validate a risk relationship with genetic markers and MRONJ. Until these relationships are established or refuted, AAOMS considers it prudent to recognize that these factors may play a role in the development and management of MRONJ.

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