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Pictorial Review

Osteoradionecrosis of the mandible: through a radiologist's eyes

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Head and neck malignancies constitute a major cause of morbidity and mortality all over the world. Radiotherapy plays a pivotal role in the management of these tumours; however, it has associated complications, with mandibular osteoradionecrosis (ORN) being one of the gravest orofacial complications. Early diagnosis, extent evaluation, and detection of complications of ORN are imperative for instituting an appropriate management protocol. ORN can closely mimic tumour recurrence, the differentiation of which has obvious clinical implications. The purpose of the present review is to acquaint the radiologist with the imaging features of mandibular ORN and the ways to differentiate ORN from tumour recurrence.

Introduction

Head and neck tumours constitute a heterogeneous group of malignancies involving various anatomical sites and with different clinical, pathological, and treatment considerations. Overall, they account for approximately 560,000 new cases worldwide annually. Also, they are a major cause of morbidity and mortality, responsible for about 300,000 deaths each year.[1] Radiotherapy (RT) plays a vital role in the management of head and neck cancers. It is used either as a primary treatment modality or as an adjuvant to surgery for local control of the disease. It can also be used with concurrent chemotherapy or as a palliative treatment modality for unresectable tumours. RT is an extremely potent treatment modality; however, it has side effects on the adjacent normal tissues. Mandibular osteoradionecrosis (ORN) is one of the most serious orofacial complications of RT for head and neck cancers.[2–4] As accurate evaluation of ORN has considerable clinical implications, the purpose of this review was to depict the varied radiological presentations of ORN.

Clinical considerations

Mandibular ORN is defined as an area of exposed bone through an opening in the overlying skin or mucosa, persisting as a non-healing region for a period of ≥3 months[5,6] (Fig 1). This may present clinically with symptoms such as pain, swelling, malocclusion, dysphagia, orocutaneous fistula, trismus, or facial disfiguration.[7] Severe cases can lead to death.[8]

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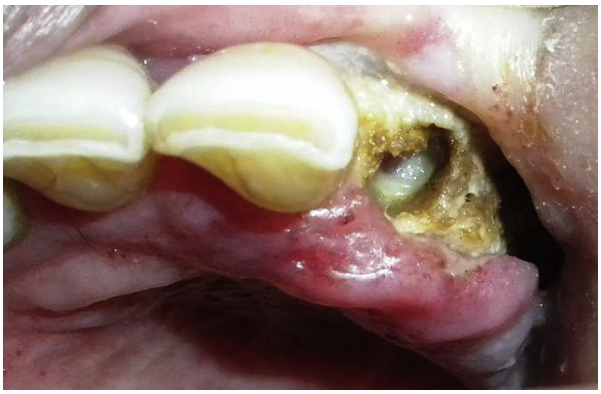

Figure 1 Post-RT oral ulcer with exposure of the underlying bone. The ulcer persisted for more than 3 months, and hence, was clinically diagnosed as ORN.

There are a few factors that determine the risk of ORN, such as primary site and stage of the tumour, total radiation dose, brachytherapy, extent of mandible included in the radiation field, fractionation, dentition status and oral hygiene, acute or chronic trauma, nutritional status, concomitant chemoradiation, alcohol or tobacco use, etc.[7]

Radiation-related factors form one of the major determinants of the possibility of ORN in patients receiving RT. Newer RT techniques, such as intensity-modulated radiation therapy (IMRT), have been introduced, which reduce the overall incidence of ORN.[9–11] IMRT is a high-precision technique, which uses computer-controlled linear accelerators to deliver precise radiation doses to a malignant tumour or specific areas within the tumour. It thus allows higher radiation doses to be focused on the tumour, while minimizing the dose to the adjacent normal structures.[12,13] Ben-David et al.[10] reported no case of mandibular ORN after IMRT for head and neck cancer, using a strict prophylactic dental care policy. Peterson et al.[11] reviewed 18-years of literature regarding the impact of cancer therapies on the prevalence of ORN, and reported a weighted ORN prevalence of 7.4% for conventional RT, 6.8% for chemoradiotherapy, 5.3% for brachytherapy, and 5.1% for IMRT. New RT techniques have thus contributed in reducing the incidence of ORN in head and neck RT.

Early and late-onset ORN

Based on the onset of symptoms, ORN can be classified as early and late-onset ORN.[14] Early-onset ORN is defined as clinical features noted within 2 years of RT. It is predominantly caused due to high radiation doses that are >70 Gy.[6,14] Late-onset ORN is postulated due to trauma in a chronically hypoxic environment.[14]

Pathogenesis

Various theories have been proposed to explain the pathogenesis of ORN. Ewing[15] was the first to identify the osseous changes associated with RT in 1926, and called it "radiation osteitis". Watson and Scarborough[16] in 1938, postulated the causes of "radiation osteitis" to be radiation, trauma, and infection. However, Marx et al.[5] put forth the idea of "endarteritis due to radiation therapy" as the cause for ORN. He proposed that endarteritis leads to hypoxia, hypocellularity, and hypovascularity, which in turn lead to tissue breakdown and chronic non-healing wounds. Another recently proposed theory suggests that osteoclastic injury due to radiation, leads to hampered osteoclast-mediated bone turnover. This in turn leads to ORN.[17,18] A new theory, called the "fibro-atrophic theory" states that the radiation-induced fibro-atrophic mechanism leads to ORN. This constitutes three phases: the prefibrotic phase, the constitutive organized phase, and the late fibro-atrophic phase.[19]

Radiological considerations

Radiological investigations are required in ORN to detect the presence, severity, and extent of ORN, and to monitor the progress of conservative treatment, if instituted. Major diagnostic concern in a suspected case of ORN is to exclude tumour recurrence. The various morphological imaging techniques that contribute to the evaluation of ORN are conventional radiographic techniques [mainly panoramic radiography (PR), multidetector CT (MDCT), and MRI].

PR

Conventional radiography, most commonly PR, has been widely used for evaluation of suspected ORN. PR depicts osseous changes of ORN, however, with lesser sensitivity than cross-sectional imaging techniques.[20] Early osseous changes are not easily detected, as it requires at least 30–50% reduction in the bone mineral density to be detected on conventional radiographs.[21] PR is also not able to depict accurately the soft-tissue changes associated with ORN. As a two-dimensional (2D) projection, PR suffers from several limitations, such as magnification, superimposition, misrepresentation, and distortion of structures. However, PR is a readily available, fast, and convenient technique, which involves reduced radiation exposure. Hence, PR is recommended for follow-up and monitoring patients who are at risk of ORN; but is not very accurate for evaluation of extent.[20]

Radiation damage to the mandible can lead to loss of bone mass with resorption of the osseous trabeculae. On OPG, it is seen initially as rarefaction of the affected bone, or later, as lytic areas within the mandible (Fig 2). Disorganization and thickening of trabeculae can also be one of the features of radiation damage (Fig 3). Sequestrum, which is defined as "dead bone", may be seen as a radiodense area amidst the affected rarefied portion of the mandible. Progression of the disease can lead to pathological fracture in severe cases, which is seen as a cortical break (Fig 4).

MDCT

MDCT can accurately evaluate the extent and severity of the osseous changes, along with the associated soft-tissue