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Mandibular osteomyelitis: evaluation and staging in 18 patients, using magnetic resonance imaging, computed tomography and conventional radiographs

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SUMMARY. **Over a period of 3 years, 18 patients with mandibular osteomyelitis were prospectively investigated by conventional radiograph, computed tomography (CT) and in 6 cases by magnetic resonance imaging (MRI). The diagnosis was based on histology in 17 patients operated upon.**

INTRODUCTION

Osteomyelitis of the jaw is defined as an inflammation of the mandibular cortical and cancellous bone, which is commonly caused by bacterial invasion from a contiguous focus. Odontogenic foci are the most frequent sources, consisting of periodontal disease and infections of the pulp or of extraction wounds (*Mercuri*, 1991; *Sailer*, 1991; *Hudson* 1993; *Lundeen* and *Barnett*, 1994). Infected fractures are the second most common cause of mandibular osteomyelitis (*Calhoun* et al., 1988; *Koorbusch* et al., 1992; *Taher*, 1993). Predisposing conditions such as chronic alcoholism (*Davies* and *Carr*, 1990), or underlying bone pathologies such as osteopetrosis (*Steiner* et al., 1983) are uncommon. The clinical course of mandibular osteomyelitis is variable. With an arbitrary time limit of one month after the initiation of symptoms, osteomyelitis is classified as acute or chronic (*Mercuri*, 1991; *Marx*, 1991). Chronic osteomyelitis may persist after an acute episode (secondary chronic osteomyelitis), or it may pursue an insidious course (*Vargas* et al., 1984; *Marx*, 1991) that has never undergone an appreciable acute phase (primary chronic osteomyelitis). The diagnosis of mandibular osteomyelitis requires radiological confirmation and reassessment by follow-up examinations in order to evaluate the response to treatment. Bone scintigraphy may be performed in the acute stage to establish the diagnosis (*Hardt*, 1991; *Rohlin*, 1993) or as a follow-up examination (*Hardt*, 1991; *Kaneda* et al., 1995). Conventional radiographs, although routinely applied, are limited by low sensitivity in the acute stage (*Mercuri*, 1991; *Hudson*, 1993). However, the value of computed tomography (CT) and magnetic resonance imaging (MRI) in the work-up of mandibular osteomyelitis is still controversial (*Yoshiura* et al., 1994; *Reinert* et al., 1995; *Seabold* et al., 1995). In a prospective study the CT and MRI findings were therefore evaluated in comparison with conventional radiographs in 18 patients with mandibular osteomyelitis.

MATERIAL AND METHODS

Eighteen patients suspected of having odontogenic mandibular osteomyelitis, on account of their clinical symptoms and signs, were examined prospectively during a period of 3 years. Patients with osteoradionecrosis of the mandible were not included in the study. Males outnumbered females in a ratio of 12 to 6. The patients ranged in age from 23 to 81 years. The mean age was 50.2 years for males and 46.7 years for females, with a mean age of 49 years for the whole group.

Radiological examinations consisted of conventional radiographs (panoramic radiograph, lateral oblique mandible and posteroanterior view), CT in 18 patients and MRI of the lower jaw in 6 cases.

Computed tomography examinations were performed on a Siemens HiQS CT scanner with intravenous contrast application and 2 mm thick contiguous slices parallel to the mandibular body in the axial plane, and to the ascending ramus in the coronal plane.

Magnetic resonance imaging examinations were performed on a 1.5T GE Signa and consisted of a sagittal and coronal T1 weighted series (TR 500–600, TE 17–20 ms) before and after intravenous contrast administration, an axial contrast enhanced T1 weighted series, and a T2 weighted sequence (TR 2 500, TE 20/80 ms). Slice thickness was 3.5 mm and 4 mm for the T1 and T2 weighted series respectively.

In order to assure comparability, conventional radiographs and CT and/or MRI were obtained within 5 days, on average within 3 days. Follow-up examinations consisted of conventional radiographs in every case as well as CT in 8 cases and MRI in

the case of one patient. Follow-up CT examinations and the single follow-up MRI were performed postoperatively with an average delay of 5 months and a range from 1 to 10 months. In 2 cases a second preoperative CT examination was performed.

The films were re-read by a radiologist (B. F. Schuknecht) and a maxillofacial surgeon with longstanding experience in maxillofacial radiology (F. R. Carls). Conventional radiographs, CT and MRI were cumulatively assessed in the aforementioned sequence. Computed tomography was considered as the 'gold standard' for cortical bone lesions, sequestra and subperiosteal bone deposition (ossified periosteal reaction). The presence of sequestra was confirmed by histology in every patient (6 cases). Involvement of cancellous bone by CT was only found indicative for osteomyelitis in the presence of additional endosteal cortical erosions or transcortical defects. To be considered pathological, involvement of cancellous bone on MRI required the presence of

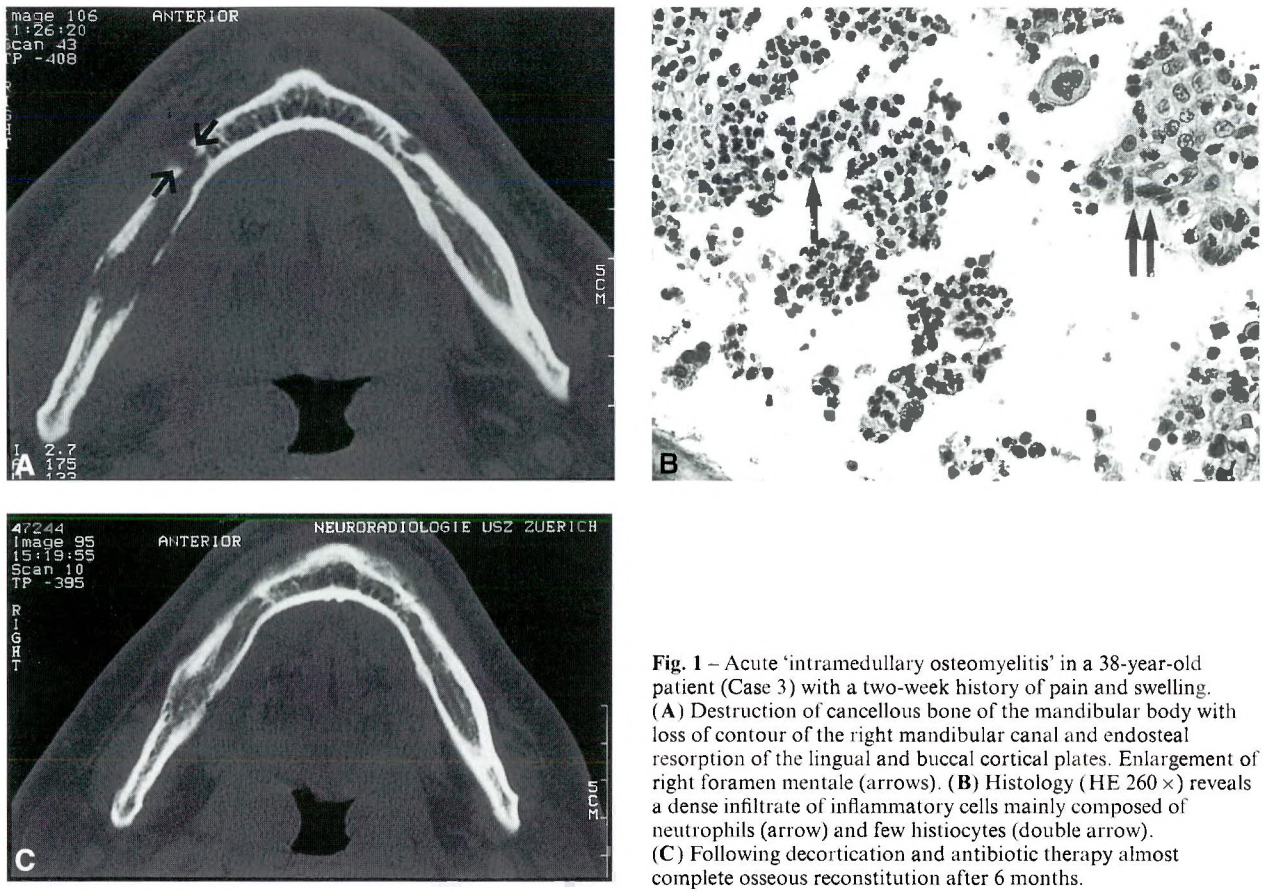


Fig. 1 – Acute 'intramedullary osteomyelitis' in a 38-year-old patient (Case 3) with a two-week history of pain and swelling. (**A**) Destruction of cancellous bone of the mandibular body with loss of contour of the right mandibular canal and endosteal resorption of the lingual and buccal cortical plates. Enlargement of right foramen mentale (arrows). (**B**) Histology (HE 260 ×) reveals a dense infiltrate of inflammatory cells mainly composed of neutrophils (arrow) and few histiocytes (double arrow). (**C**) Following decortication and antibiotic therapy almost complete osseous reconstitution after 6 months.

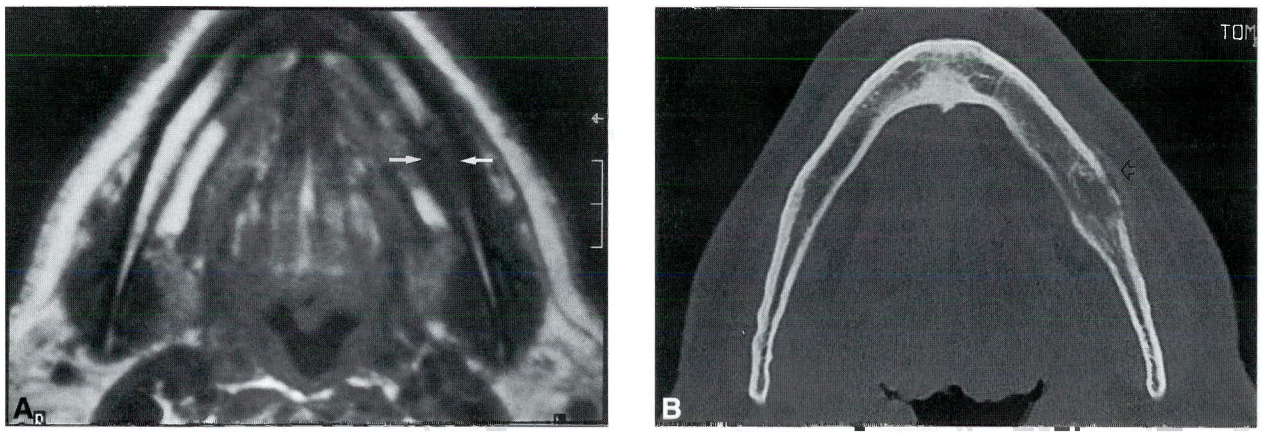


Fig. 2 – Axial non-contrast T1 weighted MR image reveals (**A**) circumscribed cancellous bone involvement (hypointense signal), thinning of the buccal and lingual cortices (white arrows) and lingual fat infiltration. High resolution CT depicts (**B**) less extensive bone marrow changes but is superior in delineating demineralization of lingual cortex and interruption of buccal plate with linear subperiostal bone deposition (open arrow). Cancellous bone sclerosis adjacent to osteolysis is only faintly appreciable on MRI in comparison with CT in a 47-year-old patient with acute osteomyelitis of the left molar region.

a Gadolinium enhancing lesion and of intermediate to high signal intensity on a T2 weighted sequence. In view of a high proportion of previous tooth extractions (44.5%), that had been performed on an outpatient basis and preceded the work-up for osteomyelitis by 1.5–4 months, scintigraphy was not included in the diagnostic protocol. In 17 cases CT examinations, and in 6 cases MRI examinations, were performed before surgery. In one case (Table 1, Case 4) surgery was not performed. Two patients had undergone their first surgical therapy for mandibular osteomyelitis in another hospital, respectively, 2 months and 1.5 years previously. Surgery was performed based on the concept of early decortication of either the buccal or lingual cortical plate (*Vargas* et al., 1984) or partial mandibular resection with immediate reconstruction (*Sailer*, 1991). Complementary therapy consisted of systemic antibiotic and hyperbaric oxygen therapy. Fifteen patients underwent decortication, and in 2 patients partial mandibular resection and reconstruction was performed. The histology obtained was compared with the imaging findings in the 10 patients with the least time interval (3–7 days) between the radiological examinations and surgery. The clinical findings and particular therapeutic considerations are the subject of an on-going study.

RESULTS

Acute and subacute osteomyelitis

Four patients with a history of symptoms ranging from 8 days to 2.5 weeks were examined. In a second group of 4 patients symptoms prevailed for 2.5–4 weeks (subacute osteomyelitis). A summary and comparison of the plain film, CT and MRI findings is provided in Tables 1 and 2. Plain films were negative in 2 of 4 patients (50%) in the acute stage, whilst in 3 other cases (1 acute, 2 subacute) conventional radiographs revealed only subtle areas of demineralization in the premolar regions. In only one of the four cases was osteomyelitis identified on the basis of conventional radiographs. Computed tomography and MRI images depicted lesions that consisted initially of cancellous bone osteolysis, endosteal erosions, and cortical defects (Figs. 1 & 2)

Histopathologically, an intense inflammatory reaction was present in the acute cases with abundant neutrophils changing towards an increasing number of histiocytes in the subacute stage (Fig. 1b). In the subacute stage sequestra were detected on plain radiographs in 2 of 3 cases, by CT in all the cases, in whom histology had proven non-vital cortical bone (Figs. 3 & 4). Cortical plate erosion and cancellous bone osteolysis appeared one molar or premolar region greater on CT; in 4 out of 6 cases (66.6%) with positive plain film findings. In comparison with CT, MRI in the 2 patients on whom it was performed revealed a larger T2 hyperintense and T1 hypointense medullary bone lesion (Fig. 2). Periosteal calcifications were identified by CT in 4 cases (Figs. 2, 3, 4). Magnetic resonance imaging, however, provided evidence of contrast enhancing thickened periostium in an additional patient in the acute and subacute stage.

Chronic osteomyelitis

In 7 patients, mandibular osteomyelitis was classified as secondary chronic on the basis of symptoms of more than 4 weeks duration and the presence of a previous acute episode. A causative event could not be detected in the history of 3 patients with primary chronic osteomyelitis. As is shown in Table 1, the secondary chronic type on plain films and CT was characterized by an increasing degree of cancellous bone sclerosis, periosteal calcifications in conjunction with focal areas of osteolysis or sequestration (Fig. 5).

Histopathologically, in chronic inflammation lymphocytes and plasma cells were found to predominate in the vicinity of devitalized bone (Fig. 4b). Computed tomography was more sensitive than conventional radiographs in the detection of medullary sclerosis (Fig. 6) and inferior alveolar nerve canal involvement. The latter was missed by plain films in 2 of 3 cases. Sequestra, proven by histology in 3 cases, were detected in equal frequency by conventional radiographs and CT. Cortical bone erosion and sequestration was associated with linear periosteal reactions that were recognized by CT in 6 out of 7 cases, by plain films in 2 cases and by MRI in 2 cases. Only MRI was able to identify a non-ossified periosteal reaction in 2 cases (Fig. 5 & 7). Primary chronic osteomyelitis was diagnosed by plain films in all 3 patients. Extensive sclerosis of the cancellous bone was demonstrated by plain films and CT, while MRI revealed diffuse medullary bone T1/T2 hypointensity with only a little increase in signal intensity after intravenous contrast administration (Fig. 7). In primary chronic osteomyelitis, CT and MRI revealed the least degree of soft tissue swelling compared with acute/subacute and secondary chronic osteomyelitis. A proposal for a diagnostic pathway is provided by Figure 8.

DISCUSSION

Mandibular osteomyelitis remains a challenge with respect to both diagnosis and management. Complications arising from missed or delayed diagnosis include formation of sequestra and subsequent fistulae, recurrent exacerbation of chronic osteomyel-

Table 1 – Conventional radiograph, CT and MRI findings in 18 patients with mandibular osteomyelitis

						Conventional radiographs		Computed Tomography			Magnetic resonance imaging					
Patient	Sex	Age	Duration	Stage	Location	Lesion	Periost.	Cortical bone	Marrow	Periost.	Cortical bone	Marrow			Periost.	Follow-up
1	F	52	2 weeks	acute	molar	–	–	erosion	(lytic)	l[1]	thinned	T1↓	T2↑	Gd+	no	CT
2	F	63	2 weeks	acute	premolar	osteolysis	–	erosion	(lytic), sclerosis[1]	–	–		–		–	CT
3	M	38	2 weeks	acute	premolar	osteolysis	–	defect	lytic	–	–		–		–	CT
4	M	47	2.5 weeks	acute	premolar	–	–	defect	lytic	b	thinned	T1↓	T2↑	Gd+	o	CT
5	M	49	2.5 weeks	subacute	molar	osteolysis	–	defect, fistula	lytic	l	–		–		–	–
6	M	23	4 weeks	subacute	premolar	sequestrum, fracture	–	sequestrum[2]	lytic	b	–		–		–	–
7	M	71	4 weeks	subacute	molar	sequestrum	–	sequestrum[2], fistula	lytic, sclerosis	–	–		–		–	–
8	M	81	4 weeks	subacute	premolar	osteolysis	–	sequestrum[2], fistula	lytic	–	thinned, sequestrum	T1↓	T2↑	Gd+	no	CT
9	M	56	5 weeks	sec. chronic	premolar	osteolysis	–	erosion	sclerosis	–	–		–		–	–
10	M	42	6 weeks	sec. chronic	molar,ramus	sequestrum	–	sequestrum$_2$	lytic, sclerosis	l+b	–		–		–	–
11	M	57	2 months	sec. chronic	molar	osteolysis	–	erosion	sclerosis	b	–		–		–	–
12	F	26	4 months	sec. chronic	molar,ramus	sequestrum, sclerosis	+	sequestrum$_2$	sclerosis	l>b	–		–		–	–
13	M	25	11 months	sec. chronic	angle,ramus	sequestrum, sclerosis	–	sequestrum$_2$	sclerosis	l+b	thickened, sequestrum	T1↓	T2↓	Gd(+)	no	CT
14	F	45	1.5 years	sec. chronic	body,ramus body	sclerosis osteolysis	+	erosion	sclerosis	b	–		–			CT
15	F	35	4 years	sec. chronic	hemimandible	sclerosis osteolysis	–	erosion	sclerosis	l	thickened, erosion	T1↓	T2↓	Gd–	o, no	MR
16	M	61	1.5 years	prim. chronic	hemimandible	sclerosis, enlargement	–	thickened	sclerosis	b[1]	thickened	T1↓	T2↓	Gd+	no	CT
17	M	51	2 years	prim. chronic	hemimandible	sclerosis	–	thickened	sclerosis	–	–		–		–	–
18	F	59	6 years	prim. chronic	hemimandible	sclerosis, enlargement	–	thickened	sclerosis	–	–		–		–	–

[1] On follow-up, [2] in conjunction with erosion. sec.chron = secondary chronic, prim.chron = primary chronic, l = lingual b = buccal, o = ossified, no = non-ossified

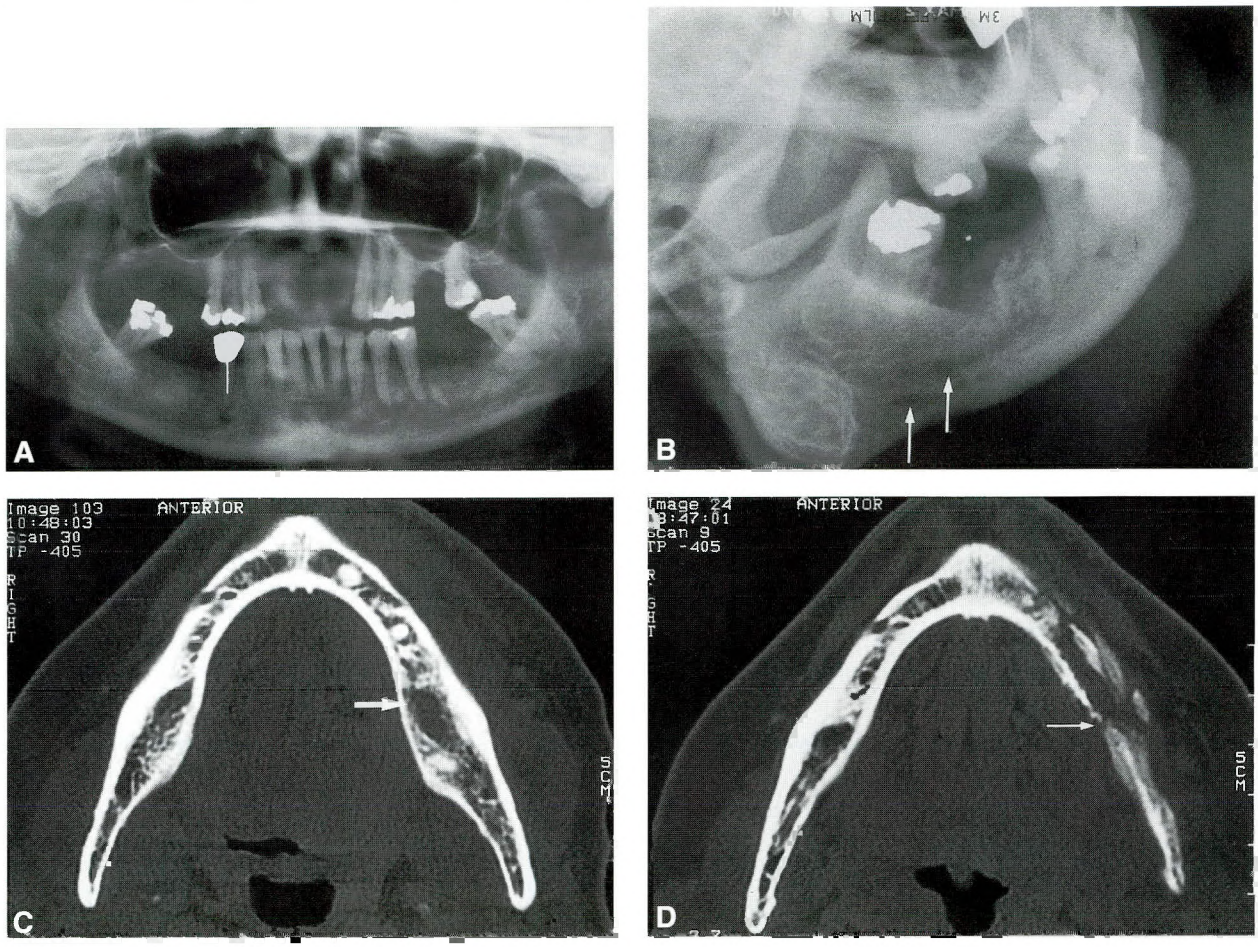


Fig. 3 – Orthopartomography (OPG) (**A**) without evidence of osteomyelitis. Lateral oblique view (**B**) with subtle osteolytic foci (arrows) below empty socket 2.5 weeks after extraction of carious left lower molar in a 63-year-old patient. Axial CT (**C**) depicts discrete lingual endosteal cortical erosion (arrows) and demineralization adjacent to empty socket. After 3 months of intermittent antibiotic courses (due to an initial refusal of surgery and non-compliance) progression from acute (**C**) to secondary chronic osteomyelitis (**D**). Pathological fracture (arrow) adjacent to an area of osteolysis and sclerosis with ossified periosteal reaction. In addition two buccal sequestra are present.

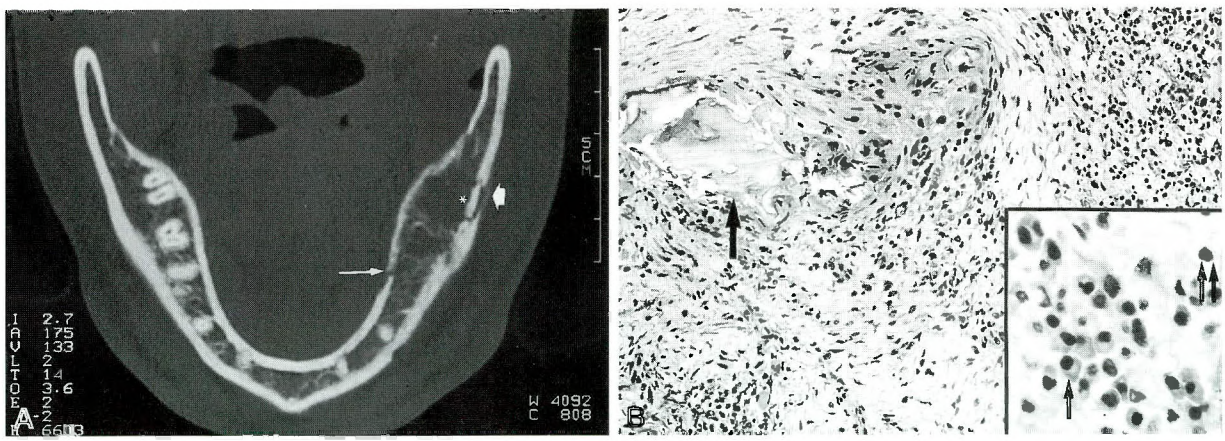


Fig. 4 – (**A**) Axial CT with subacute 'subperiosteal osteomyelitis' in a 23-year-old patient 4 weeks after extraction of left lower molar and 2.5 weeks after drainage of a perimandibular abscess. Sequestrum (*) covered by buccal periosteal reaction (broad arrow) called 'involucrum'. In addition, central ostolysis is present with adjacent lingual endosteal erosion, demineralization and transcortical extension (arrow). (**B**) Histology (HE 300 ×, inset 600 ×) depicts a fragment of necrotic bone (arrow) surrounded by inflammatory cells consisting mainly of plasma cells (inset, arrow) and lymphocytes (inset, double arrow).

itis, pathological fracture, bone deformity and, rarely, neoplastic conversion (*Mercuri*, 1991; *Hudson*, 1993; *Yoshiura* et al., 1994). Early diagnosis and implementation of therapy is therefore imperative (*Adekeye* and *Cornah*, 1985; *Sailer*, 1991). A broad diagnostic armamentarium is available that includes conventional radiographs, bone scintigraphy, CT and recently MRI. However, consensus is poor with

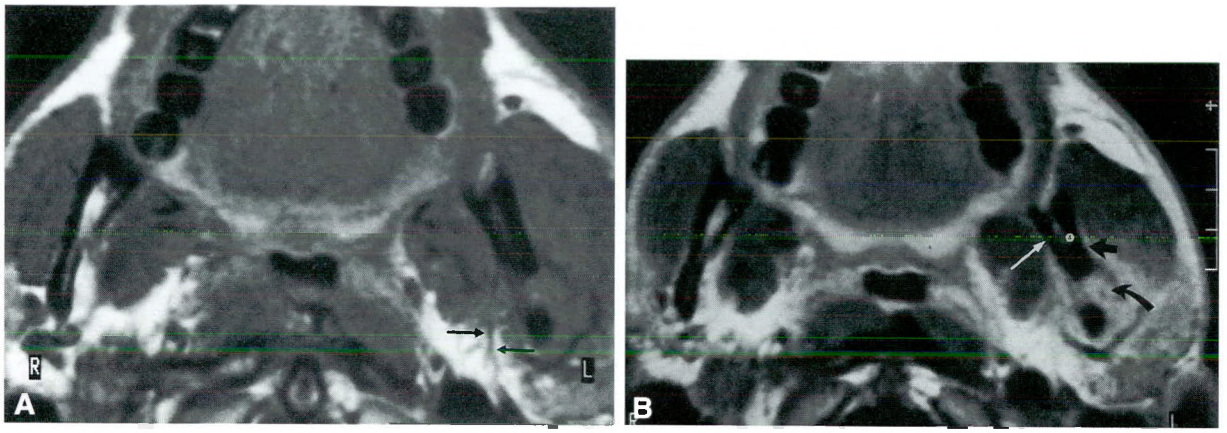


Fig. 5 – Axial T1 weighted MR image before (**A**) and after contrast application (**B**). Perimandibular fat plane medial to ascending ramus and posterior to masseter muscle infiltrated by isointense tissue surrounding inferior alveolar nerve (small arrows). Marked contrast enhancement with buccal periosteal involvement (straight black arrow) transcortical extension (curved arrow) and masseter infiltration. Thickened lingual cortical plate (white arrow) of ascending ramus. Twenty-five year old male with a history of left molar extraction followed by perimandibular abscess 11 months previously.

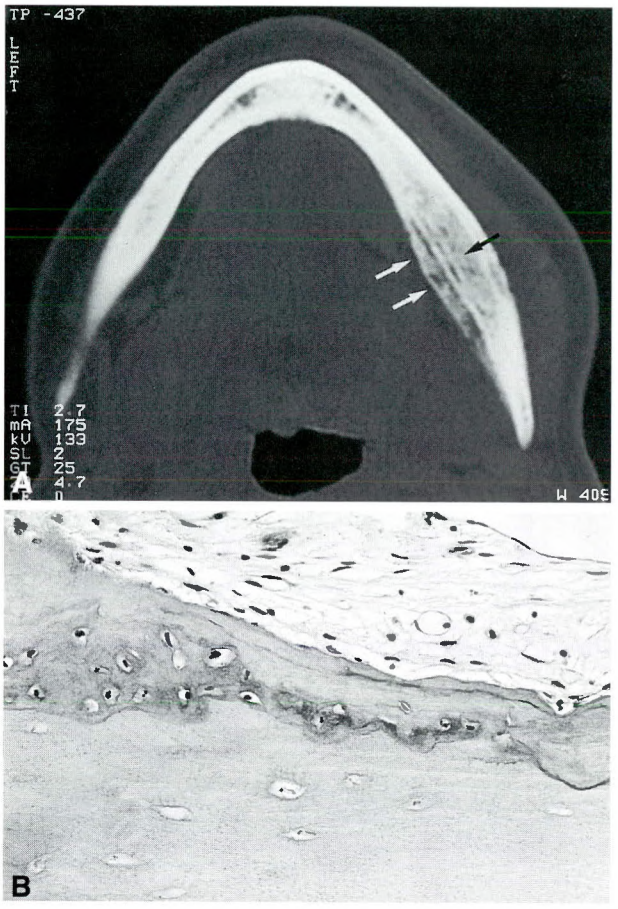


Fig. 6 – (**A**) 'Onion skin' layers of subperiosteal bone (white arrows) extending outward from the cortical margin and cancellous bone sclerosis (long arrow) in a 45-year-old female with secondary chronic osteomyelitis of right hemimandible. Persistent right mandibular swelling after extraction of right lower molars 1.5 years previously. (**B**) Histology (HE 300 ×) showed appositional bone layed down on necrotic cortical bone. Almost no viable osteocytes are present.

regard to the rational employment of the adequate imaging modality.

Conventional radiographs, and the orthopanoramic view in particular, are an integral part in the evaluative work-up of a patient suspected of developing mandibular osteomyelitis (*Johannsen*, 1977; *Worth* and *Stoneman*, 1977; *Jacobsson* et al., 1978; *Obwegeser* and *Sailer*, 1978; *Montonen* et al., 1993). This is despite the fact that osseous changes may not become visible until 10–12 days (*Capitano* and *Kirkpatrick*, 1970), or 2–3 weeks (*Davies* and *Carr*, 1990) after the initial symptoms. However, in the appropriate clinical setting the presence of periodontal disease and root remnants are indicators that justify the examination even in the potential early absence of osteolysis or sequestration. In our study, osteomyelitis was diagnosed within the first 4 weeks in only 3 out of 8 patients by conventional radiographs (37.5%), and in only 1 of 4 patients within the first 2 weeks. In retrospect, plain films in another 3 out of 8 cases (37.5%) revealed subtle signs of inflammation. Only after 4 weeks were conventional radiographs definitively diagnostic in every patient.

In agreement with *Wannfors* and *Hammarström* (1985), the extent of mandibular osseous changes in this study was found to correlate with the duration of the disease: extension into the ascending ramus occurred in 4 out of 7 patients with secondary chronic inflammation (57.1%), while it was not present in the acute and subacute types. Primary chronic osteomyelitis in 3 cases involved the entire hemimandible and in the 'quiet phase' exhibited a more uniform radiopaque appearance than the secondary chronic type.

Scintigraphy may reveal increased bone metabolism as early as 24–48 h (*Hardt*, 1991) or 3 days (*Rohlin*, 1993) after the onset of symptoms. Thus technetium-99m or gallium-67 scans are able to demonstrate the change in mandibular osteoblastic and

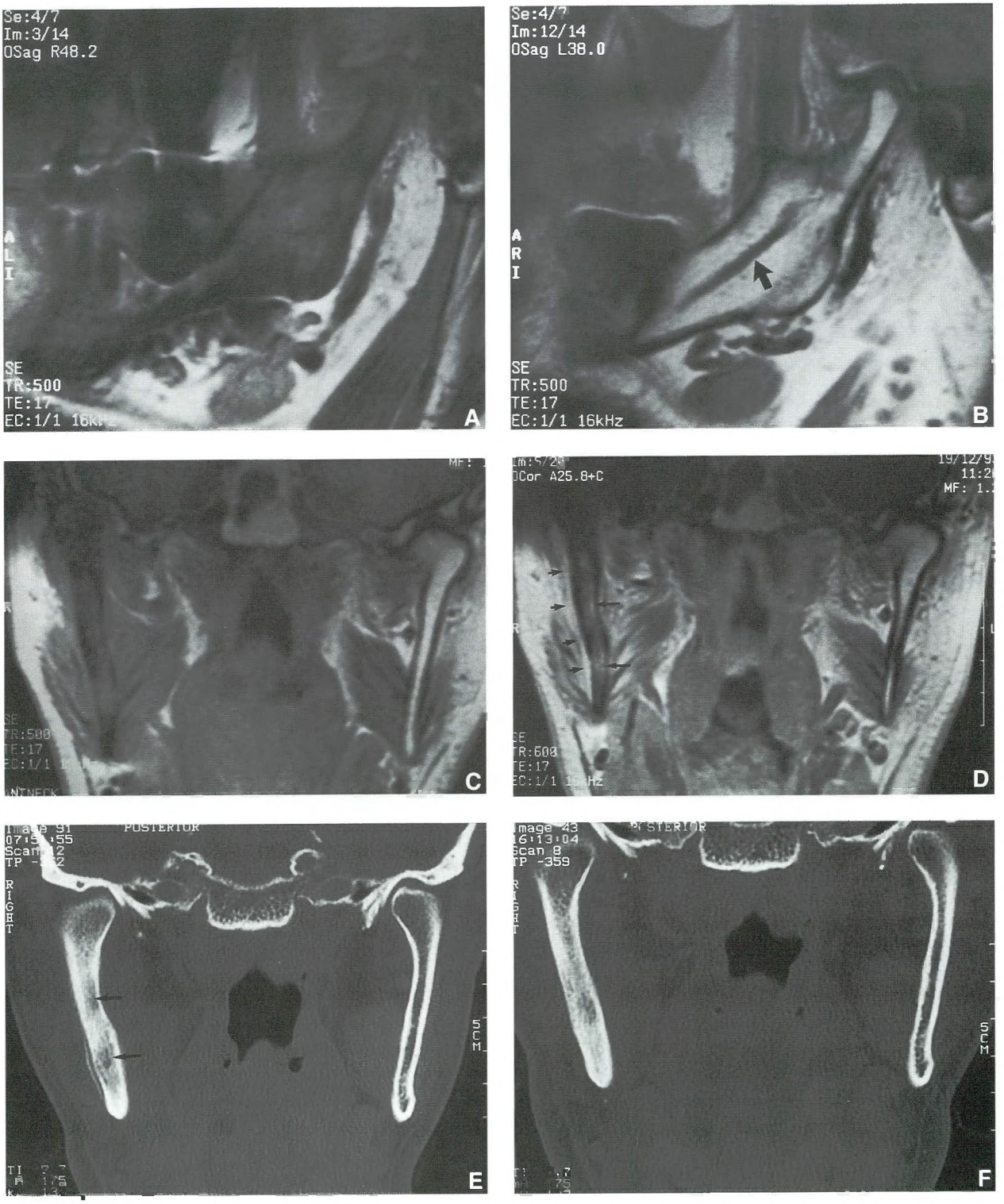


Fig. 7 – Recurrent episodes of swelling of right hemimandible in a 61-year-old patient 3 years after extraction of right lower molar and 1.5 years after buccal decortication of mandibular body. Sagittal T1 weighted MR images with a striking difference of signal intensity between diseased right (**A**) and normal left hemimandible (**B**). Mandibular canal and inferior alveolar nerve (arrow) are easily recognized within normal fat containing bone marrow. Coronal T1 weighted images before (**C**) and after contrast injection (**D**) reveal contrast enhancement with increased signal intensity of thickened periostium particularly on buccal side (arrows) and inflammatory intramedullary foci (long arrows). Corresponding CT (**E**) demonstrates areas of demineralized cancellous bone (arrows) and calcified portions of periosteal reaction, that had not been present 10 months previously. (**F**) Exacerbation of primary chronic osteomyelitis.

osteoclastic activity, and the presence of an infective focus well ahead of the morphologic changes (*Mercuri*, 1991). The high sensitivity of scintigraphy, which is reported to be almost equivalent to MRI (*Tsuchimochi* et al., 1991; *Reinert* et al., 1995), does not, however, have the same degree of specificity. Increased activity in the presence of recent tooth extractions, soft tissue inflammation and persistence

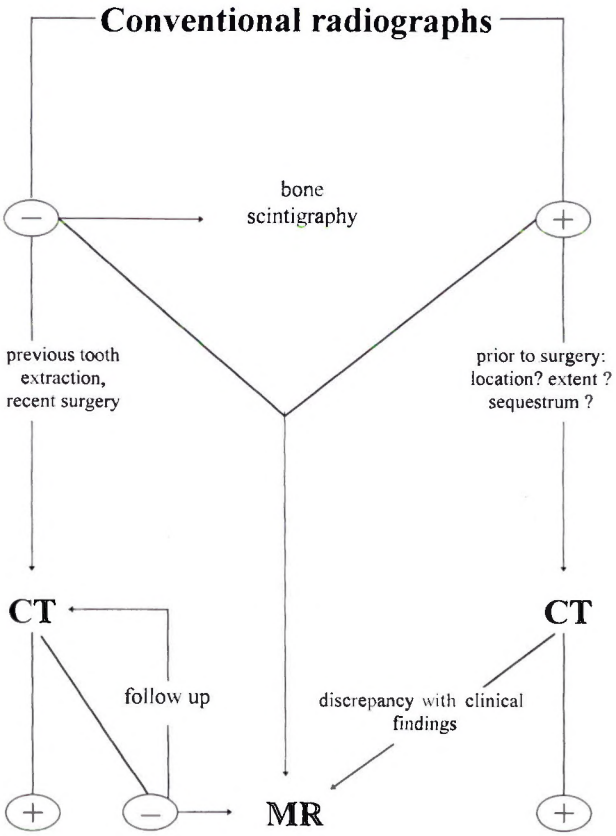


Fig. 8 – Diagnostic pathway in patients suspected of mandibular osteomyelitis.

of activity up to 4 months postoperatively constitute restrictions that limit the diagnostic contribution of scintigraphy in the acute stage, as well as in early postoperative follow-up examinations. Moreover, the poor spatial resolution of scintigraphy does not provide the detailed osseous information that is required preoperatively (*Sailer*, 1991; *Hudson*, 1993).

The demand for a more reliable imaging technique combining high sensitivity, spatial resolution and soft tissue information has led to an increase in the use of CT (*Osborn* et al., 1982; *Van Merkesteyn* et al., 1988; *Felsberg* et al., 1990; *Kanemoto* et al., 1992, *Ohlms* et al., 1993, *Yoshiura* et al., 1994) and recently of MRI (*Kaneda* et al., 1995; *Reinert* et al., 1995; *Seabold* et al., 1995). Lesion location and extent prior to the availability of CT and MRI were determined by conventional X-rays (*Vargas* et al., 1984) and recurrence was often attributed to an insufficiently radical surgical technique (*Montonen* et al., 1993). Accordingly, comparison of CT and plain films revealed a larger lesion extension within the mandibular body in 66.6% of cases in the acute and subacute stages on CT in our series. Superiority of CT is also underlined by *Kaneda* et al. (1995), who reported positive CT findings in 2 out of 4 acute cases interpreted as normal on plain films. In secondary chronic osteomyelitis the location and extent of cortical erosion and medullary sclerosis were demonstrated to better advantage by CT in 5 of 7 cases (71.4%). This also holds true for the identification of sequestra which, in accordance with *Yoshiura* et al. (1994), had been missed on plain films in one-third of cases in the subacute stage in our series. Sequestra, however, are considered rare in acute osteomyelitis (*Mercuri*, 1991) and more typically are found in chronic osteomyelitis (*Vargas* et al., 1984; *Kaneda* et al., 1995). The 3 patients encountered with sequestra within 4 weeks of onset in this series indicate that the transition from acute to chronic osteomyelitis, in accordance with histological findings, occurs earlier than after 1 month. Infiltration of the cancellous bone and replacement of marrow fat by inflammatory tissue accounts for the remarkably high sensitivity of MRI as compared with CT (*Chandnani* et al., 1990) and even scintigraphy (*Williamson* et al., 1991). In accordance with *Kaneda* et al. (1995) MRI revealed a more extensive intramedullary inflammation than CT in acute and subacute osteomyelitis. A distinction between active inflammation and bone marrow oedema, however, only appears to be possible by comparison of pre- and postcontrast T1 weighted images.

Superior delineation of the osteomyelitic process by CT and MRI, as compared with conventional radiographs, allowed the differentiation into two subtypes: a more extensive 'intramedullary' osteomyelitis and a more localized 'subperiosteal' osteomyelitis. Computed tomography and MRI therefore provided the radiological correlate for a differentiation, which had been applied by *Mercuri* (1991) to the acute stage on clinical grounds. In the former type, cancellous bone infiltration and endosteal resorption are due to primary intramedullary extension. Involvement of the mandibular canal may occur (*Felsberg* et al., 1990) and was found to correlate with inferior alveolar nerve hypaesthesia in every one of 6 patients in our series. The second type—acute 'subperiosteal' osteomyelitis—is characterized by early extension of the inflammatory process through the cortical bone via Volkmann's canals (*Mercuri*, 1991). Computed tomography in the 2 cases involved in this series was able to delineate erosion of the buccal and/or lingual cortical plate precisely. With a single exception, plain films were regularly unable to attribute a lesion to the lingual or buccal side.

Subperiosteal bone deposition was delineated by CT as early as 10 days after the initiation of symptoms. In accordance with *Yoshiura* et al. (1994), periosteal reactions most commonly occurred in secondary chronic osteomyelitis. Predominant buccal extension of osteomyelitis described by *Van Merkesteyn* et al. (1988) and *Yoshiura* et al. (1994) on the basis of CT findings, however, does not conform with our observations. Inflammation was found to affect the buccal and lingual cortical plate in 6 and 5 cases respectively. Extension along the

ascending ramus, however, was most pronounced on the buccal aspect in 3 of 4 cases.

Magnetic resonance imaging is the only imaging modality to reveal non-ossified periosteal reaction, which was depicted in 2 cases each in the acute/subacute and chronic stage. Magnetic resonance imaging thus provided the radiological correlation for the common intraoperative and histological finding of an inflammatory thickened periostium. As opposed to non-calcified periosteal inflammation, MRI was less sensitive in the detection of the presence of subperiosteal bone deposition and of a sequestrum in one case each. In primary chronic osteomyelitis, CT and MRI revealed extensive intramedullary sclerosis and T1 and T2 hypointensity respectively.

Remodelling of the cortical plate, mandibular enlargement, and paucity of inflammatory lesions in our patients are in accordance with plain film findings reported by *Marx* (1991) and *Worth* and *Stoneman* (1977). In the event of recurrent exacerbation, CT and MRI facilitated lesion localization by depicting areas of diminished sclerosis or the presence of intramedullary and/or periosteal contrast enhancement.

CONCLUSION

Despite sophistication in the conservative treatment by bacteriocidal antibiotics and hyperbaric oxygen, osteomyelitis of the jaw proved a disease that, in this series, necessitated surgery in all but one patient. However, improved delineation of osteomyelitis by CT, and in a few cases by MRI facilitated the maxillofacial surgeon's decision to intervene surgically. Thus, early detection of osteomyelitis and surgery might offer a chance to reduce substantially the frequently lengthy and uncertain course of 'healing' in patients with mandibular osteomyelitis.

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Mandibular osteomyelitis: evaluation and staging in 18 patients, using magnetic resonance imaging, computed tomography and conventional radiographs

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SUMMARY. **Over a period of 3 years, 18 patients with mandibular osteomyelitis were prospectively investigated by conventional radiograph, computed tomography (CT) and in 6 cases by magnetic resonance imaging (MRI). The diagnosis was based on histology in 17 patients operated upon.**

INTRODUCTION

Osteomyelitis of the jaw is defined as an inflammation of the mandibular cortical and cancellous bone, which is commonly caused by bacterial invasion from a contiguous focus. Odontogenic foci are the most frequent sources, consisting of periodontal disease and infections of the pulp or of extraction wounds (*Mercuri*, 1991; *Sailer*, 1991; *Hudson* 1993; *Lundeen* and *Barnett*, 1994). Infected fractures are the second most common cause of mandibular osteomyelitis (*Calhoun* et al., 1988; *Koorbusch* et al., 1992; *Taher*, 1993). Predisposing conditions such as chronic alcoholism (*Davies* and *Carr*, 1990), or underlying bone pathologies such as osteopetrosis (*Steiner* et al., 1983) are uncommon. The clinical course of mandibular osteomyelitis is variable. With an arbitrary time limit of one month after the initiation of symptoms, osteomyelitis is classified as acute or chronic (*Mercuri*, 1991; *Marx*, 1991). Chronic osteomyelitis may persist after an acute episode (secondary chronic osteomyelitis), or it may pursue an insidious course (*Vargas* et al., 1984; *Marx*, 1991) that has never undergone an appreciable acute phase (primary chronic osteomyelitis). The diagnosis of mandibular osteomyelitis requires radiological confirmation and reassessment by follow-up examinations in order to evaluate the response to treatment. Bone scintigraphy may be performed in the acute stage to establish the diagnosis (*Hardt*, 1991; *Rohlin*, 1993) or as a follow-up examination (*Hardt*, 1991; *Kaneda* et al., 1995). Conventional radiographs, although routinely applied, are limited by low sensitivity in the acute stage (*Mercuri*, 1991; *Hudson*, 1993). However, the value of computed tomography (CT) and magnetic resonance imaging (MRI) in the work-up of mandibular osteomyelitis is still controversial (*Yoshiura* et al., 1994; *Reinert* et al., 1995; *Seabold* et al., 1995). In a prospective study the CT and MRI findings were therefore evaluated in comparison with conventional radiographs in 18 patients with mandibular osteomyelitis.

MATERIAL AND METHODS

Eighteen patients suspected of having odontogenic mandibular osteomyelitis, on account of their clinical symptoms and signs, were examined prospectively during a period of 3 years. Patients with osteoradionecrosis of the mandible were not included in the study. Males outnumbered females in a ratio of 12 to 6. The patients ranged in age from 23 to 81 years. The mean age was 50.2 years for males and 46.7 years for females, with a mean age of 49 years for the whole group.

Radiological examinations consisted of conventional radiographs (panoramic radiograph, lateral oblique mandible and posteroanterior view), CT in 18 patients and MRI of the lower jaw in 6 cases.

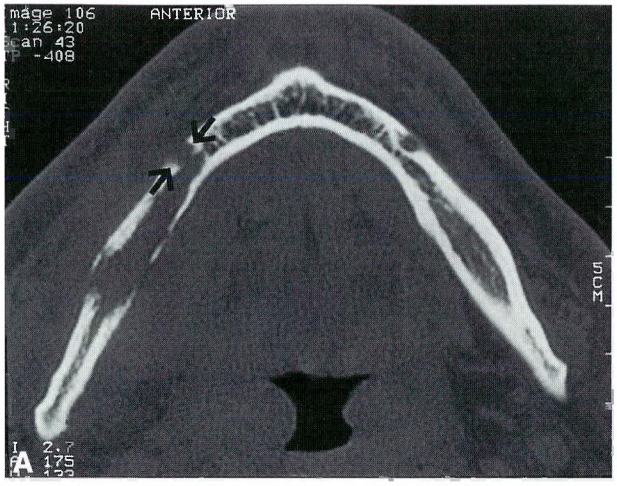
Computed tomography examinations were performed on a Siemens HiQS CT scanner with intravenous contrast application and 2 mm thick contiguous slices parallel to the mandibular body in the axial plane, and to the ascending ramus in the coronal plane.

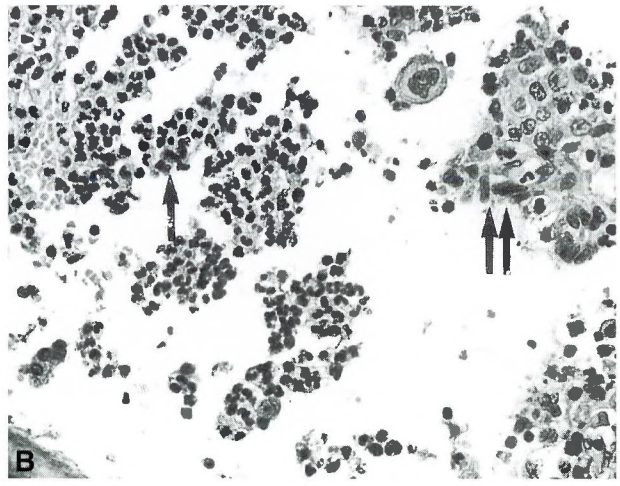
Magnetic resonance imaging examinations were performed on a 1.5T GE Signa and consisted of a sagittal and coronal T1 weighted series (TR 500–600, TE 17–20 ms) before and after intravenous contrast administration, an axial contrast enhanced T1 weighted series, and a T2 weighted sequence (TR 2 500, TE 20/80 ms). Slice thickness was 3.5 mm and 4 mm for the T1 and T2 weighted series respectively.

In order to assure comparability, conventional radiographs and CT and/or MRI were obtained within 5 days, on average within 3 days. Follow-up examinations consisted of conventional radiographs in every case as well as CT in 8 cases and MRI in

the case of one patient. Follow-up CT examinations and the single follow-up MRI were performed postoperatively with an average delay of 5 months and a range from 1 to 10 months. In 2 cases a second preoperative CT examination was performed.

The films were re-read by a radiologist (B. F. Schuknecht) and a maxillofacial surgeon with longstanding experience in maxillofacial radiology (F. R. Carls). Conventional radiographs, CT and MRI were cumulatively assessed in the aforementioned sequence. Computed tomography was considered as the 'gold standard' for cortical bone lesions, sequestra and subperiosteal bone deposition (ossified periosteal reaction). The presence of sequestra was confirmed by histology in every patient (6 cases). Involvement of cancellous bone by CT was only found indicative for osteomyelitis in the presence of additional endosteal cortical erosions or transcortical defects. To be considered pathological, involvement of cancellous bone on MRI required the presence of





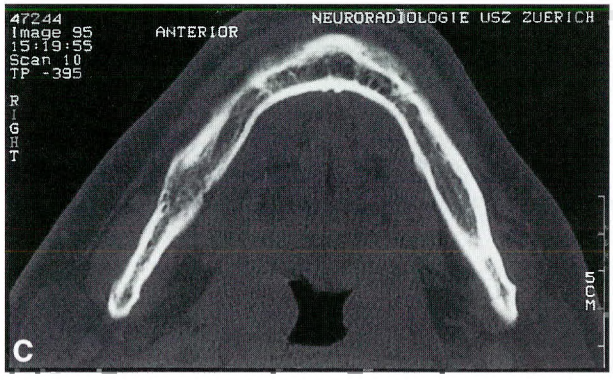
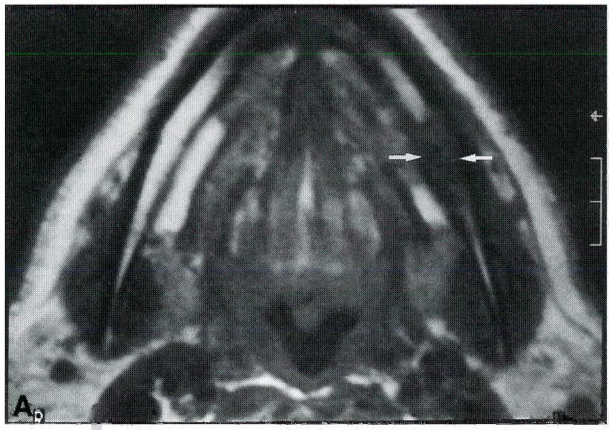


Fig. 1 – Acute 'intramedullary osteomyelitis' in a 38-year-old patient (Case 3) with a two-week history of pain and swelling. (**A**) Destruction of cancellous bone of the mandibular body with loss of contour of the right mandibular canal and endosteal resorption of the lingual and buccal cortical plates. Enlargement of right foramen mentale (arrows). (**B**) Histology (HE 260 ×) reveals a dense infiltrate of inflammatory cells mainly composed of neutrophils (arrow) and few histiocytes (double arrow). (**C**) Following decortication and antibiotic therapy almost complete osseous reconstitution after 6 months.



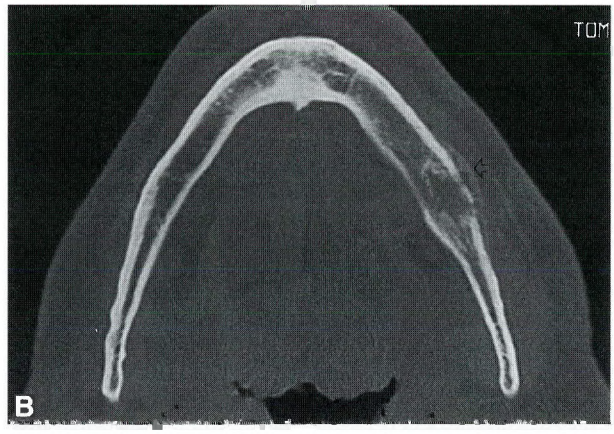


Fig. 2 – Axial non-contrast T1 weighted MR image reveals (**A**) circumscribed cancellous bone involvement (hypointense signal), thinning of the buccal and lingual cortices (white arrows) and lingual fat infiltration. High resolution CT depicts (**B**) less extensive bone marrow changes but is superior in delineating demineralization of lingual cortex and interruption of buccal plate with linear subperiostal bone deposition (open arrow). Cancellous bone sclerosis adjacent to osteolysis is only faintly appreciable on MRI in comparison with CT in a 47-year-old patient with acute osteomyelitis of the left molar region.

a Gadolinium enhancing lesion and of intermediate to high signal intensity on a T2 weighted sequence. In view of a high proportion of previous tooth extractions (44.5%), that had been performed on an outpatient basis and preceded the work-up for osteomyelitis by 1.5–4 months, scintigraphy was not included in the diagnostic protocol. In 17 cases CT examinations, and in 6 cases MRI examinations, were performed before surgery. In one case (Table 1, Case 4) surgery was not performed. Two patients had undergone their first surgical therapy for mandibular osteomyelitis in another hospital, respectively, 2 months and 1.5 years previously. Surgery was performed based on the concept of early decortication of either the buccal or lingual cortical plate (*Vargas* et al., 1984) or partial mandibular resection with immediate reconstruction (*Sailer*, 1991). Complementary therapy consisted of systemic antibiotic and hyperbaric oxygen therapy. Fifteen patients underwent decortication, and in 2 patients partial mandibular resection and reconstruction was performed. The histology obtained was compared with the imaging findings in the 10 patients with the least time interval (3–7 days) between the radiological examinations and surgery. The clinical findings and particular therapeutic considerations are the subject of an on-going study.

RESULTS

Acute and subacute osteomyelitis

Four patients with a history of symptoms ranging from 8 days to 2.5 weeks were examined. In a second group of 4 patients symptoms prevailed for 2.5–4 weeks (subacute osteomyelitis). A summary and comparison of the plain film, CT and MRI findings is provided in Tables 1 and 2. Plain films were negative in 2 of 4 patients (50%) in the acute stage, whilst in 3 other cases (1 acute, 2 subacute) conventional radiographs revealed only subtle areas of demineralization in the premolar regions. In only one of the four cases was osteomyelitis identified on the basis of conventional radiographs. Computed tomography and MRI images depicted lesions that consisted initially of cancellous bone osteolysis, endosteal erosions, and cortical defects (Figs. 1 & 2)

Histopathologically, an intense inflammatory reaction was present in the acute cases with abundant neutrophils changing towards an increasing number of histiocytes in the subacute stage (Fig. 1b). In the subacute stage sequestra were detected on plain radiographs in 2 of 3 cases, by CT in all the cases, in whom histology had proven non-vital cortical bone (Figs. 3 & 4). Cortical plate erosion and cancellous bone osteolysis appeared one molar or premolar region greater on CT; in 4 out of 6 cases (66.6%) with positive plain film findings. In comparison with CT, MRI in the 2 patients on whom it was performed revealed a larger T2 hyperintense and T1 hypointense medullary bone lesion (Fig. 2). Periosteal calcifications were identified by CT in 4 cases (Figs. 2, 3, 4). Magnetic resonance imaging, however, provided evidence of contrast enhancing thickened periostium in an additional patient in the acute and subacute stage.

Chronic osteomyelitis

In 7 patients, mandibular osteomyelitis was classified as secondary chronic on the basis of symptoms of more than 4 weeks duration and the presence of a previous acute episode. A causative event could not be detected in the history of 3 patients with primary chronic osteomyelitis. As is shown in Table 1, the secondary chronic type on plain films and CT was characterized by an increasing degree of cancellous bone sclerosis, periosteal calcifications in conjunction with focal areas of osteolysis or sequestration (Fig. 5).

Histopathologically, in chronic inflammation lymphocytes and plasma cells were found to predominate in the vicinity of devitalized bone (Fig. 4b). Computed tomography was more sensitive than conventional radiographs in the detection of medullary sclerosis (Fig. 6) and inferior alveolar nerve canal involvement. The latter was missed by plain films in 2 of 3 cases. Sequestra, proven by histology in 3 cases, were detected in equal frequency by conventional radiographs and CT. Cortical bone erosion and sequestration was associated with linear periosteal reactions that were recognized by CT in 6 out of 7 cases, by plain films in 2 cases and by MRI in 2 cases. Only MRI was able to identify a non-ossified periosteal reaction in 2 cases (Fig. 5 & 7). Primary chronic osteomyelitis was diagnosed by plain films in all 3 patients. Extensive sclerosis of the cancellous bone was demonstrated by plain films and CT, while MRI revealed diffuse medullary bone T1/T2 hypointensity with only a little increase in signal intensity after intravenous contrast administration (Fig. 7). In primary chronic osteomyelitis, CT and MRI revealed the least degree of soft tissue swelling compared with acute/subacute and secondary chronic osteomyelitis. A proposal for a diagnostic pathway is provided by Figure 8.

DISCUSSION

Mandibular osteomyelitis remains a challenge with respect to both diagnosis and management. Complications arising from missed or delayed diagnosis include formation of sequestra and subsequent fistulae, recurrent exacerbation of chronic osteomyel-

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Table 1 – Conventional radiograph, CT and MRI findings in 18 patients with mandibular osteomyelitis

						Conventional radiographs		Computed Tomography			Magnetic resonance imaging					
Patient	Sex	Age	Duration	Stage	Location	Lesion	Periost.	Cortical bone	Marrow	Periost.	Cortical bone	Marrow			Periost.	Follow-up
1	F	52	2 weeks	acute	molar	–	–	erosion	(lytic)	l[1]	thinned	T1↓	T2↑	Gd+	no	CT
2	F	63	2 weeks	acute	premolar	osteolysis	–	erosion	(lytic), sclerosis[1]	–	–		–		–	CT
3	M	38	2 weeks	acute	premolar	osteolysis	–	defect	lytic	–	–		–		–	CT
4	M	47	2.5 weeks	acute	premolar	–	–	defect	lytic	b	thinned	T1↓	T2↑	Gd+	o	CT
5	M	49	2.5 weeks	subacute	molar	osteolysis	–	defect, fistula	lytic	l	–		–		–	–
6	M	23	4 weeks	subacute	premolar	sequestrum, fracture	–	sequestrum[2]	lytic	b	–		–		–	–
7	M	71	4 weeks	subacute	molar	sequestrum	–	sequestrum[2], fistula	lytic, sclerosis	–	–		–		–	–
8	M	81	4 weeks	subacute	premolar	osteolysis	–	sequestrum[2], fistula	lytic	–	thinned, sequestrum	T1↓	T2↑	Gd+	no	CT
9	M	56	5 weeks	sec. chronic	premolar	osteolysis	–	erosion	sclerosis	–	–		–		–	–
10	M	42	6 weeks	sec. chronic	molar,ramus	sequestrum	–	$sequestrum_2$	lytic, sclerosis	l+b	–		–		–	–
11	M	57	2 months	sec. chronic	molar	osteolysis	–	erosion	sclerosis	b	–		–		–	–
12	F	26	4 months	sec. chronic	molar,ramus	sequestrum, sclerosis	+	$sequestrum_2$	sclerosis	l>b	–		–		–	–
13	M	25	11 months	sec. chronic	angle,ramus	sequestrum, sclerosis	–	$sequestrum_2$	sclerosis	l+b	thickened, sequestrum	T1↓	T2↓	Gd(+)	no	CT
14	F	45	1.5 years	sec. chronic	body,ramus body	sclerosis osteolysis	+	erosion	sclerosis	b	–		–			CT
15	F	35	4 years	sec. chronic	hemimandible	sclerosis osteolysis	–	erosion	sclerosis	l	thickened, erosion	T1↓	T2↓	Gd–	o, no	MR
16	M	61	1.5 years	prim. chronic	hemimandible	sclerosis, enlargement	–	thickened	sclerosis	b[1]	thickened	T1↓	T2↓	Gd+	no	CT
17	M	51	2 years	prim. chronic	hemimandible	sclerosis	–	thickened	sclerosis	–	–		–		–	–
18	F	59	6 years	prim. chronic	hemimandible	sclerosis, enlargement	–	thickened	sclerosis	–	–		–		–	–

[1] On follow-up, [2] in conjunction with erosion. sec.chron = secondary chronic, prim.chron = primary chronic, l = lingual b = buccal, o = ossified, no = non-ossified

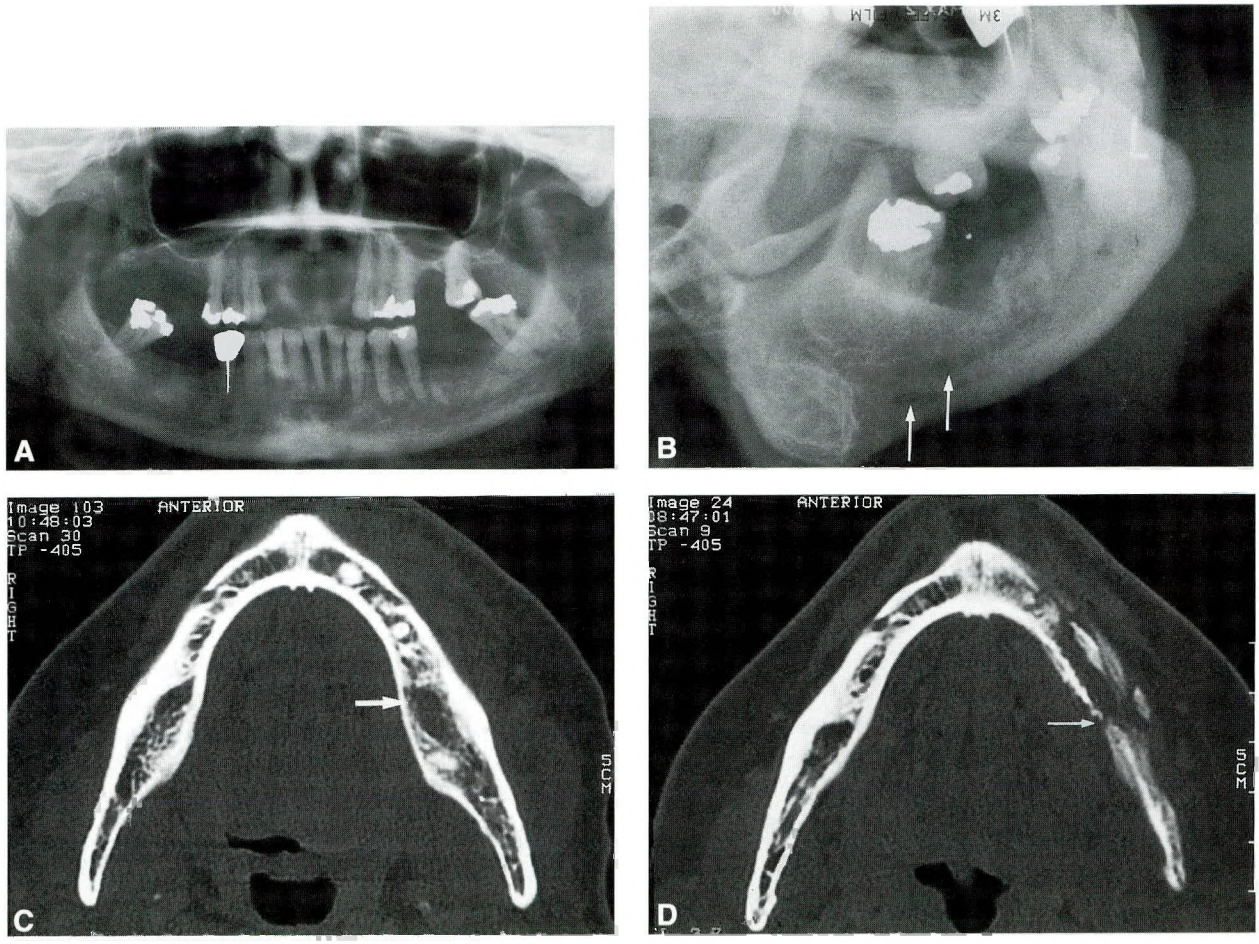


Fig. 3 – Orthopartomography (OPG) (**A**) without evidence of osteomyelitis. Lateral oblique view (**B**) with subtle osteolytic foci (arrows) below empty socket 2.5 weeks after extraction of carious left lower molar in a 63-year-old patient. Axial CT (**C**) depicts discrete lingual endosteal cortical erosion (arrows) and demineralization adjacent to empty socket. After 3 months of intermittent antibiotic courses (due to an initial refusal of surgery and non-compliance) progression from acute (**C**) to secondary chronic osteomyelitis (**D**). Pathological fracture (arrow) adjacent to an area of osteolysis and sclerosis with ossified periosteal reaction. In addition two buccal sequestra are present.

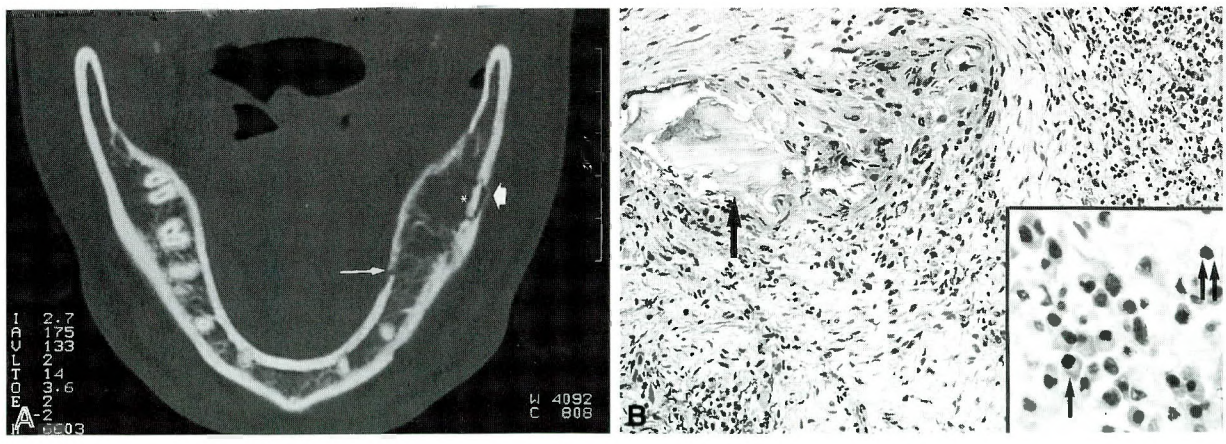


Fig. 4 – (**A**) Axial CT with subacute 'subperiosteal osteomyelitis' in a 23-year-old patient 4 weeks after extraction of left lower molar and 2.5 weeks after drainage of a perimandibular abscess. Sequestrum (*) covered by buccal periosteal reaction (broad arrow) called 'involucrum'. In addition, central ostolysis is present with adjacent lingual endosteal erosion, demineralization and transcortical extension (arrow). (**B**) Histology (HE 300 ×, inset 600 ×) depicts a fragment of necrotic bone (arrow) surrounded by inflammatory cells consisting mainly of plasma cells (inset, arrow) and lymphocytes (inset, double arrow).

itis, pathological fracture, bone deformity and, rarely, neoplastic conversion (*Mercuri*, 1991; *Hudson*, 1993; *Yoshiura* et al., 1994). Early diagnosis and implementation of therapy is therefore imperative (*Adekeye* and *Cornah*, 1985; *Sailer*, 1991). A broad diagnostic armamentarium is available that includes conventional radiographs, bone scintigraphy, CT and recently MRI. However, consensus is poor with

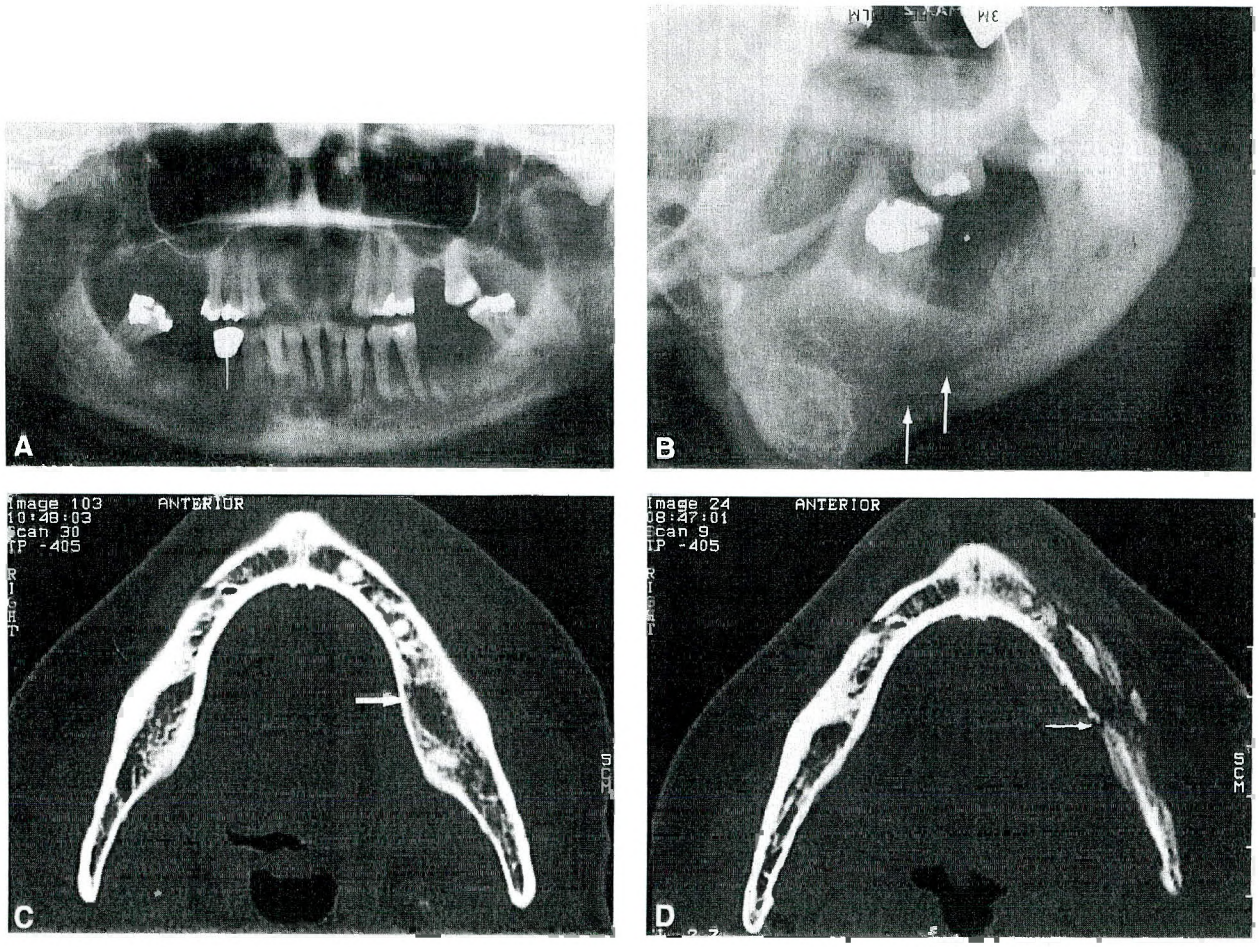


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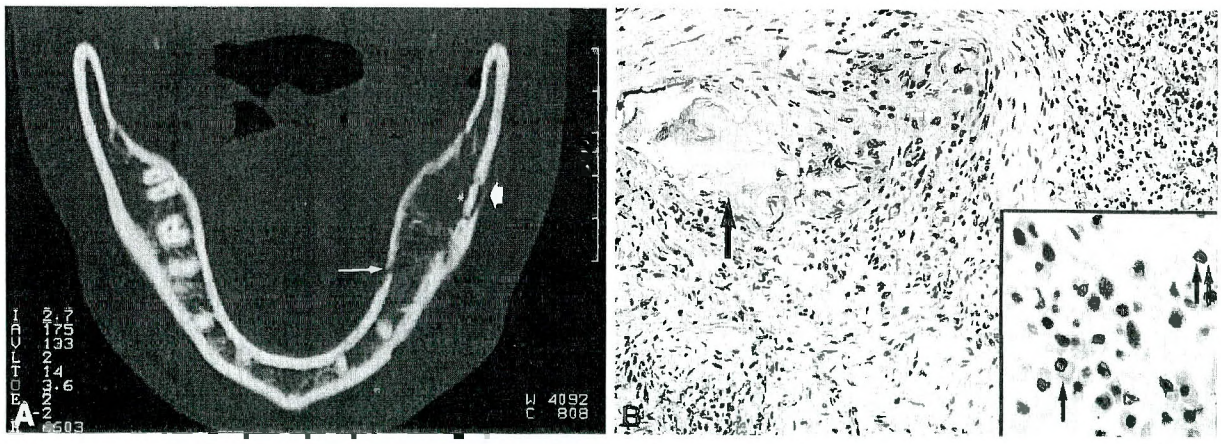


Fig. 4 – (**A**) Axial CT with subacute 'subperiosteal osteomyelitis' in a 23-year-old patient 4 weeks after extraction of left lower molar and 2.5 weeks after drainage of a perimandibular abscess. Sequestrum (*) covered by buccal periosteal reaction (broad arrow) called 'involucrum'. In addition, central ostolysis is present with adjacent lingual endosteal erosion, demineralization and transcortical extension (arrow). (**B**) Histology (HE 300 ×, inset 600 ×) depicts a fragment of necrotic bone (arrow) surrounded by inflammatory cells consisting mainly of plasma cells (inset, arrow) and lymphocytes (inset, double arrow).

itis, pathological fracture, bone deformity and, rarely, neoplastic conversion (*Mercuri*, 1991; *Hudson*, 1993; *Yoshiura* et al., 1994). Early diagnosis and implementation of therapy is therefore imperative (*Adekeye* and *Cornah*, 1985; *Sailer*, 1991). A broad diagnostic armamentarium is available that includes conventional radiographs, bone scintigraphy, CT and recently MRI. However, consensus is poor with

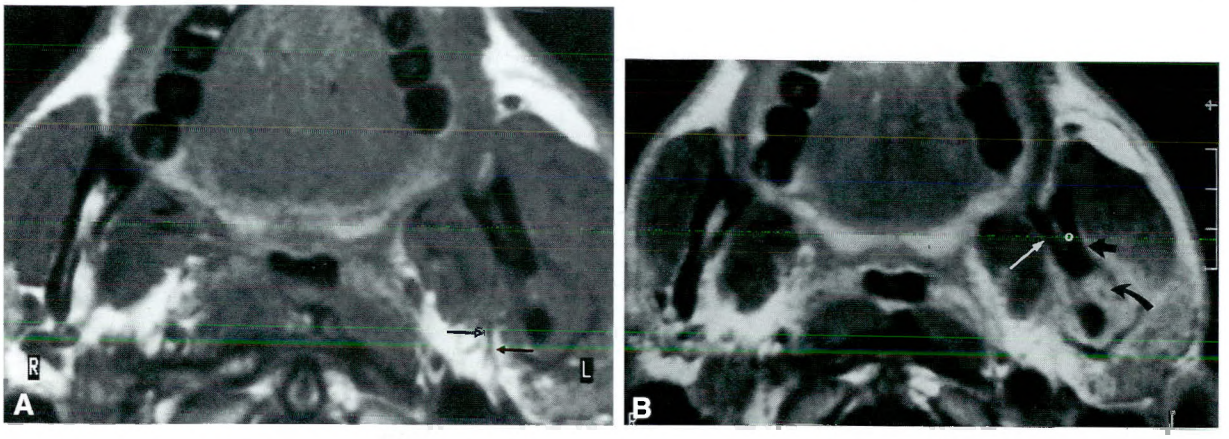


Fig. 5 – Axial T1 weighted MR image before (**A**) and after contrast application (**B**). Perimandibular fat plane medial to ascending ramus and posterior to masseter muscle infiltrated by isointense tissue surrounding inferior alveolar nerve (small arrows). Marked contrast enhancement with buccal periosteal involvement (straight black arrow) transcortical extension (curved arrow) and masseter infiltration. Thickened lingual cortical plate (white arrow) of ascending ramus. Twenty-five year old male with a history of left molar extraction followed by perimandibular abscess 11 months previously.

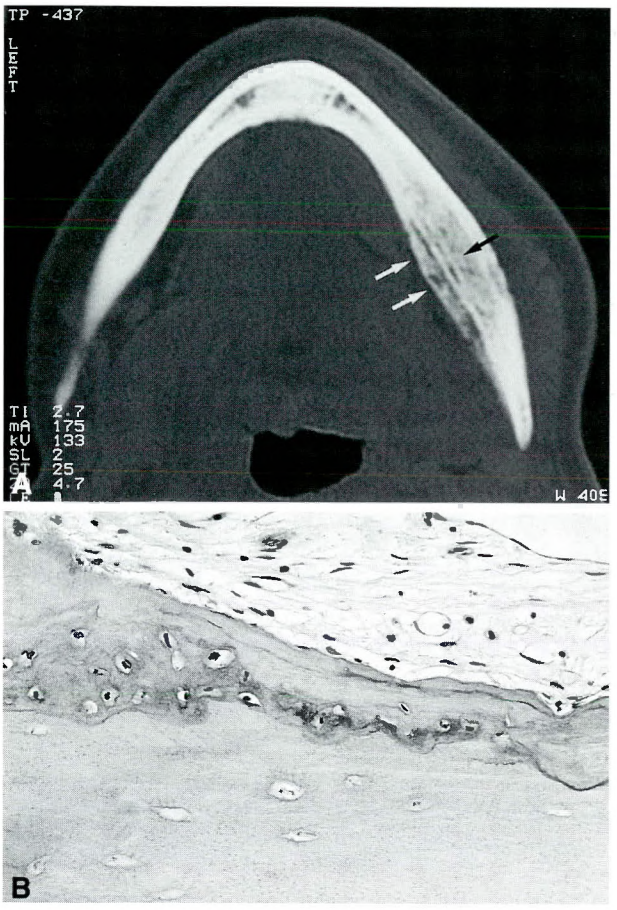


Fig. 6 – (**A**) 'Onion skin' layers of subperiosteal bone (white arrows) extending outward from the cortical margin and cancellous bone sclerosis (long arrow) in a 45-year-old female with secondary chronic osteomyelitis of right hemimandible. Persistent right mandibular swelling after extraction of right lower molars 1.5 years previously. (**B**) Histology (HE 300 ×) showed appositional bone layed down on necrotic cortical bone. Almost no viable osteocytes are present.

regard to the rational employment of the adequate imaging modality.

Conventional radiographs, and the orthopanoramic view in particular, are an integral part in the evaluative work-up of a patient suspected of developing mandibular osteomyelitis (*Johannsen*, 1977; *Worth* and *Stoneman*, 1977; *Jacobsson* et al., 1978; *Obwegeser* and *Sailer*, 1978; *Montonen* et al., 1993). This is despite the fact that osseous changes may not become visible until 10–12 days (*Capitano* and *Kirkpatrick*, 1970), or 2–3 weeks (*Davies* and *Carr*, 1990) after the initial symptoms. However, in the appropriate clinical setting the presence of periodontal disease and root remnants are indicators that justify the examination even in the potential early absence of osteolysis or sequestration. In our study, osteomyelitis was diagnosed within the first 4 weeks in only 3 out of 8 patients by conventional radiographs (37.5%), and in only 1 of 4 patients within the first 2 weeks. In retrospect, plain films in another 3 out of 8 cases (37.5%) revealed subtle signs of inflammation. Only after 4 weeks were conventional radiographs definitively diagnostic in every patient.

In agreement with *Wannfors* and *Hammarström* (1985), the extent of mandibular osseous changes in this study was found to correlate with the duration of the disease: extension into the ascending ramus occurred in 4 out of 7 patients with secondary chronic inflammation (57.1%), while it was not present in the acute and subacute types. Primary chronic osteomyelitis in 3 cases involved the entire hemimandible and in the 'quiet phase' exhibited a more uniform radiopaque appearance than the secondary chronic type.

Scintigraphy may reveal increased bone metabolism as early as 24–48 h (*Hardt*, 1991) or 3 days (*Rohlin*, 1993) after the onset of symptoms. Thus technetium-99m or gallium-67 scans are able to demonstrate the change in mandibular osteoblastic and

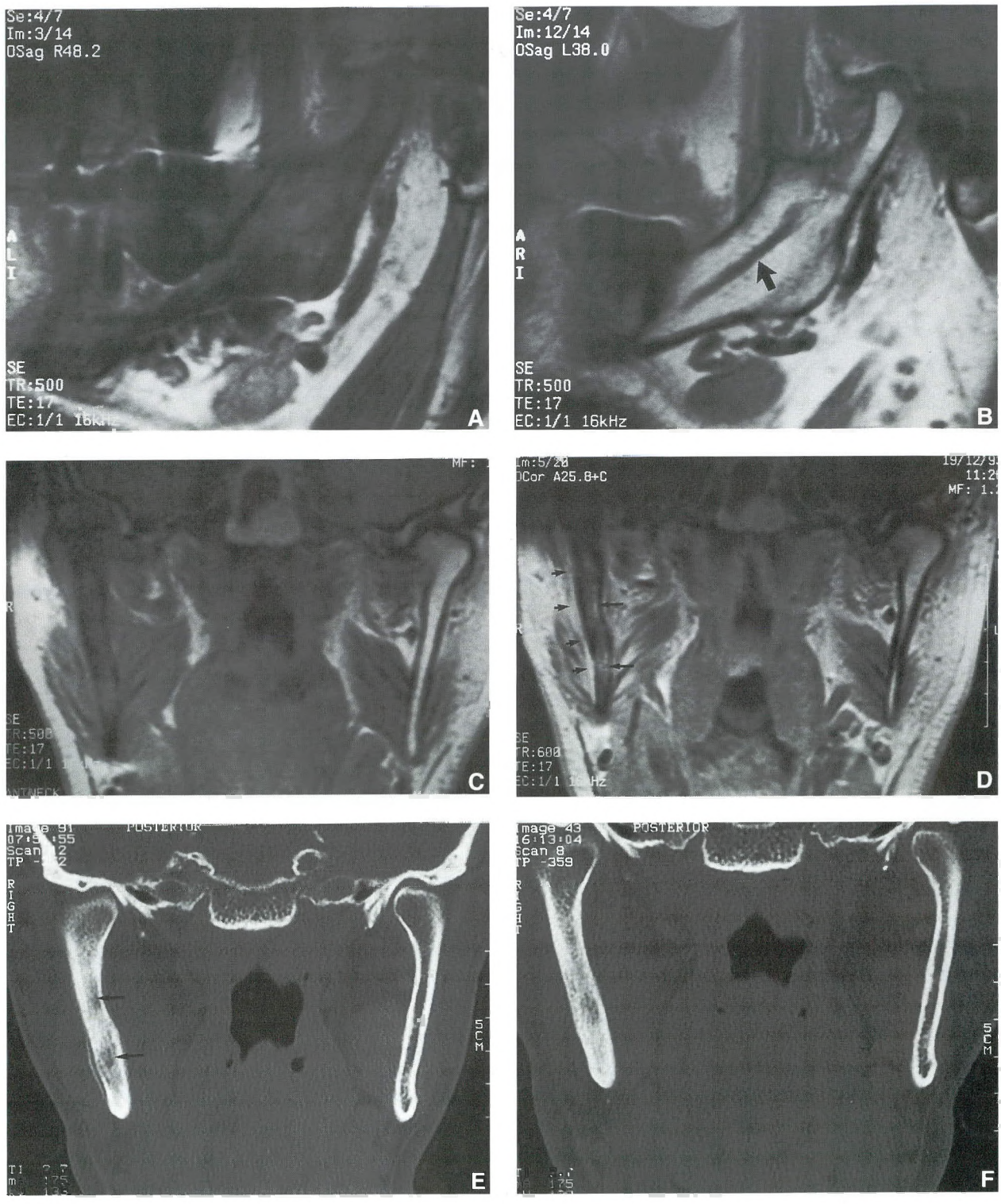


Fig. 7 – Recurrent episodes of swelling of right hemimandible in a 61-year-old patient 3 years after extraction of right lower molar and 1.5 years after buccal decortication of mandibular body. Sagittal T1 weighted MR images with a striking difference of signal intensity between diseased right (**A**) and normal left hemimandible (**B**). Mandibular canal and inferior alveolar nerve (arrow) are easily recognized within normal fat containing bone marrow. Coronal T1 weighted images before (**C**) and after contrast injection (**D**) reveal contrast enhancement with increased signal intensity of thickened periostium particularly on buccal side (arrows) and inflammatory intramedullary foci (long arrows). Corresponding CT (**E**) demonstrates areas of demineralized cancellous bone (arrows) and calcified portions of periosteal reaction, that had not been present 10 months previously. (**F**) Exacerbation of primary chronic osteomyelitis.

osteoclastic activity, and the presence of an infective focus well ahead of the morphologic changes (*Mercuri*, 1991). The high sensitivity of scintigraphy, which is reported to be almost equivalent to MRI (*Tsuchimochi* et al., 1991; *Reinert* et al., 1995), does not, however, have the same degree of specificity. Increased activity in the presence of recent tooth extractions, soft tissue inflammation and persistence

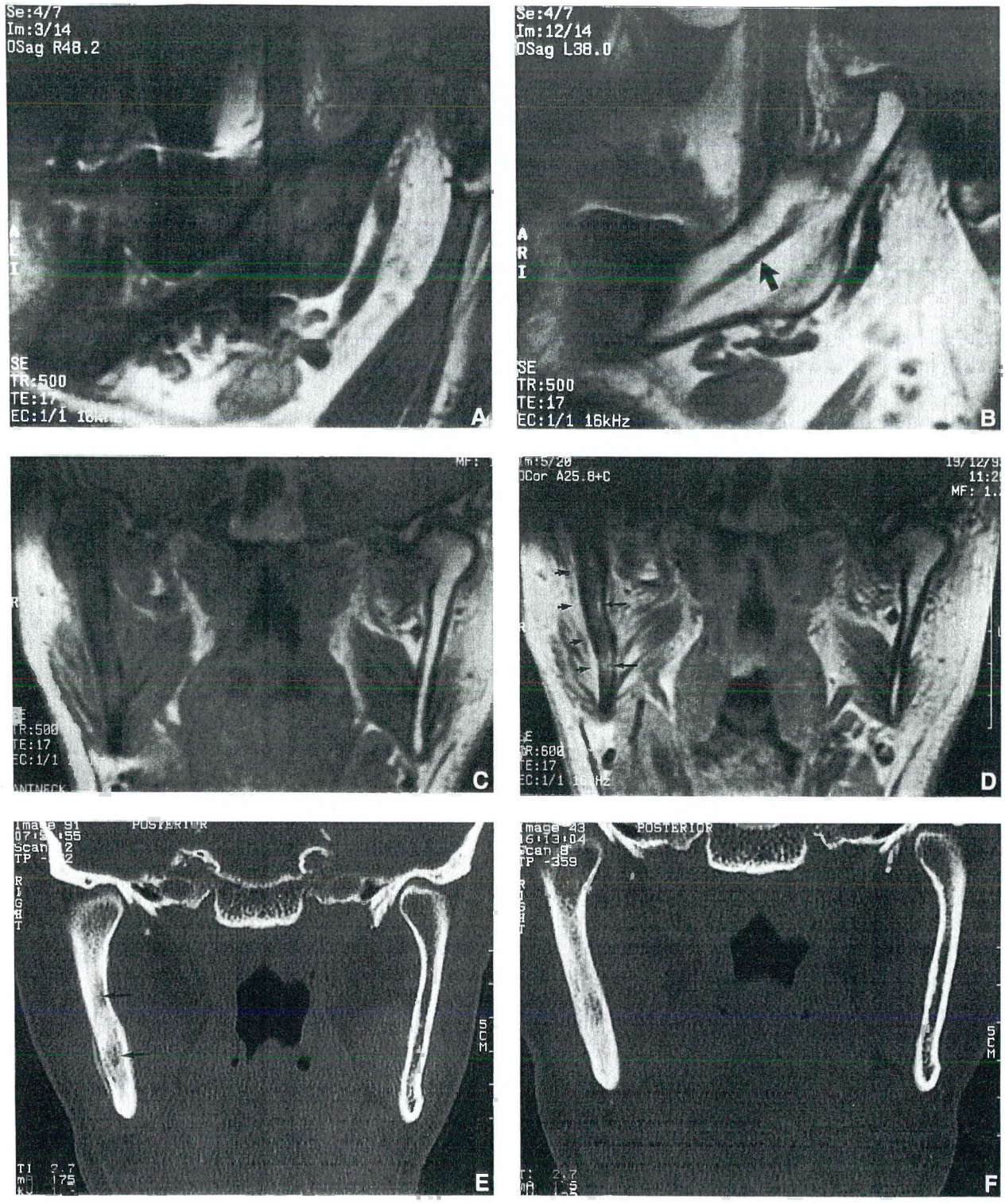


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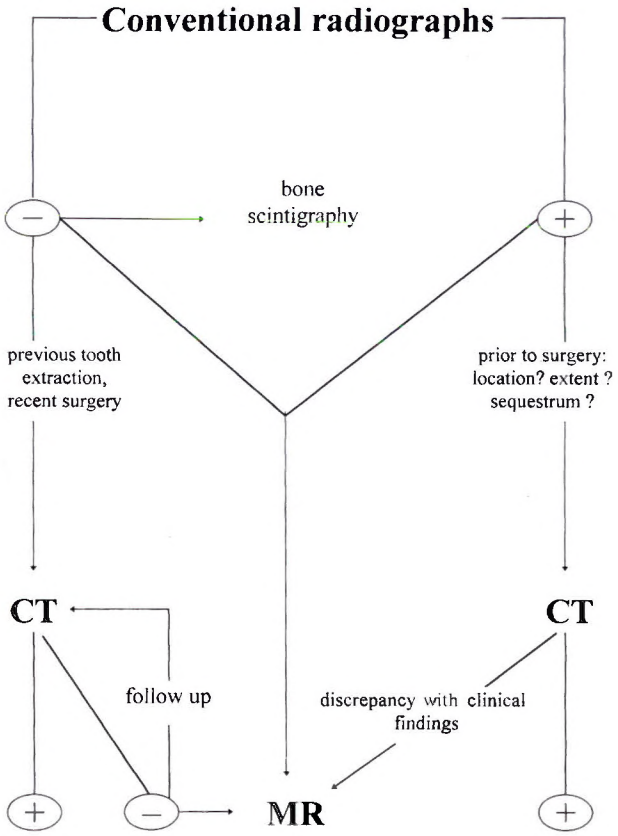


Fig. 8 – Diagnostic pathway in patients suspected of mandibular osteomyelitis.

of activity up to 4 months postoperatively constitute restrictions that limit the diagnostic contribution of scintigraphy in the acute stage, as well as in early postoperative follow-up examinations. Moreover, the poor spatial resolution of scintigraphy does not provide the detailed osseous information that is required preoperatively (*Sailer*, 1991; *Hudson*, 1993).

The demand for a more reliable imaging technique combining high sensitivity, spatial resolution and soft tissue information has led to an increase in the use of CT (*Osborn* et al., 1982; *Van Merkesteyn* et al., 1988; *Felsberg* et al., 1990; *Kanemoto* et al., 1992, *Ohlms* et al., 1993, *Yoshiura* et al., 1994) and recently of MRI (*Kaneda* et al., 1995; *Reinert* et al., 1995; *Seabold* et al., 1995). Lesion location and extent prior to the availability of CT and MRI were determined by conventional X-rays (*Vargas* et al., 1984) and recurrence was often attributed to an insufficiently radical surgical technique (*Montonen* et al., 1993). Accordingly, comparison of CT and plain films revealed a larger lesion extension within the mandibular body in 66.6% of cases in the acute and subacute stages on CT in our series. Superiority of CT is also underlined by *Kaneda* et al. (1995), who reported positive CT findings in 2 out of 4 acute cases interpreted as normal on plain films. In secondary chronic osteomyelitis the location and extent of cortical erosion and medullary sclerosis were demonstrated to better advantage by CT in 5 of 7 cases (71.4%). This also holds true for the identification of sequestra which, in accordance with *Yoshiura* et al. (1994), had been missed on plain films in one-third of cases in the subacute stage in our series. Sequestra, however, are considered rare in acute osteomyelitis (*Mercuri*, 1991) and more typically are found in chronic osteomyelitis (*Vargas* et al., 1984; *Kaneda* et al., 1995). The 3 patients encountered with sequestra within 4 weeks of onset in this series indicate that the transition from acute to chronic osteomyelitis, in accordance with histological findings, occurs earlier than after 1 month. Infiltration of the cancellous bone and replacement of marrow fat by inflammatory tissue accounts for the remarkably high sensitivity of MRI as compared with CT (*Chandnani* et al., 1990) and even scintigraphy (*Williamson* et al., 1991). In accordance with *Kaneda* et al. (1995) MRI revealed a more extensive intramedullary inflammation than CT in acute and subacute osteomyelitis. A distinction between active inflammation and bone marrow oedema, however, only appears to be possible by comparison of pre- and postcontrast T1 weighted images.

Superior delineation of the osteomyelitic process by CT and MRI, as compared with conventional radiographs, allowed the differentiation into two subtypes: a more extensive 'intramedullary' osteomyelitis and a more localized 'subperiosteal' osteomyelitis. Computed tomography and MRI therefore provided the radiological correlate for a differentiation, which had been applied by *Mercuri* (1991) to the acute stage on clinical grounds. In the former type, cancellous bone infiltration and endosteal resorption are due to primary intramedullary extension. Involvement of the mandibular canal may occur (*Felsberg* et al., 1990) and was found to correlate with inferior alveolar nerve hypaesthesia in every one of 6 patients in our series. The second type—acute 'subperiosteal' osteomyelitis—is characterized by early extension of the inflammatory process through the cortical bone via Volkmann's canals (*Mercuri*, 1991). Computed tomography in the 2 cases involved in this series was able to delineate erosion of the buccal and/or lingual cortical plate precisely. With a single exception, plain films were regularly unable to attribute a lesion to the lingual or buccal side.

Subperiosteal bone deposition was delineated by CT as early as 10 days after the initiation of symptoms. In accordance with *Yoshiura* et al. (1994), periosteal reactions most commonly occurred in secondary chronic osteomyelitis. Predominant buccal extension of osteomyelitis described by *Van Merkesteyn* et al. (1988) and *Yoshiura* et al. (1994) on the basis of CT findings, however, does not conform with our observations. Inflammation was found to affect the buccal and lingual cortical plate in 6 and 5 cases respectively. Extension along the

ascending ramus, however, was most pronounced on the buccal aspect in 3 of 4 cases.

Magnetic resonance imaging is the only imaging modality to reveal non-ossified periosteal reaction, which was depicted in 2 cases each in the acute/subacute and chronic stage. Magnetic resonance imaging thus provided the radiological correlation for the common intraoperative and histological finding of an inflammatory thickened periostium. As opposed to non-calcified periosteal inflammation, MRI was less sensitive in the detection of the presence of subperiosteal bone deposition and of a sequestrum in one case each. In primary chronic osteomyelitis, CT and MRI revealed extensive intramedullary sclerosis and T1 and T2 hypointensity respectively.

Remodelling of the cortical plate, mandibular enlargement, and paucity of inflammatory lesions in our patients are in accordance with plain film findings reported by *Marx* (1991) and *Worth* and *Stoneman* (1977). In the event of recurrent exacerbation, CT and MRI facilitated lesion localization by depicting areas of diminished sclerosis or the presence of intramedullary and/or periosteal contrast enhancement.

CONCLUSION

Despite sophistication in the conservative treatment by bacteriocidal antibiotics and hyperbaric oxygen, osteomyelitis of the jaw proved a disease that, in this series, necessitated surgery in all but one patient. However, improved delineation of osteomyelitis by CT, and in a few cases by MRI facilitated the maxillofacial surgeon's decision to intervene surgically. Thus, early detection of osteomyelitis and surgery might offer a chance to reduce substantially the frequently lengthy and uncertain course of 'healing' in patients with mandibular osteomyelitis.

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