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Radiation osteitis of the clavicle

(following radiotherapy and radical neck dissection of head and neck cancer)

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SUMMARY

The bone alterations in the region of the clavicle (3 cases) are similar to those we have observed and described elsewhere in the skeleton i.e., the mandible, maxillary and ethmoid bones. Rarefaction is the result of three different types of bone destruction: osteoclasia, a kind of osteocytic osteolysis only observed after irradiation and obviously related with infection, and a pure demineralization of the osseous tissue by contact with pus. Reconstruction processes, although unable to prevent spontaneous fracture, are also present and correspond to islets of chondroid tissue surrounded by lamellar bone. However, these recently deposited calcified tissues are already necrotic since most of their lacunae are empty.

KEY WORDS:

Radiation osteitis, clavicle, microradiograph.

RÉSUMÉ

Les modifications osseuses dans la région de la clavicule (3 observations) sont semblables à celles observées ailleurs dans le squelette, par exemple la mandibule, le maxillaire et l'os ethmoïde. La raréfaction osseuse est le résultat de trois types différents de destruction: l'ostéoclasie, une espèce d'ostéolyse ostéocytaire observée après irradiation, en rapport certain avec une infection et une déminéralisation pure du tissu osseux en contact avec du pus. Les phénomènes de reconstruction, bien qu'incapables d'éviter une fracture spontanée, sont également présents et ils correspondent à des îlots de tissu chondroïde au sein de travées d'os lamellaire. Cependant ces tissus calcifiés récemment déposés sont déjà nécrosés puisque les ostéoplastes sont vides.

MOTS-CLÉS:

Ostéite postradique, clavicule, microradiographie.

INTRODUCTION

For many decades, clinicians have been well aware that irradiating a cancer often results in alterations of the exposed bones leading to osteoradionecrosis or to spontaneous fracture (Baensch, 1927).

Although the frequency of these complications has considerably diminished, mainly due to the use of high-energy irradiation (Pointon, 1977), the risks increase, once again, in direct proportion to the time delay following the treatment (Meunier, 1986; Epstein et coll., 1987) or if surgery is associated with radiotherapy (Kaplan et coll., 1977).

The clavicle may be the center of such accidents during the treatment of a malignant tumor at the base of the neck (Waldvogel et coll., 1970) or of the vocal cords with an extension under the glottis (Krespi et coll., 1983).

The aim of this paper is to show that the clinical and microradiographical observations in three cases of osteoradionecrosis of the clavicle are identical when compared with a former study of about forty cases of radiation osteitis of the mandible (Dambrain et coll., 1979). The main advantage of microradiographic analysis is to furnish detailed images up to the cytological level (Amprino, 1952).

MATERIALS AND METHODS

Three cases of infected radiation osteitis of the clavicle from three human males are described and reviewed in table I. A microradiographical and histological analysis of the undecalcified sections of the surgically resected fragment has been carried out according to the classical method previously described (Dhem, 1967).

Once removed, the specimens were immersed in absolute methanol. After embedding in methyl methacrylate, the specimens were cut in transversal sections and were then brought to a uniform thickness of 80 microns by manual grinding under absolute methanol. Light microscope examinations are performed on the microradiographs.

TABLE I
Clinical findings
(1) M.P.M.: major pectoralis myocutaneous flap.
(2) L.D.M.F.: latissimus dorsi myocutaneous flap.
(3) The numbers between brackets indicate the delay (in months) from the beginning of the infection to the re-appearance of the tumor.

N°	Age	Site of tumor	Stage	Treatment	Clavicle ORN
1	50	right edge of tongue	T2NoMo	^{60}Co+ ^{192}Ir	(7) fistula of right clavicle+ 1th rib+ manubrium stern.
2	79	right piriformis sinus	?	radical neck dissection	(9) spontaneous fracture of right clavicle
		left retromolar trigonum	?	^{60}Co 70 Gy tumor 56 Gy neck	(16) fistula of right clavicle+ L.D.M.F.
3	60	Base of tongue right	T2NoMo	Pharyngectomy+ M.P.M. (1) right Co 50 Gy bilat.	(4) Spontaneous fracture of left clavicle/fistula
		(4) right tonsil	T2NoMo	^{60}Co (? Gy)	(5) excision and L.D.M.F. (2) left

RESULTS

Patients underwent a clavicle resection following radiotherapy and radical neck dissection of head and neck cancer. The operated areas were depressed and were covered by a healed and dyschromic skin (Fig. 1). The diaphyseal area of the clavicle which had been connected with the external surroundings before exeresis shows a white and smooth aspect in contrast to the epiphyseal extremities (Fig. 2).


1

Fig. 1: Clinical aspect of the neck after ablation of the clavicle.
Fig. 1: Aspect clinique du cou après résection de la clavicule.

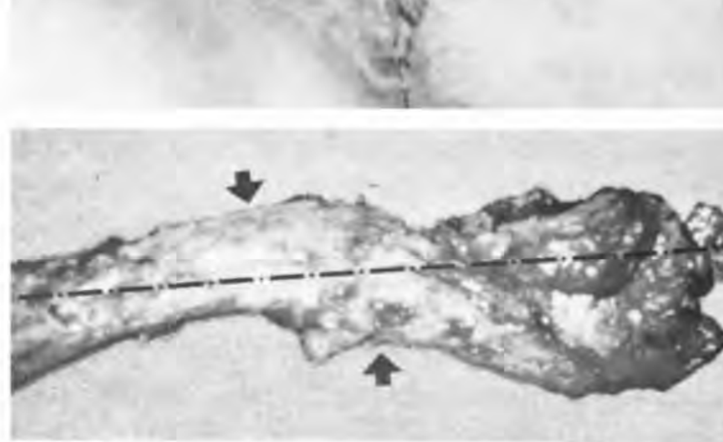
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Fig. 2: The fragment of the clavicle. Between thin arrows, the area was in connection with the exterior surroundings. The dotted line indicates the level where the sections have been taken.
Fig. 2: Le fragment de clavicule. La plage indiquée par les flèches était en relation avec le milieu extérieur. La ligne en pointillé précise le niveau de prélèvement des coupes.

The microradiographic analysis applied to the main axis of the fragments of clavicle we have collected, is able to demonstrate, at low magnification (Fig. 3 and 5), that the bone cortex is interrupted in the same way as after a fracture. In some places (arrows in Fig. 3), the limits of the bone are very irregular, scalloped, corresponding to an osteoclast resorption.

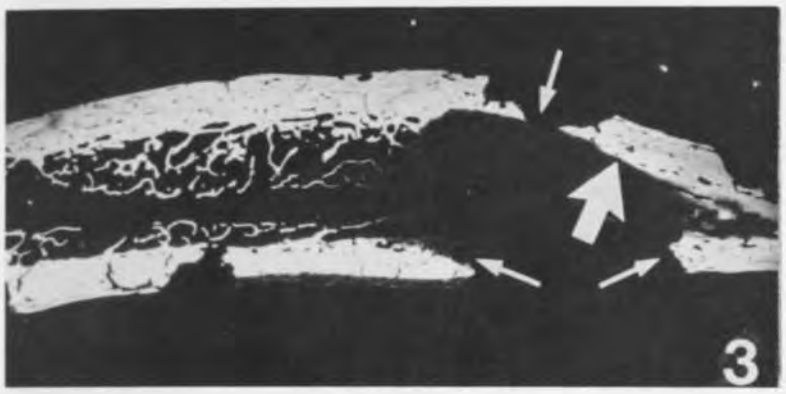

Fig. 3: Microradiographic aspect (×1,3) of a longitudinal section from the clavicle (case n° 1). Thin arrows: scalloped limits of bone corresponding to osteoclastic resorption. The thick arrow shows the field enlarged in figure 4.
Fig. 3: Aspect microradiographique (×1,3) d'une coupe longitudinale de la clavicule (cas n° 1). Les limites anfractueuses de l'os correspondent à la résorption ostéoclastique (fine flèches). Le champ pointé par la grosse flèche est agrandi en figure. 4.

An enlargement of the field, indicated by a thick arrow in Fig. 3, shows the presence of very polymorphous foci of bone destruction (Fig. 4A) in which resorption is never complete as seen by the persistance of many thin spicules. Moreover, these foci always develop near the preexisting Haversian canals without, however, affecting all of them.

In the coresponding section after methylene blue staining (Fig. 4B), one can see the deepest part of the cortex which is invisible on the microradiograph because of a demineralization process.

Fig. 4A

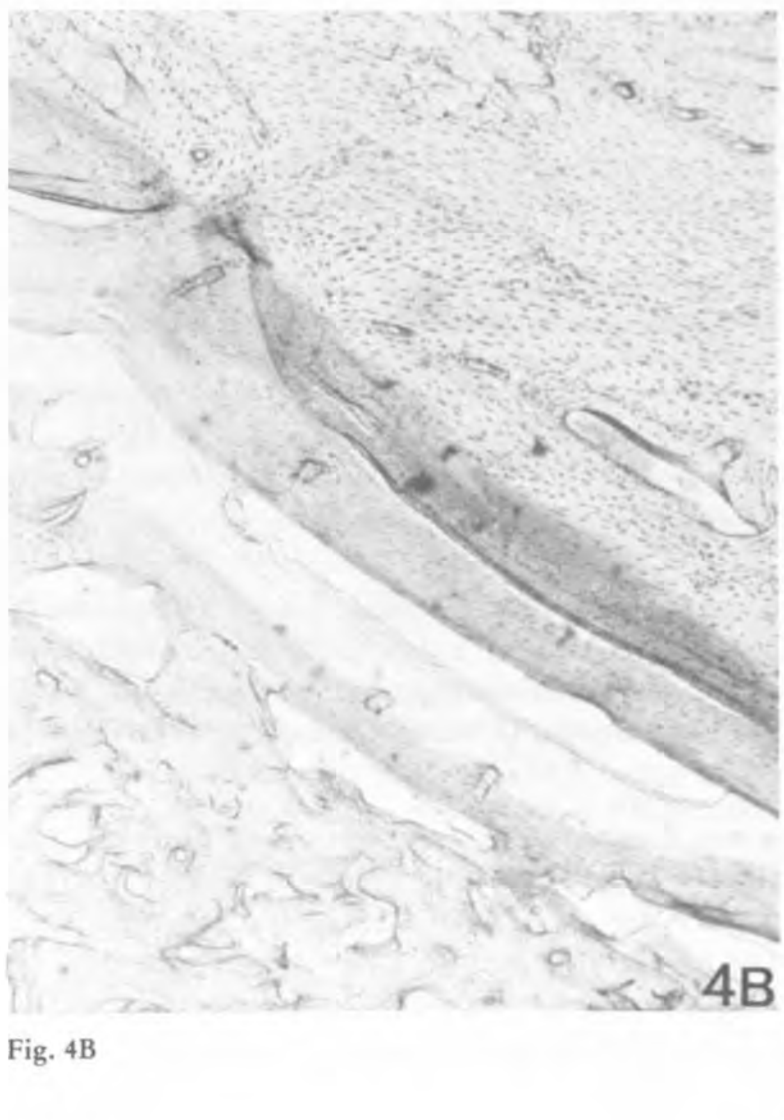

Fig. 4B

Fig. 4: Pathognomonic lesion of osteoradionecrosis (×52). Microradiograph (A). Arrow indicates spicules. Aspect of the same field at the surface of the section stained with methylene blue (B).
Fig. 4: Agrandissement d'une lésion pathognomonique de l'ostéoradionécrose (×52). En A: microradiographie. La flèche indique des spicules. En B: champ de la coupe colorée au bleu de méthylène.

Reconstruction processes also exist. They are already visible at low magnification (Fig. 5) within the intertrabecular spaces. A more detailed observation (Fig. 6) clearly shows the presence of chondroid tissue islets surrounded by lamellar bone. This interpretation is confirmed by the examination of the corresponding field in the section itself (Fig. 7). Moreover, in this last figure, it is also possible to observe that all the cellular lacunae are empty.

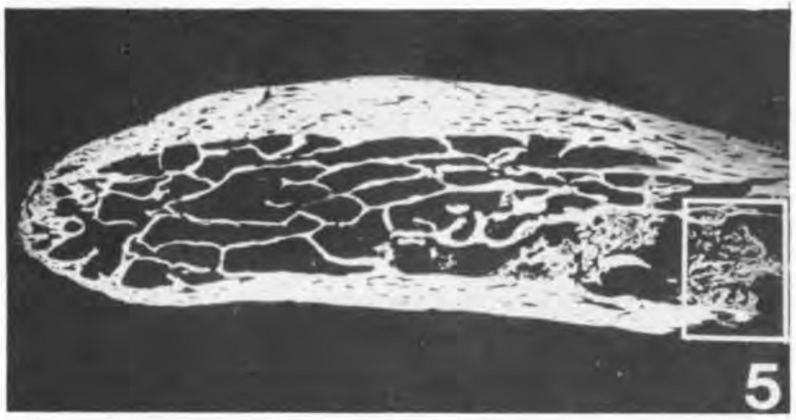

Fig. 5: Microradiographic aspect (× 1,3) of a longitudinal section from the clavicle (case n° 2).
Fig. 5: Aspect microradiographique (× 1,3) d'une coupe longitudinale d'une clavicule (cas n° 2).

Fig. 6: Detailed microradiograph (× 11) of figure 5 illustrating the chondroid tissue islets (framed area and arrows).
Fig. 6: Détail de la figure 5 montrant des îlots de tissu chondroïde (× 11) indiqués par le rectangle et les fèches.

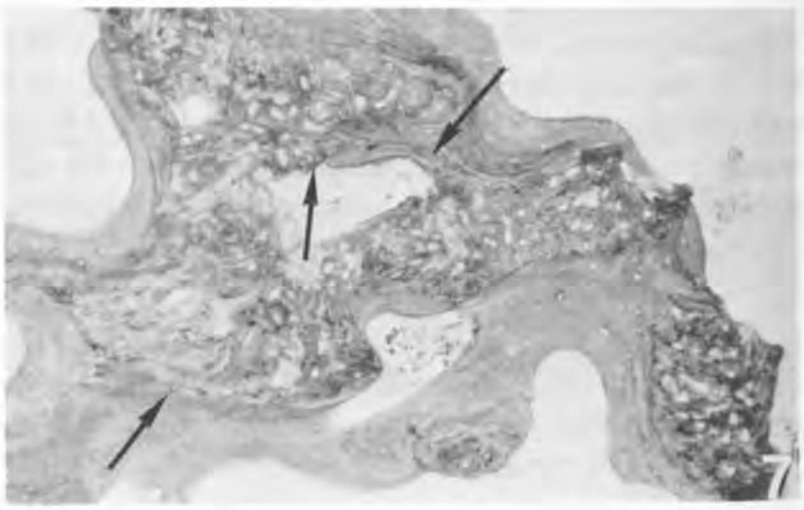

Fig. 7: Enlargement of the section stained with methylene blue shows a dead chondroid tissue as show arrows (× 57).
Fig. 7: Un agrandissement de la coupe colorée au bleu de méthylène montre un tissu chondroïde mort pointé par des flèches (× 57).

DISCUSSION

Fracture of the clavicle (Fig. 3 and 5) following radical neck dissection and postoperative radiotherapy has been described recently by Strauss et coll., 1982. It has been shown (Ord and Langdon, 1986) that it can also occur in the absence of irradiation.

The modifications occurring in bone after irradiation have been described a long time ago (Nageotte, 1922) and were very well documented by Ewing (1926). According to this author, when a sufficient dose of radiation is given, all the bone cells are killed either directly or indirectly through vascular lesion.

Recently, it has again been asserted (Berthrong, 1986) that there are no morphological signs of bone irradiation except necrosis. However, our microradiographic analysis of thick undecalcified sections obviously shows very specific foci of bone destruction (Fig. 4) never observed in any other bone disease leading to osteoporosis (Dhem, 1973). These foci of bone destruction have also been observed in all the mandibular fragments we have studied (Dambrain et coll., 1979) and which were resected because of severe osteoradionecrosis. They are also present in the mandible of the cat after irradiation by ^{60}Co (Dambrain et coll., 1988a, 1988b).

These foci of bone destruction are obviously not of osteoclastic origin for many reasons. First, the smallest cavities have a diameter very similar to that of an osteocyte lacuna. Secondly, in the largest ones, the dissolution of bone is never complete (Fig. 4A).

At the present time, we suggest that they represent a particular type of osteocytic osteolysis, very well studied by Belanger et coll., (1963). It could be objected that all the osteocytes have disappeared after irradiation as shown by our Fig. 7. However, when looking at irradiated bone, field by field at high magnification, as we have done for the resected mandibules (Dambrain and Dhem, 1984), it appears that these cells do not totally disappear. Paradoxically, they are the most numerous where bone resorption is the most marked.

The fact that the foci of bone destruction often develop around the preexisting Haversian canals can also suggest the possible existence of an extrinsic factor, like infection, to explain their origin.

True decalcification of bone as seen in Fig. 4 is exceptionnal. It also exists in some irradiated mandibular fragments (Dambrain, 1989) when they are bathing in the mouth after rupture of the oral mucosa. To explain this phenomenon, it is not necessary to reintroduce the cold theory of «Halisteresis» (Leriche, 1939). The acidity of the saliva, for the mandible, and of the pus, for the clavicular fragments, could be sufficient to dissolve the bone mineral.

Concerning the observed reconstruction processes (Fig. 6 and 7), they explain the well known radiological aspects of osteoradionecrosis where increased bone density is mixed with rarefaction. This new deposited bone is similar to that observed in osteomyelitis. However, histological examination of chronic sclerosing osteomyelitis of the clavicle of children and of young adults (Jacobsson et coll., 1978; Jurik and Moeller, 1987) revealed, in all the patients, signs of subperiosteal and medullary new bone formation with increased occurrence of osteoblasts surrounding closely spaced trabecula of bone.

The most interesting fact is that this reconstruction is initiated by chondroid tissue islets (Fig. 6 and 7) which are also present in a normal fracture callus (Hancox, 1972). But in the irradiated clavicle, the cellular lacunae of this tissue are empty. Consequently, it may be affirmed that all these new calcified tissues are already dead. All the histologic, microradiographic and immunologic characteristics of this tissue have been recently described (Goret-Nicaise and Dhem, 1982, 1985). This has not been observed in the irradiated mandibles where reconstruction is firstly insured by woven bone.

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