The bone reactional capability and the names of inflammatory bone diseases

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Abstract

The bone reactions before functional demands and aggressions are different according to the local morphology, intensity and duration of the irritation and systemic state of the patient. In this work, initially it was sought to correlate these three important factors to comprehend the final result on the bone structure, especially from the imaging point of view. Then, it was presented the concepts of universally accepted names to identify inflammatory bone diseases, in order to facilitate the scientific and clinical communication between professionals.

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Introduction

The human skeleton is totally renewed in every 2 to 4 years in children and in 4 to 10 years in adults. The bone composition presents soft and mineralized tissues. The mineralized part of the bone is represented by cortical and trabeculae, in which are included osteoblasts, osteocytes and osteoclasts. The non-mineralized part of the bone are the periosteum, endosteum and the bone marrow, which fills the spaces delimited by bone trabeculae. The periosteum is constituted of a fibrous connective tissue densely collagenized in its external half while its inner half is intercalated by collagen fibers that enter and merge with the mineralized bone matrix of the cortical, fixating it tightly on the external bone surfaces. On the inner part, the interface with bone cortical, the periosteum is presented fully cellularized, with osteoblasts and clasts in abundance, as well as young cells, undifferentiated and even bone tissue stem cells or reserve cells. All the bone blood flow necessarily passes or go through the periosteum. The endosteum represents the inner and thinner analogue of the periosteum, located on the surface of trabeculae and inner parts of cortical. It is also constituted by connective tissue with few collagen fibers and rich in osteoblastic, reserve, lining and/or osteoprogenitor cells including bone tissue stem cells. The endosteum coats the bone trabeculae and naturally continues with the hematopoietic, fibrous and/or adipose tissue that fill the medullary spaces. The bone also presents as part of its structure the bone marrow, which can be hematopoietically active, when it is red; or inactive, when substituted by adipose or fibrous tissue, presenting a yellow or grayish white coloration. The mature bone cells are the osteoblasts, osteocytes and osteoclasts that, in syntony with other components, such as macrophages, promote bone remodeling and, at the same time, contribute to the performance of their functions in this tissue. On the bone remodeling process, besides the cells, three enzymes are fundamental and work as parameter to measure methabolic activity on human skeleton: acid phosphatase, located in osteoclasts, that also releases the collagenase, both involved in bone resorption; on the other hand, there is the alkaline phosphatase, located in osteoblasts and related to osteogenesis.

The bone tissue adaptive and reactive capacity

The bone adaptations to new situations and functions, resulting from its reactive capacity, and the inflammatory bone diseases are very important in the daily clinical practice of the implantodontist:

1. For the frequency.
2. For the sequelae resulting from its occurrance.
3. For the possibility of being resulting from important dental or implant alterations, but not noticed.
4. Because it can be due to professional interventions, such as bone surgery, inadequate therapy and lack of accurate identification of the patient's organic debility in anamnesis and systematic evaluation.

The bone reactive capacity and its resistance to stimuli or aggressors depend on three fundamental factors:

1) Local bone morphology

A spongy bone tissue more compact or dense presents small medullary spaces and provides little space for abundant inflammatory exudates. Very soon, any inflammatory process can increase the pressure inside the small medullary spaces, prematurely compressing the vessels, complicating the venous return and leading the medullary tissue to necrosis more quickly. A necrosed area of medullary tissue may be the ideal stage for bacterias to stay and form microbial biofilms. The bone tissue with sparser or loosely distributed trabeculae, before an aggression, provides more spaces for the

inflammatory exudate and infiltrate, allowing a longer period which increases its denfense capacity for elimination of aggressors in the local. By logical deduction, it can be asserted that the bone tissue more compacted is a lot more physically strong, but biologically fragile for it demands the inflammatory process to work very quickly. The opposite occurs with the less compacted and more spongy bone: there is more time and space for inflammatory tools to fight the aggressors.

2) Intensity and duration of the aggression

The mild and continuous irritation, or referred as chronic, as well as all the aggressors, provides an initial acute inflammation, but quickly grows to mild or moderate chronic phase, with limited accumulation of mediators in the local. Many mediators of inflammatory exudate are inducers of bone resorption, but have bipolar effects: when in high concentration, induce prodominant clastic activity; but when in low levels in the same bone environment, induce the synthesis osteoblastic action with osteogenesis, being predominant on trabeculae and cortical surfaces. The mediators inducer of osteogenesis, on trabeculae and subperiosteal surfaces, gradually change the local bone morphology, that remains organized. As the irritation increases its harmful power, the osteogenesis may also occur but not so organized. The quick and intense irritation, or referred as acute, as well as all the aggressors, provides an initial acute inflammation, but a lot more exudative and rich in mediators inducer of bone resorption, and may induce necrosis areas of medullary tissue, endosteal and osteocytes. It can be asserted that mild or chronic irritations induce osteogenesis or bone reactions predominantly producer of synthesis phenomena, while the severe or acute aggressions cause resorptive, osteolytic or destructive bone reactions.

3) Systemic state of the host

The systemic state of the host can be determinant on bone reactions before aggressions. Generally, it can be noticed that the osteomyelitis occur only in patients systematically compromised or with wide sclerosing local bone diseases. The three most common causes of osteomyelitis in the organism are: (a) traumas with exposed fractures, (b) bone surgery in contamined environments and (c) proximity between bone and infectious focus in other tissues. On the maxillae, these three situations occur daily in thousands of people in the daily practice of Odontology, and the number of osteomyelitis do not stand out in relation to the other skeletal structures. When the patient is systematically normal, the same causes that would induce osteomyelitis promote osteitis – also an inflammatory process, however localizated and focused, with minor consequences, for osteolytic areas are limited and small, being predominant areas of bone sclerosis and the symptomatology is very low. The osteitis prognosis is very good.

After bone adaptations, the inflammatory diseases: nomenclature and concepts

The inflammatory or reactive bone diseases may represent the exhaustion of bone adaptive capacity before external ou internal aggressors. The terminology used

to identify the inflammatory or reactive bone diseases is very important to standardize diagnosis, procedures, treatment and follow-up protocols. Before conceptualizing each one of the names used to identify the inflammatory or reactive diseases, it is very important to distinguish the terms "disease" and "lesion", since they have common use and different meanings. The diseases, or clinical entity, are evolutionary biological alterations and processes outside the functional and structural normality of tissues and organs. They are presented with specific and repeated pictures, that allow their identification and diagnosis by any qualified professional or habilitated for this job. These diseases induce transitory or permanent anatomic structural alterations on tissues and organs. These alterations are denominated "lesions". Lesion in any anatomic alteration whatsoever on tissues and organs, ie, represents a term of very wide use.

Inflammatory diseases can be nominated in their diagnosis as follows:

» Osteomyelitis: disease characterized by symptomatic bone inflammation of abrupt onset that can involve the three structural components – the mineralized part, the periosteum and the tissue components of medullary spaces.[2,7,8,10,15] Its origin is predominantely microbial but it can be physical or chemical. Generally the compromised bone area is wide and diffuse, with predominance of osteodestruction phenomena. The osteomyelitis hardly occurs in systematically healthy patients. Practically all cases have a base disease, such as diabetes mellitus, immunodepression, anemia, among others; or, the patient presents on the osteomyelitis area, an advanced sclerosing bone disease, such as florid cemento-osseous dysplasia, for example.

» Osteitis: disease characterized by asymptomatic inflammatory process that slowly can also involve the three bone structural components, but generally it is localized and with predominance of osteoproductive phenomena.[1,5,6,9,11,12,14,17] Generally its cause has low intensity and long duration.

» Periostitis: disease related to an inflammatory response of the periosteum before aggressors that work directly or indirectly on its structures. When the cause is acute or intense and work directly, it can be destructive and is part of other wider processes, such as dentoalveolar abscess and osteomyelitis.[4,13,16,18,19,20] However, when the cause is chronic, of low intensity and long duration on its structures, the involved periosteum reacts producing new layers of bone on the cortical surface, being nominate periostitis ossificans or productive, formerly also denominated, erroneously, Garrè's osteomyelitis.

» Osteoradionecrosis and Osteoradiomyelitis: they can be considered an specific or special variant of osteomyelitis in areas of osteonecrosis by radiation, almost always for therapeutic purposes in oncology.[3,10] The osteoradionecrosis, based in studies in animals, can be considered an state in which the irradiated bone, for some years, presents:

a) Chronic hypoxia, promoted by endoarteritis obliterans, complicating the passage of blood to the cells, for, in part, the vascular lumens are ocuppied by the increase on thickness of the blood vessels inner wall.
b) Hypovascularization, for all the local cell population is reduced incluing the endothelial cells that constitute the inner layer of vessels.
c) Local hypocellularity in the irradiated area, for the mitotic index in the region is very low reducing its reparative or reactive capacity.
d) Death of osteocytes, very important cells on bone histophysiology. Each osteocyte connects to other 40 or 50 cells, making an intercommunicating network to trabeculae and cortical sur-

faces, thus controlling the bone shape, its subperiosteal responses and yet strongly influencing the local and systemic ionic balance.

For a period of 5 to 10 years, the irradiated bone tissue presents low defense and reactive capacity, at the same time it reduces its reparative potential. After this period, the irradiated region tend to go back to its previous reparative potential. In this bone conditions, the bacteria and other less aggressive aggressors find place and conditions to proliferate in this impaired bone structure and the inflammatory process becomes inefficient to contain them, establishing an acute and then chronic secondary suppurative osteomyelitis, also known by the name osteoradiomyelitis, although it is a hardy used term in literature. It seems logic to distinguish that osteoradionecrosis is the state of irradiated bone and osteoradiomyelitis corresponds to osteomyelitis or inflammation on the modified bone.

» Osteonecrosis: the increase of bone surgeries and the placement of bone integrable implants generalized the use of some terms not very used by clinicians until then, for example the osteonecrosis. Osteonecrosis can be conceptualized as death of the bone without infection, being induced by several factors as trauma, excessive heat, thrombus and plunger, radiation, graftings and chemical products.[3,10] Now the term necrosis, conceptually, should only be applied to cells, for it represents the cell death in a living organism without any genetic participation in its occurrance. The bone, as an anatomic organ, do not necrose, instead it becomes biologically unfeasible as a tissue in our organism context. Many agents can work on the bone and kill its cells, necrose them; if that happen to osteocytes, which are its inner cells and most protected by the mineralized matrix, it can be asserted that the bone is biologically unfeasible. It can be said that a bone without osteocytes needs to be entirely remodeled, it is without biological viability, must be resorbed and substituted by a new bone tissue rich in osteocytes. Physical agents, such as radiation and excessive heat, and chemical products can work on the bone tissue. Both types of aggressors may lead to necrosis of osteocytes and, therefore, these injuried areas may receive the name osteonecrosis, but not as a clinical entity or well defined disease. The death of osteocytes and/or an area with osteonecrosis induce on the bone periphery, and then on its interior, an inflammatory process localized and limited to a determined area and with low symptomatology. The bone tissue unviable by the death of osteocytes has certain aggressiviness to surrounding tissues, induces an inflammatory process not very much symptomatic and limited on this bone area, ie, induces an osteitis. In other words, the osteonecrosis induces and is resolved after an osteitis. After some days of aseptic inflammation on the local, or osteitis on spongy bone, it evolves to formation of granulation tissue, by the migration, proliferation and invasion of young neighboring endothelial and osteoblastic cells, permeating medullary spaces of the necrosed bone area. Gradually, the neoformed part substitutes the old part of the bone, substituting it entirely. In cortical osteonecrotic areas, the osteitis almost occurs in its interface and, gradually the clasts resorb and invade the small spaces and the neighboring osteoblasts are formed and interfer on the osteonecrotic area, mixing the old part with the new one, until all the osteonecrosed tissue is substituted. The formation of granulation tissue is too little and limited. The osteonecrosis and subsequent osteitis may interfer, retarding or impeding, the bone repair and bone integration. They are:

a) Osteonecrosis by local hyperthermia: situation in which part of the bone in a surgical area loses its viability by dehydration or denaturation, which means loss of water with coagulation of its proteins and loss of vigor of its cells. The generated heat may be by outworn surgical

electric saw and milling cutters on the placement of implants. This tissue should be resorbed by the clasts to, then, be substituted by normal bone in a repair context. While it is not entirely resorbed, it will be infiltrated by polynuclear and mononuclear leukocytes, as well as by clasts. In the local, the inflammatory exudate ou edema will also be present, characterizing a chronic osteitis induced by excessive heat or local hyperthermia. Since the cause was eliminated with the surgery closure, the solution is to wait for the organism to repair the area and reassess the possible sequelae if apply.

b) Chemical osteonecrosis: eventually, chemical products may be poured on the bone environment, such as, for example, chlorinated soda used in endodontic irrigations. The acute inflammatory process may dilute the chemical substance, that in some days will disappear from the local. The local chronic osteitis, its macrophages, other phagocytes along with the clasts, will promote a cleansing of the area that gradually will be repaired as long as not secondarily contamined by bacteria. In many cases, this process was called chemical osteomyelitis, but the process is limited to the local and with no systemic participation, not justifying the use of the term osteomyelitis.

c) Drug induced osteonecrosis: term used to identify areas of bone unfeasibility that is said associated to use of bisphosphonates, especially in cancer patients. These drugs do not kill the osteocytes or other bone cells, as well as do not obliterate the vessels and not even depress the immune system.

However, cancer patients are systematically impaired, especially by the numerous and strong drugs they take as well as by the chemotherapy and radiotherapy they are subjected to. The patients become immunosuppressed, their tissues become hypovascularized and little cellularized. Any microorganism that reach the bone in this type of patient can induce pictures of suppurative osteomyelitis, which evolution leads to formation of fistulae and bone theft. The ingestion of bisphosphate represents more of a superposition on the situation than the initial cause of this osteonecrosis, although many surgeons insist in assign this type of problem in cancer patients to bisphosphonates – which in the biological and medical areas, is not valued. Cancer patients present several debilitating conditions, local and systematic, that increase their susceptibility to osteomyelitis.

Other terms widely used in bone biopathology

In the maxilla, systemic metabolic bone diseases hardly modify the trabelucae and cortical morphology, for the tax or speed of bone remodeling is very low. When it affects the maxilla the disease is in advanced or terminal stage. Long before this stage, other clinical problems made the patient seek medical care and orientation. Even though, some concepts about the bone state are important for frequently are used or mentioned when describing pathological conditions of all natures in the maxilla. They are:

1) Osteopenia: bone state characterized by thinner and shorter trabelulae and slender cortical, increasing the susceptibility to fractures. Several systemic metabolic bone diseases may promote this bone state very hard to show in the maxilla being more frequently diagnosed in long bones. It does not represent a disease but a bone state or condition.

2) Osteoporosis: state characterized by an osteopenic bone, when suffer subclinical or clinically diagnosed fractures. It can be asserted that osteopenia can evolve to osteoporosis but not necessarily. This term is necessarily related to presence of fractures on osteopenic bone.

The osteoporosis can be classified in primary, when post menopausal; and secondary when is due endocrine or kidney diseases. Other factors associated to osteoporosis are smoking, alcoholism, low calcium intake and surgical or precocious menopause. It does not represent a disease but a bone state or situation that can be induced by many diseases.

3) Osteomalacia: a bone state very characteristic of adults, resulting of a disorder on inadequate mineralization of newly formed bone matrix. The term osteomalacia means "soft bones". The osteomalacia has an osteopenic pattern with fractures or pseudofractures. Several diseases can result in osteomalacia, almost always related to disorder on vitamin D metabolism.
4) Osteopetrosis: a group of at least nine developmental disorder, rare and congenital, that characterize a disease induced by an autosomal developmental disorder, also known as stone bone or marble bone disease, which shows its intense radiopaque aspect. The bone texture is very hard as a stone also involving cartilagenous areas. The bone is easily fractured. There is almost no marrow and it is described the splenomegaly and hepatomegaly with increased lymph nodes to compensate the lack of hematopoiesis, besides severe anemia. It end up occurring compression of nerves in the foramen and promoting facial palsy.
5) Sclerosis or bone condensation: state with imaging appearance of increase on thickness and number of bone trabeculae, reducing the size and appearance of medullary spaces on radiographs and tomographies.

Final considerations

The acquaintance of bone biopathology has fundamental importance, since the teeth are inserted in bone, naturally or orthodontically move by the bone, as well as maxillae frequently receive and adapt to bone integrated implants. On rehab, orthodontic and pre surgical plannings, the prior diagnosis of the bone state implies in recognizing the lesions and pathological situations that involve in clinical practice. The success of odontologic treatments, especially its stability, is closely associated to structural and functional balance of maxillary bones. The standardization of nomenclature and concepts facilitate the communication and the stablishment of uniformed protocols and conducts.

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