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Osteoporosis, jawbones and periodontal disease

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Abstract

The association between osteoporosis and jawbones remains an argument of debate. Both osteoporosis and periodontal diseases are bone resorptive diseases; it has been hypothesized that osteoporosis could be a risk factor for the progression of periodontal disease and vice versa.

Hypothetical models linking the two conditions exist: in particular, it is supposed that the osteoporosis-related bone mass density reduction may accelerate alveolar bone resorption caused by periodontitis, resulting in a facilitated periodontal bacteria invasion. Invading bacteria, in turn, may alter the normal homeostasis of bone tissue, increasing osteoclastic activity and reducing local and systemic bone density by both direct effects (release of toxins) and/or indirect mechanisms (release of inflammatory mediators). Current evidence provides conflicting results due to potential biases related to study design, samples size and endpoints. The aim of this article is to review and summarize the published literature on the associations between osteoporosis and different oral conditions such as bone loss in the jaws, periodontal diseases, and tooth loss.

Further well-controlled studies are needed to better elucidate the inter-relationship between systemic and oral bone loss and to clarify whether dentists could usefully provide early warning for osteoporosis risk.

Key words: *Osteoporosis, periodontitis, oral bone loss, tooth loss, edentulism, bone mineral density.*

Introduction

Osteoporosis (OP) is a systemic skeletal disease characterized by low bone mass and micro architectural deterioration of bone tissue, with a consequent increase in fragility and susceptibility to fracture of bones. In the past, OP was considered a physiological process associated with ageing, but today it is recognized as a multifactorial chronic systemic disease. OP may affect also the jawbones, whose structure may be impaired by other conditions resulting in bone loss. One of these, is periodontitis (PD), a chronic infection-mediated condition modulated by different genetic and environmental factors, characterized, in advanced forms, by loss of the soft tissue attachment to teeth and resorption of alveolar bone . PD is the prototype of a low grade local infection (bacteria of the oral plaque) associated with local (within the periodontal tissues) immune-inflammatory response causing periodontal tissue damages/destruction and a mild individual systemic inflammatory response contributing to the global inflammatory burden and to its related dangerous effects. PD is very prevalent in the general population in the same age range affected by OP. In fact, moderate and advanced periodontitis affects, respectively, approximately 30% and 10% of the adult populations of United States. Deep periodontal pockets (the clinical sign of periodontal attachment loss) are present in 2-18% of adults in western countries and at higher prevalence in developing countries (1) .

It might be expected that the alveolar bone destruction seen in periodontitis could be magnified in the presence of generalized skeletal disturbances such as OP. Nonetheless, it is increasingly becoming evident that PD may have several systemic implications (e.g. increased risk for cardiovascular disease), and hypothetical models exist linking OP and PD (1). It is well known that several systemic and local factors may modulate the loss of bone mass and that some of them, as well as many risk factors (Table 1), may be shared between the two conditions.

Material and Methods

The authors performed a literature review in MEDLINE/ PubMed and Cochrane Oral Health Group's Trial Register by the main key words related (osteoporosis AND periodontitis, osteoporosis AND oral bone loss, osteoporosis AND tooth loss, osteoporosis AND edentulism, osteoporosis AND bone mineral density). In this paper we are going to review further evidence regarding the potential correlation between OP and PD.

Results

-Osteoporosis and The Jawbones

OP can affect several skeletal sites including jawbones. Nonetheless, jawbones have some peculiar features related to the type of ossification and the high turnover induced by masticator mechanical stresses. Morphological studies have shown that the cortical bone porosity of the upper jaw increases with age; in addition, a considerable variation of the thickness and cortical porosity exists in different areas of the mandible (area of incisors, premolars and molars) in relation to sex, with significantly higher values in males than females. The body of the mandible and the posterior alveolar processes, consisting predominantly of cortical bone, are very similar to the diaphysis of long bones, while in the anterior alveolar processes of the mandible and in the alveolar processes of the jaw, bone architecture is mostly trabecular. According to some authors the rate of bone turnover at the level of alveolar processes would be greater than in long bones, so the loss of bone mass could manifest earlier at the alveolus than at other skeletal segments, thus, representing an early indicator of OP. These observations are consistent with those described by von Wowern et al. (2) who proposed that the mandible suffers from continuous modifications of bone mineral content (BMC) and bone mineral density (BMD) with ageing and in relation to sex. In fact, in older people the mandibular BMC increases, albeit slightly, in males, while it decreases in females (3). This is explained by the presence in elderly males of a compensatory mechanism by which the inner cortical bone is thicker in order to maintain the stability of the atrophic mandibular body, with a reduction of the trabecular bone area. This mechanism does not seem to exist in postmenopausal women, because of OP and/or other such as hormonal and genetic systemic factors.

In addition, whenever teeth are lost the resorption of alveolar residual ridges progressively occurs whether the subject remains edentulous or is rehabilitated with removable prostheses. It has been also found that in patients with osteopenia or OP the porosity observed in the jaws (atrophy from disuse) increases, and that the improvement in chewing produced by prosthetic rehabilitation reduces the amount of bone resorption.

The correlation between changes in systemic BMD and the jawbones, has been assessed by Dual Photon Absorptiometry (DPA) Dual Energy X-ray Absorptiometry (DEXA) and Quantitative Computed Tomography (QCT) (4-5), suitably modified to determine the in vivo BMC. Recently, in some clinical studies the traditional techniques of panoramic radiograph of dental arches or intra-oral (periapical or bitewing) radiograms have been used to assess bone density of the jaws. Most studies showed that these radiographic investigations, used on a routine basis by dentists, have the potential to raise suspicion for OP (Table 2). The relevance of these findings for both early diagnosis of OP is straightforward and underlines the need, for both physicians and dentists, to familiarize with them.

-Periodontitis and Osteoporosis

PD is a complex disease entity with a multifactorial eti-

Table 1. Risk factors for osteoporosis (OP) and periodontal disease (PD).

RISK FACTOR S FOR OP

SYSTEMICS

- Female gender
- Low body weight / stature / very thin body
- Premature menopause (<45 years)
- Extended periods of amenorrhea
- Lack of estrogen / testosterone
- Previous osteoporotic fracture of the hip, spine or wrist
- Family history of osteoporotic fracture

MALNUTRITION AND MALABSORBIMENT CONDITIONS

-Deficient intake of calcium, phosphorus, sodium magnesium, vitamins D, K, B6, B12
- High consumption of animal protein, coffee, soda, spinach, wheat derivatives
- *Anorexia*
- Cystic fibrosis
-Inflammatory bowel disease (Chron's disease and ulcerative colitis)
- Gastrectomy / gastro intestinal bypass
-Celiac

DRUGS

- Aluminum-containing antacids
- Antiseizure medications (Dilantin or Phenobarbital)
- Aromatase inhibitors (Arimidex, Aromasin and Femara)
- Cancer chemotherapeutic drugs
- Cyclosporine A and FK506 (Tacrolimus)
- Systemic glucocorticoid therapy for > 3 months with ≥ 5mg/diecortisone and prednisone
- Gonadotropin releasing hormone (GnRH) (Lupron and Zoladex)
- Lithium
- Medroxyprogesterone acetate for contraception (Depo-Provera)
- Methotrexate
- Proton pump inhibitors (PPIs) (Nexium, Prilosec and Prevacid)
- Selective serotonin reuptake inhibitors (SSRIs) (Lexapro, Prozac and Zoloft)
- Tamoxifen (premenopausal use)
- Thiazolidenediones (Actos and Avandia)
- Thyroid hormones in excess
- Loop diuretics
- Anticonvulsivant and heparin long term therapy

HEREDITARY SKELETAL DISEASES

- Osteogenesis imperfecta
- Rickets
- Hypophosphatasia

ENDOCRINE AND METABOLIC DISEASES

- Hypogonadism,
- Hyperparathyroidism
- Hyperthyroidism,
- Cushing Syndrome
- Acidosis
- Gaucher's Disease

MARROW DISEASES

- Multiple myeloma
- Lymphoma / leukemia
- Mastocytosis
- Thalassemia

OTHER MEDICAL CONDITIONS THAT CAN LEAD TO OSTEOPOROSIS

- Chronic renal insufficiency
- Hypercalciuria
- Hepatic Disease
- Systemic Lupus Erythematosus
- Breast cancer
- Emphysema
- Female athlete triad
- Idiopathic scoliosis
- Kidney disease
- Multiple sclerosis
- Organ transplants
- Parkinson's disease
- Post-polio syndrome
- Prostate cancer
- Rheumatoid arthritis
- Severe liver disease (including biliary cirrhosis)
- Thyrotoxicosis
- Depression
- Prolungate immobility (trauma of spinal cord, stroke, muscular dystrophy, ankylosing spondylitis)

OTHER FACTORS

- Inactive lifestyle
- Physical inactivity

COMMON RISK FACTORS

SYSTEMICS, NOT CHANGED

- Ageing
- Gender
- Race
- Ethnicity
- Genetic predisposition

BEHAVIORAL AND ENVIRONMENTAL

- Smoke
- Abuse of alcohol (ingestion of more than 2/3 units of alcohol per day)
- Socioeconomic status

ACQUIRED IMMUNODEFICIENCY (AIDS / HIV)

ENDOCRINE AND METABOLIC DISEASES

- Insulin-dependent diabetes mellitus

DRUGS

- Antiepyleptics (*phenytoin*, fenobarbital)
- Cyclosporin

RISK FACTORS FOR PD

SYNDROMES AND HEREDITARY DISEASES WITH ALTERATION OF CONNECTIVE TISSUE

- Down syndrome
- Ehlers-Danlos syndrome
- Papillon-Lefèvre syndrome

SYNDROMES AND HEREDITARY DISEASES WITH PHAGOCYTIC DISFUNCTION

- Quantities disorders or neutropenia
- Congenital neutropenia (Kostmann syndrome)
- Chronic benign neutropenia (familial)
- Cyclic neutropenia
- Felty Syndrome
- Functional disorders of adhesion
- Leukocyte adhesion deficiency
- Functional disorders of chemotaxis
- Hypergammaglobulinemia syndrome or Job's syndrome
- Chediak-Higashi syndrome
- Lazy leukocyte syndrome
- Disorders of phagocytosis and the mechanisms microbicides
- Deficiency of myeloperoxidase
- Chronic granulomatous disease
- Deficit of specific granules

DISVITAMINOSI

DRUGS

- Calcium antagonists,
- Oral contraceptives, antiinflammatory drugs
- Protease inhibitors (saquinavir, ritonavir)

STRESS

HORMONE VARIATIONS

- Puberty, menstruation, pregnancy, menopause

OSTEOPOROSIS and OSTEOPENIA

RADIOTHERAPY

BEHAVIORAL AND ENVIRONMENTAL

- Bacterial plaque and poor oral hygiene

MICROBIOLOGICAL

- Actinobacillus actinomycetemcomitans
- Bacteroides forsythus
- Porphyromonas gingivalis
- Virus

LOCAL

- Risk factors tooth related (mucogingival anomalies, presence of iatrogenic factors)
- Occlusal trauma

Table 2. Assessment of oral BMD by means oral radiographic techniques.

Authors	Methodical	Index of OP	Patients number	Correlation
Klemetti et al 1994 (10)	BMD of cortical mandible by means DPR	BMD of spine and femur	227 postmenopausal women	+
Taguchi et al 1995 (11)	N. of tooth, MCW by means DPR	-	170 women e 99 men	+
Jonasson et al 2001(12)	MABM by means periapical Rx	BMD forearm	80 women	+
Bozic and Ihan Hren 2006 (13)	DPR	BMD	36 women with OP *vs* 20 without OP	+
Taguchi et al 2006 (14)	DPR	BMD	836 women	+
Karayianni et al 2007 (15)	MCW by means DPR	BMD	653 women	+
Taguchi et al 2007 (16)	Erosion of cortical mandible	BMD of spine and femur	455 women	+
Devlin et al 2007 (17)	MCW by means DPR	BMD of spine and femur	653 postmenopausal women	+
Vlasiadis et al. 2007 (18)	N. of tooth loos, MCW, PMI, MIC grade by means DPR	BMD of spine	133 postmenopausal women	+
Vlasiadis et al. 2008 (19)	N. of tooth loos, MCW, Metacarpal Index, MIC grade by means DPR	BMD of spine	141 postmenopausal women	+
Celenk and Celenk 2008 (20)	BMD by means CT	Bone density of cervical vertebrae	114 patients (46 women, 68 men)	N.E

BMD = Bone Mineral Density; CI = Height of Mandibular Inferior Cortex; CT = Computerized Tomography; DPR = Dental Panoramic Radiograph; MABM = Mandibular Alveolar Bone Mass; MCI = Mandibular Cortex Index; MCW = Mandibular Cortical Width; MIC grade = Morphologic classification of inferior cortical mandibular; N.E. = Not Estimable OP = Osteoporosis; PMI = Panoramic Mandibular Index.

ology in which the inflammatory response of the periodontal tissue to bacterial infection ends up with periodontal ligament detachment from the cement, formation of periodontal pockets, alveolar bone resorption, gingival recession, tooth mobility/migration.

Periodontitis is the major cause of alveolar bone resorption and tooth attachment loss resulting in tooth loss and, consequently, additional bone resorption. It is influenced by environmental factors as well as by genetic factors; thus, periodontal diagnosis requires oral/periodontal and assessment that's to say: 1) patient's medical and dental histories; 2) presence of clinical signs of inflammation of gingival tissues, including bleeding on probing; 3) probing depths; 4); extent and pattern of attachment loss and bone defects 5) presence of various signs and symptoms, including pain, tooth mobility and amount of the observable plaque and calculus (6-7). Obtaining these data needs a thorough clinical and radiographic examination of both intraoral and extra oral structures (8).

The first reports on the possible association between systemic osteoporotic bone loss and local oral bone loss were released back in the '60s by Groen et al. (9) who suggested a possible correlation between the two conditions in patients presenting with both PD and BMD reduction at the forearm and at the spine. Since then, several studies have suggested a possible correlation between loss of systemic bone mass (osteopenia/osteoporosis) and loss of alveolar bone; the latter, however, has been addressed considering the following different series of parameters, many of which are only surrogate measures of PD:

a) clinical attachment level (CAL), depth of the periodontal pocket (PPD);

b) alveolar crest height (ACH) or height of the residual alveolar bone (ABH);

c) tooth loss (TL).

The most significant published works for each of them are detailed (Tables 3,4).

Discussion

OP may affect jawbones and the resulting modifications visible at the routine radiological examination (i.e. dental panoramic radiograph) may be useful for OP early diagnosis. In addition, these modifications might potentially speed up periodontal tissues breakdown caused by PD (2). Under this point of view, although several reports on an epidemiologic basis, support a potential association between PD and OP, the comprehensive analysis of the reported data provides conflicting results; however, it should be noted that reported studies have a wide variation in terms parameters used for assessing both OP and PD, thus a reliable comparison is somewhat problematic, and, in addition, their design (most of them are cross-sectional, uncontrolled and with small sample size restricted to postmenopausal women) is not adequate to draw robust conclusions (3-4).

Table 3. Studies on the association between indexes of OP and CAL/PPD.

Authors	Oral Index	Index of OP	Study design	Correlation
Groen et al. 1968 (9)	CAL	OP by means rx	NC	+
Phillips and Ashley 1973(21)	PPD	Metacarpal Index	CSS	+
Ward and Manson 1973 (22)	PPD	Metacarpal Index	CSS	-
Kribbs et al. 1983 (23)	PPD	Forearm BMD	CSS	-
Kribbs et al. 1990 (24)	PPD	BMD in health women	CSS	-
Kribbs 1990 (25)	CAL, PPD	OP yes/no	CSS	-
Von Wovern et al. 1992 (26)	CAL	BMC	P	-
Elders et al. 1992 (27)	PPD	BMD of spine, MCT	CSS	-
Mohammad et al. 1996 (28)	CAL	BMD of spine	CSS	+
Von Wovern et al. 1996 (29)	CAL	BMC	CSS	-
Hildebolt et al 1997 (30)	CAL	BMD of spine and femur	CSS	-
Mohammad et al 1997 (31)	CAL	BMD of spine	CSS	+
Weyant et al 1999 (7)	CAL	BMD of spine, femur and wrist in postmenopausal women	CSS	-
Payne et al 2000 (32)	CAL	BMD of spine in postmenopausal women	P	+
Ronderos et al 2000 (33)	CAL	BMD in men and women	CSS	+
Tezal et al 2000 (34)	CAL	BMD of spine, femur and wrist in postmenopausal women	CSS	+
Pilgram et al 2002 (35)	CAL	BMD of femur and column	CSS	-
Yoshihara et al 2004 (36)	PAL	BMD in men and women	LS	+
Famili et al 2005 (37)	CAL	BMD of femur	-	-
Brennan et al 2007 (38)	CAL	BMD of spine, femur and forearm in postmenopausal women	CSS	+
Phipps et al 2007 (39)	CAL, PPD	BMD of spine and femur in men	LS	-
Hattatoglu-Sonmez et al 2008 (40)	CAL, PPD	BMD spine and femur in pre and postmenopausal women	CSS	-

BMD = Bone Mineral Density; CAL = Clinic Attachment Level; CSS = Cross Sectional Study; LS = Longitudinal Study; MCT = Metacarpal Cortical Thickness; NC = No Controlled Study; OP = Osteoporosis; P = Prospective Study; PAL = Probing Attachment Level; PPD = Periodontal Pocket Depth; RX = x rays.

Table 4. Studies on the association between BMD and ACH/ABH.

Authors	Oral Index	Index of OP	Study design	Correlation
Ward and Manson 1973 (23)	ABL	Metacarpal Index	CSS	N.E.
Humphries et al 1989 (41)	Resorption of residual ridge	Fracture, sex, age	CSS	+
Ortman et al 1989 (42)	Resorption of residual ridge by means DPR	Sex, age	CSS	+
Elders et al 1992 (27)	ABH by means bitewing	BMD of spine, MCT	CSS	-
Hirai et al 1993 (43)	Resorption of residual ridge by means DPR	OP yes /no	CSS	+
Wactawski-Wende et al 1996 (44)	ACH	BMD of spine and femur	CSS	+
Payne et al 1999 (45)	ABH by means bite-wing	BMD of spine	LS	+
Payne et al 2000 (32)	ACH by means bite-wing	BMD of spine and alveolar bone	P	+
Hildebolt et al 2000 (46)	Distance between CEJ-AC measured by means bite-wing	BMD of spine and femur	CSS	+
Pilgram et al 2000 (47)	ABH by means bite-wing, PPD, gingival recession	Postmenopausal women in HRT	CSS	+
Tezal et al 2000 (34)	ABL, ACH, and CAL by means periapical and bite-wing rx	BMD of spine and femur	CSS	+
Hildebolt et al 2002 (48)	ACH by means bite-wing	BMD of spine and femur	P	N.E
Wactawaski - Wende Jet al 2005 (49)	ACH by means periapical rx	BMD of spine, femur and forearm in postmenopausal women	CSS	+
Brennan-Calanan et al 2008 (50)	ACH by means periapical rx and bitewing	BMD spine, femur and total body in postmenopausal women	CSS	-

ABH = Alveolar Bone High; ABL = Alveolar Bone Loss; ACH = Alveolar Crestal Height; BMD = Bone Mineral Density; CAL = Clinic Attachment Level; CEJ-AC = Cement Enamel Junction -Alveolar Crest; CSS = Cross Sectional Study; DPR = Dental Panoramic Radiograph; HRT = Hormonal Replacement Therapy; LS = Longitudinal Study; MCT = Metacarpal Cortical Thickness; N.E. = Not Estimable; OP = Osteoporosis; P = prospective study; PPD = Periodontal Pocket Depth.; RX = x rays.

On the other hand, besides the presence of common risk factors, a possible interplay between OP and PD is also suggested at a pathogenetic level. In fact, a bi-directional interference between PD and OP has been proposed: in particular, the reduced BMD, characterizing OP and the related alteration of trabecular pattern may lead to a more rapid jawbones resorption caused by PD, resulting in the invasion of periodontal bacteria (6-9). Invading bacteria, in turn, may alter the normal homeostasis of bone tissue, increasing osteoclastic activity and reducing local and systemic bone density by both direct effects (release of toxins) and/or indirect mechanisms (release of inflammatory mediators; in particular, interleukin-1 and interleukin-6) .

Thus, a relationship between OP and PD might be probable, but further prospective and sensitive studies are required in order to provide definitive evidence.

By now, available data underline the primary importance of dentists in the early diagnosis of OP, because of the opportunity to assess the health of the entire skeleton of the patient through dental radiography. This is of considerable clinical interest, considering that such dental radiological investigations are routinely performed for diagnosis and treatment of dental and periodontal diseases, which are particularly frequent in the same population affected by OP. This may also provide clues for new preventive strategies and/or early therapeutic approach resulting in a potential reduction of bone resorption and contributing to maintain bone biomechanical characteristics (e.g. architecture, remodelling, quality of matrix collagen and its mineralization).

In fact, the prevention of OP is the most rational and modern approach to defeat the disease (1), and early diagnosis is one of the foundations of modern medicine; the dentist seems to have an important role not only in monitoring/maintaining the oral and periodontal health and its relationships with systemic health, including OP, but also in drafting diagnostic/therapeutic paths and participating in counselling for OP in collaboration with general practioners and other specialists.

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