The relationship between general osteoporosis of the organism and periodontal diseases

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***Key words**: osteoporosis, bone density, densitometry, mandible, periodontal diseases.*

***Summary.** Osteoporosis and periodontitis are very prevalent diseases and are most common in middle-aged and elderly women. These diseases are related as both damage bone tissue and share common risk factors. Discussions about the association between these two bone-damaging diseases began in 1960. A hypothesis was raised that systemic imbalance in bone resorption and deposition might manifest itself in the alveolar bone earlier than in other bones. When analyzing systemic and local changes in bone density, a number of issues were investigated and attempted to answer the question of whether dental osteopenia is a local manifestation of osteoporosis having similar etiology and risk factors, or it is an independent process depending primarily on factors that cause periodontal disease. Histomorphometric and microradiographic studies showed that increasing porosity of the cortical layer in mandible resulted in the decrease in bone mass.*

Bone strength is best expressed through bone mineral density, and it can be called a diagnostic criterion of osteoporosis. The examination of bone mineral density is called densitometry and may be performed using dual-energy x-ray absorptiometry.

Orthopantomography is a method that is widely applied in odontological practice and is also informative in determining the bone density of the mandible. It can be applied when performing orthopantomographic and vertical linear measurements, as well as in determining indices in the studies of osteoporotic changes.

Since many patients attend odontological clinics, nearly all of them undergo orthopantomography. This is a good possibility to investigate osteoporotic changes in the mandible, to select individuals for further studies, and to ensure clinical benefit and good treatment results.

Introduction

Osteoporosis and periodontitis are two independent diseases. It is thought that these diseases are related as both damage bone tissue, share common risk factors, are most common in middle-aged and elderly women (1), and are very prevalent. The risk factors that are common for both diseases are easy to identify: smoking people sooner lose their teeth compared to non-smokers since periodontal disease in such people develops faster (2, 3). Smoking is also one of risk factors for the development of osteoporosis (2, 4, 5), since smokers' organisms produce acids that are neutralized by calcium obtained from the bones. In smoking women, menopause may start five years earlier, since nicotine impedes the production of estrogens, and the accumulated cadmium disrupts the osseous tissue (1). A deficiency of Ca and vitamin D in food, inappropriate nutrition, alcohol consumption, hormone therapies, and diseases such as diabetes or hyperthyroidism stimulate the resorption of the alveolar process and the development of osteoporosis (2, 4–6). In addition, hereditary factors are never excluded in the presence of periodontal diseases or osteoporosis (7). Thus, osteoporosis and periodontitis are not only a medical but also a social and economic problem.

Discussions about the association between these two bone-damaging diseases began in 1960. Histomorphometric and microradiographic studies showed that people aged more than 50 years experience significant changes in the osseous tissue, occurring in mandibular trabecular and cortical bone tissue, and increasing porosity of the cortical layer results in

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the decrease in bone mass (4). E. Manzke (8) raised a hypothesis that systemic imbalance in bone resorption and deposition may manifest itself in the alveolar bone earlier than in other bones. During a long period of the research, a number of comparative studies on different bones (*e.g.* spinal vertebrae and mandible, mandible and radius, wrist, thigh-bone, and other bones of the skeleton) were performed (9), and it was suggested to pay attention to the influence of systemic factors that are responsible for the development of the osteoporosis process and to the relationship of these factors with the local ones that increase the alveolar resorption of mandible. Due to its anatomical–morphological properties, maxilla was rarely used in the studies of changes in osseous tissues.

When analyzing systemic and local changes in bone density, a number of relevant issues were investigated and attempted to answer, including the following: Is dental osteopenia a local manifestation of osteoporosis having similar etiology and risk factors, or whether it is an independent process depending primarily on factors that cause periodontal disease? What research techniques are precise enough for determining bone density in the mandible? How does the osteoporotic process damage different skeletal structures? Perhaps periodontitis is the first prognostic sign of osteoporotic changes in spinal and long bones? J. J. Groen, F. Duyvensz, J. A. Halsted thought that spinal vertebrae and the mandible had similar muscle fixation, and therefore, they compared radiograms and raised a hypothesis that radiograms of alveolar processes could be good indicators for the diagnosis of systemic osteoporosis (10). These authors have even proposed a term – "alveolar or periodontal osteoporosis."

P. J. Kribbs in 1983 (11) and 1989 (12) and N. von Wowern in 1994 (13) concluded that mandibular osseous mass correlated with the total skeletal bone mass. The majority of performed studies showed that a relationship existed between total skeletal bone mass and the amount of estrogens in the organism, and that diminution of estrogen levels affected the bone density of the jaws (9). A. R. Becker, who performed his investigation in 1997, determined a negative correlation between the number of remaining teeth and the time of the beginning of menopause in women of postmenopausal age in whom no hormone replacement therapy was applied (14). R. E. Persson in 1998 (15) and J. B. Payne in 1999 (16) studied older women who underwent hormone replacement therapy and concluded that periodontium in such women was healthier than in those who did not receive such treatment. A. Taguchi in 1995 and L. Birkenfeld in 1999 performed a descriptive study on women who had experienced spinal fractures. The majority of them had periodontitis and few remaining teeth in the oral cavity. The authors suggested that there could be a high percentage of people with periodontal diseases among those with osteoporosis (17, 18).

Not all studies confirmed the presence of a relationship between periodontal diseases and osteoporosis, but in 1997, C. F. Hildebolt in his article stated that such relationship existed (4).

In August 1992, a relationship between oral and skeletal osteoporosis was confirmed, and an agreement on the necessity of radiological diagnosis was made (4). In 1992, the US National Health Institute ordered special studies for the determination of the relationship between oral condition and osteoporosis. The application of the panoramic radiogram test for people with osteoporosis for the confirmation of the diagnosis of periodontitis was among the set objectives.

The application of panoramic radiograms for bone density studies was analyzed by K. A. Southard in 1992, E. Klementti in 1993 and 1994, A. Taguchi in 1995, and by A. M. Bollen in 2000.

The aim of all researchers was to identify and select individuals with osteopenia and osteoporosis for further studies and to ensure clinical benefit and good treatment results. Since many patients attended odontological clinics, nearly all of them underwent dental radiography and orthopantomography, and perfect possibilities emerged for the investigation of osteoporotic changes in the mandible and the analysis of radiographic and clinical data (7). M. G. Perno in 2002 stated that it was well known how to treat osteoporosis or periodontal diseases separately, but there was no clear definition concerning how to treat patients who have both diseases (6). The question of whether curative means and measures applied for osteoporosis are also effective in periodontitis still remains unanswered.

Osteoporosis

Osteoporosis is a chronic, progressive reduction of the mineral density and the matrix of the bone and resulting in the loss of bone mass and changes in the micro-architecture of the bone. From the functional perspective, the bone becomes brittle and is prone to break rapidly (19). This disease is most frequently defined as the most prevalent metabolic bone disease in the world. Bone strength is best expressed through bone mineral density (BMD), and therefore, it can be called a diagnostic criterion (5).

T level is the BMD deviation of the examined person, expressed in the number of standard deviations from the maximal mean bone density in young healthy people of the same sex.

The diagnostic criteria recommended by the World Health Organization (1994) are the following:

Normal bone mass is diagnosed when T level is between +1 and –1;

Osteopenia is diagnosed when T level is between –1 and –2.5;

Osteoporosis is diagnosed when T level is below –2.5;

Severe osteoporosis is diagnosed when T level is below –2.5, and there is a fracture of one or more bones.

Together with T level, Z level is determined. Z level is the examined person's BMD deviation expressed in the number of standard deviations from the mean BMD value in people of the same age and sex.

Risk factors

It has been proven that bone mass is determined by genetic factors (7). The bone mass increases from birth up to approximately thirty years of life (20, 21). This is the age when the bone mass reaches its maximum. However, individuals with limited mobility or those with no balanced nutrition ration cannot achieve optimal and uniform firmness of the skeleton at the same age. After 30 years of age, both men and women experience a bone-mass decrease of about 1% yearly (1, 2). Bone loss in men develops significantly more slowly because the composition of their skeleton is more solid. Women are characterized by especially progressive period of bone destruction 5–10 years after the menopause since a decrease in estrogen levels in the organism entails the activity of osteoclasts. This is called postmenopausal osteoporosis. The decrease in estrogen levels is a physiological feature of a woman of menopausal age. Ovaries produce lesser amounts of estrogens, which result in the loss of the osseous tissue. Estrogens have a positive effect on the cervix and the glandular tissue of the breast; they maintain the sexual function, normal metabolism of the osseous tissue, and the balance of lipids in blood. During the first 5–7 years after the menopause, a woman may lose up to 20% of the bone mass, in other words 2–3% of the trabecular and 1–2% of the cortical bone mass (19). Mostly bone mass decreases in spinal bone (22).

More than half (54%) of women during the postmenopausal period are diagnosed with osteopenia, and 30% – with osteoporosis (1). During the later periods, this process becomes more stable and develops more gradually.

The development of osteoporosis is influenced by risk factors, such as insufficient or excessive physical activity (fracture and risk to fall depends on force of muscles), smoking, immoderate consumption of alcohol and/or caffeine, poor nutrition, deficiency of calcium (if calcium is deficient in the diet at a young age, the bone mass in a young organism may decrease by 5–10%) and B-group vitamins, vitamins C, D, and K, as well as prolonged usage of certain pharmaceutical preparations (glucocorticoids, immunodepressants, anticonvulsants, etc.) (1, 4, 5, 23). One factor cannot be substituted by domination of other factors (23).

Some authors identify inevitable risk factors, such as race, early menopausal age due to hysterectomies or oophorectomies, female sex, older age, poor health, and dementia (2, 3, 6). R. E. Persson in 2002 stated that there were only two statistically identified factors associated with osteoporosis – female sex and race (ethnic group) (24). Mean bone mineral density of black people is by 8–12% higher than Europeans (22).

Epidemiology

Epidemiological studies show that at present more than 325 million individuals aged 65 years and older have osteoporosis worldwide (2). Osteoporosis results in 2.5 million bone fractures annually, and it is predicted that this number will increase. Globally, it has been calculated that in 1990 thighbone fractures occurred in 560,000 individuals in Europe, in 360,000 in Northern America, and in 570,000 people in Asia. The US National Institute of Arthritis and Musculoskeletal and Skin Diseases announced that in the US the number of people with osteoporosis reached 20 million in 2000, and that the annual number of related bone fractures reached approximately 2 million (20% – in thighbone, 45% – in the spine, 15% – in wrist bones, and 20% – in other bones). According to research findings, one out of two women and one out of six men up to 90 years of age had bone fractures related to osteoporosis, and in 12 and 20% of cases, respectively, the fractures entailed lethal complications (2). The probability of fractures increases with age primarily in women and then – in men. According to calculations, in 2020, only in the European Union women may experience up to 1 million fractures annually (5). The highest number of spinal vertebra fractures is registered in Scandinavia (25).

Measurements of bone mineral density

Bone mineral density is the standard for the diagnostics of osteoporosis. This is the amount of mineral substances in the bone measured in grams. The examination of bone mineral density is called densitometry. This examination may be performed using several different study techniques: dual-energy x-ray absorptiometry (DEXA, DXA), quantitative computerized tomography (QCT), and ultrasound densitometry. The latter is most frequently used in the examinations of peripheral bones (19).

The most popular method of investigation is DEXA, where bone density is measured in grams per square centimeter in both central and peripheral bones. This study is precise and has certain advantages since the patient receives a low dose of irradiation (1–5 μSv), and it is fast to perform (takes 2–4 minutes). DEXA is the most commonly used method after the changes have already been determined using ultrasound or peripheral densitometry.

QCT studies are most commonly performed in the spine, and the bone density is measured in grams per cubic centimeter. During the examination, the patient receives irradiation at a dose of 50–70 μSv. The study lasts for 15 minutes (5).

Ultrasound densitometry is the method of choice for the screening of the subjects. Ultrasound densitometry is most commonly used in the examination of the heel bone (19). DEXA is recommended only after the determination of changes in bone mineral density.

Periodontal diseases

Gingivitis is an inflammation of soft tissues surrounding the tooth. This is a direct immune response to microbial plaque attached to the surface of the tooth. The clinical manifestations of gingivitis are redness and swelling of the gums and bleeding upon soft touching or probing. Periodontal ligaments and alveolar bone are not involved in the process, and therefore, this process is evaluated as an easily controllable one, since once the microbial plaque is removed, the inflammation rapidly resolves, and the gums heal.

Periodontitis is an inflammation of bacterial origin that destroys the dental supportive structures and leads to progressive destruction of periodontal ligaments and alveolar bone.

Periodontal diseases are infectious ones since they develop due to the accumulation of dental plaque on dental surfaces and other sites of the retention of infection, such as hanging fillings, improper positioning of teeth in the dental arch, carious sites situated close to gums and improper crowns, and in the already existing gingival pockets. Healthy oral cavity is known to contain over 500 species of various microorganisms (3), but only a small part of them (approximately 5%) cause periodontal infection. There is a widespread opinion that microbial flora is changing, what is most commonly influenced by antibiotic therapy. If oral hygiene is poor, the gram-positive aerobic bacteria situated on dental surfaces and grooves usually turn into gram-negative anaerobic bacteria that are pathogenic to periodontal tissues and cause a progressive destructive process, *i.e.* degeneration of the connective tissue, bone resorption, and tooth loss. In the mechanism of the development of periodontitis, the inflammatory-immune response predominates, but differently from gingivitis, non-stabilized and untreated process leads to tooth loss. Clinically, the gums look inflamed, swollen, cyanotic, bleed upon touching or probing, gingival pockets of various depth are detected with a periodontal probe, and teeth have various degrees of mobility. Orthopantomography shows various degrees of vertical or horizontal resorption of the alveolar process.

A separate group of periodontal diseases of noninfectious origin is differentiated. This is a periodontal pathology caused by mechanical, thermal, or chemical factors. This group also includes periodontal diseases caused by viruses (HIV infection, herpetic gingivostomatitis) where the determination of the cause of gingival inflammation is difficult (3).

The effect of female hormones on periodontal tissues has been studied (26). Changes in sex hormone levels during the periods of adolescence, menstruations, pregnancy, and menopause cause the inflammation of the gingiva (9). During the pre-menstrual period, an increase in progesterone levels may cause gingivitis. Progesterone dilates blood vessels, increases the severity of the inflammatory process, and impedes the production of collagen. Estrogens stimulate proliferation and differentiation of cells, as well as the cornification of gingival epithelium. For this reason, estrogen deficiency accompanies reduction of collagen in the connective tissue (26). The period of menopause is characterized by a decreased salivation in the oral cavity, thinning out of the oral mucous membrane, feeling of burning and soreness, progression of gingival recession, and increase in the number of carious cavities, the development of dysesthesia, disorders in taste sensations, progression of periodontitis, resorption of the alveolar process, and osteoporotic changes in the bones (26). M. Tezal states that changes in the systemic bone density also simultaneously entail changes in the height and the density of the alveolar bone and changes in the height of the clinical junction of periodontal tissues (27).

F. Grodstein in his studies found that women who had osteoporosis and underwent estrogen therapy had a significantly higher probability to preserve their teeth, whereas women with osteoporosis who did not undergo any estrogen therapy and poorly performed oral hygiene procedures had a high risk of losing their teeth. This risk may be reduced by prescribing treatment with hormone preparations (28).

It is noteworthy that periodontal diseases are a process that is influenced by a number of factors, and the main etiological factor of this process is microbial film;

however, local and systemic factors that condition the pathogenesis of periodontal diseases should not be disregarded either. These factors should be identified, their risk should be evaluated, and further spreading of the destruction should be prevented.

Significance of orthopantomography

Orthopantomography is a method that is widely applied in odontological practice and is performed for the evaluation of the general condition of the dental-maxillo-mandibular system, in the examination of patients with periodontal diseases, during preparations for dental implantation surgery, etc. This method is convenient and fast, and patient receives low irradiation doses. This technique is also informative in determining bone density because it can be applied when performing orthopantomographic and vertical linear measurements, as well as in determining indices (29, 30). In the studies of osteoporotic changes, patients of various ages undergo measurements of the thickness of the cortical layer of the mandibular base (17, 29). Radiographic examinations show the reduction of this layer in older women. The process of natural age-related reduction should also be kept in mind.In the foramen mentale area of the mandibula, the mental index (MI) is determined, in the area of mandibular angle – the gonial index (GI), and to the front of the mandibular angle – the antegonial index (AI). Of these three indices, the MI has the greatest significance for the evaluation of osteoporotic changes in bone density (29).Vertical linear measurements performed in orthopantomograms allow calculating of the panoramic mandibular index and the mandibular cortical index, which are important in the studies of mandibular bone density (29, 30).

The application of special computerized measurements allows calculating of the optical bone density in the scanned orthopantomograms of the mandible (31).

E. Klementti (32) proposed a morphological evaluation of the cortical layer of the mandibula:

Class 1 – the internal margin of the cortical layer is even;

Class 2 – lacunar resorption is present on the internal surface of the cortical layer;

Class 3 – the internal layer is porous.

Radiological examination is informative in determining the type and the degree of alveolar resorption, the condition of the peridontium, and the number of teeth. These parameters provide valuable information when searching for correspondence and the correlation of data in studies.

Ryšys tarp bendrosios skeleto osteoporozės ir priedančio audinių ligų

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Raktažodžiai: osteoporozė, kaulų tankis, densitometrija, apatinis žandikaulis, priedančio audinių ligos.

Santrauka. Osteoporozė, priedančio audinių ligos – tai plačiai paplitusios ligos, būdingos vidutinio ir brandaus amžiaus pacientėms. Šios ligos turi nemažai bendrų rizikos veiksnių. Jos abi vystosi pažeisdamos kaulinį audinį. 1960 metais pradėtas tyrinėti ryšys tarp šių ligų. Iškelta hipotezė, kad pirmieji sisteminiai kaulo pokyčiai anksčiau gali pasireikšti alveoliniame kaule nei kituose. Tyrinėti sisteminiai ir vietiniai kaulų tankio pokyčiai, bandyta atsakyti į daug aktualių klausimų: ar žandikaulio osteopenija yra lokalus bendrosios osteoporozės pasireiškimas su panašia etiologija, rizikos veiksniais, ar tai yra atskiras procesas, priklausantis pirmiausia nuo priedančio audinių ligą sukeliančių veiksnių? Atliktos histomorfometrinės, mikroradiografinės studijos ir nustatyta, kad, didėjant žandikaulio kaulinės medžiagos porėtumui, sumažėja kaulinė masė. Kaulų tvirtumą rodo kaulų mineralinis tankis. Tai svarbus osteoporozės diagnostikos kriterijus. Dažniausiai šis tyrimas atliekamas dvigubos energijos rentgeno absorbciometrijos metodu.

Odontologijoje priedančio audinių ligomis sergančių pacientų ištyrimui atliekamos ortopantomogramos, kurių duomenimis remiantis, galima taip pat diagnozuoti osteoporozinius pokyčius žandikaulyje, atlikti vertikalius linijinius matavimus, apskaičiuoti įvairius indeksus, kurie yra svarbūs osteoporozinių pokyčių dydžiui įvertinti.

Pacientai, besilankantys odontologo kabinete, būna ištirti radiografiniais tyrimų metodais. Tai galėtų tapti vienu iš būdų atrenkant osteopenija ir osteoporoze sergančius žmones ir sudarytų sąlygas siųsti pacientus tolesniam tyrimui, be to, užtikrinti pacientui klinikinę naudą bei gerus gydymo rezultatus.

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