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REVIEW ARTICLE

Mandibular Bone Mineral Density to predict Skeletal Osteoporosis: A Literature Review

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ABSTRACT

Until and unless the disease is recognized as a disease entity, a little progress has been made in understanding its etiology and in developing a predictable treatment planning, restoration, and prevention of the tissues. In a process carried out to study a disease entity, whether it be cardiac disease, dental caries, or periodontal disease, it is helpful to study its pathology (the gross and microscopic structural changes of the disease), its pathophysiology (the mechanisms or disordered functions of the disease), its pathogenesis (the life history), and its epidemiology (the worldwide prevalence of the disease and various interrelated factors). The ultimate aim of such researches is the better understanding of the etiology and pathogenesis of the disease, and thereby with such understanding leading to a predictable treatment planning and ultimately the prevention or control of these factors. Osteoporosis is a major health entity affecting the elderly population and thereby resulting in approximately 1.3 million spontaneous fractures in the USA every year. The above clinical condition is a deficiency of bone mass, or skeletal osteopenia, to that level where bone cannot provide adequate mechanical support. Many of the reported studies used inadequate measures of both skeletal and mandibular bone in evaluating their possible relationships. This literature review attempts to determine relationships between the total skeletal bone mass and bone mass of the mandible in the population suffering with osteoporosis.

Keywords: Bone mineral density, Osteoporosis, Residual ridge resorption, Skeletal.

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INTRODUCTION

Until and unless the disease is recognized as a disease entity, a little progress has been made in understanding its etiology and in developing a predictable treatment planning, restoration, and prevention of the tissues. For example, dental caries is acknowledged today as a complex disease entity, not simply as cavities in the teeth, before today's massive sophisticated attack wherein it could be regarded, against this almost universal, as a disease affecting the stomatognathic system. Similarly, the residual ridge reduction (RRR) must thereby be considered as a complex disease affecting the stomatognathic system with identifiable characteristics and unwanted squeal affecting billions of people. In a process carried out to study a disease entity, whether it be cardiac disease or dental caries or periodontal disease, it is helpful to study its pathology (the gross and microscopic structural changes of the disease), its pathophysiology (the mechanisms or disordered functions of the disease), its pathogenesis (the life history), and its epidemiology (the worldwide prevalence of the disease and various interrelated factors). The ultimate aim of such researches is the better understanding of the etiology and pathogenesis of the disease, and thereby with such understanding leading to a predictable treatment planning and ultimately the prevention or control of these factors.[1-3]

Osteoporosis is considered to be one of the major bone entity affecting the elderly population and thereby resulting in more than 8.9 million fractures annually, resulting in an osteoporotic fracture every 3 seconds. The above clinical condition is a deficiency of bone mass, or skeletal osteopenia, to that level where bone cannot provide adequate mechanical support. An International Osteoporosis Foundation (IOF) survey, conducted in 11 countries, showed denial of personal risk by postmenopausal women, lack of dialogue about osteoporosis with their doctor, and restricted access to diagnosis and treatment before the first fracture result in underdiagnosis and undertreatment of the disease. About 20 to 25% of hip fractures occur in men. The overall mortality is about 20% in the first 12 months after hip fracture and is higher in men than women. It is estimated that the residual lifetime risk of experiencing an osteoporotic fracture in men over the age of 50 is up to 27%, higher than the lifetime risk of developing prostate cancer of

11.3%. It has been suggested, but not clearly established, that the mandibular bone loss and osteopenia of the remaining skeleton may be related. The literature has shown significant relationships between the total body calcium (TBC), total skeletal bone mass, bone mineral content of the radius, and mandibular bone density in women with osteoporosis. Many edentulous subjects with severe alveolar bone resorption also have been depicted to have the association of low bone mineral density (BMD) of the radius. Edentulous men needing vestibuloplasty have significantly lower bone density of the radius than have an age-matched control group of men with intact dentition. On radiological findings, a thinned mandibular angular cortex at the gonion was consistently observed in the postmenopausal women with chronic renal failure.[4]

Many of the reported studies used inadequate measures of both skeletal and mandibular bone in evaluating possible relationships. This literature review attempts to determine relationships between the total skeletal bone mass and bone mass in the mandible in the population suffering with osteoporosis.

OSTEOPOROSIS AND RESIDUAL RIDGE MODELING

Residual ridge is a term used to describe the shape of the clinical alveolar ridge after healing of bone and soft tissues following tooth extraction. The residual ridge alveolar bone undergoes a lifelong catabolic remodeling even after the healing of wounds, and is one of the most striking feature of the extraction wound healing. The size of the residual ridge is reduced most rapidly in the first 6 months, but the bone resorption activity of the residual ridge continues throughout life at a slower rate, resulting in removal of a large amount of jaw structure. This continuous process has been described as RRR. The clinical and pathophysiologic features of Types I and II osteoporosis have been refined from the above-established views of osteoporosis. Type I osteoporosis is defined as the specific consequence of menopausal estrogen deprivation, and characteristically presents the bone mass loss, notably in the trabecular bone. Type II osteoporosis reflects a composite of age-related change in intestinal, renal, and hormonal functions. In Type II osteoporosis, both the cortical as well as the trabecular bone are affected.[5]

Hirai et al investigated the relationship between the height of the mandibular residual ridge and the severity of osteoporosis in elderly edentulous patients. The height of the mandibular residual ridge was measured using the mental foramen on panoramic radiographs. The frontal and lateral radiographs of the vertebrae determined the severity of osteoporosis. All of the patients underwent a blood analysis in order to obtain the hormonal findings. The correlation coefficient between age and the height of residual ridge was statistically significant. The residual ridge in women was lower than that of men, showing a statistical significance. The correlation coefficient was –0.42 between degrees of severity of osteoporosis and the height of the residual ridge, which was significant. The parathyroid hormone level was high in patients with a low residual ridge, and the calcitonin (CT) level was low. Thus, the above study indicates that osteoporosis has a strong effect on the RRR in edentulous patients.[6]

Hildebolt reviewed the literature on the possible association between osteoporosis and oral bone loss, with an emphasis on radiological studies. Such an association between RRR and osteoporosis was first suggested in 1960. Subsequent histomorphometric and micro radiographic studies showed that after the age of 50 there was a marked increase in the cortical porosity of the mandible, with this increase being greater in the alveolar bone than in the mandibular body; and that with this increase in porosity, there was a concomitant decrease in bone mass, which appeared to be more pronounced in females than in males. These studies also demonstrated a considerable amount of variation in the amounts of cortical and trabecular bone within and among individuals. It was suggested that systemic factors responsible for osteoporotic bone loss might combine with local factors (periodontal diseases) to the increased rates of periodontal alveolar bone loss. Although not all studies found associations between osteoporosis and oral bone loss, the conclusion of this review was that, such an association exists; yet additional longitudinal investigations are needed to confirm this, and before the implications of this association could be fully utilized in clinical dentistry, inexpensive methods must be developed for sensitive and specific measures of oral bone loss.[7]

Postic et al conducted a study with the aim to determine the intensity and correlation of the osteoporotic changes in the bone density of the skeleton and body mass index (BMI) with a reduction in edentulous mandibles. In this study, around 89 edentulous patients with decreased BMD comprised the study group, and 43 edentulous patients with normal BMDs formed the control group. The age of the patients ranged between 50 and 75 years. Radiographs of the hands and panoramic radiographs were carried out for all the patients. The values of BMI, metacarpal index, density of lumbar spine (L2-L4), in the phalanx and segments of the mandibles as well as the heights of the edentulous alveolar ridges were measured, assessed, and calculated. The lowest value of the total skeletal density was established in the osteoporotic patients on the basis of the average T-score of about –2.5 in men

and women. Minimum values of the heights of the edentulous ridges (right/left, in mm) were measured in both osteoporotic female and male patients. By comparison of the densities of the metacarpal bones, proximal phalanx, segments of the edentulous mandibles and based on the numerical values of the heights of the edentulous ridges, $\chi^2 = 3.81$ was found in men and $\chi^2 = 4.03$ was found in women with normal bone densities; $\chi^2 = 5.92$ was found in men and $\chi^2 = 6.25$ was found in women with osteopenia; $\chi^2 = 2.63$ was found in men and $\chi^2 = 3.85$ was found in women with osteoporosis, on the p level of probability of 0.05. They thereby concluded that systemic osteoporosis causes a decrease of the jawbone density and induces residual edentulous alveolar ridge reduction.[8]

Bones mass measuring techniques are used to evaluate interrelationships between different regions of the skeleton, to distinguish the diseased from the normal state, and to monitor bone mass changes in the progress of disease or treatment. Various studies have assessed interrelationships between bone mass measurements in different regions of the skeleton in osteoporotic population. Significant relationships have been reported between mandibular and skeletal bone mass both in osteoporotic population with osteoporosis and in non-osteoporotic geriatric population. Several studies also have attempted to contrast population with osteoporosis and those without the disease. No previous studies have been reported comparing normal population with age-matched osteoporotic population in mandibular bone mass and density and other dental measures. Thus, it can be concluded that whether such oral measures can identify osteoporotic from normal persons or not is still unknown. Further studies and researches are indicated to determine the relationship amongst the osteoporotic population and bone remodeling.

CO-RELATIONSHIP BETWEEN BMD OF THE JAWS AND OTHER SKELETAL SITES

Drage et al investigated the relationship between BMD of the jaws (mandible and maxilla) and other skeletal sites. In addition to the above, various other parameters, such as the influence of gender, smoking, and the number of years without natural teeth, were examined. Around 20 edentulous patients with a mean age of 67.1 years had dual-energy X-ray absorptiometry (DEXA) scans to assess the BMD of the lumbar spine and hip, together with the ramus, body and symphysis of the mandible, and the anterior of the maxilla. The BMD values for the ramus were similar to the femur but significantly lower than the BMD values of the lumbar spine. The body and anterior mandible had higher values and the anterior maxilla lower values than the BMD values of the femur and ramus. The ramus BMD showed moderately strong relationships with the standard measures of BMD in the spine and hip, but the BMD of other areas of the jaws showed no relationship with skeletal sites. An inverse relationship with increasing age was found in the BMD for both the hip and the ramus, although the ramus of the mandible may show the correlation of BMD with skeletal sites and the areas of the jaws where implants may be placed or not. Therefore, they concluded that BMD of the skeletal sites could not be used to predict BMD of the jaws.[9]

Miliuniene et al conducted a study to evaluate the association between lumbar spine BMD and mandible cortical bone height at the mental foramen and at the angle of the jaw. A total of around 130 female patients living in Lithuania were examined. All of the participants were ruled out for having endocrine, metabolic, or skeletal disorders. The BMD was measured in the lumbar spine area L2-L4. The BMD of the mandible was examined on panoramic X-ray images. On each radiograph cortical thickness of mandible was measured at the mental foramen and at the angle of the jaw. The results demonstrated a tendency of high probability of osteoporosis in cases where radiomorphometric parameters are low. There was a significant difference between BMD of lumbar spine and cortical bone height of mandible below the foramen mentale and at the angle of the jaw.[10]

Gulsahi et al conducted a study to evaluate maxillary, mandibular, and femoral neck BMD using DEXA and also to determine if there is any correlation between the BMD of the jaws and panoramic radiomorphometric indices. Around 50 edentulous patients aged between 41 and 78 years were examined by panoramic radiography. The BMD of the jaws and femoral neck was measured with a DXA; BMD was calculated at the anterior, premolar, and molar regions of the maxilla and mandible. The mean maxillary molar BMD was significantly greater than the maxillary anterior and premolar BMD. Furthermore, the mean mandibular anterior and premolar BMD was significantly greater than the mean mandibular molar BMD. Although BMD in the maxillary anterior and premolar regions were correlated, BMD in all the mandibular regions were highly correlated. Maxillary and mandibular BMD were not correlated with femoral BMD. In addition, mandibular cortical index (MCI) classification, mental index (MI) or panoramic mandibular index (PMI) values were not significantly correlated with the maxillary and mandibular BMDs. The BMD in this study was highest in the mandibular anterior region and lowest in the maxillary anterior and premolar regions. The BMD of the jaws was not correlated with either femoral BMD or panoramic radiomorphometric indices.[11]

Aggarwal et al conducted a study considering that osteoporosis is a systemic disorder characterized by low

bone mass, leading to fractures reported commonly in females after menopause. The investigations for osteoporosis most commonly used DEXA, i.e., a very costly and not easily available mode of investigation. Few studies have proposed the use of orthopantomogram as a diagnostic marker for osteoporosis as it is simple, quick, easy, inexpensive, noninvasive, and widely used. Thus the present study has been undertaken to assess the relation between MCI of panoramic radiograph and BMD of body measured by DEXA. The study comprised 50 postmenopausal females. All the females were subjected to panoramic radiographs and DEXA in order to assess the comparative BMD results. The visual analysis was done based on the radiographic appearance of the lower border of the mandible on the left side by two observers who were blinded about DEXA results. Intra/interobserver variability was ruled out by visual analysis at two occasions that was followed by comparison of different grades of MCI and BMD statistically. There was a very significant difference in the three groups of mandibular cortical index of panoramic radiograph as interpreted by the two observers. The intraobserver reproducibility of this index had moderate agreement and the interobserver agreement of this index followed fair reproducibility. This study concluded that there is a significant correlation between MCI and BMD of the lumbar vertebrae as determined by the DEXA. So, visual examination of the panoramic radiographs can be used as a screening procedure for diagnosis and referral of patients for further evaluation of osteoporosis.[12]

Various studies have demonstrated the relationships between skeletal osteopenia and mandibular bone using single measurements of skeletal osteopenia and most often evaluated only the edentulous population by measuring the height of the edentulous alveolar ridge for the assessment of mandibular bone loss. The height of the edentulous alveolar ridge is one of several parameters measured in the edentulous subject. For the population suffering from osteoporosis, several skeletal regions were measured for assessing osteoporosis and several measures were completed for assessing mandibular bone. The edentulous mandible is a target bone of considerable interest for the prosthodontist; yet at most, only minimal evidence of a relationship between skeletal bone loss and mandibular resorption has been reported. Further various studies are indicated to evaluate the co-relationship between BMD of the jaws and other skeletal sites.

PREDICTING SKELETAL OSTEOPOROSIS THROUGH MANDIBULAR BMD

Horner et al reviewed a considerable amount of work performed on methods of detecting individuals with low bone mass at an early stage. Some researchers have considered if dental radiographs could have a role in the detection of individuals with osteoporosis. A basic requirement for this would be that bone mass in the jaw relates significantly to that of other skeletal sites in which osteoporosis is a significant problem. The primary aim of this research was to investigate the relationship between mandibular BMD and that of other skeletal sites commonly used for bone densitometry in the detection of osteoporosis. The secondary aim was to assess the validity of mandibular BMD as a predictor of BMD in various other skeletal sites. Forty edentulous females underwent DEXA of the lumbar spine (L2-L4), DEXA of the right femoral neck, single photon absorptiometry of the proximal and distal forearm, and DEXA of the mandible. Significant correlations were observed between BMD in the mandibular body, ramus and symphysis, and all other skeletal sites. Five patients (12.5%) had age-matched Z-scores of –1.0 or lower in all three nonmandibular sites (lumbar spine, femoral neck, and forearm). Using these patients as the proportion of the population with a positive finding of "low bone mass," the sensitivity and specificity of mandibular BMD in predicting low bone mass for these patients was determined. Where a diagnostic threshold for low mandibular BMD was set at one standard deviation below the mean, the mandibular body BMD measurement gave high sensitivity (0.8) and specificity (0.97), the symphysis BMD low sensitivity (0.4) but a high specificity (0.77), while the ramus BMD had a moderate level of sensitivity and high specificity. It is concluded that mandibular BMD assessed by DEXA correlates significantly with BMD measurements of other important skeletal sites. The higher correlation coefficients and the greater sensitivity and specificity for the body of mandible suggest that this site should be used for any potential clinical application of dental radiographs in the detection of osteoporosis.[13]

Hekmatin et al conducted a study to evaluate the prediction of lumbar spine BMD from the mandibular cortical width (MCW) in postmenopausal women. On the panoramic radiographic images, the MCW was measured by drawing a line parallel to the long axis of the mandible and another line tangential to the inferior border of mandible and a constructed line perpendicular to the tangent intersecting inferior border of mental foramen and analyzed the correlation of recorded MCW with BMD and T-score by using Statistical Package for the Social Sciences (SPSS) software and linear regression and bivariate correlation tests. Bivariate correlation showed a significant correlation between BMD and MCW. There was also a significant correlation between T-score and MCW. To detect the accurate association between the BMD and MCW and also T-score and MCW, linear regression analyses tests showed two associations to predict the BMD and T-score

from MCW with confidence interval of 95%. These associations were as follows: T-score= –7.087 + 1.497 × MCW, BMD= 0.334 + 0.163 × MCW. The MCW is a good index to help the dentists to predict the osteoporosis by panoramic radiographs and has a significant role in patient screening and early diagnosis of osteoporosis.[14]

Govindraju et al conducted a study to evaluate the influences of gender and age on the radiomorphometric indices and to assess the differences in the various indices, if any, between digital and analog radiographs. Two hundred and fifty six panoramic radiographs were obtained and they were grouped into eight age groups that were between 21 and 60 years with 5-year intervals between them, with equal sex distributions. The MCI, MI, and PMI were analyzed. C2 and C3 categories of MCI increased as age advanced in females. The MI values showed a significant difference in genders and they decreased from younger to older females. The PMI was significant for both the genders. This study showed that MCI, MI, and PMI indices were useful in identifying patients with low skeletal BMD or osteoporosis and that digital panoramic radiographs were better than analog radiographs for measuring the indices.[15]

A considerable amount of work has been performed on methods of detecting individuals with low bone mass at an early stage. Some researchers have considered if dental radiographs could have a role in the detection of individuals with osteoporosis. A basic requirement for this would be that bone mass in the jaw relates significantly to that of other skeletal sites in which osteoporosis is a significant problem. Still, researches are required in the field of osteoporosis to determine the effect of this disease for predicting skeletal osteoporosis and its effect and inter-relation to mandibular BMD.

SUMMARY

There are various systemic factors that contribute to alveolar bone loss and decreased success of use of dental prostheses. Osteoporosis should be considered as one of the major disease entity affecting today's geriatric population. The citations in the literature regarding the high numbers of osteoporotic fractures in the geriatric population, thereby, help us to illustrate the scope of this problem. The condition of osteoporosis results in bone loss and reduced BMD in the maxillae and mandible as well as in other bones of the body. Regional differences in jaw anatomy and bone structure may explain some of the variations in clinical success rate of implant therapy in the maxilla and the increased rate of residual ridge resorption reported in the mandible. Surveys have shown that implant therapy in the maxilla has a significantly higher clinical failure rate than in the mandible, and regional differences in maxillary BMD may be partly responsible. Various authors have demonstrated that bone "quality" may be an important predictor of implant osseointegration, but whether BMD or another measure of the arrangement of bone trabeculae in bone is important is unknown. In addition to the local bone density and architecture, implant failure rate reported in some studies may be due to many confounding factors, such as plaque accumulation, mechanical forces applied to implants, implant design, time to loading, and other considerations. It is highly feasible that the disease makes a strong contribution to the deterioration of the dental health in the geriatric patient. Rampant residual ridge resorption and its co-relation to general skeletal bone loss as a result of osteoporosis is a multifactorial problem and thus a topic of further research. It is part of the responsibility of the clinician to consider all factors involved in this state. The clinician would serve the patient well by working in conjunction with the patient's physician in the diagnosis and treatment of osteoporotic states.

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