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Bone Density Relationship of Mandible and Cervical Vertebrae in Panoramic Radiography

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ABSTRACT

Purpose : Upper cervical vertebrae are commonly imaged together with the jaw bones in panoramic radiography. There have been many studies investigating the possible role of mandible as an indicator of osteoporosis. But the result doesn't show unanimity. This study measured bone densities of mandible and second and third cervical vertebrae to find out any relationship between these two areas. These results may contribute in panorama being used as a screening method in detecting possible osteoporotic patient.

Materials and Methods : Randomly selected 226 digitized panoramic images with cervical vertebrae shadows from 156 dental patients between 5 to 80 years of age were used. And the bone densities of second and third cervical vertebrae, apical areas of first and second mandibular molars and interdental areas were measured. The bone density measurements were restricted to the cancellous bone and the average and standard deviations and paired t-tests were done to each measurements.

Results : All the measurements were statistically significantly related. The best relationship was found between the third cervical vertebrae and first and second mandibular apical areas. The average and standard deviations of the measured bone density ratios of these areas were 1.20 ± 0.45 and 1.34 ± 0.48 each.

Conclusion : Patients whose panoramic bone density of the third cervical vertebrae are much below those of mandibular first or second molar apical areas may have osteoporosis. ***(Korean J Oral Maxillofac Radiol 2000 ; 30 : 259-263)***

KEY WORDS : radiography, panoramic, osteoporosis, mandible

Introduction

Osteoporosis, a generalized decrease in bone mass, is a public health problem among the elderly. Although it may occur as a result of many different metabolic bone disorders, the disease dramatically accelerates after the age of menopause and in women whose ovaries have been removed.[1] After the menopause, the general skeletal bone mass rapidly decreases due to estrogen deficiency, and this process often leads to osteoporosis.[2,3] Recently Riggs et al[4] proposed a new unitary model for the pathophysiology of involutional osteoporosis that identifies estrogen deficiency as the cause of both the early, accelerated and the late, slow phases of bone loss in postmenopausal women and as a contributing cause of the continuous phase of bone loss in aging men.

The main complication of osteoporosis is fracture of a vertebra or the proximal femur. The risk of such a fracture is dependent mainly on the fragility of bone, that is, the bone mineral density (BMD). As it is very difficult to treat this fracture once it has occurred and progressed in latent osteoporotic patients, it is important to identify the precursive signs.[5-8] Many investigators have attempted to measure the BMD with the use of newly developed methods such as quantitative computed tomography,[9-11] dual photon absorptiometry,[12] and dual X-ray absorptiometry.[13-15] Significant correlations have been reported in postmenopausal women for the bone mass at different sites, such as the spine, hip and forearm, despite their different ratios of trabecular to cortical bone and different rates of bone loss.[16-18] However, there are technologic barriers that limit the measurement of BMD in the mass screening for osteoporosis.

It has been suggested that there may be a relationship between mandibular osteopenia and osteoporosis of the remaining skeleton.[19] If that is true, evaluation of dental radio-

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graphs for osseous changes might be a useful measure to screen for osteoporosis. The effect of osteoporosis on the jawbones has been studied intensively, especially with new radiologic methods.[13,20] Hildebolt[19] reviewed articles that although not all studies found associations between osteoporosis and oral bone loss, the conclusion of his review is that such an association exist.

Panoramic radiography is a means of diagnosis often used by dentists nowadays. Attempts have also been made to demonstrate changes in jawbones caused by osteoporosis on panoramic images. Klemetti et al[21] tried to determine whether it was possible to predict the general mineral density of the skeleton from changes in the bony structures on panoramic x-ray images. The diagnostic efficacies of three panoramic-based indices were compared with classification of bone mineral density by dual-energy x-ray absorptiometry. The panoramic indices were cortical bone height, an ordinal classification of inferior cortex, and the Panoramic Mandibular Index. The results indicated that panoramic radiography should not be used to assess the patient's status regarding osteoporosis, although the means of the variables in different mineral density groups of skeleton may differ significantly. For diagnosing osteoporosis risk, the sensitivity and specificity of the variables were low. But Taguchi et al[22] evaluated the usefulness of width and morphology of the inferior cortex of the mandible on panoramic radiographs in the diagnosis of postmenopausal osteoporosis and suggested that panoramic radiography could be reliable in screening for osteoporosis. In another study Taguchi et al.[23] selected four oral signs-the number of teeth present, the degree of alveolar bone resorption, and the width and the grade of mandibular inferior cortex-as indicators of the patients with thoracic spine fractures because they had been reported to have a positive correlation to general mineral status or osteoporotic condition and would be assessed on panoramic radiographs. They found that the degree of tooth loss would be a clinical indicator of jaw bone involvement in postmenopausal osteoporosis.

Postmenopausal osteoporosis is usually evaluated in the region of the lumbar and thoracic spine. Thoracic spine fractures are reported to comprise 50% to 70% of all spinal fractures.[23] And since upper cervical vertebrae are commonly imaged together with the jaw bones in panoramic radiography. This study measured bone densities of mandible and second and third cervical vertebrae to find out any relationship between these two areas. These results may contribute panorama being used as a screening method in detecting possible osteoporotic patient.

Materials and Methods

Randomly selected 226 panoramic images which included cervical vertebrae shadows from 156 dental patients between 5 to 80 years of age were used. The panoramic views were taken by PM 2002 machine (Planmeca, Finland). The images were digitized using flatbed scanner (HP Scanjet 6350C with transparency unit) at 200 d.p.i. resolution. And the bone densities of second, third, and fourth cervical vertebrae, apical areas of first and second mandibular molars and interdental areas were measured using Photoshop program. The measured apical areas were randomly selected between the roots of the first and second molars and above the mandibular canal. The apical areas with radiolucent or radiopaque lesions were excluded. For edentulous ridges, the corresponding areas were measured. The bone density measurements were restricted to the cancellous bone where the least amount of ghosting interfered the mandible and to the lower third of the body of cervical vertebrae where the transverse processes did not overshadow. With these measurements, the ratios of vertebral measurements to the ipsilateral mandibular measurements were obtained.

Results

The study population consisted of 47 males and 109 females from 5 to 80 years of age. The mean age was 37.4 years

Table 1. Age and sex distribution of study population

Age	Male	Female	Total
0-10	4	1	5
11-20	10	15	25
21-30	16	26	42
31-40	4	21	25
41-50	5	10	15
51-60	4	15	19
61-70	2	14	16
71-80	2	7	9
Total	47	109	156

Table 2. The means and standard deviations of the ratios

	M1/C3*	M2/C3**	No. of Images
Male	1.20±0.47	1.35±0.49	68
Female	1.19±0.44	1.34±0.48	158
Total	1.20±0.45	1.34±0.48	226

* the measured bone density ratio of third cervical vertebral body to the first mandibular apical area

** the measured bone density ratio of third cervical vertebral body to the second mandibular apical area

Table 3. Distribution of ratios at each standard deviation intervals

SD	$<\pm1$	$<\pm2$	$<+3$	$<+4$	$<+5$	$<+6$	$<+7$	Total
M1/C3*	184 (81.4%)	31 (13.7%)	8 (3.5%)	2 (0.9%)	1 (0.4%)			226 (100%)
M2/C3**	192 (85.0%)	19 (8.4%)	12 (5.3%)	1 (0.4%)	1 (0.4%)		1 (0.4%)	226 (100%)

SD; standard deviations
* the measured bone density ratio of third cervical vertebral body to the first mandibular apical area
** the measured bone density ratio of third cervical vertebral body to the second mandibular apical area

(32.1 years for males and 39.7 years for females). Age and sex distributions are presented in Table 1.

Among the second, third and fourth cervical vertebrae, only the third cervical vertebrae were most clearly imaged with least overlapping providing best measuring environment. So the measured bone density of the third cervical vertebral body was used as a reference to the mandibular measurements. The average and standard deviation (SD) of the measured bone density ratios of third cervical vertebral body to the first mandibular apical area was 1.20 ± 0.45 (varied from 0.42 to 3.87, that is, within-2 SD to +6 SD ranges from the average). And the average and standard deviation of the measured bone density ratios of third cervical vertebral body to the second mandibular apical area was 1.34 ± 0.48 (varied from 0.62 to 4.25, that is, within-2 SD from +7 SD ranges from the average). The male averages and standard deviations of these were 1.20 ± 0.47 and 1.35 ± 0.49 each, those of the females were 1.19 ± 0.44 and 1.34 ± 0.48 each. One hundred eithty four (81.4%) of the first molar ratios were within the 1 SD range, 31 (13.7%) were between the 1 SD and 2 SD range and 11 (4.9%) were outside these ranges. One hundred ninety two (85.0%) of the second molar ratios were within the 1 SD range, 19 (8.4%) were between the 1 SD and 2 SD range and 15 (6.96) were outside of these ranges (Table 2, 3)

Discussion

Many oral signs, such as the number of teeth present, alveolar bone resorption, periodontal condition, the mandibular bone mineral density measured on oral radiographs, the cortical thickness of the mandible on panoramic radiographs, the width of lamina dura, and the morphology of the mandibular inferior cortex, have been evaluated to distinguish between normal and osteoporotic populations.[23-27]

Hildebolt[19] thoroughly reviewed the literature concerning the possible association between osteoporosis and oral bone loss with emphasis on radiologic studies and said that although not all studies found associations between osteoporosis and oral bone loss, the conclusion of his review is that such an association exists. Those reviews 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 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, with the loss in bone mineral content estimated to be 1.5% per year in females and 0.9% in males.

Since these studies[19] also demonstrated a considerable amount of variation in the amounts of cortical and trabecular bone within and among individuals it is wise to get as much information as possible from dental radiographs of each patients. The upper cervical vertebrae are commonly imaged together with the jaw bones in panoramic radiography. Because the skeletal site most affected by osteoporosis is spine we might get some additional information of patient's spinal status from these cervical vertebral images on panoramas even though Taguchi et al[23] reported that the cortical thickness of the mandible measured on panoramic radiographs did not indicate the thoracic spine fracture status in osteoporotic women.

Inherent variables of the panoramic images included the ghosting of the spine and contralateral mandibular angles, superimposed air spaces, and variability and thickness of superimposed soft tissue. Mohammad[28] said the general area identified as the least variable was the mandibular premolar area in his study and the tooth-root apex of the first premolar (or canine) was used as a standard for all measurements.

But it was found in this study that the ghosting of the cervical vertebrae covered most of the premolar areas which was more conspicuous when the panoramic images were digitized. Even the mental foramen which is used as an important landmark in many studies especially in edentulous jaws were also involved in spinal ghost zones. So the apical areas of the first and second molars were used as measurement areas where the ghosting of the contralateral mandibular angle ended and before the overlapping of the hyoid bones began in

case they overlapped the inferior part of the mandible. These areas seemed to provide the least amount of interference. At first the bone densities of second, third and fourth cervical vertebrae were tried to be measured but not all the panoramic images provided the optimal condition of these areas except for the third vertebra. So only the measured bone density of the third cervical vertebral body could be used as a reference to the mandibular measurements. These ratios varied from 0.42 to 3.87 for the first molar and 0.62 to 4.25 for the second molar but most of the study population fell within the range of 1 SD making the average ratios 1.20 and 1.34 each.

Bassi et al[29] correlated mandibular bone density, vertebral density and resorption of the edentulous ridge in a group of 17 partially edentulous subjects. Bone density was quantified by Quantitative Computerized Tomography (QCT); resorption was evaluated on panoramic radiographs. Mean bone density in dentate areas was significantly higher than that in edentulous areas; mandibular bone density was not found to relate significantly to vertebral bone density, nor to ridge resorption. Mandibular bone density here was of trabecular but not including the cortical margins. In their study, considerable variation was found among bone density values obtained at different ROIs in the edentulous regions of the 17 patients and also among those measured in the dentate zones. This may be because the location of the trabeculae within the mandibular bone varies, in turn probably depending on the varying distribution of the masticatory load in the different zones of the mandible. From their tables presented the ratios of vertebral bone density to the edentulous mandibular density could be gained and these varied from 0.70 to 4.77 with mean 2.71, and 1.62 to 6.55 with mean 3.68 to dentate.

These ratios cannot directly compared to those of this study because they measured the lumbar vertebrae but the range of ratios were somewhat similar. The average of this study is lower than Bassi et al's[29] which means that in this study the density of the vertebra is higher. The possible reason for this may be that the cervical vertebral body images on panorama are whole lateral view with soft tissues of neck superimposed while QCT provides qualitative evaluation of trabecular portion of vertebral body. Anyway the relative bone density ratios between the mandible and cervical vertebra could be some additional information of the spinal status of patient. In this study more than 80 % of the study population were within the 1 SD ratio range but a few of them were even within +6 to +7 ranges. The positively increased ratio means that the cervical vertebral bone densities are much lower than those of the mandibles.

WHO[30] defines osteoporosis as bone mass decrease reaches more than 2.5 SD than average and osteopenia as that falls between 1-2.5 SD. This study includes dental patients without any symptoms of osteoporosis and that the mean age is only 37.4 years which may not reflect risk group, but the patients with too high ratios may have osteoporosis and need further evaluation.

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