Assessment of mandibular radiomorphometric indices as predictors of osteoporosis in postmenopausal women (Cephalometric reconstructed computed tomographical study)

Alaa S. Mahdi, B.D.S. [1]
Lamia Al-Nakib, B.D.S., M.Sc. [2]

ABSTRACT

Background: Osteoporosis affects almost all of the bones in the female body; the most important one in the facial bone is mandible. Menopause is defined as an absence of the menses for one year. During this time, estrongen, progesterone and ovarian androgens production are diminished due to adult onset ovarian failure which leads to osteoporosis. This study aimed to evaluate the use of computed tomography mandibular morphometric indices for the assessment of pre and postmenopausal osteoporotic women.

Subjects and material: This study conducted on 50 Iraqi females divided into 2 groups 20 -30years old as a control group and over50 years old as a study group attending Al-Karkh hospital, Department of Computed Tomography.(each group25 female). Information from each female was recorded and mentioned on a case sheet specially prepared. Data collected, when analysed, using SPSS version 13 program loaded on a computer machine.

Results: All the measurements in this study(gonial angle in degree, antigonial angle in degree and depth in millimetre, mandibular and mental thickness in millimetre, bone mineral density in HU and mandibular cortex index),there were no statically significant differences between right and left side P-value <0.001. Gonial angle had statistically positive linear correlation with age in the study group P-value <0.001. Bone mineral density and mandibular and mental thickness had statically negative linear correlation with age. Antigonial angle increased as age increased till reach 180 degree in some cases and the depth decreased correlated to the age till reach zero mm in some cases P-value <0.001. Mandibular cortex index increased in bone irregularity related to increase in age.

Conclusion: It was concluded that osteoporosis and osteoporosis risk in postmenopausal females could be detected by using CT scan through measuring certain mandibular radiomorphometric indices. (J Bagh Coll Dentistry 2014; 26(2): 50-57).

الخلاصة

تنخر العظام يؤثر على كل عظام الانثى ما بعد انقطاع الطمث, من ضمن العظام عظام الوجه والفكين خاصة عظمة الفك الاسفل .

يتأثر هذا العظم وضمن متغيرات تشمل اضمحلال العظم , ترقرق الطبقة السفلى للذقنيهوالخديه , عدم انتظام الصفيحات العظميه التي تؤدي الى خشونة العظم وعدم انتظامه في الاشعه, تغير زاوية عظمة الفك الاسفل وزيادة درجتها, زيادة زاوية اسفل الذقن لتصل الى 180 درجه تقريبا ومسافة اسفل الذقن تتغير تباعا .

تمت هذه الدراسه على 50 امرأه عراقيه وقسمت الى قسمين (20_30) سنه والنموذج القياسي فوق ال 50 سنه النموذج البحثي.

قصدوا مستشفى الكرخ التعليمي قسم الاشعهوالمفراس الحلزوني اخذت المعلومات الطبيه والسريريه من المريضه وسجلت في ورقة تشخيص خاصه خصصت لكل مريض.

جمعت النتائج وحللت احصائيا برسوم بيانيه باستعمال برنامج (SPSS)النسخه13

اوضحت النتائج لكل المتغيرات التي جمعت (زاوية الفك الاسفل, الزاوية الخديه , العمق الخدي ,سمك العظم في المنطقة الذقنيه والخديه, وكثافة العظم والمقياس السمكي الخدي) بانه لايوجد اختلاف بين الجهتين (اليمنى واليسرى) لكل مريض لزاوية الفك الاسفل تغير بصورة طرديه وعلاقة موجبه مع العمرلكل مريض.

كثافة العظم والسمك الخدي الذقني يتغير بصوره عكسيه وسالبه مع زيادة العمر.

الزاويه الخديه تتغير بزيادة العمر لتصل تقريبا 180 درجه في بعض الحالات اما العمق فيصل مستوى الصفر في بعض الحالات التي يصل فيها الزاويه الخديه ل 180 درجه.

المقياس السمكي الخدي يزداد عدم انتظامه (للعظم) بزيادة العمر الصنف الثاني والصنف الثالث.

اخيرا نتوصل بان هشاشة العظام وخطر الاصابه بها عند الاناث ما بعد انقطاع الطمث يزداد بزيادة العمر ويمكن ان يشخص عن طريق مقايس معينة في الفك الاسفل بسهوله باستعمال المفراس الحلزوني.

INTRODUCTION

Osteoporosis affects all bones, including those of the facial skeleton. To date the facial bones have not drawn much attention due to the minimal probability of morbid fractures [1].

There is scientific evidence that the decrease in bone mass due to osteoporosis also affect the mandible. Because of high costs and limited availability of DXA equipment it is worthwhile to look for alternative diagnostic techniques for osteoporosis [2,3].

Not everyone will get osteopenia or osteoporosis. However there are certain risk factors that can increase the likelihood that a person will have moderate to severe loss of bone mass, including the following [1, 2]:

- **Gender:** Women are a higher risk because they have less bone mass than men. Women also often experience a loss of bone mass after menopause.
- **Race:** Asian and Caucasian women, especially those who are small-boned, are at highest risk.
- **Family history:** Patients with a family history of low bone mass have a 50%-85% increased risk of developing osteoporosis.

(1) M.Sc. Student, Department of Oral Diagnosis, College of Dentistry, University of Baghdad.
(2) Assistant Professor, Department of Oral Diagnosis, College of Dentistry, University of Baghdad.

- **Age:** Most people (men and women) lose about .5% of bone mass every year after the age of 50.
- **Lifestyle choices:** A poor diet with a lack of calcium and vitamin D, smoking, excessive use of alcohol or caffeine, and lack of exercise contribute to a loss of bone mass.
- **Other medical conditions:** Hyperthyroidism, hyperparathyroidism, and Cushing's syndrome, can contribute to bone loss. Certain medications (such as prednisone or phenytoin) are known to cause bone loss as well [1].

Considering that odontological patients are frequently referred for being submitted to panoramic radiography a widely available, low-cost method capable of demonstrating aging-related morphological alterations of the mandible, several indices, techniques for analysis and images processing have been researched in order to evaluate the applicability of this type of radiography for detecting bone mass loss. However, the results of these studies have been contradictory [4-6]

In 2010 Huumonen, et al [5] found that the indices evaluated were reproducible; panoramic mandibular and mental indices presented the highest sensitivity in the detection of osteopenia/osteoporosis, however the panoramic mandibular index specificity was low. Although all the indices evaluated could identify low bone density, only the panoramic mandibular and mental indices could differentiate patients affected by osteopenia/osteoporosis.

In the present study, normal reference measurements were used as the standard for the assessment of possible means of early detection of osteoporosis by radiographic examination, which is simple, and affordable by

PATIENTS AND METHODS

The sample included fifty (50) Iraqi female patients attending AL-Karkh Hospital Department of CT for different purposes from 6 Dec. 2012 till 1 Jul. 2013.

The sample divided into two groups according to their age as following:

1st group: 25 subject with 20-30y as control group
2nd group: 25 subject with more than 50 ys as study group

Exclusion criteria

1-Metabolic bone disease
2-Cancer with bone metastasis
3-Diabetes
4-Major renal impairment

5-Medication that affected bone metabolism other than estrogen
6-smoker

Mandibular cortical thickness

From CT viewer icons get sagittal view and scrolling the mouse to get the point that intersection of inferior border of mandible with line pass through the anterior border of the mandible. The thickness of the mandibular cortex was measured on the line perpendicular to the inferior border of the mandibular cortex at the intersection with the tangent line. The measurement was done for both sides.

Mental Cortex Thickness

From the icons CT viewer sagittal view could be obtained the reading taken in slices passing through mental foramen The thickness of the cortex at mental area will be measured on the line perpendicular to the parallel lines drown in upper and lower borders of inferior border of the mandible at the middle of the mental foramen (full cortex thickness)

Scrolling the mouse to get opposite side and same technique was repeated to measure the mental cortex thickness of other side.

Figure 1: Mental cortical thickness

Gonial angle

From sagittal view this angle readied by drown two lines the 1st with the inferior border of the mandible the 2nd from the outer border of the ramus.

Figure 2: Gonial angle

Antigonial depth and angle
From sagittal view :
a. Two lines parallel to the antigonial region that interseted at the deepest point of the antigonial notch.
b. Antigonial depth was measured as the distance along perpendicular line from the deepest point of the notch concavity to a tangent through the inferior border of the mandible.

Bone minerial density value
BMD were recorded in the mental and gonial areas at full thickness of the cortical bone in Hounsfield unit

Figure 3: Bone density in mental area in HU

Mandibular cortex index
Klemettis classification for osteoporosis:
Class I: Smooth & even endosteal margin in inferior cortex on one or both sides
Class II: Semilunar defect on one or both sides

Class III: Heavy resorptive or porosity sign on one or both sides
This result obtained by change the windowing contrast from modified to bony shadow to see any defect in cortical bone that may appear in one or both sides.

RESULTS
Assessment of menopausal effect
The mean of gonial angle was significantly higher among post-menopausal cases (121.9) degree comparing with control (114.4) degree in (Table.1)
Menopausal on average increases gonial angle by mean of 7.5 degree than antigonial angle that was 3 degrees which indicated for moderate strong effect more than antigonial angle about twice time in revealing the menopausal effect (Cohen's d=0.55). The result was obviously but the differences failed to reach the level of statistically significance.

Mandibular cortex index (MCI)
The median MCI was significantly higher percentage among post-menopausal cases (class II) was 44%compare to control sample as shown in (table 2)

The linear correlation between outcome measurements among cases only
According to the table 3, one can determine the relation between the variables strong weak or moderate
0-0.2 =very weak
0.21-0.4=weak
0.41-0.7=moderate strong
0.71-0.9=strong
0.91-1=very strong

The bone mineral density in gonial area had statistically significant strong positive (direct) linear correlation with bone density in mental area. r=728 (p<0.001)
From table (3) mandibular and mental cortex thickness had moderate strong positive linear correlation r=0.6 p<0.001
Gonial and antigonial angle had statistically non significant very weak correlation r=0.269 p=0.06NS
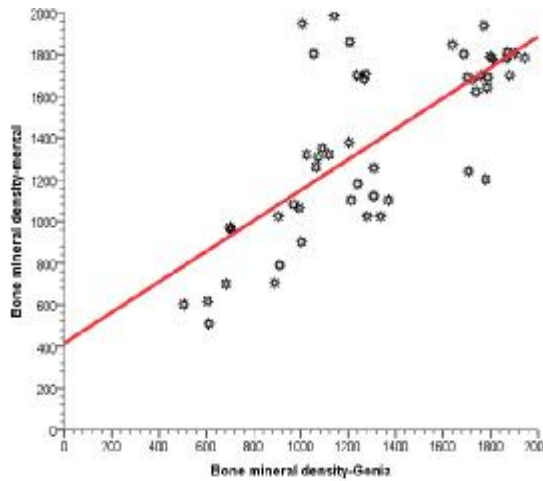
Figure 4: Relation between bone mineral density-gonia and mental area

Association between MCI and other variable among cases

The mean gonial angle was Lowest in class I MCI (117 degree) increasing to 122.1 degree in class II MCI cases to reach its highest mean 126.5 degree among class III MCI cases. (Table 4)

R=0.516 p<0.001 the difference among mean in goinal angle were statistically significant and moderate strong positive linear correlation between GA and MCI.

From table5 the relation between MCI and bone mineral density in both mental and gonial area the mean decreased with class increased (1729.1 to 1426.2 to 947.1) that were mental area while in gonial (1511.1 to 1421.6 to 930.4) so there was moderate strong correlation between bone density and MCI

Effect of age on outcome measurement among cases

After classifying the study group into three groups with ten class interval 50-59and 60-69 and 70-73.

Gonial angle and antigonial angle and depth:

The mean of gonial angle increase with ages increased 117.2 to 124.7 to 131.5

There was strong correlation between gonial angle and increasing age, gonial angle had a statistically significant strong linear correlation with age p<0.001 as shown in (table 6).

Mental and mandibular thickness

The mean of mental thickness was decreased with age increased from 3.7mm in 1st age class to 3.1mm in the second class, to 2.1mm in 3rd age class and strong correlation r=0.71 p<0.001 as shown in (table 7).

The mandibular thickness also decreased with aged class from2.4mm to 2.1mm to 1.6mm the mandibular thickness had weak correlation with age r=0.43 p<0.001.

So the mental thickness had stronger correlation with age than mandibular thickness depending on r value.

Mandibular cortex index:

The median in 1stclass (50-59y) was class I. In the 2nd class (60-69y) was class II, while in the 3rd class (70-73y) was class III. That indication for increasing bone change with age and strong correlation r=0.672 p<0.001in (table 8)

Table1: Difference between cases and control group for gonial angle and antigonial angle size and depth

Variables	Controls (young adult females)	Cases (post-menopausal age female)	P	Mean difference	Cohen's d
Gonial angle			0.007	7.5	0.55
Range	(112 - 140)	(110 - 136)			
Mean	114.4	121.9			
SD	17.89	7.23			
SE	2.53	1.02			
N	50	50			
Anti-gonial angle size			0.09[NS]	3.0	0.34
Range	(153 - 180)	(152 - 180)			
Mean	169.9	172.9			
SD	9.92	7.51			
SE	1.4	1.06			
N	50	50			
Anti-gonial depth			0.26[NS]	-0.1	-0.22
Range	(0 - 1.2)	(0 - 1.2)			
Mean	0.6	0.5			
SD	0.46	0.43			
SE	0.07	0.06			
N	50	50			

Table 2: Mandibular cortex index (MCI) in control group and cases

Mandibular cortical index	Controls (young adult females)		Cases (post-menopausal age female)	
	N	%	N	%
Class-1	50	100.0	14	28.0
Class-2	0	0.0	22	44.0
Class-3	0	0.0	14	28.0
Total	**50**	**100.0**	**50**	**100.0**

P (Mann-Whitney) < 0.001

Table 3: Relation between variables in cases (postmenopausal) only.

	Gonial angle	Anti-gonial angle	Anti-gonial depth	Bone mineral density-mental	Bone mineral density-Gonia	Mental cortical thickness
Anti-gonial angle	r=0.269 P=0.06[NS]					
Anti-gonial depth	r=-0.164 P=0.26[NS]	r=-0.872 P<0.001				
Bone mineral density-mental	r=-0.642 P<0.001	r=-0.303 P=0.033	r=0.165 P=0.25[NS]			
Bone mineral density-Gonia	r=-0.537 P<0.001	r=-0.287 P=0.043	r=0.308 P=0.03	r=0.728 P<0.001		
Mental cortical thickness	r=-0.519 P<0.001	r=-0.039 P=0.79[NS]	r=-0.058 P=0.69[NS]	r=0.692 P<0.001	r=0.486 P<0.001	
Mandibular cortical thickness	r=-0.368 P=0.008	r=-0.403 P=0.004	r=0.403 P=0.004	r=0.523 P<0.001	r=0.476 P<0.001	r=0.626 P<0.001

Table 4: Relation of MCI in postmenopausal to gonial angle and antigonial angle and depth.

Variables	Mandibular cortical index			P
	Class I	Class II	Class III	
Gonial angle				0.001
Range	(110 - 126)	(110 - 130)	(114 - 136)	
Mean	117	122.1	126.5	
SD	4.84	7.33	6.2	
SE	1.29	1.56	1.66	
N	14	22	14	
r=0.516 P<0.001				
Anti-gonial angle				0.01
Range	(160 - 180)	(152 - 180)	(163 - 180)	
Mean	174.7	169.5	176.5	
SD	7.96	7.2	5.26	
SE	2.13	1.54	1.41	
N	14	22	14	
r=0.043 P=0.77[NS]				
Anti-gonial depth				0.014
Range	(0 - 1.2)	(0 - 1.2)	(0 - 0.8)	
Mean	0.3	0.7	0.4	
SD	0.52	0.35	0.35	
SE	0.14	0.07	0.09	
N	14	22	14	
r=0.018 P=0.9[NS]				

Table 5: Relation between MCI and bone mineral density in postmenopausal females in mental and gonial area cases (post-menopausal age female)

Variables	Mandibular cortical index			
	Class-1	Class-2	Class-3	P
Bone mineral density-mental				<0.001
Range	(1320 - 1986)	(1024 - 1860)	(509 - 1699)	
Mean	1729.1	1426.2	947.1	
SD	224.91	289.7	356.36	
SE	60.11	61.76	95.24	
N	14	22	14	
r=-0.758 P<0.001				
Bone mineral density-Gonial area				<0.001
Range	(1005 - 1946)	(1054 - 1880)	(505 - 1786)	
Mean	1511.1	1421.6	930.4	
SD	363.23	288.35	390.91	
SE	97.08	61.48	104.47	
N	14	22	14	
r=-0.544 P<0.001				

Table 6: Relation of age with gonial angle, antigonial angle and depth.

Variables	Age (years)			
	50-59	60-69	70-73	P
Gonial angle-Right				<0.001
Range	(110 - 127)	(110 - 130)	(128 - 136)	
Mean	117.2	124.7	131.5	
SD	5.42	5.65	2.66	
SE	1.11	1.26	1.09	
N	24	20	6	
r=0.747 P<0.001				
Anti-gonial angle				0.03
Range	(160 - 180)	(152 - 180)	(176 - 180)	
Mean	173.8	170.1	178.7	
SD	7.36	7.67	1.63	
SE	1.5	1.72	0.67	
N	24	20	6	
r=0.035 P=0.81[NS]				
Anti-gonial depth				0.017
Range	(0 - 1.2)	(0 - 1.2)	(0 - 0.6)	
Mean	0.4	0.7	0.3	
SD	0.49	0.31	0.29	
SE	0.1	0.07	0.12	
N	24	20	6	
r=0.105 P=0.47[NS]				

Table 7: Relation between age and mandibular and mental thickness in postmenopausal female

Variables	Age (years)			
	50-59	60-69	70-73	P
Mental cortical thickness (mm)				<0.001
Range	(3 - 4.3)	(2 - 3.9)	(1.9 - 2.2)	
Mean	3.7	3.1	2.1	
SD	0.36	0.51	0.1	
SE	0.07	0.11	0.04	
N	24	20	6	
r=-0.71 P<0.001				
Mandibular cortical thickness (mm)				<0.001
Range	(1.8 - 3.5)	(1.8 - 2.6)	(1.5 - 1.9)	
Mean	2.4	2.1	1.6	
SD	0.46	0.22	0.16	
SE	0.09	0.05	0.07	
N	24	20	6	
r=-0.435 P=0.002				

Table 8: Relation between age and MCI in post menaposaul female

Variables	Age (years)					
	50-59		60-69		70-73	
Mandibular cortical index	N	%	N	%	N	%
Class I	14	58.3	0	0.0	0	0.0
Class II	8	33.3	14	70.0	0	0.0
Class III	2	8.3	6	30.0	6	100.0
Total	24	100.0	20	100.0	6	100.0

P (Kruskal-Wallis) <0.001, r=0.672 P<0.001.

DISCUSSION

In this study the mandibular and mental cortex thickness was significantly lower among postmenopause when compared to premenopause study group and there was a statically highly significant inverse relation between menopausal and the mandibular and mental thickness with (P value <0.001) and this result indicate that the elderly age groups (postmenopausal has significantly lower thicknesses when compared to the younger age group(premenopausal)which emphasized the fact that it was an age related phenomena this finding is in agreement that found by others [12,13]. As the human increased in age this angle will increased so the notch disappeared till reached near 180 degree due to many factors depended either male or female [14].

In post menapousal female in this study this angle will reached large divergent level of angle to reached 180 degree that mean no notch or angle that agree with Shahabi et al. [15].

Morphology of the mandible changes with age consequence of tooth loss which can be expressed as widening of the gonial angle shorting of the ramus and condylar height [16].

Taguchi et al [17] found that multiple linear regression showed that the BMD was significantly decreased with age [16,17] which is similar to the present study.

The association between the mandibular cortical thickness and bone mineral density was statistically significant even after adjustment for hormonal treatment, smoking, age at menopause, and body mass index ($P = 0.04$).

In 2001, Shepherd [16] stated that bone loss is a closely age related phenomenon. Radio morphological change in the mandible either in cortical or trabecular bone is inversely correlation with age that agrees with our study and the result [18].

Von Wowern [19] stated that human bones decrease in density and increase in porosity beginning at about decade of life after the age of 40, the BMD of the skeleton decreases, so that by the age of 65, about one third of the bone minerals has been lost. Decreased physical activity, lower secretion of estrogen, diet, race, and heredity may all play a role in age-related bone loss.

REFERENCES

1. Ardakani FE, Naifar N. evaluation of changes in the mandibular angular cortex using panoramic imaging. J Contemp Dent Pract 2004; 5(3): 1-15.
2. Abhyankar S. Long-term effect of cigarette smoking smoking in women. Am J Obstetrics and Gynecology 2010; 162: 502-14.
3. Dutra V, Devlin H, Susin C, Yang J, Horner K, Fernandes AR. Mandibular morphological changes in low bone mass edentulous females: evaluation of

panoramic radiographs. Oral Med Oral Pathol Oral Radiol Endod 2011; 102(5): 663-8

4. Genant HK, Jergas M, Palermo L, et al. Comparison of semiquantitave visual and quantitive morphometric assessment of prevalent and incident vertebral fractures in osteoporosis. J Bone Miner Res 1998; 11: 984-96.

5. Huumonen S, Sipila K, Haikola B, Tapio M, Soderholm AL, Remes-Lyly T, Oikarinen K, Raustia A.M :Influence of Edentulousness on Gonial angle, Ramus and Condylar Height. J Oral Rehabil 2010; 37: 34-8.

6. Klemetti E, Vainio P, Lassila V et al. Cortical bone mineral density in the mandible and osteoporosis status in postmenopausal women. Scand J Dent Res 2009; 101(4): 219-23.

7. Thrasivoulos K, Tzello G. The facial skeleton in patient with osteoporosis; field of sign and treatment complications. J Osteoporosis 2011; Article ID 147689.

8. Miliiuniene E, Alekna V, Peciuliene V, Tamulaitiene M, Maneliene R. Relationship between mandibular cortical bone height and bone mineral density of lumbar spine. Stomatologija, Baltic Dental and Maxillofacial J 2008; 10: 72-5.

9. National Institutes of Health: Osteoporosis Prevention, Diagnosis and Therapy: NIH Consensus Statement. Online 2000 March 27-29.

10. Oda H, Matsuzaki EL, Tokuhashi Y, Wakabayashi K, Uematsu, Iwahashi M. Degeneration of intervertebral discs due to smoking: experimental assessment in a rat-smoking model. J Orthopedic Sci 2004; 9: 135-41.

11. Polat P, Ceylan G, Suma S, Yanikogln N. The effect of tooth extraction on cortical thickness and bone mineral density of the mandible: evaluation with computerized tomography. Turk J Med Sci 2001; 31: 271-4.

12. Reddy S, Karthikeyan R, Sherlin HJ. Oral signs and salivary parameters as indicators of possible osteoporosis and osteopenia in postmenopausal women. a study of 45 subjects. Braz J Oral Sci 2008; 7(24):1502-6.

13. Richard DJ, Subramaniam M, Spelsberg TC. Molecular and cellular mechanisms of estrogen action on the skeleton. J Cell Biochem 1999; Suppl 32-33: 123-32.

14. Santini A, Land M. A comparison of the position of the mental foramen in chinese and British mandibles. J Acta Anat 1990; 137(3): 208-12.

15. Shahabi M, Ramazanzadeh BA, Mokhber N. Comparison between the external gonial angle in panoramic radiograph and lateral cephalograms of adult patients with class I malocclusion. J Oral Sci 2009; 51:425-9.

16. Shepherd JE. Effects of estrogen on cognition, Mood and Degenerative Brain Diseases, J Am Pharm Asso Mar-Apr2001; 41(2): 221-8.

17. Taguchi A, Sanada M, Krall E, et al. Relationship between dental panoramic radiograph finings and biochemical markers of bone turnover. J Bone Miner RES 2003; 18: 1689-94.

18. Uthman AT. Radiomorphometric indices of the mandible in 40-60 years old adults. Iraqi Dental J 2003; 33: 258-71.

19. Von Wowern N. Microradiographic and histomorphometric indices of mandibles for diagnosis of osteopenia. Scand J Dent Res 1982; 90(1): 47-63.