The Utility of CBCT in Assessment of Mandibular Bone Cortex in Osteoporotic and Non- Osteoporotic Females

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استخدام الاشعة المقطعية ذات الشعاع المخروطي لتقييم سمك الحافة السفلية لعظم الفك للنساء المصابات وغير المصابات بمرض هشاشة العظام

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Abstract

Background: Bone is a living tissue, it consistently undergoes modeling and remodeling to withstand growth and functional demands. Differences in female Hormones influence bone quality and quantity particularly through post menopause leading to susceptibility to osteoporosis. This is a study of the effect of osteoporosis on mandibular cortical width in post-menopausal females to distinguish it from aging effect by using Cone Beam Computed Tomography (CBCT).

Aims: to distinguish the effect of osteoporosis from the effect of aging on mandibular cortical bone by using Cone Beam Computed Tomography (CBCT).

Material and method: group sample composed of 60 Iraqi females sectioned into 3 groups based upon their age and osteoporosity status that was estimated by Dual Energy X-ray Absorbometry (DEXA) scan , Group A (20-30 years, non-osteoporosis), Group B (50years and above, non-osteoporosis), and Group C (50years and above with osteoporosis), each patient had a cone beam computed tomography scan, then mandibular cortical width at mental foramen area was studied among groups. Also Receiver Operating Characteristic (ROC) curve was used to check Mandibular Cortical Width diagnostic reliability.

Result: Mandibular Cortical Width showed non-significant difference between Group1 and Group2, while it showed a high significant difference between Group2 and Group3. Also ROC curve analysis showed very good diagnostic reliability.

Conclusion: Mandibular Cortical Width was not affected by ageing factor, whereas it showed a significant decrease due to osteoporosis effect.

Keywords: Osteoporosis, Age, Mandibular Cortical Width, CBCT, ROC curve.

المستخلص

الخلفية: ان العظم نسيج حي، يخضع باستمرار للتجديد وإعادة البناء لتحمل النمو والمتطلبات الوظيفية. تؤثر الاختلافات في الهرمونات الأنثوية على جودة وكمية العظام خاصة خلال فترة ما بعد انقطاع الطمث مما يؤدي إلى احتمالية الإصابة بمرض هشاشة العظام. هذه دراسة لتأثير هشاشة العظام على عرض قشرة الفك السفلي عند الإناث بعد سن اليأس لتمييزه عن تأثير الشيخوخة باستخدام الأشعة المقطعية ذات الشعاع المخروطي (CBCT).

الهدف: التمييز بين تأثير مرض هشاشة العظام عن تأثير الشيخوخة على عظم الفك السفلي باستخدام الاشعة المقطعية ذات الشعاعي المخروطي (CBCT). مما يمكن من الكشف المبكر عن مرض هشاشة العظام

طريقة البحث والمواد المستخدمة: تم تقسيم عينة مكونة من 60 أنثى عراقية مقسمة إلى 3 مجموعات بناءً على العمر وقياس كثافة العظم التي تم تقديرها بواسطة مسح امتصاص الأشعة السينية ثنائي الطاقة (DEXA)، المجموعة أ (20-30 سنة، غير مصابة بهشاشة العظام)، المجموعة ب (50 سنة وما فوق، غير مصابة بهشاشة العظام)، والمجموعة ج (50 سنة وما فوق مصابات بهشاشة العظام) .

تم اخذ اشعة (CBCT) لكل مريضة، ثم تمت دراسة مؤشر عرض الفك السفلي في منطقة الثقبة العقلية بين المجموعات.

النتيجة: باستخدام منحنى خصائص تشغيل جهاز الاستقبال (ROC) للتحقق من موثوقية تشخيص عرض الفك السفلي القشري لوحظ انها تعطي قابلية تشخيصية جيدة جدا لمرض هشاشة العظام حيث ظهر فرقًا غير معنوي بين المجموعة 1 والمجموعة 2، بينما أظهر فرقًا معنويًا مرتفعًا بين المجموعة 2 والمجموعة 3.

الاستنتاج: لم يتأثر العرض القشري للفك السفلي بعامل الشيخوخة ، بينما أظهر انخفاضًا معنويًا بسبب تأثير هشاشة العظام. لذا يمكن الاستفادة من جهاز الأشعة المقطعية ذات الشعاع المخروطي من الكشف المبكر عن مرض هشاشة العظام

الكلمات المفتاحية: هشاشة العظام، العمر، سمك الحافة السفلية لعظم الفك، الأشعة المقطعية ذات الشعاع المخروطي، منحنى ROC.

Introduction

Osteoporosis is a widespread health issue. It is distinctive for decreased bone mineral density and increased fracture liability.(*White, 2002*) Fracture may occur at any bone especially femoral, vertebrae and distal forearm. (*Chami et al., 2006*) It affects females more with percentage of 1:2 whereas percentage in men is1:5 after 50 years old.(*Patel et al., 2015*)

Dual-energy X-ray absorptiometry (DEXA) is the best modality used in bone evaluation ,,gold standard" to determine bone mineral density loss.(*Popescu et al., 2011*) "The silent thief" is often how osteoporosis is described because it progress with no symptoms that can be felt by the patient.(*Al-Sowayan, 2014*) Also early detection is important to decrease fracture rates and enhance the life quality for patients and health care system.(*Papamanthos et al., 2014*)

On the other hand since the appearance of Cone beam computed tomography (CBCT) in dentistry in 1998, it is commonly used. It produces 2- and 3-dimensional images of the interpreted location with cheaper expenses and less radiation comparison with multi-detector computed tomography (MDCT).(*Barngkgei et al., 2015*) This imaging modality also facilitate evaluation of linear values of bony and dental structures to be fulfilled correctly and reliably . (*LAÇIN et al., 2018*)(*LAÇIN, 2018*)(*FOKAS et al., 2018*)

The jawbone is composed of spongy trabecular inner bone surrounded by compact bone of high density externally.(*BKO et al., 2020*) Many previous researches had studied MCW and the relation of BMD deterioration and aging process with MCW, but most of these researches used OPG, CT, or even intra oral radiographs.

The jawbone cortex is different from other body parts (e.g., cortical femur and tibia) it is thinner. This is the reason why resolution low computed tomography (CT), could under estimate its thickness due to the partial volume effect. On the other hand, cone beam CT (dental CBCT) has a less dose of radiation and better resolution, these features enable more precise measurement of jawbone cortical thickness and this makes it favorable for most dental practioners. (*Wang et al., 2021*) Osteoporosis related to aging primarily reduces the density of trabecular bone, and not many researchers investigated the relationship of cortical bone thickness to osteoporosis especially that of the jawbone. (*Wang et al., 2020*) Few to our knowledge have studied osteoporosis using CBCT but none had studied MCW in osteoporotic patients using CBCT.

Aim of the study: This study is done to estimate the efficacy of CBCT to diagnose osteoporosis, or at least to predict those patients earlier and refer them to a specialist to improve prognosis and prevent future fractures.

Materials and Methods

A sample of 60 individuals was selected depending upon female patients attending **AL-Sadir Specialized Dental Center** for CBCT evaluation, they were all volunteers, at the same day Each patient was asked to perform a DEXA scan for bone mineral density evaluation at **AL-Wasity Medical Hospital** at the DEXA unit, based upon age and bone mineral density the sample was categorized into three groups: Group A: 20 non-osteoporotic females with(20-30) years old as control group, Group B: 20 non osteoporotic postmenopausal females with 50 years old and above, and Group C: 20 postmenopausal osteoporotic females with 50 years old and above.

All patients were signed on an informed consent form after their agreement to participate in this study, the aim of the study and methodology was explained in details for each patient they were also informed that they were free to withdraw at any time they want during the study in accordance with the *Declaration of Helsinki 1964*, and its later amendments.

Exclusion criteria included originally diagnosed patients with any other metabolic bone disease, diabetics, people who smoke and alcoholics, pregnancy, cancers with bone metastasis or renal disease, patients taking any medication that affects bone metabolism, and patients suffering from an acute traumatic injury to the mandible.

The T-score in the lumber spine was measured by Dual Energy X-ray absorptiometry (DEXA) scanner (Stratos) machine, origin (France) , DEXA device uses a pencil beamwidth method with micro-emission of x-ray with a scan time of 90 seconds and a bear weight of 150 kg, a computer system for image manipulation and displaying on a computer LCD monitor (LG).

Bone mineral density (BMD) was evaluated according to World Health Organization (WHO), normal (T-score ≥ -1.0), osteopenia (T- score between -1.0 and -2.5), and osteoporosis (T- score ≤ -2.5) (Asian-audit, 2009). The CBCT machine used in the research was a Kodak 9500 cone beam 3D system produced by Care Stream, France, year 2012, with Large wide - field mode (18height 20.6 cm diameter) (full skull) parameters of 10 ma, 90kv, and exposure time of 10.08 seconds with voxel size 300, and viewer operating systems (care stream 3D imaging established by the same CBCT manufacturing company) with LG computer device with windows XP to visualize and manipulate images.

CBCT scan analysis: Following the exposure, the picture was shown on the monitor as secondary reconstructed images in three orthogonal planes (axial, sagittal, and coronal), as well as a three-dimensional image (3D), and the subsequent measurements were made: The curved slicing option was chosen, then the coronal view was picked, and an arch was manually produced (arch reconstruction), then it was picked, and an arch line was formed to rebuild the OPG lay out view, and by scrolling the mouse, it was ensured that the lower edge of the mandible fully appears especially at the mental foramen area, the mental foramen was located, then sagittal view from the curved slicing was selected and by scrolling the mouse the mental foramen opening area (slice) was selected. Cortical width at mental foramen region was assessed by measuring the width from the upper edge (inner side) of lower cortical bone to the lower external side of the cortical bone (the whole cortex), The cortical width was assessed bilaterally and the mean cortical width was calculated. Fig. 1.

Statistical analysis: Interclass correlation was used to check inter-examiner and intra-examiner calibration. Statistical analysis was computer aided using SPSS version (21) (statistical program for social sciences), and the T-score of the DEXA scan was normally distributed. Mandibular Cortical Width (MCW) and Age both had normal distribution, MCW was best explained by Kruskall-wallis test to describe the mean, standard deviation (SD), median, and mean rank. Additionally statistical significance was evaluated using Multiple-Mann Whitney-U test. Receiver Operator Characteristic (ROC) curve was used to evaluate the diagnostic reliability of Mandibular Cortical Width (MCW) as a measurement tool to detect osteoporosis patients. The area under the curve (AUC) measures the validity of the variables measured

(test) in comparison with other tests. Sensitivity, Specificity and cutoff values were also determined. For all tests, Statistical significance level was set at $P<0.05$.

Results

The study sample was separated into three groups based on DEXA readings and age to see if the variable is changed by age, osteoporosis, or both: Group A composed of non-osteoporotic (20-30) years old, Group B composed of non-osteoporotic 50years and above, and Group C composed of osteoporotic 50years and above. Descriptive and statistical analysis for MCW among study groups showed a high significant difference among groups $p<0.01$ Table 1.

At $p>0.05$, multiple comparisons of MCW between study groups revealed no significant difference between Group A and Group B, but a significant difference between Group B and Group C Table 2.

Table (3) shows the validity of MCW as diagnostic tools for osteoporosis, MCW was highly significant at $p<0.01$ and has a very good validity as it, (AUC=0.890), with an optimal cutoff value of (2.6250).

Discussion

Periosteal bone balance is mildly positive, Endosteal and cancellous bone balances are somewhat negative, resulting in cortical and cancellous thinning as people age. Endosteal resorption outpaces periosteal creation, resulting in these relative alterations.(*Kini and Nandeesh, 2012*).

This study showed that the MCW is not significant with age although the mean rank for the Group A was higher than Group B but it was not

statistically significant this is confirmative to studies of Kingsmill and Boyde,(1998); Soltani *et al.,*(2017). Our result disagrees with the studies of Dutra *et al.,* (2005) who stated that aging has a consistent remodeling effect on the cortex of the mandible by using panoramic radiography.

Small sample size and inclusion of subjects with osteopenia with T-score (-1to -2.4) could be of direct effect to the results that did not reach the level of significance.

Regarding osteoporosis MCW was strongly affected and it was decreased as the mean rank for the Group C was lower than the mean rank for Group B with high significance. Our result agrees with Ledgerton *et al.,* (1999) and Bras *et al.,*(1982) who stated that the Mandibular inferior cortical thickness is reduced in older females and it could be used as a predictor for osteoporosis And agrees with Taguchi et al,2003, and Papamanthos *et al*,(20140 studies. Black *et al.*(1996) stated that Endosteal, intracortical and trabecular bone resorption in association with osteoporosis are well known in the skeleton.

Kribbs *et al.,*(1989) and Klemetti *et al.,* (1993) found that The thickness of the inferior border tends to be reduced in subjects with osteoporosis.

Bollen *et al.,* (2000) and Klemetti *et al.,*(1994) said that Individuals with osteoporosis are likewise more likely than controls to have erosions on the mandible's inferior border.

When we used ROC Curve in this study to measure the diagnostic reliability for GAI, and MCW in relation to a reference line and to check their ability to predict presence of osteoporosis in patients, MCW was very good as the AUC was (0.890) with sensitivity of 90% and specificity of 95% with cut-off point was (2.6250), This agrees with the result of Nagi *et al.,*(2014), also with study of Papamanthos *et al.,* (2014).

Conclusion: CBCT image can be used as a mean to diagnose and predict osteoporosis patients by measuring MCW with a very good diagnostic reliability, also MCW is related to BMD condition rather than aging.

Table (1): Descriptive and statistical test of Mandibular Cortical Width among study groups.

Statistics	Groups			Kruskal-Wallis test
	Non-Osteoporosis 20-30	Non-Osteoporosis 50+	Osteoporosis 50+	Sig.
Minimum	3.05	2.15	1.35	0.000 HS
Maximum	5.25	4.65	5.10	
Mean	3.768	3.540	2.343	
±SD	.611	.571	.835	
Median	3.550	3.625	2.175	

HS=Highly significant at P<0.01.

Table (2): Multiple Comparisons of Mandibular Cortical Width among groups.

(I) Groups	(J) Groups	P-value
Non-osteoporosis (20-30) MR=21.50	Non-Osteoporosis (50+) MR=19.50	0.602 NS
Osteoporosis (50+) MR=12.70	Non-Osteoporosis(50+) MR=28.30	0.000 HS

HS=Highly significant at P<0.01, NS=Non Significant at P>0.05, MR=Mean Rank

Table (3): Validity of Mandibular Cortical Width and in diagnosis of osteoporosis

Variable	AUC	Optimal Cutoff point	%Sensitivity	%Specificity	SE	Asymptotic Sig.
MCW	0.890	2.6250	90	95	0.063	0.000

HS=Highly significant at P<0.01.

Fig. (1): Mandibular cortical width measurement.

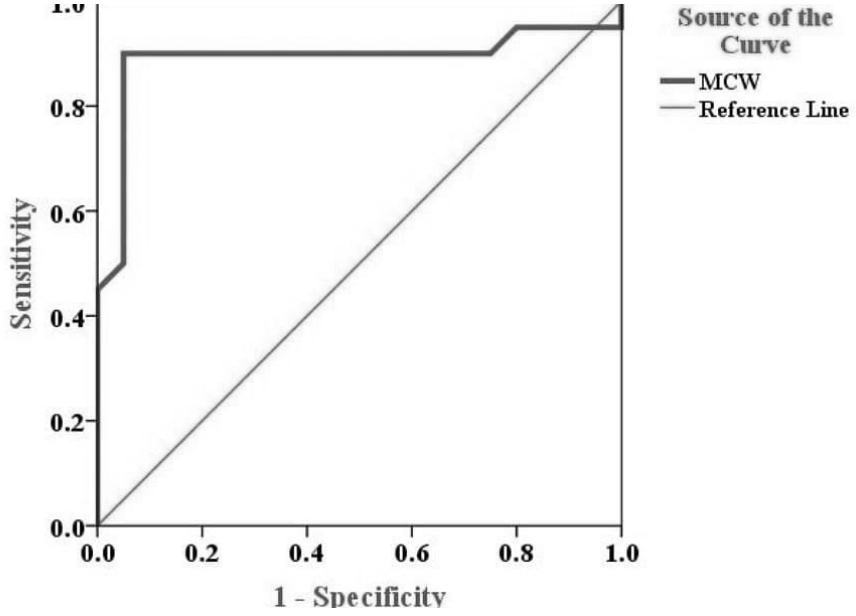

Fig. (2): ROC area for MCW measuring the diagnostic reliability for Osteoporosis.

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