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EC DENTAL SCIENCE
Research Article

Osteoporosis Features Observed in Mandible Cortex from Orthopantomogram

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Received: January 02, 2019; **Published:** January 29, 2019
DOI: 10.31080/ECDE.2019.18.00916

Abstract

Objectives: Osteoporosis is a systemic disease usually occurring in middle age to old age group of people in which bone density gets reduced and bones become porous and fragile resulting into the risk of fracture. Disease indications obtained from digital dental Orthopantomographic (OPG) X-ray image (recommended by dental surgeons while planning dental treatment) will be additional benefit to a patient, just because, such systemic disease indications are known while undergoing dental treatment without separate clinical tests to be carried out for diagnoses. This paper aims to analyze research carried out to extract Osteoporosis indications from OPG. Research carried out in various countries world-wide is discussed here to summarize list of features observed visually by various medical practitioners from OPG images.

Analysis: Features like mandible angle, mandible cortical index, pixel intensity, teeth count, mandibular alveolar bone mass and alveolar bone resorption pattern are considered to be important to diagnose osteoporosis symptoms from OPG. Medical professionals carried out a survey on many patients to visually locate osteoporotic symptoms from OPG images and symptoms were mapped to corresponding Dual Energy X-ray Absorptiometry (DEXA) T-score results. Research was successful in diagnosing osteoporotic health condition as normal, osteopenic or osteoporotic.

Findings: It can be concluded that automation of locating symptoms of osteoporosis disease is an area of interest for researchers. It is obvious that, patient will be interested to know his osteoporotic health condition while undergoing dental treatment.

Keywords: *Orthopantomograph (OPG); Mandible; Feature extraction; Mandibular Cortical Index (MCI)*

Abbreviations

OPG: Orthopantomogram; BMD: Bone Mineral Density; DEXA: Dual Energy X-ray Absorptiometry; WHO: World Health Organization; MCI: Mandibular Cortical Index; PI: Pixel Intensity; MABM: Mandibular Alveolar Bone Mass; ABRP: Alveolar Bone Resorption Pattern; ANN: Artificial Neural Network; SOFM: Self-Organizing Feature Map; SOM: Self-Organizing Map; ART: Adaptive Resonance Theory; GLCM: Gray Level Co-occurrence Matrix

Introduction

Osteoporosis a loss in Bone Mass or Bone Mineral Density (BMD), mainly due to aging, is a non-reversible systemic disease. Its prevention is preferred over its cure as it is difficult to treat when it progresses. Dual Energy X-ray Absorptiometry (DEXA) test, a special type of X-ray, investigates osteoporosis. The World Health Organization (WHO) has established diagnostic levels of BMD in terms of T-score [1-3].

A T-score is measured by comparing individual's BMD with BMD of a healthy 30-year-old adult. A T-score = 0 refers to a most healthy adult. Usually, a range of -1 to +1 is considered to be a T-score of a healthy adult. As shown in the table 1, T-score between -1 and -2.5 indicates low BMD, indicating presence of initial stage of osteoporosis, known as osteopenia. A T-score of -2.5 or lower indicates osteoporosis. The greater is the negative number, the osteoporosis is more severe [3].

Health condition	Range of T-score
Normal	+1 to -1, a healthy adult. (BMD > 833 mg/cm^2)
Low bone mass (Osteopenia)	-1 to -2.5, (BMD between 833 and 648 mg/cm^2)
Osteoporosis	-2.5 or less than -2.5, (BMD below 648 mg/cm^2)

Table 1: *T-Score levels in BMD.*

Available research indicates that, OPG, a panoramic X-ray of a jaw recorded while planning dental treatment is a diagnostic marker for osteoporosis. The relation between osteoporosis and OPG features is of special interest to a patient as he will come to know his osteoporotic condition while undergoing dental treatment. This paper presents analysis of available research where relations between osteoporosis and OPG features are studied to establish correlation between them.

Detection of osteoporosis symptoms

Mahabubul Islam Mazumder., *et al.* [1] correlated features of mandibular cortical bone from OPGs with BMD T-scores of 97 postmenopausal osteoporotic patients. All patients were evaluated by DEXA for BMD and OPG. Mandibular Cortical Index (MCI) was categorized as C_1, C_2 and C_3 according to appearance of the mandibular inferior cortex distal to the mental foramen (one of the two small round holes on the front surface of the mandible bone). Figure 1 displays mandible, maxilla and mental foramen on a typical digital OPG image. Table 2 shows details about the criteria C_1, C_2, and C_3. The study concluded that C_1, C_2, C_3 classes of MCI could be correlated well with osteoporosis variable [1,2,4].

Criterion	Details
C_1	Endosteal margin of the cortex (inner layer of the cortex) was even and sharp on both sides of the mandible
C_2	Endosteal margin had semilunar defects (resorptive cavities) with cortical residues one to three layers thick on one or both sides
C_3	Endosteal margin consisted of thick cortical residues and appeared clearly porous

Table 2: *MCI index criteria.*

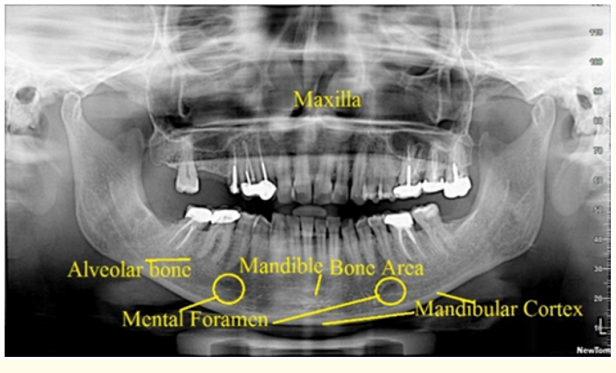

Figure 1: *Digital OPG showing maxilla, mandible cortex, mental foramen and alveolar bone.*

Alveolar bone (as shown in figure 1) is a tissue that supports the teeth in maxilla (fixed bone of upper jaw) and mandible (strongest bone in lower jaw). In reference [2], authors observed the alveolar bone changes in osteopenic and osteoporosis conditions of postmenopausal women (in osteopenia the bone loss is not as severe as in osteoporosis). Totally 1315 postmenopausal women were included in this study. All patients were evaluated by DEXA for BMD and dental radiographs such as OPG and RadioVesioGraphy (RVG). RVG is a latest intraoral radiographic imaging system. Among those women, 72 were normal, 276 were osteopenic and 967 were osteoporotic. MCI, Pixel Intensity (PI), Mandibular Alveolar Bone Mass (MABM) and Alveolar Bone Resorption Pattern (ABRP) were evaluated from the dental radiograph. Gray levels of PIs were considered from 0 (dark area) to 256 (white area). Dark area indicated bone loss whereas light area represented bone gain. MABM was a mean of PI values from the alveolar bone (area away from teeth joints area i.e. apical area) on the digital apical intraoral radio-graph. ABRP was alveolar bone loss pattern in horizontal and vertical direction. Horizontal bone resorption pattern was increased in postmenopausal osteoporotic patients rather than osteopenic and normal patients. The research concluded that the changes in post-menopausal alveolar bone were strongly correlated with the BMD of osteoporotic bone.

Reference [4] gave a significant correlation between MCI and BMD of the lumbar vertebrae, determined by DEXA. In this research work, 50 postmenopausal Indian women patients were subjected to digital panoramic radiographic examination followed by DEXA for estimation of bone mineral density of the lumbar vertebrae. Digital OPG images were visually observed and interpreted by two observers. Lower border of the mandible near the mental foramen of the left side in panoramic radiographs was observed manually. The results were analyzed to assess the relation between the MCI of panoramic radiograph and BMD obtained from DEXA. The re-search concluded that assessment of lower border of mandible is a key for early diagnosis of osteoporosis.

The purpose of research in [5] was to find the association between mandibular cortical erosion and number of teeth present in Japanese men and women aged 40 years and above. Multiple regression analysis revealed significant association between moderately eroded cortex and severe eroded cortex with decreased number of teeth present. Severely eroded cortex had significantly fewer teeth than those with a normal cortex moderately eroded cortex.

The study conducted in European country Lithuania [6], for 129 postmenopausal women where calcaneal (heel) BMD was mapped on MCI. The morphological changes at the mandibular cortex rep-resented in MCI were related to the changes in calcaneal BMD. In some cases, it was found that, in spite of having good quality mandibular cortex, some subjects still had inclination towards osteopenia. It was concluded here that MCI accuracy may not be sufficient for precise evaluation in screening of postmenopausal osteoporosis.

Research presented in [7] obtained MCI by observing OPG and was compared with DEXA T-score. The study concluded that MCI could be used for simple screening to detect osteoporosis. In the research carried out in Pakistan [8], authors observed de-crease in angle of mandible at the stage of osteopenia, and concluded that the angle could be conveniently used for early detection of osteoporosis. Mujeeb., *et al.* [9] performed a study on Indian population. They revealed that BMD declines by an average of 11% every 10 years in females. Thus, early detection of osteoporosis is an immediate need for its prevention.

Results and Discussion

Year	Country	Patient count	Features used	Conclusion
2016	Bangladesh	97	MCI	Correlation between MCI and DEXA result exists
2016	Lithuania	129	MCI	MCI can be used as diagnostic tool for osteoporosis
2016	Japan	839	MCI	The association between mandibular cortical erosion and number of teeth present in Japanese men and women aged 40 years and older.
2015	Bangladesh	1315	MCI, PI, MABM, ABRP	MCI can be used as diagnostic tool for osteoporosis
2015	India	50	MCI	Lower border of mandible is a key for early diagnosis of osteoporosis
2012	Bulgaria	1 (72 year)		MCI can be used as diagnostic tool for osteoporosis
2012	Pakistan	174	Mandible angle	As mandible angle was decreased at the stage of osteopenia, could be used for early detection of osteoporosis.

Table 3: *Mandible features observed in OPG corelated with osteoporosis.*

It the observations noted by experienced medical practitioners, stated in sec. 5 above, were on real time basis. Patients were undergone DEXA test and OPG X-ray. OPG images were observed and various features like MCI, mandible angle, PI, MABM, ABRP were noted manually. Statistical methods like mean and standard deviation were used to present results. Though very few papers are re-viewed here, lot of similar work is available which supports extraction of osteoporosis symptom features form OPG manually.

In the above research work, almost all the researchers collected additional information about patients like their gender, age, height, weight, diabetes mellitus, hypertension, alcohol consumption, smoking history etc. Even after considering above parameters, correlation between MCI and BMD was consistent indicating osteoporosis with low MCI. These researches have referred more than 100 articles supporting their results. These details are summarized in table 3.

Automation of above problem requires writing computer algorithm which includes use of image processing and machine learning techniques. Automatic extraction of osteoporotic symptoms from OPG will surely be beneficial to medical practitioners. Comparatively less literature is available for automatic osteoporotic feature extraction from OPG.

The required algorithms have been developed and presented in [10-13]. Reference [10] presented Strip Algorithm using various image processing techniques to separate mandible cortical structure from OPG images. Results were tested on 100 OPG images. In reference [11], mandibular statistical texture features were extracted using Gray Level Co-occurrence Matrix (GLCM). These GLCM features are contrast, correlation, energy and homogeneity. These features were also studied at different angles viz., 00, 450, 900 and 1350. In [12] Artificial Neural Network (ANN) used GLCM features obtained from extracted mandible cortex. Unsupervised learning ANN algorithm which is a Self-Organizing Map (SOM) was used to cluster GLCM features. Analysis demonstrated that features at 1350 gave averaging results. All above three algorithms could be combined for further processing to find MCI and to classify OPGs in C_1, C_2 and C_3 classes.

Conclusion

SOM training. Research carried at various places in European and Asian countries like Lithuania, Bulgaria, India, Japan, Bangladesh, Pakistan observed osteoporotic symptoms from OPG image. Patients under-went DEXA test and OPG X-ray. OPG features like mandible angle, teeth count, MCI, PI, MABM, ABRP were noted down and analyzed visually by experienced medical practitioners. Majority research articles, relay on MCI index C_1, C_2 or C_3 to guess normal, osteopenic or osteoporotic patients respectively. Other features like MCI, mandible angle, PI, MABM, ABRP were also observed and related to guess osteoporotic condition.

As there is constant increase in number of osteoporosis patients, prevention of osteoporosis is important than its cure. Automatic detection of osteoporotic symptoms from OPG image is an area of research which will help patients to early detection of osteoporosis symptoms.

Acknowledgements

Sincere thanks go to Dr. Madhavi Waze, MDS and Dr. Suhas Waze, from Pune for Their guidance to understand probable research areas in the field of Dentistry. Dr. Kapil Kshirsagar, Maxillofacial Surgeon from Pune, helped during feasibility studies. Dr. Milind Darda, Orthodontist and Dr. Smita Kamtane, Oral and Maxillofacial radiologist from Pune provided access to real image data, available in their laboratory.

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Volume 18 Issue 2 February 2019