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Review Article

Osteoporosis: Detection Using Dental Radiography

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Abstract

Osteoporosis has been a cause for major concern for all the nations where the population of senior citizens has seen a spurt on account of better healthcare. However, where a timely diagnosis cannot be made, it causes a lot of suffering to the patient. The study aims at exploring the potential of dental radiography as a tool for diagnosis where a dentist could identify groups at high risk of suffering from this ailment much before they suffer from any fracture and to prevent it from happening by mitigating the various factors that may cause it. Going beyond the conventional techniques of diagnosis, this study evaluates the efficacy of the novel methodology studied under Osteodent Project for determining risk or vulnerability to osteoporosis through radio-morphometric and visual indices or photodensitometric analysis of trabecular patterns. Dental Radiography is not the sole diagnostic method for this ailment but an adjunct to screening techniques that can be used by a dentist for undiagnosed cases in patients who are unaware of being at risk. Since dental X-rays capture a two-dimensional image, visual examination becomes imperative to assess dimensions of bone and make requisite calculations for bone mineral density to predict the risk of osteoporosis.

Keywords: Osteoporosis; Dental radiography; Diagnosis.

Introduction

Osteoporosis is a common medical condition in which mineral density of bones is reduced with microarchitectural scaffold deterioration leading to a greater propensity towards fractures and breaks. Undesirably, it may only be apparent when it's too late ensuing hefty cost for treatment, care and time for convalescence for the sufferer. It invariably has a low mortality rate but morbidity from it causes a huge socioeconomic burden [1]. A recent consensus reports that over the age of 50, 1 in 3 women and 1 in 12 men have osteoporosis.

As is expected, the focus has been on developing new treatments, but more importantly, diagnostic methods which are

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accurate, cost-effective and readily available are the need of the hour. Diagnosis of osteoporosis is based on clinical signs and symptoms, X- rays, bone scans, bone mineral density assessment, etc. Dual Energy X-ray Absorptiometry (DEXA) is the most premium method for that. It is, however, expensive and not readily available [2].

Osteoporosis is known to affect all bones, including the ones in head and neck. Loss of dentition is commonplace in such patients. Thus, the radiologic examination of jawbones can be seen as a resourceful diagnostic tool for early diagnosis and easily follow up. For instance, Panoramic radiograph can be employed for screening of patients with low bone mineral content.

Osteoporosis

In so far as metabolic bone diseases are concerned, osteoporosis is the most rampant ailment among the elderly. It could arise from a plethora of causes and based on those, it is distinguished segregated as primary or secondary osteoporosis.

Epidemiology: In European populace, the age-standardized incidence is 12.2% for men and 12% for women in the age range of 50 to 79 years by the European Vertebral Osteoporosis Study [3]. As the population grows older, the numbers are predicted to surge to more than 14 million worldwide by 2020. Previously considered as a disease of women; it is now known that osteoporosis also ails men. 1 out of every 4 men as against 1 out of every 2 women over the age of 50 have been predicted to suffer an osteoporosis-related fracture in their life [4].

Although numbers of fragility fractures prevail amongst women, the mortality pertaining to fractures is higher among men. However, such mortality has a greater correlation to their comorbidities instead of the fracture itself. About half of the patients suffering from a hip fracture tend to lose the ability to walk unassisted and report a mortality rate of 12%–20% within 6 months of the fracture [5].

Risk factors: Include advancing age, female gender, Asian or Caucasian ethnicity, rheumatoid arthritis, history of fractures amongst relatives of first-degree, low body weight, hormone deficiency, prolonged consumption of glucocorticoids, chain-smoking, deficiency of vitamin D or calcium, alcoholism or a sedentary way of life.

Pathogenies: Osteoporosis is a condition that arises from the disparity in bone formation and resorption. When osteoblasts cannot rebuild the bone matrix as fast as it is degraded by the osteoclasts, low bone mass density is seen.

The three chief mechanisms that individually or together, lead to osteoporosis are an insufficient peak bone mass, unwarranted bone resorption, and insufficient new bone formation during remodelling [6].

RANKL or Receptor Activator of Nuclear factor Kappa-B Ligand causes activation of osteoclasts. It's produced by osteoblasts and lymphocytes. RANK (receptor activator of nuclear factor Kappa-B) is stimulated by its action. Osteoprotegerin binds RANKL before it has a chance to bind with RANK, thereby suppressing its ability to increase bone resorption. Regulation of bone turnover is dependent

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on local production of interleukins, eicosanoids, etc. imbalance of which may cause osteoporosis [6].

Hormonal influences control bone resorption. During the lack of oestrogen in menopause, bone resorption increases and deposition of new bone decreases in weight-bearing bones. Bone deposition gets impaired generally owing to a diet that is deficient in vitamin D and Calcium. Parathyroid glands secrete parathormone or PTH in response to low blood calcium levels leading to an increase in bone resorption to safeguard adequate blood calcium levels [6].

Conventional diagnostic techniques

Diagnostic imaging has two main goals: to detect osteoporosis and to measure bone mass for osteopenia. Despite the dawn of novel and extremely accurate and precise quantitative techniques, the radiologic appearances essentially remain the same not depending on the cause.

Bone dosimetry along with various other methods to check the Bone Mineral Density are used to currently diagnose osteoporosis. These include [7]:

- DEXA or peripheral DEXA that uses low-intensity X-ray radiation which can sense even minuscule bone loss usually to help at measuring the bone density of heel, forearm, finger, hip or spine.
- Quantitative Ultrasound (QUS) which measures bone mass at finger or heel using sound waves
- Peripheral QCT (PQCT) that is used for the forearm
- Quantitative Computed Tomography (QCT) that is used to measure bone mass at the hip or spine
- Single Photon Absorptiometry (SPA) which can be used for the wrist
- Dual Photon Absorptiometry (DPA) which can be used for the entire body besides specific parts such as hip or spine
- Single-energy X-ray Absorptiometry (SXA) which can be used at the wrist or heel

Bone Turnover Markers (BTM) have also proven successful in clinical trials for the detection of osteoporosis [8]. These include neo-epitope which is a fragment of type-I collagen, which makes up the bulk of the bony matrix, broken down by enzyme cathepsin. Another collagen product C-telopeptide, excreted in the urine, can also be used.

Dental Radiography

Associations have been drawn between osteoporosis or underlying low bone mineral density and clinical signs on dental radiographs, principally the width of the inferior mandibular cortex and the texture of the trabecular bone. This allows the use of orthopantomograms and periapical radiographs which can help predict osteoporosis early on. Following methods can be used.

Radio-morphometric indices: They utilize dimensions from the orthopantomograms evaluating loss of bone which indicates a probable reduction in bone mineral density. Two studies were carried out by Horner and Devlin on this subject. In 1998, they used Mandibular Cortical Thickness and Panoramic Mandibular Index in

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analogue X-rays only to discover a positive association of a decrease in the indices to bone density reduction [9]. Utilizing the dimensions of mandibular cortical bone, especially its thickness in the area of the mental foramen or Mental Index (MI), in the antegonial area called the Antegoneal Index (AI) and in area of the angle called Gonial Index (GI), they discovered noteworthy results only in the case of MI in 2002 [10]. Arifin et al. used a computerized technique for determining the MTC through digital X-rays, finding it appropriate to analyse Bone Mineral Density [11]. Using MCT, Osteoporosis Self-assessment Tool and a visual estimate to study risk factors, Taguchi et al. concluded that dentists can point out in female patients the need for further osteoporosis tests [12].

Karayianni et al. in 2007 compared X-ray findings and surveys for identifying the developmental vulnerability of women to osteoporosis. With collaboration from European research centres to study the potential application of dental X-rays at diagnosing osteoporosis, it was a part of the OSTEODENT project, 2003.

This project's objective was to determine which X-ray index or which combination of clinical and X-ray indices would be most effective and useful for dentists to diagnose osteoporosis. Mandibular Cortical Thickness (MCT) measurements from the X-rays were used in tandem with survey data to calculate the risk rate of survey respondents to osteoporosis or Osteoporosis Index Risk (OSIRIS) through estimation of risk to a decline in bone mineral density [13]. It involved four variables: weight, age, trauma history from moderate contusion and hormonal replacement therapy. It has been established that compared to the cortical bone measurements in X-rays, OSIRIS has greater diagnostic legitimacy.

As part of the project, they measured MCT dimensions and visually examined cortical bone, to conclude that cortical thickness < 3 mm must be evaluated further to determine the presence of osteoporosis [14].

Further Allen et al. showed that an automatic system in panoramic X-rays was used by Delvin et al. in this project for measurement of cortical bone's thickness [15]. Merging this data from the risk rates given by OSIRIS led to the conclusion that dentists are indispensable to preliminarily detect patients who are at high risk of developing osteoporosis.

Visual indices: Lee et al. in 2005 analysed reports by 3 radiologists and 1 dentist who examined mandibular inferior cortex in the X-rays to find out if it was thin while measuring the thickness of the cortical bone [16]. Inferences from various concurred upon the notion that erosion at the cortical bone if analysed, would be a good indicator to identify candidates for posterior densitometric studies with high accuracy of about 73% [17].

Photo-densitometric analysis and trabecular pattern: The periapical X-rays and the trabecular pattern have been used to predict the bone mineral density. Jonasson et al. studied the trabecular pattern, alveolar bone mass quantified by photodensitometry in premolar region and the interdental alveolar thickness using dental callipers between lower premolars about 6mm apical to cementoenamel

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junction, to estimate skeletal bone mineral density in 2001 [18].

Evaluation of trabecular pattern was performed using the groundwork laid by the Osteodent project, to categorize the patterns into three groups – the first being a dense and homogeneous pattern, the second being a sparse and homogeneous pattern and the third being a heterogeneous pattern. Further, the factors of risk of fracture were considered and it was found that females at risk for osteoporosis can be diagnosed by evaluating the trabecular pattern with the aid of premolar or intraoral X-rays [19].

Mandibular premolar region samples from cadavers were taken and captured with digital X-rays, using aluminium to determine the Grayscale. Volumetric tests were carried out with tests for determining bone mineral density. Some artificially decalcified samples were X–rayed to calculate the degree of decalcification to obtain a technique for assessing the density of bone mineral by using X-rays intra-orally, juxtaposing the decalcification using a scale of aluminium as a reference [20]. The next year, as a part of the osteodent project, conventional intraoral X-rays were used to conclude that premolar region densitometry could be used to diagnose osteoporosis reasonably well [21].

The Fractal Dimension (FD) and Pixel Intensity (PI) were studied in the panoramic digital X-rays to appraise their efficacy for detecting densitometric change associated with osteoporosis in bones.

The area of the angle, body and canine - premolar region are selected as the Regions of Interest (ROIs) at orthopantomograms' left side. For FD analysis, the two ROI of the canine- premolar area and of the angle are processed by transforming them into 8-bits and processed. The inference drawn from the study is that identifying changes linked to osteoporosis can be done in cancellous bone using digital radiographs [22]. For PI analysis, the dimensions of the 3 ROIs are equated with standardized scales of aluminium.

Another study established the relationship between dental areas and osteoporosis, using visual estimates from orthopantomogram and periapical X-ray photodensitometry. Along with that -loss of support, the total number of permanent teeth, depth of pockets and tooth mobility was also assessed. The periapical X-rays of the molar region and anterior region of maxilla and the mandible and photodensitometry evaluation was done using the scale of aluminium. Prediction of osteoporosis by oral examination and X-ray findings was established in this study [23].

Densitometry of the mandible (DEXA): Horner et al used densitometry, with contralateral sides of the jaw overlapping and took dimensions of three ROIs including the mandibular symphysis, body and ascending ramus. Then, DEXA authenticated in the primary study was compared with results from the orthopantomograms, establishing a correspondence between parameters used in orthopantomograms for osteoporosis diagnosis with those of DEXA [24].

Conclusion

There is adequate evidence that features of reduced skeletal bone mineral density can easily be assessed on dental x-rays. Bone loss due to osteoporosis occurs throughout the body and recording these features on

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jaws has the plus that radiographs are taken at this site for other reasons, meaning opportunistic diagnosis can be made before a fracture can occur, even in patients considered low risk. Dental Radiography is not the sole diagnostic method for this ailment but an adjunct to screening techniques that can be used by a dentist for undiagnosed cases in patients who are unaware of being at risk. Since dental X-rays capture a two-dimensional image, visual examination becomes imperative to assess dimensions of bone and make requisite calculations for bone mineral density to predict the risk of osteoporosis. As dental visits are more common, there is a prospect for the dentist with specific training to be more closely involved in keeping track of the overall well-being of the patient.

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