Short Research Article

**COMPARISON OF MANDIBULAR BONE RIDGE IN NON-DIABETICS AND DIABETIC PATIENT IN HOSPITAL ENVIRONMENT: INITIAL SAMPLE FROM A CLINICAL OBSERVATION**

**ABSTRACT**

Aim: This study aims to evaluate and compare the mandibular panoramic radio morphometric indices between patients with diabetes mellitus and non-diabetic individuals to understand the potential effects of DM on mandibular bone structure.

Study design: Case control study

Place and duration of study: This study was conducted in Department of Prosthodontics and Department of Radiology, ADHIPARASAKTHI Dental College and Hospital's, Melmaruvathur, from May 2024 to October 2024.

Materials and Methods: A total of 50 participants were included in the study. They were divided into two groups based on HbA1c levels. Group A (diabetic patients) and Group B (non-diabetic). Panoramic radiographs were obtained for each participant. Key mandibular radio morphometric indices, PMI and MI, were analysed. Descriptive and analytical statistics were performed to compare cortical bone thickness between diabetic and nondiabetic groups.

Results: Diabetic patients exhibited alterations in mandibular bone structure, which may be indicative of bone deterioration associated with diabetes. However, this difference was found to be statistically insignificant.

Conclusion: The study highlights the potential of using mandibular panoramic radiographs to evaluate the impact of diabetes on mandibular bone structure. These findings suggest that patients with diabetes may be at higher risk for mandibular bone loss and should be closely monitored for oral health complications. Further studies are needed to explore the underlying mechanisms of these radiographic changes and their clinical implications.

*Keywords: Diabetic, Mandibular cortical thickness, PMI, MI*

**1. INTRODUCTION**

Diabetes mellitus, a significant non-communicable disease, has emerged as a major global health challenge. Its defining feature is hyperglycaemia, which can also impact mineralized skeletal tissues. These effects include alterations in the bone matrix and bone demineralization, contributing to increased bone fragility. According to Wu et al., diabetes significantly promotes osteoclastogenesis and increases osteoblast apoptosis. [1]

Both type 1 and type 2 diabetes are known to profoundly affect bone health. The quality of the alveolar bone plays a critical role in the pathophysiology of diabetes-related oral conditions. As such, assessing bone density is vital for the diagnosis and management of periodontal issues, including dental implant placement and bone grafting procedures. [2]

Despite the high prevalence of diabetes, research on its relationship with mandibular bone mineral density (BMD) remains limited. Addressing this gap is crucial, as the condition's impact must be factored into routine dental clinical practices. [3]

The clinical bone mineral density measurement is best assessed by the standard method, Dual Energy X-Ray Absorptiometry (DEXA). However, its use for mandibular assessment is rare due to challenges like superimposition of opposite sides and the high cost of the procedure. This emphasizes the need for more cost-effective methods to assess skeletal density accurately. [4]

Panoramic radiographs, widely utilized in dental practice, provide a practical alternative. These images allow the application of radio morphometric indices, which are used to quantitatively and qualitatively evaluate mandibular bone mass and resorption. Studies have demonstrated a strong correlation between mandibular BMD and overall skeletal BMD. [5]

A literature review highlights that the inferior cortex thickness of the mandible is a reliable predictor of osteoporosis risk. [6] The aim of this study is to investigate diabetes-induced alterations in mandibular bone by analysing radio morphometric measures on panoramic radiographs of diabetic and non-diabetic individuals.

**2. MATERIAL AND METHODS**

This case control study was conducted in Department of Prosthodontics and Department of Radiology, ADHIPARASAKTHI Dental College and Hospital's, Melmaruvathur from May 2024 to October 2024.

A total of 100 patients aged between 40 and 70 years were included in the study. The study and the procedures involved were explained to the patients in a language they understood before beginning of the procedure. A routine health check-up was conducted to ensure there were no other systemic diseases present. A detailed medical history was taken from each patient to identify potential predisposing factors for diabetes. Factors such as age, genetic predisposition, environmental influences (including diet, physical activity, stress, and exposure to toxins or infections), obesity, hormonal imbalances, lifestyle choices (such as smoking and excessive alcohol consumption), and socio-economic status can all play a significant role in the development of diabetes. Additionally, common signs and symptoms of diabetes, such as polyuria, polyphagia, and polydipsia, were observed. Glycated haemoglobin (HbA1c) analysis was performed on all individuals to confirm the diagnosis and assess glycaemic control. The patients were then divided into the study group, which consisted of consenting individuals with a history of diabetes (confirmed by HbA1c levels ≥6.5).

Exclusion Criteria:

History of traumatic mandibular injuries, orthognathic operations, jaw bone pathology, radiation therapy to the head and neck region, or other systemic disorders affecting bone

A total of 100 patients were included in the study. A written informed consent was obtained from all participants.

 FIG 1 : Patient Grouping

Patient Characteristics and Grouping:

* Demographic details and diabetes history were recorded for all participants.
* HbA1C levels were evaluated, with values > 6.5% categorized as Group 1 (diabetics) and the remainder as Group 2 (non-diabetics).
* A panoramic radiograph was obtained for all participants as recommended by their clinicians as part of their diagnostic investigations.

Radiographic Procedure:

* Sirona ORTHOPHOS XG was used to capture 100 orthopantomograms (OPGs).
* Image quality was assessed using SIDEXIS 4 software to confirm the absence of artefacts that could alter the anatomy under investigation.
* Images were saved in DICOM format for consistent and detailed analysis.

Standardized Imaging Process:

* All radiographs were taken by a single examiner to ensure consistency.
* Patients were positioned in the panoramic machine with:
	+ The vertical reference line of the machine aligned with the sagittal plane of the patient.
	+ The horizontal reference line (Frankfort plane) parallel to the floor.

Radio morphometric Analysis:

Panoramic radio morphometric indices, such as the Panoramic Mandibular Index (PMI) and Mental Index (MI), were assessed and compared between diabetic and non-diabetic groups to evaluate potential mandibular bone alterations associated with diabetes.

Panoramic Mandibular Index (PMI)

PMI is a radiographic ratio used to assess the thickness of the mandibular cortex in relation to the distance between the mental foramen and the inferior mandibular border, derived from panoramic radiographs. A reduced PMI indicates cortical thinning, which may serve as a marker for systemic osteoporosis or other metabolic bone disorders. [5]

Applications in Dentistry:

* Implant Planning: Assists in evaluating bone health and ensuring sufficient cortical support for dental implants or prosthetic anchorage.
* Edentulous Patients: Useful in assessing bone quality for designing and placing dentures or other oral appliances.

Additionally, PMI aids in forensic identification and evaluation of disease conditions like hyperparathyroidism, diabetes, and chronic kidney disease.

Apart from being non-invasive and cost effective, it can also provide indirect insights into overall bone health. By integrating PMI into routine dental evaluations, practitioners can enhance patient care by identifying potential bone health issues early and tailoring treatment plans accordingly.

The Mental Index (MI) is a radiographic measurement that evaluates the thickness of the mandibular cortical bone in the region near the mental foramen. The MI represents the thickness of the mandibular cortical bone, measured in millimeters, directly below the mental foramen as observed on a panoramic radiograph. [5]

Table 1: DESCRIPTION of Panoramic Mandibular Index (PMI) and Mental Index (MI)

|  |  |  |
| --- | --- | --- |
| INDEX | DESCRIPTION  | NORMAL VALUE |
| Panoramic Mandibular Index ( PMI )  | The PMI is calculated as the ratio of the mandibular cortical thickness measured on the line perpendicular to the bottom of the mandible, at the middle of mental foramen, to the distance between the superior margin of inferior mandibular cortex and bottom of the mandible.[5] | >0.3 |
| Mental Index ( MI )  | The mandibular cortical thickness is measured at the center of the mental foramen on the line that is perpendicular to the mandible's bottom.[5] | >3.1 mm |

 Line drawn perpendicular to the bottom of the mandible

 from the middle of mental foramen (B)

PMI

 The distance between the superior margin of inferior

 mandibular cortex and bottom of the mandible (C)

The index values were computed digitally and tabulated in Microsoft excel spreadsheet.

3. results

The collected data were analysed using SPSS software version 23 (IBM, USA). The Kolmogorov-Smirnov test was applied to verify that the data followed a normal distribution. The mean and standard deviation (SD) for both diabetic and non-diabetic groups were calculated and summarized. To compare the two groups, an independent t-test was performed. A p-value ≤ 0.05 was considered as the threshold for statistical significance, indicating a meaningful difference between the groups.

Table 2: Descriptive statistics for the diabetic group among the study population

|  |  |  |  |
| --- | --- | --- | --- |
| **PARAMETER** | **N** | **MEAN**  | **S.D** |
| **B** | 50 | 15.90 | 2.276 |
| **C** | 50 | 4.37 | .858 |
| **PMI** | 50 | 3.75 | .825 |
| **MI** | 50 | 16.99 | 2.443 |

This table presents the descriptive statistics, including the mean and standard deviation (S.D.), for key parameters measured in the diabetic group of the study population. The sample size (N) for all parameters is 50.

**Parameter B**

* + Mean: 15.90
	+ Standard Deviation: 2.276
	+ This indicates that the average value for parameter B is 15.90, with variability of ±2.276 around the mean.

**Parameter C**

* + Mean: 4.37
	+ Standard Deviation: 0.858
	+ The relatively low standard deviation suggests less variability in the data for this parameter.

**PMI (Panoramic Mandibular Index)**

* + Mean: 3.75
	+ Standard Deviation: 0.825
	+ This suggests moderate variability in the distribution of PMI values within the diabetic group.

**MI (Mental index)**

* + Mean: 16.99
	+ Standard Deviation: 2.443
	+ This parameter shows the highest mean value among the listed parameters, with a standard deviation of 2.443, indicating a relatively wider spread of values**.**

Table 3: Descriptive statistics for the non-diabetic group among the study population

|  |  |  |  |
| --- | --- | --- | --- |
| PARAMETER | N | MEAN  | S.D |
| B | 50 | 16.15 | 2.558 |
| C | 50 | 4.82 | 1.264 |
| PMI | 50 | 3.50 | .831 |
| MI | 50 | 17.01 | 2.779 |

This table presents the descriptive statistics, including the mean and standard deviation (S.D.), for key parameters measured in the non-diabetic group of the study population. The sample size (N) for all parameters is 50.

 **Parameter B**

* + Mean: 16.15
	+ Standard Deviation: 2.558
	+ The average value for parameter B is slightly higher than in the diabetic group (15.90), with moderate variability.

**Parameter C**

* + Mean: 4.82
	+ Standard Deviation: 1.264
	+ The mean value is higher than in the diabetic group (4.37), with a larger standard deviation, suggesting more variation in this parameter among non-diabetic individuals.

**PMI (Panoramic Mandibular Index)**

* + Mean: 3.50
	+ Standard Deviation: 0.831
	+ This is slightly lower than in the diabetic group (3.75), indicating a potential difference in periodontal health between the two groups.

**MI (Mental Index)**

* + Mean: 17.01
	+ Standard Deviation: 2.779
	+ The mean value is very close to that of the diabetic group (16.99), but with a slightly higher standard deviation, indicating greater variability.

**Comparison with Diabetic Group**

* B and C values are slightly higher in the non-diabetic group compared to the diabetic group, suggesting potential differences in the measured parameters between the two populations. MI is lower in non-diabetics, which may indicate better periodontal health. MI values are almost identical between both groups, suggesting no major difference in this parameter.

Table 4: Intergroup comparison between the diabetic and non-diabetic group by using independent t test among the study population

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| PARAMETER | GROUP | MEAN | S.D | MEAN DIFFERENCE | 95% CONFIDENCE INTERVAL | SIG |
| LOWER | UPPER |
| B | DIABETIC | 15.90 | 2.276 | -.27800 | -1.66930 | 1.11330 | .690 |
| NON DIABTEIC | 4.37 | .858 |
| C | DIABETIC | 3.75 | .825 | -.45600 | -1.07887 | .16687 | .148 |
| NON DIABTEIC | 16.99 | 2.443 |
| PMI | DIABETIC | 16.15 | 2.558 | .24048 | -.23578 | .71674 | .315 |
| NON DIABTEIC | 4.82 | 1.264 |
| MI | DIABETIC | 3.50 | .831 | -.06200 | -1.56529 | 1.44129 | .934 |
| NON DIABTEIC | 17.01 | 2.779 |

*\*p value less than or equal to 0.05 is considered statistically significant difference*

This table presents the results of an independent t-test comparing key parameters between the diabetic and non-diabetic groups. The mean differences, confidence intervals (95%), and significance (p-values) are analysed to determine statistical significance.

Parameter B: *P = 0.69* (Not Significant) There is no statistically significant difference in Parameter B between the two groups.

Parameter C: *P = 0.14* (Not Significant) although the non-diabetic group has a slightly higher mean, the difference is not statistically significant.

PMI (Panoramic Mandibular Index): *P = 0.31* (Not Significant) No significant difference in PMI between diabetic and non-diabetic groups.

MI (Mental Index): *P = 0.93* (Not Significant) The difference in MI is minimal and statistically insignificant.

None of the parameters (B, C, and PMI, MI) show statistically significant differences between diabetic and non-diabetic groups. This suggests that within this study population, diabetes status does not have a statistically significant impact on the measured parameters. Future studies with larger sample sizes or additional variables may be needed to explore potential differences further.

**4. DISCUSSION**

**Diabetes mellitus (DM)** is a chronic metabolic disorder characterized by **persistent hyperglycaemia**, resulting from defects in **insulin secretion, insulin action**, or both.Type 1 Diabetes is an autoimmune condition where the immune system destroys insulin-producing beta cells in the pancreas while Type 2 is characterized by **insulin resistance** and eventual decline in insulin production. According to the International Diabetes Federation (IDF), diabetes affected 537 million adults (20-79 years) globally in 2021, with numbers expected to rise to 643 million by 2030. Countries like India are experiencing a diabetes epidemic due to rapid urbanization, dietary changes, and lifestyle shifts.

The literature highlights evidence linking **diabetes mellitus** as a significant **risk factor for osteoporotic fractures**. [7] Researchers have focused on the **alveolar bone**, noting its structural similarity to vertebral bodies, as both lack **muscular insertions**. Utilizing **dental radiographs**, they suggested that, with **standardized imaging techniques** and appropriate controls, radiographs of the **alveolar process** could serve as a more effective indicator of **systemic osteoporosis**. [8]

Histological quantification has revealed that **cortical porosity of the mandible** increases with age, exhibiting significant **intra-mandibular variation**. The **alveolar process** demonstrates greater activity in **bone resorption and deposition** compared to the mandibular body. [9][10] However, the **alveolar bone** is highly influenced by **local factors**, such as **periodontal disease** and **denture quality**. As a result, bone values obtained from a single biopsy of the alveolar process may not accurately reflect the **overall structure of the mandible**. [11].

In the present study, **radio morphometric indices of the mandible** were measured and evaluated using **panoramic radiographs**. Dental radiographs, when performed using a **standardized technique**, have the potential to serve as a **reliable indicator** of **systemic osteoporosis**. [12] Since **dental panoramic radiography** is commonly used as a routine screening tool in general dental practice, the **assessment of radio morphometric indices** through this imaging technique may prove useful in identifying individuals with **low bone mineral density (BMD)**.[3]

A total of 50 patients participated in the study, where they were all advised to undergo 2D orthopantographs. The OPGs were examined by a single examiner using a ruler in SIDEXIS 4 software to calculate the PMI and MI indices. The index values were computed digitally and tabulated in Microsoft excel spreadsheet. Independent t-test was used to compare mean values between the diabetic and non-diabetic group.

The results indicated that there was no significant variation in the panoramic mandibular index (PMI) between diabetic patients and healthy controls. When comparing the average mental index (MI) between the two groups, the mean MI for diabetic patients was slightly lower than that of the healthy controls, the difference was not statistically meaningful.

**5. CONCLUSION**

PMI and MI could serve as useful screening tools for assessing quantitative bone changes related to diabetes. However, due to the differing pathogenesis of type 1 and type 2 diabetes mellitus, the resulting bone changes vary as well. The results indicate a mild variation in index values between the diabetic and non-diabetic groups, although this difference was statistically insignificant.

**Ethical Approval:**

**As per international standards or university standards written ethical approval has been collected and preserved by the author(s).**

**Consent**

**As per international standards or university standards, Participants’ written consent has been collected and preserved by the author(s).**

**Disclaimer (Artificial intelligence)**

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

1. CHAT GPT

2. META AI

**REFERENCES**

1. Wu YY, Xiao E, Graves DT. Diabetes mellitus related bone metabolism and periodontal disease. Into J Oral Sci. 2015 Jun 26; 7(2):63-72. doi: 10.1038/ijos.2015.2. PMID: 25857702; PMCID: PMC4817554.

2. Jian-Min Liu, Clifford J. Rosen, Patricia Ducy, Stavroula Kousteni, Gerard Karsenty; Regulation of Glucose Handling by the Skeleton: Insights From Mouse and Human Studies. *Diabetes* 1 November 2016; 65 (11): 3225–3232

3. Bajoria AA, Ml A, Kamath G, Babshet M, Patil P, Sukhija P. Evaluation of Radio morphometric Indices in Panoramic Radiograph - A Screening Tool. Open Dent J. 2015 Jul 31; 9:303-10.

 4. Gaur B, Chaudhary A, Wanjari PV, Sunil MK, Basavaraj P. Evaluation of panoramic Radiographs as a Screening Tool of Osteoporosis in Post-Menopausal Women: A Cross Sectional Study. J Clin Diagn Res. 2013; 7(9):2051-55

5. Anju P Dvi1 , Been rm2 , Seem Kuru3 , Dhny ry Sm4 , S Arvin5 , rin Lzr ChnyAssessment of Panoramic Radio morphometric Indices of Mandible in Diabetes Mellitus Patients and Non Diabetic Individuals

6. Govindraju P, Chandra P. Radio morphometric Indices of the Mandible – An Indicator of Osteoporosis. J Clin Diagn Res. 2014; 8(3):195-98

7. Hofbauer LC, Brueck CC, Singh SK, Dobnig H. Osteoporosis in patients with diabetes mellitus. J Bone Miner Res. 2007;22:1317–28.

8. Groen J.J., Duyvensz F., Halsted J.A. Diffuse alveolar atrophy of the jaw (non-inflammatory form of paradental disease) and pre-senile osteoporosis. Gerontology. Clan. (Basel) 1960; 2:68–86

9. Manson J.D., Lucas R.B. A micro radiographic study of age changes in the human mandible. Arch. Oral Biol. 1962; 7:761–769.

10. Atkinson P.J., Woodhead C. Changes in human mandibular structure with age. Arch. Oral Biol. 1968; 13(12):1453–1464.

11. Von Wowern N. Variations in bone mass within the cortices of the mandible. Scand. J. Dent. Res. 1977; 85(6):444–455

12. Von Women N., Klausen B., Kollerup G. Osteoporosis: a risk factor in periodontal disease. J. Periodontol. 1994; 65(12):1134–1138

Kribbs PJ, Chestnut CH 3rd, Ott SM, Kilcoyne RF, Relationships between mandibular and skeletal bone in an osteoporotic population *J Prosthet Dent* 1989 62:703-07.

13. Leite AF, Figueiredo PT, Guia CM, Melo NS, de Paula AP, Correlations between seven panoramic radiomorphometric índices and bone mineral density in postmenopausal women *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2010 109(3):449-56.

14. Joshi A, Varthakavi P, Chadha M, Bhagwat N, A study of bone mineral density and its determinants in type 1 diabetes *J Osteoporos* 2013 2013:397814

15. Taguchi A, Tsuda M, Ohtsuka M, Kodama I, Sanada M, Nakamoto T, Use of dental panoramic radiographs in identifying younger postmenopausal women with osteoporosis *Osteoporos Int* 2006 17(3):387-94.

16. Ledgerton D, Horner K, Devlin H, Worthington H, Radiomorphometric indices of the mandible in a British female population *Dentomxillofac Radiol* 1999 28(3):173-81.

17. Dutra V, Devlin H, Susin C, Yang J, Horner K, Fernandes ARC, Mandibular morphological changes in low bone mass edentulous females: evaluation of panoramic radiographs *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2006 102:663-68.

18. Benson BW, Prihoda TJ, Glass BJ, Variations in adult cortical bone mass as measured by a panoramic mandibular index *Oral Surg Oral Med Oral Path* 1991 71:349-56.

19. Adil C, Aydin T, Taspinar O, Kiziltan H, Eriş AH, Hocaoglu IT, Bone mineral density evaluation of patients with type 2 diabetes mellitus *J Phy Ther Sci* 2015 27(1):179-82

20. Marinho NB, Vasconcelos HC, Alencar AM, Almeida PC, Damasceno MM, Risk for type 2 diabetes mellitus and associated factors *Act Paul Enferm* 2013 26(6):569-74.

21. Shaikh MA, Yakta D, Baloch GH, Shaikh D, The age of onset of type 2 diabetes mellitus in adult population *Ann Pak Inst Med Sci* 2008 4(2):109-12.

22. Yousefzadeh G, Shokoohi M, Najafipour H, Inadequate control of diabetes and metabolic indices among diabetic patients: A population based study from the Kerman Coronary Artery Disease Risk Study (KERCADRS) *Int J Health Policy Manag* 2015 4(5):271-77.

23. Harris SB, Worrall G, Macaulay A, Norton P, Webster-Bogaert S, Donner A, Diabetes management in Canada: baseline results of the group practice diabetes management study *Can J Diabetes* 2006 30:131-37.

24.. Mark T, Andrew J, Merlin C, The management of diabetes in Indigenous Australians from primary care *BMC Public Health* 2007 7:303

25. Scragg R, Sowers M, Bell C, Serum 25-hydroxyvitamin D, diabetes, and ethnicity in the Third National Health and Nutrition Examination Survey *Diabetes Care* 2004 27:2813-18.
26. Danielson KK, Elliott ME, LeCaire T, Binkley N, Palta M, Poor glycaemic control s associated with low BMD detected in Premenopausal Women with Type 1 Diabetes *Osteoporos Int* 2009 20(6):923-33.
27.  Devlin H, Horner K, Mandibular radiomorphometric indices in the diagnosis of reduced skeletal bone mineral density *Osteoporos Int* 2002 13(5):373-78.

28. Valerio G, del Puente A, Esposito del Puente A, Buono P, Mozzillo E, Franzese A, The lumbar bone mineral density is affected by long-term poor metabolic control in adolescents with type 1 diabetes mellitus *Horm Res* 2002 58:266-72.
29. Dhaon P, Shah VN, Type 1 diabetes and osteoporosis: A review of literature *Indian J Endocr Metab* 2014 18:159-65.

30. Kamalanathan S, Nambiar V, Shivane V, Bandgar T, Menon P, Shah N, Bone mineral density and factors influencing it in Asian Indian population with type 2 diabetes mellitus *Indian J Endocr Metab* 201418:831-37.

31. Bras J, van Ooij CP, Abraham-Inpijn L, Kusen G J, Wilmink JM, Radiographic interpretation of mandibular angular cortex: a diagnostic tool in metabolic and tooth loss. Part I. Normal State *Oral Surg Oral Med Oral Path* 1982 53:541-45.

 32.. Kribbs PJ, Chestnut CH 3rd, Ott SM, Kilcoyne RF, Relationships between mandibular and skeletal bone in a population of normal women *J Prosthet Dent* 1990 63:86-89.

Gaur B, Chaudhary A, Wanjari PV, Sunil MK, Basavaraj P, Evaluation of panoramic Radiographs as a Screening Tool of Osteoporosis in Post Menopausal Women: A Cross Sectional Study *J Clin Diagn Res* 2013 7(9):2051-55.  [[Google Scholar](https://scholar.google.co.in/scholar?hl=en&q=Gaur+B%2C+Chaudhary+A%2C+Wanjari+PV%2C+Sunil+MK%2C+Basavaraj+P%2C+Evaluation+of+panoramic+Radiographs+as+a+Screening+Tool+of+Osteoporosis+in+Post+Menopausal+Women:+A+Cross+Sectional+Study+J+Clin+Diagn+Res+2013)]

33. Dagistan S, Bilge OM, Comparison of antegonial index, mental index, panoramic mandibular index and mandibular cortical index values in the panoramic radiographs of normal males and male patients with osteoporosis *Dentomaxillofac Radiol* 2010 39:290-94.
34. Govindraju P, Chandra P, Radiomorphometric Indices of the Mandible – An Indicator of Osteoporosis *J Clin Diagn Res* 2014 8(3):195-98.
35. Gulsahi A, Paksoy CS, Ozden S, Kucuk N O, Cebeci ARI, Genc Y, Assessment of bone density in the jaws and its relationship to radiomorphometric indices *Dentomaxillofac Radiol* 2010 39:284-89

36. Asha ML, Bajoria AA, Babshet M, Patil P, Naveen S, Bone mineral density measurement of the jaws– a review *J Investigative Dent Sci* 2014 1(1):1-8.

37. Bajoria AA, Asha ML, Kamath G, Babshet M, Patil P, Sukhij P, Evaluation of radiomorphometric indices in panoramic radiograph – a screening tool *The Open Dent J* 2015 9:303-10.

 38. Gunczler P, Lanes R, Paz Martinez V, Martinis R, Esaa S, Colmenares V, Decreased lumbar spine bone mass and low bone turnover in children and adolescents with insulin dependent diabetes mellitus followed longitudinally *J Pediatr Endocrinol Metab* 1998 11:413-19
39. Brandi ML, Bone health and diabetes *Medicographia* 2010 32:364-69.

40. Saha MT, Sievanen H, Salo MK, Tulokas S, Saha HH, Bone mass and structure in adolescents with type 1 diabetes compared to healthy peers *Osteoporos Int* 2009 20:1401-06

41. Hofbauer LC, Brueck CC, Singh SK, Dobnig H, Osteoporosis in patients with diabetes mellitus *J Bone Miner Res* 2007 22:1317-28.

42. Kribbs PJ, Chestnut CH 3rd, Ott SM, Kilcoyne RF, Relationships between mandibular and skeletal bone in an osteoporotic population *J Prosthet Dent* 1989 62:703-07.

Pittas AG, Start PC, Harris SS, Hughes BD, The effects of calcium and vitamin D supplementation on Blood Glucose and markers of inflammation in Non diabetic adults *Diabetes Care* 2007 30:980-86.

43. Gedik O, Akalin S, Effects of vitamin D deficiency and repletion on insulin and glucagon secretion in man *Diabetologia* 1986 29:142-45

44. Orwoll E, Riddle M, Prince M, Effects of vitamin D on insulin and glucagon secretion in non-insulin-dependent diabetes mellitus *Am J Clin Nutr* 1994 59:1083-87.
45. Tanaka Y, Seino Y, Ishida M, Yamaoka K, Yabuuchi H, Ishida H, Effect of vitamin D3 on the pancreatic secretion of insulin and somatostatin *Acta Endocrinol (Copenh)* 1984 105:528-33.

46. Borissova AM, Tankova T, Kirilov G, Dakovska L, Kovacheva R, The effect of vitamin D3 on insulin secretion and peripheral insulin sensitivity in type 2 diabetic patients *Int J Clin Pract* 2003 57:25-61.

 47. Fliser D, Stefanski A, Franek E, Fode P, Gudarzi A, Ritz E, No effect of calcitriol on insulin-mediated glucose uptake in healthy subjects *Eur J Clin Invest* 1997 27:629-33.

48. Yaturu S, Humphrey S, Landry C, Jain SK, Decreased bone mineral density in men with metabolic syndrome alone and with type 2 diabetes *Med Sci Monit* 2009 15:5-9

49. Ma L, Oci L, Jiang L, Estrade K, Chen H, Wang Z, Association between bone mineral density and type 2 diabetes mellitus: a meta analysis of observational studies *Eur J Epidemiol* 2012 27:319-32.

50. Wang XR, Pei Y, Correlation of bone mineral density with disease duration and body mass in elderly men with type 2 diabetes mellitus *J Clin Rehab Tissue Eng Res* 2008 15:2891-94.