



## Original Research Article

# Using a panoramic radiographic study, the Panoramic Mandibular Index (PMI), Mandibular Cortical Width (MCW) or Mental Index (MI) are used to assess bone mineral density (BMD) in postmenopausal women and identify sexual dimorphism

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## ABSTRACT

**Introduction:** Regressive changes take place in all human tissues, including bone, throughout life. One of these alterations in the human skeletal system is osteoporosis, which starts with the slight bone changes known as osteopenia. Jawbones are where this bony alteration starts in the majority of severe instances. Due to hormonal changes, post-menopausal women have a higher incidence of osteoporosis than the general population, which typically begins in the fourth decade of life. The jaw's bony alterations may be evaluated with the use of a panoramic radiograph, which is also useful in identifying osteoporotic abnormalities. We can examine the qualitative and quantitative panoramic indices in a panoramic radiograph, such as the panoramic mandibular index (PMI), to ascertain sexual dimorphism and estimate bone mineral density (BMD), which is primarily influenced by age and gender.

**Materials and Methods:** A total of 100 patients, 50 men and 50 women, between the ages of 50 and 80, were gathered for the examination. Each patient's orthopantomogram (OPG) was recorded and examined using Sideaxis 4 Viewer (Sinora) software. Three experts completed all of the measurements, and the mean value was statistically analysed.

**Result:** The results was obtained using an independent t-test. For both groups, the standard deviation was 7.022 and the mean age was 59.450. Males had mean SLs of 17.32 mm, ILs of 14.15 mm, and MCWs of 4.23 mm. Females had mean SLs of 15.45mm, ILs of 12.94mm, and MCWs of 3.89mm. Further calculations revealed that the mean sPMI and mean iPMI in men and females were, respectively, 0.24mm and 0.29mm, 0.22mm and 0.26. The P values for the sPMI, iPMI, and MCW parameters were, respectively, 0.084, 0.020, and 0.001 and were all significant.

**Conclusion:** After evaluating all the data, it can be said that radio morphometric indices PMI and MCW or MI may be trusted to accurately measure bone mineral density. Nevertheless, due to the paucity of studies, PMI and MCW results for assessing sexual dimorphism may differ.

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## 1. Introduction

Bone remodelling is a normal process in which it constantly changes as a result of ongoing resorption and formation.

In this process, the total bone mineral density (BMD) is maintained as the old bone is removed and new bone is produced. BMD declines in older persons as a result of an increase in bone resorption relative to bone production. The resorption rate is significantly greater and BMD declines in postmenopausal women. Resorption causes osteopenia,

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which develops into osteoporosis over a longer period of time. BMD is a gauge that is often used to quantify bone mass in  $\text{mg}/\text{cm}^2$  at a particular location.<sup>1,2</sup>

"Disease characterised by low bone mass and micro architectural degeneration of bone tissue, resulting to heightened bone fragility and a corresponding increase in fracture risk" is how osteoporosis is defined. Age and gender are the two physiological elements that control osteoporosis the most. Several variables affect the prognosis of osteoporosis.<sup>2,3</sup>

Osteoporosis may be shown in many different areas of the human body, but as dental professionals, we are particularly interested in the mandible as a diagnostic region. The quantity and quality of the jawbones are crucial factors in dental treatment and treatment outcomes. By evaluating the BMD, osteoporosis, or osteopenia in various places, such as the inferior cortex of the mandible, cortical width of the mandible, and so forth, in an orthopantomogram, we can determine the quality and amount of jaw bone.<sup>1,4</sup>

Human identification is a crucial goal in forensic science. The sick person can be positively identified via dental identification. The panoramic radiograph is an important technique to identify the victims in mass murder and catastrophe victim identification. We can identify the victim by examining different orofacial regions in panoramic radiography. The victim's gender must first be determined in order to identify the victim. The sexual dimorphism in an orthopantomogram may be evaluated in a number of ways, including by measuring the mandible's length and the cortical bone's breadth.<sup>4</sup>

To identify osteoporosis, osteopenia, or to compare them to sexual dimorphism, a variety of radiomorphometric indices including the panoramic mandibular index (PMI), mental index (MI), gonion index (GI), antigonial index (AI), and mandibular cortical index (MCI) are utilised. The PMI is the ratio of the mandibular cortex's thickness to the distance between the inferior mandibular cortex and the mental foramen.<sup>5,6</sup>

Nevertheless, the gold standard for BMD measurement is the dual energy x ray absorptiometry (DXA) scan. The DXA scanner generates both high- and low-energy x-rays, and it detects how many of these penetrate the bone. It computes the difference between the bone's absorption of high- and low-energy x-rays. The World Health Organization (W.H.O.) has established certain standards for determining bone density.<sup>7</sup> To identify the normal, osteoporosis, and osteoporosis in humans, it advises calculating the T-score. The T-score is determined by comparing the patient's measured BMD to the mean BMD in young adults, which is then compared to the standard deviation of the young adult population. T -1.0, -2.5, T -1.0, and T -2.5, respectively, stand for osteopenia, osteoporosis, and normal.<sup>7,8</sup>

## 2. Materials and Methods

This study was authorised by the institution's research ethics committee. For the study, 100 patients (50 men and 50 women) who visited Teerthankar Mahaveer Dental College's department of oral medicine and radiology were randomly chosen. The age range was taken to be 50–78 years old, with a mean age of 59.45. The patients were first informed of the significance and necessity of the research and given the instruction to remove all artificial items, such as dentures, ear rings, and hair bands, from the head and neck region prior to the scans. The patients' informed permission was gained for the same.

### 2.1. Inclusion criteria were

1. A Individual above the age of 50
2. After menopause (after 12 months of amenorrhea with no obvious pathology)
3. Women who have never had a hysterectomy or an oophorectomy

### 2.2. Exclusion criteria were

1. Those who smoke, drink, or have any systemic illness that can affect the bones
2. Pathologies, such as cysts and tumours, altered the jawbones

The study's objectives were to identify sexual dimorphism and use the panoramic mandibular index and mandibular cortical width or mental index as screening tools for BMD evaluation. Gender identification and osteoporosis risk assessment were the main goals of the study.

All of the patients had orthopantomograms using radiation protection techniques (Planmeca Proline XC, Finland). According to patient-related criteria, 68-72 kVp and 7 mA were chosen, with a total filtration of 2.5 mm Al. The Planmeca Romexis programme then obtained the OPGs while taking the patient's information into account, and the Sidexis 4 software evaluated them. To ensure a more accurate assessment, the three oral medicine and radiology professionals worked under identical circumstances.

All the measurements were done in the Sidexis 4 software. Following measurements were calculated-

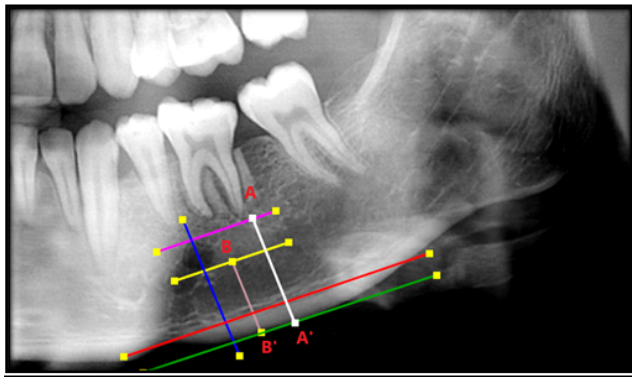
1. Superior Length (SL) - SL is the distance between the superior margin of the mental foramen and the inferior border of mandible. In figure 1. A-A' represents the SL.
2. Inferior Length (IL) – IL is the distance between inferior margin of the mental foramen and the inferior border of the mandible. In figure 1. B-B' represents the IL.
3. Mandibular cortical width (MCW) or mental index (MI) - First described by Ledgerton et al.<sup>3</sup> A perpendicular line was traced which passes through the center of mental foramen to the lower border of

mandible tangentially. In figure 2. C-C' represents the MCW.

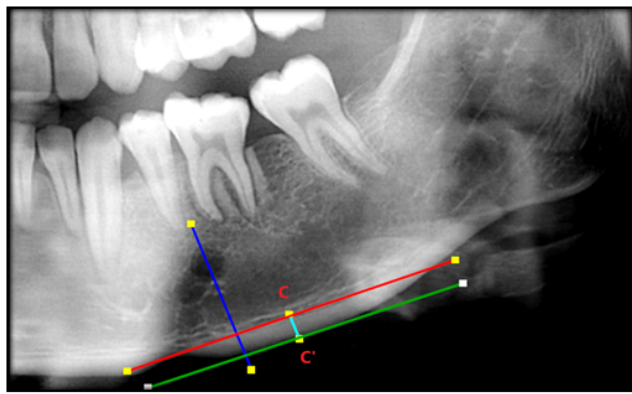
After the measurements of these three distances, PMI was calculated. It was first described by Benson et al in 1991.<sup>1-3</sup>

1. Superior PMI (sPMI = MCW/SL or MI/SL)
2. Inferior PMI (iPMI = MCW/IL or MI/IL)

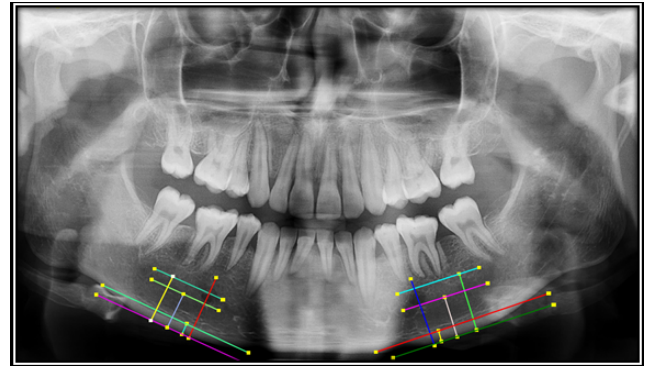
The bone density may vary due to the varying occlusal stresses in both sides, thus all measures were computed bilaterally in the OPGs. The mean values of the subjects' right and left sides were then subjected to statistical analysis using the t-test. One of the observers recorded all the information gathered from each patient and entered it into an unique pro forma created just for the research (Table 1 & 2). The Pearson's correlation was used to gauge the observers' level of accuracy. There was a substantial correlation coefficient.



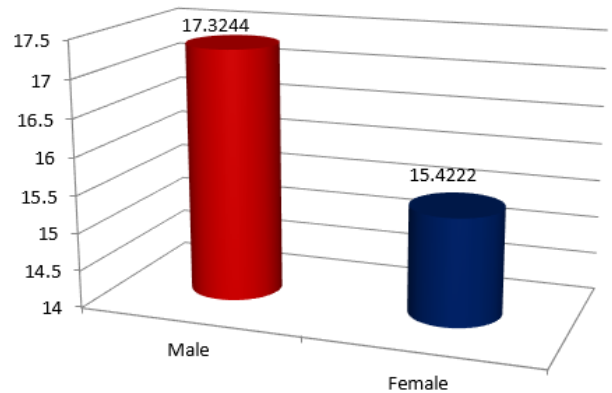
**Figure 1:** SL is the distance between the inferior border of the mandible and the superior margin of the mental foramen. A-A' stands for the SL. The inferior edge of the mental foramen and the inferior border of the mandible are separated by the distance IL. B-B stands for the IL.



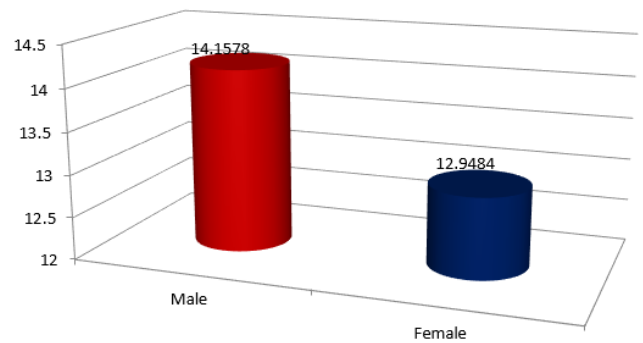
**Figure 2:** MCW or MI are represented by C-C'.



**Figure 3:** All of the individuals' SL, IL, and MCW or MI were measured bilaterally in this way, and the mean value was computed.



Graph 1:



Graph 2:

**Table 1:**

Sample No.	Sex	Age (Years)	Mean SL Of Left & Right (mm)	Mean IL Of Left & Right (mm)	Mean MCW or MI Of Left & Right (mm)	sPMI = MCW or MI/SL Mean of Left & Right (mm)	iPMI = MCW or MI/IL Mean of Left & Right (mm)
1.	Male	50	20.13	16.90	5.11	0.25	0.30
2.	Male	50	19.25	16.82	4.91	0.25	0.29
3.	Male	50	19	16.71	2.44	0.12	0.14
4.	Male	51	18.47	15	3.95	0.21	0.26
5.	Male	51	17.67	15.11	4.78	0.27	0.31
6.	Male	52	18.56	16	5.09	0.27	0.31
7.	Male	52	19.12	16.21	3.99	0.20	0.24
8.	Male	53	20.49	16.25	3.67	0.17	0.22
9.	Male	53	21.38	16.01	3.56	0.16	0.22
10.	Male	53	16.09	14	4.91	0.30	0.35
11.	Male	53	17.22	14.11	5	0.29	0.35
12.	Male	54	17.34	13	4	0.23	0.30
13.	Male	54	16.05	13.89	3.82	0.23	0.27
14.	Male	54	17.65	13.41	2.99	0.16	0.22
15.	Male	55	15.76	12.55	3.11	0.19	0.24
16.	Male	55	16.77	13.80	2.43	0.14	0.17
17.	Male	55	18.59	13.31	3.92	0.21	0.29
18.	Male	55	19.43	14.01	4.33	0.22	0.30
19.	Male	55	15.66	12.11	3.98	0.25	0.32
20.	Male	55	14.76	12	4.90	0.33	0.40
21.	Male	55	14.90	11	2.13	0.14	0.19
22.	Male	55	16.08	12.97	3.22	0.20	0.24
23.	Male	55	16	12.98	3.45	0.21	0.26
24.	Male	55	17.46	14	4.01	0.22	0.28
25.	Male	56	16.55	13.01	3.44	0.20	0.26
26.	Male	56	16.33	13.97	4.33	0.26	0.30
27.	Male	57	15.91	12	5	0.31	0.41
28.	Male	57	14.61	12	4.99	0.34	0.41
29.	Male	57	17.87	14.95	4.97	0.27	0.33
30.	Male	57	16.04	14	3.98	0.24	0.28
31.	Male	57	16	13.39	4.15	0.25	0.30
32.	Male	58	17.91	14.91	4.54	0.25	0.30
33.	Male	58	18	15.21	5.11	0.28	0.33
34.	Male	58	16	13.05	4.91	0.30	0.37
35.	Male	59	15	12.46	3.42	0.22	0.27
36.	Male	59	15.77	12.22	4.22	0.26	0.34
37.	Male	59	17.34	14.56	3.19	0.18	0.21
38.	Male	59	17.09	14.78	5.21	0.30	0.35
39.	Male	59	16.97	14.99	4.19	0.24	0.27
40.	Male	60	16.74	14	5	0.29	0.35
41.	Male	60	16.91	13.92	4.97	0.29	0.35
42.	Male	60	16.84	14.02	4.32	0.25	0.30
43.	Male	60	17.40	15	3.99	0.22	0.26
44.	Male	61	21.02	17.92	5.11	0.24	0.28
45.	Male	61	19.81	16.22	5.36	0.27	0.33
46.	Male	65	19	15.22	5.98	0.31	0.39
47.	Male	66	18.87	14.67	4.99	0.26	0.34
48.	Male	67	16.44	13.02	4.89	0.29	0.37
49.	Male	67	15.97	13.25	3.99	0.24	0.30
50.	Male	68	16	13	4	0.25	0.30
		Mean Age = 56.82	Mean SL = 17.32	Mean IL = 14.15	Mean MCW or MI = 4.23	Mean sPMI = 0.24	Mean iPMI = 0.29

**Table 2:** sPMI& iPMI in females

S. No.	Sex	Age (Years)	Mean SL Of Left & Right (mm)	Mean IL Of Left & Right (mm)	Mean MCW or MI Of Left & Right (mm)	sPMI = MCW or MI/SL Mean of Left & Right (mm)	iPMI = MCW or MI/IL Mean of Left & Right (mm)
1.	Female	50	16.06	14.22	3.33	0.20	0.23
2.	Female	50	14.04	11.98	4	0.28	0.33
3.	Female	50	16.44	13.23	4.11	0.25	0.31
4.	Female	51	14.22	11.98	2.65	0.18	0.22
5.	Female	51	13.99	11.99	3.54	0.25	0.29
6.	Female	52	14.77	12.11	4.44	0.30	0.36
7.	Female	52	15.23	12.98	4.89	0.32	0.37
8.	Female	53	15	12.56	3.98	0.26	0.31
9.	Female	54	16	13.98	4.56	0.28	0.32
10.	Female	54	14.87	12.11	4.32	0.29	0.35
11.	Female	55	15.33	12.98	4.65	0.30	0.35
12.	Female	56	16.22	14.11	3.98	0.24	0.28
13.	Female	56	17.32	15	4.09	0.23	0.27
14.	Female	56	14.11	12	2.43	0.17	0.20
15.	Female	56	15.09	12.22	3.54	0.23	0.28
16.	Female	56	15.34	12	3.51	0.22	0.29
17.	Female	56	16.99	14	5.44	0.32	0.38
18.	Female	57	17	14.53	5	0.29	0.34
19.	Female	57	16.43	13.98	4.45	0.27	0.31
20.	Female	58	13.39	12.98	3.23	0.24	0.24
21.	Female	58	14.34	12.33	3.29	0.22	0.26
22.	Female	58	15.09	13.21	4.93	0.32	0.37
23.	Female	59	15.99	13	4	0.25	0.30
24.	Female	60	16.43	14.76	3	0.18	0.20
25.	Female	60	16.65	14.34	2.33	0.13	0.16
26.	Female	61	15.77	12.32	1.54	0.09	0.12
27.	Female	62	15.33	12	3.04	0.19	0.25
28.	Female	63	15.97	14.1	4.21	0.26	0.29
29.	Female	64	14.99	12.44	4.44	0.29	0.35
30.	Female	65	15.34	12	3.54	0.23	0.29
31.	Female	66	16.42	14.44	3.56	0.21	0.24
32.	Female	66	18.43	16	3.15	0.17	0.19
33.	Female	67	14.55	12	2.50	0.17	0.20
34.	Female	67	15.97	13	4.20	0.26	0.32
35.	Female	68	15.56	12	4.01	0.25	0.33
36.	Female	68	15.44	12.22	3.98	0.25	0.32
37.	Female	68	15.01	12.97	4.33	0.28	0.33
38.	Female	69	15.34	13.33	2.11	0.13	0.15
39.	Female	70	16.78	15	1.34	0.07	0.08
40.	Female	70	14.44	11.98	1.90	0.13	0.15
41.	Female	71	14.54	12.49	2.21	0.15	0.17
42.	Female	71	13.53	11	2.44	0.18	0.22
43.	Female	71	15.98	13.30	2.58	0.16	0.19
44.	Female	72	14.54	12.65	2.65	0.18	0.20
45.	Female	72	14.37	11	2.98	0.20	0.27
46.	Female	73	16.65	14.08	4.79	0.28	0.34
47.	Female	74	15.29	13.09	3.95	0.25	0.30
48.	Female	75	15.99	12.44	3.70	0.23	0.29
49.	Female	78	14.56	11.98	1.56	0.10	0.13
50.	Female	78	13.98	11.01	1.32	0.09	0.11
		Mean Age = 62.08	Mean SL = 15.45	Mean IL = 12.94	Mean MCW or MI = 3.89	Mean sPMI = 0.22	Mean iPMI = 0.26

**Table 3:** Meanage of the study subjects

Age_Years	100	Minimum	Maximum	Mean	Std. Deviation
		50.00	78.00	59.4500	7.02287

**Table 4:** Sexualdimorphism in SL parametre

	Sex		Mean	Std. Deviation	Std. Error Mean	T value	P value
SL	Male	50	17.3244	1.64755	.23300	6.478	0.001 (Sig)
	Female	50	15.4222	1.05358	.14900		

**Table 5:** Sexual dimorphism in IL plane

	Sex		Mean	Std. Deviation	Std. Error Mean	T value	P value
IL	Male	50	14.1578	1.51185	.21381	4.531	0.001 (Sig)
	Female	50	12.9484	1.12989	.15979		

**Table 6:** Sexualdimorphism in MCW parameter

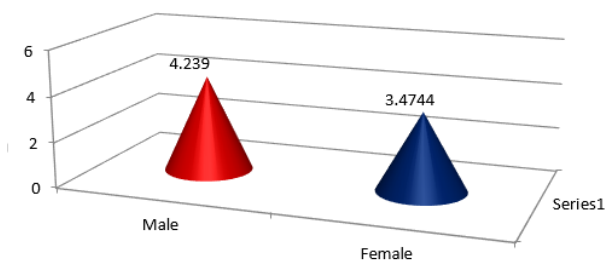
	Sex		Mean	Std. Deviation	Std. Error Mean	T value	P value
MCW	Male	50	4.2390	.83651	.11830	4.060	0.001 (Sig)
	Female	50	3.4744	1.03632	.14656		

**Table 7:** Sexualdimorphism in sPMI parametre

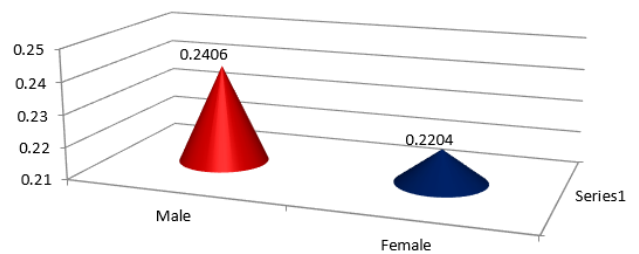
	Sex		Mean	Std. Deviation	Std. Error Mean	T value	P value
spmi	Male	50	.2406	.05016	.00709	1.445	0.084 (Sig)
	Female	50	.2204	.06468	.00915		

**Table 8:** Sexualdimorphism in iPMI parametre

	Sex		Mean	Std. Deviation	Std. Error Mean	T value	P value
ipmi	Male	50	.2954	.05946	.00841	2.357	0.020 (Sig)
	Female	50	.2630	.07691	.01088		



Graph 3:

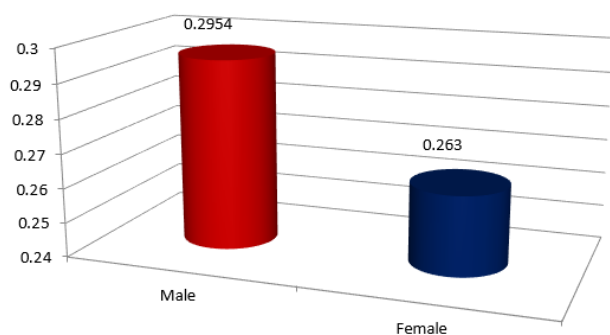


Graph 4:

**3. Result**

The average age was 56.82 years for men and 62.08 years for women. The average SL, IL, and MCW in men were 17.32mm, 14.15mm, and 4.23mm, respectively. The mean

sPMI and iPMI for men were subsequently determined to be 0.24 and 0.29, respectively. Females’ respective mean SL, IL, and MCW measurements were 15.45mm, 12.94mm, and 3.98mm. The mean sPMI and iPMI for females were afterwards 0.22 and 0.26, respectively. (Tables 1 and 2)



**Figure 4:**

The 100 research participants had an average age of 59.45 years. The age-related standard deviation (SD) was 7.02287. (Table 3). Males had greater mean SL and IL than females, with mean differences of 1.90 and 1.20, respectively, and these differences were statistically significant (Tables 4 and 5). Males also had greater mean MCW or MI than females, with a statistically significant mean difference of 0.80. (Table 6). Males had slightly higher mean sPMI and iPMI scores than females, respectively, with mean differences of 0.02 and 0.03 that were statistically significant (Tables 7 and 8).

#### 4. Discussion

Sex hormones like testosterone and oestrogen in males and females, respectively, promote bone formation.<sup>8</sup> Males and females attain their peak bone mass at ages 40 and 30 and 35, respectively. Certain cytokines induce osteoclastic activity of bone, whereas oestrogen inhibits this action, avoiding osteoporosis.<sup>9</sup> Parathyroid hormones will boost osteoclastic activity when oestrogen levels fall. As oestrogen levels fall, calcium absorption also suffers, which in turn has an impact on vitamin D production.<sup>8,9</sup> The PMI was initially suggested as a radiomorphometric technique by Benson et al in 1991. They proposed that the distance between the inferior border of the mandible and the mental foramen remained mostly consistent throughout life.<sup>9,10</sup> It is partially based on the approach recommended by Wical and Swoope for determining the relationship between mandibular height below the inferior margin of the mental foramen and residual ridge resorption (RRR). The PMI evaluation process is a straightforward process. Finding the boundaries of the mental foramina in certain cases was the only challenge in this investigation. In this study, the mean of the bilateral measures was computed.[11-12,22]<sup>11,12</sup>

Male and female sPMI and iPMI in this study were 0.24 and 0.29 and 0.22 and 0.26, respectively, with a mean difference of 0.02 and 0.03 that was comparable to the study carried out in the American population by Benson et al.<sup>1,6,8</sup>

(Mean PMI- 0.31-0.35 in males and 0.25-0.26 in females). In the Indian population, Bertha et al. found a similar finding (mean PMI 0.28–0.36 for women and 0.30–0.38 for men). In their studies of the Indian population, Rao et al.<sup>16</sup> and Khaitan et al.<sup>1</sup> similarly obtained comparable results: the mean PMI in men and females was 0.26-0.28, while the mean sPMI and iPMI in males and females, respectively, were 0.23-0.27 and 0.29-0.35.

Similar in our study, the majority of recent research indicates that men have a wider range of PMI (sPMI and iPMI) than women. The greater risk category for osteoporosis can thus be ruled out using the radiomorphometric index (PMI). Women who have recently had menopause are at a greater risk than males of same age for developing decreased BMD.

A cortical width of 3 mm was deemed to be the ideal criterion for referral for bone densitometry by Devlin and Horner.<sup>13-15</sup> The results of our present study's MCW in males and females were 4.23 and 3.98, respectively. This was comparable to the outcome of the study by Khaitan et al.<sup>1</sup> (3.96-4.71 in males and 3.86-4.54 in females). Similar results to those of our current study (3.928 in males and 3.155 in females) were noted by Hardanti et al. White et al.,<sup>1,14</sup> and Klemetti et al.<sup>16-19</sup> both agreed that MCW is more appropriate in the mid-4mm range.

The sPMI and iPMI were evaluated for both the groups (0.24 and 0.29 for men and 0.22 and 0.26 for females, respectively), in order to evaluate sexual dimorphism. In the present study, we discovered that the mean sPMI and iPMI were statistically significantly greater in men than in women. Kalinowskiet al.<sup>16,17,19</sup> discovered a comparable outcome.

In our research, the mean SL and IL were found to be greater in men than in females (17.32 and 14.15 for males and 15.45 and 12.94 for females, respectively), which was in accordance with the results of Khaitan et al.<sup>1,18</sup>

All of the study's metrics, including SL, IL, PMI, MCW, and MI, produce statistically significant results when assessing sexual dimorphism.

#### 5. Limitations

For the purposes of evaluating BMD and sexual dimorphism, this study does not represent any particular age or racial group. Our sample size was modest, thus bigger population groupings may have different results. We only evaluated age groups above 50 to identify sexual dimorphism, although it may differ in younger years.

#### 6. Conclusion

After evaluating all the data, it can be said that radio morphometric indices PMI and MCW or MI may be trusted to accurately measure bone mineral density. Nevertheless, due to the paucity of studies, PMI and MCW results

for assessing sexual dimorphism may differ. Nonetheless, in the current investigation, we were able to evaluate sexual dimorphism using PMI and MCW results that were statistically significant.

## 7. Ethical Clearance

Taken from university ethical committee for research.

## 8. Source of Funding

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## 9. Conflict of Interest

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