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Original Research Article

Comparative Study of DEXA and 1.5 Tesla MRI in Quantitative Estimation of Bone Mineral Density in Lumbar Spine

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ABSTRACT

Background- DEXA scan is gold standard tool according to WHO for evaluation of BMD but it emits ionizing radiation so it is harmful for patient and role of advance MRI imaging technique demonstrating evaluation of BMD for osteoporotic and osteopenic changes with no radiation.
Aim and Objectives– To determine the importance of DEXA and 1.5 Tesla MRI in qualitative estimation of bone mineral density in lumbar spine. The study described the correlation between the BMD and T-Score of DEXA, with MRI, T1 and T2 values
Material and method- 50 subjects underwent both DEXA and conventional MRI. T1 and T2 signal intensity values were compared with BMD and T score of DEXA scan of L3 vertebral body
Result- Both T1 and T2 signal intensities tended to increase with reducing BMD and T score.
Conclusion- An inverse relationship between BMD and T score of DEXA were found with T1 and T2 signal intensity of MRI
1.5 Tesla M.R.I can be used to evaluate bone mineral density. Since M.R.I does not use any ionizing radiation, thus it has advantage over DEXA in assessment of bone mineral density.
Keywords: DEXA, MRI, Bone Mineral Density, BMD, Lumbar Spine

INTRODUCTION

Osteoporosis, the most common of all metabolic bone disorders, is defined by the World Health Organization (WHO) as "a skeletal disease, characterized by low bone mass and micro-architectural deterioration of bone tissue, with a consequent increase in bone fragility and susceptibility to fracture".[1] (Guglielmi G, 2011)

1.1 Classification of osteoporosis

Osteoporosis can be classified into two basic forms:

1. **Primary osteoporosis:-** It is also known as involutional osteoporosis, results from cumulative bone loss as people age and undergo hormonal changes. It is further divided into two subgroups:-
   a) **Type I (Postmenopausal) Osteoporosis:-** Type I osteoporosis occurs in a group of postmenopausal women, typically between 50 and 65 years of age, this type of osteoporosis occurs due to accelerated trabecular bone resorption related to estrogen deficiency. The most common characteristic fracture pattern in this group of women involves the spine and wrist.

b) **Type II (Senile) Osteoporosis:-** Senile osteoporosis, occurs due to proportionate loss of cortical and trabecular bone. The most common characteristic fracture pattern includes hip, proximal humerus, tibia and pelvis (Sawyer AJ, 1993).[2]

2. **Secondary Osteoporosis:-** It results from various medical conditions or diseases, or from the use of certain medications that adversely affect skeletal health.

Bone is a highly metabolic tissue, performing multiple functions such as stabilization of the body, protection of the inner organs, and calcium storage. It is a composite tissue, mainly consisting of type I collagen (40%), hydroxyapatite (45%) and water (15%). On a structural level, it is built up by trabecular bone and cortical bone. Trabecular bone is a combination of rods and plates within a cortex of variable thickness. Bone constantly models and remodels in young individuals. This process is vital for bone health because it repairs micro fractures which result from repeated stresses by removing old bone and forming new bone. At a cellular level, the bone remodeling unit is composed of osteoblasts, which form bone, and osteoclasts, which break down bone (Blake GM, 1997).[3]

Dual energy X ray absorptiometry (DEXA) is an X ray imaging technique primarily used to derive the mass of one material in the presence of another through knowledge of their unique X-ray attenuation at different energies. DEXA is an extremely accurate and precise method for quantifying bone mineral density (BMD) and mass body composition assessment. (Pooley RA, 2005). [4]

1.2 HISTORY

1.2.1 Development of DEXA

Early attempts at bone densitometry used conventional x-rays with a step wedge made from an aluminum or ivory phantom included in the field of view as a means of calibration. The bone density was calculated by a visual comparison of the density of the bone and the known densities of the each of the steps on the phantom (Blake GM, 1997), (Guglielmi.G, 2012).[3,5]

This process allowed the calculation of the amount of bone tissue in the region scanned by means of subtraction of the photons attenuated by the soft tissue from the photons attenuated by bone and soft tissue. This technique proved to be very useful in terms of bone quantification, but it was limited to a peripheral site.

Dual-photon absorptiometry (DPA) provides the simultaneous transmission of gamma rays with photon energies of 44 keV and 100 keV from gadolinium-153. Algebraic equations used to derive Estimates of bone and soft tissue.

It was very helpful to measure bone density at axial sites (i.e., the spine or hip) in which the soft tissue is of variable thickness, & which was not possible in SPA.

Since the late 1980s, the expensive and potentially hazardous radioactive sources used in both SPA and DPA have been superseded by single x-ray absorptiometry (SXA) and dual-energy x-ray absorptiometry (DEXA). Similarly to DPA, the fundamental principle of DEXA is the measurement of the transmission of x-rays, produced from a stable x-ray source, at high and low energies. (Nouh MR, 2015)[3,5,6]

The introduction of DEXA is very advantageous by using x-rays instead of SPA or DPA include a shorter acquisition time and improved accuracy and precision as a result of the increased photon flux.

1.3 Principles of DEXA

The fundamental principle of DEXA is the measurement of transmission of x-rays with high- and low-energy photons through the body. DEXA is a projectional technique in which three-dimensional objects are analyzed as two-dimensional. The x-rays used in diagnostic imaging and

densitometry must have sufficient energy to pass through the body and still be detectable by sensors after passage. The extent of attenuation varies with the energy of the photons and the density and thickness of the material through which they pass. Attenuation will follow an exponential pattern often observed in other biological situations (Khairi.MR, 1975).[3,7]

Bone mineral density (BMD) is defined as accumulation of mineral (calcium hydroxyapatite) per unit of bone. It is a measure of the amount of minerals (mostly calcium & phosphorous) contained in a certain volume of bone.

Bone mineral density measurements are used to diagnose osteoporosis (a condition marked by decreased bone mass), to see how well osteoporosis treatments are working, and to predict how likely the bones are to break (Madsen M, 1976).[7,8]

According to World Health Organization, the gold standard for diagnosis and assessment of osteoporosis is the evaluation of BMD by using dual-energy X-ray absorptiometry (DEXA).

The T-score is defined as the number of standard deviations the patient's BMD is above or below the sex-matched mean reference value of young adults. The T-score thus provides a comparison of the patient's BMD to the mean peak bone mass The T-score is calculated by taking the difference between a patients's measured BMD and the mean BMD of healthy young adults, matched for gender and ethnic group, and expressing the difference relative to the young adult population SD (Nuti. R, 1991), (Cummings SR, 1993)[10,11]

$$\text{T-score} = \frac{\text{Measured BMD - young adult mean BMD}}{\text{Young adult SD.}}$$

Therefore, a T-score result indicates the difference between the patients's BMD and the ideal peak bone mass achieved by a young adult.

In addition to the T-score, another useful way of expressing BMD measurements is in Z-score.

The Z-score is defined as the number of standard deviations the patient's BMD is above or below the sex-matched mean reference value for individuals of the same gender and age. The Z-score, therefore, enables a comparison of the patient's BMD to individuals of the same age.[3]

$$\text{Z-score} = \frac{\text{Measured BMD - age-matched mean BMD}}{\text{Age - matched SD.}}$$

1.4 History of MRI

MRI (an abbreviation of **magnetic resonance imaging**) is an imaging modality that uses non-ionizing radiation to create useful diagnostic images. The "Nuclear" was dropped off about 25 years ago because of fears that people would think there was something radioactive involved, which there is not.

NMR was discovered simultaneously by two physicists, Felix Bloch and Edward Mills Purcell, just after the end of World War II They received the Nobel Prize in Physics in 1952 for this discovery.

MRI, the use of NMR to produce 2D images was accomplished by Paul Lauterbur, imaging water, and Sir Peter Mansfield who imaged the fingers of a research student, Dr Andrew Maudsley in 1976. Maudsley continues to make a significant contribution to MRI R&D today[4]. "Raymond Damadian" obtained human images a year later in 1977. "Lauterbur" and "Mansfield" received the Nobel Prize in Physiology or Medicine in 2003 for their development of MRI. (Jenkins.JPR, 1899)[9]

An MRI scanner consists of a large, powerful magnet in which the patient lies. Imaging of almost any part of your body can be obtained in any plane (Yeung DK, 2004), (Hatipoglu HG,2007).[12,13]

Magnetic Resonance (MR) is the best noninvasive imaging modality to evaluate vertebral bone marrow because of its inherent soft-tissue contrast and non-ionizing nature. Conventional sequences used basically to image marrow include T1W, fat-suppressed T2W and short tau inversion recovery (STIR) imaging provides

gross morphological data. The spine is the largest store of bone marrow in the body. Osteoporosis is associated with an even greater increase in marrow fat content. In the third lumbar vertebral body, for example, post-menopausal subjects with normal bone mineral density (BMD) have less marrow fat content than subjects with osteopenia. Similarly, subjects with osteopenia have less marrow fat content than those with osteoporosis (Fanucci E, 2007), (Fan. B, 2010).[5,14,15]

1.5 Routine MR sequences for spinal bone marrow imaging

1.5.1 T1-weighted imaging:

Both red and fat marrows contain lipid and water with various proportions. The red marrow appears as low signal due to its higher water content on T1W images yet it has to be higher than that of intervertebral discs and paraspinal muscles. On another hand, a high lipid content of yellow marrow returns high signal intensity comparable to that of subcutaneous fat on T1W images. This makes T1W the money's worth sequence of MR screening of bone marrow (Agrawal K, 2015)[18]

1.5.2 T2-weighted imaging

The signal returning from both water and fat are high yet signal returning from red marrow is slightly lower than that of yellow marrow. So, the ability of T2-sequence to differentiate marrow hyperplasia from marrow lesions is limited without the use of fat suppression especially on the fast spin echo (FSE) acquisitions.

MATERIALS & METHODS

The present study was designed to determine the importance of **DEXA and 1.5 Tesla MRI in quantitative estimation of bone mineral density in lumbar spine.** The study described the correlation between the Dexa BMD, T-Score with T1 and T2 values.

2.1 STUDY DESIGN

A controlled cross-sectional study was conducted.

2.2 SAMPLE SELECTION

The present study was performed on 50 patients within period of 4 months from January 2018 – April 2018 with clinical symptoms of low back pain in Department of Radiology of Shri Guru Gobind Singh Tricentanary Hospital (SGT) having age between 25 – 75 years. The data was collected from the patients referred from the Department of Orthopedic, Shri Guru Gobind Singh Tricentenary Medical College (SGT) Budhera, Gurgaon, Haryana. Data were anonymized after the examination and analyzed for the purpose of a controlled cross-sectional design.

According to their T scores results and World Health Organization criteria, the patients were categorized into three groups:

1. Normal (T >-1)
2. Osteopenia (T = -1 to – 2.5)
3. Osteoporosis (T<-2.5)

The selection of the patients were done on the basis of following inclusion and exclusion criteria and designated as sample (Pinheiro MM,2010) (Ganda K, 2014).[16,17] Sample charts are attached as annexure ii.

2.3 INCLUSION CRITERIA:

All the patient reporting with undetermined backache in the age group of 25 -75 years. No history of spine, hip, or pelvic disease or pathology.

2.4 EXCLUSION CRITERIA:

1. Patient with a known pre-existing bone disease such as tumor, metastasis, or metabolic disorder
2. Any history of traumatic spinal injury.
3. The patient on drug therapy that may affect BMD were not included to the study
4. Any radiological evidence of spondylitis confirmed by radiological features.
5. Any history of previous operation or radiotherapy.

2.5 PARAMETERS STUDIED:

This study has patients who had suffered from low back pain. A total of 4 parametric variables were studied. They were obtained from the Dexa and MRI of normal

population in department of radiology of SGT Hospital and of low backache patients.

2.6 METHODS OF DATA COLLECTION

DEXA was used to measure the bone mineral density (BMD) and on the basis of the T–score, the 50 subjects were categorized into three subgroups: normal 12 (34%), osteopenic 13 (36%) and osteoporotic 25 (30%). Significant differences were observed in the bone mineral density among these three subgroups: normal subjects had a BMD between 0.938 to 1.307 g/cm^2 and osteopenic subjects between 0.689 to 0.966 g/cm^2 whereas osteoporotic subjects had a BMD between 0.621 to 0.758 g/cm^2.

All examinations were performed on a 1.5T whole body MR imaging system (Multiva; Philips) using a spinal array surface coil. Sagittal Tl and T2 weighted imaging of the lumbar spine were acquired. T1-weighted images were acquired by using a fast spin-echo sequence (TR, 575 msec; TE,8 msec ; section thickness, 4 mm; FOV, 301(AP) X 361(FH) X 66(RL) mm; matrix, 336X301 ; NEX, 1; slices, 15; gap, 0.4mm; fold over direction, FH; time of acquisition, 98 sec). T2- weighted images were obtained by using a fast spin-echo sequence (TR, 3275 ms; TE, 88 msec; section thickness, 4 mm; FOV, 30 mm; matrix, 336 X 192; NEX, 2 slices, 15; gap, 0.4mm; fold over direction, FH; time of acquisition, 194 sec). The mean and SD of the signal intensity

Values were measured from operator-defined regions of interest on T1, T2,Regions of interest (ROI) as circle of size 1 cm² were placed in the center of L3 vertebra (0.5 cm away from the periphery of vertebra to avoid the cortex). For each vertebral body, the region of interest was drawn manually on the images for quantitative measurement of the T1 and T2 value of the L3 vertebra, while T1 and T2 were expressed as SNR (Agrawal K,2015), (Kroger H, 2015), (Tawfeeq RHA, 2017).[18,19,20]

2.6.1 Measurement of DEXA T-Score and BMD

The bone density of the vertebral body was expressed as a T-Score-value measured by anterio-posterior projection DXA at L3 lumbar vertebra BMD data were obtained on a DEXA scanner (Discovery; Hologic, Bedford, Mass). The L1 through L4 vertebrae were scanned and measured in the antero-posterior direction. Subjects were positioned supine with the lower part of the legs elevated to reduce lordosis of the lumbar region. After completion of DEXA scanning, BMD (grams per square centimeter) as well as *t* and *z*-scores for individual lumbar vertebrae (L1–L4) were calculated by using the manufacturer software automatically on the basis of age- and sex-matched control participants.

2.6.2 Measurement of T1 and T2 Signal intensity value

The mean of the signal intensity values were measured from operator-defined regions of interest on T1, T2W images .Region of interest (ROI) as circle of size 1 cm² were placed in the center of L3 vertebra (0.5 cm away from the periphery of vertebra to avoid the cortex). For each vertebral body, the region of interest was drawn manually on the images for quantitative measurement of the T1 and T2 value of the L3 vertebra, while T1 and T2 were expressed as SNR.

The observations were recorded on a pre-designed performa and analyzed statistically.

Statistical procedures were carried out in following steps:

1. Data compilation and presentation
2. Statistical analysis

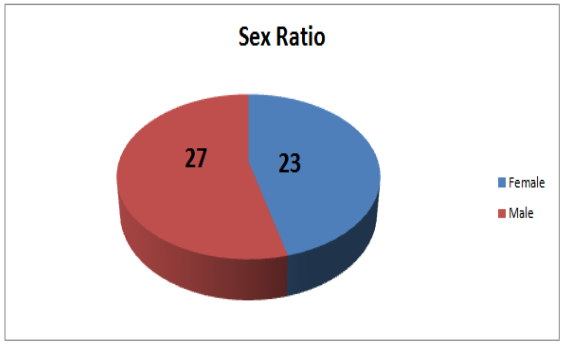
The data collected was compiled, tabulated, analyzed and subjected to statistical tests. Analysis was done using SPSS

RESULT

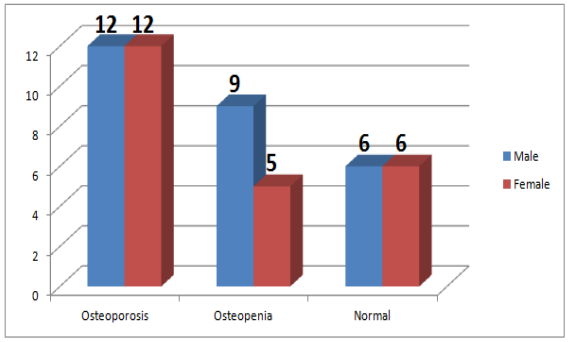
Demographical data-

Sex ratio-

In our study total 50 patient were evaluated out of which 27 were male 23 were female.



Graph 3.1: shows gender ratio of study



Graph 3.2: Shows gender ratio in osteoporosis and osteopenia

Table 3.1: No. Of patient distribution according to T score-

Normal (T > -1)	Osteopenia (T = -1 to -2.5)	Osteoporosis (T< -2.5)
12(34%)	13(36%)	25(30%)

Among the 50 patients, 25 patient were osteoporotic 13 patient were found to have osteopenia and rest of 12 were normal.

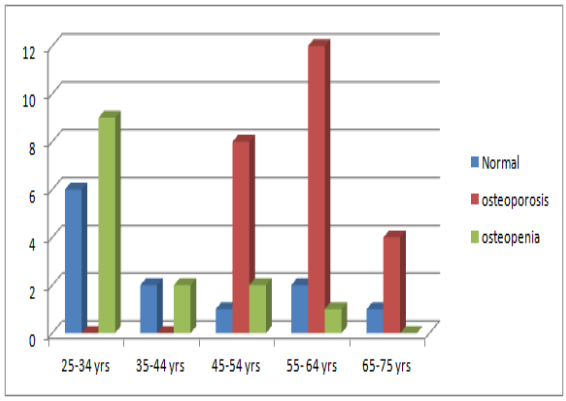
A total of 50 subject divided into 5 age group

- 25-34 yrs- According their T score 6 (40%) were normal, 9 (60%) were osteopenic and 0 osteoporotic were found.
- 35-44 yrs- According their T score 2 (50%) were normal, 2 (50%) were osteopenic and 0 osteoporotic were found.
- 45-54 yrs- According their T score 1 (9.09%) were normal, 2 (18.18%) were osteopenic and 8 (72.72%) osteoporotic were found.
- 55-64 yrs-- According their T score 2 (13.33%) were normal, 1 (6.66%) were osteopenic and 12 (80%) osteoporotic were found.
- 65-75yrs-- According their T score 1 (20%) were normal, 0 were osteopenic and 4 (80%) osteoporotic were found.

The data is tabulated as under table 3.2-

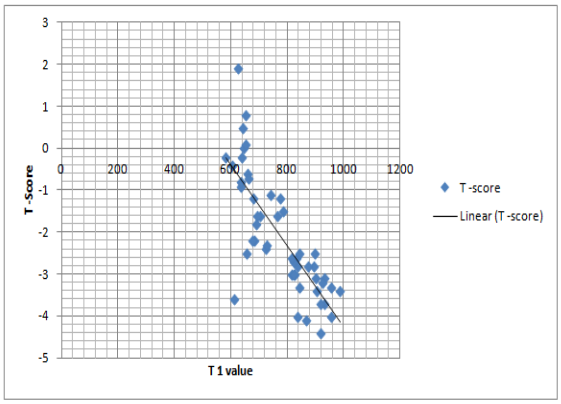
Age V/s T score	25-34 yrs.	35-44 yrs.	45-54 yrs.	55-64 yrs.	65-75 yrs.
Normal	6 (40%)	2 (50%)	1 (9.09%)	2 (13.33%)	1 (20%)
Osteoporosis	0	0	8 (72.72%)	12 (80%)	4 (80%)
Osteopenia	9 (60%)	2 (50%)	2 (18.18%)	1 (6.66%)	0

Table 3.2 : No. of patient of each age group correlated with their t score-

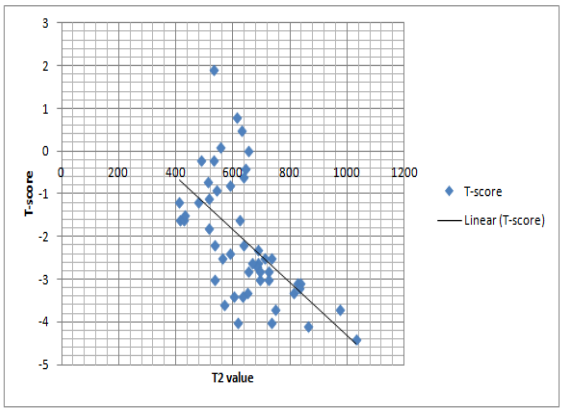


Graph 3.3: shows age group ratio with clinical findings in this survey

In this study found that there was a reverse linear relationship between T score and T1 value.T1 signal intensity tended to increase with reducing T score values with a statistical significance with a an r = -0.788 and $p < 0.000$.
This is illustrated with the help of scattered graph (graph 3.4)
In this study found that there was a reverse linear relationship between T score and T2 value.T2 signal intensity tended to increase with reducing T score values with a statistical significance with a an r = -0.580 and $p < 0.000$
This is illustrated with the help of scattered graph (graph 3.5)



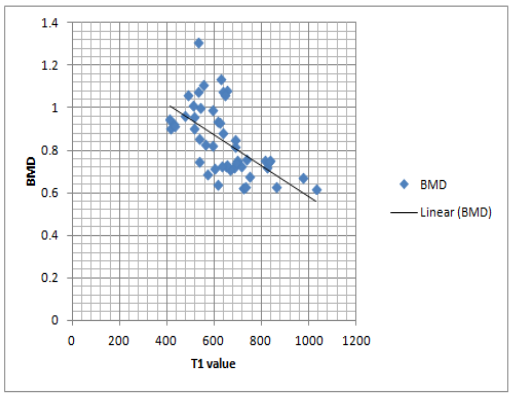
Graph 3.4: Scattered plot shows the relationship between T-score and T1 value at L3 vertebral body



Graph 3.5: Scattered plot shows the relationship between T-score and T2 value at L3 vertebral body

In this study found that there was a reverse linear relationship between BMD and T1 value.T1 signal intensity tended to increase with reducing T score values with a statistical significance with a an r = -0.788 and $p < 0.000$

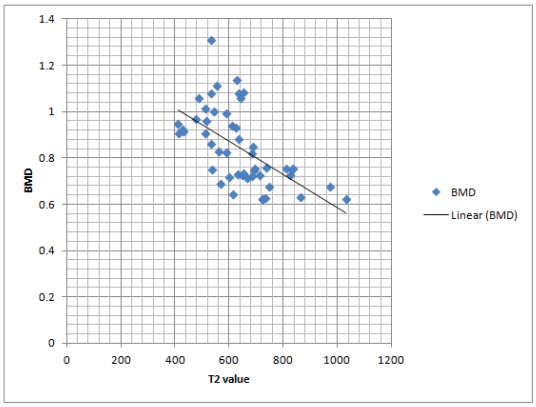
This is illustrated with the help of scattered graph (graph 3.6)



Graph3.6: Scattered plot shows the relationship between BMD and T1 value at L3 vertebral body

In this study found that there was a reverse linear relationship between BMD and T2 value.T2 signal intensity tended to increase with reducing T score values with a statistical significance with a an r = -0.590 and $p < 0.000$

This is illustrated with the help of scattered graph (graph 3.7)



Graph 3.7: Scattered plot shows the relationship between BMD and T2 value at L3 vertebral body

DISCUSSION

The present study was designed to determine the importance of **DEXA and 1.5 Tesla MRI in qualitative estimation of bone mineral density in lumbar spine.** The study described the correlation between the BMD, T-Score of DEXA with MRI T1 and T2 values.

It was a controlled cross sectional study the study includes total 50 subjects and divided into 3 groups according to WHO T score into Normal, osteoporosis and osteopenia. Subject selected from age group of 25-75 yrs. The Subjects were referred to us from orthopedic Department for evaluations of back pain were included in this study as per inclusion criteria. All radiological findings were carefully collected as per study and Pearson correlation test was applied to analyze subjective criteria of study.

A- Demographical Data-

i. Surveillance and outcome according to sex – In this present study 27 were male out of which 12 were affected with osteoporosis and 9 were affected with osteopenia and 23 female out of which 6 were normal, 12 were osteoporotic and 5 were osteopenic.

B- Subjective Criteria-

i Discussion on patient distribution according to T score- In the present study According to T score 34 % subject were normal, 25% osteoporotic and 36 % osteoporosis.

ii Discussion on no. of patient according to age group correlated with their T score- Total 50 subjects divided into 5 age group in which subjects of 25-34 yrs- Age group according their T score 6 (40%) were normal, 9 (60%) were osteopenic and 0 osteoporotic were found. 35-44 yrs- According their T score 2 (50%) were normal, 2 (50%) were osteopenic and 0 osteoporotic were found. 45-54 yrs- According their T score 1 (9.09%) were normal, 2 (18.18%) were osteopenic and 8 (72.72%) osteoporotic were found. 55-64 yrs-- According their T score 2 (13.33%) were normal, 1 (6.66%) were osteopenic and 12 (80%) osteoporotic were found. 65-75yrs-- According their T score 1 (20%) were normal, 0 were osteopenic and 4 (80%) osteoporotic were found.

iii Discussion on result of Relationship between T score and T 1 value-In this present study found that there is a reverse linear relationship between T score and T1 value. T1 signal intensity tended to increase with decrease of T score values with an $r = -0.788$, $p < 0.000$

iv Discussion on result of Relationship between T score and T 2 value-In this present study found that there is a reverse linear relationship between T score and T2 value. T2 signal intensity tended to increase with decrease of T score values with an $r = -0.580$, $p < 0.000$.

v Discussion on result of Relationship between BMD and T 1 value- In this present study found that there is a reverse linear relationship between BMD and T1 value. T1 signal intensity tended to increase with decrease of BMD values with an $r = -0.788$, $p < 0.000$.

vi Discussion on result of Relationship between BMD and T 2 value- In this present study found that there is a reverse linear relationship between BMD and; T2 value. T2 signal intensity tended to increase with decrease of BMD values with an $r = -0.590$, $p < 0.000$.

vii Limitation of study- In this present study was limited due to

1-BMD and T score of 4 lumber vertebra in a given subject would likely be highly Correlated.

2- MRI is a costly investigation as all subjects cannot afford it.

3- Present study did not standardize groups according to their body weight and body fat status this might bring controversies when assessing the T1 and T2 values.

CONCLUSION

- There is reverse correlation between T score and T1 value.
- There is reverse correlation between T score and T2 value.
- There is reverse correlation between BMD and T1 value.
- There is reverse correlation between BMD and T2 value.
- Thus 1.5 Tesla M.R.I can be used to evaluate bone mineral density. Since M.R.I does not use any ionizing radiation, thus it has advantage over DEXA in assessment of bone mineral density.

Abbreviations:

- DEXA- Dual Energy X-Ray Absorptiometry**,**
- BMD- Bone Mineral Density
- WHO- World Health Organisation
- SD- Standard Deviation
- MRI – Magnetic Resonance Imaging
- FSE- Fast Spin Echo
- DWI- Diffusion Weighted Imaging
- ADC- Apparent Diffusion Coefficient
- DTI- Diffusion Tensor Imaging

REFERENCES

1. Guglielmi G, Muscarella S, Bazzocchi A. Integrated imaging approach to osteoporosis: state of-the-art review and update. Radiographics. 2011 Sep-Oct; 31(5):1343-64.
2. Sawyer AJ, Bachrach LK, E. B. Fung. Bone Densitometry in Growing Patients:

Guidelines for Clinical Practice. Br J Radiol 1993; 66:902–906.
3. Blake GM, Fogelman I. Interpretation of bone densitometry studies. Semin Nucl Med.1997; 27:248–260. (z-score)
4. Pooley RA. AAPM/RSNA physics tutorial for residents: fundamental physics of MR imaging. Radiographics. 2005; 25 (4): 1087-99.
5. Guglielmi.G. Osteoporosis and Bone Densitometry Measurements, Medical Radiology. Diagnostic Imaging; 2012:614.
6. Nouh MR, Eid AF. Magnetic resonance imaging of the spinal marrow: Basic understanding of the normal marrow pattern and its variant. World J Radiol; 2015 December 28; 7(12): 448-458.
7. Khairi.MR, Johnston CC. The loss of bone mineral with aging and its relationship to risk of fracture. J Clin Invest. (1975); 56(2): 311–318.
8. Madsen M, Peppler W, Mazess RB. Vertebral and total body bone mineral content by dual photon absorptiometry. Calcif Tissue Res 1976; 21 Suppl: 361–364.
9. Jenkins. JPR,Stehli.GM. Sivewright.G, Hicky.DS, Hillier. VS, Isherwood.I. Quantitative magnetic resonance imaging of vertebral bodies: A T 1 and T 2 study. Rev Saude Publica. (1899); 44(3):379-85.
10. Nuti. R, Martini. G, Righi. G, Frediani. B, Turchetti.V. Comparison of total body measurements by dual-energy X-ray absorptiometry and dual-photon absorptiometry. JBMR (1991); 6(7) 681-687.
11. Cummings SR, Black DM, Nevitt MC, Browner W, Cauley J, Ensrud K. Bone density at various sites for prediction of hip fractures. The Study of Osteoporotic Fractures Research Group. Lancet. 1993; 341(8837):72-5.
12. Yeung DK, Wong SY, Griffith JF, Lau EM. Bone marrow diffusion in osteoporosis: evaluation with quantitative MR diffusion imaging. J Magn Reson Imaging. (2004); 19 (2):222-8.
13. Hatipoglu HG, Selvi A, Ciliz D, Yuksel E (2007) reported that Quantitative and Diffusion MR Imaging as a New Method To Assess Osteoporosis. AJNR Am J Neuroradiol (2007); 28:1934 –37.
14. Fanucci E, Manenti G, Masala S, Laviani F, Di Costanzo G, Ludovici A et al. Multiparameter characterisation of vertebral osteoporosis with 3-T MR. Radiol med ; (2007) :112.
15. Fan. B, Lu Y,Genant. H, Fuerst T, Shepherd J. Does standardized BMD still remove differences between Hologic and GE-Lunar state-of-the-art DXA systems? Osteoporos Int. (2010) 21:1227–123.
16. Pinheiro MM, Reis Neto ET, Machado FS, Omura F , Yang JH, Szejnfeld J et al. Risk factors for osteoporotic fractures and low bone density in pre and postmenopausal women. RevSaude Publica. (2010); 44(3): 479-85.
17. Ganda K, Nguyen TV, Pocock N. Gender disparity in BMD conversion: a comparison between Lunar and Hologic densitometers. Arch Osteoporos (2014) 9: 180.
18. Agrawal K, Agarwal Y, Chopra RK, Batra A, Chandra R ,Thukral BB. Evaluation of MR Spectroscopy and Diffusion-Weighted MRI in Postmenopausal Bone Strength. Cureus (2015); 7(9): e327. DOI 10.7759/cureus.327.
19. Kroger H, Vainio P, Nieminen. Estimation of spinal bone density using conventional MRI: Comparison between MRI and DXA in 32 subjects. Acta Orthopaedica Scandinavica; 2015:6, 532-534.
20. Tawfeeq RHA, Abdulazeez RAJ, Noori FA. Role of T1 Weighted and Diffusion Weighted Magnetic Resonance imaging application in the diagnosis of osteoporosis in lumbar spine in postmenopausal women. TQMJ (2017): Vol. (14), No. (2).

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