Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 17s (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

Impact of DEXA-Based Bone Mineral Density Evaluation on Orthopedic Surgical Decision Making

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Cite this paper as: Wissam Ahmed Abdullah, (2025) Impact of DEXA-Based Bone Mineral Density Evaluation on Orthopedic Surgical Decision Making. *Journal of Neonatal Surgery*, 14 (17s), 550-559.

ABSTRACT

Background: Many elderly patients undergoing orthopedic procedures, such as arthroplasty or spinal fusion, often present with compromised bone quality. Dual-energy X-ray absorptiometry (DEXA) measures bone mass and area through a two-dimensional method. Although bone depth is not measured, the dimensions of the bone can influence the observed bone mineral density (BMD). DEXA scans are essential in assessing bone mass density and identifying potential bone-related issues.

Method: A prospective cohort study was carried out involving 120 patients who were slated for orthopedic surgery. Participants were selected using convenience sampling from the hospital's orthopedic surgery department. The study aimed to refine the decision-making process for orthopedic surgeries by assessing osteoporosis via dual-energy X-ray absorptiometry (DEXA) examinations. The study cohort was segregated into a control group comprising 40 healthy individuals and two experimental groups, each comprising 40 patients diagnosed with osteoporosis.

Results: The analysis of variance (ANOVA) test uses the P value and F value to assess the significance of the results. The results show a decline in bone density among individuals with chronic conditions like heart disease, diabetes, and hypertension. These disorders can directly influence osteoporosis, damaging blood vessel health, impair bone absorption capacity, and compromise the immune system's ability to secrete hormones, including insulin. Obesity and insufficient physical activity also heighten the risk of osteoporosis in individuals with hypertension and diabetes.

Conclusion: Incorporating dual-energy X-ray absorptiometry (DEXA) scans into the preoperative evaluations of elderly patients undergoing orthopedic surgery is essential for improving patient outcomes. Identifying those at elevated risk for osteoporosis and related complications allows healthcare professionals to tailor both surgical and medical strategies, thereby enhancing postoperative recovery and optimizing long-term outcomes. .

Keywords: *DEXA, orthopedic surgery, osteoporosis*

1. INTRODUCTION

A significant proportion of elderly individuals who undergo orthopedic surgery, such as arthroplasty or spinal fusions, commonly experience poor bone health (1). Studies indicate that over 50 percent of these patients have either osteopenia or osteoporosis (2, 3). However, while orthopedic surgeons actively include patients in obtaining secondary fracture care after a fragility fracture, the preoperative screening and rectification of skeletal deficiencies still needs to be carried out (4). Some data suggests a connection between inadequate bone health and adverse outcomes in terms of functional recovery, complications, and the need for additional surgeries in individuals undergoing elective procedures (5). Regrettably, within the present healthcare system, orthopedic surgeons who specialize in surgical procedures on the skeleton have limited involvement in diagnosing and managing bone illnesses. Overweight and obesity found to be a risk factor for Osteoarthritis, osteoporosis (6)

DXA is a method of measuring bone mass or area using a 2-dimensional approach (7). While bone depth does not have a role, the size of the bone can impact the apparent bone mineral density (BMD)(7). In essence, two vertebrae with the same volumetric densities can exhibit varying areal densities due to variations in size (8). Consequently, there is a direct correlation between the size of the bone and the perceived bone mineral density (BMD), with larger bones having a greater apparent BMD (7). While DXA is the widely accepted benchmark for evaluating fracture risk, alternative methods can provide

valuable insights into bone mass evaluation (9). This study aims to evaluateto evaluate DEXA scans in quantifying bone mass densities and detecting bone-related problems.

2. METHOD

Study design

A prospective cohort study was conducted on 120 patients scheduled for orthopedic surgery. Convenience sampling was utilized to enlist participants from the affiliated hospital's orthopedic surgery department. The study aimed to enhance orthopedic surgical decision-making by assessing osteoporosis through dual-energy X-ray absorptiometry (DEXA) examinations.

Participants

The study involved 120 patients, selected based on predefined inclusion and exclusion criteria. Participants were divided into three groups: a control group of 40 healthy individuals and two experimental groups, each of 40 patients diagnosed with osteoporosis. The experimental groups were devoid of chronic or other concurrent health conditions, in contrast to the control group, which included individuals with various comorbidities.

Criteria for inclusion:

Participants eligible for this study should be aged between 10 and 60, regardless of gender, and may present with normal bone mineral density, osteoporosis, or chronic illnesses. They must undergo a DEXA examination and be under the care of consultant physicians in the hospital's medical department. Inclusion necessitates a diagnosis of osteoporosis and the presence of chronic illnesses.

Criteria of exclusion

The study will exclude individuals under 10 years or over 60, pregnant or breastfeeding women, and patients with significant chronic conditions unrelated to bone health. Those who previously had orthopedic surgery on the spine or lower limbs, are on medications affecting bone metabolism, or have contraindications for a DEXA scan will also be excluded. Additional exclusion criteria include abnormal hematological findings indicative of acute or chronic conditions unrelated to bone health, inability to provide informed consent, non-adherence to the research protocol, and incomplete demographic, laboratory, or DEXA data. The aim is to ensure a comprehensive understanding of bone health and its impact on bone density measurements and surgical outcomes.

Ethical considerations

Informed consent was mandatory for all participants, and the study received approval from the ethical committee at the University of Baghdad."

Statistical analysis

The acquired results will undergo statistical analysis to assess the impact of Iron deficiency disease on bone mineral density (BMD) in both males and females.

The specimens are categorized into four distinct categories. The dose data for the types of equipment now used for DXA is limited compared to the data available for other radiography modalities. The effective dose for a spine plus femur DEXA scan can range from less than 1 μSv to 15 μSv. The dose in pencil beam systems typically falls below 1 μSv. However; fan beam systems have been observed to range between 1 μSv and 10 μSv. According to one study, the estimated effective dose from a cone beam system is approximately 18 μSv. Recent results for current pencil beam scanners indicate that entrance surface doses for fan beam systems fall within the range of 9 μGy to 200 μGy. The effective dose from a chest radiograph often falls within the range of 20 μSv to 50 μSv. Doses have been included because they play a role in dual-energy X-ray absorptiometry (DEXA), and through this role bone mass density can be assessed for decision-making in orthopedic surgery. The analysis of variance (ANOVA) test was used, which is a powerful statistical tool used to compare the means of two or more groups. Significance beta groups were also tested (Sig. bet. Grps.), which is a statistical test used to evaluate the differences resulting from the comparison.

3. RESULTS

The study reveals a balanced distribution of males and females in three groups. Group 1 has a broad age range of 60.0 to 79.0 years, with a slightly elevated average age of 72.40 years. The median age is 69, with half of the group younger than 69 and the other half older. The middle 50% of the population falls between 69 and 71 years. Group 2 has a more limited age span (65.0 – 72.0 years), with an average age of 68.03 years, suggesting a younger group. The median age is 70, with an interquartile range (IQR) of 70 to 68 years. Group 3 has an average age of 71.2 years, with a standard deviation of 2.63, suggesting minimal variation in age around the average. The median age is 71 years, and the middle 50% of the population

ranges from 69 to 72 years. (Table 1)

Table 1: The three studied groups according to demographic data.

	Group 1 (n = 40)		Group 2 (n = 40)		Group 3 (n = 40)	
	No.	%	No.	%	No.	%
Sex						
Male	11	47.8	11	40.7	10	34.3
Female	12	52.3	16	59.3	19	65.7
Age (years)						
Min. – Max.	60.0 – 79.0		65.0 – 72.0		67.0 – 75.0	
Mean ± SD.	72.40 ± 4.65		68.03± .265		71.2. ± 2.63	
Median (IQR)	69 (71 - 69)		70 (70 – 68)		71 (72– 69)	

Table 2: Comparison between the three studied groups according to demographic data

Characteristics	**Group 1 (n = 40)**		**Group 2 (n = 40)**		**Group 3 (n = 40)**		**F**	**p**
	No.	**%**	**No.**	**%**	**No.**	**%**		
Sex								
Male	***26***	***65***	***15***	***37.5***	***14***	***35***	-	-
Female	***14***	***35***	***25***	***62.5***	***26***	***65***		
Age (years)								
Min. – Max.	***60.0 – 11.0***		***60.0 – 17.0***		***60.0 – 22.0***		**2.035**	**0.13**
Mean ± SD.	***50.9 ± 11.8***		***52.5± 9.3***		***55.4 ± 6.9***			
Median	***55***		***55***		***58***			

Where:

IQR: Inter quartile range ***SD: Standard deviation***

F: F for One-way ANOVA test

p: p-value for comparing between the three studied groups

The table demonstrates how the genders are distributed differently across all categories. More significant than that of men. In the control group, the proportion of women in the first group was 3.7.5%; in the second and third groups, it was 65% and 65%, respectively. The age distribution of the study participants is also shown statistically in the table. In the first group, the average age was 50.9 years; in the second, 52.5 years; and in the third, 55.4 years.

Table: Comparison between Outcomes in Study between the three studied groups according to CBC

	laboratory	*Group 1 (n = 40)*	*Group 2 (n = 40)*	*Group 3 (n = 40)*	*F*	*p*
WBCs(kμ/l)	*Min. – Max.*	*8.58– 3.83*	*8 – 3.5*	*8.5 – 4.6*	*3*	*0.053*
	Mean ± SD.	*6.7 ± 1.14*	*6.7± 1.15*	*5.4 ± 1.2*		
	Median (IQR)	*7.15(3)*	*7.15(2)*	*5.6(3)*		
	Sig. bet. Grps.	*p_1=0.91, p_2=0.04, p_3=0.03*				
RBCs(mμ/l)	*Min. – Max.*	*6.5– 4.1*	*6.2 – 3.8*	*6.5 – 3.85*	*1*	*0.33*
	Mean ± SD.	*4.4 ± 1*	*4.5± 0.49*	*4.6 ± 0.63*		
	Median (IQR)	*4.6(2)*	*4.5 (2)*	*4.6 (2)*		
	Sig. bet. Grps.	*p_1=.0.68, p_2=0.44, p_3=0.43*				
Hemo globin(g/dl)	*Min. – Max.*	*17.5– 14*	*15.75 – 12.6*	*17.5 – 12.5*	*52*	*<0.05*
	Mean ± SD.	*15.1 ± 071*	*13.6 ± 0.64*	*15 ± 085*		
	Median (IQR)	*15 (2)*	*13.5(2)*	*15(2)*		
	Sig. bet. Grps.	*p_1<0.005,p_2<0.001*,p_3<0.001**				
PLATELETS(kμ/l)	*Min. – Max.*	*19.25– 14.3*	*20 – 15.73*	*19.2 – 14.3*	*43.2*	*<0.001**
	Mean ± SD.	*16.5 ± 0.80*	*18.1 ± 0.91*	*16.55 ± 0.88*		
	Median (IQR)	*16.5 (3)*	*18.1 (2)*	*16.5 (2)*		
	Sig. bet. Grps.	*p_1<0.005,p_2<0.001*,p_3<0.001**				
ESR((mm/h).	*Min. – Max.*	*264– 140*	*296 – 140*	*295 – 150*	*24*	*<0.001**
	Mean ± SD.	*213 ± 47.3*	*220.1 ± 37.4*	*259 ± 34.3*		
	Median (IQR)	*220(70)*	*222 (68)*	*224 (66)*		
	Sig. bet. Grps.	*p_1<0.005,p_2<0.001*,p_3<0.001**				

F: F for One way ANOVA test, Pairwise comparison bet. each 2 groups was done using Post Hoc Test (Tukey)

p: p value for comparing between the three studied groups

p1: p value for comparing between group 2&group 3

p2: p value for comparing between group 2& Control

p3: p value for comparing between group 3and Control

Based on Table 3 In the context of the analysis of variance (ANOVA) test, the P value and F value serve as two primary metrics for assessing the importance of the findings: A P value is a measure of statistical significance. A small P value (less than 0.05) indicates that there is a statistically significant result, whereas a considerable P value (more than 0.05) indicates that there is no statistical significance. The term "it" refers to the ratio of the variance (f) between the data sets to the variance within the data sets. A high value of this parameter implies a substantial disparity between the data sets, whilst low values suggest that there is no noteworthy distinction. The table indicates that the p-value was below 0.05, indicating statistical significance. Furthermore, the value of (f) = p.05 indicates that the differences and variance are statistically significant. Generally, it has no significant impact on the quantity of red blood cells and white blood cells, nor does it influence the

proportion of hemoglobin in the blood or the count of platelets. Nevertheless, certain studies have demonstrated that being exposed to high levels of radiation can result in a reduction in the quantity of white blood cells. In addition to measuring heart rate. Certain drugs, diabetes treatment, heart disease treatment, diuretics, and chemotherapy can have an impact on the levels of white blood cells, sedimentation rate, platelet count, and hemoglobin percentage in the bloodstream. Thus, the third group exhibited a decline in white blood cell count ranging from 1 to 9%, although the number of red blood cells remained relatively unaffected.

Table 4: Comparison between Outcomes in Study between the three studied groups according to Blood pressure, diabetes, HR, and T(T-score)

	laboratory	*Group 1 (n = 40)*	*Group 2 (n = 40)*	*Group 3 (n = 40)*	*F*	*p*
T(T-score)	*Min. – Max.*	*2– (-1)*	*-2.5– (-3.9)*	*-3.9– (-4.7)*	*147*	*<0.001**
	Mean ± SD.	*-3.3 ± 0.63*	*-3.3 ± 0.43*	*-3.7 ± 1.2*		
	Median (IQR)	*-0.9 (.06)*	*-2.9 (0.4)*	*-3.9 (1)*		
	Sig. bet. Grps.	*p_1<0.001*,p_2<0.001*, p_3<0.001**				
HR	*Min. – Max.*	*96– 88*	*97 – 90*	*119 – 98*	*258*	*<0.001**
	Mean ± SD.	*92 ± 2.2*	*93± 2.48*	*110± 5.4*		
	Median (IQR)	*93 (8)*	*95 (10)*	*111 (16)*		
	Sig. bet. Grps.	*p_1=0.018,p_2<0.001*, p_3<0.001**				
diabetes	*Min. – Max.*	*171– 152*	*181 – 155*	*217 – 186*	*273*	*0.001**
	Mean ± SD.	*162 ± 5.1*	*166 ± 8.1*	*200 ± 9.9*		
	Median (IQR)	*162 (10)*	*167 (12)*	*200 (12)*		
	Sig. bet. Grps.	*p_1=0.005,p_2<0.001*,p_3<0.001**				
Blood pressure D iastolic)mmHg	*Min. – Max.*	*89– 81*	*89 – 82*	*96– 85*	*251*	*<0.001**
	Mean ± SD.	*82± 5.5*	*82 ± 6.25*	*90 ± 6.6*		
	Median (IQR)	*82 (8)*	*82 (10)*	*91(10)*		
	Sig. bet. Grps.	*p_1=0.005,p_2<0.001*,p_3<0.001**				

F: F for One way ANOVA test, Pairwise comparison bet. each 2 groups was done using Post Hoc Test (Tukey)

p: p value for comparing between the three studied groups

p1: p value for comparing between group 2&group 3

p2: p value for comparing between group 2& Control

p3: p value for comparing between group 3and Control

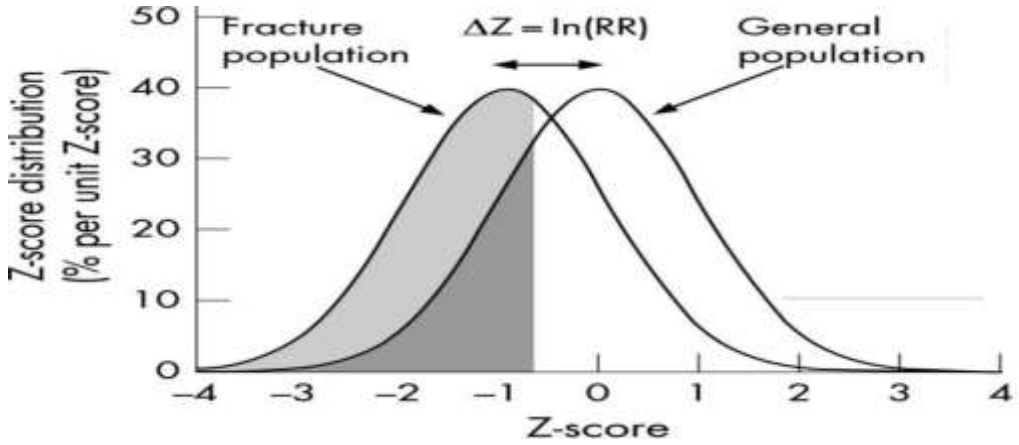

Figure2: Distribution of Z-score values

Based on Table 5 In the analysis of variance (ANOVA) test, the P value and F value are two primary indicators used to assess the significance of the results. A P value is a measure of statistical significance. A little P value, typically less than 0.05, shows that there is statistical significance. On the other hand, a significant P value, typically more than 0.05, indicates that there is no statistical significance. The term "it" refers to the ratio of the variance (f) between the data sets to the variance within the data sets. A high value of this parameter implies a substantial disparity between the data sets, whilst low values suggest the absence of a significant difference. The table demonstrates that the p-value is less than 0.05, indicating statistical significance. Furthermore, the statistical analysis revealed that the value of (f) = p.05, indicating that both the differences and variance are statistically significant. Table No. (5) indicates a decline in bone density among individuals with chronic conditions such heart disease, diabetes, and hypertension. Conversely, Group 2, consisting of patients without any chronic illnesses, had higher bone density compared to Group 3. Consequently, chronic illnesses are present. It is associated with reduced bone density or caused by drugs used to treat these conditions. These disorders have a direct influence on osteoporosis and can adversely damage the health of blood vessels. Both hypertension and diabetes can impact the vascular health, leading to reduced blood flow to the bones and impairing their capacity to absorb essential minerals. Hypertension and diabetes can impact the endocrine system's ability to secrete hormones, including insulin, which is crucial for maintaining bone health. Impact on the immunological system: Hypertension and diabetes can compromise the immune system, hence heightening the susceptibility to bone infections.

Furthermore, there are additional factors that can heighten the risk of osteoporosis in individuals with hypertension and diabetes, including: Obesity heightens the likelihood of developing osteoporosis, particularly among women. Insufficient physical activity: Insufficient physical exercise diminishes bone strength and heightens the likelihood of developing osteoporosis.

Figure 2 displays the distribution of Z-score values in the fracture population, illustrating a comparison between persons who are considered normal and individuals who have osteoporosis. The curve has a symmetrical distribution with a bell-shaped pattern centered at Z = 0—the curve representing the cohort of patients who are at risk of experiencing osteoporotic fractures. The bell-shaped curve is similar to the general population, except it is shifted by a Z-score differential of ΔZ = ln(RR), where RR = relative risk.

Table 6: Comparison between Outcomes in Study between the three studied groups according kv_p, DAP,CTFOR arm

	laboratory	*Group 1 (n = 40))*	*Gtoup 2 (n = 40)*	*Group 3 (n = 40)*	*F*	*p*	*Persistenc*
kv_p	*Min. – Max.*	*120– 80*	*140 – 90*	*140 – 120*	*151*	*<0.001**	
	Mean ± SD.	*85.75 ± 8.91*	*105.5± 13.1*	*128 ± 9.7*			
	Median (IQR)	*80(10)*	*100(16)*	*120(16)*			
	Sig. bet. Grps.	*p_1<0.005,p_2<0.001*,p_3<0.001**					

DAP	***Min. – Max.***	***4– 2***	***5– 3***	***6 – 4***		
	Mean ± SD.	***3.2 ± 0.47***	***4.2± 0.47***	***4.2± 0.45***	***173***	***<0.001****
	Median (IQR)	***5(1)***	***4 (1)***	***3 (1)***		
	Sig. bet. Grps.	$p_1<0.005, p_2<0.001^*, p_3<0.001^*$				
CT	***Min. – Max.***	***0.026– 0.024***	***0.028 – 0.028***	***0.72 – 0.028***	***218***	***<0.001****
	Mean ± SD.	***0.025 ± 0.00074***	***0.026± 0.00054***	***0.027±.00049***		
	Median (IQR)	***0.025 (0.22)***	***0.027(022)***	***0.028(0.22)***		
	Sig. bet. Grps.	$p_1<0.005, p_2<0.001^*, p_3<0.001^*$				

F: F for One way ANOVA test, Pairwise comparison bet. each 2 groups was done using Post Hoc Test (Tukey), p: p value for comparing between the three studied groups

p1: p value for comparing between group 2&group 3, p2: p value for comparing between group 2& Control, **p3: p value for comparing between group 3and Control**

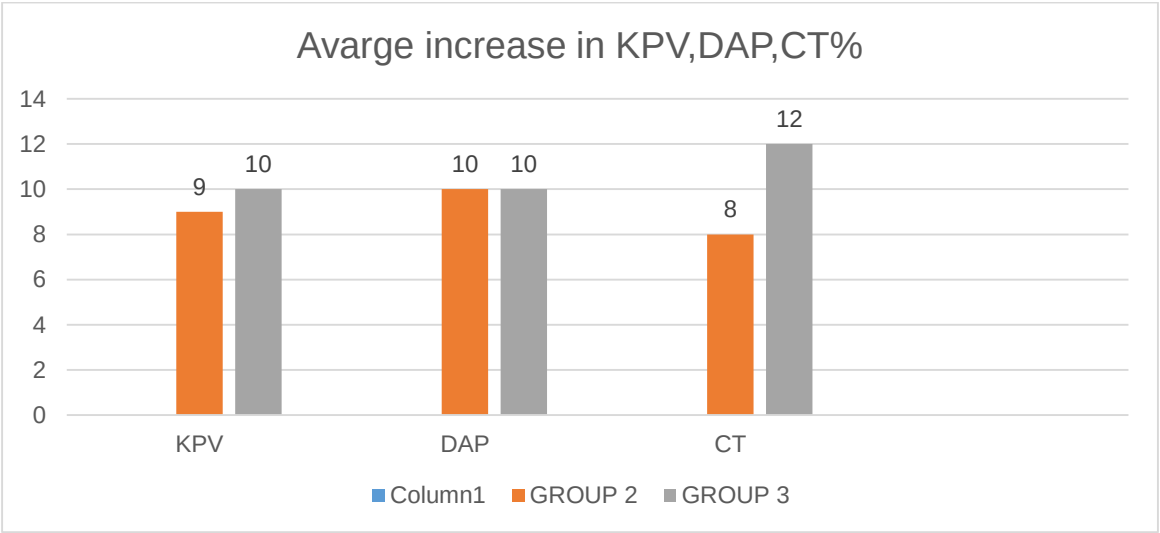

Figure 2: shows Average increase in KPV, DAP, CT

Based on Table 5 In the context of the analysis of variance (ANOVA) test, the P value and F value serve as the primary metrics for assessing the statistical significance of the findings. A P value is a measure of statistical significance. A small P value, typically less than 0.05, shows that there is statistical significance. Conversely, a significant P value, typically more than 0.05, indicates that there is no statistical significance. The term "it" refers to the ratio of the variance (f) between the data sets to the variance within the data sets. A high value implies a substantial disparity between the data sets, whereas low values suggest no meaningful distinction. According to the table, the p-value was less than 0.05, indicating statistical significance. Furthermore, the significance level (f) = p.05 indicates that both the differences and variance are statistically significant.

Based on figure 2, the suitable KVp values are determined by various elements such as the specific area being examined,

whether it is the thigh, spine, head, or arm. In addition to the patient's size and the type of device. The magnitude of the suitable absorbed doses (DAP) for the treatment of osteoporosis is contingent upon many aspects, which encompass: Treatment modality: The recommended therapeutic doses vary across different forms of osteoporosis therapy. The examination site can be the thigh, spine, head, or arm. Additionally, the dimensions of the patient and the specific characteristics of the device are important factors to consider. The examination performed on the arm, as shown in Table (i), reveals that osteoporosis necessitates an 8% to 10% increase in KPV, DAP, and CT. In the case of osteoporosis with chronic diseases, the percentages of KPV, DAP, and CT increase by 8%. The value is 12 percent. Results will be evaluated after clarification of sampling size and adequate tests for evaluation of collected data

4. DISCUSSION

DEXA is an essential method for evaluating bone density, renowned for its accuracy and dependability (10). This diagnostic tool, which does not require any invasive procedures, assesses BMD to evaluate the health of bones and diagnose disorders including osteoporosis and osteopenia (11).

The DEXA scan functions by utilizing two X-ray beams with varying energy levels (12). The instrument quantifies the X-ray energy absorption of bone tissue as the beams traverse through it (13). Subsequently, the differential rates of absorption are employed for the computation of BMD.

DEXA scans are commonly conducted on the lumbar spine, hip, and occasionally the forearm (14). These sites are selected based on their prevalence as fracture sites in patients with osteoporosis. The DEXA is expeditious, typically lasting between 10 to 30 minutes, and has minimum radiation exposure, which is notably lower than that of a conventional chest X-ray (15).

DEXA scan findings are often presented in the form of T-scores and Z-scores (16). The T-score measures the patient's bone density relative to the ideal peak bone density of a healthy young adult of the same gender (17).

A T-score equal to or more than -1.0 is considered within the normal range, while a T-score between -1.0 and -2.5 suggests the presence of osteopenia (18). A T-score of -2.5 or below is indicative of osteoporosis (19). The Z-score, in contrast, compares the patient's bone density to the expected value for an individual of the same age, sex, and body size (20). A Z-score that is less than -2.0 may indicate the necessity for additional medical assessment (21).

DEXA is widely recognized as the most reliable method for diagnosing osteoporosis because of its high level of accuracy, consistency, and capability to track the progress of treatment over a period of time (22). DEXA facilitates early intervention, hence enhancing patient outcomes and improving the quality of life for persons who are at risk of or currently experiencing bone density abnormalities (23).

Utilizing DEXA as a preoperative evaluation technique in surgery demonstrates evidence-based medicine by utilizing precise bone density measures to support clinical decision-making (5). This method guarantees enhanced patient results, especially in surgical procedures where the quality of the bone is a crucial determinant.

There is increasing evidence to support the incorporation of DEXA into preoperative regimens (24). Evidence suggests that identifying and addressing low BMD before surgery can decrease the occurrence of problems after the operation and enhance surgical results (1, 5). Patients diagnosed with osteoporosis who receive personalized therapies before surgery demonstrate improved recovery rates and reduced occurrences of implant-related failures (1, 25). The discussion is very redundant without actual discussion of results in comparison to available literature, also points of weakness of the study is not clarified in the discussion section.

5. CONCLUSION:

DEXA scans are a perfect example of how evidence-based medicine improves patient care. DEXA scans provide valuable information about bone health, allowing surgeons to tailor surgical plans to each patient's needs. This ultimately leads to better surgical outcomes by decreasing the chance of complications. It is crucial to include cutting-edge diagnostic instruments, such as DEXA scans, in preoperative evaluations to maximize surgical success.

Conflict of interests

No conflict of interest

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