

Multidetector CT in Quantitative Morphometric Assessment of Post-Menopausal Vertebral Fractures in Black Women of Central Africa

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Abstract

Background: Osteoporosis and major Non-Communicable Diseases (NCDs) are identified by WHO as leading cause of death worldwide. Its economic burden is heavy worldwide and in particularly in low income countries. DXA availability is poorly in our country. Spine CT scanner with sagittal reformation images are known for the ease quotation of vertebral fractures by quantitative morphometric system described by Genant et al. (1996). This study aims to determine the rate and the features of vertebral fractures in postmenopausal black women living in Kinshasa/DRC using CT scanner sagittal reconstructions.

Patients and methods: 430 consecutives post-menopausal women referred for Thoraco-lumbar CT scanner from June 2011 to June 2016 were enrolled in this study and theirs CT images used to quote vertebrae.

Results: 12.89% of a total of 4730 vertebrae were fractured whose more than half (7.82%) of grade 1. The fracture rate is lower than in Caucasian and ASEAN and increase with ageing and duration of menopause (24.51% in 70 years of age and over).

Conclusion: Vertebral fracture global frequency was 12.89%. Vertebral fractures are present in our population and adverse consequences will arises in terms of morbidity and mortality. Lack of infrastructure, health policy and powerty will contributes to boost for a bader pronostics.

The method is reproducible and can be used as routine clinical tools in conditions of poor availability of DXA.

Keywords

vertebral fractures, osteoporose, multidetector CT, Central Africa, Congolese

1. Introduction

Osteoporosis and major Non-Communicable Diseases (NCDs) namely cardiovascular illnesses, diabetes mellitus, obesity, cancer, chronic respiratory diseases, accounting for 2/3 of all causes of deaths, are identified by the World Health Organization (WHO) as the leading cause of death worldwide. Osteoporose's impact is projected to further increase due to global urbanization, sedentary lifestyle, obesity epidemic, and an increase in life expectancy in populations across the globe (Burge et al., 2007; who study group, 2010; IOF study group, 2011; Cipriani et al., 2017).

Osteoporosis is sharing common risk factors with NCDs (Leslie et al., 2017) and contribute substantially to a heavy social and economic burden Worldwide (Fechtenbaum et al., 2005) and in particularly in low income countries, i.e., the Democratic Republic of Congo (DRC).

In the Middle East and Africa region, 8-20% of the population is currently over 50 years and the proportion will reach up to 25% in 2020 and 40% in 2050 (Cooper et al., 1992; Burge, 2007; who study group, 2010; IOF study group, 2011; Cipriani et al., 2017).

In osteoporosis, several women aged over 50 years of age will experience a hip and or a vertebral fracture resulting in morbidity with loose of functional independence (Edmond et al., 2005) and mortality as a consequence of lack of prevention policy, low or lack access to care (Cooper et al., 1992; Melton et al., 1993; Melton et al., 2003; Woolf et al., 2003; Hasserijs et al., 2005; Johnell et al., 2006; who study group, 2010; IOF study group, 2011).

The vertebral fracture or abnormalities may be a localized or diffuse reduction of the vertebral body height occurring without any violent trauma (Freedman et al., 2008). They are often asymptomatic, undetected by clinicians and underdiagnosed by radiologists in radiological image (rx) (Grados et al., 2001; Delmas et al, 2005; Woo et al., 2008; Hospers et al., 2009; Delmas et al., 2009). Although often detected incidentally by imaging explorations performed for other purposes. Despite the ease of identifying vertebral fractures in computer tomography scanner (CT, TDM or CT scanner), assessment of vertebrae in axial sections only instead of sagittal sections are source of under diagnosis and under reporting of vertebral fractures (Lenchik et al., 2004; Bauer et al., 2006; Muller et al., 2008; Muller et al., 2008; Woo et al., 2008; Williams et al., 2009). The detection is improved by scanner using lateral view or radio mode with limited success or sagittal reconstructions (Genant et al., 1996; Muller, 2008; Kim et al., 2012; Oei et al., 2013; Takada et al., 1998; Takada et al., 2013; Alacreu et al., 2017; Glinkowski et al., 2017; Gausden et al., 2017; Lee et al., 2017) and some authors reported newly introduced automated detection and soft-ware assisted systems (Narloch et al., 2016; Burns et al., 2017).

Data about double x absorptiometry, newly introduced in our country are not yet available. Audit about osteoporosis in the Middle East and Africa region has establish the gaps in knowledge and care relevant to osteoporosis, the scarcity of data available on osteoporosis and practically non-existence and lack of the data on vertebral fracture incidence in these region and countries (IOF study group, 2011).

This study aims to determine the rate and the features of vertebral fractures in a consecutive study group constituted of postmenopausal black women living in DRC referred for thoracolumbar screening and assessed with CT scanner using sagittal reconstructions.

2. Materials and Methods

This is a prospective and multi-centric study conducted from June 2011 to June 2016.

2.1 Patients

The study group is constituted of consecutive postmenopausal black women referred to CT scanner for dorso-lumbar screening whose indication where amenorrhea of at least one year and mood disorders associated with low back pain.

Women were checked by a physician and were eligible for the study if they:

- Had been postmenopausal for at least one year of amenorrhea.
- Had No diseases nor medications known to affect bone metabolism (cancer, diabetes, prolonged diseases of the liver, kidney, thyroid gland, etc. or treatment using corticosteroids greater than or equal to 3 months, anticonvulsants, thyroid hormones, etc.).
- Had no previous high energy vertebral fractures.

2.2 Methods

Menopausal status and Anthropometric parameters (age, height, and weight) were collected according to standardized procedures. Weight was measured (kg) using commercially available portable digital scales to the nearest 0.1 kg and height was measured (cm) using a vertical stadiometer to the nearest 0.1 cm.

Four CT scanners machines were used with the same standard protocol: General Electric light speed 8 rows, Siemens (Siemens Medical System, Sensation, Erlangen, Germany), Philips 8 rows, Hitachi Eclos with 16 rows.

The standard scanning protocol includes a lateral radio mode from T5 to S4 and a helical acquisition followed by multi-planar reconstruction.

Three radiologists reviewed CT images of all patients. A consensus was used to solve disagreements. The review included a morphometric quantitative analysis of each vertebra, on the more balanced sagittal reconstruction, which was rated according to the system proposed by Genant et al. (1996).

2.3 Measurements

2.3.1 Morphometric Quantitative Measurements

Six points were marked for each vertebra defining vertebral height (Figure 1): the anterior (ha), the posterior (hp) and the middle (hm) vertebral heights.

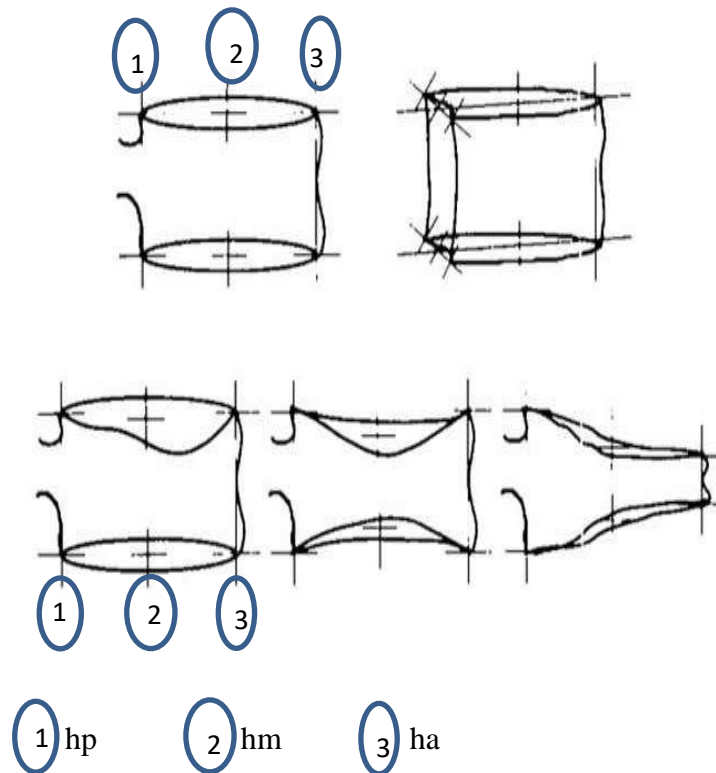


Figure 1. Schematic Representation of Measurements

The measurements of the anterior, median and posterior vertebral heights yielded quantitative variables whose ratios give the percentages of loss of vertebral heights (Genant et al., 1996; Muller, 2008; Kim et al., 2012; Oei et al., 2013; Takada et al., 1998; Alacreu et al., 2017).

The following ratios were calculated:

- APR antero posterior ratio = ha/hp cuneisation index
- MPR Middle POSTERIOR RATIO = hm/hp concavity index
- HPR posterior-posterior adjacent ratio = hp/hpa

Ratio allows calculation of percentages of loss of height (loss of height is equivalent of 100% of vertebral height minus the ratio).

According to the shape of the vertebra, each vertebra was rated as follows: grade 0: normal vertebra ratio less than 20% grade 1: minimal fracture: 20% to 25% loss of one or several heights grade 2: moderate fracture: 25% to 40% loss of one or several heights; grade 3: height grade fracture: > 40% loss of one or several heights.

The spinal deformity index is the summation of grade of all fractured vertebrae but was not used in this paper.

2.4 Statistical Analysis

The Coefficient of Variation (CV) were calculated according to the proposition of Glüer et al. (1995).

The statistical analysis was performed using commercially available software the Statistica program for

Windows 5.1 (Tulsa, OK, USA, 1996) and SPSS version 21.

The results were expressed as mean, standard deviation (mean \pm SD), range (minimum and maximum values), absolute (n), ratio (%) and relative (%) frequencies.

The differences in height and ratio values were analyzed using the Student's *t*-test.

The associations between the qualitative variables were established using the Pearson Chisquare test.

The threshold of significance was set at 0.05.

The study design was approved by the local ethics committee, informed consent was obtained from each subject, and the study was conducted in accordance with the declaration of Helsinki for human studies.

3. Results

Four hundred thirty consecutives patients were enrolled into this study.

3.1 The Coefficient of Variation

The coefficient of variation (CV% = SD/mean \times 100%) was 0.95% and standardized CV (sCV = CV%/4SD/mean) was 2.35%.

3.2 Vertebral Body Heights in Post Menopausal Women

Means vertebral heights and standard deviation are presented in Table 1.

Table 1. Vertebral Height (means \pm s.d) in Our Study Group

	n	ha \pm s.d	hm \pm s.d	hp \pm s.d
LEVEL		(mm)	(mm)	(mm)
D4	430	23,9 \pm 3,2	23,7 \pm 2,9	22,9 \pm 3,7
D5	430	24,5 \pm 3,2	24,1 \pm 3,2	24,3 \pm 3,2
D6	430	24,6 \pm 3,0	24,5 \pm 2,8	24,4 \pm 3,1
D7	430	23,9 \pm 3,2	24,1 \pm 3,3	23,6 \pm 2,7
D8	430	24,1 \pm 3,2	23,9 \pm 3,1	23,4 \pm 3,3
D9	430	24,3 \pm 2,9	24,4 \pm 2,6	24,1 \pm 3,2
D10	430	24,1 \pm 3,2	24,2 \pm 2,4	24,3 \pm 3,3
D11	430	24,2 \pm 2,8	24,3 \pm 3,6	23,8 \pm 2,9
D12	430	23,9 \pm 3,2	24,05 \pm 3,3	23,8 \pm 3,1
L1	430	24,2 \pm 3,2	24,9 \pm 3,3	25,3 \pm 3,3
L2	430	25,9 \pm 3,3	25,6 \pm 2,8	25,9 \pm 3,2
L3	430	28,6 \pm 3,5	27,6 \pm 3,3	27,1 \pm 3,2
L4	430	27,1 \pm 3,2	26,7 \pm 3,5	26,4 \pm 3,6
L5	430	26,5 \pm 3,8	25,8 \pm 3,6	25,7 \pm 3,9

The scale of variation of vertebral heights is wide and the different varies from less to highly significant when comparing vertebra per vertebra height ($p = 0.43$ to $p < 0.001$).

Considering vertebra level per vertebra: as low we are, as great are the height and wide is the scale difference.

3.3 Quantitative Morphometric Quotations

3.3.1 Grades of Vertebrae

Mensurations of vertebral height yield calculations of ratio and percentages of loss of height which enables grading of vertebrae as shown in Table 2 below.

Table 2. Global Gradation of Vertebrae in Our Study Group

GRADATION	%LOSS	n	%
GRADE0	< 20%	4120	87.1
GRADE1	20-25%	370	7.82
GRADE2	25-40%	213	4.5
GRADE3	> 40%	27	0.57
TOTAL		4730	100

Statistical significant difference ($p < 0.0001$) was seen in rate of different grades.

12.89% of a total of 4730 vertebrae was fractured which more than half (7.82%) of grade 1 (see Figure 2).

Height grades vertebral fractures were rare (0.57%).

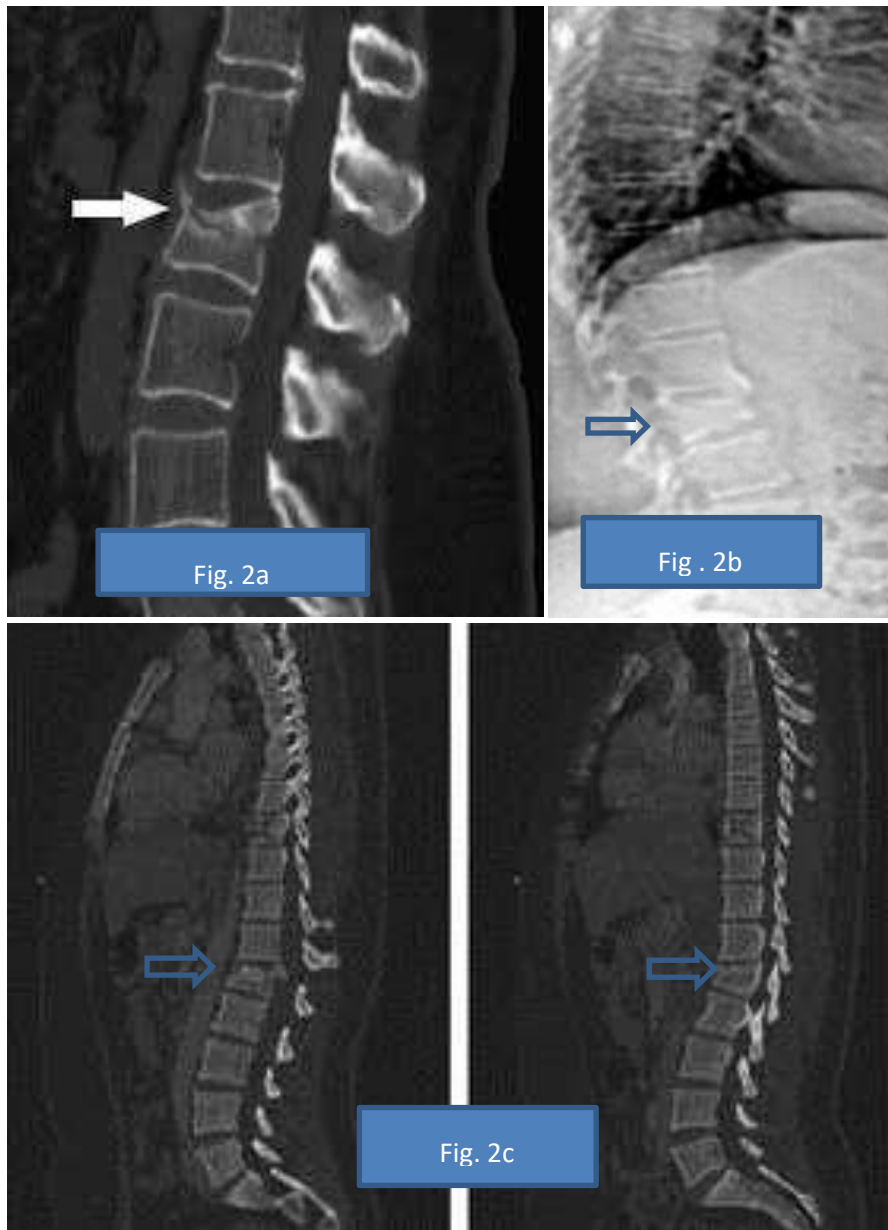


Figure 2. Images of Osteoporotic Vertebral Fractures in Post-Menopausal Women. Figure 2a CT Grade 1; 2b CT Lateral rx Grade 2; 2c CT Grade 3 Vertebral Fractures

3.3.2 Age-Related Changes in Fractures Rates

Age related variation of vertebral fractures rates from 430 patients (4730 vertebrae) aged 45 to 87 years are shown in Table 3.

Table 3. Age Related Variation of Vertebral Fractures Rates

Age group (year)	N subjects	Number of vertebrae	Number of fractures	Fracture frequency (%)
< or = 54	103	1133	103	9.70
55-59	121	1331	121	9.09
60-64	79	869	84	9.66
65-69	71	781	144	18.43
70 and over	56	616	151	24.51
Total	430	4730	61	12.89

We disclosed 610 (12.89%) fractured vertebrae of different grades.

In 45 to 64 years, the frequency of fractures is almost the same (9.09 to 9.7%). No significant change in rate ($p > 0.5$).

By 65 years, the frequency of fractures is almost double (18.43% and 24.51%). The average rate was then 21.11% and difference was significant with rate before 65 years of age ($p > 0.0001$).

3.3.3 Duration of Menopause-Related Changes in Fractures Rates

Variation in rates of fractures with duration of menopause are reported in Table 4.

Table 4. Duration of Menopausis-Related Variation of Vertebral Fractures Rates

Duration of menopause (year)	N subjects	Vertebral number	Fractures number	Fractures rates (%)
< or = 5ans	85	935	99	10.59
6-10ans	104	1144	113	9.87
11-15ans	111	1232	115	9.33
16-20ans	70	781	147	18.82
20ans	60	660	136	20.60
Total	430	4730	610	12.89

A statistically significant association is noted between the duration of menopause and the rates of fractures ($p < 0.02$), specially when compare patients with duration under and over 15 years of age ($p < 0.0001$).

3.3.4 Age Related Loss of Vertebral Height

Variation in vertebral height with age with are reported in Table 5.

Table 5. Age Related Mean Loss in Vertebral Height

Age group (years) more	Mean loss in vertebral height (%)					p
	< or = 54	55-59	60-64	65-69	70 and over	
D7	6,0	6,5	6,9	8,0	9,5	0,032
D8	6,3	6,5	7,4	11,1	11,2	0,03
D9	6,5	7,0	7,8	10,1	12,2	0,03
D9	6,8	6,9	8,3	11,2	11,0	0,046
D11	6,9	7,4	8,4	11,0	11,1	0,038
D12	7,1	7,8	8,3	10,1	12,1	0,02
L1	7,1	8,6	8,4	9,4	9,7	0,046
L2	7,5	8,5	8,2	12,4	10,6	0,009
L3	9,8	9,1	10,6	11,2	9,9	0,016
L4	10,6	9,6	12,8	11,7	15,3	0,048
L5	11,2	12,7	13,6	17,1	17,8	0,016

These vertebral losses with age are statistically significant for all vertebrae (p from 0.048 to 0.016), there is also a statistically significant increase of vertebral height losses with ageing.

3.3.5 The Duration of Menopausis Related Losses of Vertebral Height

Variation in vertebral height with duration of menopause are reported in Table 6.

Table 6. Duration of Menopause-Related Loss of Vertebral Height

Age groupe (year)	< or = 5	6-10	11-15	16-20	21 and more	P
Vertebral level	Loss (%)	Loss (%)	Loss (%)	Loss (%)	Loss (%)	
D7	7,1 ± 5,9	7,2 ± 3,8	8,7 ± 5,4	9,3 ± 4,2	11,2 ± 5,4	0,042
D8	7,4 ± 5,9	8,5 ± 6,6	8,6 ± 5,7	11,2 ± 6	10,4 ± 6,3	0,003
D9	9,2 ± 4,3	9,5 ± 7,2	10,4 ± 6,4	10,5 ± 5,3	10,3 ± 4,3	0,04
D10	9,3 ± 5,0	10,3 ± 4,8	11,2 ± 7,7	12,5 ± 5,5	11,8 ± 8,7	0,039
D11	9,6 ± 4,7	10,6 ± 5,2	10,6 ± 5,3	11,7 ± 7,0	12,2 ± 6,3	0,042
D12	9,1 ± 5,3	9,6 ± 7,2	10,4 ± 7,4	11,3 ± 5,3	12,3 ± 4,3	0,048
L1	8,1 ± 5,9	7,6 ± 4,8	9,3 ± 5,4	7,7 ± 4,1	10,5 ± 8,7	0,029
L2	7,6 ± 4,9	8,6 ± 5,6	8,6 ± 5,7	11,7 ± 7,0	10,2 ± 6,3	0,04
L3	9,1 ± 5,3	9,2 ± 7,2	11,4 ± 7,4	10,3 ± 5,3	10,3 ± 4,3	0,048
L4	9,0 ± 6,0	10,5 ± 6,8	13,2 ± 8,7	11,5 ± 5,7	14,2 ± 8,7	0,042
L5	13,2 ± 7,6	17,4 ± 10,7	14,8 ± 7,9	16,1 ± 10,0	20,9 ± 6,4	0,039

Loss of vertebral height was seen on all vertebrae and increases with duration of menopause from 7,1 ± 5,9% to 20,9 ± 6,4% and was significant on all level.

4. Discussion

The aim of this study was to determine the rate and the features of vertebral fractures in black central Africa postmenopausal women using sagittal reconstructions from CT scanner.

The study shows that intra and inter observer coefficient of variation was 0.95%. and standardized was 2.35% these CV was lower or, at least, equivalent to those disclosed by Genant et al. (1996) using lateral view of x-ray what means a good reproductibility of our measurements and rating.

Quantitative assessment (vertebral morphometry) used in our study is based upon strict six point placement on sagittal reformed images in place of lateral view rx where varying radiographic quality and parallax distortion of the borders of the vertebral body cause many problems in the placement of the points. This is why some authors access that six points rx assessment are restricted to research purposes and are not easily amenable for daily clinical use and the visual semiquantitative are preferred for routine clinical use (Jager et al., 2010), although it allows several source of errors and have a poor specificity: it is obvious that Vertebral fractures also need to be differentiated from normal variants like limbus vertebra, cupid-bow appearance and vertebral deformities such as H-shaped vertebra in sickle cell anemia, etc., and avoiding misinterpretation induced in x ray by scoliosis, obliquity and false biconcave appearance of vertebral end-plates known as “bean-can effect” and that it also need double centering exposure to cover all the thoraco-lumbar field, attention may be paid to CT scanner:

Beside of Introduction of Vertebral Fracture Assessment (VFA) with DXA and use of automated six point detection/placement and soft-ware assisted systems (Narloch et al., 2016; Burns et al., 2017), the widespread availability and use of Multidetector CT enables radiologist to detect fractures incidentally on routine sagittal reformations in patients undergoing CT scans for osteoporose screening and other indications; use of six points vertebral morphometry became a routine clinical tools (Muller, 2008; Kim et al., 2012; Oei et al., 2013; Takada et al., 2013; Jager et al., 2010).

Despite the ease of identifying vertebral fractures in CT, assessment of vertebrae in axial sections only instead of sagittal sections are source of under diagnosis and under reporting of vertebral fractures and due to its high radiation burden: broutine use of CT for detecting fractures is not practical worldwide (Takada et al., 2013; Alacreu et al., 2017; Glinkowski et al., 2017; Gausden et al., 2017; Lee et al., 2017; Jager et al., 2010). Use of only lateral scout CT images has been proposed to be a reasonable middle path, thereby retaining the superior resolution of CT at a much lesser radiation dose (Muller, 2008; Takada, 2013; Glinkowski, 2017), but in comparative studies (Kim, 2012; Takada, 2013), cv were higher than visual semi quantitative assessment and higher than in the present study. Netherless these disadvantages of CT scanner, it’s use must be questioned in countries where availability of CT scanner is higher than DXA and cost is almost the same.

The vertebral heights found in this study vary on a wide scale (Table 1) and seems to be as the wider as the vertebra is low located in the vertebral column. To the extent that height and vertebral dimensions depend on the ethnicity and stature of individuals (O’Neill et al., 1996; Muhammad et al., 2014) and that the normative data of the vertebrates of our population are not yet available and are being

developed by members of our group of work, we have delayed the analysis of data on vertebral heights to the development and publication of these normative data.

In the current study, the vertebral losses with age (Table 5) and duration of menopause (Table 6) are statistically significant for all vertebrae (p from 0.048 to 0.016). There is also a statistically significant increase in losses of vertebral height with ageing which leads to the development of fractures whose frequency increases with age and duration of menopause in a significant way. This study disclosed 12.8% fractured vertebrae of different grades (Tables 3 and 4). From 45 to 64 years of age and less than 15 years duration of menopause, the rate of vertebral fractures is almost the same (10.59 to 9.87%). By 65 years of age and thereafter or up to 15 years of duration of menopause, the frequency of fractures was double (18.43 and 24.51%). The average rate was then 21.11%. The frequency remains nevertheless low in comparison with the studies in Caucasians (Cooper et al., 1992; O'Neill et al., 1996; Delmas et al., 2009; Cipriani et al., 2017; Alacreu et al., 2017) which report overall higher rates.

O'Neill et al. (1996) and Delmas et al. (2009) reported a frequency of diagnosed osteoporotic vertebral fractures of 10-25% after 50 years of age. Data from population studies on Indian women have reported a similar 17% prevalence of vertebral fractures (Muhammad et al., 2014). Our study mean frequency is in the lower limit. Differences were seen between our data and South African Black or American Africans, with ASEAN and ASEAN with American Caucasians or Europeans (Aspray, 1995; Lau et al., 1996; Luckey et al., 1996; Tracy et al., 2006; Muhammad et al., 2014; Conradie et al., 2015). These differences seem due to ethnicity as seen in the United States (Luckey et al., 1996; Tracy et al., 2006) and South Africa (Conradie et al., 2015) where people living in the same country show a higher rate of fractures in white.

From 20-25% Caucasian women and men above 50 years fractured, there is a steadily increasing upward trend in incidence of vertebral fractures with age and from 50 to 85 years of age, the rate of vertebral fractures in women goes from 5% to 50% (Cooper et al., 1992; Fechtenbaum et al., 2005; WHO study group, 2010; IOF study group, 2011), which is higher above increase occurred in our study (Tables 3 and 4) from 9.7% to 24.51% of between 50 and 86 years of age due to an exponential increase of the fracture rate after 64 years of age which is corroborated by several authors (Melton et al., 1989; Kado et al., 2004; Burns, 2017; Ganesan et al., 2017).

5. Conclusions

Quantitative morphometric assessment of vertebral fractures on sagittal CT reformatted slices in central African post-menopausal women aged 45 to 87 years of age disclose low intra and inter-observer coefficients of variation. Vertebral fracture global frequency was 12.89%. The fracture rate is lower than in Caucasian and ASEAN and increases with ageing and duration of menopause (24.51% in 70 and over age group). The method is reproducible, able to assess morphometric changes induced in vertebrae by age and duration of menopause and can be used as routine clinical tools in conditions of poor availability of DXA.

References

- Alacreu, E., Moratal, D., & Arana, E. (2017). Opportunistic screening for osteoporosis by routine CT in Southern Europe. *Osteoporos Int.*, 28(3), 983-990. <https://doi.org/10.1007/s00198-016-3804-3>
- Aspray, T. J. (1995). Low bone mineral content is common but osteoporotic fractures are rare in elderly Gambian women. *J Bone Miner Res.*, 10, 890-902.
- Bauer, J. S., Muller, D., Ambekar, A., Dobritz, M., Matsuura, M., Eckstein, F., ... Link, T. M. (2006). Detection of osteoporotic vertebral fractures using multidetector CT. *Osteoporos Int.*, 17, 608-615. <https://doi.org/10.1007/s00198-005-0023-8>
- Burge, R., Dawson-Hughes, B., Solomon, D. H., Wong, J. B., King, A., & Tosteson, A. (2007). Incidence and economic burden of osteoporosis-related fractures in the United States, 2005-2025. *J Bone Miner Res.*, 22, 465-475. <https://doi.org/10.1359/jbmr.061113>
- Burns, J. E., Yao, J., & Summers, R. M. (2017). Vertebral Body Compression Fractures and Bone Density: Automated Detection and Classification on CT Images. *Radiology. Sep.*, 284(3), 788-797. <https://doi.org/10.1148/radiol.2017162100>
- Cipriani, C., Pepe, J., Bertoldo, F., Bianchi, G., Cantatore, F. P., Corrado, A., ... Pedrazzoni, M. (2017). The epidemiology of osteoporosis in Italian postmenopausal women according to the National Bone Health Alliance (NBHA) diagnostic criteria: A multicenter cohort study. *J Endocrinol Invest.*, 9, 761-764. <https://doi.org/10.1007/s40618-017-0761-4>
- Conradie, M., Conradie, M. M., Scher, A. T., Kidd, M., & Hough, S. (2015). Vertebral fracture prevalence in black and white South African women. *Arch Osteoporos.*, 10, 203. <https://doi.org/10.1007/s11657-015-0203-x>
- Cooper, C. D. (1992). Secular trends in the incidence of postmenopausal vertebral fractures. *Calcified tissue int.*, 51, 100. <https://doi.org/10.1007/BF00298496>
- Delmas, P. D. et al. (2005). Underdiagnosis of vertebral fractures is a worldwide problem: The IMPACT study. *Bone Miner Res.*, 557-563. <https://doi.org/10.1359/JBMR.041214>
- Delmas, P. D., Al-Busaidi, A. T. W., Sparow, P. J., Adams, J. E., & Whitehouse, R. W. (2009). Under-reporting of osteoporotic vertebral fractures on computed tomography. *Eur J Radiol.*, 69, 179-183. <https://doi.org/10.1016/j.ejrad.2007.08.028>
- Edmond, S. L., Kiel, D. P., Samelson, E. J., Kelly-Hayes, M., & Felson, D. T. (2005). Vertebral deformity, back symptoms, and functional limitations among older women: The Framingham Study. *Osteoporos Int.*, 16, 1086-1095. <https://doi.org/10.1007/s00198-004-1815-y>
- Fechtenbaum, J. et al. (2005). The severity of vertebral fractures and health-related quality of life in osteoporotic postmenopausal women. *Osteoporosis int.*, 16, 2175-2179. <https://doi.org/10.1007/s00198-005-2023-0>
- Freedman, B. A., Potter, B. K., Nesti, L. J., Giuliani, J. R., Hampton, C., & Kuklo, T. R. (2008). Osteoporosis and vertebral compression fractures continued missed opportunities. *Spine J.*, 8, 756-762. <https://doi.org/10.1016/j.spinee.2008.01.013>

- Ganesan, S., Acharya, A. S., Chauhan, R., & Acharya, S. (2017). Prevalence and Risk Factors for Low Back Pain in 1,355 Young Adults: A Cross-Sectional Study. *Asian Spine J.*, *11*(4), 610-617. <https://doi.org/10.4184/asj.2017.11.4.610>
- Gausden, E. B., Nwachukwu, B. U., Schreiber, J. J., Lorch, D. G., & Lane, J. M. (2017). Opportunistic Use of CT Imaging for Osteoporosis Screening and Bone Density Assessment: A Qualitative Systematic Review. *J Bone Joint Surg Am.*, *99*(18), 1580-1590. <https://doi.org/10.2106/JBJS.16.00749>
- Genant H. K., Jergas, M., Palermo, L., Nevitt, M., Valentin, R. S., Black, D., & Cummings, S. R. (1996). Comparison of semiquantitative visual and quantitative morphometric assessment of prevalent and incident vertebral fractures in osteoporosis: The study of osteoporotic fractures research group. *J bone miner res.*, *11*(7), 984-996. <https://doi.org/10.1002/jbmr.5650110716>
- Glinkowski, W. M., & Narloch, J. (2017). CT-scout based, semi-automated vertebral morphometry after digital image enhancement. *Eur J Radiol.*, *94*, 195-200. <https://doi.org/10.1016/j.ejrad.2017.06.027>
- Gluer, C. C., Blake, G., Lu, Y., Blunt, B. A., Jergas, M., & Genant, H. K. (1995). Accurate assessment of precision errors: How to measure the reproducibility of bone densitometry techniques. *Osteoporos Int.*, *4*, 262-270. <https://doi.org/10.1007/BF01774016>
- Grados, F., Roux, C., de Vernejoul, M. C., Utard, G., Sebert, J. L., & Fardellone, P. (2001). Comparison of four morphometric definitions and a semiquantitative consensus reading for assessing prevalent vertebral fractures. *Osteoporos Int.*, *12*, 716-722. <https://doi.org/10.1007/s001980170046>
- Hasserijs, R., Karlsson, M. K., Jonsson, B., Redlund-Johnell, I., & Johnell, O. (2005). Long-term morbidity and mortality after a clinically diagnosed vertebral fracture in the elderly—A 12- and 22-year follow-up of 257 patients. *Calcif Tissue Int.*, *76*, 235-242. <https://doi.org/10.1007/s00223-004-2222-2>
- Hospers, I. C., van der Laan, J. G., Zeebregts, C. J., Nieboer, P., Wolffenbuttel, B. H., Dierckx, R. A., ... Slart, R. H. (2009). Vertebral fracture assessment in supine position: Comparison by using conventional semiquantitative radiography and visual radiography. *Radiology.*, *251*, 822-828. <https://doi.org/10.1148/radiol.2513080887>
- International osteoporosis foundation study group. (2011). *The middle east and Africa regional audit: Epidemiology, costs and burden of osteoporosis in 2011*. 2011 International Osteoporosis Foundation report.
- Jager, P. L., Riemer, H. J. A., Slart, C. L. Webber, J. D. Adachi, A. L. Papaioannou, & Karen, Y. G. (2010). Combined Vertebral Fracture Assessment and Bone Mineral Density Measurement: A Patient-friendly New Tool with an Important Impact on the Canadian Risk Fracture Classification. *Canadian Association of Radiologists Journal*, *61*, 194-200. <https://doi.org/10.1016/j.carj.2009.12.012>
- Johnell, O., & Kanis, J. A. (2006). An estimate of the worldwide prevalence and disability associated

- with osteoporotic fractures. *Osteoporos Int.*, *17*, 1726-1733.
<https://doi.org/10.1007/s00198-006-0172-4>
- Kado, D. M., Huang, M. H., Karlamangla, A., & Barret-Common Greendale, G. A. (2004). Hyperkyphotic posture predicts mortality in older community dwelling men and women: A prospective study. *JAM Geriatric soc.*, *62*, 1662-1070.
<https://doi.org/10.1111/j.1532-5415.2004.52458.x>
- Kim, Y. M., Demissie, S., Genant, H. K., Cheng, X., Yu, W., Samelson, E. J., ... Bouxsein, M. L. (2012). Identification of prevalent vertebral fractures using CT lateral scout views: A comparison of semi-automated quantitative vertebral morphometry and radiologist semi-quantitative grading. *Osteoporos Int.*, *23*(3), 1007-1016. <https://doi.org/10.1007/s00198-011-1774-z>
- Lau, E. (1996). Normal ranges for vertebral height ratio and prevalence of vertebral fracture in Hong Kong Chinese: A comparison with American caucasians. *J Bone Miner Res.*, *11*(9), 1364-1368.
- Lau, E., Ong, K., Kurtz, S., Schmier, J., & Edidin, A. (2008). Mortality following the diagnosis of a vertebral compression fracture in the Medicare population. *J Bone Joint Surg Am.*, *90*, 1479-1486.
- Lee, S. J., & Anderson, P. A., & Pickhardt, P. J. (2017). Predicting Future Hip Fractures on Routine Abdominal CT Using Opportunistic Osteoporosis Screening Measures: A Matched Case-Control Study. *AJR Am J Roentgenol.*, *209*(2), 395-400.
- Lenchik, L., Rogers, L. F., Delmas, P. D., & Genant, H. K. (2004). Diagnosis of osteoporotic vertebral fractures: Importance of recognition and description by radiologists. *AJR Am J Roentgenol.*, *183*, 949-958.
- Leslie, W. D., Morin, S. N., & Majumdar, S. R. (2017). Lix LMEffects of obesity and diabetes on rate of bone density loss. *Osteoporos Int.*, *9*, 4223-4229.
- Luckey, M. M. et al. (1996). A prospective study of bone loss in African American and white women: A clinical research center study. *J. Clin. Endocrinol Metab.*, *81*, 2948-2954.
- Melton, L. J. (2003). Adverse outcomes of osteoporotic fractures in the general population. *J Bone Miner Res.*, *18*, 1139-1141.
- Melton, L. J. et al. (1989). Epidemiology of vertebral fractures in women. *Am J Epidemiol.*, *129*, 1000-1011.
- Melton, L. J., Lane, A. W., Cooper, C., Eastell, R., O'Fallon, W. M., & Riggs, B. L. (1993). Prevalence and incidence of vertebral deformities. *Osteoporos Int.*, *3*, 113-119.
- Muhammad, M. A., Muhammad, W., Hussain, S., & Gohar, J. (2014). Lumbar Morphometry: A Study of Lumbar Vertebrae from a Pakistani Population Using Computed Tomography Scans. *Asian Spine J.*, *8*(4), 421-426.
- Muller, D., Bauer, J. S., Zeile, M., Rummeny, E. J., & Link, T. M. (2008). Significance of sagittal reformations in routine thoracic and abdominal multislice CT studies for detecting osteoporotic fractures and other spine abnormalities. *Eur Radiol.*, *18*, 1696-1702.
- Narloch, J., & Glinkowski, W. (2016). Software-assisted morphometry and volumetry of the lumbar

- spine. *Neurol Neurochir Pol.*, 50(3), 143-150.
- O'Neill, T. W. et al. (1996). The prevalence of vertebral deformity in European men and women: The European vertebral osteoporosis study. *J Bone Miner Res.*, 11, 1010.
- Oei, L., Rivadeneira, F., Ly, F., Breda, S. J., Zillikens, M. C., Hofman, A., ... Oei, E. H. (2013). Review of radiological scoring methods of osteoporotic vertebral fractures for clinical and research settings. *Eur Radiol.*, 23(2), 476-486.
- Oleksik, A., Lips, P., Dawson, A., Minshall, M. E., Shen, W., Cooper, C., & Kanis, J. (2000). Health-related quality of life in postmenopausal women with low BMD with or without prevalent vertebral fractures. *J Bone Miner Res.*, 15, 1384-1392.
- Takada, M., Wu, C. Y., Lang, T. F., & Genant, H. K. (1998). Vertebral fracture assessment using the lateral scoutview of computed tomography in comparison with radiographs. *Osteoporos Int.*, 8, 197-203.
- Tracy, J. K., Meyer, W. A., Grigoryan, M., Fan, B., Flores, R. H., Genant, H. K., ... Hochberg, M. C. (2006). Racial differences in the prevalence of vertebral fractures in older men: The Baltimore Men's Osteoporosis Study. *Osteoporos Int.*, 17(1), 99-104.
- Williams, A. L., Al-Busaidi, A., Sparrow, P. J., Adams, J. E., & Whitehouse, R. W. (2009). Under-reporting of osteoporotic vertebral fractures on computed tomography. *Eur J Radiol.*, 69, 179-183.
- Woo, E. K., Mansoubi, H., & Alyas, F. (2008). Incidental vertebral fractures on multidetector CT images of the chest: Prevalence and recognition. *Clin Radiol.*, 63, 160-164.
- Woolf, A. D., & Pfleger, B. (2003). Burden of major musculoskeletal conditions. *Bull World Health Organ.*, 81, 646-656.
- World Health Organization (WHO). (2010). *Global Status: Report on Non-Communicable Diseases*.