

Original Research Article

The correlation of Singh index and cortical thickness index toward bone mineral density in women older than 60 years old with femoral neck fracture

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ABSTRACT

Background: Femoral neck fracture is one of the most common fractures in elderly. Proximal femur fracture in elderly patients is considered a severe morbidity which has a negative impact on the life expectancy and quality of life. Aim of this study was to find the correlation of cortical thickness index (CTI) and SI toward bone density (BMD) in female patients over 60 years of age with femoral neck fracture.

Methods: This is an observational cross-sectional study. Subjects were selected from Sanglah general hospital outpatient department, Denpasar, Bali during the period October 2020 to January 2021 by inclusion requirements and then randomized into two groups. Data were taken through history taking, physical examination as well as supporting investigations such as contralateral hip joint radiograph and BMD measurements. Statistical analysis was done from those data.

Results: It has been obtained that there was a positive correlation of Singh index (SI) and CTI toward BMD. The correlation coefficient (r) between SI and BMD was 0.874 ($p=0.000$). The r between CTI and BMD was 0.854 ($p=0.000$). Both variables were significant.

Conclusions: There were significantly strong correlations between SI and BMD ($r=0.874$, $p=0.00$), also CTI and BMD ($r=0.854$, $p=0.00$) in female patients over 60 years of age with femoral neck fracture.

Keywords: Femoral neck fracture, Singh index, Cortical thickness index, Bone mineral density

INTRODUCTION

Femoral neck fracture is one of the most common fractures in elderly. This fracture is related to bone density in elderly which decreases in quality, commonly called osteoporosis. Osteoporosis is a systemic bone disease that causing problems in elderly because it reduces the quality of life. Treatment of femoral neck

fracture in osteoporosis patients requires complex management and can lead to high morbidity and mortality due to its complications.

The population of elderly is increasing, accompanied by an increasing life expectancy.¹ Osteoporosis is a metabolic disorder that causes global problems in elderly patients.² Osteoporosis is the most common bone disease with incidence up to 200 million people in the world.

Whilst hip fracture more likely to occur in elderly. The incidence of hip fractures increases 100-1000-fold in adults over 60 years of age.⁴ An estimated 1.7 million hip fractures occurred annually in 1990, one third of cases occurred in Asia. Mortality rate increases due to hip fracture complications and less than 50% is able to achieve mobility the same as before the fracture occurs.³ Hip fractures include fractures of the intertrochanter femur and femoral neck. Fracture susceptibility to the hip is defined as a fracture caused by low energy trauma which predominantly occurs in trochanter femur and femoral neck.

Proximal femur fracture in elderly patients is considered as a severe morbidity which has negative impact on the life expectancy and quality of life.⁶ Anatomically, the proximal part of the femur is the most common site for osteoporosis.⁷ The pattern of trabeculae at the proximal femur was analyzed based on the density, number and grade of the trabeculae.⁸

One of the parameters analyzing trabecular pattern of proximal femur is by using SI. The SI was first introduced around 1960 using plain X-rays to show trabeculae pattern of proximal femur, which can be used as a predictor of osteoporosis as well as showing the degree.^{8,9} In addition, other parameters used to assess the degree of osteoporosis is CTI based on the morphology.^{10,11} The gold standard to diagnose osteoporosis is by measuring bone mineral density through dual-energy X-ray absorptiometry (DXA).¹²

DXA used for measuring BMD is not commonly available so that sometimes it can be difficult to diagnose osteoporosis, especially in remote areas where the modalities are very limited. It is being a difficulty as early detection of osteoporosis is very important to prevent complications such as hip fracture. SI and CTI are indicators that can be considered as alternatives in estimating osteoporosis degree and risk to fracture. Those measurements are possibly useful in remote areas where the main modality is restricted to plain X-ray. The correlation between SI and CTI toward BMD as a standard to diagnose osteoporosis needs to be furtherly studied to determine whether these two radiological parameters can predict the degree of osteoporosis.

From above, this study aimed to find the correlation of CTI and SI toward BMD in female patients over 60 years of age with femoral neck fracture.

METHODS

Determining the correlation of CTI and SI toward BMD in women over 60 years of age with femoral neck fracture, the design was an observational cross-sectional study. Subjects were taken from Sanglah general hospital outpatient department, Denpasar, Bali during October 2020 to January 2021 that met the inclusion requirements and then randomized them into two groups. The subjects

were selected by inclusion criteria's, passed the exclusion criteria's and using the simple random sampling method.

The inclusion criteria's included female patients, over 60 years old, having a history of femoral neck fracture and had undergone surgery at least one month or more before the examination was carried out, could normally walk before experiencing femur neck fracture, could walk independently after recovery from the operation, with or without assistive devices (other than wheelchairs). The exclusion criteria's were a history of bilateral femoral neck fractures, a history of systemic malignancy or autoimmune disease, a history of immobilization for more than 1 month, a history of neglected fractures for more than 1 month, a history of complications in the form of osteomyelitis or septic arthritis in hip joint and refusing to participate. There were also drop out criteria's like incomplete medical record, the patient cannot be contacted/recalled to be followed up and has died.

The research procedure started from finding the medical records of patients according to the criteria's, collecting data and searching the subjects using consecutive sampling. All research subjects were called to come to orthopedic and traumatology outpatient department of Sanglah general hospital, Denpasar. Data were collected through history taking, physical examination as well as supporting investigations such as contralateral hip joint radiograph and BMD measurements. Statistical analysis was performed using SPSS v23.0.

We measure sample size using correlation test, with this formula:

$$n = \left\{ \frac{Z\alpha + Z\beta}{(0,5 \ln \frac{1+r}{1-r})} \right\}^2 + 3,$$

where,

n=sample size,

Z α =normal standard deviation,

α =0.05,

Z α =1.96,

Z β =power research,

β =0.8,

Z β =0.842,

r=correlation coefficient between BMD and CTI that in research that conducted by Köse et al is 0.59110.

From formula above, the sample size can be calculated, with the correction for drop out criteria 10%, so the calculation of sample size is:

$$\frac{\Sigma \text{ sampel}}{(1-0.1)} = \frac{20}{0,9} = 22.$$

RESULTS

This study was conducted on 22 female patients aged over 60 years with a history of femoral neck fractures undergone surgery for at least one month or more before the examination.

The table distribution above shows data of 22 female patients over 60 years of age with a history of femoral neck fracture undergone surgery. The subjects average of age was 71.31 years, with height average was 153.95 cm, body weight average was 54.73 kg, body mass index average was 22.97 and duration of menopause average was 21.45 years. The average of SI was 2.86±0.941, the

CTI average was 0.5686±0.08615 and the (BMD) average was -2.9727±0.86475 (Table 1).

From the Table 2, it is found that most of subjects were 60-70 years old (11 patients, 50%) followed by range of 71-80 years old as many as 8 patients (36%) and above 81 years old as many as 3 people (14%). Most of the patients with menopause were over 20 years period of time (13 patients, 59%), followed by 8 patients (36%) were already have menopause for 10-20 years and those less than 10 years only found in 1 patient (5%). Patients with SI 2 and 3 were both 9 patients (40.9%), SI 4 and 5 both amounted to 2 patients (9.1%), whilst SI 1 and 6 were not found in any of the patients. Patients with a bone mineral density of less than -1 were 1 patient (5%), -1 to 2.5 were 6 patients (27%), and more than -2.5 were 15 patients (68%).

Table 1: Sample characteristics.

Characteristics	Mean±SD (n=22)	Minimum	Maximum
Age (in years)	71.3182±7.89446	60	87
Height	153.95±5.473	142	165
Weight	54.73±11.162	32	73
Body mass index	22.9727±3.86525	14	28.9
Duration of menopause (years)	21.4545±7.53865	6	33
SI	2.86±0.941	2	5
CTI	0.5686±0.08615	0.3	0.71
BMD	-2.9727±0.86475	- 4.4	- 0.8

Table 2: Sample characteristics defined by frequencies.

Variables	Range	Frequencies (%)
Age (in years)	60-70	11 (50)
	71-80	8 (36)
	80-90	3 (14)
Duration of menopause	<10	1 (5)
	10-20	8 (36)
	>20	13 (59)
SI	1	0 (0)
	2	9 (40.9)
	3	9 (40.9)
	4	2 (9.1)
	5	2 (9.1)
	6	0 (0)
BMD	<-1	1 (5)
	-1 SD, -2.5	0 (0)
	>-2.5	22 (100)

These data show that SI data were not distributed normally (p<0,05), whereas CTI and BMD were distributed normally with p>0.05 (Table 3).

Based on the statistical analysis, it can be seen that there was a positive correlation of SI and CTI toward BMD.

The r between the SI and BMD was 0.874, which is a strong correlation, with p value 0.000. The r between the CTI and BMD was 0.854, which is also a strong correlation with p value 0.000 (Table 4).

Table 3: Normality test for the variables.

Variables	Shapiro-Wilk		Normality test
	Statistic Z	P value	
SI	0.797	0.000	Not normal
CTI	0.877	0.249	Normal
BMD	0.972	0.765	Normal

Table 4: Correlation test between variables.

Variable	Pearson's correlation test	Spearman correlation test	P value
SI toward BMD	-	0.874	0.000
CTI toward BMD	0.854	-	0.000

DISCUSSION

A total of 22 subjects, the average age was 71.32 ± 3.48 years old (range from 60-87 years), with the largest range was 60-70 years old (50%) (Table 1). This finding was similar to recent study stating that osteoporosis rates increased at over 60 years of age and increased by the age.¹³ The average body weight in this study was 54.73 ± 11.162 kg (range from 32-73 kg) and the average BMI was 22.97 ± 3.87 (range from 14.00 to 28.90) (Table 1). This result was in accordance with another previous study which stated that the more the BMI increasing, the more the risk of osteoporosis obtained.¹⁴ The BMD average value was -2.97 ± 0.86 (range from -0.80 to -4.40), the average value of the SI was 2.86 ± 0.941 (range from 2 to 5) and the CTI average was 0.57 ± 0.086 (range from 0.5304 to 0.6068). Twenty-two subjects of this study had experienced menopause for approximately 21.45 ± 3.63 years (range from 6.00 to 33.00 years). It was in accordance with previous study which concluded that osteoporosis was affected by menopause, so the longer the period of menopause, the greater the chance of getting osteoporosis. From a total of 22 subjects of women aged above 60 years with femoral neck fractures, the SI was varied, grade 2 was 9 subjects (40.9%), grade 3 was 9 subjects (40.9%), grade 4 was 2 subjects (9.1%), degree 5 was 2 subjects (9.1%), but none of them was grade 1 and 6 (Table 2). From this study, it was concluded that SI and BMD had significantly strong positive correlation ($p < 0.05$) calculated by Spearman correlation test ($p = 0.000$ and $r = 0.874$) (Table 4).

There are several studies that support the findings about correlation of SI and CTI, written by Sah et al (2007) which examined the correlation between T-scores, BMD and radiographic parameters such as SI and CTI in menopause women above 60 years old, giving results that there was a correlation between SI and the T-score. In this study, it was also concluded that $SI \leq 4$ had a high risk of suffering from osteoporosis, so that it required further evaluation by examining the BMD. That statement was determined due to the fact that SI value below 4 had thinning trabeculae. This fact was in line with osteoporosis theory which there was a lack of bone

mineral density on bones that also resulted in more susceptible to injury¹⁸⁻²⁰

From a total of 22 subjects of women aged 60 years with femoral neck fractures, the CTI was 0.5686 ± 0.08615 (range from 0.3 to 0.71) and it was found that CTI and BMD had a significantly very strong positive correlation ($p < 0.05$) analyzed using the Pearson's correlation test ($p = 0.00$, $r = 0.854$).

Previous studies also showed that the CTI had a correlation with BMD, the lower the CTI, the higher the risk of osteoporosis. One research conducted by Lee et al held in 2017 at Korea severance hospital of 14 female patients with atypical femoral fractures (AFF) with an average age 72.6 years old showed similar results. Lee et al observed femur fracture patients receiving long-term bisphosphonate drugs and investigated the association between CTI and BMD. He found that CTI and BMD were higher in femur fracture patients receiving long-term bisphosphonate drugs compared to non-long-term bisphosphonate users. This suggested an association between CTI and BMD in atypical femoral fractures.²¹

Another study conducted in Japan retrospectively also supported the correlation between CTI and BMD. Nguyen et al in 2018 conducted a study at the department of orthopedic surgery, Hamamatsu teaching hospital, found that in 560 patients who underwent BMD and CTI examinations, it was found that CTI results were significantly correlated with BMD, so that CTI could be used as a predictor of BMD levels. This study also suggested that gender did not affect the correlation between CTI and BMD.²²

However, the results of this study were not supporting the previous study conducted by Baumgartner et al which examined the correlation between CTI and BMD in patients with proximal femur fractures. It suggested that no correlation was found between CTI and BMD in proximal femur fracture patients. The results of that study do not support the use of CTI as a predictor for osteoporosis.²³

Previous studies have largely shown a correlation between CTI scores and BMD, so that many have recommended the use of CTI as a predictor for osteoporosis, before doing further evaluation using the DXA.^{21,22,24}

Limitations

The limitation of this study was that it was held in only one centre. Multicenter study should be carried out so that more conclusive results can be obtained.

CONCLUSION

There is a significantly strong correlation between SI and BMD ($r=0.874$, $p=0.00$) and also CTI and BMD ($r=0.854$, $p=0.00$) in female patients above 60 years old with femoral neck fracture.

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