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Bone mineral density in patients with chronic spinal cord injury: An observational study

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ABSTRACT

Background: Spinal cord injury (SCI) is accompanied by loss of bone mass caused by accelerated bone remodeling, with bone resorption exceeding bone formation which causes net bone loss. The significance of osteoporosis after SCI is that it results in skeletal fragility and an increased risk of fractures. Complications from fractures lead to an increase not only in the associated morbidity and mortality, but also in the health-care costs that they generate. **Aims and Objectives:** The objective of the study was to evaluate bone mineral density (BMD) in patients with SCI in Indian population and to determine the effects of the neurological level, severity of injury, and mobility status on BMD. **Materials and Methods:** This study was a prospective and observational study conducted on 52 chronic SCI patients. After detailed history and examination, patients were assessed using American spinal injury association impairment scale following which BMD was assessed by Dual Energy X-ray Absorptiometry Scan. Correlation between the T score and neurological level, severity of injury and mobility status was assessed. $P<0.05$ was considered statistically significant. **Results:** Out of 52 patients included, 41 were having complete SCI and 35 were non-ambulatory. T score was significantly ($P<0.001$) lower in lumbar spine and both femur in complete SCI patients. The T score was indicative of increased osteoporosis in non-ambulatory patients. BMD did not differ significantly ($P<0.059$) in patients with relation to various neurological levels. **Conclusion:** From this study, we conclude that osteoporosis is commonly present in patients with complete SCI and non-ambulatory was more affected. Early mobilization of these patients reduces the development of osteoporosis.

Key words: Spinal cord injury; Bone mineral density; Dual energy X-ray absorptiometry; Osteoporosis

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INTRODUCTION

Spinal cord injury (SCI) is a devastating disorder that can have consequences causing impairment in physical, psychological, and social functioning.[1]

Individuals with SCI are at an increased risk of developing complications due to inactivity, among which loss of bone mineral density (BMD) is very common. The bone resorption occurs rapidly in the initial 18–24-month post-injury followed by gradual bone loss and reduced bone formation in the chronic phase.[2]

The exact cause of disturbance of bone metabolism in SCI patients is not known. Various factors have been thought to be affecting bone metabolism in SCI patients including, a decrease in the mechanical load applied to bone due to prolonged immobilization, blood circulation abnormalities at the sublesional level which could affect bone cell differentiation, and hormonal deficiencies.[3]

The relevance of osteoporosis after SCI is that it contributes to fragility of the bones and an increased risk of fractures which contribute to an increase in the associated morbidity and mortality.[4]

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Osteoporosis usually affects the pelvis and lower extremities in persons with paraplegia, while in tetraplegic patients, in addition to the pelvis and lower extremities, bone loss is also reported in the upper extremities. It has also been shown that the duration of injury also affects the degree of bone loss.[5,6]

In the initial phase post-injury, bone loss occurs in the sublesional areas and primarily in weight bearing trabecular rich sites such as the distal femur and proximal tibia.[3]

Bone loss at spine is not as marked as that in the hip, this could be attributed to weight bearing at the spine post-injury while sitting, associated degenerative changes in the spine which affect the assessment of spine BMD and could be "falsely increased" by neuropathic spondylopathy.[3,7]

Degree of demineralization for lumbar spine, pelvis, and lower limbs has been found to be independent of neurological level after SCI[8] but the level of mobility after SCI is associated with the degree of BMD loss.[9,10] Early mobilization is associated with minimal loss of trabecular bone when compared to those who were immobilized for prolonged duration. Although individuals with complete injury may have more severe bone loss when compared to those with incomplete injury but it has been observed that in patients with complete injury who performed standing during acute phase with the help of assistive devices and orthosis had better BMD than those who did not.[10-12]

To diagnose osteoporosis, dual energy X-ray absorptiometry (DEXA) is considered as the "gold or criterion standard" by the World Health Organization and is the most commonly used osteoporosis evaluation technique.[13] To specify the categories, a standardized score, called the T-score, is used to compare BMD to average values of healthy young adults.

Aims and objectives

The aim of this study was to assess BMD in patients with chronic SCI and to determine the effects of the neurological level, severity of injury, and mobility status on BMD.

MATERIALS AND METHODS

This study was a single-centered, observational, and cross-sectional study conducted in Department of Physical Medicine and Rehabilitation of a tertiary care hospital from November 2016 to December 2017. Approval of Institutional Ethical Committee (IEC/VMMC/SJH/OCTOBER/2016) was taken. Written informed consent was taken from participants and they were assured of confidentiality of the data and their right to participate in the study. The diagnosed cases of traumatic SCI with minimum duration of injury of 1 year were included in the study. Subjects those who were having diseases and taking medications that could affect bone metabolism and post-menopausal women were excluded from the study.

World-wide prevalence rate of SCI ranges from 236 to 1800 per million.[14] Taking this value as reference, the minimum required sample size with 80% of power of study and 5% of level of significance was calculated. Sample size of 52 was calculated using the formula $ME = z^*Sqrt(p(1-p)/N)$ Where Z is value of Z at two-sided alpha error of 5%, ME is margin of error at 1.5% and p is prevalence rate.

Complete assessment including detailed history and clinical examination of all patients was done. Neurological examination was done to assess the severity as per American spinal injury association impairment scale (AIS). Mobility status was considered as follows:[15]

- Community ambulation: Are able to transfer from sit to stand, don and doff orthotics independently, and walk at least 150 ft.
- House-hold ambulation: Able to walk independently in the home but requiring a wheelchair for longer distances.
- Exercise ambulation: Can stand and take a few steps using lower limb orthosis but require another person for support.
- Non-ambulatory: These patients cannot stand or walk and are fully wheelchair dependent.

BMD evaluation was done using DEXA by OSTEOSCORE-3 (Digital 2D Densitometer) at following sites: Spine, forearm, and hip.

The WHO classification of osteoporosis is on the basis of T score was used for the study:[16]

- Normal: – T Score -1.0 or >−1.0
- Osteopenia: – T Score between −1.0 and −2.5.
- Osteoporosis: – T Score -2.5 or <−2.5
- Severe osteoporosis: – T Score – 2.5 or <−2.5 plus fragility fracture

Data were entered in Microsoft Excel and analyzed in Statistical Package for the Social Sciences version 21. Categorical variables were presented in number and percentage while continuous variables were presented as mean±SD. For comparison of T score, Student's t-test was used and where there were more than two groups; ANOVA was used. $P<0.05$ was considered statistically significant.

RESULTS

Fifty-two chronic SCI patients were included in the study. The age of the patients included in the study ranged from

21 to 56 years with male predominance. Majority of the patients (34) had D10-D12 neurological level of injury (Table 1).

Forty-one patients (78.8%) were having complete SCI categorized as AIS-A while 11 patients (21.2%) were having incomplete SCI of which five had AIS-C and six had AIS-D.

No significant difference in T score at lumbar spine, hip, and forearm was observed with different neurological level of injury. Although the T score in spine was lower when compared to femur and forearm (Table 2).

Mean T score in lumbar spine and femur was found to be significantly lower in patients of complete SCI (AIS-A) as compared to those with incomplete injury (Table 3).

Out of 52 patients, 35 (67.3%) patients were non-ambulatory while only 13 patients (25%) were ambulatory with the help of ambulatory aids and four patients were exercise ambulators. T Score was lower in spine and both femurs in non-ambulatory patients as compared to ambulatory ones. There was no significant difference in T Score of forearm between ambulatory and non-ambulatory patients. Although the T score was better in exercise ambulators when compared to non ambulators, it was still significantly lower when comparing with household ambulators (Table 4).

Table 1: Demographic profile of the patients (n-52)

Characteristics	No of patients	Percentage
Age (years)		
21–30	12	23.08
31–40	24	46.15
41–50	13	25.00
>50	3	5.77
Gender		
Male	42	80.77
Female	10	19.23
Neurological level		
Cervical	4	7.69
Upper thoracic	2	3.85
Lower thoracic	44	84.61
Lumbar	2	3.85

DISCUSSION

In this study, most of the patients were in the age group 31–40 years and the male-to-female ratio was 4.2:1. According to this study, young adult males are more prone to SCI and as they are only earning member in most of the families in Indian society and are more prone to injuries. These findings are in accordance to some previous studies.[17-19]

In this study, out of 52 patients, 41 patients had complete lesion (AIS A) and 11 had incomplete lesion and most common neurological level of injury was D10-D12. The incidence of complete SCI (AIS-A) varies greatly in the literature, still most of the studies have observed that complete injuries are more common.[17-20] Similarly, neurological level of injury involving the thoracolumbar region is more commonly observed in various studies.[17-19]

Loss of bone mass is higher in the sub lesional levels post-SCI and most commonly present in the femur and tibia.[3,5-8,21] In this study, patients had more severe reduction of T score of the lumbar spine and hip as compare to forearm. None of the patients had T score < − 1in the forearm while in the hip, majority of the patients had T score < − 1. Number of the previous studies have observed that bone density of the lumbar spine does not alter in SCI patients significantly.[3,5-8,21] In contrast, this study shows that the T score of lumbar spine was significantly reduced as compared to that at hip and was significantly associated with the severity of injury and ambulatory potential. This could be explained by prolonged immobilization of most patients after surgical correction and delayed referral

Table 2: T score according to neurological level of spinal cord injury patients

Neurological level	T-score (mean±SD)				
	Lumbar spine	Right femur	Left femur	Right forearm	Left forearm
C5	−1.6±0.57	−1.6±1.13	−1.6±0.99	−0.45±0.07	−0.6±0.1
C6	−1.3±0.14	−0.7±0.14	−0.8±0.14	−0.6±0.28	−0.7±0.14
D5	−3.7±0	−2.7±0	−2.8±0	−0.9±0	−0.8±0
D6	−3.5±0	−2.5±0	−2.6±0	−0.8±0	−0.6±0
D8	−2.87±0.89	−1.98±0.71	−1.9±0.63	−0.67±0.16	−0.75±0.08
D9	−3.1±0.22	−1.78±0.25	−1.88±0.25	−0.75±0.1	−0.85±0.1
D10	−2.59±0.8	−1.73±0.81	−1.73±0.78	−0.53±0.08	−0.6±0.12
D11	−2.69±0.49	−1.49±0.27	−1.52±0.29	−0.55±0.12	−0.6±0.12
D12	−2.81±0.18	−1.56±0.14	−1.51±0.17	−0.63±0.08	−0.71±0.09
L2	−1.2±0	−1.5±0	−1.8±0	−0.4±0	−0.4±0
L3	−1.7±0	−0.3±0	−0.5±0	−0.4±0	−0.3±0
P-value	0.059	0.058	0.066	0.057	0.059

Table 3: T Score according to severity of lesion classified by Asia Impairment Scale

AIS	T-score (mean±SD)				
	Lumbar spine	Right femur	Left femur	Right forearm	Left forearm
A	−2.9±0.45	−1.81±0.5	−1.82±0.48	−0.6±0.14	−0.66±0.14
C	−1.48±0.31	−1.06±0.75	−1.02±0.73	−0.58±0.16	−0.64±0.17
D	−1.23±0.19	−0.65±0.19	−0.73±0.1	−0.52±0.16	−0.67±0.12
P-value	<0.0001	0.0002	0.0002	0.291	0.059

Table 4: T score according to ambulatory status

Ambulatory status	T-score (mean±SD)				
	Lumbar spine	Right femur	Left femur	Right forearm	Left forearm
Non ambulatory	−3±0.32	−1.9±0.44	−1.9±0.44	−0.61±0.14	−0.66±0.13
Exercise ambulatory	−2.82±0.21	−1.48±0.05	−1.42±0.05	−0.65±0.06	−0.78±0.05
Household ambulatory with walker	−1.63±0.4	−1.4±1.05	−1.53±0.93	−0.43±0.06	−0.43±0.15
Household ambulatory with elbow crutches	−1.28±0.17	−0.68±0.15	−0.72±0.11	−0.55±0.16	−0.66±0.14
P-value	<0.0001	<0.0001	<0.0001	0.066	0.059

T score of lumbar spine, hip, and forearm when correlated with the duration of injury did not show any significant association

to rehabilitation services. Availability of rehabilitation services is still scarce in Indian setup especially in rural areas where large proportion of the population resides. Most of the patients reach late for rehabilitation either due to lack of availability of resources, lack of accessibility, poor socioeconomic status, or due to lack of knowledge regarding rehabilitation management among general population and health-care providers.

T score at spine, hip, and forearm was independent of the neurological level of injury which is similar to the findings observed in the previous studies. Decreased bone density is more severe in the sub lesional levels in SCI and the severity of bone loss is found to be different in patients with quadriplegia (forearm, spine, and hip) and paraplegia (spine and hip) and not when comparing different neurological levels.[3,5,6,8]

In SCI individuals with complete lesions, bone mass loss may be more severe than in those with incomplete lesions.[6,10-12,22] In the present study also, patients who had complete injury (AIS-A) had lower T score as compared to those with incomplete injuries and were more prone to osteoporosis. Complete injury is more commonly associated with prolonged immobilization in acute stage and less chances of independent ambulation which prevents weight bearing on the lower extremities and makes them more prone to severe bone loss.

It was also observed that patients who are ambulatory with assistive devices (walker/elbow crutches) had better T scores as compared to those who are non-ambulatory or wheelchair bound. Even those patients who were only doing exercise ambulation had better T score than non-ambulatory patients. These findings are similar to what has been observed in the previous studies correlating bone density with ambulatory potential.[9,10,12,23]

Limitations of the study

One of the major limitations of the study is that there is no control group to compare the results. We have not correlated BMD of chronic spinal injury patients with their age. Follow-up of these patients was not done in the study.

CONCLUSION

Chronic SCI and subsequent osteoporosis have an enormous impact on the person. There is a significant risk of fragility fractures in the lower extremity after SCI and it increases with the severity of SCI. The importance of early diagnosis of decreased bone mass in patients who have suffered SCI is the prevention of pathologic fractures and their complications. Maintenance of BMD is essential in SCI rehabilitation to maintain bone health and assist in ambulation, transfer, and activities of daily living.

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