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Osteoporosis-related fractures after spinal cord injury: a retrospective study from Brazil

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Abstract

Study design Retrospective study

Objectives To describe the epidemiological and clinical profile in a retrospective chart review of individuals with spinal cord injury (SCI) and osteoporosis-related fractures.

Setting A Brazilian rehabilitation hospital.

Methods This is a retrospective chart review that included 325 individuals with SCI and osteoporosis-related fractures who were admitted to a Brazilian rehabilitation hospital between January 1997 and December 2017.

Results Overall, 52% were males with a mean (SD) age of 44.8 (± 16.7) years at the time of first fracture. Overall, 82% had paraplegia and 56% had a thoracic neurological level. The mean (SD) time between SCI and fracture was 9.7 (± 9.3) years. In 59% of cases the immediate cause of the fracture was a fall. The locations of the fractures were distal femur (27%), proximal femur (27%), and tibia and/or distal fibula (28%). The fractures occurred mostly at home (63%). Complications occurred in 19% of individuals and 25% reported worse performance in activities of daily living and 29% a deterioration in ambulation after they had recovered from the fracture. A second fracture was described in 15% of individuals, and five individuals had a third fracture. The mean (SD) level of 25 hydroxyvitamin D [25 (OH) D] was 25.6 (± 15.2) ng/ml, and only 11 individuals (3%) underwent dual energy X-ray absorptiometry (DEXA), and 26 individuals (8%) were treated with antiresorptive drugs after fracture.

Conclusion Little is done to prevent fractures in individuals with SCI and understanding the clinical and epidemiological profiles will help identify risk factors and establish prevention programs and appropriate treatment.

Introduction

Osteoporosis affects the health of individuals with SCI because it increases the risk of fractures with consequences, such as skills, ulcers, immobility, depression, and mortality [1–7].

Bone demineralization after SCI occurs in 4% of bone loss per month in the first year [8–10], primarily in the knees. Demineralization begins in the early days, peaks around the 10th–16th week and stabilizes around the

16th–24th month [8, 9]. Recent studies suggest that the bone loss extends 3–8 years after SCI [10]. Previous studies demonstrated bone demineralization >20% in the hip, 37–52% in the distal femur and 36–70% in proximal tibia after 1–3 years after SCI [10–13].

Bone loss associated with spinal cord injury is related to immobility and metabolic changes [14, 15]. Individuals with SCI exhibit hypercalcemia, hypercalciuria, hyperparathyroidism, and decreased levels of osteocalcin. The loss of bone mineral density is 2–4 times greater than the loss that occurs in an immobilized individual without SCI [15]. Other related factors may contribute to this bone loss, such as vitamin D deficiency and the use of methylprednisolone, anticonvulsant drugs, and psychotropic substances [4].

The consequence of osteoporosis in individuals with SCI is fracture due to bone fragility. Fractures may occur in 25–46% of these individuals over their lifetimes [4–7, 16, 17]. Fractures are primarily related to torsional forces during transfer, passive mobilization, compressive

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forces and falls [4–8, 17]. Individuals with tetraplegia have more osteoporosis than those with paraplegia, however individuals with paraplegia have a higher frequency of fractures due to exposure to falls [4–7, 16, 17].

The following risk factors have been described in previous studies as associated with increased fracture: ASIA Impairment Scale (AIS) or B; age 40+ years old; SCI longer than three years; age at SCI of 16 years or less; three servings of coffee per day; smoking; woman; family history of osteoporotic fractures; low bone mineral density; low weight bone mass index < 19 kg/cm²; alcohol intake >30 g/day; paraplegia, and the use of corticosteroids [4–7]. Craven et al. [4] developed protocols conducive to treatment based on these risk factors.

Bone densitometry scan (DEXA) in individuals with SCI is a confirmatory test to predict the future risk of fracture. The use of *T*-scores proposed by the World Health Organization (WHO) or the Fracture Risk Assessment Tool (FRAX) for individuals with SCI is debatable [9]. Some studies suggested that a low score of FRAX and DEXA of the hip predicted fracture in individuals with SCI [18], and some authors suggest DEXA measurement of the distal femur and proximal tibia, with specific protocols for the evaluation of these sites [19].

The aims of this study are:

- To describe the epidemiological and clinical profiles from a retrospective chart review of individuals with SCI and osteoporosis-related fractures in our population.
- To compare the type of locomotion (wheelchair or ambulation) with the fracture site and to compare the age of the first fracture with gender.

Methods

The present study is a retrospective chart review of individuals with SCI from the Rehabilitation Program at the Belo Horizonte Unit of the Sarah Network of Rehabilitation Hospitals from Association of Social Pioneers.

Individuals were admitted from January 1997 to December 2017 and every individual had at least one osteoporosis-related fracture during the period of investigation.

Data were obtained from electronic records containing information about all consultations and examinations with the participants. Fractures were defined using International Statistical Classification of Diseases, ninth revision codes (ICD-9).

The time (in years) between SCI and the osteoporosis-related fracture was extracted. In addition, data as per the International Spinal Cord Injury Fracture History Extended Data Set [20] were extracted. This included: fracture location in one of the five groups (proximal femur, distal femur,

distal tibia and/or fibula, foot, and others); and fracture etiology (unknown, turning over in bed/transfer, fall from wheelchair or standing height, self-passive mobilization, dropped object on body, stretching/physical therapy activities, findings on x-ray, caught foot on object while wheeling, weight-bearing or assisted ambulation activities, and others). We considered transfer as the cause of fractured if the fracture occurred during the transfer per se and classified the cause of fracture as a fall if the fracture occurred after the transfer.

Some fractures were excluded: fall from greater than standing height, sports injuries, and motor vehicle/motorcycle accidents. We considered only surgery (yes or no) for fracture treatment. We excluded patients with diagnosis of congenital spinal disease as bifid spine and genetic diseases as progressive paraparesis.

The following fracture complications were also extracted: none, skin ulcer, infection, amputation, fracture non-union/delayed union, deep venous thrombosis, loss of range of motion. We entered 40 for the WHO FRAX age if the participant was younger than 40 years old, and “yes” for secondary osteoporosis was entered for all individuals with SCI. Results are expressed as percentages in the 10-year probability of major osteoporotic fracture.

We used the American Spinal Injury AIS from the American Spinal Injury Association (ASIA) [21] for level classification.

The following factors were used as independent variables: (1) socioepidemiological characteristics including sex, age, and schooling (in years) (2) lifestyle, including drugs, alcohol intake of three or more units/day and tobacco consumption; (3) clinical data, such as weight, height, family history of fracture, and comorbidities (diabetes mellitus, hypertension, hypothyroidism, rheumatoid arthritis); (4) physical signs as Ashworth Scale [22] for the wrist extensors, triceps, knee extensors and ankle extensors was used to evaluate spasticity of lower and upper limbs, the use of some type of support for locomotion, the level of the neurological lesion (cervical, thoracic or lumbosacral), range of motion measurement after fracture was performed using a goniometer; (5) medications; and (6) laboratory findings including vitamin D, calcium, phosphorus, magnesium, parathyroid hormone, and alkaline phosphatase levels and (7) DEXA result for total femur/femoral neck bone measurement density (g/cm²).

Socioepidemiological, lifestyle, and clinical data refer to the time of SCI. Physical signs, medication, laboratory data and DEXA refer to the time of the fracture.

Individuals age was considered at the age of SCI and the occurrence of fracture. We divided the participants as ambulatory (at least daily training or walking with an orthosis and walker or sticks) or wheelchair-bound (no walking training at all).

Statistical analysis

Data from the electronic health records were entered into a Microsoft Excel 2010 spreadsheet and analyzed using the IBM SPSS Statistics for Windows, Version 21.0. An exploratory analysis of the data was performed to ascertain the characteristics of the study population and the prevalence of the variables described. The presence of associations was considered at the 0.05 significance level. Pearson's correlation coefficient, Student's *t* test and Yate's Chi-square test (χ^2) were used to test for associations between groups in univariate analyses.

Results

We conducted a retrospective study comprising individuals selected from a cohort of patients with traumatic and non-traumatic SCI with fractures related to SCI ($n = 1535$). A total of 325 participants with SCI and 378 osteoporosis-related fractures were selected for analyses after the application of inclusion and exclusion criteria (excluded $n = 1210$). Characteristics of the participants are described in Table 1.

Ambulatory individuals (49%) and wheelchair-bound (51%) individuals exhibited similar frequencies. The time to the first fracture was varying from a few months (minima 3 months) to many years (maxima 66 years) after SCI.

The most frequent cause of fracture was falls (Table 2) with 78 individuals (24%) reporting falls from their wheelchairs, and 114 individuals (35%) experiencing falls from their own height while standing or walking. The three most common locations of the fractures were the tibia and/or distal fibula (27%), distal femur (27%), and proximal femur (26%). Only 20 fractures were in the proximal tibia and/or fibula (6%). The most common location of fractures among ambulatory individuals was the distal tibia/fibula (36%) and among wheelchair-bound individuals was the femur (68%). Wheelchair-bound participants fractured mainly the femur compared to ambulatory participants who fractured mainly the distal lower limb (tibia/fibula/ foot) ($p < 0.0001$). Mean (SD) age of first fracture for women were 50.1 (± 17.0) and for men 40.0 (± 14.9) ($p < 0.001$). Forty-eight (15%) individuals experienced a second fracture, and five (2%) individuals experienced a third fracture (Table 2).

The mean (SD) major osteoporotic risk factor found on FRAX was 3.9% (± 1.9) and there was a weak negative linear relationship with time to fracture ($r = -0.19$; $p = 0.016$; $n = 165$). Only 11 participants (3%) underwent DEXA and the median values were 0.60 g/cm² for total femur and 0.72 g/cm² for neck femur. Only 26 (8%) participants underwent bisphosphonate treatment after fracture. Just 41% of electronic records described the environment

Table 1 Clinical and epidemiological profiles of 325 participants with SCI and osteoporotic-related fractures

Features	<i>N</i> (%)
Sex	
Female	155 (47.7%)
Male	170 (52.3%)
Age SCI (years)	
Mean (standard deviation)	34.6 (16.5)
Schooling	
No study	8 (2.5%)
1–8 years	164 (50.5%)
9+ years	148 (45.5%)
Not informed	5 (1.5%)
Patients characteristics	
Traumatic SCI	196 (60.3%)
Paraplegics	260 (80.0%)
ASIA A	152 (46.8%)
Thoracic level	186 (57.2%)
Spasticity	206 (63.4%)
Smokers	52 (16.0%)
Alcoholism	23 (7.1%)
Drug addiction	13 (4.0%)
Diabetes melitus	19 (5.8%)
Rheumatoid arthritis	4 (1.2%)
BMI (kg/cm ²)	
Mean (standard deviation; <i>n</i>)	24.8 (5.6; 160)
25-OH D (ng/ml)	
Mean (standard deviation; <i>n</i>)	25.6 (15.3; 94)
<20 ng/ml	34 (36.2%)

and fractures occurred mostly at home (Table 2). The following variables were not analyzed due to missing data: history of family fractures (27%), vitamin D (71%), calcium (68%), phosphorus (69%), magnesium (86%), parathyroid hormone (84%), and alkaline phosphatase levels (41%).

Discussion

The present study has been described osteoporosis-related fractures in individuals with SCI. The prevalence of fractures attributable to osteoporosis in Brazilian individuals has been described only in person without neurological impairment [23].

Our study found similar clinical and epidemiological profiles to other publications [3, 13, 14], including the prevalence of individuals with paraplegia, AIS A, spasticity, age of fracture (40+ years old) and time to fracture. Men and women had a similar frequency of fractures in the present study.

Table 2 Characteristics of osteoporotic-related fractures in 325 participants with SCI

Event related to 1° fracture	<i>n</i> (%)
Fall	192 (59.1%)
Stretching/physical therapy activities	29 (8.9%)
Unknown	27 (8.3%)
Turning over in bed/transfer	18 (5.5%)
Findings on x-ray	5 (1.5%)
Caught foot on object while wheeling	6 (1.8%)
Weight-bearing or assisted ambulation activities	6 (1.8%)
Dropped object on body	4 (1.3%)
Others	38 (11.8%)
Fracture location 1° fracture	<i>n</i> (%)
Distal femur	89 (27.4%)
Proximal femur	87 (26.8%)
Distal tibia or fibula	90 (27.7%)
Proximal tibia or fibula	20 (6.2%)
Foot	20 (6.2%)
Others	19 (5.8%)
Age 1° fracture (years)	
Mean (standard deviation)	44.8 (16.7)
Age 2° fracture (years)	
Mean (standard deviation)	50.0 (16.7)
Duration SCI and 1° fracture (years)	
Mean (standard deviation)	9.7 (9.3)
Duration SCI and 2° fracture (years)	
Mean (standard deviation)	12.1 (9.0)
1° fracture environment	<i>n</i> (%)
Inside home	84 (62.7%)
Outside home	47 (35.1%)
Bathroom	19 (14.2%)
Bedroom	17 (12.7%)
Other places at home	48 (35.8%)
Other places	3 (1.6%)
Treatment 1° fracture	<i>n</i> (%)
Hospitalized	155 (47.7%)
No Surgery	178 (54.8%)
Surgery	148 (45.5%)
Complications 1° fracture	<i>n</i> (%)
Worse ambulation	94 (28.9%)
Worse in daily activities	82 (25.2%)
Deformity	19 (5.8%)
Skin lesion	15 (4.6%)
Pseudoarthrosis	13 (4.0%)
Infection	13 (4.0%)

Most fractures occurred in the tibia and/or distal fibula, distal femur, or hip/proximal femur, and only a few cases occurred in the proximal tibia. Some previous findings demonstrated most fractures in the tibia/fibula [17, 24] and

in the hip [25]. These results contrast some previous studies that demonstrated distal femur and proximal tibia as the most common fracture locations and bone loss. Some authors suggest DEXA measurement of the distal femur and proximal tibia [10, 12, 19, 26]. Our study found that fractures in hip/proximal femur and distal tibia/fibula were as common as the distal femur. However, the present study included individuals who were ambulatory and wheelchair dependent at a similar frequency. Ambulatory individuals fractured more often the distal tibia/fibula, and wheelchair-bound patients fractured the distal and proximal femur

The most frequent cause of the fractures was fall from a wheelchair or their own height while walking or standing. This result is not surprising because falls are a common health problem in individuals with SCI, and prevention of falls should be a priority. Another study found transfer as the main cause of fracture [17, 27]. However, we only considered transfer as the cause of fractured if the fracture occurred during the transfer per se, and classified the cause of fracture as a fall if the fracture occurred after the transfer or if the individuals fell on the floor during the transfer. This classification may explain the difference in results.

Notably, one-third of the participants had 25 hydroxyvitamin D [25(OH)D] levels <20 ng/ml. Previous studies found that 14–32% of individuals with SCI were deficient in vitamin D and 32% were deficient in vitamin D insufficient [27, 28]. In this study, we detected similar findings which emphasizes that even in a tropical country like Brazil, vitamin D deficiency is a common health problem as has already been published [28]. Nevertheless, 25(OH)D levels <20 ng/ml were not related to a short time development of fractures in our study.

Most participants were hospitalized after the fracture, and some had complications. Almost one-third of the participants reported worse performance in activities of daily living and ambulation after the fracture had healed. This result reflects the impact of fractures on the lives of individuals with SCI.

Brazil is still a country with a young population with SCI, and falls and fractures will be a major health problem in these individuals as they age. Special attention should be paid to the prevention of fractures, and appropriate treatments should be instigated to prevent excessive bone loss.

The design of this study precludes any causal conclusion. We noted that much of the data that could be associated with fracture occurrence were missing, such as history of family fractures, environmental conditions where the fractures occurred, and vitamin D, calcium, phosphorus, magnesium, parathyroid hormone alkaline phosphatase levels, which indicates that these investigations are not performed even in a rehabilitation hospital. Most of the physicians are not educated to measure these risk factors. DEXA was performed only in a few cases, and even after an

osteoporotic fracture only 8% of patients received bisphosphonate prescriptions, which indicates that most physicians neglect osteoporosis after SCI.

Individuals with osteoporosis-related fractures after SCI had several complications. Most individuals were hospitalized, and half of them underwent surgery. These issues mean increased disability and cost for the health system. Understanding the clinical and epidemiological profile of this population will can help identify risk factors and establish prevention programs and appropriate treatment. Campaigns to prevent falls and stimulate the appropriate identification and treatment of osteoporosis in individuals with SCI should be promoted.

Data availability

Anonymized data will be shared by request from any qualified investigator.

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Author contributions All authors contributed equally to the manuscript.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical statement The Research Ethics Committees of the Sarah Network of Rehabilitation Hospitals approved this study number: 66396817.7.0000.0022

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