

Bone loss and steady state after spinal cord injury: A cross-sectional study using pQCT

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Aim

The aim of the present study was to describe the adaptation of bone geometry and bone density in the trabecular and cortical compartment in subjects after spinal cord injury.

Methods

Ninety-nine motor complete SCI subjects with a duration of paralysis of between 2 months and 50 years were included in the study. Twenty-seven were tetraplegics and 72 paraplegics, 89 had a spastic and 10 a flaccid paralysis. Distal epiphyses and mid-shafts of the femur, tibia, and radius were measured by peripheral quantitative computed tomography. The same measurements were performed in a reference group of 18 healthy able-bodied subjects of the same age range.

Results

Within the first 5 years after spinal cord injury rapid bone loss occurred predominantly in the epiphyses of the femur and tibia. The temporal pattern of bone loss showed considerable individual differences. At four (femur) to seven (tibia) years a steady-state was reached, where trabecular bone mineral density (BMD) of the epiphyses was reduced by 73% in the tibia and 54% in the femur. The cross-sectional area of the thin cortical shell of the epiphyses was reduced by 85% in the femur and 67% in the tibia. Bone

mass was reduced by 58% and 48% in the distal tibia and distal femur, respectively

In the diaphysis the differences were smaller: mean cortical thickness decreased by 33% in the tibia and 35% in the femur. Diaphyseal bone mass was reduced by 34% and 25% in the tibial and femoral diaphysis, respectively. Cortical BMD of the shaft was not different from an able-bodied reference group, although a slight decrease was observed within the first five years after injury, which recovered thereafter. The total bone cross-sectional area did not change but the cortical area was reduced by 34% and 28% in the femoral and tibial diaphysis, respectively, indicating endosteal resorption.

Bone loss in the radius of tetraplegic subjects was less extensive compared to the lower extremities but showed a similar pattern. Radius bone parameters were only reduced in tetraplegics and not in paraplegics with respect to the reference group.

Discussion

The two main processes that reduce bone mass in the lower extremities of SCI people are a vast loss of trabecular bone in the epiphyses and a thinning of the bone shaft by endosteal resorption. The periosteal expansion with age observed in ambulatory subjects as described by Russo et al.¹ was not observed. The transient decrease in cortical BMD is likely to be due to increased remodelling during the first few (<5) years after the injury, after which cortical BMD shows normal values.

P. Eser has no conflict of interest. H. Schiessl and J. Willnecker hold corporate appointments with Stratec Medizintechnik GmbH. H. Schiessl has a corporate appointment with Novotec Medical.

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Reference

1. Russo CR, Lauretani F, Bandinelli S, Bartali B, Di Iotio A, Volpato S, Guralnik JM, Harris T, Ferrucci L. Aging bone in men and women: beyond changes in bone mineral density. *Osteoporos Int* 2003; 14:531-538.

	Parameter	Reference Group	Spastic Group time p.i.>5y	Flaccid Group time p.i.>5y	Difference Reference to Spastic Group	Difference Reference to Flaccid Group	ANOVA p value†
tibia	n	18 (*n=17)	48 (*n=47) (°n=39)	6 (*n=2)			
4%	BMDtrab [mg/cm ³]	244.4 ± 35.5	66.6 ± 21.1	50.5 ± 40.1	-72.7 %	-79.3%	***
	BMDtot [mg/cm ³]	311.1 ± 42.7	137.3 ± 29.6	118.1 ± 48.4	-55.9 %	-62.0 %	***
	CSAcort [mm ²]	231.2 ± 86.0	73.8 ± 33.3	57.7 ± 37.4	-67.1 %	-75.0 %	***
	mass [g]	4.12 ± 0.83	1.78 ± 0.36	1.54 ± 0.63	-56.8 %	-62.6 %	***
14%	mass [g]	3.01 ± 0.42	1.98 ± 0.38	1.73 ± 0.42	-34.2 %	-42.5 %	***
38%	BMDcort [mg/cm ³]	1159.4 ± 28.6	1133.5 ± 46.3*	1131.0 ± 51.3	-2.2 %	-2.4 %	n.s.
	CSAcort [mm ²]	334.7 ± 41.8	245.2 ± 53.3*	236.1 ± 98.8	-26.7 %	-29.5 %	***
	CSAtot [mm ²]	457.0 ± 45.4	442.8 ± 75.3*	425.3 ± 103.5	-3.1 %	-6.9 %	n.s.
	THIcort [mm]	5.81 ± 0.62	3.98 ± 0.85*	3.91 ± 1.56	-33.1 %	-31.3 %	***
	mass [g]	4.17 ± 0.51	3.21 ± 0.64*	3.04 ± 1.17	-23.0 %	-27.1 %	**
femur	n	18	44 (*n=43)	5			
4%	BMDtrab [mg/cm ³]	252.7 ± 28.2	114.6 ± 27.5*	85.3 ± 27.5	-54.6 %	-66.2 %	***
	BMDtot [mg/cm ³]	275.7 ± 30.0	147.9 ± 27.2*	121.4 ± 25.8	-46.4 %	-56.0 %	***
	CSAcort [mm ²]	445.8 ± 194.4	64.7 ± 44.6*	49.8 ± 30.2	-85.5 %	-88.8 %	***
	mass [g]	11.04 ± 1.48	5.83 ± 1.16	4.95 ± 1.04	-47.2 %	-55.2 %	***
25%	BMDcort [mg/cm ³]	1111.0 ± 22.8	1106.3 ± 26.9°	1069.1 ± 19.9*	-0.4 %	-3.8 %	n.s.
	CSAcort [mm ²]	314.4 ± 37.1	216.3 ± 45.1*	192.5 ± 45.8	-31.2 %	-38.8 %	***
	CSAtot [mm ²]	895.9 ± 136.8	907.1 ± 200.1*	1046.7 ± 121.7	+1.3 %	+16.8 %	n.s.
	THIcort [mm]	3.33 ± 0.54	2.19 ± 0.44*	1.77 ± 0.44	-34.2 %	-46.8 %	***
	mass [g]	4.59 ± 0.59	3.11 ± 0.61*	3.08 ± 0.65	-32.2 %	-32.9 %	***

for the ANOVAs, CSA parameters and tibia cortical thickness were normalized by division through body height
 † p values of Bonferroni-tests for reference group vs. spastic and vs. flaccid group.

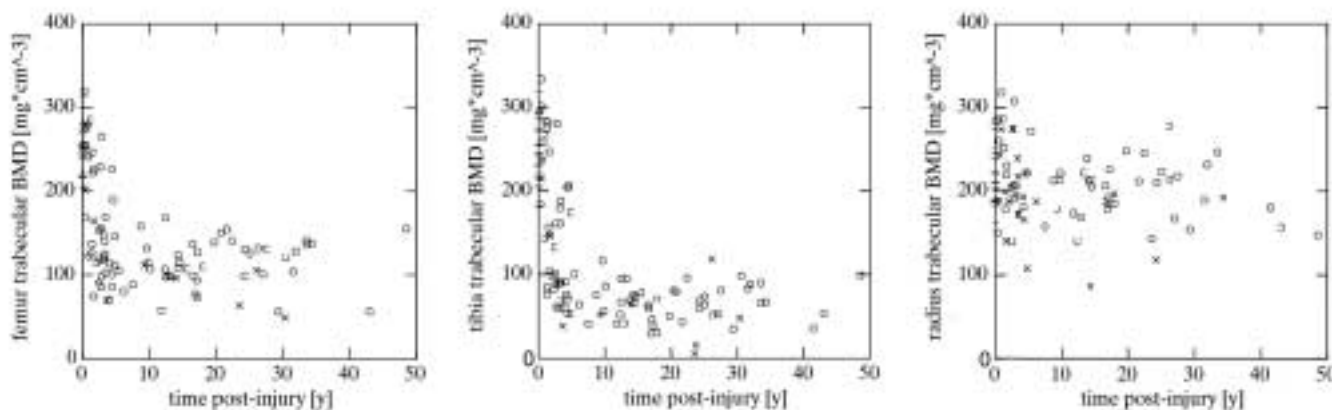


Table 1. Mean and standard deviations for all measured bone parameters of the tibia and femur for the reference, the spastic, and the flaccid group (both including only subjects with a lesion duration of ≥5 years).