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Bone mineral loss after lower extremity trauma

62 cases followed for 15–38 years

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62 former patients, who had been treated at our department for tibial shaft fracture (n 38) or knee ligament injury (n 24) 15–38 years earlier, were re-evaluated for post-traumatic osteopenia. 62 age- and sex-matched subjects without fracture served as controls. By means of a Lunar DEXA apparatus we measured the bone mineral density (BMD) in the total body, the hips and special regions of interest (ROI) in the lower extremities. We found a difference in the BMD between the injured and uninjured legs, most obvious in the femur condyle. Measurements of bone mineral loss early after the injury did not correlate with the present late measurements. The former fracture patients had at the time of follow-up the same BMD in the rest of their bodies as a whole, compared with controls.

We conclude that post-traumatic osteopenia is still evident in the injured leg decades after the injury.

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There is always a local loss of bone mineral in a limb after an injury (Nilsson 1966, Andersson and Nilsson 1979a,b, Obrant and Nilsson 1984), but it is still not known whether this loss is permanent or reversible. With the introduction of the Dual-energy X-ray absorptiometry (DEXA) technique (Mazess et al. 1990) we have a precise method of determining the bone mineral content. The aim of our study was to find out if the post-traumatic bone mineral loss is reversible.

Material and methods

Selected for the study were 38 cases with earlier tibial shaft fracture and 24 with earlier knee ligament injury. They had all been measured with single photon absorptiometry in the lower extremity after their injury (Nilsson 1966, Andersson och Nilsson 1979a, b). The tibial fracture group consisted of 24 men (30–83 years at the time of follow-up) and 14 women (54–83 years). 10 patients had transverse, 6 comminuted and 22 long oblique or spiral fractures. 7 of the patients had open injuries. 23 patients had been treated with plaster only, 10 with fixation by screws, 3 with plates and 2 with Rush-pin fixation. The knee ligament injury group, consisted of 15 men (31–78 years) and 9 women (30–69 years), half of whom had been operated on with ligament suture, followed by plaster fixation for 5 weeks and half had been treated with an orthosis for 3 weeks. All the patients had recovered full function. None had had additional fractures.

Re-examination was on an average 21 (15–38) years after the injury. Participants had their BMD measured in their total body, hip (neck, Ward's triangle and trochanteric region), femoral condyle, tibial condyle and tibial diaphyses (Figure 1) with a Lunar DEXA apparatus (Mazess et al. 1990). For the various parts of the skeleton the method presents BMD as areal density (g/cm^2).

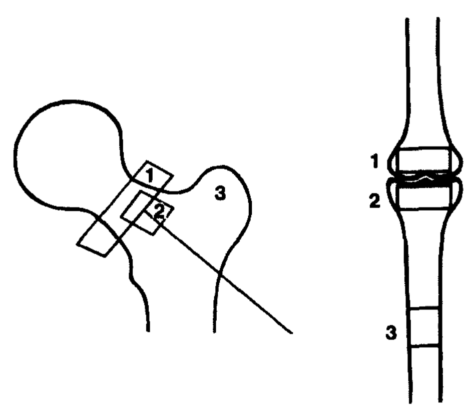

Figure 1. Measured regions in the hip (1 neck, 2 Ward's triangle, 3 trochanter region) and regions of interest (ROI) in 1 the femoral condyle, 2 tibial condyle, and 3 tibial diaphysis.

Table 1. BMD in the trochanter (T) and femoral condyle (F) of the lower extremities—comparison between sides (g/cm²)

	All injured cases (n 62)			All cases with fractures (n 38)			All cases with ligament injuries (n 24)			All cases with fractures more than 28 years ago (n 22)		
Side	injured		uninjured	injured		uninjured	injured		uninjured	injured		uninjured
T	0.83 *0.17*	ns	0.84 *0.16*	0.80 *0.18*	*	0.83 *0.16*	0.88 *0.15*	ns	0.87 *0.15*	0.80 *0.19*	ns	0.81 *0.16*
F	1.33 *0.27*	***	1.39 *0.29*	1.28 *0.29*	*	1.33 *0.30*	1.42 *0.22*	**	1.48 *0.23*	1.24 *0.30*	*	1.30 *0.32*

*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$

62 paired age- and sex-matched individuals, either hospital employees or persons randomly selected from the city file, served as controls.

Statistical calculation was done by the Student's *t*-test between pairs and between means and by calculation of regression equations.

Results

In almost all measuring sites the once-injured leg had somewhat lower BMD values, compared to the uninjured, and were significant only in the femoral condyle ($P < 0.001$; Table 1). The same result was found when patients with ligament injuries (femoral condyle $P < 0.01$) and tibia fractures (femoral condyle $P < 0.05$, trochanteric region $P < 0.05$) were examined separately. Moreover, patients with 28–38-year-old tibial fractures still retained their post-traumatic osteopenia in the ipsilateral femoral condyle ($P < 0.05$; Table 1). Separated into sexes, the result remained the same in men ($P < 0.001$ in femoral condyle), but no difference was found in women.

There was no BMD difference in any of the non-fractured regions between the injured patients and the controls.

Discussion

40 of our 62 cases had had their tibial condyle BMD measured at the time of the injury with a single photon technique and had been followed with repeated measurements for 1 year (Andersson and Nilsson 1979a, b). 22 tibial fracture patients had their femoral condyle BMD measured up to 10 years after the injury (Nilsson 1966).

Nilsson and Westlin (1969) found that the bone mineral content decreased by 9 percent in the distal end of the femur after excision of a ruptured semilunar cartilage, and Andersson (1979a) found an 18 percent loss in the proximal end of the tibia after suturing injured knee ligaments. After a tibia shaft fracture there is an average mineral loss of 40 percent in the proximal end of the tibia in the fractured leg after 4 months (Andersson and Nilsson 1979b). After 1 year the net loss was still 25 percent. Wendeberg (1961) found a low uptake of Strontium 85 early after tibia shaft fracture, but the value increased during the first 6 months to 5 times the normal. Later the ratio slowly decreased but, in some cases measured up to 9 years after the injury, the activity recorded over the fractured limb was still higher than normal. This long-lasting effect was also described by Nilsson (1966) who found a remaining bone mineral difference up to a decade after tibia shaft fracture.

In our series we found a remaining difference in the femoral condyle more than 30 years after the injury. It is not surprising that it was in this region, with its large volume of trabecular bone, that the highest difference was found. In the tibial condyle, high turnover and remodeling may have interfered in either direction, but neither fracture patients nor those with ligament injuries deviated in their tibia BMD. In no measured region did we find a higher bone mineral density, rather the contrary, in the once injured side compared to the uninjured.

In contradiction to earlier findings by Nilsson (1966), we found a remaining difference in bone mineral between the injured and uninjured legs in men, but not in women. The women in our study were older than those in the cited study (Nilsson 1966). One explanation for the different results could be the influence of the menopause. The increased bone loss in women after this time period could be decisive and therefore mask the BMD difference caused by the injury.

The final bone mass deficit in the femoral condyle was—after all this time—about 4 percent, which was less than during the initial years. The recovery may be real—bone has been added or the injured leg has contributed less to the age-related loss of bone mass. When comparing with the initial loss of bone 1 year after the injury (Andersson and Nilsson 1979a, b) we

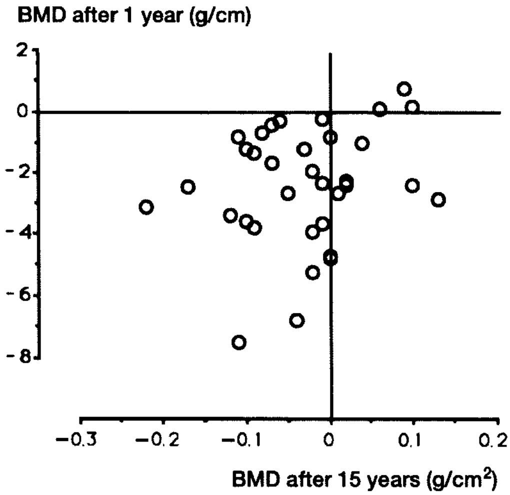

Figure 3. Comparison of early and late post-traumatic osteopenia. BMD after 1 year, measured with SPA, and after 15 years with DPX. No correlation was found.

found no correlation with the loss of bone at this late follow-up (Figure 2). It seems therefore that the magnitude of the reversal phase is not proportional to the initial bone mineral loss.

We have shown previously that patients with tibial fracture are more prone to have new fractures in the future as compared to controls (Karlsson et al. 1992). One explanation could be a reduced bone mass, but we found no such difference in this study. Another explanation is a greater susceptibility to accidents in individuals who once had a serious leg injury.

The marked difference in bone mass between the ligament injury group and the fracture group is explained by difference in age, mean 47 years and 61 years, respectively. Furthermore, a majority of the cases in the ligament injury group suffered their injury during sports and thus are likely to have a greater than average bone mass.

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