OSTEOPENIA IN ALCOHOLICS AFTER TIBIA SHAFT FRACTURES

FREDRIK NYQUIST*, MAGNUS K. KARLSSON, KARL J. OBRANT and J.-Å. NILSSON

Departments of Orthopaedics and Statistics, Malmö University Hospital, Lund University, Malmö, Sweden

(Received 27 January 1997; in revised form 18 April 1997; accepted 22 April 1997)

Abstract — A marked reduction of 40–70% in regional bone mineral density (BMD) has been reported after fractures of long bones, and this post-traumatic osteopenia may to some extent persist for several years, perhaps lifelong. In this cross-sectional study, we investigated whether prolonged alcohol abuse had any effect on the degree of post-traumatic osteopenia after isolated tibia shaft fractures, the rationale for such a suspicion being the deranged bone metabolism found in alcoholics. We also wanted to investigate whether dual energy X-ray absorptiometry (DEXA) or quantitative ultrasound technique could detect differences between abusers and non-abusers in post-traumatic bone loss. We measured the BMD in 61 male patients with isolated tibia shaft fractures (1984–94) with the Lunar DPX-L® and the Lunar Achilles®. Twenty-four of the patients were verified to be high consumers of alcohol. After correction for differences in age and the time elapsed since the fracture event, we found significantly lower (11%; \( P = 0.017 \)) BMD in the femoral neck of the fractured leg in abusers when utilizing the DEXA technique. No differences between abusers and non-abusers in BMD were detectable when using the ultrasound technique. We found a fair correlation (\( r = 0.63–0.81 \)) between the DEXA and the ultrasound techniques in regions with spongious bone. Our findings suggest that alcohol abuse has some, albeit a limited, effect on the degree of post-traumatic osteopenia and that ultrasound measurements in the calcaneus are of little use in detecting an increased post-traumatic osteopenia in this patient group.

INTRODUCTION

One of the early responses of bone to trauma is an increase in the rate of bone mineral turnover (Bauer, 1954). Many investigators have also reported a significant reduction of areal bone mineral density (BMD) after a fracture of long bones, not only at the fracture site but also at adjacent sites both proximal and distal to the fracture (Andersson and Nilsson, 1979; Ulivieri et al., 1990). This reduction in BMD persists after union, but there is a wide range in both the amount of loss and extent of recovery (Eyres and Kanis, 1995). These differences may be due, in part, to the attainable accuracy of the techniques used to measure the BMD (Eyres and Kanis, 1995).

Several studies have demonstrated that chronic alcohol abuse may lead to osteopenia and an increased incidence of fractures (Nilsson and Westlin, 1973; Dalén and Feldreich, 1974; Spencer et al., 1986). The cause of this osteopenia remains unclear but earlier studies suggest that there may be an imbalance between formation and bone resorption among alcoholics that could result in rapid bone loss (Nilsson and Westlin, 1973; Dalén and Feldreich, 1974; Spencer et al., 1986; Lindholm et al., 1991; Nyquist et al., 1996) and that there may still be a persistent high bone turnover after 5 years of abstention from alcohol (Nyquist et al., 1996). Post-traumatic osteopenia could be an interesting model for the study and detection of changes in bone metabolism and bone morphology, as rapid and major changes occur after a fracture (Bauer, 1954; Andersson and Nilsson, 1979; Obrant, 1984; Obrant and Nilsson, 1984; Ulivieri et al., 1990; Eyres and Kanis, 1995). These rapid changes in bone metabolism and morphology are therefore at potential risk of being altered by alcohol abuse.

One purpose of the present study was to assess whether prolonged alcohol abuse has any effect on the degree of post-traumatic osteopenia after isolated tibia shaft fractures. In addition the study also addressed the question of whether dual energy X-ray absorptiometry (DEXA) or quantitative ultrasound bone imaging is the most suitable method of detecting post-traumatic bone

*Author to whom correspondence should be addressed at: Department of Orthopaedics, Malmö University Hospital, S-205 02 Malmö, Sweden.
loss in alcoholics and which of the two ultrasound variables, speed of sound (SOS) or broadband ultrasound attenuation (BUA), would be the most appropriate variable for the detection of changes in bone mineral turnover.

MATERIALS AND METHODS

Included in the study were 61 male patients with isolated, tibia shaft fractures, treated at the Department of Orthopaedics, Malmö University Hospital, between 1984 and 1994. Patients who had sustained additional fractures in the lower extremities or who had multifractures at the time of injury were excluded.

Of the 61 patients analysed, 24 men (mean age at follow-up 52 years, range 32–65) were verified alcohol abusers, who had been registered at the Department of Alcohol Diseases (DAD) at the same hospital. A resident is registered at the DAD if and when he reports voluntarily because of drinking problems or is brought in by the police because of severe and potentially life-threatening drunkenness. Twenty of the registered abusers had a diagnosis of alcohol dependence (DSM-III-R, American Psychiatric Association, 1987). The remaining four were classified as excessive consumers since they had more than once been referred to the DAD and/or more than once misused alcohol when referred to the Department of Diagnostic Radiology (DDR) at the same hospital. The Malmo University Hospital is the only provider of hospital medical care in the city of Malmo. The cross-references between the orthopaedic, DAD and DDR records are reliable (Johnell et al., 1985). The time elapsed since the fracture event in this group was 5–133 months.

The isolated tibia shaft fractures sustained by the 24 abusers were compared with those sustained by the remaining 37 patients (mean age of 43 years at follow-up, range 20–71), who were classified as not being alcoholics or high consumers and therefore served as controls. To minimize the risk of unrevealed alcohol abuse in our control group we studied the registration at the DAD, and verified that none of these individuals was registered as a problem drinker according to hospital records.

As in earlier studies, all records at the DDR were validated as regards alcohol abuse and registration at the DAD (Israel et al., 1980; Kristenson et al., 1980; Johnell et al., 1985; Nordqvist and Petersson, 1996). The total number of fractures, all other radiological referrals and records were registered in our study group and we found no evidence of unrevealed alcohol abuse. The time elapsed since the fracture event in this group was 7–126 months.

Protocol of study

Tibia shaft fracture was defined as a fracture distal to the tibial tuberosity to 3 cm above the ankle joint (Edwards and Nilsson, 1965). Causative traumatic events were registered. The AO classification (Müller et al., 1990) and the classification of Edwards and Nilsson (1965) were used. The healing time of the fracture was registered and defined according to Edwards and Nilsson (1965) as the period of time between the accident until full clinical stability of the fracture was attained and the patient was allowed to walk without plaster and with full weight-bearing. At this time X-rays revealed callus formation in all patients. A questionnaire was used to analyse previous or present diseases and other treatments known to interfere with bone metabolism. Results of laboratory tests are presented in Table 1.

The areal BMD (g/cm²) measurements were performed at the Department of Orthopaedics using a Lunar DPX-L® apparatus. The BMD was measured bilaterally in the hip (neck, Ward’s triangle and trochanteric region), the spine (L2-L4) and total body.

Regions of interest (ROI) were analysed in the distal femur diaphysis (ROI 1), the femoral condyle (ROI 2), the tibial condyle (ROI 3), the tibial diaphysis (ROI 4) and the distal tibia (ROI 5) according to Figure 1. The coefficients of variation in areal BMD determined by double measurements after repositioning healthy individuals are presented in Table 2. Also the body composition of fat and lean body mass was calculated.

The ultrasound variables, SOS and BUA, were calculated with the Lunar Achilles® in the calcaneus bilaterally. All measurements were performed by the same laboratory technician.

The patients were analysed 5–60 months after the trauma. At the time of measurement all fractures were healed both clinically and radiologically.
Fig. 1. Measured regions in the hip (1 neck, 2 Ward's triangle, 3 trochanteric region) and regions of interest (ROI) in: 1, the femoral diaphysis; 2, femoral condyle; 3, tibial condyle; 4, tibial diaphysis; and 5, distal tibia.

Informed consent was obtained from all patients. In a questionnaire we analysed the smoking habits, the degree of malnutrition and the physical activity.

Statistics

All results were expressed as means ± SEM. Statistical analyses were done using the Macintosh Statistica software and SAS. The Mann–Whitney test, \( \chi^2 \)-test, Pearson’s correlation analysis and analysis of covariance were used.

RESULTS

There was no difference in height or weight between the two groups. The abusers were older than the controls (\( P = 0.006 \)).

The results of the laboratory tests are presented in Table 1. Carbohydrate-deficient transferrin (CDT), a marker of alcohol abuse, was found to be increased in the abusers (\( P = 0.002 \)).

No difference in the number of smokers was found between the groups, although the abusers have been smoking for a longer period of time (35 ± 9.4 vs 21 ± 10.0 years; \( P < 0.001 \)).

We found no difference in the amount or type of physical activity taken between the two groups either previously or at present. None of the individuals studied undertook strenuous activities. No difference was observed between the groups in the number of vegetarians or in the amount of coffee consumed.

No statistical differences between the two groups were found in fracture location, fracture type, type of fracture treatment or complication rate. No statistical differences were observed between the abusers and the controls in BMD total body, spine (L2–L4), body composition of fat or lean body mass after correction for differences in age.

In almost all measured regions of the lower

<table>
<thead>
<tr>
<th>Table 1. Laboratory test results in the study population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serum variable</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Alkaline phosphatase</td>
</tr>
<tr>
<td>Creatinine</td>
</tr>
<tr>
<td>Albumin</td>
</tr>
<tr>
<td>Calcium</td>
</tr>
<tr>
<td>CDT %*</td>
</tr>
</tbody>
</table>

*Carbohydrate-deficient transferrin.
†Significance of difference between groups, \( P = 0.002 \).
Values other than ranges are means ± SEM.
Table 2. Precision of areal bone mineral density (g/cm²), lean body mass (g) and fat content (%) in different skeletal regions with DEXA technique. Precision of measurements made by ultrasound.

<table>
<thead>
<tr>
<th>Measured regions</th>
<th>DEXA</th>
<th>Ultrasound</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Neck</td>
<td>1.6</td>
<td>2.6</td>
</tr>
<tr>
<td>Ward's</td>
<td>2.9</td>
<td>0.3</td>
</tr>
<tr>
<td>Trochanter</td>
<td>2.2</td>
<td>2.2</td>
</tr>
<tr>
<td>ROI 1</td>
<td>2.8</td>
<td></td>
</tr>
<tr>
<td>ROI 2</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td>ROI 3</td>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td>ROI 4</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>ROI 5</td>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>Fat (total body)</td>
<td>4.1</td>
<td></td>
</tr>
<tr>
<td>Lean body mass</td>
<td>0.6</td>
<td></td>
</tr>
</tbody>
</table>

SOS: speed of sound; BUA: broadband ultrasound attenuation; ROI: regions of interest.

extremities in both groups of patients, the injured leg had a lower BMD as compared with the uninjured leg. Among the abusers, the reduction was +2–12% and among controls 1–11% (Table 3).

The abusers had a significant BMD reduction on the fractured side in the neck region \((P = 0.004)\), Ward's triangle \((P = 0.004)\) and ROI 3 \((P = 0.04)\). On the uninjured side the abusers had a significant BMD reduction in ROI 5 \((P = 0.02)\).

When the DEXA measurements were corrected for differences in age and differences in time passed since fracture, the significant difference remained only in the neck region on the fractured side \((P = 0.017)\).

No statistical differences between the two groups were seen in the ultrasound measurements of the calcaneus bilaterally.

The correlation coefficients \((r)\) between the DEXA and ultrasound measurements varied between 0.14 and 0.85. We could not identify any difference in the DEXA/ultrasound correlation between the two groups. The best correlation between DEXA and ultrasound was found when the DEXA measurements were done in regions with more spongious bone \((r = 0.63–0.81)\) (ROI 2/ROI 3), close to the fracture, both in abusers and controls. The correlation between the two techniques did not improve significantly when the abusers and controls were considered as one group to validate the two techniques.

Table 3. Bone mineral density in different skeletal regions of the fractured limb expressed as a percentage of the measurement in the non-injured limb

<table>
<thead>
<tr>
<th>Region of interest (ROI)</th>
<th>Control subjects (%)</th>
<th>Alcohol abusers (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Femoral neck</td>
<td>99</td>
<td>89</td>
</tr>
<tr>
<td>Ward’s</td>
<td>99</td>
<td>88</td>
</tr>
<tr>
<td>Trochanter</td>
<td>96</td>
<td>92</td>
</tr>
<tr>
<td>ROI 1</td>
<td>95</td>
<td>94</td>
</tr>
<tr>
<td>ROI 2</td>
<td>89</td>
<td>89</td>
</tr>
<tr>
<td>ROI 3</td>
<td>91</td>
<td>92</td>
</tr>
<tr>
<td>ROI 4</td>
<td>97</td>
<td>97</td>
</tr>
<tr>
<td>ROI 5</td>
<td>97</td>
<td>102</td>
</tr>
</tbody>
</table>

DISCUSSION

The persistence of bone loss after fractures or other trauma has been shown in many previous studies, but the degree of loss reported has varied. This probably reflects the use of different techniques and the varied skeletal sites measured as well as their relationship to the site of the fracture (Andersson and Nilsson, 1979; Ulivieri et al., 1990; Eyres and Kanis, 1995).

The amount of bone loss after an isolated tibial shaft fracture does not appear to be related to the severity of the trauma, the method of fixation or the duration of immobilization (Ulivieri et al., 1990). Post-traumatic bone mineral loss is further thought to be a result of decreased functional loading of the fractured limb; recovery of lost mineral content is slow and the deficit, as much as 40%, may persist for an extensive period after fracture (Nilsson, 1966; Andersson and Nilsson, 1979).

In contrast to the findings in an earlier study (Nyquist et al., 1997), we found no differences in fracture location, fracture type, fracture treatment or healing time between the abusers and the controls. This may be due to the relatively limited number of abusers investigated in the present study.

In our study, the reduction of BMD in the fractured leg was +2–12% among the abusers and 1–11% among the controls. This post-traumatic reduction of the BMD was significant only in the
hip region after correction for age difference and time since fracture. Although chronic alcohol abuse is known to cause osteopenia and alterations in bone metabolism (Saville, 1965; Feitelberg et al., 1987; Laitinen et al., 1992; Chavassieux et al., 1993; Holbrook and Barrett-Connor, 1993), the degree of post-traumatic changes in BMD in abusers seems to be altered only in the proximal part of the fractured limb.

In the present study, we found no statistical differences between the two groups in the BMD measured at the fracture site in the tibia diaphysis. This was somewhat surprising. Perhaps the alteration in bone metabolism and bone healing is less influenced by chronic alcohol abuse than was previously thought, although there is always a substantial risk of a type II error with such a limited number of abusers analysed. Another explanation for the lack of difference in the DEXA measurements between the abusers and controls could be the surprisingly limited differences in smoking habits, the degree of malnutrition and physical activity.

Ultrasound is being assessed as a radiation-free technique in the management of osteoporosis because of its ability to provide architectural information in addition to density data. Much interest has been focused on the comparison of ultrasound with the established DEXA technique. In our study we found a fair correlation between areal BMD measurements and the ultrasound measurements in the calcaneus when the DEXA measurements were done in regions with more spongious bone, but overall the correlation was considered to be poor.

One of the questions raised in this study was which of the two ultrasound variables, SOS and BUA, would be the most appropriate in detecting post-traumatic osteopenia. Morphological studies of post-traumatic osteopenia have shown a considerable increase of the osteoid tissue — in some instances the entire trabeculae may become demineralized, whereas the trabecular bone volume is less influenced (Obrant, 1984; Obrant and Nilsson, 1984). BUA, which is supposed to reflect the trabecular connectivity, was thus postulated to be less altered as compared with SOS, which is supposed to reflect the calcium content in bone (Alves et al., 1996). In this study we found no evidence of SOS being a more accurate way of detecting post-traumatic osteopenia than BUA and, furthermore, we were not able to detect an increased post-traumatic osteopenia by the ultrasound technique among abusers when the bone mineral content in the calcaneus region was measured bilaterally with a Lunar Achilles apparatus.

We were unable to identify an increase in post-traumatic bone loss in abusers, except for the trochanteric region. The clinical impact of our findings is not evident, since, as has been shown in a study by Karlsson et al. (1993), the osteopenia in the injured limb after tibial shaft fractures is not associated with further fractures. Patients who earlier sustained a tibial shaft fracture are more fracture-prone in general and the increased fracture rate in abusers is probably more liable to be caused by neurological defect and an increase in repetitive trauma than in an increased degree of post-traumatic osteopenia.

Acknowledgements — Financial support was obtained from the Swedish Medical Research Council (project no. K97-17X-09906-06B), Lund University Research Funds and Johan and Greta Kock Foundation.

REFERENCES


Feitelberg, S., Epstein, S., Ismaril, F. and d’Amanda, C.


