# BONE FLUORIDE IN PROXIMAL FEMUR FRACTURES

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**SUMMARY: Bone fluoride concentration and bone mineral density (BMD) were evaluated in 51 female patients who had undergone hip arthroplasty due to proximal femur fracture. The hip fractures were divided into 42 neck and head fractures and 9 trochanteric fractures. BMD in the contralateral femoral neck and Ward triangle was determined by dual-energy X-ray absorptiometry measurement performed within 7 days after operation. The fluoride concentration was measured in cortical and trabecular bone samples from the resected femoral head and neck. There were very strong positive correlations between age and fluoride concentrations in trabecular and cortical bone. BMD correlated negatively with bone fluoride concentration. Cortical bone taken from patients with trochanteric fractures showed higher fluoride concentrations than in cortical bone taken from patients with femoral neck and head fractures.**

Keywords: Bone fluoride concentration, Bone mineral density, Femoral neck and head fracture, Proximal femur fracture, Trochanteric fracture.

## INTRODUCTION

Fluoride is a strong stimulator of bone formation.[1] However, this potency is also known from endemic, industrial and toxic fluorosis.[2,3] Since fluorides were first used to treat osteoporosis in humans in 1961,[4] both the efficacy and risks of fluoride therapy continue to be controversial.[1,5] Major concern persists due to lack of effectiveness of fluoride treatment in decreasing the vertebral fracture rate, but it may also increase the risk of nonvertebral fractures.[1,2] Danger of an increased rate of proximal femoral fractures in fluoride-treated patients has been described by several authors.[6-8]

Because fluoride is an active bone seeking ion, bone fluoride concentrations are dependent upon the magnitude and duration of fluoride exposure and the age of an individual.[9,10] High $F^-$ concentrations in bones can occur even in individuals not exposed to excessive fluoride, whether by therapeutic regimens or by drinking fluoridated water.

Experimental studies have shown that fluorotic bone is more resistant to compressive forces and less resistant to torsional and bending strain.[2,11] The influence of fluoride on bone strength depends upon the proportion of cortical and trabecular bone, since trabecular bone is more resistant to deleterious fluoride effects than cortical bone.[5]

The aim of this study was to investigate the influence of bone fluoride content on fracture patterns in the proximal femur.

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## PATIENTS AND METHODS

Between 1994 and 1997 fifty-one female patients underwent hip arthroplasty due to proximal femur fracture. The age of the patients ranged from 54 to 92 years with a mean of 73 years. Fractures were classified according to AO/ASIF (Arbeitsgemeinschaft für Osteosynthesefragen, Association for the Study of Internal Fixation) criteria[12] (Figure 1). There were 9 extracapsular trochanteric fractures and 42 intracapsular neck and head fractures.

**Proximal femur fractures**

extracapsular trochanteric — intracapsular neck — head

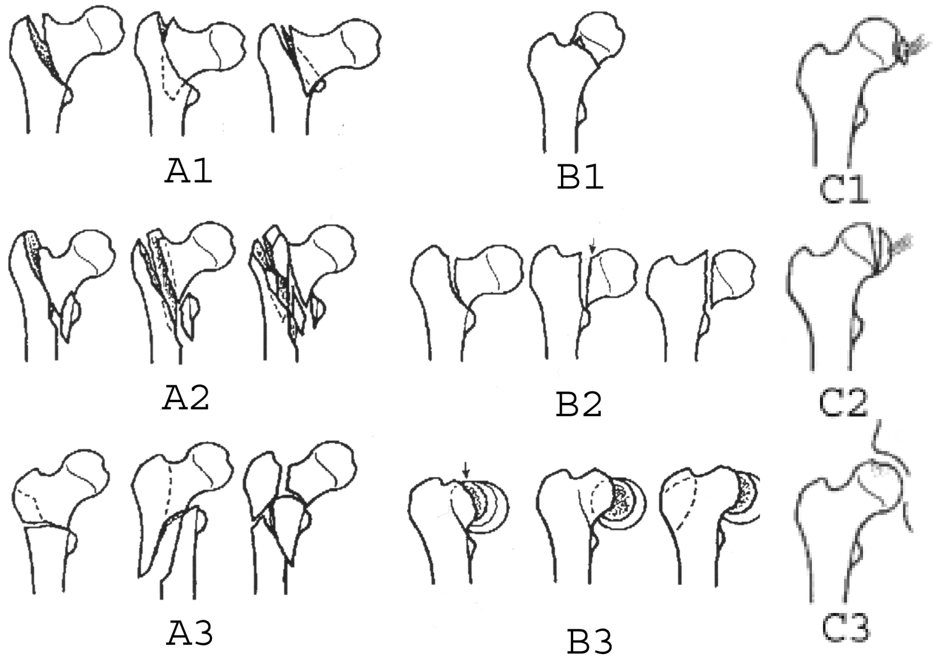


**Figure 1**. AO/ASIF classification of proximal femur fractures.

The operations were performed within three days after trauma. Forty-eight patients underwent total hip replacement with different cemented and uncemented endoprothesis systems and three patients underwent hip hemiarthroplasty. Small samples of cortical and trabecular bone were intraoperatively taken from the resected femoral head and neck and stored frozen. The fluoride concentration was measured with an Orion fluoride ion-selective electrode after dissolving the defatted bone pieces in perchloric acid.[13] The coefficient of variation for fluoride measurements was 2.7%.

In the postoperative week, each patient underwent BMD (bone mineral density) measurement of the contralateral femoral neck and Ward triangle with a DPX-L densitometer (Lunar, Madison, Wisconsin, USA). The precision error was 2.3%.

Data were compared by means of nonparametric tests (Kruskal - Wallis test followed, if significant, by group comparisons with the Mann - Whitney U test). Differences were considered significant if $P < 0.05$. The results were expressed as means ± standard deviation (Mean ± SD). Linear regression analysis of the data was done to determine a correlation between fluoride concentration in cortical and trabecular bone and other factors, such as age and BMD in the contralateral femoral neck and Ward triangle.

## RESULTS

Evaluation of differences between trochanteric and femoral neck and head fractures revealed higher fluoride concentrations in patients with trochanteric fractures (Table).

**Table.** BMD and bone fluoride concentration in patients with trochanteric fracture and femoral head and neck fracture

| | Neck and head fracture (n = 42). Mean ± SD | Trochanteric fracture (n = 9). Mean ± SD |
|---|---|---|
| BMD in femoral neck (mg/cm$^2$) | 639 ± 90 | 584 ± 120 |
| BMD in Ward triangle (mg/cm$^2$) | 492 ± 88 | 448 ± 106 |
| $F^-$ in cortical bone (mmol/kg) | 41.78 ± 7.67 | 51.25 ± 5.56 |
| $F^-$ in trabecular bone (mmol/kg) | 59.81 ± 17.75 | 70.15 ± 11.82 |

Values are mean ± standard deviation. Values in the following group are different: $F^-$ in cortical bone: neck and head fracture vs trochanteric fracture: $P < 0.001$.

There was a very strong positive correlation between age and fluoride concentration in cortical bone ($r = 0.71$, $P < 0.0001$) (Figure 2) and also between age and fluoride concentration in trabecular bone ($r = 0.78$, $P < 0.0001$) (Figure 3). On the other hand, a strong negative correlation was found between BMD in the Ward triangle and fluoride concentration in trabecular bone ($r = -0.53$, $P < 0.0001$) (Figure 4) and between BMD in the femoral neck and fluoride concentration in cortical bone ($r = -0.56$, $P < 0.001$) (Figure 5).

BMD values in the femoral neck and Ward triangle also showed significant negative correlation with age ($r = -0.39$, $P < 0.0001$ and $r = -0.55$, $P < 0.0001$) (Figures 6 and 7).

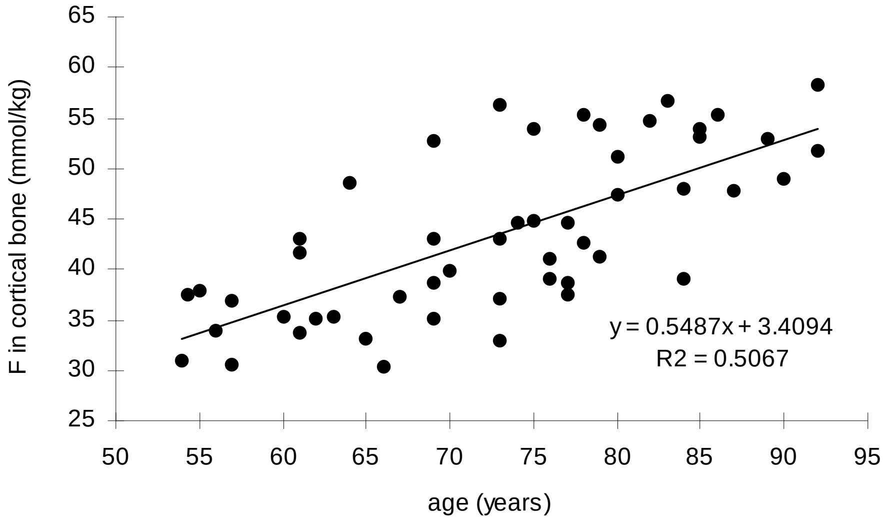


**Figure 2.** Correlation of bone fluoride content in cortical bone with patient`s age.

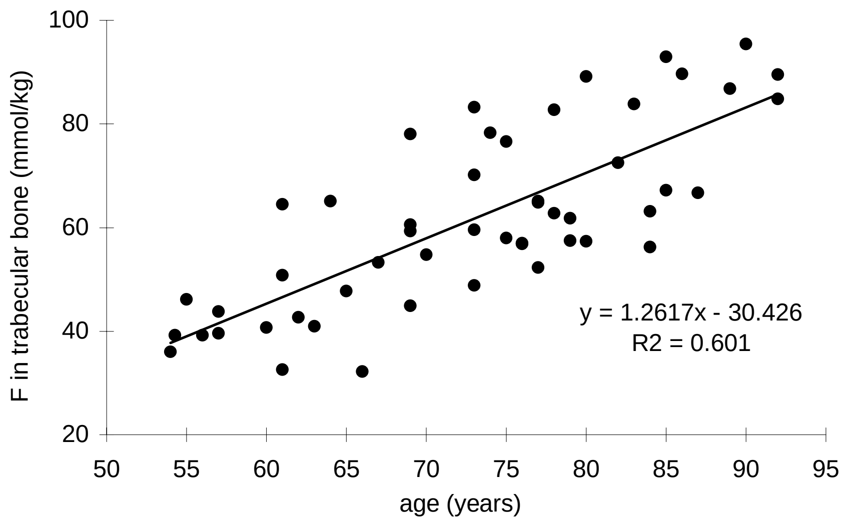


**Figure 3.** Correlation of bone fluoride content in trabecular bone with patient`s age.

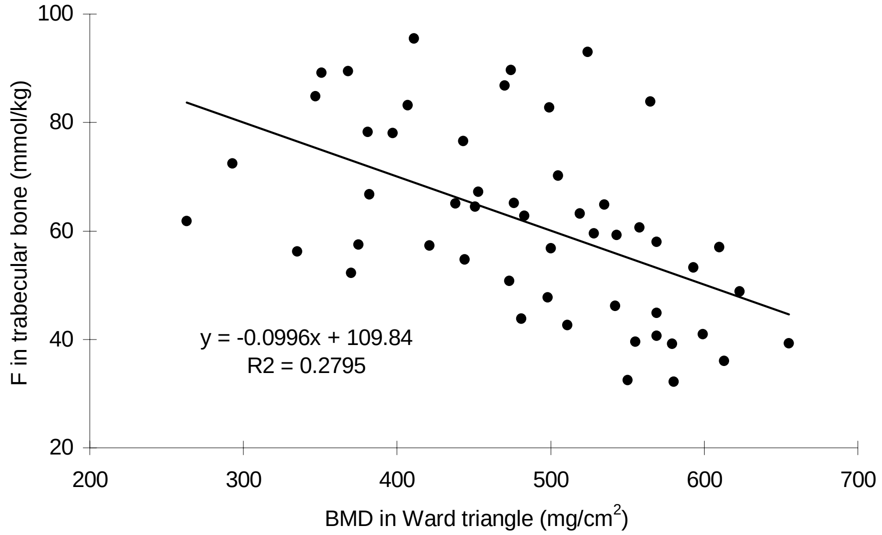


**Figure 4.** Correlation of bone fluoride content in trabecular bone with bone mineral density in the Ward triangle.

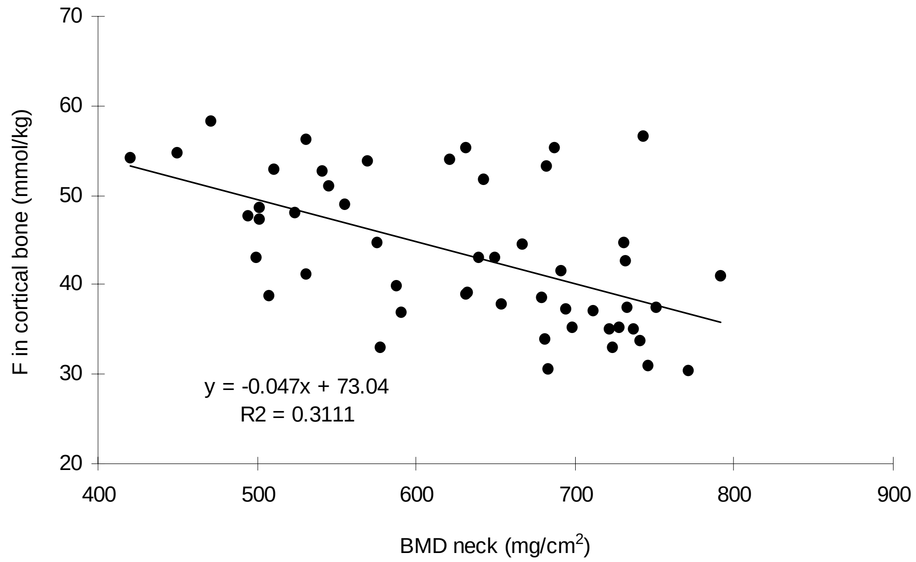


**Figure 5.** Correlation of bone fluoride content in cortical bone related with bone mineral density in the femoral neck.

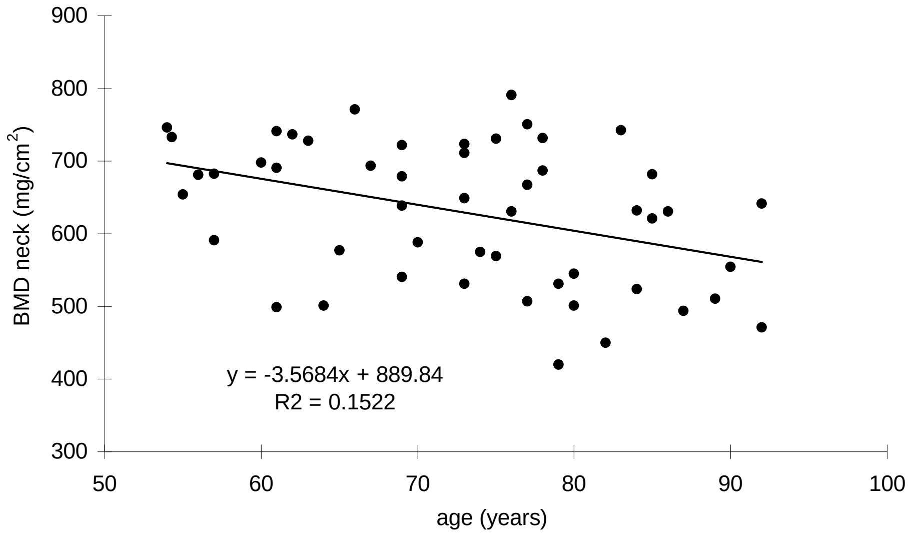


**Figure 6.** Correlation of bone mineral density in the femoral neck with patient`s age.

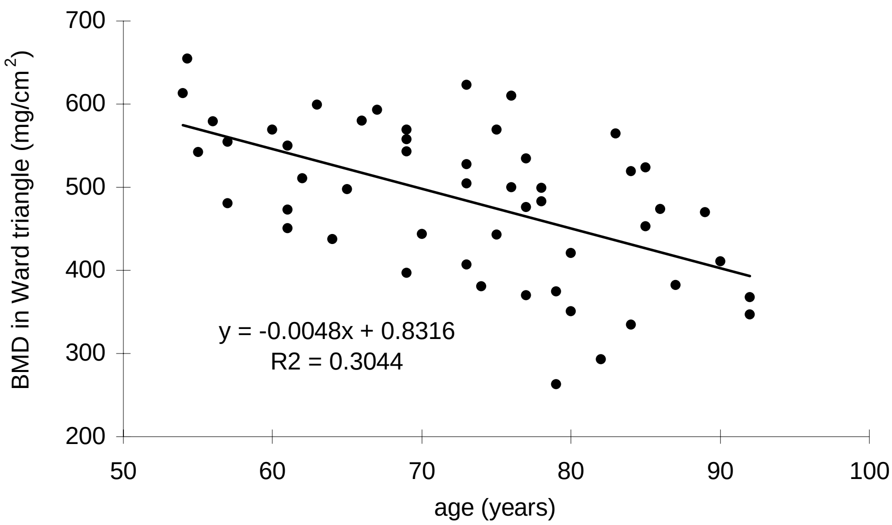


**Figure 7.** Correlation of bone mineral density in the Ward triangle with patient`s age.

## DISCUSSION

This study demonstrated a significant age-related increase in fluoride content of trabecular and cortical bone resected from the proximal femur. This observation agrees with results of numerous studies indicating that fluoride gradually accumulates in bones throughout life.[9,10,14] The study also revealed an inverse relationship between bone fluoride content and bone mineral density.

The concept that osteopenia might be less severe in individuals with a history of fluoride exposure was first proposed by Leone e*t al*[15] in 1955 and has since been the subject of many investigations.[14] A protective effect of fluoride incorporated into bone was suggested by Faccini, [16] who observed in his experimental studies in rabbits a decreased resorption of fluoride-containing bone when compared to normal bone. Grynpas[17] suggested that bones with higher fluoride content show more resistance to acid dissolution and a reduced rate of bone resorption. Bohatyrewicz *et al*[18] demonstrated that higher fluoride concentrations in bone surrounding hip prosthesis decrease the periprosthetic bone loss after arthroplasty. These observations, however, were never successfully translated into prophylactic benefit for people with low bone mass in diseases such as osteoporosis who were exposed to artificial water fluoridation or natural fluoride sources.[5,9,14,19]

The detrimental effect of fluoride continuously accumulating in bones has been widely described.[2,9,11] The femoral head and neck differs from the trochanteric region in terms of its form and trabecular and cortical bone tissue distribution.[20] Femoral head and neck fractures show some similarities with axial skeleton fractures because of the presence of about equal parts of trabecular and cortical bone. Trochanteric fractures represent typical appendicular fractures due to predominance of cortical bone. Since trabecular bone quality is not relevant for mechanical strength of the trochanteric region, the concentration of fluoride in cortical bone becomes critically important for trochanteric fractures. This might explain why the higher fluoride concentration in cortical bone tissue predisposes the patients to suffer trochanteric fractures between all types of the proximal femur fractures.

## CONCLUSIONS

- The fluoride concentration in trabecular and cortical bone increases with age.
- Bone mineral density in the femoral neck and Ward triangle correlates negatively with fluoride concentration in bones.
- Patients with trochanteric fractures have significantly higher fluoride concentration in cortical bone than patients with femoral neck and head fractures.

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