Variations in Pb and Ca concentrations at bone transition zones
determined by SR-XRF with a microbeam at BL L

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The distribution of mineral and trace elements in human bone is not clearly resolved. While within substantia compacta (SC) and substantia spongiosa (SS) elements seem to be nearly equally distributed, concentrations of lead (Pb) and Ca in SC and SS are different [1]. Thus, concentrations of these elements at the transient zone SC/SS should be altered, and this alteration might be different in different bone regions due to different mechanical stress properties. Preliminary investigations in hip bones (hip head) have shown a decrease of Pb and Ca at the transition SC/SS [1]. In the current investigation we studied mineral and trace elements in three human hip bones slices, and slices from knee bones with a thickness of about 4 mm from hip and knee operated patients. Figure 1 shows characteristic samples and areas from where samples were taken.

Figure 1: Bone slices and areas from where samples were taken, schematically

The micro X-ray fluorescence facility at the bending magnet Beamline L at HASYLAB/ DESY, was used. A monochromatic beam with an energy of 16.5 keV from a Si(111) double crystal monochromator, focused to about 20 µm by a polycapillary was used [2]. Measurements in hip bone and knee slices from three different patients showed consistent results, independently whether spot measurements (20µm) in SC or SS were used respectively, or profiles over SC/SS. Ca and Pb were found to be higher in SC than in SS in hip head, knee femur and knee tibia. But the ratios of Pb(SC)/Pb(SS) or Ca(SC)/Ca(SS) were markedly different in different bone areas (e.g. Table 1), indicating different metabolisms.
Relative concentrations of the investigated elements are shown in Figure 3 (normalized to the maximum counts). No differences were found in measuring discrete points in SC and SS separately as compared with results from corresponding line scans, when using mean values in SC and SS (Table 1).

<table>
<thead>
<tr>
<th></th>
<th>Tibia (n=5)</th>
<th>Femur (n=5)</th>
<th>Hip(Head) (n=5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pb (scan)</td>
<td>1 ± 0.15</td>
<td>1 ± 0.34</td>
<td>1 ± 0.36</td>
</tr>
<tr>
<td>Pb (points)</td>
<td>0.41 ± 0.008</td>
<td>0.38 ± 0.19</td>
<td>0.23 ± 0.023</td>
</tr>
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</table>

Table 1: Lead intensities (normalized to maximum counts) in SC and SS in different bones/areas.

Moreover from the line scans we may say that the transition zone ranges between 500 and 1000µm (Figure 3). Afterwards there seem to be constant concentration distributions of the investigated elements in SS in line scans. Our current investigations show that the major fraction of lead is bound in the outer bone compartment namely in the pars compacta and in the transition zone SC/SS, respectively. The results thus could help interpreting the slow bone kinetic of lead.

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References