# HUMAN BONE AS "COMPOSITE MATERIAL"

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**Abstract:**

Human bones present interesting, extraordinary, exceptional nature as of birth until passing away. With respect to the composites produced by conventional manufacturing methods, human bones are always dynamic even in the cases where there is no movement of body, active not only because of diffusional phenomena as in conventional materials. Dynamical processes include osteoblast-osteoclast activities, piezoelectricity, flow through Haversian canals, mass transport etc., which make constitution of bone complicated, time dependent and rate dependent as well.
In this study, micro-structural differences and variations on the mechanical behavior of bone depending on the type and anisotropy of human bones and changes of constitutions due to injections of anticoagulants to the animal bones are discussed from materials point of view. Several different types of mechanical test, micro-structural analysis, XRD (X-Ray Diffraction) and FTIR (Fourier Transform Infrared Spectroscopy) studies revealed structural changes due to injection and depending on the type of bones. Structurally it is found that same bone may alter its crystallographic nature by time and because of external effects, which make bone extremely dynamic and result in continuous changes in behavior.

**Materials and Methods:**

For studying mechanical behavior human bones, "femur, tibia, fibula of the same patient and spongeous bone on the hip joint" obtained from amputation due to non-pathological reasons and to study structural changes rat bones obtained after sacrificing of animal, that were injected by various of anticoagulants, were used in experiments.
Mechanical tests on human bones were performed by indentation. Structural studies on bones of the sacrificed animal, which were injected by anticoagulant during healing process after fracture, were performed by XRD and FTIR.

**Results and Discussion:**

Fig 1 shows Vickers hardness values on femoral head section. Variations in hardness show anisotropy in single section of bone, which in turn imply that behavior changes in very short distances.

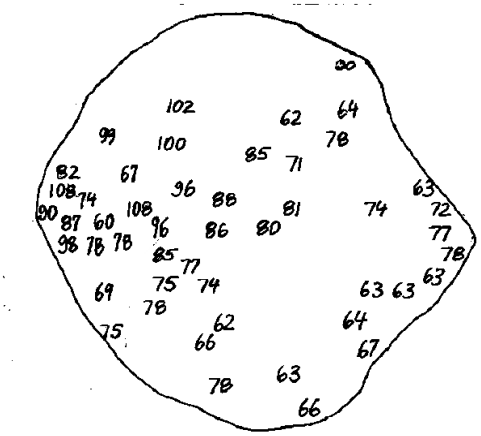

Fig. 1.- Vickers hardness distribution on the cross-section femoral head.

The differences among three bones, femur-tibia- fibula belonging to the same person, in terms of "stress-strain" and "relaxation" curves can be seen in Figure 2. All three bones` behavior against to the same mechanical conditions is different, which would be explained by micro-structural feature. In this case balancing of body can be explained with the other parameters as all three bones join in the knee joint.

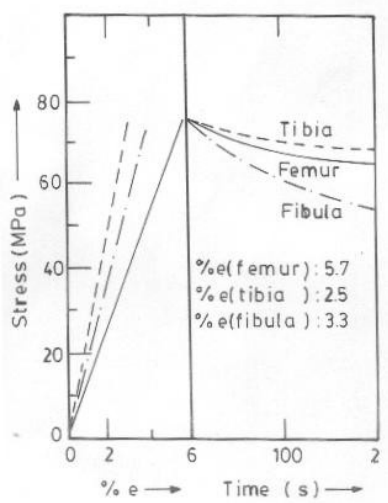


Fig. 2.- Partial "stress-strain" and "relaxation" curves of three bone, femur, tibia and fibula of the same person.

Figure 3 and 4 inform that injection of anticoagulants makes rearrangement of atoms in inorganic part either via change in crystalline structure or transforming structure to the amorphous case. This behavior needs more extensive researches on the mechanisms of atomic movement. However this situation makes clear that the type of anticoagulant transforms previous bone to another material during healing.

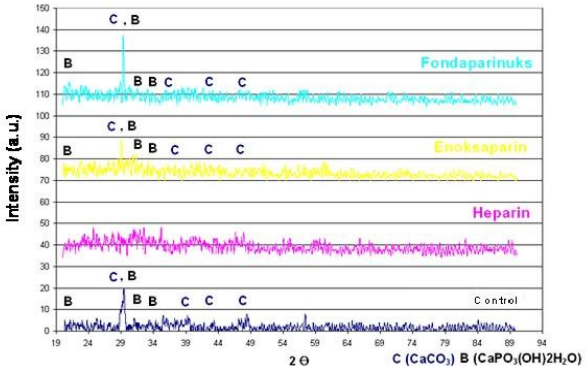


Fig. 3.- XRD studies on the fractured bone injected by anticoagulants.

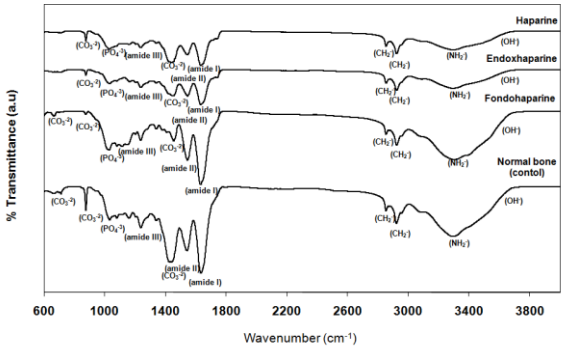


Fig. 4.- FTIR results on the fractured bone injected by anticoagulants.