ILIAC CREST FABRIC MEASUREMENTS IN OSTEOPOROTIC PATIENTS

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INTRODUCTION: The accurate clinical assessment of bone strength and fracture risk is important for management of bone loss diseases such as osteoporosis. Current techniques such as quantitative computed tomography (QCT) and dual photon absorptiometry (DPA) rely on mass measurement for assessing bone mechanical integrity. Such methods do not, however, always provide reliable estimates of bone strength and fracture risk. One reason is that the trabecular bone architecture, which is not identified in mass measurements, can also be an important factor contributing to bone strength. We have previously applied digital image processing and texture analysis techniques to both plain radiographs and vertebral CT scans for quantifying trabecular architecture [1-3]. The purpose of the present study was to determine the relationship between iliac trabecular architecture and bone density in osteoporotic patients.

MATERIALS AND METHODS: Iliac crest bone biopsies were obtained from 20 osteoporotic patients, 13 with vertebral or long bone fractures and 7 without. The mean age of the fracture group was 59±16 and of the non-fracture group 48±17. Bone sections were fixed in 10% formalin, dehydrated in graded alcohol and xylene, and embedded in polymethylmethacrylate. Sections were cut 5 μm in thickness on a Jung-Riechert polycut S motorized sledge microtome, and stained by the Von Kossa method. The slides were analyzed on a digital image processing microcomputer based system. The processing consisted of first thresholding the image to create a binary representation of the cancellous bone. The thresholded histological images were then analyzed using fabric as described by Whitehouse [4]. The fabric of a planar structure is characterized by the mean intercept length (MIL) as a function of the angle at which the MIL is measured. The MIL is the average trabecular thickness obtained by using a set of test lines oriented at a specific angle with respect to the specimen. The MIL obtained for each sample was used to estimate an ellipse in a minimum mean square error sense. The ratio of the minor to major axes of this ellipse was used to characterize the anisotropy of the structure and was termed the fabric asymmetry index (FAI). The MIL data for one patient with vertebral fractures is presented in Fig. 1, together with the estimated ellipse for which FAI=0.71. The patients were also evaluated using dual photon absorptiometry of the lumbar spine and the average bone mineral density (BMD) in g/cm^2 of L1-L4 recorded. Finally, the trabecular bone volume (TBV) was measured from the prepared sections.

RESULTS: The Von Kossa stained bone samples were of sufficient contrast so that simple histogram thresholding provided accurate image segmentation. Averages of the data for all 20 patients, classified according to those with and without fractures, including DPA of the spine, FAI, and TBV is presented in the Table. Note that while the BMD and TBV show a 14 and 10 percent respective increase in the non-fracture group as compared to the fracture group, the FAI only increases by about 2 percent.

DISCUSSION AND CONCLUSION: Estimating fracture risk and bone strength in osteoporotic patients is an important clinical problem. Using bone mass alone is clearly a suboptimal solution but no other means currently exists for assessing bone integrity *in vivo*. Fabric is one measure of trabecular architecture which has been shown, after mass, to be the most important feature related to bone strength. Whereas mass accounts for approximately 65 percent of the variation in observed bone strength, fabric can explain approximately an additional 20 percent [5]. The measurement of fabric in iliac crest biopsies in osteoporotic patients was done in an attempt to demonstrate a relationship between bone mass and fabric in the context of clinical findings such as the incidence of non-traumatic fractures. The above data show a large variation in FAI which, however, does not provide additional discrimination for patients with and without fractures. This may be due in part to the relatively small number of cases studied or to the fact that the iliac crest is a non-weightbearing bone and not representative of bone at other sites, such as the spine. The results here suggest, then, that the iliac crest should not be used for assessment of architectural features in the spine or other weightbearing bones. Additionally, this study demonstrates for the first time the estimation of trabecular bone fabric (i.e., FAI) from clinical data. Although the FAI of the iliac crest does not seem to provide information on fracture incidence, measurement of the FAI at other sites might prove to be an important diagnostic test.

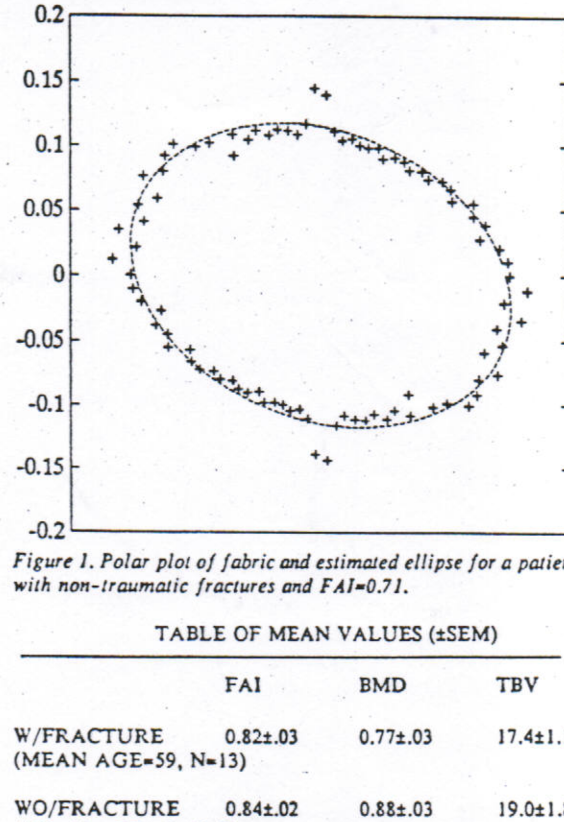

Figure 1. Polar plot of fabric and estimated ellipse for a patient with non-traumatic fractures and FAI=0.71.

TABLE OF MEAN VALUES (±SEM)

	FAI	BMD	TBV
W/FRACTURE (MEAN AGE=59, N=13)	0.82±.03	0.77±.03	17.4±1.1
WO/FRACTURE (MEAN AGE=48, N=7)	0.84±.02	0.88±.03	19.0±1.8

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