Introduction:
African-Americans have a lower fracture risk than Caucasians [1] but the reason for this difference remains unclear. Arguments have been offered that fracture risk is governed by extrinsic factors [2, 3], e.g., differences in bone size, or intrinsic factors [4-6], e.g. differences in bone mineral density (BMD) [7, 8]. The latter finding, which was primarily obtained from dual energy X-ray absorptiometry (DXA), generally concluded that bone from African-Americans had a greater BMD than bone from Caucasians. Other mineral density assessment techniques, notably quantitative backscatter electron imaging (qBEI) and computerized tomography (CT), provided data that suggested the opposite [9, 10]. To gain new insight regarding the race-related intrinsic material properties of bone, the present study sought to test the null hypothesis that there are no differences in the relative quantity or quality of trabecular bone mineral obtained from African-American and Caucasian subjects.

Methods:
One hundred ten iliac crest bone biopsies were obtained from 42 African-Americans (54.2 ± 7.9 yrs.) and 68 Caucasians (57.2 ± 8.0 yrs) with renal bone disease in an IRB approved study. Subjects who: 1) used drugs known to alter bone metabolism, 2) had diabetes or a kidney transplant, or 3) were outside the age range of 40 to 70 years were not included in this study. Subjects were paired for age, gender and bone turnover. Undecalcified bone biopsy specimens were embedded in methyl methacrylate, and sectioned to a thickness of 4 microns. Each section was placed between two barium fluoride windows and subjected to Fourier Transform Infrared spectroscopy by using (FTIR) a continuum microscope (Thermo Electron, Waltham, MA). Three locations on each of three arbitrarily chosen trabeculae from each section were examined. FTIR spectra from each location were collected with a 4 cm⁻¹ resolution by using 200 scans in transmission mode. The mineral-to-matrix ratio (bone mineralization) was calculated by integrating the area under the phosphate peak 900-1200 cm⁻¹ (mineral) and normalizing it by the area under the Amide I peak 1590-1720 cm⁻¹ (matrix). Similarly, the carbonate-to-phosphate ratio (crystal purity) was calculated by integrating the area under the carbonate peak 850-890 cm⁻¹ and normalizing it by the area under the phosphate peak (Fig 1). The technique used for all measurements has been previously reported [11].

![Representative FTIR Spectra](image)

Discussion:
Both mineral content and mineral perfection are considered to have a role in governing bone strength. Although the present study showed that there was no difference in bone mineral quantity, i.e. mineral-to-matrix ratio, between Caucasians and African Americans, there was a significant difference in mineral quality. Specifically, Caucasians had a significantly increased carbonate substitution within their bone mineral crystal structure compared to African Americans. This finding has not been previously reported. Carbonate substitutes for OH and PO₄ ions in the crystalline structure of hydroxyapatite and is therefore considered an impurity. Carbonate, as well as other impurities, renders bone mineral crystals smaller and less perfect [12]. Departures from "normal" crystal size and perfection have been thought to alter the mechanical properties of bone in a manner reflective of that which occurs for mineral content [13].

The observed difference in bone mineral quality may have a role in explaining part of the reason why Caucasian bone does not appear to resist fracture to the same degree as African-American bone.

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References:

Fig. 1

Results:
Mean mineral-to-matrix ratio of trabecular bone from Caucasians (3.626 ± 0.384) was slightly more than 1% greater than the corresponding mean value for African-Americans (3.588 ± 0.415), and as would be expected, this difference was statistically indistinguishable. However, the mean carbonate-to-phosphate ratio of bone mineral from African-American subjects (0.0093 ± 0.0017) was 11.2% less (p < 0.001) than that of Caucasian subjects (0.0104 ± 0.0011).