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Static Testing of Decalcified Bone Matrix Preparations for ACL Reconstruction

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Introduction: The age-related properties of the materials provided for clinical use by tissue banks today are ill defined at best. There is concern that most published data reflects only the properties and behavior of the younger donors which may not properly reflect values of the true mixture of ages of available donors.

Purpose: The purpose of this study was to determine the effects of age and sex on the mechanical properties of decalcified bone strips which have been prepared for various allograft applications.

Methods: Strips of decalcified human cortical bone approximately 1 cm wide by 12 cm long were reconstituted in normal saline for 24 hours at room temperature prior to preparation for testing. Each specimen was cut with a steel rule die to create a 5 mm wide by 2 cm long center section outside the tensile testing grips which was the full thickness of the specimen, see Fig. 1. The uncut portions of the specimens were impregnated with low vicosity PMMA and held in the grips of an MTS 858 Minibionics II testing machine and pulled in tension at a rate of 2 cm/sec. to apply a 100% strain rate/sec. The PMMA in the gripped portion of the specimens was necessary in order to assure that the failure occurred in the The stiffness, energy to failure, yield and ultimate strengths were calculated from the load - displacement curves of the MTS, and the failure modes were photographed and noted. Another set of specimens were clamped between 2 plates with aligned holes and tested to failure in shear by sliding the plates on each other to misalign the holes and place a shear load on the clamped specimen.

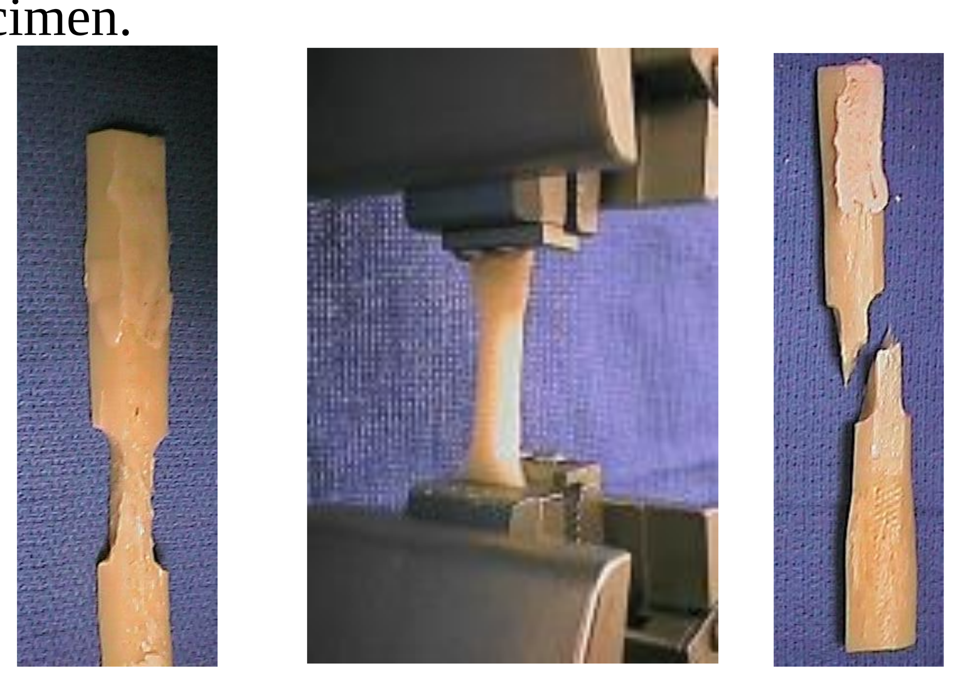

Figure 1 - A decalcified bone strip prepared for testing, left, and in the MTS jaws for tensile test, center, & failure mode, right.

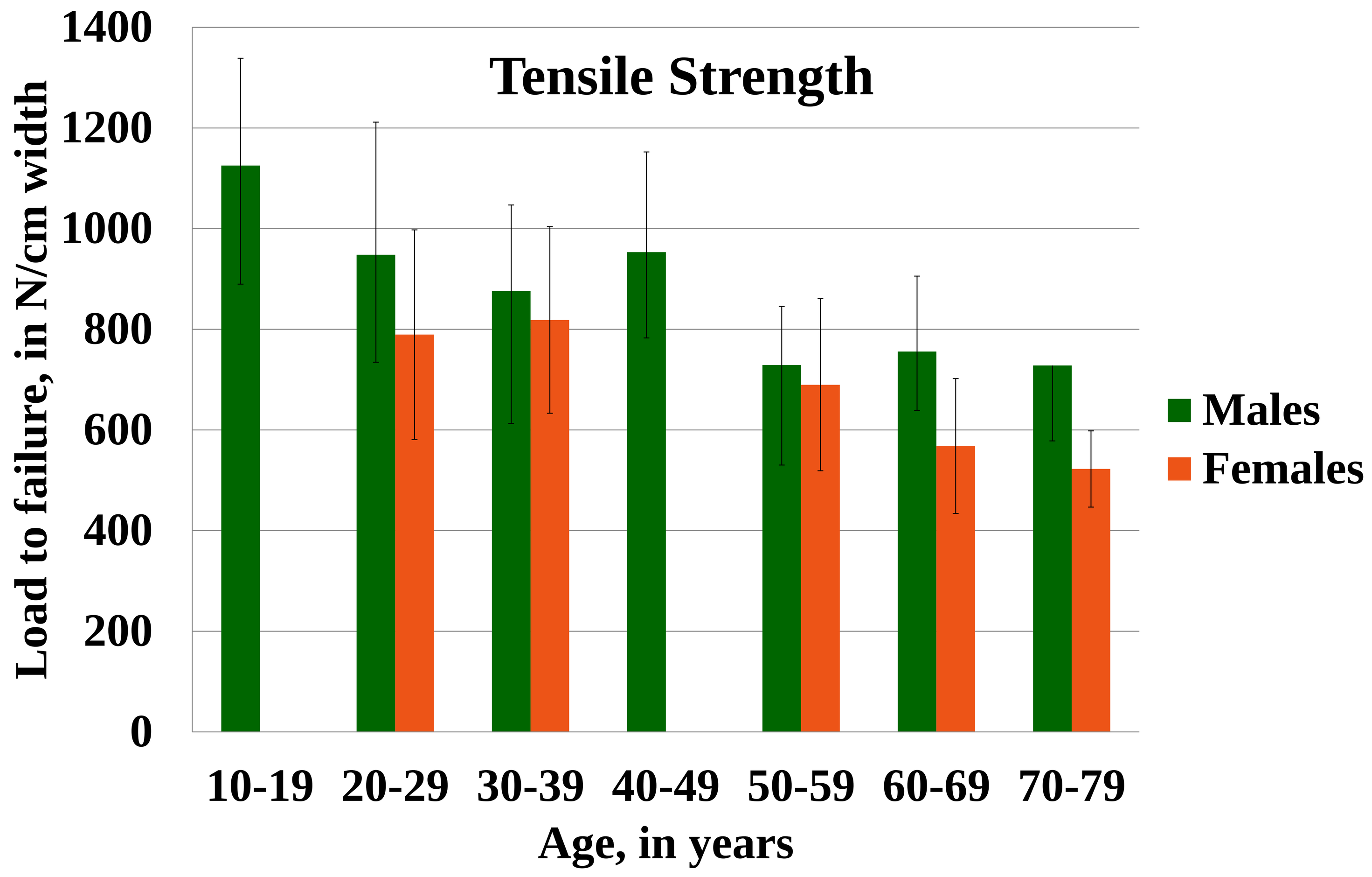

Figure 2 - Tensile load by age decades

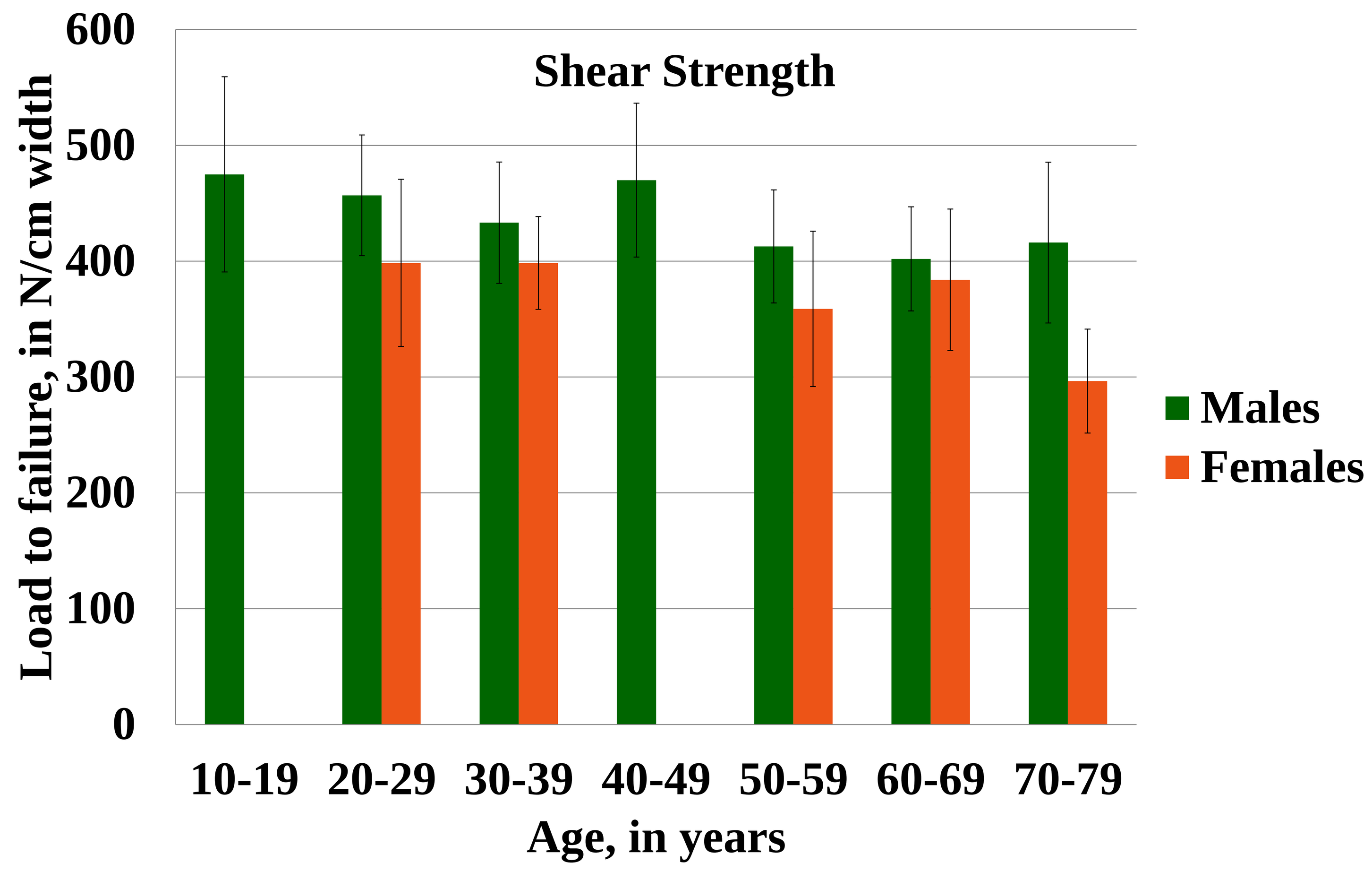

Figure 3 – Shear load by age decades

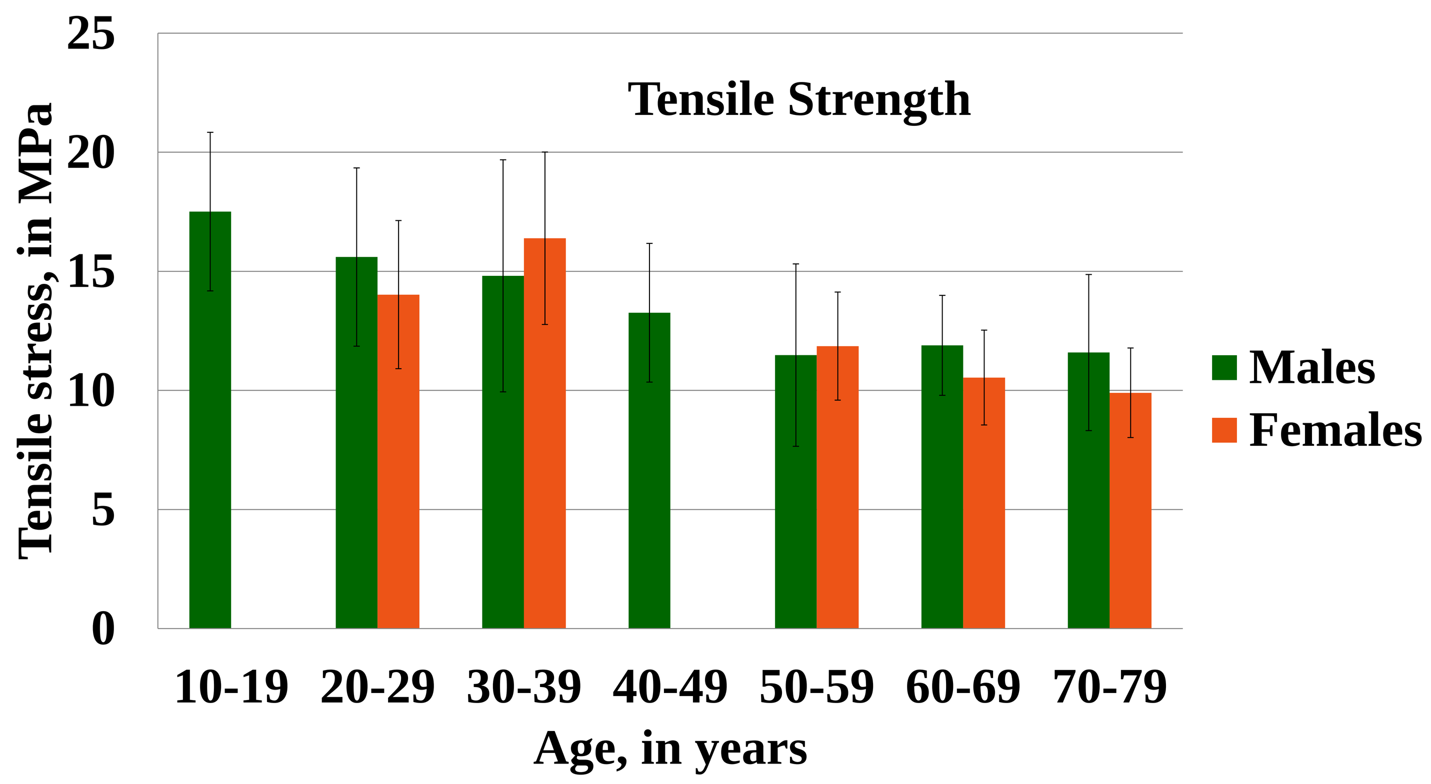

Figure 4 – Nominal tensile stress by age decades

Results: A total of 161 samples were tested; 119 from males, and 42 from females ranging in age from 12 to 79 years old. There were approximately 15 strips of bone to test for each decade of age for males and about 7, for females.

There was a statistically significant trend for structural tensile strength to be inversely proportional to age, see Figure 2 ($P < 0.001$ for males and 0.001 for females by Anova multiple comparison). The shear load to failure also correlated significantly with age, see Figure 3 ($P < 0.001$ for males and 0.001 for females).

Nominal ultimate stress calculations for both tension and shear showed significant correlation with age for females ($P < 0.001$). But for males, only the ultimate shear stress calculations correlated significantly with age ($P < 0.02$).

Comparing the males to females, the male bones were thicker and stronger in tensile and shear load to failure, with only the 50 - 59 YO groups not statistically significantly different. But the calculated stress to failure was much closer. Only the male 70 - 79 YO group was significantly stronger in tensile stress than the females. The female bone strips had greater shear stress than the males for 3 of the 5 age groups. Only the 50 - 59 age groups were significantly stronger for females and for the 70 - 79 age group, the males were significantly stronger.

Conclusion: Both the tensile and shear strength of decalcified bone matrix are inversely proportional to age in both males and females. The femoral cortical samples from males were significantly larger that for the same age group of females. Thus the ultimate stress in tension and shear are much closer than the load to failure between males and females.

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