REMODELING POTENTIAL OF THE HYPERMINERALIZED CALCIFIED FIBROCARTILAGE IN THE PROXIMAL FEMUR

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Introduction

It is well known that hip fractures will exponentially increase with the aging population. The literature documents that the cortex of the femoral neck provides significant biomechanical properties that are essential in preventing failure during a fall. Recently it has been shown that a Hypermineralized Calcified Fibrocartilage (HCF) layer on the femoral neck and trochanteric region increases with aging and can constitute up to 60% of the fractional volume of the cross sectional area of the femoral neck. A recent study has indicated that the HCF was the apparent adhesive interface between cortical bone and capsular, tendon, and ligament insertions and appears to be avascular. The objective of this study was to determine if there was any remodeling capacity in the HCF compared to the underlying cortical bone. The null hypothesis tested was that there would be no difference in the remodeling of the HCF compared to the underlying cortical bone.

Materials and Methods

The ovine model has been shown to have similar morphological features to human bone, as well as similarities in regards to the presence of HCF on the proximal femur. Therefore an ovine model was used in this investigation. Ten female sheep aged 3.5-4 years were double-labeled with tetracycline 11 days apart and sacrificed 5 days later. The double tetracycline label was used to determine the mineral apposition rate and regions of bone viability in both the HCF and cortical bone. The right or left proximal femur from each animal was randomly selected for dehydration and embedding in Methyl Methacrylate. Each proximal femur was sectioned in the greater trochanteric region perpendicular to the axis of the femoral neck at 5 mm increments to ensure the inclusion of capsular, tendon, and/or ligament insertions. These sections were ground to light and stained with a dilute basic fuchsin solution to differentiate the cortical bone, fibrous tissue, and HCF. Fluorescent light microscopy was used to quantify the number of double and single labels in the HCF and cortical bone for comparison. The mean number of double labels in each tissue was statistically analyzed using the paired T-Test to assess any difference in amount of remodeling between the two tissues.

Results

A significantly greater number of double labels was found in the cortical bone compared to the HCF (P < .001, \( \alpha = 0.05 \)). The mean number of double labels found in the HCF was 1 ± 1 per cross section. The mean number of double labels in the cortical bone was 33 ± 21 per cross section. Single labels (20 ± 15 per cross section), indicating viability, in the cortical bone were also found in a significantly greater number (P < .001, \( \alpha = 0.05 \)) compared to the HCF (1 ± 1 per cross section).

Discussion

The results of this investigation disprove the null hypothesis, demonstrating that while the cortical bone was viable and actively remodeling, the HCF appeared to have very limited remodeling capacity (Figure 1). This does not mean there may not be another biological mechanism by which HCF may remodel or repair, but the absence of blood supply and limited viability index suggest that such a capability would be highly unlikely.

Further studies investigating how, with aging, HCF becomes a more predominant tissue in the proximal femur are required. The current working hypothesis is that endosteal resorption and cortical bone remodeling with age are likely to cause increased porosity along the femoral neck. These factors appear to contribute to increased volume fraction of HCF measured on the outer margin of the proximal femur (Figure 2) with age.

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References


Figure 1. Image showing remodeling in cortical bone and absence of remodeling in HCF.

Figure 2. Image showing high volume fraction of HCF compared to cortical bone.