INTRODUCTION
Previously we have demonstrated that in the fractured femoral neck, the elevated cortical porosity is dependent on giant canals (diameter > 385µm). These giant canals, in turn, were found to be positively associated with the phenomenon of spatially clustered remodelling osteons (super-osteons). It was proposed that the deleterious giant canals form through the deregulated amalgamation of canals within clusters of remodelling osteons (super-osteons). Hence, the aim of this study was to establish whether super-osteons develop in association with ageing.

MATERIALS AND METHODS
Femoral shafts were from cases of sudden death of people who had no known diseases affecting their bones. The population consisted of 33 males (M) and 33 females (F) and were split into the following age groups: 20-40 years (y), 41-60y, 61-80y and above 80 years. Microradiographic images were prepared of the cross-section of the femoral shaft. Using NIH Image the number, size and locations of all Haversian canals were mapped. By using an edge-detection algorithm (Sobel), highlighting the most marked differentials in grey level, the recently remodelled osteonal systems were identified on the microradiographs. Cluster analysis (JMP software) of these osteons identified the number and size of super-osteons. By dividing the cortical shell into Periosteal (1.5 mm from the periosteal surface), Endosteal (1.5 mm from the endocortical surface) and Intra-cortical (Area between Periosteal and Endosteal regions) rings of cortical bone the location of these super-osteons was categorised.

RESULTS
Within the cortex there were no gender or age differences in the Haversian canal density (mm²). However, cortical porosity, in the oldest males was over twice that in the youngest males (p<0.05). In the oldest females the cortical porosity was approximately three times that in the youngest females (p<0.05). The proportion of giant canals which are a major influence on the degree of porosity was not gender dependent but increasing age resulted in a significant increase in the proportion of giant canals (20-40 years 0.22±0.05%, Above 80 years 1.18±0.3%, p<0.01). The amount of cortical remodelling as evidenced by the percentage of young osteons was significantly influenced by gender with the remodelling in females being on average 34% greater than the males (p=0.034, Matching Fit). Within both the males and females there were no significant differences in the degree of remodelling between the age groups (Fig. 1).

In this study, as in the femoral neck, there was significantly more clustering per unit area in the actual distribution of the recently remodelled osteons compared with a randomly generated distribution. This was evidenced by the decrease in the proportion of the youngest osteons existing as singletons, rather than clusters (random, 60.66±2.18; real, 40.58±1.8; p<0.0001). For males and females of all ages the endosteal ring of cortical bone had the lowest density of remodelling clusters with the periosteal ring having the greatest density (Fig. 2). In the males, the density of clusters did not significantly change between the age groups in the endosteal and periosteal rings (Fig. 2). However in the intra-cortical ring the density of clusters was significantly greater in the 41-60 age group compared to the 61-80 and >80 groups (Fig. 2). In the females the density of clusters within each of the rings of cortical bone did not significantly differ between the age groups (Fig. 2).

DISCUSSION
The data from the current study suggest that remodelling osteons tend to be spatially co-localised in the femoral shaft as well as neck so that the clustering phenomenon is present throughout adult life. In addition, this study has shown that in the femoral shaft clustering of remodelling osteons is not greatly influenced by gender and the degree of clustering does not increase greatly with ageing. These data are consistent with the concept that remodelling initiates within adjacent osteon groups linked by vascular anastomoses. As would be expected the porosity of the shaft was at least doubled in the oldest subjects. A major contribution to this porosity was the 5x increase in the presence of giant canals with age. The negative relationship between the presence of remodelling clusters and giant canals suggests the possibility that loss of targeted control of remodelling depth could result in the merging of osteonal systems to form deleteriously large cavities within the cortex.

BIBLIOGRAPHY

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