Depth related changes in aging bone

Samantha Davies[1], Charlene Greenwood[2], Keith Rogers[1] & Rita Hardiman[3]

1. Cranfield Forensic Institute, Cranfield University, Shrivenham, UK
2. School of Chemical and Physical Sciences, Keele University, Keele, UK
3. Melbourne Dental School, University of Melbourne, Melbourne, Australia

Introduction

Injury and musculoskeletal disorders, such as osteoarthritis (OA), are the cause of 56% of Army medical discharges [1]. Excessive overloading can cause damage to the hip and knee joints, as can aging. Microstructure of bone changes significantly with age affecting the strength of the bone [2]. Bone remodels with mechanical stimulus, leading to its heterogeneous structure, this suggests that structure may change as function of depth [3].

The aim of this study was to (i) evaluate the hypothesis that the structure of the femoral head changes significantly with age; (ii) to determine how the structure changes with depth and (iii) determine how the structure differs between sexes.

Results

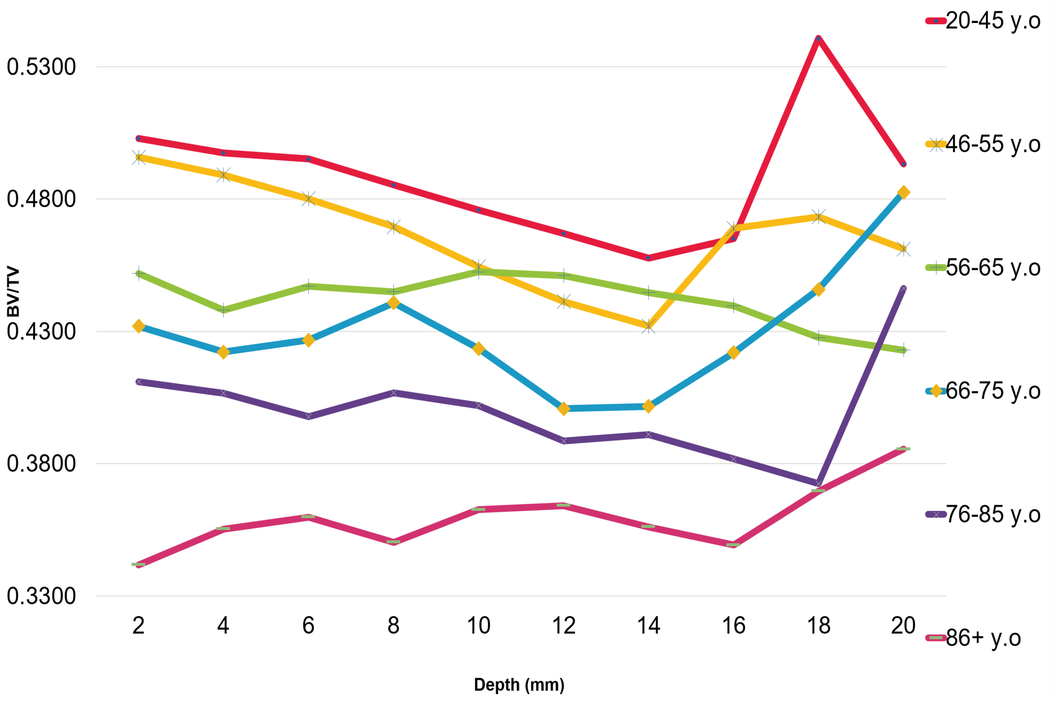

Figure 3: Changes to BV/TV of male femoral heads with depth

Table 1: The significant differences seen between microarchitectural parameters with depth, age and sex. Ticks indicate a statistical difference of $p < 0.05$

		Male	Female
BV/TV	Age	✔	✔
	Depth	✗	✗
TbTh	Age	✔	✔
	Depth	✗	✗
TbSp	Age	✔	✔
	Depth	✗	✗
TMD	Age	✔	✔
	Depth	✔	✔
BMD	Age	✔	✔
	Depth	✗	✗

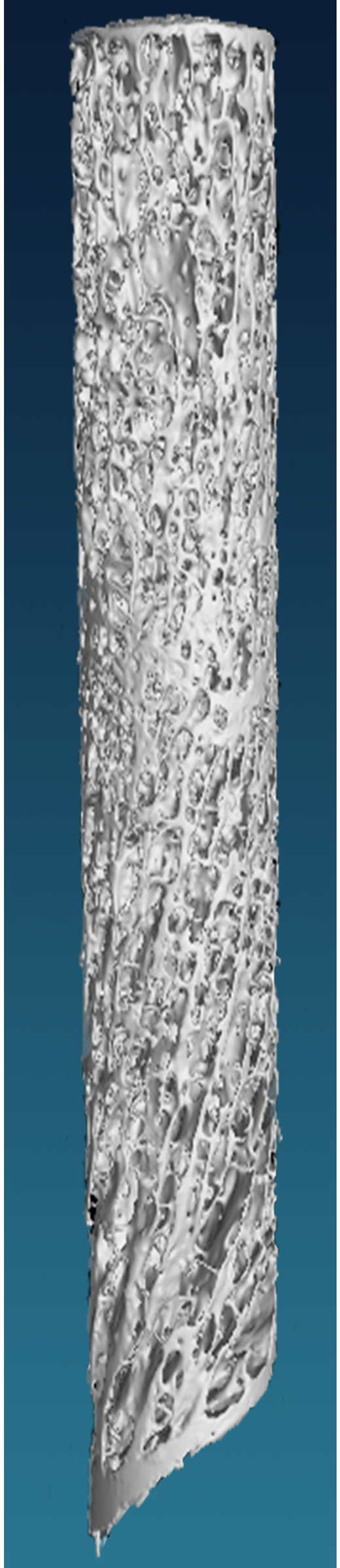

Figure 1: Sample µCT reconstruction image of femoral core

Materials and Methods

Femoral head samples, from 18 males and 17 females, were collected from cadavers from the Melbourne Femur Collection (donors ages ranged from 20-93 years old). The donors had no known diseases. Trabecular bone cores were taken along the principle compressive trabeculae of the femoral head. The specimens were scanned using a µCT scanner (XT H 225, X-Tek Systems Ltd.). Cores were sectioned into 10 x 2mm slices and the average greyscale of each section was measured – allowing for the calculation of volumetric tissue mineral density (vTMD) via a hydroxyapatite calibration phantom. Microarchitectural parameters, including bone volume fraction (BV/TV), trabecular thickness (Tb.Th) and trabecular spacing (Tb.Sp) were calculated for each 2mm slice. Volumetric bone mineral density (vBMD) was calculated using vTMD and BV/TV.

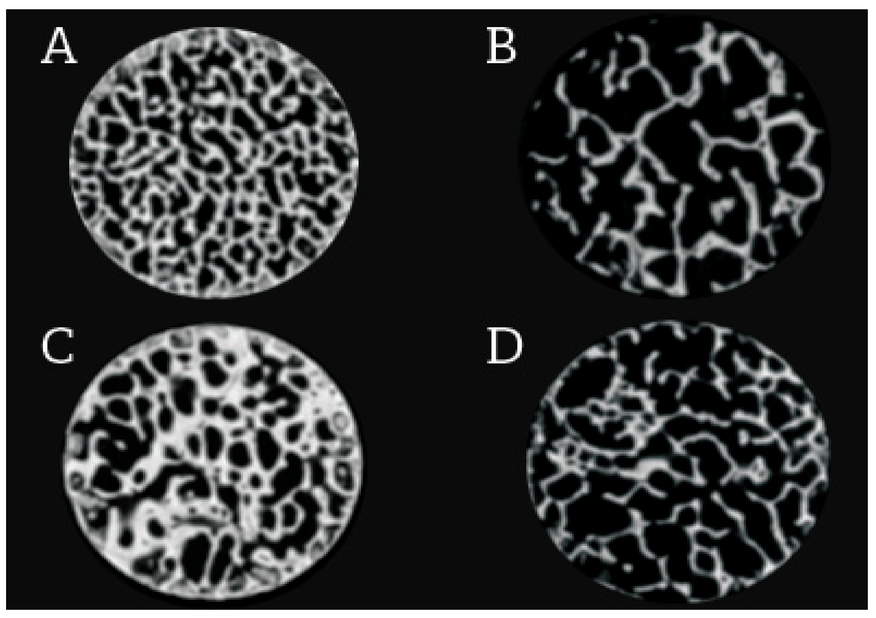

Figure 2: Cross sectional µCT images of A) Male 21 y.o at 2mm, B) Male 93 y.o at 2mm, C) Male 21 y.o at 18mm, D) Male 93 y.o at 18mm

Discussion

- The microarchitecture of the femoral head changes significantly with age and is dependent on sex and depth
- The subchondral bone is in direct contact with the basal layers of the articular cartilage and is therefore in a different biochemical and mechanical environment to the underlying trabecular bone [4]
- It is proposed that discrepancies between sexes are a result of hormonal differences which can influence bone remodelling
- Depth, sex and age should all be considered when designing a patient's joint replacement or osteochondral implant

Conclusion

The structure of the femoral head changes significantly with age, sex and depth. This knowledge can be used to improve implant integration for OA treatment.

References

1. Ministry of Defence. 2019.
2. Chen *et al.* Int. J. Endocrinol. 2013; 1–9.
3. Turunen *et al.* Bone. 2013; 54(1): 118–125.
4. van der Harst *et al.* Osteoarthr. Cartil. 2004; 12(9): 752–761.

Funding

This work was funded by an Engineering and Physical Sciences Research Council (EPSRC) Doctoral Training Partnership (EPSRC/3445-SA021N) for providing the funding for this research