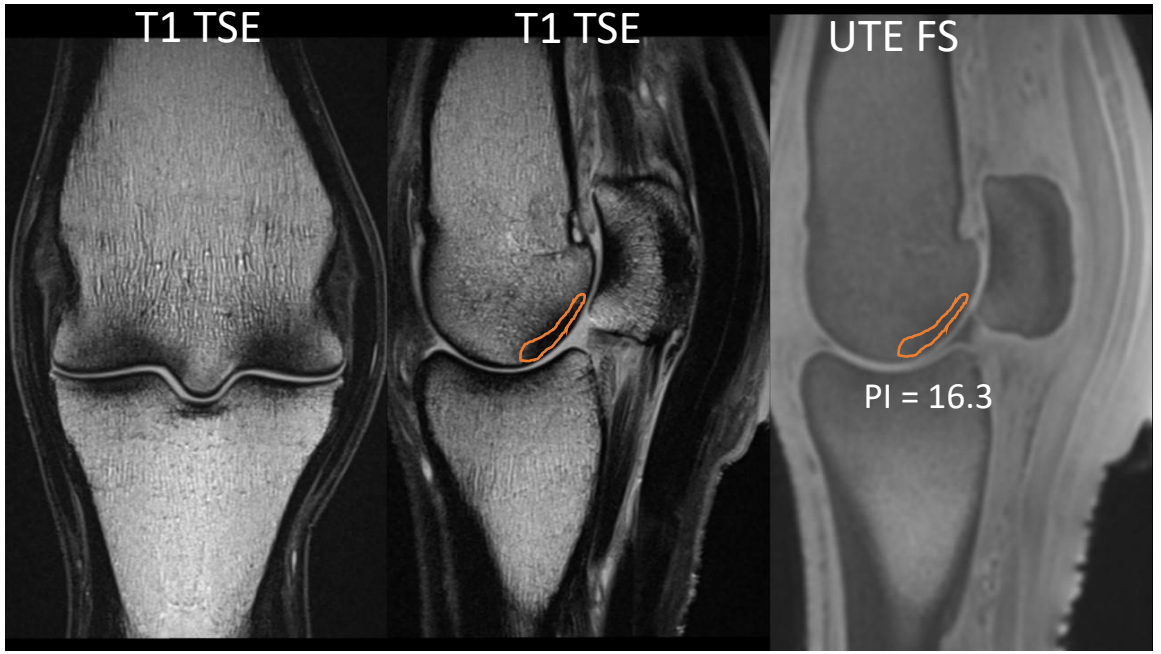
Do Fissures Influence Bone Porosity in the Distal Metacarpus of the Thoroughbred Racehorse? A Feasibility Study

Rachel Macleod

Supervisors: Dr Sarah Taylor, Dr Carola Daniel and Dr Lucy Kershaw

Kindly sponsored by the Beaufort Cottage Educational Trust



Introduction: Background

- Fractures of the lateral condyle of MC3 are the most common reason for euthanasia on UK racecourses (Parkin et al., 2004)
- Significant welfare concern
- Pre-fracture markers:
  - Bone density/porosity correlated with stress fracture risk in human athletes (Bennell et al., 1996).
- Ultrashort Echo Time (UTE) MRI sequences used to evaluate bone porosity
- Subchondral bone appears as a signal void on conventional MRI due to its short T2* (Ma et al., 2020).
- UTE sequences aim to capture more signal from the subchondral bone collecting data using a very short TE

Introduction: Water in Bone

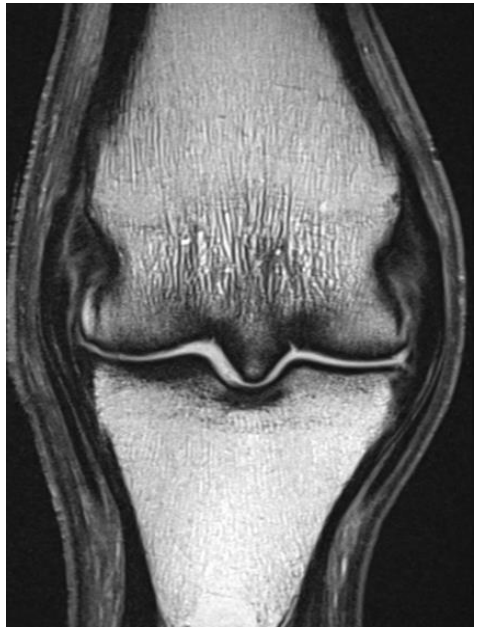
- Bone is composed of three main components: hydroxyapatite crystals, collagen and water
- Water exists in two forms: bound water and pore water
- Bound water: very short T2* (0.3ms) and not normally detectable with MRI, except UTE
- Pore water: free water in bone pores: vascular canals, lacunae and canaliculi; T2* of 1ms-1s
- Porosity index (PI) represents cortical bone porosity and has been shown to correlate with bone porosity measured by micro-CT (Rajapakse et al., 2015)
- UTE image = bound water + pore water
- Long TE image = pore water only
- Ratio of these two signals = PI
- PI = PW : (PW + BW)

THE UNIVERSITY of EDINBURGH

BCET Beaufort Cottage Educational Trust

Aim:

To determine if there is a difference in the porosity index of the parasagittal groove of the third metacarpal (MC3) in horses with fissures compared to controls



THE UNIVERSITY of EDINBURGH

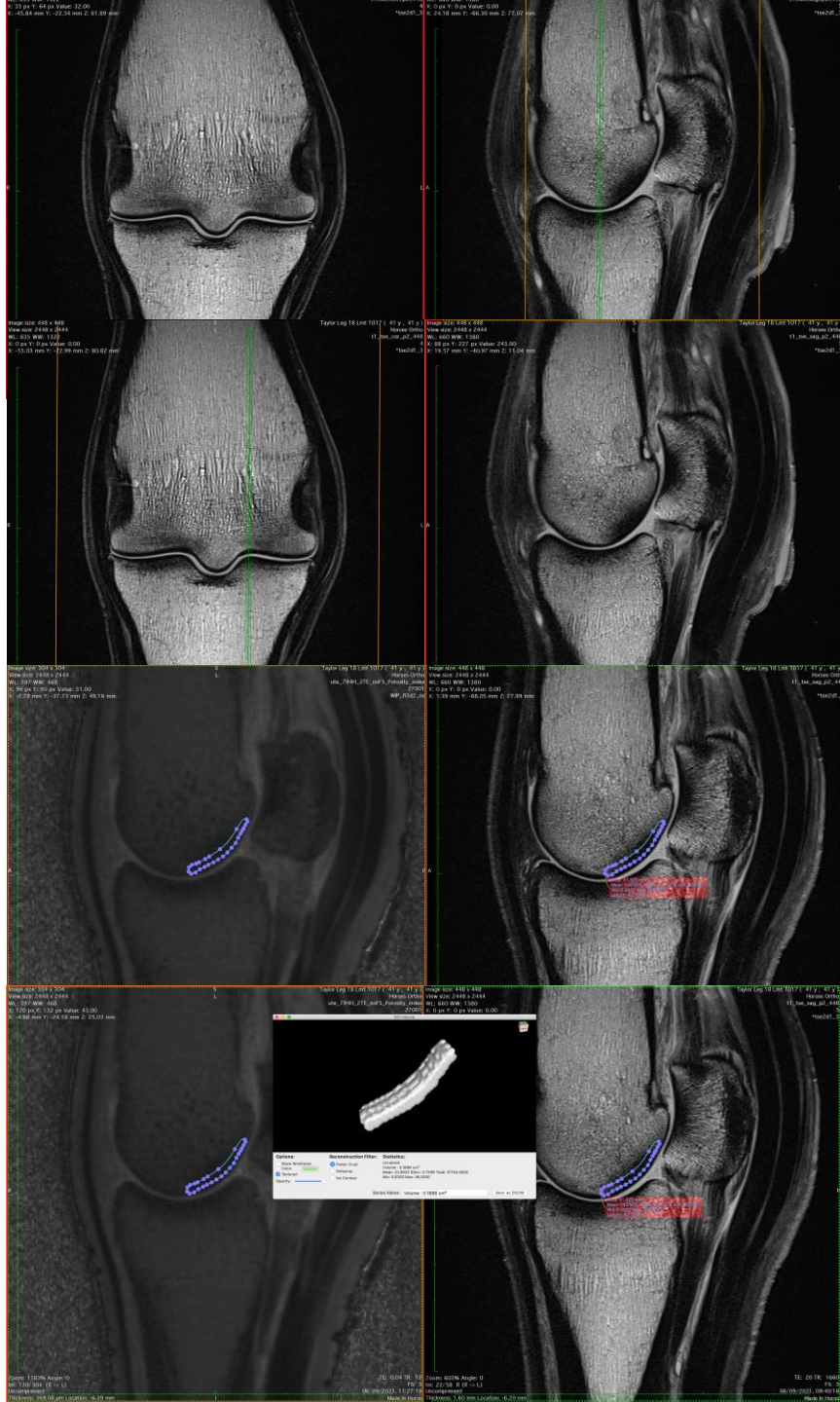
BCET
Beaufort Cottage Educational Trust

Method

- Approval: VERC of the University of Edinburgh (VERC no.: 35.21)
- Distal limbs collected from TB racehorses subjected to euthanasia on Scottish racecourses from 2019 to 2021
- Reason for euthanasia and signalment were recorded, limbs frozen at -20°C
- The limbs defrosted 24hrs prior to imaging and maintained at 20°C
- Prior to MRI, limbs were radiographed (flexed DP)
- Siemens Skyra™ 3 Tesla MRI along with a phantom
- High resolution peripheral quantitative computed tomography as part of another study
- The presence of fissure fractures on T1 TSE was recorded

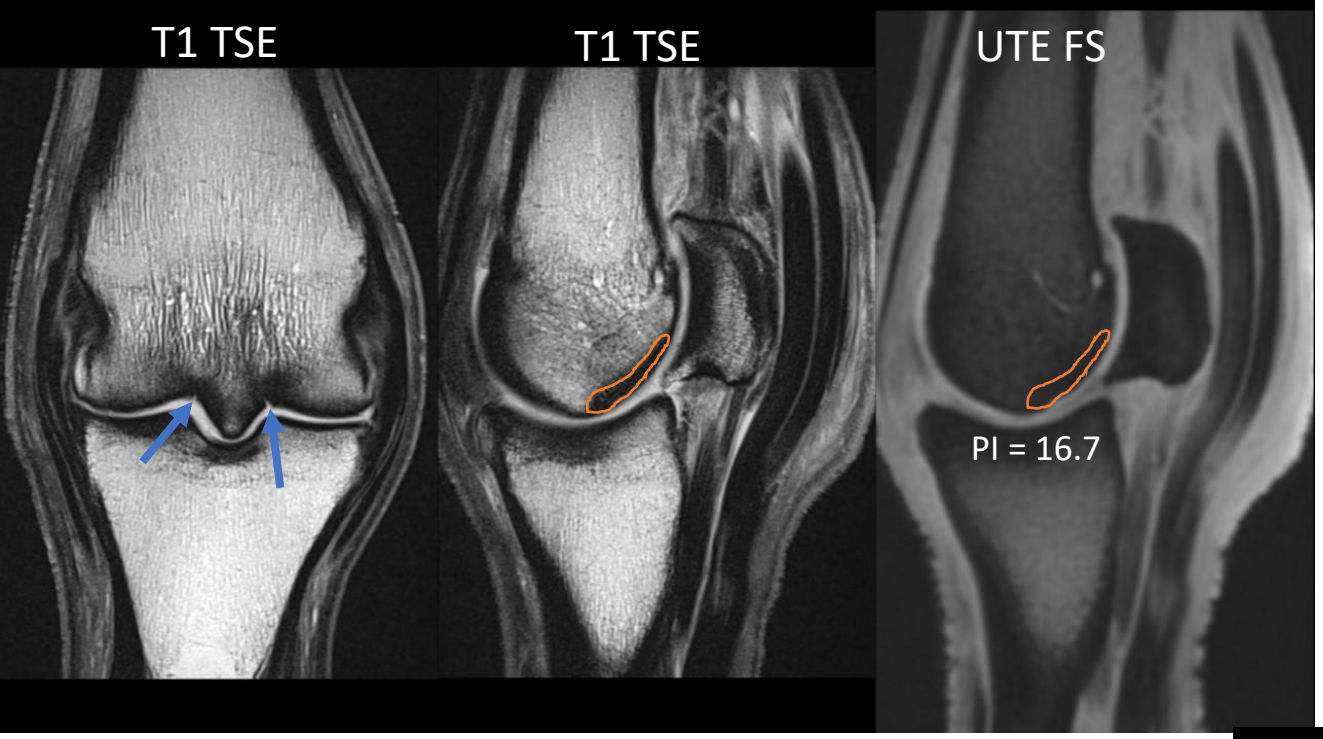
Scanning and ROI Measurement

- Scanning protocol: T1 TSE, UTE, TIRM (STIR) in three orthogonal planes
- Regions of interest (ROI) were drawn around the cortical bone of the medial and lateral parasagittal grooves on T1 TSE sequences and copied to the UTE sequences
- The ROI position was adjusted for every slice to account for individual variation in anatomy but its shape and size remained the same for comparability
- The porosity index was calculated and recorded

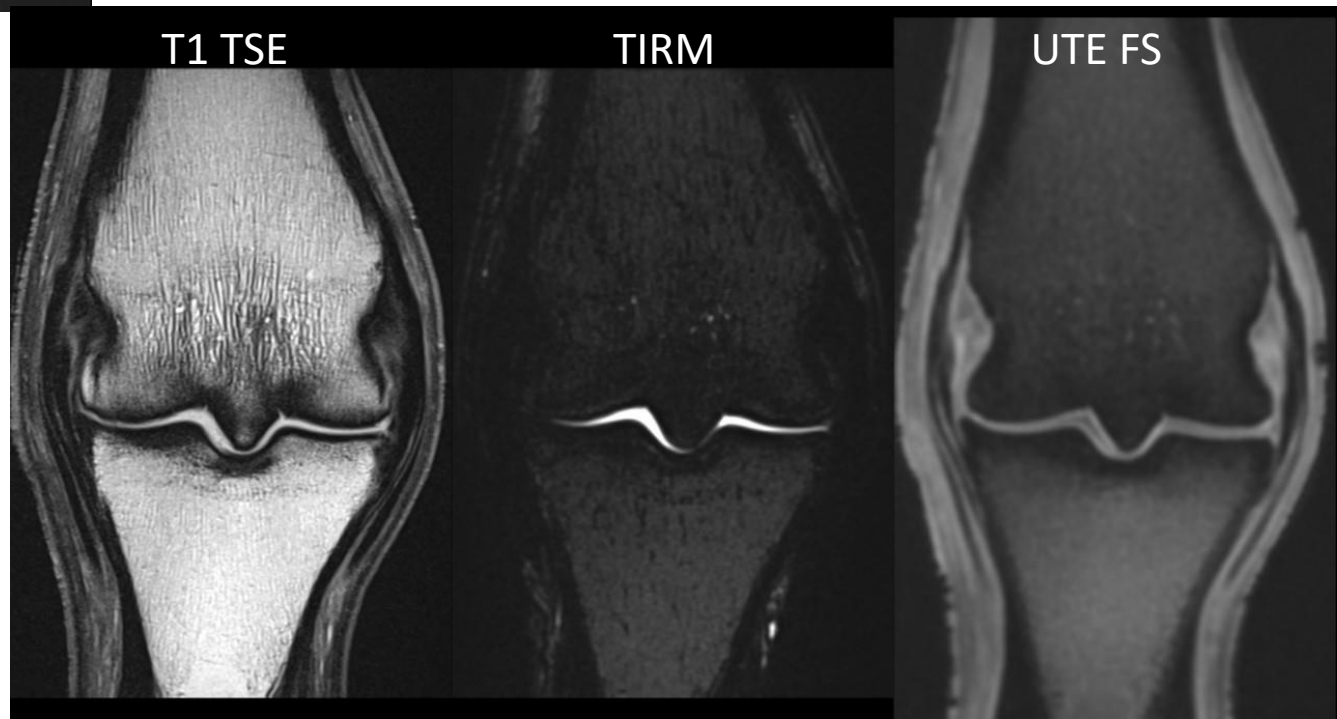


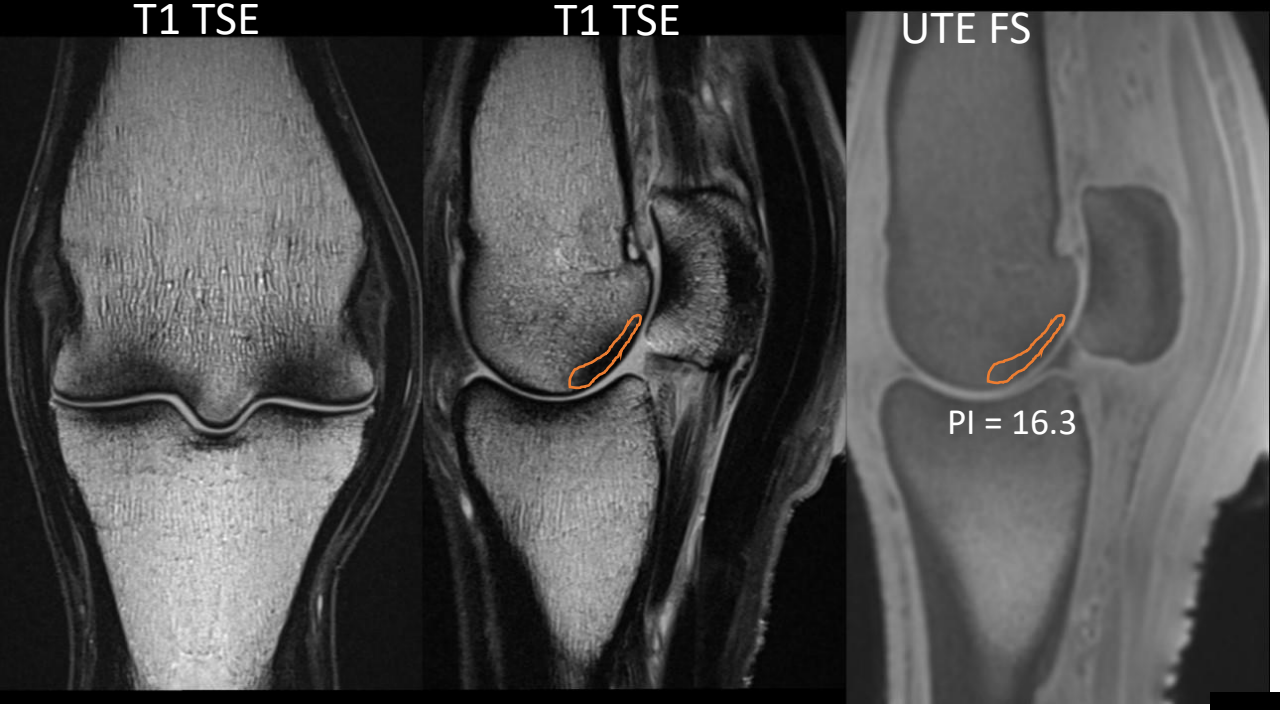
Results

- Signalment:
  - Median age = 6 years
  - Age range = 3-11 years
  - All TB geldings
- Six hind legs and two forelegs
- Reasons for euthanasia:
  - Four legs from horses with a clinical stress fracture (proximal phalanx and humeral)
  - Four legs from horses without a clinical stress fracture (sudden death and rotational fall)

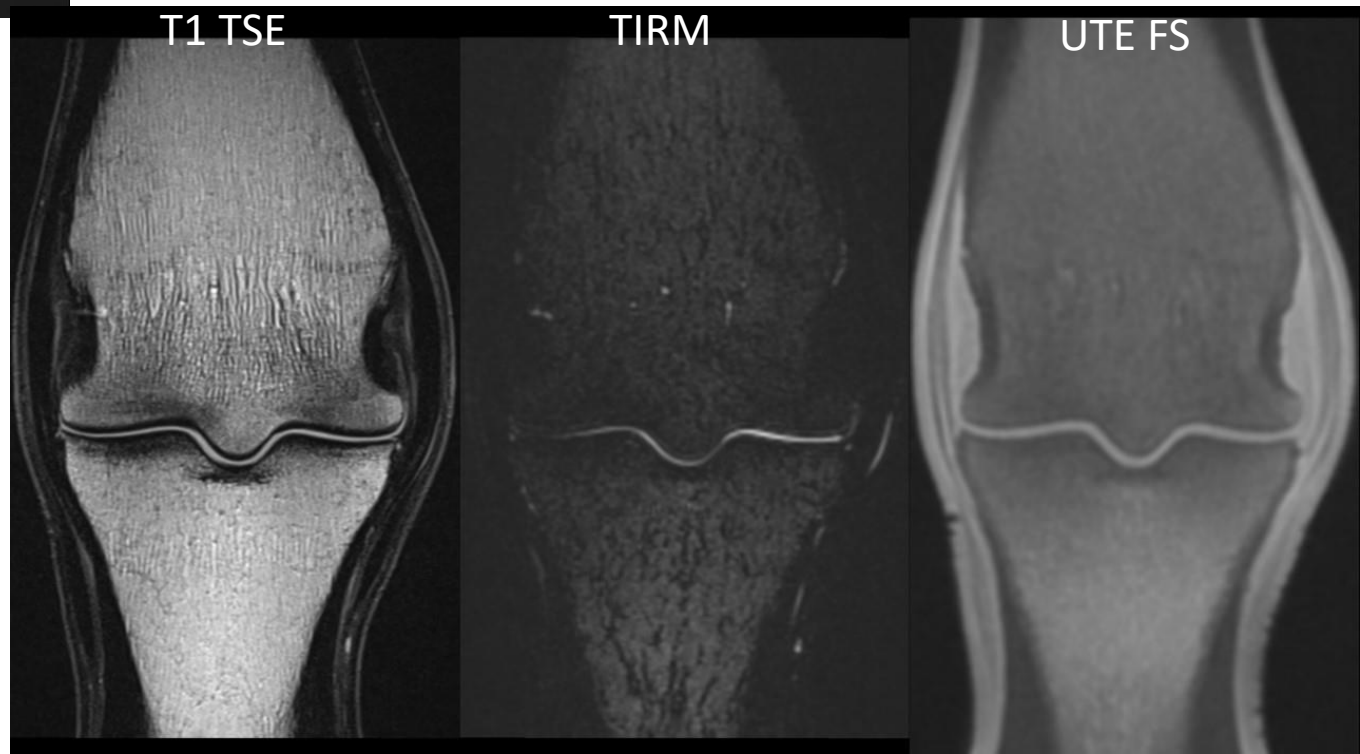


Leg 24 - Fissured





Leg 18 - Control



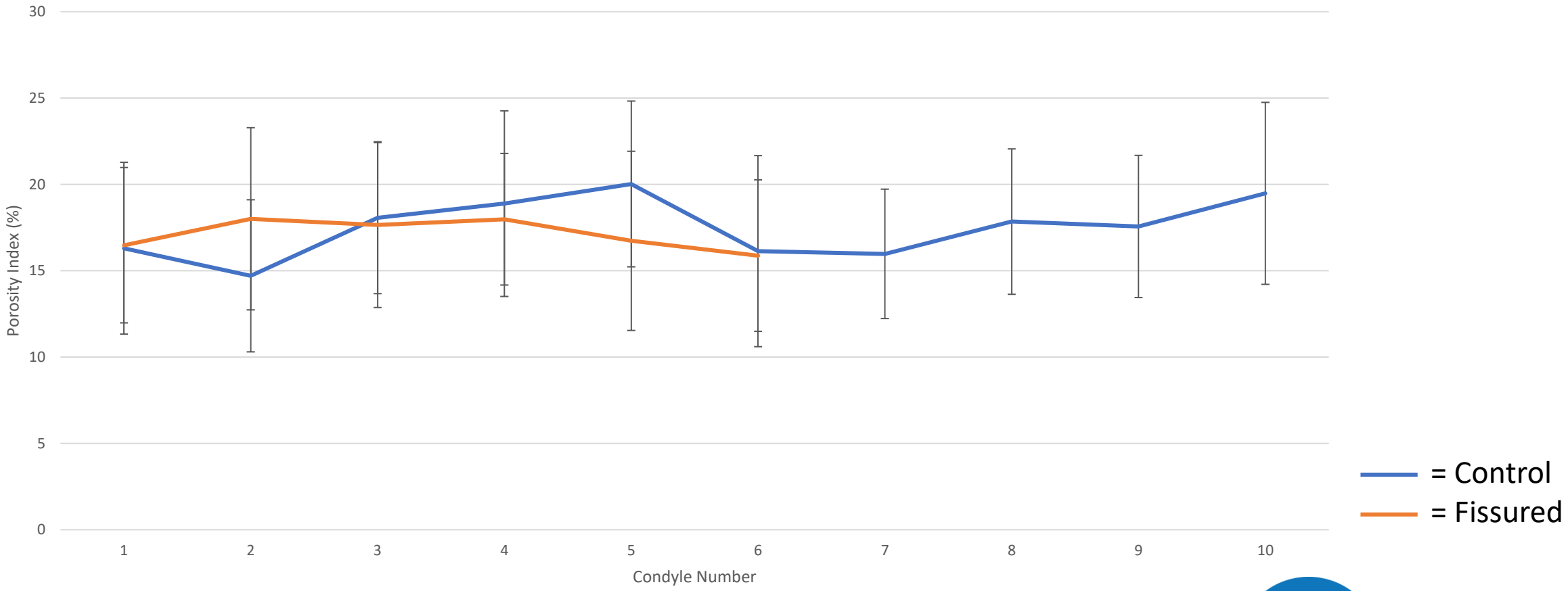
Porosity Indices

Leg Number	Lateral PSG Porosity Index (%)	Lateral PSG Standard Deviation	Medial PSG Porosity Index (%)	Medial PSG Standard Deviation
18	16.3	5	16	3.7
19	14.7	4.4	17.8	4.2
20	18.1	4.4	17.6	4.1
21	18.9	5.4	19.5	5.3
22	20	4.8	16.5	4.5
23	16.1	5.5	18	5.3
24	16.7	5.2	17.6	4.8
25	15.9	4.4	18	3.8

THE UNIVERSITY of EDINBURGH

BCET
Beaufort Cottage Educational Trust

Porosity Indices of Controls Vs. Fissured



THE UNIVERSITY of EDINBURGH

BCET
Beaufort Cottage Educational Trust

Discussion

- A method was developed to measure the porosity index of the subchondral bone surrounding the parasagittal ridge of MC3 in horses
- Porosity index values were similar to those determined in previous studies in humans (18-35% in Rajapakse et al., 2015)
- No difference in porosity index was seen between the two horses with fissures and the two controls but this is a **very small sample size**
  - Whitton et al. (2010) reported lower porosity in condylar fatigue fracture cases than resting controls

Discussion

- There was no difference in porosity index in horses with fissures versus controls.
  - Porosity increases with age (Rajapakse et al., 2015) - not controlled for in this project
  - Unknown training history
  - Fissures can be an incidental finding

Limitations

- Small sample size
- Sample population pathology
- Cadaveric material, frozen (Johnston et al., 2021)

Conclusion

- Cortical bone porosity index appears to be a quantitative MRI technique that is measurable using high field UTE sequences
- There was no difference in porosity index in horses with fissures versus controls
- Further work is required to:
  - Determine the best location of the volumetric ROI
  - Validate the porosity index values against pore size determined using microCT with a greater sample size

Acknowledgements:

- Beaufort Cottage Educational Trust
- Dr Carola Daniel, Royal (Dick) School of Veterinary Studies, University of Edinburgh
- Dr Lucy Kershaw, Queen's Medical Research Institute, University of Edinburgh
- Dr Sarah Taylor, Royal (Dick) School of Veterinary Studies, University of Edinburgh
- Owners of the horses whose bodies were donated for this research
- Pathology team of the Royal (Dick) School of Veterinary Studies, University of Edinburgh

References:

- Bennell, K., Malcolm, S., Thomas, S., Reid, S., Brukner, P., Ebeling, P., Wark, J., 1996. Risk Factors for Stress Fractures in Track and Field Athletes: A Twelve-Month Prospective Study. *The American Journal of Sports Medicine*, 24(6), pp. 810–818.
- Johnston, G., Ahern, B., Woldeyohannes, S. and Young, A., 2021. Does the Low-Field MRI Appearance of Intraosseous STIR Hyperintensity in Equine Cadaver Limbs Change when Subjected to a Freeze-Thaw Process?. *Animals*, 11(2), p.475.
- Ma, Y., Jerban, S., Jang, H., Chang, D., Chang, E. and Du, J., 2020. Quantitative Ultrashort Echo Time (UTE) Magnetic Resonance Imaging of Bone: An Update. *Frontiers in Endocrinology*, 11, p.667.
- Parkin, T., French, N., Riggs, C., Morgan, K., Clegg, P., Proudman, C., Singer, E. and Webbon, P., 2004. Risk of fatal distal limb fractures among thoroughbreds involved in the five types of racing in the United Kingdom. *Veterinary Record*, 154(16), pp.493-497.
- Rajapakse, C., Bashoor-Zadeh, M., Li, C., Sun, W., Wright, A. and Wehrli, F., 2015. Volumetric Cortical Bone Porosity Assessment with MR Imaging: Validation and Clinical Feasibility. *Radiology*, 276(2), pp.526-535.
- Whitton, R., Trope, G., Ghasem-Zadeh, A., Anderson, G., Parkin, T., Mackie, E. and Seeman, E., 2010. Third metacarpal condylar fatigue fractures in equine athletes occur within previously modelled subchondral bone. *Bone*, 47(4), pp.826-831.

THE UNIVERSITY of EDINBURGH

BCET Beaufort Cottage Educational Trust