A Masters by Research project Atypical femoral fractures

NHS Grampian/University of Exeter

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The education part

- This project is the full examined component of my Masters by Research in Medical Imaging, via distance learning with the University of Exeter. A thesis of 25-40,00 words, based on a service evaluation of GE extended femur scanning software program.
- This is a maximum 3 year course, but with pre-application guidance from Exeter, this should be completed within 2 years.
- Regular contact with my supervisors – Prof Karen Knapp and Dr Chris Wright in Exeter and Dr Rosemary Hollick from NHS Grampian, usually by Skype.
- Meetings are held monthly to evaluate progress and set new goals, with regular email contact and feedback on work in progress. Support and guidance offered on next stages of project.

Atypical femoral fractures and DXA in NHS Grampian – the project

- The aim is to produce some statistics of atypical femoral fractures (AFF) from the Grampian population and determine the utility of the new DXA software to inform a new clinical pathway to use within our service. This will be used to predict AFF in the local population and as a springboard to further research in this area.
- New departmental protocol using extended femur scanning as standard practice for all patients over the age of 18 years from 1/9/18. Very small additional radiation dose of 0.37 µSv per femur and slight increase in time of scan of 12 seconds per femur (Van De Laarschott et al 2017).
- GE rolled out extended femur scanning software to identify beaking in 2015 - What is beaking? It is thought that AFFS are a form of stress fracture which occurs within the shaft of the femur, and that there is an area of diffuse periosteal reaction at the lateral cortex, which may be a fracture initiation site. The area of cortical thickening is known as a beak, and the process of thickening is known as beaking.

GE software – the practicalities

- Extended femur scanning begins just superior to the supracondylar flare, and ends above the hip joint, with no detriment to BMD measurement at the hip (Mckiernan et al 2011). Centring point is mid patella.
- The extended femur scanning is designed to enable users to identify potential thickening within the lateral cortex of the shaft and diaphysis of femur – known as beaking, and ultimately fragility fractures known as AFF. This has been shown to happen independently of osteoporosis or bisphosphonate drugs (Hagen et al 2014, Hagino et al 2018), but is most commonly associated with prolonged bisphosphonate use.
- Still very rare phenomenon, affecting a small minority of patients - 5 in every 10,000 patients with bisphosphonate exposure (NOS 2014)
- ASBMR classification for what constitutes an atypical femoral fracture

ASBMR criteria

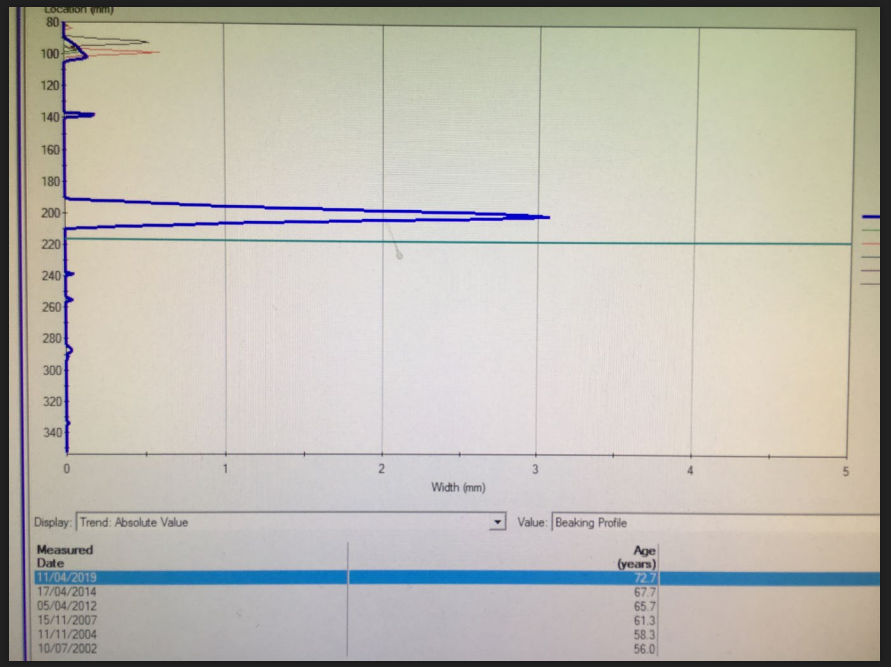
Four of five major criteria should be observed; additional minor criteria are not necessary for diagnosis but could be observed in association to the major criteria.

Fractures of the femoral neck, intertrochanteric fractures with spiral subtrochanteric extension, periprosthetic fractures, and pathological fractures associated with primary or metastatic bone tumours and miscellaneous bone diseases (eg, Paget's disease, fibrous dysplasia) are excluded.

Major	**- The fracture is associated with minimal or no trauma, as in a fall from a standing height or less** **- The fracture line originates at the lateral cortex and is substantially transverse in its orientation, although it may become oblique as it progresses medially across the femur** **- Complete fractures extend through both cortices and may be associated with a medial spike; incomplete fractures involve only the lateral cortex** **- The fracture is noncomminuted or minimally comminuted** **- Localized periosteal or endosteal thickening of the lateral cortex is present at the fracture site ("beaking" or "flaring")**
Minor criteria	- Generalized increase in cortical thickness of the femoral diaphyses - Unilateral or bilateral prodromal symptoms such as dull or aching pain in the groin or thigh - Bilateral incomplete or complete femoral diaphysis fractures - Delayed fracture healing

Many false positives

Majority of false postives are found very low in the shaft of femur.

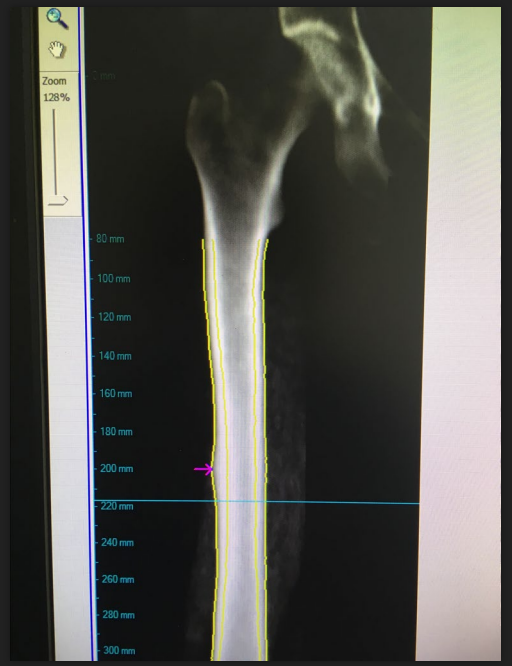


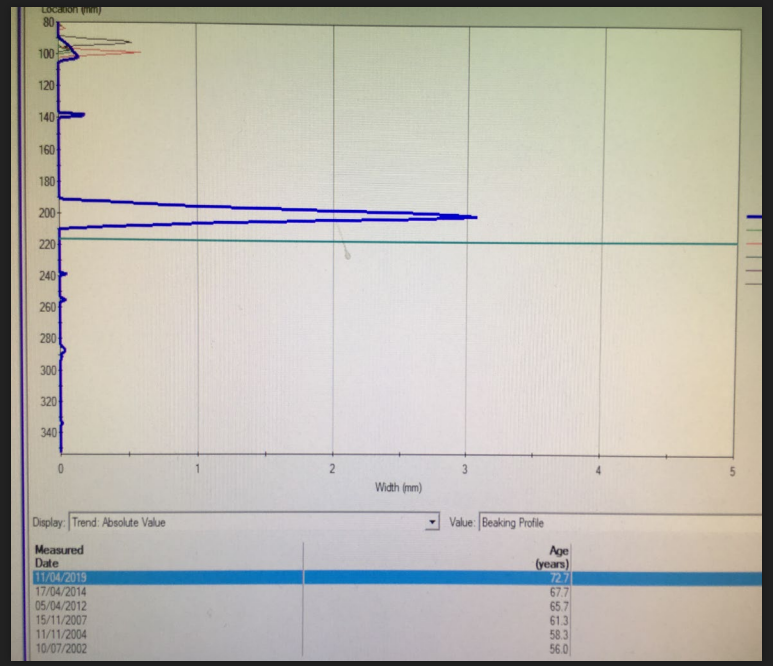
Case study

- The following patient (Female, Caucasian, 72 yrs, past HRT, men age 48) has had several DXA scans in past. Has been on bisphosphonates from 2002, 2 yr holiday 2012-2014, restarted 2014 to date of scan.
- Left hip has been pinned, so right leg scanned.
- No prodromal pain in groin or outer thigh area reported, no restrictions in movement or activity.
- Based on visual appearance and beaking index from DXA scan, a decision was made to send patient for x-rays bilaterally of femora, indicated as protocol due to significant risk to contralateral femur of beaking and fracture, estimated risk 40-50% (Lo et al 2012, Compston 2011).
- There is evidence that there is a significant lack of compliance with published guidelines for radiologist reporting of AFF. The findings of one large scale study indicated that none of the 16 patients exhibiting evidence of an incipient AFF had been identified (Harborne et al 2015). The majority of these were known to metabolic bone services, over 60% were taking bisphosphonates, only 1 patient was asked about prodromal pain in groin/outer thigh area.

Beaking on imaging

- Images from scan database
- true positive on DXA





What does the radiologist think?

"organised periosteal reaction at the lateral side of the middle third of the femoral shaft. Aetiology unclear."

To nail or not to nail…

- Orthopaedic protocols on prophylactic femoral nailing seem to vary not only between hospitals and trusts, but also between orthopaedic surgeons. This is supported in various studies, although there is no definitve single approach to surgical management (Oh et al 2013, Hagino et al 2018)
- Discussions with patients, presenting case for prophylactic pinning, rest and reduction of weight bearing or watch and wait strategy. May suggest re-imaging in 3 months, either with x-ray or MRI.
- There is no evidence that the cortical thickening is new – it may have been present and unchanged for many years, until we have used the extended femur software for some time, or more studies are published, it will be hard to tell.
- What would you choose to do if this was your femur?

Further development - audits currently underway

- Scan positioning and accuracy of the subsequent analysis – points to develop in practice
- Visual assessment of scans for beaking/cortical anomalies – most in agreement
- Single operator precision – working on ethics approval currently
- Reanalysis of 30 scans to measure any software changes to Beaking Index measurements – no change identified on any scan.
- Future works may involve x-ray of patients with false positive beaking on DXA

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