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Disuse osteopenia following leg fracture in postmenopausal women: Implications for HIP fracture risk and fracture liaison services

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ABSTRACT

Introduction: Disuse osteopenia is a known consequence of reduced weight-bearing and has been demonstrated at the hip following leg injury but has not been specifically studied in postmenopausal women.

Method: Bilateral DXA (GE Lunar Prodigy) bone mineral density (BMD) measurements were taken at the neck of femur (NOF), total hip region (TH) and lumbar spine in postmenopausal female groups comprising controls ($N = 43$), new leg fractures (#<3wks) ($N = 9$), and participants who had sustained a leg fracture more than one year previously (#>1yr) ($N = 24$). #>1yr were assessed at a single visit and the remaining groups at intervals over twelve months. Weight-bearing, function, 3-day pedometer readings, and pain levels were also recorded.

Results: The #<3wks demonstrated significant ($p < 0.05$) losses in ipsilateral TH BMD at 6 weeks from baseline 0.927 ± 0.137 g/cm^2, to 0.916 ± 0.151 g/cm^2 improving to 0.946 ± 0.135 g/cm^2 (n.s) at 12 months following gradual return to normal function and weight-bearing activity. The #>1yr scored significantly below controls in almost all key physical and functional outcomes demonstrating a long-term deficit in hip bone density on the ipsilateral side.

Conclusion: The clinical significance of post-fracture reduction in hip BMD is a potential increased risk of hip fracture for a variable period that may be mitigated after return to normal function and weight-bearing. Improvement at 12 months in #<3wks is not consistent with #>1yr results indicating that long-term impairment in function and bone health may persist for some leg fracture patients. Unilateral bone loss could have implications for Fracture Liaison Services when assessing the requirement for medication post fracture.

Introduction

Alongside numerous lifestyle, hormonal and pharmacological factors affecting maintenance of bone health, skeletal mechanical loading is the key stimulus for bone remodelling and it follows that a reduction in weight-bearing will have a negative impact on the remodelling process. Reduced weight-bearing activity is an inevitable consequence of lower limb fracture and the condition of disuse osteopenia, characterised by reduced BMD and micro-architectural changes, may arise as a result.[1–5] The consequence of disuse osteopenia may be a reduction in the structural integrity of bones predisposing them to increased fracture risk either at the original injury site or secondary site that has also been subject to a bone density loss.[6–8] Prolonged immobility following lower limb fracture potentially results in either unilateral or bilateral loss in hip BMD.[9–17] Fractures of the hip, are more closely linked to BMD than other fracture types and have the most serious social and economic consequences due to high rates of subsequent morbidity and mortality.[18] As the rate of hip fracture increases exponentially with age, estimated to be a 17% lifetime risk from the age of 50 years in white females,[18,19] it potentially represents a major problem for post-menopausal women who are already losing bone systemically due to reduced oestrogen levels and may be at greater risk of not recovering bone following a period of disuse.

Jarvinen and Kannus[14] provide a comprehensive review of studies, up to 1997, of injuries to the lower extremities and their effect on bone density. The studies are grouped into knee injuries,

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femoral shaft, tibial shaft and ankle fractures. It is evident from all of these studies that varying degrees of bone loss are associated with lower limb injury. This also includes bone density changes in the contralateral limb. Several studies include measurement of BMD changes in the proximal femur.[9–12,15,20] These studies, with one exception,[11] showed long-term bone loss in the ipsilateral proximal femur to a varying degree as a result of lower limb injury.

Although ankle fractures are not considered to be a typical osteoporotic fracture, postmenopausal females frequently present with ankle fractures that often result from relatively minor trauma. Fracture Liaison Services (FLSs) aim to identify patients at increased risk of further low-trauma fractures due to bone fragility and routinely refer patients for DXA scans around 6 weeks post-fracture at a stage when bone loss may be at its peak. DXA scanning protocols may only include unilateral hip measurements, and a misleading assessment of BMD status may result where disuse-related bone loss has not been equal bilaterally. Effective and relatively inexpensive pharmacological interventions are available to mitigate bone loss[18] and prophylactic treatment, without prior screening, may be indicated for high risk groups immediately following injury, particularly when additional risk factors for osteoporosis are present. A FRAX® calculation is helpful in this situation.[21]

This study combined a prospective observational design with a cross-sectional study to investigate the extent of bone loss at the proximal femur as a result of mechanical unloading following leg fracture in a post-menopausal population. Factors that contribute to both loss and recovery of bone mass and quality were also evaluated with the aim of identifying participants who may be at heightened hip fracture risk following a protracted period of disuse.

Materials and methodology

Participants

The study recruited postmenopausal women over the age of 45 years. The groups comprised 43 controls with no history of leg fracture after the age of 21 years, 9 participants (#<3wks) who sustained a leg fracture within the previous 3 weeks, and 24 participants (#>1yr) who had sustained a leg fracture more than one year previously, post menopause and within the previous ten years.

Exclusion criteria for the #<3wks and #>1yr groups were treatment by external fixation and immobilization <6 weeks. Participants already on treatment for low BMD were not excluded as it was statistically probable that a high proportion of the study population would be in the osteopenic or osteoporotic range at baseline and already receiving treatment. It was expected that some participants would be diagnosed with low BMD during the study and would commence treatment within the study period. It was felt important to keep the patients in the study as close as possible to those seen in clinical practice to ensure that the results are generalisable to the wider population.

Patients were recruited from the Emergency Department and Fracture Clinic at the Princess Elizabeth Orthopaedic Centre (PEOC) at the Royal Devon &Exeter (RD&E) Hospital.

The project was approved by the Devon and Torbay Research Ethics Committee REC Ref:09/H0202/64. All participants provided informed consent.

Method

The #<3wks participants attended at baseline (visit 1) and following intervals of six weeks (visit 2), six months (visit 3) and twelve months (visit 4). As no changes were expected in the control group at six weeks, this group only attended follow-up visits at six and twelve months. The #>1yr group attended at a single visit at their own convenience.

At visit 1 participants completed the following:

- Questionnaire providing participants' medical and lifestyle history relating to bone health.
- A visual pain scale (pain VAS) with score range from 0 (no pain) to 100 (intolerable pain). This included pain due to any cause not necessarily related to their fracture.
- The Lower Extremity Functional Scale (LEFS).[22] A maximum score of 80 represents full functionality in all domains.

Height was measured (±0.01 m) using a stadiometer (Seca, Germany). Total weight was measured (±0.1 kg) using weighing scales (Seca 877, Germany). Relative left/right weight-bearing through the legs was measured using two sets of identically calibrated weighing scales (Seca 877, Germany) using the method described by Hopkins et al[23] All participants underwent DXA (GE Lunar Prodigy, Bedford, MA) scans of bilateral hips and lumbar spine, in accordance with the manufacturer's protocols.

Three-day pedometer readings, in the week following their visit, were provided by participants.

For the controls and #<3wks groups, baseline procedures (excepting the medical history/lifestyle questionnaire) were repeated at follow-up visits. As no changes were expected in the lumbar spine for any participants these measurements were not deemed necessary at the 6 week visit.

Statistical analysis

Data were analysed using SPSS v. 22. Differences at baseline between each fracture group and controls were compared using the two-sample t test for normally distributed variables, Mann–Whitney U test for skewed continuous variables and the Chi-square Test for categorical variables. The change between baseline and follow-up visit was compared using the two-sample (independent groups) t test.

Left and right side DXA measurements were re-designated as ipsilateral and contralateral sides; the left side was designated as the ipsilateral side for the control group.

Results

Figs. 1–3 show baseline differences between groups and changes over 12 months in BMD at the NOF, TH and lumbar spine. The #>1yr BMD measurements were significantly lower ($p < 0.05$) for all regions compared to controls excepting the contralateral TH.

Baseline differences between groups

All participants were of Caucasian ethnicity. The results show that participant characteristics (Table 1) were well matched at the baseline visit. There were no significant differences between groups in their history of medical conditions relating to bone health. Participants were asked about their own history of fracture (excluding their current injury where applicable) sustained at any age and due to any cause; the results showed significant differences ($p < 0.015$) between the groups with a median of 1 previous fracture for the #<3wks and #>1yr groups compared to zero for the controls.

With regard to medications known to impact on bone health, either positively or negatively, Tables 1 and 2 show that the groups were well matched with the notable exception of significantly ($p < 0.05$) higher use of bisphosphonate treatments and prescribed calcium supplements and lower use of multivitamins in the #>1yr group.

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