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Hip fractures in the elderly: The role of cortical bone

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ABSTRACT

Introduction: Osteoporosis is characterised by poor bone quality arising from alterations to trabecular bone. However, recent studies have also described an important role of alterations to cortical bone in the physiopathology of osteoporosis. Although dual-energy X-ray absorptiometry (DXA) is a valid method to assess bone mineral density (BMD), real bone fragility in the presence of comorbidities cannot be evaluated with this method. The aim of this study was to evaluate if cortical thickness could be a good parameter to detect bone fragility in patients with hip fracture, independent of BMD.
Methods: A retrospective study was conducted on 100 patients with hip fragility fractures. Cortical index was calculated on fractured femur (femoral cortical index [FCI]) and, when possible, on proximal humerus (humeral cortical index [HCI]). All patients underwent densitometric evaluation by DXA.
Results: Average value of FCI was 0.43 and of HCI was 0.25. Low values of FCI were found in 21 patients with normal or osteopenic values of BMD, while low values of HCI were found in three patients with non-osteoporotic values of BMD.
Discussion and conclusion: Cortical thinning measured from X-Ray of the femur identifies 21% additional fracture cases over that identified by a T-score <-2.5 (57%). FCI could be a useful tool to evaluate bone fragility and to predict fracture risk even in patients with normal and osteopenic BMD.

1. Introduction

During the twentieth century, life expectancy rose dramatically amongst the world's wealthiest populations from around 50 years to over 75 years. This increase can be attributed to a number of factors, including improvements in public health, nutrition and medicine, which led to a decline in late-life mortality. Now, many major industrial countries are facing an ageing population. Italy is currently one of the countries with a higher percentage of elderly people in the general population. People aged at least 85 years are estimated to exceed 12% of the entire population by the year 2050 [1]. In this perspective, chronic and degenerative diseases – including osteoporosis and fragility fractures – pose enormous challenges for both individuals and societies in terms of quality of life and economic burden [2–5]. Actually, the World Health Organization considers osteoporosis to be one of the most critical health problems after cardiovascular disease [6]. In Italy, osteoporosis potentially affects 5,000,000 people, of which 80% are women of postmenopausal age. In particular, 1 out of 3 women and 1 out of 8 men in the over 50 s population are estimated to be affected by osteoporosis [7]. Osteoporosis is characterised by an impairment of both structural properties and bone quality, and predisposes the patient to an increased risk of fragility fracture, defined as "a fracture resulting from a low-energy trauma (such as a fall from a standing position) that would not damage a normal bone" or "a fracture caused by a fall from a height equal to or less than that of the patient" [8]. The skeletal sites that are most commonly affected by a fragility fracture are femoral neck, proximal humerus, vertebrae, wrist and ankle. Osteoporotic fractures, and particularly hip fractures, can lead to important consequences, such as hospitalisation followed by long periods of immobility, need for surgical treatment, increased disability and partial or complete loss of autonomy in daily activities; furthermore they result in significant 1-month and 1-year mortality (5–20%) [9]. It must then be considered that the presence of a fragility fracture leads to a high risk for a subsequent fracture with rates increasing from 2 to 5 times.

Bone mineral density (BMD) still represents the most important parameter to evaluate fracture risk caused by bone changes, in particular on trabecular bone, and dual-energy X-ray absorptiometry (DXA) is considered the gold standard method for its evaluation [10]. According to World Health Organization criteria, osteoporosis is defined as a BMD that lies 2.5 standard deviations

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or more below the average value for a young healthy women reference population (a T-score of <−2.5 SD) [11]. However, BMD now has a different role and it does not reflect the real fracture risk in many conditions. Several studies demonstrated that patients affected by some comorbidities, such as diabetes or hypertension, have a fracture risk that is independent of BMD. As described by an Italian group, a fragility fracture represents the major risk factor for a new fracture even more than a low BMD, particularly in patients affected by some comorbidities that influence cortical bone [12]. In fact, even though for decades the prevailing view was that trabecular bone loss is an important measure of fragility, about 70% of all bone lost during ageing is cortical. Bone biomechanics studies demonstrated that fractures of predominantly trabecular sites, such as vertebral and femur fractures, propagated from defects in cortical bone [13]. As trabecular bone is lost, the thin shell of cortical bone takes up the load. So, trabecular thinning and loss of connectedness of trabeculae, cortical thinning and porosity all play an important role in bone fragility. Recently, Zebaze studied cross-sectional areas using high-resolution peripheral CT to quantify and compare cortical and trabecular bone loss from the distal radius of adult females, and measured porosity using scanning electron microscopy [14]. He explored the occurrence of porosity in cortical bone and recognised that the mechanism was thinning cortex from the inside, particularly the intracortical remodelling upon Haversian canals traversing in the inner part of the cortex [15].

Cortical bone has a critical role in the axial load-bearing capacity of long bones; therefore, decreases in cortical density and cortical thickness, and increases in cortical porosity are considered surrogate markers for bone loss. The evaluation of cortical bone thus has an important role in assessing fracture risk and it is necessary to identify new instrumental methods that establish loss of competence in the condition in cases where BMD is not reliable.

Several authors have proposed that changes in plain radiographs could be used to predict bone quality in the proximal femur [16]. The cortical index is one of the indices for measurement of morphological changes in the proximal femur in the anteroposterior (AP) radiograph: this enables the study of cortical architectural characteristics, and could reflect morphological changes associated with osteoporosis [17]. Femoral cortical index (FCI) can be calculated using the ratio between the thickness of the cortical bone and the diameter of the femoral shaft 10 cm distal to the centre of the small trochanter in an AP view X-Ray of the femur (Fig. 1) [18]. It is possible to evaluate the cortical index in other bones like wrist, tibia and proximal humerus, using similar methods.

The aim of this study was to evaluate if the cortical index could be a good technique to detect bone fragility in patients with hip fracture.

2. Materials and methods

A total of 156 surgical procedures for hip fracture were performed in our hospital, Policlinico Tor Vergata, from January 2014 to September 2015. A retrospective study was conducted on 100 consecutive patients (13 male, 87 female) with hip fracture. The average age of patients was 80.1 years (range 60–106 years).

Inclusion criteria were a fragility fracture of the femur, absence of primary and secondary tumour lesions and the ability to walk before falling. Fifty-one of the patients showed medial fractures, treated with hip prosthesis, and 49 patients showed lateral fractures, treated with reduction and fixation with intramedullary nail. Radiographic measurements were performed on fractured femur in the pelvis anteroposterior (AP) view of routine clinical digitalised radiographs executed in the Emergency Department. Patients were excluded if they had a disease affecting cortical bone on the level of the measurement, such as dysplasia, Perthes disease, epiphysiolysis, or consequences of previous fractures. Also excluded were patients with neurological diseases that could impair deambulation or functionality of the lower limbs. The diameter of the shaft (x) and the internal diameter of the medullar canal (y) were measured 10 cm distal from the centre of the small trochanter, using image processing software (Carestream Solutions Version 11.0) (Fig. 1). The FCI was calculated using the following formula: FCI = (x–y)/x. The average of two measurements made by two different investigators was calculated in fractured femur.

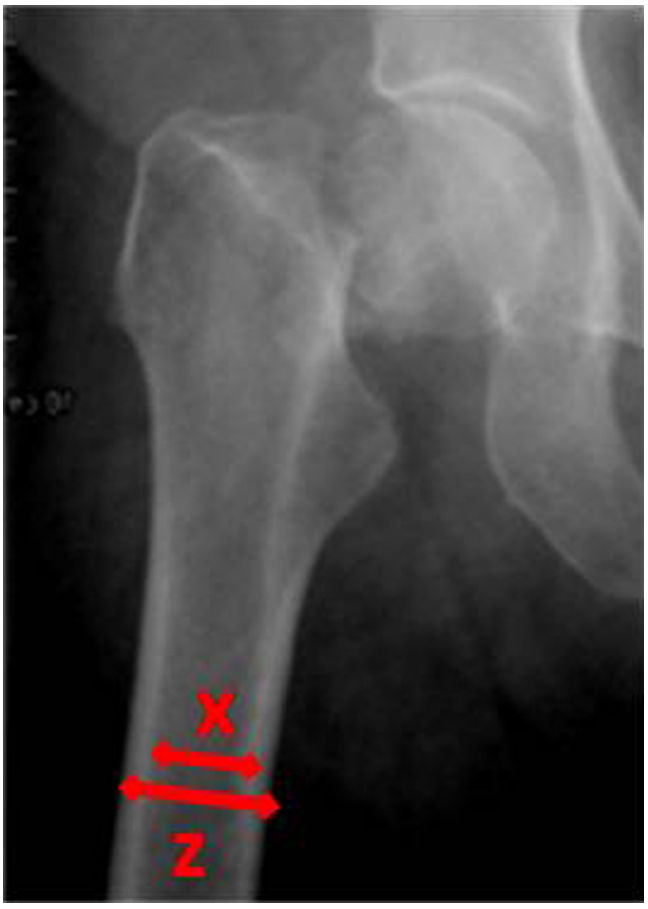

Fig. 1. Femoral cortical index (FCI) is calculated using the ratio between the thickness of the cortical bone and the diameter of the femoral shaft 10 cm distal to the centre of the small trochanter in an anteroposterior (AP) view X-Ray of the pelvis performed in the Emergency Department, on fractured femur. The diameter of the shaft (x) and the internal diameter of the medullar canal (y) 10 cm distal to the centre of the small trochanter were measured using image processing software. The FCI was calculated using the following formula: FCI = (x–y)/x.

In a sub-study, the cortical index of the proximal humerus was evaluated in a group of patients whose routine preoperative chest X-ray included almost the upper third of the humerus. The humeral cortical index (HCI) was calculated 10 cm distal to the greater tuberosity, using the ratio between the thickness of the cortical bone and the diameter of the humeral shaft (Fig. 2).

For all 100 patients, lumbar spine and non-fractured femur BMD were also evaluated a few days after surgery using iDXA (Lunar, GE Healthcare, Diegem, Belgium). DXA examination was performed to estimate a condition of osteoporosis, according to WHO criteria; lumbar spine (L1–L4) and femoral (neck and total) scans were performed [19].

Patients were discharged with adequate anti-osteoporotic therapy and integration of calcium and vitamin D, regardless of the results of DXA examination and cortical index, because the presence of proximal femur fracture following low-energy trauma

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