New Ultrasound-Based Methods for Early Osteoporosis Diagnosis and Fracture Risk Estimation

Sergio Casciaro, National Research Council, Institute of Clinical Physiology, Lecce, Italy
Maria Daniela Renna, National Research Council, Institute of Clinical Physiology, Lecce, Italy
Paola Pisani, National Research Council, Institute of Clinical Physiology, Lecce, Italy
Antonio Greco, Echolight S.r.l., Lecce, Italy
Francesco Conversano, National Research Council, Institute of Clinical Physiology, Lecce, Italy
Maurizio Muratore, O.U. of Rheumatology, “Galateo” Hospital, San Cesario di Lecce, ASL-LE, Lecce, Italy

ABSTRACT

Osteoporosis is the most common disorder of bone metabolism. The main consequence of this disease is the increased risk of fracture. Osteoporotic fractures represent a serious problem in terms of social and economic costs. Then, there is a strong need for the assessment of the best practices in prevention and treatment of osteoporosis. Dual X-ray absorptiometry (DXA) represents the current “gold standard” method for osteoporosis diagnosis. However, DXA cannot be employed for population mass screenings, because of required exposition to ionizing radiation and high management costs. The aim of this paper was to review the currently available techniques for osteoporosis diagnosis and also to illustrate the feasibility of an innovative quick, cheap and non-invasive ultrasound-based methodology. The results recently published by the authors’ research group suggest that the proposed approach has the potential for routine application in early diagnosis, which is the key to resize the impact of osteoporosis on healthcare systems.

Keywords: Early Osteoporosis Diagnosis, Fracture Risk Estimation, Healthcare Costs, Ultrasound

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INTRODUCTION

Osteoporosis is a widespread systemic disease that causes a reduction in both structure quality and mineral density of bones, consequently increasing fracture risk. Vertebral and hip fractures represent one of the most important causes of morbidity and disability in the elderly population and also cause elevated economic costs for the National Healthcare Systems.

In this context, ever new findings are emerging to assess the risk of osteoporotic fractures. In clinical practice, osteoporosis diagnosis is based on the measurement of bone mineral density (BMD) (WHO, 1994). BMD is expressed in terms of T-score, which is defined as the number of standard deviations (SDs) between the BMD of the examined patient being and the mean BMD of a standard young adult population (20–30 years of age), representing the physiologic peak of bone mass. According to the World Health Organization (WHO) guidelines, patient diagnosis is directly established on the basis of T-score value as normal (T-score ≥ −1.0), osteopenia (−2.5 < T-score < −1.0), osteoporosis (T-score ≤ −2.5), or severe osteoporosis (T-score ≤ −2.5 with presence of a previous fragility fracture) (Lindsay et al., 2001). BMD is generally estimated by X-ray based techniques, which imply ionizing radiation exposure and high management costs. Presently, there are no satisfactory clinical tools available to evaluate bone quality independently of bone density, apart from computed tomography (CT), whose economic costs and radiation exposure levels are definitely not suitable for a routine employment.

This paper, after an excursus on epidemiology and social impact of osteoporosis, gives an overview of the most widely used X-ray based techniques to perform osteoporosis diagnosis and describes the working principles of non-invasive ultrasound (US) methods for bone densitometry, underlining the corresponding advantages and limitations for their use in the clinical practice. Moreover, the present article describes a new US technique, directly applicable on the main anatomical reference sites (i.e., lumbar vertebrae and proximal femur). Promising results regarding clinical feasibility and diagnostic accuracy of this innovative methodology have been recently published by our research group (Conversano et al., 2015). In a context in which osteoporosis prevention is the last hope to significantly reduce the corresponding burden on healthcare systems, this paper summarizes the findings of our research, illustrating the effectiveness of the new US method not only in terms of diagnostic accuracy, but also in terms of fracture risk prediction. The ultimate goal is to encourage the early diagnosis of osteoporosis by the use of quick, cheap and non-invasive screening techniques.

EPIDEMIOLOGY IN ITALY AND IN THE WORLD

Osteoporosis has a significant impact on public health through the increased rates of morbidity, mortality and economic costs associated with bone fractures. The frequency of osteoporotic fractures is in fact rising in many countries. In 1990, there were an estimated 1.7 million hip fractures worldwide (Cooper et al., 1992) and by 2050 they could exceed 21 million (Cummings and Melton, 2002; Johnell and Kanis, 2006). This is in particular due to the increased longevity of the population and the consequently higher prevalence of chronic diseases, including osteoporosis and the complications due to related fragility fractures.

In Italy, since 1950, life expectancy at birth has increased by 4 months per year and, currently, is 77.9 years for men and 84.4 years for women (Istat, 2013). People over 65 years of age represent more than 20% of Italian population, and this demographic trend is also increasing. Then, one in five women and one in seven men are over 65 years of age. Among these, octogenarians are 5% and will exceed 11% in 2045 (Istat, 2013). Nowadays, in our country there are 137.7 people aged over 65 for every 100 young people under 15 years of age, with some differences between the North (157.9), Center (160.7) and South (106.6) (Istat, 2013).
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