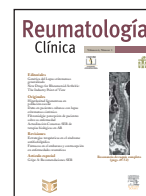


# Reumatología Clínica

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## Editorial

### Direct measurement of bone mechanical strength

#### La medición directa de la resistencia mecánica ósea

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Osteoporosis has been defined as a decrease in bone strength. Under this term we include bone quantity and quality.<sup>1</sup> Bone quantity (mineral content) is measured with widely extended densitometry. Densitometry gives a good estimate of fracture risk and is helpful in monitoring patients.<sup>2</sup> However, an important part of bone strength is not explained by this measurement. We also know that the greatest proportion of fractures due to weakness are produced in people with osteopenia.<sup>3</sup> Finally, changes in bone density only partially reflect the decrease in risk fracture produced by treatments.

All this has developed the concept of bone quality and stimulated the search for bone quality markers that will complement densitometry to better characterise strength. The problem is that a great number of determinations require a bone biopsy or the use of bone explants obtained during surgery. This means that it is impossible to use these elements in daily clinical practice. Only a few imaging techniques have been able to analyse bone strength components beyond density. Finite element analysis carried out on x-ray images, DEXA scans or more commonly on computerised tomography<sup>4</sup> is probably the most developed technique with potential clinical use. This analysis provides information on the changes in the macroscopic and microscopic architecture and mineralisation, and calculates theoretical resistance to fracture. However, algorithms employed involve assumptions about the intrinsic properties of the bone tissue unit, which cannot differentiate between different tissues with different mechanical quality.<sup>5</sup>

Clinicians had only a direct bone strength estimator when fractures were produced. Therefore, direct *in vivo* bone strength measurement through a feasible technique, which is acceptable to the patient but also sensitive and precise, continues being a field to explore. In a joint development with the Physics Department of the University of California in Santa Barbara (U.S.) and our research unit, we have developed an instrument that is able to directly analyse

the mechanical competence of several tissues.<sup>6</sup> The application that has advanced the most is one that is centred on direct analysis of bone mechanical strength measured on the tibia of the subjects. This technique is based on a microindentation made on the anterior surface of the middle third of the tibia.

In the bone microindentation validation study, we studied the capacity of the technique to discriminate between individuals with a fracture and the controls.<sup>7</sup> The variability of measurements was limited and the sample size reduced; this allowed both groups to be separated considerably better than with bone densitometry, with some areas under the curve higher than 0.9. Therefore, microindentation allows us to directly estimate the resistance to fracture by measuring distances that the microindenter is able to penetrate, fundamentally the total indentation distance and the increase in the indentation distance. All this corroborates previous bone studies with laboratory animals and corpses.<sup>8</sup>

How is the technique explained? Bone fracture starts by a microscopic breakage at tissue level, whose intimate mechanism is the separation of the mineralised collagen fibril bundles.<sup>8</sup> The crack starts with this and it spreads and progresses into a macroscopic fracture, as the force that is capable of absorbing the structure is exceeded. And this is what happens in microindentation. The indenter opens cracks, separating the mineralised collagen bundles, in the same way as when fractures are produced. In other words, microindentation produces microscopic fractures and is able very accurately gauge the force that has to be applied to produce it. That is, it directly measures bone propensity to fracture.

The technique is simple, quick and harmless. The depth of the indentation is a maximum of 200  $\mu\text{m}$ , which gives an idea of how inconsequential it is. We apply a local anaesthesia beforehand, so it is totally painless. It is carried out at an ordinary consultation and the total time for it to be accomplished is no more than 10 minutes. We are

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working on extending trials to other populations and clinical situations, on applying it to laboratory animals and simplifying the microindenter to make it completely accessible to any health professional and applicable to daily routines. If we achieve this, we will have a direct bone strength estimator with extraordinary potential.

### Conflict of interest

The authors declare no conflict of interest.

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