

Quantitative magnetic resonance imaging of the calcaneus in patients with osteogenesis imperfecta

G. Guglielmi^{1,2}, R. Toffanin³, G. Miscio¹, R. Lamanna⁴, A. Accardo⁵, C. Battista⁶, A. Scillitani⁶

¹Dept. of Radiology, "Casa Sollievo della Sofferenza", IRCCS, San Giovanni Rotondo, Italy;

²Dept. of Radiology, University of Foggia, Foggia, Italy; ³ARCHES, Castellana Grotte, Italy;

⁴UTS BIOTEC-AGRO, CR-ENEA Trisaia, Rotondella, Italy; ⁵DEEI, University of Trieste, Trieste, Italy;

⁶Unit of Endocrinology, "Casa Sollievo della Sofferenza", IRCCS, San Giovanni Rotondo, Italy

AIM: to evaluate the ability of quantitative magnetic resonance imaging (MRI) of the calcaneus to assess bone quality in patients affected by osteogenesis imperfecta (OI), a group of closely related inherited diseases characterized by abnormal bone fragility.

INTRODUCTION: Several studies have demonstrated that the effective transverse relaxation (T_2^*) depends on trabecular bone density [1,2] such that T_2^* should be shorter in normal trabecular bone than in the less dense trabecular network of osteoporotic tissue. T_2^* also has been found to reflect the trabeculae's orientation and correlate with biomechanical strength [3-5]. Therefore, together with trabecular bone volume fraction (BVF) T_2^* is another important parameter that can be measured by MRI to obtain information about bone quality.

MATERIALS AND METHODS: the apparent transverse relaxation time (T_2^*) was measured in 12 subjects (7 men and 5 women; mean age 32.1 +/- 17.1 years) affected by mild OI, types I and IV, with varying degrees of spinal bone mineral density (BMD). Five subjects had osteoporotic vertebral fractures as assessed by radiographs of the thoracolumbar spine. MRI of both feet was performed on a 3T whole-body scanner using a fast gradient-echo technique. Fifteen sagittal images with echo times ranging from 3.1 ms to 14 ms were acquired for each calcaneus. T_2^* values were estimated in the superior, anterior and posterior regions of the calcaneus following anatomic landmarks (Figure 1). BMD was determined at the lumbar spine (L1-L4) and total femoral neck by DXA. High-resolution magic angle spinning (HR-MAS) NMR spectroscopy of urine samples was performed to analyze the metabolic profiles of all subjects investigated.

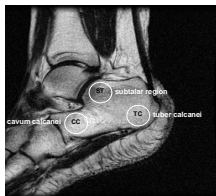


Figure 1. T_2^* calculation in selected regions of interests (ROIs).

RESULTS AND DISCUSSION: Calcaneal T_2^* values showed regional variations being typically shortest in the superior region of the calcaneus (Table 1). A significant increase ($p < 0.05$) in T_2^* values was found in 4 OI patients (1 with vertebral fractures), especially in the anterior and posterior regions of both calcanea (Fig. 1). For these subjects, R_2^* ($1/T_2^*$) showed a significant positive correlation with BMD at the lumbar spine ($r = 0.62$; $p < 0.05$). A higher correlation with BMD was observed for two of these patients (3 and 4) characterized by an atypical metabolic profile.

Table 1. Increased T_2^* values (ms) observed in four OI patients. T_2^* were measured in three different ROIs of the calcaneus, i.e. *cavum calcanei* (CC), *tuber calcanei* (TC) subtalar region (ST); BMD was determined at the lumbar spine (L1-L4) and the hip.

N.	Sex	Age	Z-score spine	Z-score hip	Fracture	T_2^* CC-R	T_2^* TC-R	T_2^* ST-R	T_2^* CC-L	T_2^* TC-L	T_2^* ST-L
2	M	53	-3.0	-2.6	T7-L4	9.4	7.0	6.4	7.6	6.1	7.5
3	F	26	-4.2	-2.6	-	9.7	8.2	8.6	9.4	6.5	7.9
4	F	26	-3.7	-2.3	-	11.0	9.5	9.0	9.5	8.1	8.8
6	M	55	-1.0	0.4	-	15.1	10.3	8.1	12.1	8.4	6.7

R: right calcaneus; L: left calcaneus

CONCLUSION: This MRI study at 3.0 Tesla shows that T_2^* of the calcaneus is sensitive to alterations in bone quality and appears potentially useful for a better radiological typing of this disease.

REFERENCES

1. Davis C.A. *et al.*, *Invest. Radiol.* 21: 472 (1986).
2. Rosenthal H. *et al.*, *Invest. Radiol.* 25: 173 (1990).
3. Chung H. *et al.*, *Proc. Natl. Acad. Sci USA* 90: 10250 (1993).
4. Yablonskiy D.A. *et al.*, *Magn. Reson. Med.* 37: 214 (1996).
5. Jergas M.D. *et al.*, *J. Comput. Assist. Tomogr.* 19: 472 (1995).

ACKNOWLEDGEMENTS: Grants from the Italian Ministry of Health (Ricerca Corrente 2007 and 2008).