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● *Clinical Note*

FEASIBILITY OF ULTRASOUND IMAGING OF OSTEOCHONDRAL DEFECTS IN THE ANKLE: A CLINICAL PILOT STUDY

A. C. Kok,* M. P. Terra,† S. Muller,‡ C. Askeland,‡ C. N. van Dijk,* G. M. M. J. Kerkhoffs,* and G. J. M. Tuijthof*§

*Department of Orthopedic Surgery, Orthopedic Research Center Amsterdam, Academic Medical Center Amsterdam, Amsterdam, The Netherlands; †Department of Radiology, Academic Medical Center Amsterdam, Amsterdam, The Netherlands; ‡SINTEF Medical Technology, Trondheim, Norway; and §Department of BioMechanical Engineering, Faculty of 3 ME, Delft University of Technology, Delft, The Netherlands

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Abstract—Talar osteochondral defects (OCDs) are imaged using magnetic resonance imaging (MRI) or computed tomography (CT). For extensive follow-up, ultrasound might be a fast, non-invasive alternative that images both bone and cartilage. In this study the potential of ultrasound, as compared with CT, in the imaging and grading of OCDs is explored. On the basis of prior CT scans, nine ankles of patients without OCDs and nine ankles of patients with anterocentral OCDs were selected and classified using the Loomer CT classification. A blinded expert skeletal radiologist imaged all ankles with ultrasound and recorded the presence of OCDs. Similarly to CT, ultrasound revealed typical morphologic OCD features, for example, cortex irregularities and loose fragments. Cartilage disruptions, Loomer grades IV (displaced fragment) and V (cyst with fibrous roof), were visible as well. This study encourages further research on the use of ultrasound as a follow-up imaging modality for OCDs located anteriorly or centrally on the talar dome. (E-mail: A.kok@amc.uva.nl) © **2014 World Federation for Ultrasound in Medicine & Biology.**

Key Words: **Ultrasound, Osteochondral defects, Talus, Ankle, Computed tomography.**

INTRODUCTION

The ankle is the secondmost predominant joint vulnerable to osteochondral defects (OCDs), exceeded only by the knee in prevalence (Saxena and Eakin 2007). Compared with defects seen in the knee, talar OCDs are usually smaller and more commonly involve bone (Gobbi et al. 2006; Magnussen et al. 2008). In general, OCDs have poor intrinsic healing potential because of the lack of vascularization of the cartilage, which leads to early development of osteoarthritis (Elias et al. 2006; Saltzman et al. 2005).

Although there has been substantial research on cartilage regeneration *in vitro* (Fortier et al. 2011; Hildner et al. 2011; Spiller et al. 2011), few studies have investigated cartilage tissue regeneration *in vivo*. Longitudinal monitoring of patients with OCDs at short intervals could contribute to this knowledge and assist in the formulation of patient-specific treatment algorithms.

Address correspondence to: A. C. Kok, Orthopedic Research Center Amsterdam, Academic Medical Center, G4-262 Meibergdreef 9, 1105 AZ Amsterdam, The Netherlands. E-mail: A.kok@amc.uva.nl

The diagnostic techniques currently used for localization, sizing, grading and follow-up of OCDs are computed tomography (CT) (Moojen et al. 2002; O'Loughlin et al. 2010), magnetic resonance imaging (MRI) (Domayer et al. 2008; Hayter and Potter 2011) and arthroscopy (Hangody et al. 2001; Lee et al. 2009). The suitability of these modalities for longitudinal follow-up varies, because of either the ionizing load (CT), the lengthy acquisition times (MRI) or the invasive nature of the procedure (intra-articular contrast is required to image cartilage with CT and arthroscopy).

Although ultrasound (US) has not been the preferred imaging modality for diagnosis of OCDs, its inherent characteristics qualify it for longitudinal monitoring. It is a non-invasive, cost-effective, fast and easily accessible technique in both experimental and clinical settings (Spannow et al. 2009). Recent studies have reported the ability of ultrasound to image abnormalities involving cartilage and the bony cortex in early- and late-stage rheumatoid arthritis (Blackburn et al. 1996; Castriota-Scanderbeg et al. 1996; Grassi et al. 1999; Hodler and Resnick 1996; Iagnocco et al. 2010; Keen and Conaghan 2009). Also, *in vitro* and *in vivo* US studies

have been performed to determine structural bone quality, osteoporosis and nasal fractures (Ardeshirpour et al. 2013; Halaba et al. 2006; Lee 2013).

The visibility of talar OCDs within reach of ultrasound is dictated by the over-projection of the tibia. Previous research on the suitability of lesions for anterior ankle arthroscopy has indicated that lesions in the posterior half of the talus do not appear in plantar flexion (van Bergen et al. 2012). Therefore, only anterior and central lesions are within the scope of ultrasound examination, representing 70%–90% of all OCDs in the ankle (Choi et al. 2009; Elias et al. 2007; Loomer et al. 1993; Saxena and Eakin 2007).

The goal of our study was to determine the feasibility of ultrasound for the visualization and grading of talar OCDs. To our knowledge, this is the first study to investigate the feasibility of using ultrasound to image OCDs in a clinical setting and to image a group representative of patients with talar OCDs.

METHODS

This study was approved by the medical ethics committee of the Academic Medical Centre (METC 2011_276). Eighteen patients were included. General inclusion criteria were: age ≥18, single-ankle pathology without surgical treatment for OCDs and a CT scan of the ankle joint in the preceding 2 y. For each patient, we had a CT scan acquired either in full plantar flexion or in a neutral position. Nine patients were included with an osteochondral defect in the anterior or central zone, expected to be visualized using ultrasound. This was either determined by protrusion of the defect from beneath the tibia either in the full plantar flexion CT scan or in the neutral position CT scan using the guideline that the anterior 50% of the talar dome will protrude from beneath the tibia in full plantar flexion (van Bergen et al. 2012). Nine additional patients who did not have an OCD in the anterior talar dome served as negative controls. After receipt of a signed informed consent, the patient underwent a short physical examination to measure the degree of ankle flexion and to determine whether there were visible signs of ankle pathology, such as swelling and scars. The patient was instructed to fully plantar flex the ankle by placing the foot on the examination bench and moving backward while keeping the sole of the foot on the bench. The maximum degree of plantar flexion was measured and recorded using a goniometer. Patients were instructed not to discuss any specifics concerning their complaints or disease.

Computed tomography protocol

Computed tomography scans were acquired during regular clinical assessment of ankle complaints according to the clinical protocol of our institution (Table 1) with a Philips MX8000 Multidetector scanner (Philips Medical Systems Eindhoven, The Netherlands). Presence or absence of an OCD was determined by different clinical radiologists unaware of the study, as part of routine clinical care. The defects were scored according to the classification of Loomer et al. (1993). This is a validated classification that uses bony aspects of a lesion to divide it into one of five grades: sub-chondral compression (grade I), partial osteochondral fracture (grade II), un-displaced complete osteochondral fracture (grade III), complete fracture with a displaced fragment (grade IV) and radiolucent defect with an intact roof (grade V). To estimate the location of the defect, the talus was divided into three equal zones: medial, central and lateral (Elias et al. 2007).

Ultrasound protocol

After ensuring the ankle was in full plantar flexion and a neutral in-eversion position, an experienced musculoskeletal radiologist (M.T.) performed the ultrasound investigation using an iU22 xMatrix scanner (Philips Medical Systems) with a 17- to 5-MHz broadband linear array transducer (Philips Medical Systems) (Table 1).

The presence or absence of an OCD was recorded based on the 2-D US images during the examination. Relevant US images were stored on digital video to allow comparison with the CT images. On detection, OCDs were localized and classified as osteochondral or chondral. In our study, chondral lesions at ultrasonography were defined as having a poorly visualized and blurred outer border of the cartilage, loss of cartilage transparency and/or increased echogenicity reflecting structural modification (Fig. 1, II). An osteochondral lesion was defined as a chondral lesion with subchondral flattening and/or disruption of the subchondral margin (Fig. 1,

Table 1. Ultrasound and computed tomography settings*

Ultrasound		Computed tomography	
Parameter	Setting	Parameter	Setting
Frequency	17 MHz	Gantry tilt (°)	0
Depth	3.0 cm	Field of view (mm)	120
Gain	49%	Slice thickness (mm)	0.6
Frame rate	High	Increment (mm/rotation)	0.3
Frames per second	30	Image matrix (row × column, isotrope volume)	512 × 512
Dynamic range	70 dB	Pitch	1.400
Persistence	2	Rotation time	1 s
Clarity	High	Resolution	High
		Radiation dose	160 mAs/slice
		Reconstruction filter setting	E

* For the investigations, an iU22 xMatrix ultrasound scanner with a 17- to 5-MHz broadband linear array transducer and a MX8000 Multidetector computed tomography scanner were used (all Philips Medical Systems Eindhoven, The Netherlands).