European Journal of Radiology 84 (2015) 1159–1164

Contents lists available at ScienceDirect

European Journal of Radiology

journal homepage: www.elsevier.com/locate/ejrad

Can 3D ultrasound identify trochlea dysplasia in newborns? Evaluation and applicability of a technique

Hendrik Kohlhof[a,1], Christoph Heidt[b,*], Alexandrine Bähler[c,2], Sandro Kohl[d,3], Sascha Gravius[a,1], Max J. Friedrich[a,1], Kai Ziebarth[d,3], Enno Stranzinger[c,2]

[a] Clinic for Orthopedics and Trauma Surgery, University Hospital Bonn, Sigmund-Freud-Str. 25, 53127 Bonn, Germany
[b] Department of Orthopedic Surgery, University Children's Hospital Zurich, Steinwiesstrasse 74, 8032 Switzerland
[c] Department of Pediatric Radiology, University Children's Hospital Berne, Freiburgstrasse 18, 3010 Berne, Switzerland
[d] Department of Orthopedic Surgery, University Hospital Berne, Freiburgstrasse 18, 3010 Berne, Switzerland

ARTICLE INFO

Article history:
Received 5 January 2015
Received in revised form 4 March 2015
Accepted 11 March 2015

Keywords:
Trochlea dysplasia
Ultrasound
Screening
Children
Patellar instability

ABSTRACT

Femoro-patellar dysplasia is considered as a significant risk factor of patellar instability. Different studies suggest that the shape of the trochlea is already developed in early childhood. Therefore early identification of a dysplastic configuration might be relevant information for the treating physician. An easy applicable routine screening of the trochlea is yet not available. The purpose of this study was to establish and evaluate a screening method for femoro-patellar dysplasia using 3D ultrasound. From 2012 to 2013 we prospectively imaged 160 consecutive femoro-patellar joints in 80 newborns from the 36th to 61st gestational week that underwent a routine hip sonography (Graf). All ultrasounds were performed by a pediatric radiologist with only minimal additional time to the routine hip ultrasound. In 30° flexion of the knee, axial, coronal, and sagittal reformats were used to standardize a reconstructed axial plane through the femoral condyle and the mid-patella. The sulcus angle, the lateral-to-medial facet ratio of the trochlea and the shape of the patella (Wiberg Classification) were evaluated. In all examinations reconstruction of the standardized axial plane was achieved, the mean trochlea angle was 149.1° (SD 4.9°), the lateral-to-medial facet ratio of the trochlea ratio was 1.3 (SD 0.22), and a Wiberg type I patella was found in 95% of the newborn. No statistical difference was detected between boys and girls. Using standardized reconstructions of the axial plane allows measurements to be made with lower operator dependency and higher accuracy in a short time. Therefore 3D ultrasound is an easy applicable and powerful tool to identify trochlea dysplasia in newborns and might be used for screening for trochlea dysplasia.

1. Introduction

The early identification of deformities and anatomical abnormalities is important information for clinicians to give advice to the parents, organize follow-up or to initiate treatment, all in the effort to prevent future problems and subsequent irreversible damage. Especially in pediatric orthopedics due to the partially guidable growth of the bone and the rapid development of technical orthotics more and more treatment methods become available. One of the screening techniques that had a notable impact on the natural history of a developmental abnormality was the ultrasound screening of the hip developed by Graf [1]. Today, techniques have further improved but modern screening techniques necessitate being quick, cost-effective, safe, and easily applicable.

Femoro-trochlea dysplasia is known to be one of the most important predisposing factors for the development of femoro-patellar instability in children and adults [2]. Instability of the patella with recurrent dislocations results in high patient morbidity and serves as a risk factor for osteo-arthritis [3]. Flattening of the lateral femoral condyle and enlargement of the bony sulcus angle more than 145° predispose to relocation of the patella [3]. In 1950, Gray and Gardener described the surface morphology of the knee which had already been determined very early in utero [4]. These findings were supported by studies on deceased fetuses

* Corresponding author. Tel.: +41 44 266 75 35; fax: +41 44 266 78 16.
E-mail addresses: Hendrik.Kohlhof@ukb.uni-bonn.de (H. Kohlhof), Christoph.heidt@kispi.uzh.ch (C. Heidt), Alexandrine.baehler@insel.ch (A. Bähler), sandro.kohl@insel.ch (S. Kohl), sascha.gravius@ukb.uni-bonn.de (S. Gravius), Max.Friedrich@ukb.uni-bonn.de (M.J. Friedrich), kai.ziebarth@insel.ch (K. Ziebarth), Enno.Stranzinger@insel.ch (E. Stranzinger).
[1] Tel.: +49 228 287 14170; fax: +49 228 287 14175.
[2] Tel.: +41 31 632 95 01; fax: +41 31 632 96 64.
[3] Tel.: +41 31 632 31 04; fax: +41 31 632 3600.

http://dx.doi.org/10.1016/j.ejrad.2015.03.015
0720-048X/

[5]. Therefore early identification of trochlea dysplasia might be useful to prevent the sequel of patellar instability. In newborns neither radiographs, nor MRI is an optimal imaging modality. Most bony structures are not ossified yet so the definitive form of the femoro-patellar joint is not visible on radiographs. The limitations of MRI for screening purposes in newborns are availability, costs, and need of sedation. Ultrasound allows identification of multiple structures: cartilage, muscles, ligaments and their attachments, and the bone [6,7]. It is a safe and quick image modality. However, quality and interpretation of the images is an issue and the technique is user dependent. First experiences with an ultrasound using a 3-dimensional system (3D) for screening of hip dysplasia showed a faster and simpler determination of a standard plane [8].

The aim of this study was to establish and evaluate the applicability of a 3D ultrasound screening method for early detection of femoro-patellar dysplasia in newborns, which is reliable, quick, and easy applicable.

2. Materials and methods

The study was approved by the Ethics Commission of the University Children's Hospital and the Cantonal Ethics Committee. Prospectively all healthy term born babies with no known other syndromes, who were planned for the regular hip-screening ultrasound were included in the study. Hip screening ultrasounds are an established examination at our center. All children at six weeks of age undergo clinical examination of the hip and hip ultrasound. Informed consent was taken prior to the examination. All ultrasounds were performed with two identical Siemens S3000™ ultrasound systems (Siemens, Erlangen, Germany). Depending on the child's size either a 14 MHz- or 9 MHz-linear transducer were used.

2.1. Technique description

For measurements an axial ultrasound image was generated using a 3D-volumetric dataset of the femoro-patellar articulation in 30° flexion of the knee. Initially the knee was held by the pediatric radiologist who performed the ultrasound, then the knee was positioned on a wedge-formed foam plastic pillow. The degree of flexion was verified using a goniometer. The 3D volumetric dataset started from the distal femur metaphysis to the tibia tuberosity. Axial, sagittal, and coronal reconstructions were used to determine a standardized axial plane of the femoral trochlea and patella. The axial plane of the femoro-patellar articulation was planned through the femoral epiphysis ossification nucleus. The patella shape was planned on a sagittal plane through the mid patella (Fig. 1). On this standardized axial plane the sulcus angle, the lateral-to-medial facet ratio of the trochlea and the shape of the patella (Wiberg Classification, Table 1) [9] were evaluated (Fig. 2).

Table 1
Wiberg Classification of the patella.

Type I	Type II	Type III
Roughly symmetrical, concave and equally sized facets	Slightly smaller size of medial facet Concave aspect of lateral facet	Markedly smaller size of medial facet More vertical orientation of medial facet

The statistical calculations were performed using SPSS® 21 (IBM, Armonk, NY, USA). All data were analyzed for normal distribution by QQ diagram and Shapiro–Wilk-test.

3. Results

In total 80 babies (50 boys and 30 girls) from the 36th to 61st gestational week received the additional ultrasound examination of both knees. One hundred and sixty femoro-patellar articulations were analyzed. An initial learning curve was observed but the additional time to the normal hip ultrasound examination was about 1–2 min. All newborn tolerated the procedure without any noticeable discomfort, no sedation used or needed in any of the cases. The best results of image acquisition were observed after breast or bottle feeding. All 3D datasets of the knee were diagnostic and

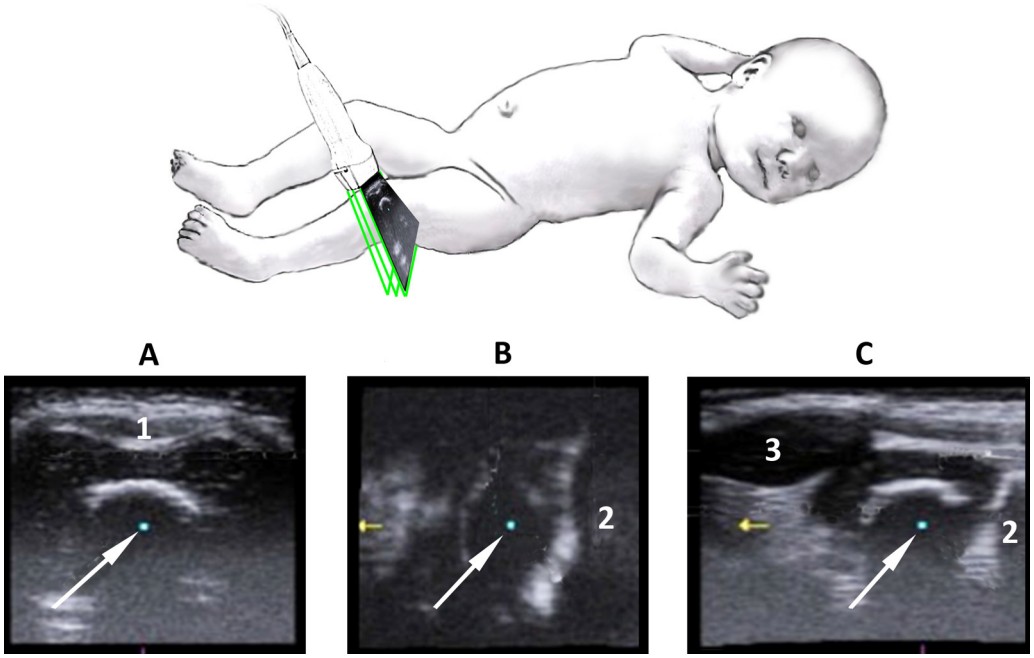

Fig. 1. Generating the axial view in 30° flexion. Axial (A), coronal plane (B), and sagittal (C) of the 3D dataset used for the reconstruction of a standardized axial plane through the center of the femoral epiphysis ossification center (arrow). Trochlea sulcus (1), femoral metaphysis (2), and patella (3). Yellow arrow indicates caudal.