

# Dynamic ultrasound investigation of clubfeet in children, 0-4 years of age, with normal controls

## Akademisk avhandling

Som för avläggande av medicine doktorsexamen vid Sahlgrenska akademien, Göteborgs universitet kommer att offentligen försvaras i R-aulan, Sahlgrenska Universitetssjukhuset, Mölndal, torsdag den 29 oktober 2020, klockan 13.00

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## Avhandlingen baseras på följande delarbeten

- I. Aurell, Y., A. Johansson, G. Hansson, H. Wallander and K. Jonsson, *Ultrasound anatomy in the normal neonatal and infant foot: an anatomic introduction to ultrasound assessment of foot deformities*. Eur Radiol, 2002. **12**(9): p. 2306-2312.
- II. Johansson, A., Y. Aurell, and B. Romanus, *Assessment of the ankle joint in clubfeet and normal feet to the age of four years by ultrasonography*. J Child Orthop, 2018. **12**(3): p. 262-272.
- III. Johansson, A., Y. Aurell, and B. Romanus, *Range of motion in the talo-navicular and the calcaneo-cuboid joints evaluated by ultrasound during clubfoot treatment with normal references up to the age of four years*. J Child Orthop, 2018. **12**(5): p. 526-538.
- IV. Johansson, A., Y. Aurell, and B. Romanus, *A prospective longitudinal study, with dynamic ultrasound and clinical examinations, during the first 4 years of life of children with clubfoot treated according to Ponseti, and of feet in a control group. The medical reports of all the children with clubfoot were reviewed up to the age of 8 years.*

Submitted

**SAHLGRENKA AKADEMIN  
INSTITUTIONEN FÖR KLINISKA VETENSKAPER**



# DYNAMIC ULTRASOUND INVESTIGATION OF CLUBFEET IN CHILDREN, 0-4 YEARS OF AGE, WITH NORMAL CONTROLS

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## Abstract

Clubfoot is one of the most common congenital deformities, 1-6/1,000 births in Europe and up to 5-6/1,000 in Polynesia. The Ponseti method is now widely regarded as the method of choice for treatment. The treatment starts soon after birth using manipulations and castings until the deformities are corrected, usually 6-10 weeks. To prevent a recurrence, the treatment continues using orthoses to the age of four years. During this period of life, large parts of the foot skeleton are cartilaginous and not visible on radiographs. Using ultrasonography (US), the non-ossified parts of the skeleton can be visualised. This thesis consists of four studies with the overall aim of developing reliable measurement variables for the evaluation of ultrasonographic images of feet during the first four years of life.

**Study I** was a longitudinal cohort study running over one year. One hundred and eight normal feet in 54 healthy children were examined soon after birth, at four or seven months and at 12 months of age. The aim was to establish reproducible standardised projection planes and reliable measurement variables for assessing the ankle joint, the talo-navicular joint and the calcaneo-cuboid joint. Three scanning planes were used, medial and lateral coronal and dorsal sagittal. Pearson's correlation coefficient for the measurements was  $r=0.65-0.94$  ( $p<0.01$ ) for intra-observer and  $r=0.53-0.93$  ( $p<0.01$ ) for inter-observer. The non-ossified parts of the skeleton were depicted as black with white dots, while the joint cartilage appeared black.

**Studies II and III** were cross-sectional cohort studies. The control group comprised 105 healthy children and the clubfoot group comprised 46 children with 71 clubfeet. The age of the children was newborn to four years. They were divided into 10 age groups (newborn, 3, 6, 12, 18, 24, 30, 36, 42 and 48 months) and were investigated once.

In **Study II**, the aim was to establish reliable variables, independent of the age-related size or the ossified nuclei, for the assessment of the ankle joint using a posterior sagittal projection. The inter-investigator agreement for the scans was 0.71 to 0.89 Intra-class Correlation Coefficient (ICC). The intra-observer agreement (ICC) was  $\geq 0.9$  for controls and  $\geq 0.8$  for clubfeet. The inter-observer agreement for controls was  $\geq 0.68$  and  $\geq 0.84$  for clubfeet for all variables.

In **Study III**, the aim was to improve the evaluation of the deformities and mobility in the talo-navicular and calcaneo-cuboid joints by adding new measurement variables; a total of 20 variables were measured. The intra-observer agreement (ICC) ranged from 0.71 to 0.99 for controls and 0.58 to 0.99 for clubfeet. The inter-observer agreement (ICC) ranged from 0.58 to 0.99 for controls and 0.45 to 0.96 for clubfeet. The correlations were higher on the medial side than on the lateral side. The mean ROM in the talo-navicular joint was  $59^\circ$  in the controls and  $41^\circ$  in the clubfeet. The corresponding values for the calcaneo-cuboid joint were  $17^\circ$  and  $8.5^\circ$ .

**Study IV** was a longitudinal, cohort, observational study from birth to the age of four years. Twenty children with 30 clubfeet and 29 controls were included. The four scanning planes described in Studies I-III were used. The children's feet were investigated by US at the same ages as in Studies II and III and the images were evaluated using the same variables. Clinical data were retrieved from the medical records to assess the correlation between US findings and clinical data and the course of treatment. The medial malleolus-navicular (MM-N) distance and the talo-navicular (T-N) angle showed the highest correlation ( $r = -0.7$  resp.  $+0.7$ ) with the number of casts needed to correct the deformities. Even after the initial correction phase, some differences between clubfeet and controls in the US findings remained to the age of four years.

**Overall conclusion:** Ultrasound investigations of normal feet and clubfeet can be conducted with good reliability from birth to the age of four years. US can be a valuable complement to the clinical evaluation of clubfeet.

**Keywords:** clubfoot, ultrasonography, Ponseti treatment, congenital deformities, range of movement, repeatability, longitudinal study