Morphologic changes of the ankle in children as assessed by radiography and arthrography

TOSHIYUKI NAKAI1, YOSHINORI TAKAKURA1, YASUHITO TANAKA1, KAZUYA SUGIMOTO1, SUSUMU TAMAI1, and NORIO KURUMATANI2

1Department of Orthopaedic Surgery, Nara Medical University, Kashihara, Nara 634-8522, Japan
2Department of Public Health, Nara Medical University, Kashihara, Nara 634-8522, Japan

Abstract: Chronological changes in the morphology of the ankle, a joint that consists primarily of chondral components in children, were investigated by arthrography and plain radiography. Arthrography was performed in 57 ankles of 40 patients with normal ankles (aged from 2 months to 3 years, 4 months; mean, 1 year, 7 months), and plain radiography was performed on 183 joints of 126 patients with normal ankles (aged from 3 years, 6 months to 14 years, 5 months (mean, 7 years, 8 months)). The angle of the distal tibial joint surface was then measured on each radiograph. Despite being evident at birth, valgus inclination in the ankle rapidly changed during the first and second years of life. Thereafter, change continued gradually and spontaneously, and the ankles were in the neutral position by 3 years of age. However, the morphology of the ankles did not change much after that time. Normal ankles show valgus inclination at birth, but this configuration is changed naturally over time, and the ankles are in the neutral or slightly varus position by the age of bone maturity.

Key words: morphologic change, ankle, children, arthrography

Introduction

To effectively correct various congenital deformities and anomalies of the foot which require early treatment, it is extremely important to recognize chronological and morphological changes of the foot in children. There have been a few reports on morphological studies of the ankle in adults, by anatomical and radiological measurements.4,8 However, to our knowledge, no study of chronological and morphological changes of the ankles in children has been published.

As shown by plain radiography, the tarsal bones of newborns consist of chondral components, and ossification is seen only in the center. Therefore, arthrography, computed tomography, or magnetic resonance imaging is necessary to examine the morphology of the tarsal bones of newborns.1,2,8,13 In the present study, we analyzed the morphology of the normal ankle joint in children younger than 3 years of age by arthrography, and that in children older than 3 years by plain radiography, to ascertain chronological changes. We also determined the time up to which the plasticity of the ankle joint in children was maintained, by examining the chronological changes.

Subjects

The foot of an infant consists primarily of chondral components, and, thus, plain radiography cannot illustrate the morphology of the ankle. The skeletal morphology of the ankle in children can be examined by plain radiography starting from about 3 years of age, as reported in a previous study based on arthrography.6 Thus, we examined the ankle joints of children younger than 3 years using arthrography, and those of children older than 3 years by plain radiography.

The point at issue in this study was the ethical problem that the subjects were children who could not give informed consent. We fully explained to parents whose children were potential subjects of the study the purpose of this investigation and the risks of arthrography; for example, allergy, shock, and infection, and requested that their children participated in this study. Only children whose parents gave us informed consent were subjects of the study. In addition, written consent for arthrography was obtained for each child. There were no side-effects of arthrography.
The angle between the tibial shaft and the tibial joint surface on the anteroposterior view (TAS angle) and the angle between the tibial shaft and the tibial joint surface on the lateral view (TLS angle) were measured on these anteroposterior and lateral arthrographs (Fig. 4). The TAS angle records the varus and valgus angulations of the joint. The line of the tibial joint surface was drawn on the upper ends of both sides of the joint space described by the arthrograph (Fig. 2). The TLS angle indicates the amount of anterior opening of the joint (Fig. 3).

The same radiographic and measurement methods used for arthrography were used for plain radiography without weight-bearing (Figs. 2, 4). Because of progress in ossification, the morphology of the ankle in subjects over 3 years of age can be assessed by plain radiography. Therefore, the line of the distal tibial joint surface was drawn on the bottom of the ossification of the tibia.

These arthrographs and plain radiographs were assessed by two orthopedic surgeons (one a veteran, the other a resident). There were no errors of measurement between the two examiners.

Results

TAS angle

Although the TAS angle in infants at birth showed valgus inclination, this changed with age. In particular, decreases in the TAS angle were significant within 2 years of birth: the mean TAS angle in infants less than 1 year old was 98.2 (SD 2.5) degrees, at age 1 year, it was 93.5 (SD 1.8) degrees, at age 2 years, it was 91.5 (SD 2.0) degrees, and at age 3 years, it was 90.6 (SD 2.4) degrees (Fig. 5). Infants less than 1 year of age showed a significantly higher mean TAS angle than those aged 1 year \( (P < 0.001) \), those age 2 years \( (P < 0.001) \), and those aged 3 years \( (P < 0.001) \). In addition, the mean TAS angle in infants aged 1 year was significantly higher than the mean TAS angle in infants aged 2 years \( (P = 0.017) \) and 3 years \( (P < 0.001) \). In other words, although the TAS angle in newborns showed a marked valgus position, this configuration changed gradually with time. The mean TAS angle in 3-year-olds was 90.6 (SD 2.4) degrees, thus showing slight valgus inclination. However, this angle did not change much after that time, but by the time the children were 10 years old, the mean TAS angle was 89.8 (SD 2.5) degrees, with the ankles in the neutral position. In addition, the mean TAS angle in children aged 13 and 14 years was 88.9 (SD 2.3) degrees, thus showing slight varus inclination.