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# The ossification of tarsal bones and distal end of the tibia in human foetus

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*The ossification level of tarsal bones and the distal end of the tibia in human foetuses of both sexes from 4 to 9 month gestational age was estimated. Our results show that ossification of the cartilaginous model tarsal bones begins from 6 to 7 months of the gestational age with the appearance of a single ossification point in the ankle bone and two ossification points in the heel bone with the following ossification of the periosteum.*

**key words: human foetuses, tibial bone, tarsal bones, ossification**

## INTRODUCTION

Osteogenesis can take place on a membranous or cartilaginous base. Most human skeletal bones are ossified on a cartilaginous base made of hyaline cartilage. Mesenchymatic cells differentiated into chondroblasts and chondrocytes form a cartilaginous model of future bones. This is a complex process progressing dynamically in time. As a result of an interstitial and appositional growth the cartilaginous models of bones grow alongside the development of the embryo and foetus.

The aim of this paper is to assess the level of ossification progression in tarsal bones and the distal end of the tibia in human foetuses at different stages of gestation.

## MATERIAL AND METHODS

82 feet of human foetuses aged 4 to 9 months of gestational age were examined (Fig. 1). The material included 38 feet of female foetuses and 44 feet of male foetuses. Their age was determined on the basis of parietal crown-rump length supplemented by the values of the entire length and foetal body mass [2, 3]

The study involved isolating the feet above the ankle joints and placing them in a formalin solution of 1.11 mol/dm$^3$ concentration for a period of two

**Figure 1.** Roentgenogram of feet of a male 7 month old foetus. Magnification — 2 ×.

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weeks. Then 5 mm thick sections of the upper tarsal joint were obtained by cutting the foot along the sagittal plane at a 90° angle to its base. The specimens underwent decalcification in nitric acid of 1.15 mol/dm$^3$ concentration for 1 to 2 days and subsequently were sliced into further sections 2 $\mu$m thick and stained by hematoxylin-eosin and van Gieson method.

The processes of ossification of tarsal bones and the distal end of the tibia were then assessed.

## RESULTS

What follows from the observation is that in the fourth and fifth gestational month the cartilaginous model constitutes the stroma of tarsal bones. The cartilage is surrounded by irregular-shaped perichondrium from which connective and vascular fascicles arise (Fig. 2).

The stroma of the tibia epiphysis is formed by a cartilaginous model made of hyaline cartilage inside which a future point of ossification can be seen.

The shaft of the tibia is surrounded by an osseous cuff encircled by periosteum.

On the epiphysis-shaft border of the long bone a growth cartilage with pistillary isogenic groups is to be seen (Fig. 3). The most external layer of the growth cartilage is made of hypertrofic chondrocytes towards which the ossification process occurs.

During the sixth and seventh gestational months in the cartilaginous models of tarsal bones a progressing process of intracartilaginous ossification can be observed (Fig. 4).

In the tibia the process of long bone ossification proceeds from the shaft.

During the eighth and ninth gestational months in the cartilaginous models of tarsal bones elements of osseous tissue in the form of osseous trabeculae

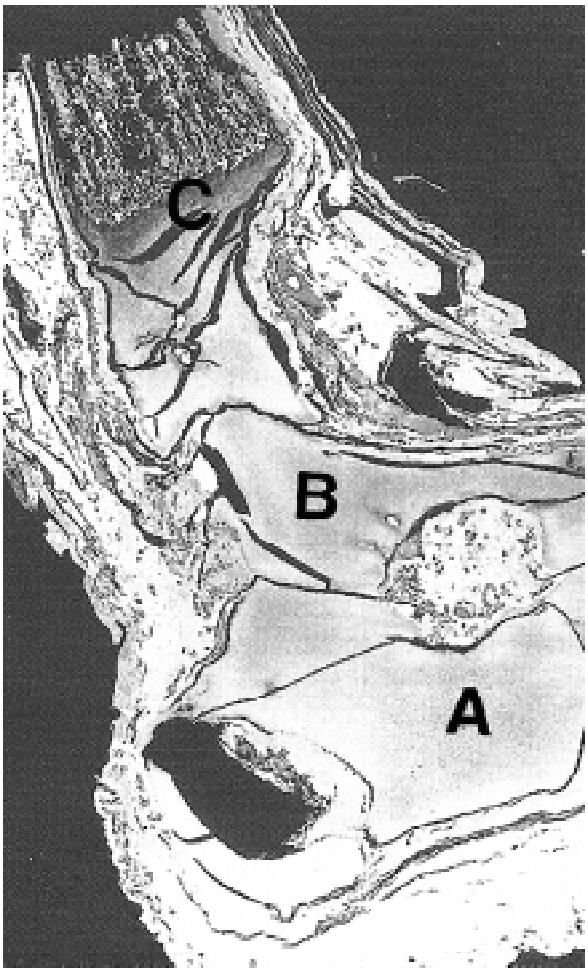


**Figure 2.** The foot of a 4 month old foetus. Magnification — 13 ×; **A.** The calcaneal bone; **B.** The ankle bone; **C.** The distal end of the tibia bone.

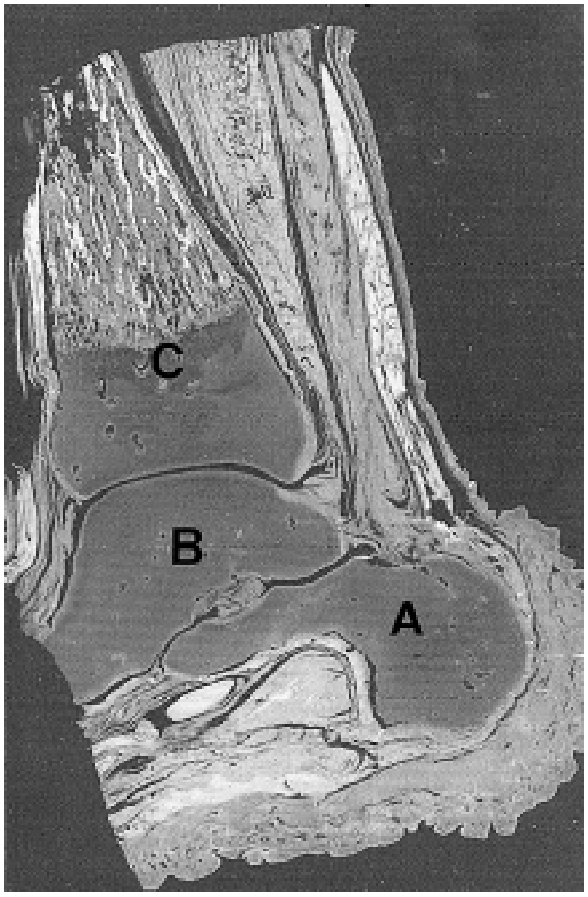


**Figure 3.** Tarsal bones and the distal end of the tibia bone of a 5 month old foetus. Magnification — 8 ×; **A.** The calcaneal bone; **B.** The ankle bone; **C.** The distal end of the tibia bone.

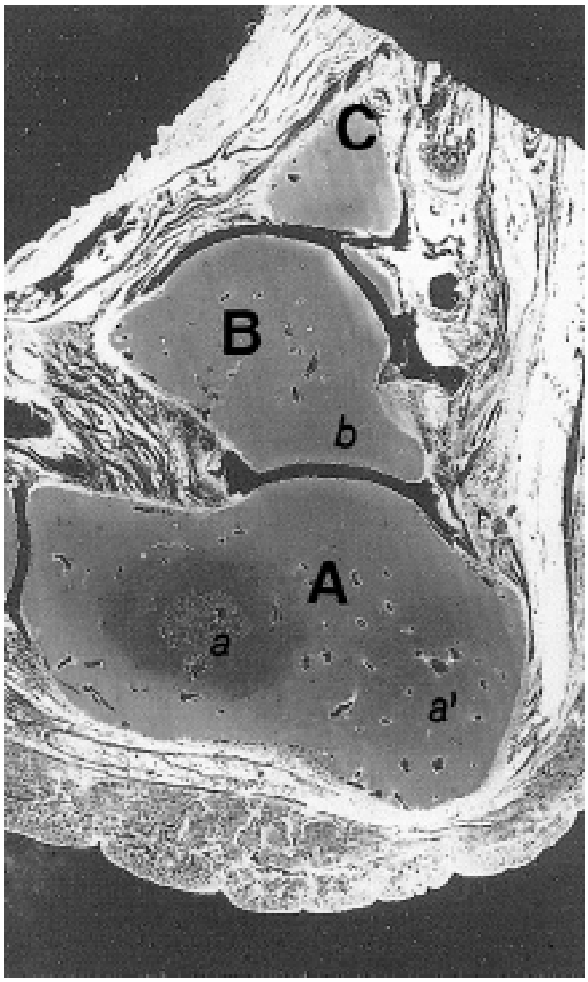


**Figure 4.** Tarsal bones and the distal end of the tibia bone in a 7 month old foetus. Magnification — 6 ×; **A.** The calcaneal bone, **a** — large ossification point, **a'** — the beginning of ossification in the calcanean tuber; **B.** The ankle bone, **b** — the formation of an ossification point; **C.** The distal end of the tibia bone.

are formed from the perichondrial side. In the ankle bone there is one and in the calcaneal bone two ossification centres with different degrees of progression.

In the tibia a wide tract of growth cartilage can be observed and in the distal epiphysis an initiated process of ossification can be seen.

## DISCUSSION

A number of authors have dealt with the development of the skeletal system in human foetuses [5, 9, 10, 15, 16]. Enerich [7] assessed the dynamics of the mineralisation process in ossification on membranous and cartilaginous basis in the foetal development of the human skeleton. Gardner et al. [9] described the internal rebuilding of the osseous tissue (cartilaginous model of bone, the growth of bone length- and thickness- wise and the growth of the epiphysis cartilage).

In the fifties and sixties some authors [11–13, 19] using radiologic tests determined the ossification points of particular long bones as well as the calcaneal and ankle bones, which was to be the basis of foetal maturity.

In later years Hartley [12] described the beginning of calcaneal bone ossification as taking place between 24 and 26 weeks of pregnancy and that of the ankle bone between 26 and 28 weeks of pregnancy. The results published by Kuhns and Finstrom [14] were slightly different — ossification points of the calcaneal bone were in 22–25 weeks of pregnancy and 25–31 weeks for the ankle bone.

Other authors estimated the growth of ossification points in human foetuses by means of the ultrasound method [4, 17, 18, 20]. In Bernaschek [1] the earliest and latest manifestation of the ankle bone ossification point were described in 23 and 29 pregnancy weeks respectively. According to Rubersz-Adamska [18] the ossification point of the calcaneal bone appears in the USG examination around 24 pregnancy weeks and the ossification point of the ankle bone around 28 pregnancy weeks, which is consistent with our observations.

Knowledge of the appearance of ossification points of tarsal bones can constitute a further parameter in the determination of foetal age.

## CONCLUSIONS

1. In the fourth gestational month the stroma of tarsal bone constitutes cartilaginous model.
2. During the sixth and seventh gestational months osteogenesis is initiated by the appearance of one ossification point in tarsal bone and two points in calcaneal bone followed by periendochondrial ossification.

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