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Transverse ligament of the knee in human embryos aged 7 and 8 weeks

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The aim of the study was to trace the transverse ligament of the knee in staged human embryos. Investigations were carried out on 42 embryos of developmental stages 18–23 (44–56 postovulatory days) from the collection of the Department of Anatomy in Poznań.

It was found that in embryos at stage 19 peripheral condensation of the mesenchymal interzone of knee joint, located anteriorly to the primordia of the cruciate ligaments, was recognizable. Clearly visible cellular primordium of the transverse ligament, connected with the medial and lateral menisci, was observed in stage 22. The primordium consisted of oval cells, arranged into densely packed parallel strands. The cells were greater than those forming the menisci.

In embryos at stage 23 all intraarticular elements (articular surfaces, menisci and their ligaments, cruciate ligaments and transverse ligament) of the knee joint were clearly evident.

key words: human development, knee joint, transverse ligament of the knee

INTRODUCTION

The transverse ligament of the knee plays an important role in stabilisation of the menisci during movements and in prevention of hyperrotations [11]. It belongs to intraarticular ligaments of the knee joint. It is thin and rounded in shape and connects the most anterior parts of the menisci.

An increasing interest in the development of the intraarticular structures of the knee joint and their clinical importance has resulted in many publications [1–3, 5, 7, 8, 11, 12]. However, the period of formation of these structures during intrauterine development differs [1, 3, 8, 10, 16]. There is no detailed description of the developing transverse ligament of the knee in human.

The aim of present study is to trace the transverse ligament of the knee in staged human embryos in order to determine the time of appearance and its relation to intraarticular structures.

MATERIAL AND METHODS

Investigations were carried out on 42 embryos at developmental stages 18 to 23 (44–56 postovulatory days). The embryos belong to collection of the Department of Anatomy University School of Medical Sciences in Poznań. The age of embryos was established according to developmental stages [15] and expressed in postovulatory days. All embryos were embedded in paraffin or paraplast and sectioned serially in three planes. Serial sections 5 or 10 μm were stained with routine histolo-

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gical. Documentation was also made with Leica Image Processing and Analysis system. Crown-rump length (C-R), plane of section, age in postovulatory days, and developmental stage are shown in Table 1.

Table 1. Crown-rump length (C-R), plane of section, age in postovulatory days, and developmental stage

Embryo	C-R length [mm]	Developmental stage	Age in days	Plane of section
B 122	14.5	18	44	Frontal
Bł 4	15.0	18	44	Transverse
A 6	15.5	18	44	Transverse
Z 11	16.0	18	44	Sagittal
B 66	16.5	19	46	Transverse
A 1	17.0	19	46	Transverse
Bł 5	17.0	19	46	Transverse
Z 13	17.0	19	46	Frontal
Bł 10	17.5	19	46	Transverse
B 123	17.5	19	46	Sagittal
Bł 9	17.5	19	46	Transverse
X 19	17,5	19	46	Sagittal
A 10	18.0	19	46	Transverse
KA 2	18.5	19	46	Transverse
KA 3	18.5	19	46	Sagittal
PJK 1	19.0	19	46	Sagittal
B 126	19.0	19	46	Transverse
B 173	19.0	19	46	Transverse
B 99	19.5	20	49	Transverse
Bł 3	20.0	20	49	Frontal
Bł 2	20.0	20	49	Sagittal
PJK 27	18.0	20	49	Transverse
B 124	19.5	20	49	Sagittal
Z 19	20.0	20	49	Transverse
B 76	20.0	20	49	Transverse
B 178	20.0	20	49	Sagittal
B 127	23.5	21	51	Sagittal
B 170	22.5	21	51	Transverse
A 4	23.5	21	51	Frontal
PK 61	24.5	21	51	Sagittal
A 13	26.0	22	52	Frontal
Z 3	26.5	22	52	Transverse
Z 2	26.5	22	52	Transverse
B 223	26.5	22	52	Sagittal
B III	27.0	22	52	Sagittal
WR II	27.0	22	52	Transverse
WR III	27.5	22	52	Transverse
B 114	28.0	23	56	Sagittal
B 187	27.0	23	56	Sagittal
B 177	28.5	23	56	Transverse
B 184	29.0	23	56	Sagittal
A 3	29.0	23	56	Transverse

RESULTS

In embryos at stage 18 (42 days) the area of the knee joint between future epiphyses of the femur and tibia consists of homogenous mesenchyme, which is designated as homogenous interzone. On the anterior surface of this interzone the primordium of the patellar ligament is visible.

In stage 19 (45–46 days) the primordia of cartilage are observed in diaphyses of the femur and tibia as well as in the head of the femur and in the proximal epiphysis of tibia. The homogenous interzone begins to differentiate into layers. The cells of the middle layer in its central part, opposite the intercondylar fossa are more loosely arranged into oblique strands. These are the primordia of the anterior and posterior cruciate ligaments. The cells of peripheral parts of interzone, forming the primordia of menisci, are densely packed, darkly stained, and they form a distinct layer (Fig. 1). Anteriorly to primordium of the anterior cruciate ligament, in the peripheral part of interzone, condensation of mesenchymal cells is recognisable. This transverse condensation, passing between the most anterior parts of the meniscal primordia, forms the transverse ligament of the knee (Fig. 2). Rounded cells of the ligament are less densely arranged than those of the menisci, and are darker than the mesenchymal cells of the articular surfaces of the tibial condyles. They form transverse bands, separated from the primordium of patella by a group of loosely arranged mesenchymal cells, light in appearance.

During stages 20 and 21 (47–51 days) the primordium of the transverse ligament becomes more evident. The process of chondrification of the condyles of the femur and tibia as well as patella is advanced. The interzone is three-layered and the middle layer shows more loose arrangement in comparison to the peripheral layers which adhere to condyles of the femur and tibia. Formation of joint cavity of the femoromeniscal, as well as that of the meniscotibial part of the knee joint, is observed in its lateral portion (Fig. 3). The medial and lateral menisci have predominantly cellular structure and their most anterior parts fuse with the cellular primordium of the transverse ligament of the knee (Fig. 4), which forms transverse strands of elongated cells, clearly separated from the patella (Fig. 4A). Also dark and small cells of the interzone are dispersed between the primordium of the transverse ligament and the medial condyle of the femur, as well as in the intercondylar fossa (Fig. 4B). On the periphery of the joint, blood vessels are present.

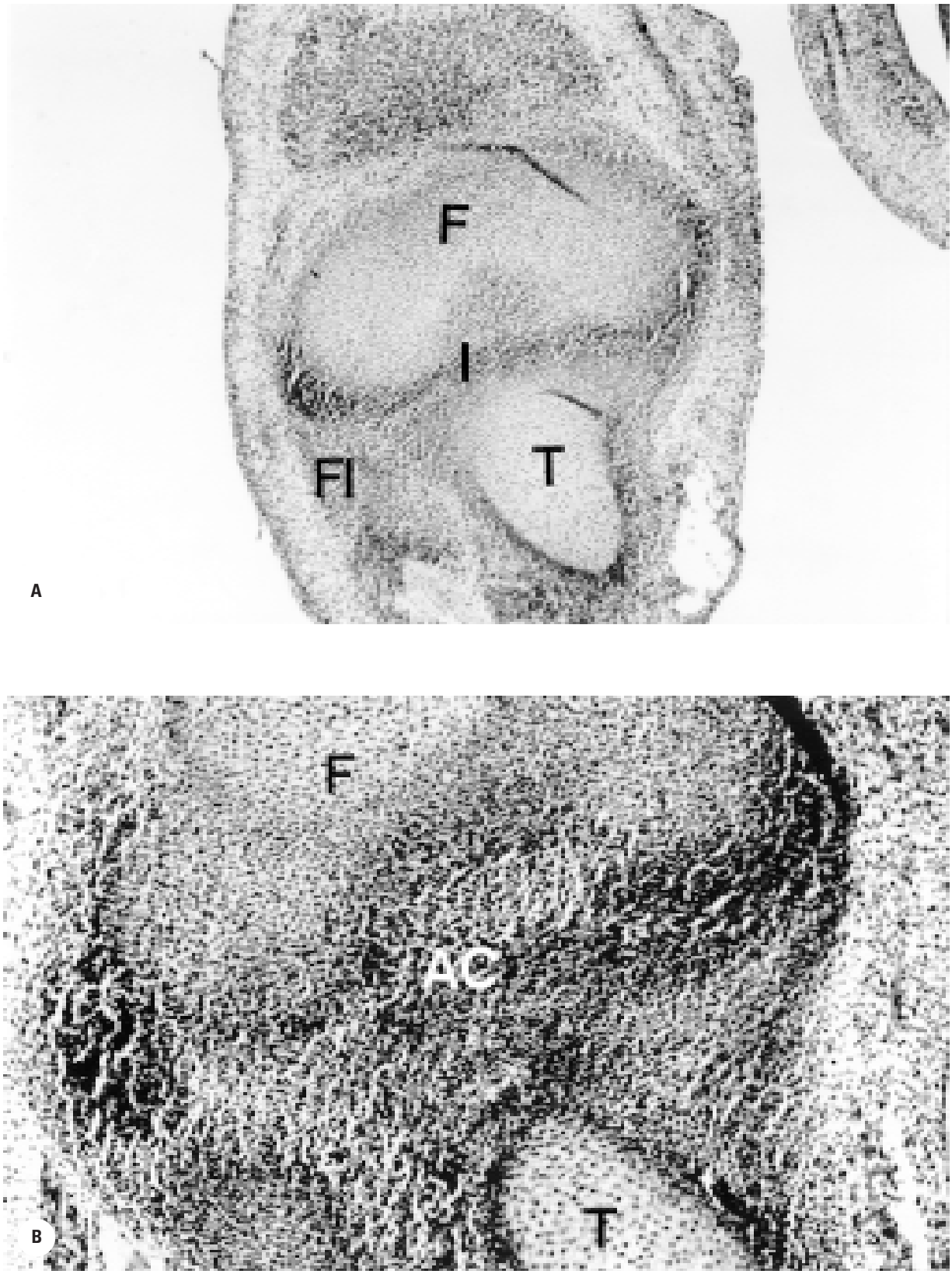

Figure 1. Interzone in the knee joint of embryo at stage 19. Frontal section, H + E; **A** × 50, **B** × 100.
Designations in figures: AC — anterior cruciate ligament, E — intercondylar eminence, F — femur, Fl — fibula, FL — lateral condyle of femur, FM — medial condyle of femur, I — interzone, J — joint cavity, L — lateral meniscus, M — medial meniscus, PC — posterior cruciate ligament, TL — transverse ligament of the knee, T — tibia.

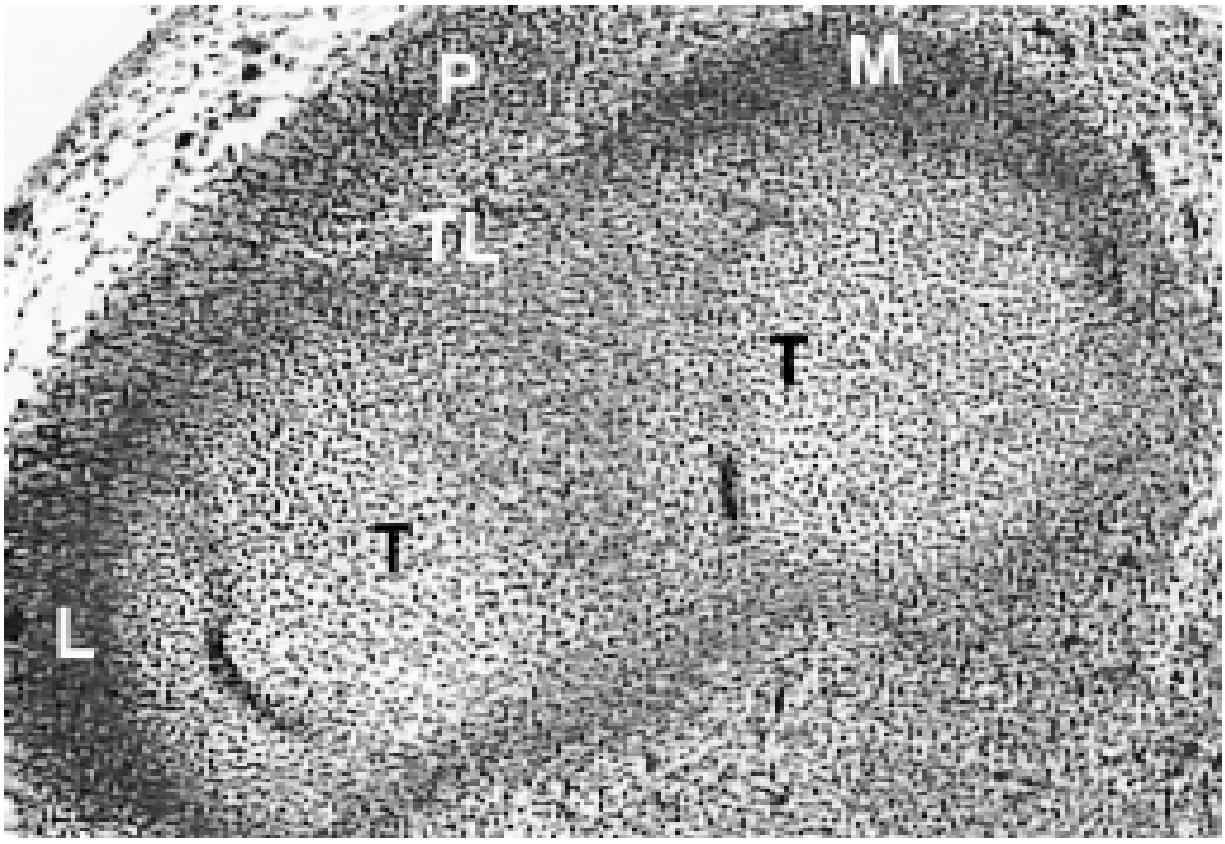

Figure 2. Primordium of the transverse ligament of the knee at stage 19. Transverse section, Mallory's method, × 100.

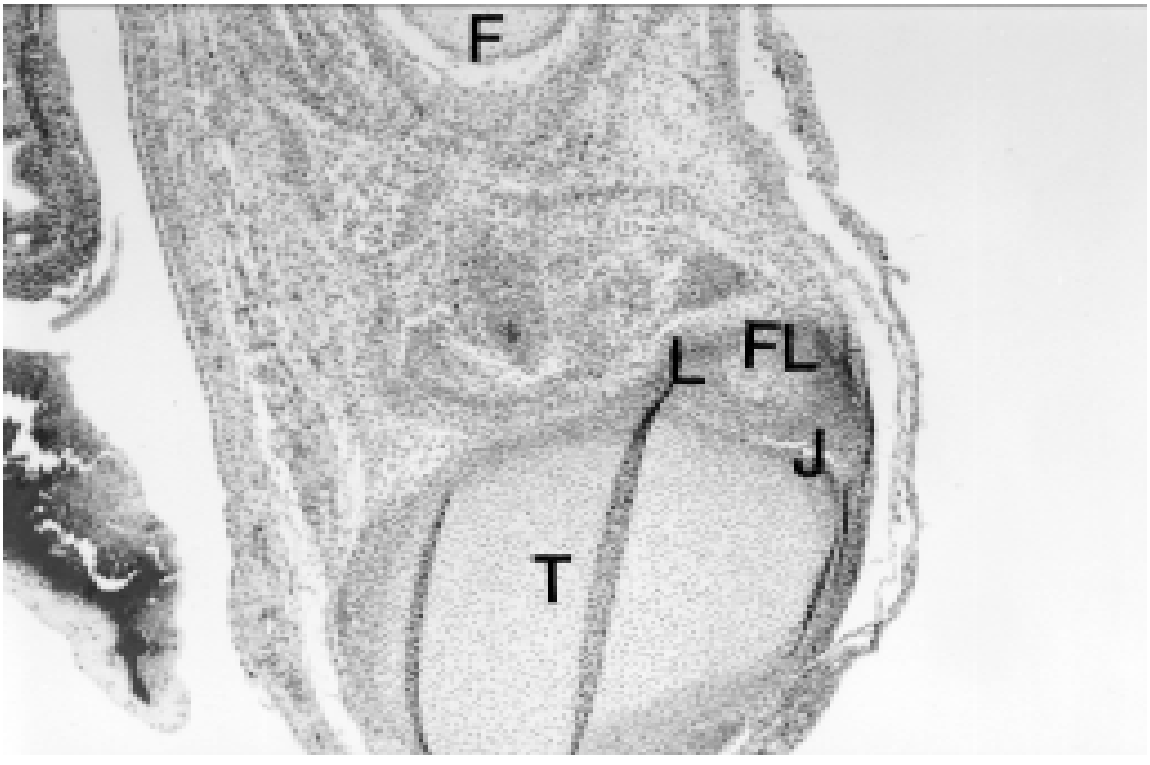

Figure 3. Formation of the joint cavity of the knee joint in embryo at stage 21. Oblique section, H + E, × 100.

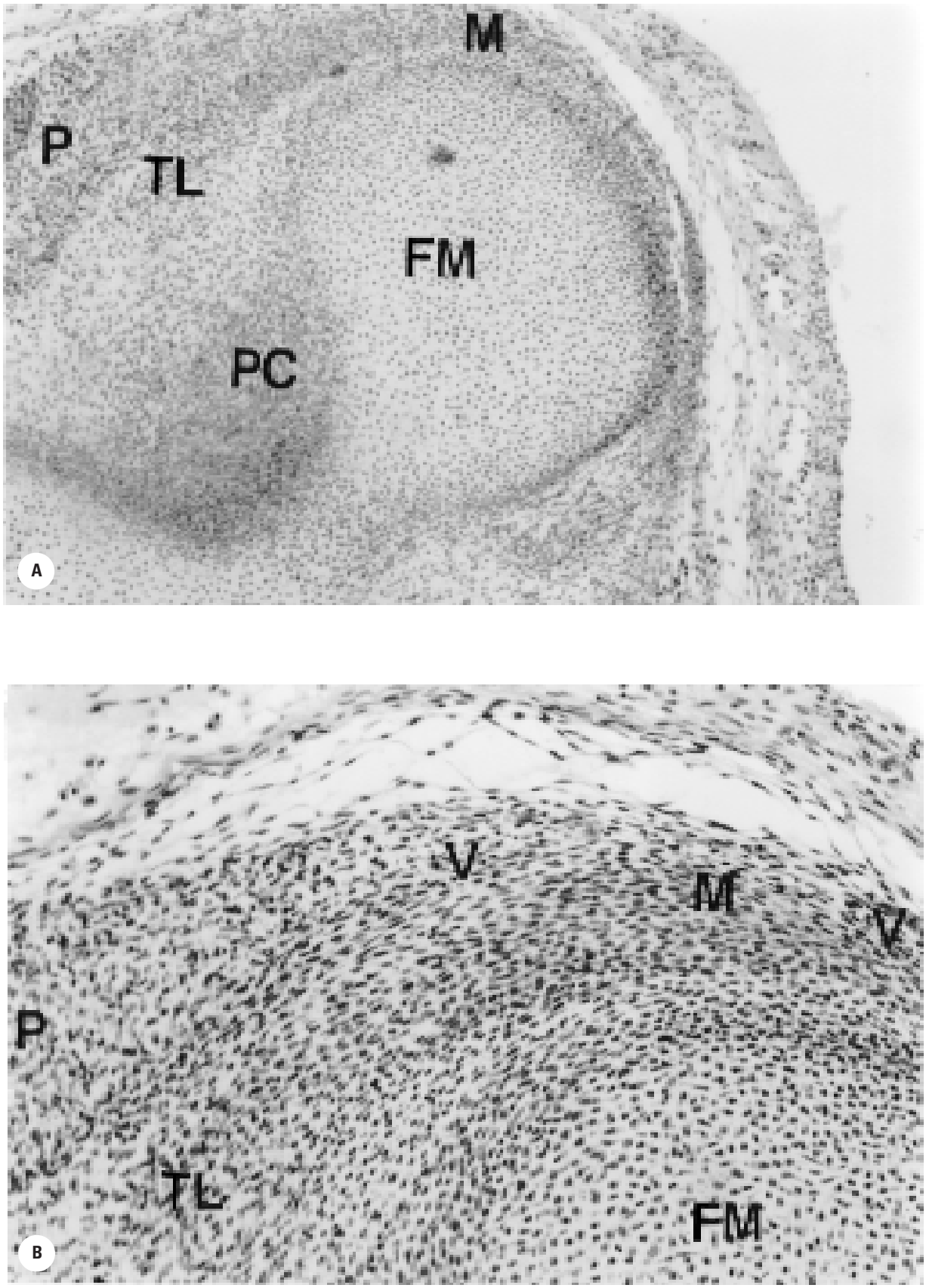

Figure 4. The transverse ligament of the knee in embryo at stage 21. Transverse section, H + E, **A** × 100, **B** × 200.

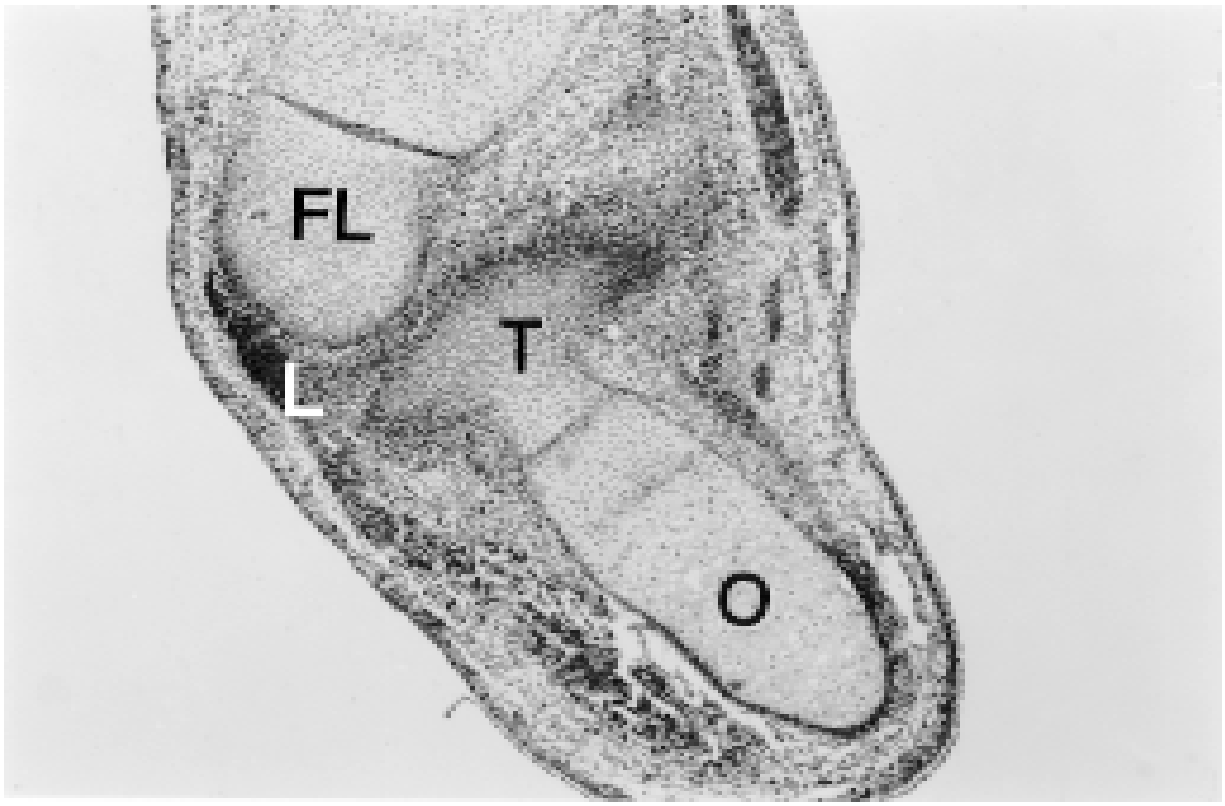

Figure 5. Ossification in shaft of the tibia in embryo at stage 22. Sagittal section, H + E, × 50.

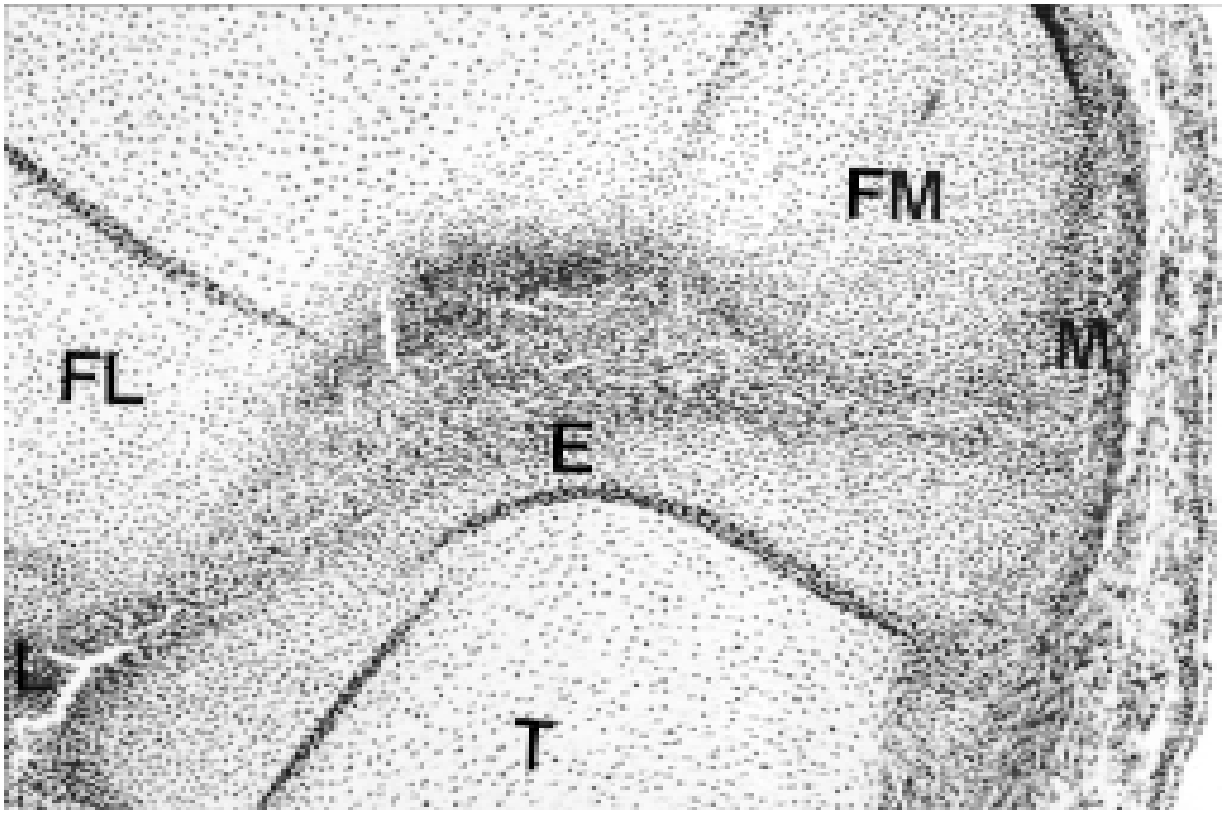

Figure 6. The intercondylar eminence of the tibia in embryo at stage 22. Frontal section, H + E, × 100.

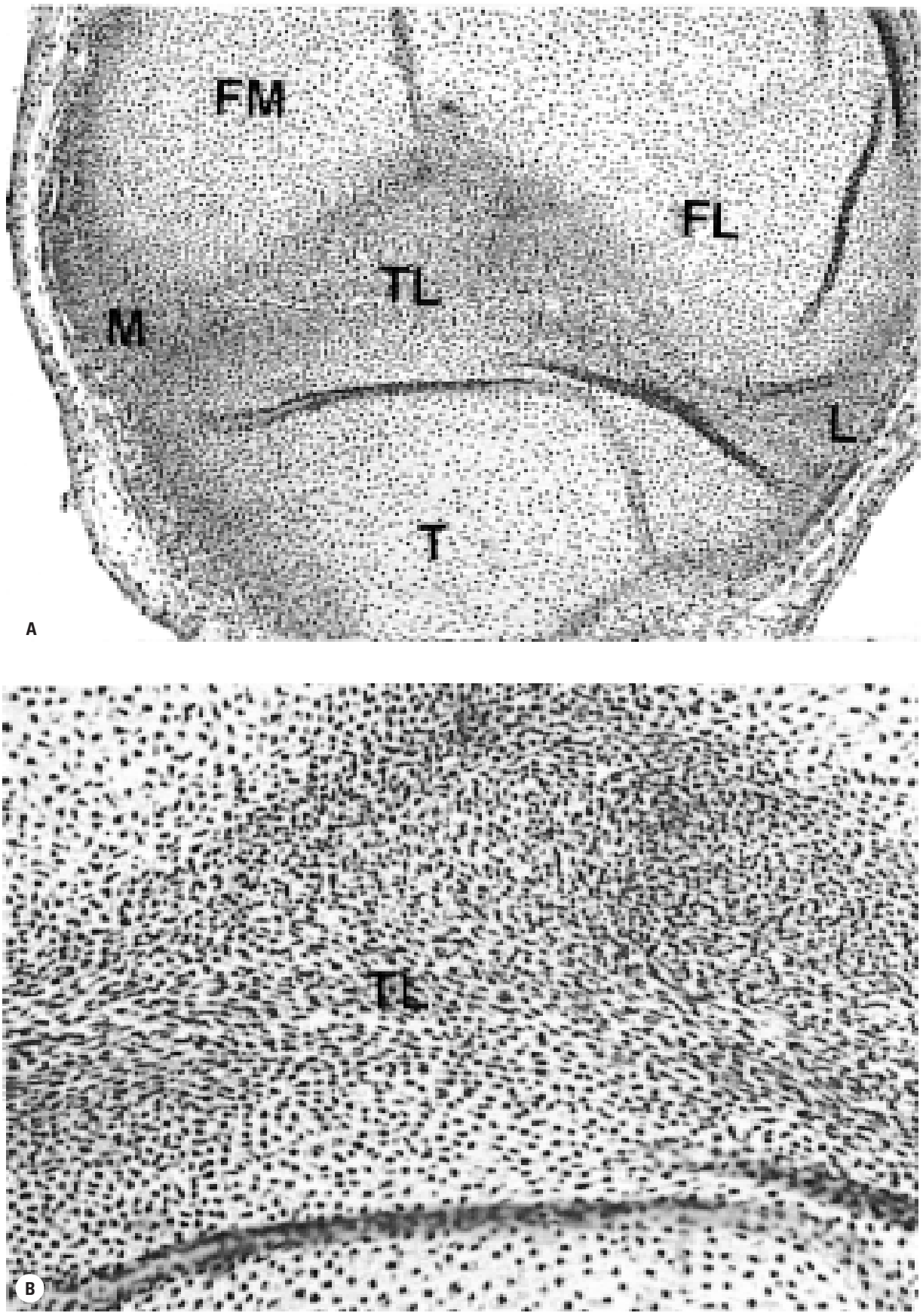

Figure 7. The transverse ligament of the knee in embryo at stage 22. Frontal section, H + E, **A** × 100, **B** × 200.

During stage 22 (52–53 days) the beginning of ossification of shafts of the femur and tibia takes place (Fig. 5). Formation of the intercondylar eminence is in progress (Fig. 6). The menisci are well developed and occupy broad area of articular surfaces of the tibial condyles. Cells forming menisci are arranged parallel to the articular surfaces of condyles. Blood vessels enter more central part of the knee joint.

The transverse ligament of the knee connects both the medial and lateral menisci (Fig. 7). Cells of the ligament are more elongated than in stage 21 and are arranged into dense 6 to 7 strands (Fig. 7B). These cells are larger than those of the menisci (Fig. 7A). Cellular strands are separated from chondrifying proximal epiphysis of the tibia by free spaces (Fig. 7B).

In embryos at stage 23 (54–56 days) all intraarticular elements of the knee joint are present (Fig. 8). The menisci have still more cellular structure and in the peripheral parts posses blood vessels. The cruciate ligaments present fibrous structure. A broad joint cavity clearly separates menisci and articular surfaces of condyles of the femur and tibia. The synovial membrane covers inner peripheral parts of the menisci and cruciate ligaments. It consists of the layer of small, darkly stained cells (Fig. 8). The transverse ligament of the knee is still cellular.

DISCUSSION

Primordia of the lower limbs appear at stage 13 opposite somites 24 to 29 [9, 14]. Mesenchymal condensation of skeleton of the lower limbs is observed in stage 16 [13]. The formation of the articular surfaces is seen in stages 17 and 18. Chondrification of shafts of the tibia and femur begins at stage 18. My observations as to the development of structures of the knee joint in embryos in stage 19 differ from those of many authors [3, 10, 13, 14].

Gardner and O'Rahilly [3] observed condensation of the cellular primordium of the cruciate ligaments only in one case and they do not mention the menisci. In my material I found in stage 19 mesenchymal condensation of cells of the interzone forming the cruciate ligaments [16] and separate primordia of both menisci [17], which are connected with the primordium of the transverse ligament of the knee.

Gardner and O'Rahilly [3] observed condensations of mesenchyme of menisci and cruciate ligaments in one embryo at stage 20. Haines [5, 6] found cruciate ligaments as condensation of mesenchyme that was located in the intercondylar space in embryos

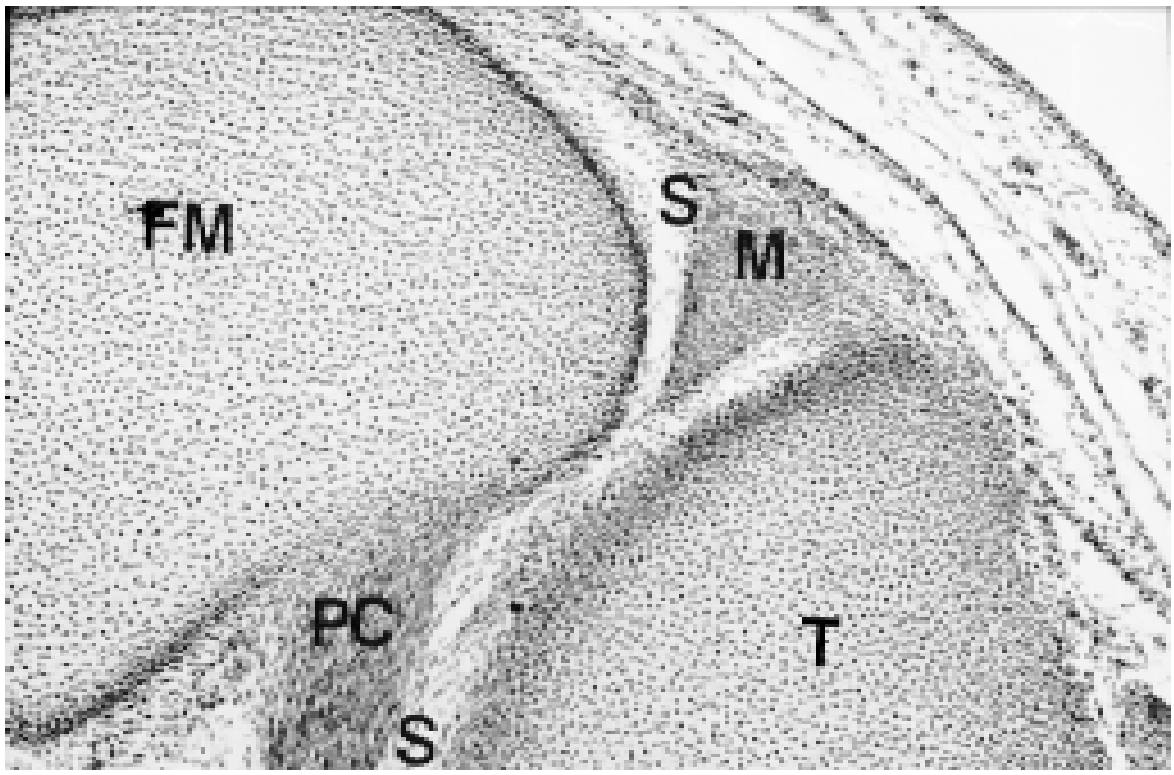

Figure 8. Transverse section of the knee joint in embryo at stage 23. H + E, x 100.

20 mm long, and Andersen [1] observed primordia of menisci in stage 21.

Merida-Velazco et al. [10] observed menisci in embryos of stage 22, but they were not clearly separated from the joint cavity until the 9th week.

McDermott [8] found an "interchondral disc" between epiphyses of the femur and tibia in embryos between 52nd and 55th day of development (in stages 21 and 22).

None of the above investigators observed the transverse ligament of the knee in embryos. It results from present investigations that all intraarticular structures of the knee joint appear earlier than described in available literature.

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