

Embryology and growth of the knee



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Objectives

Early knee joint formation

Later embryonic and fetal growth

Postnatal development

Early knee joint formation

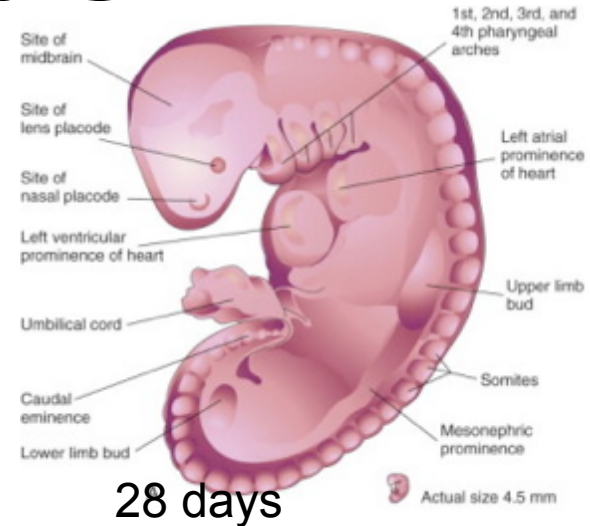
Limb buds

Upper limb buds develop opposite the caudal cervical segments

Lower limb buds form opposite the lumbar and upper sacral segments

Osteogenesis of long bones in 7th week from primary ossification centers in the middle of the cartilaginous anlage of the long bones

Lower limbs rotate in 7th week – knee faces ventrally

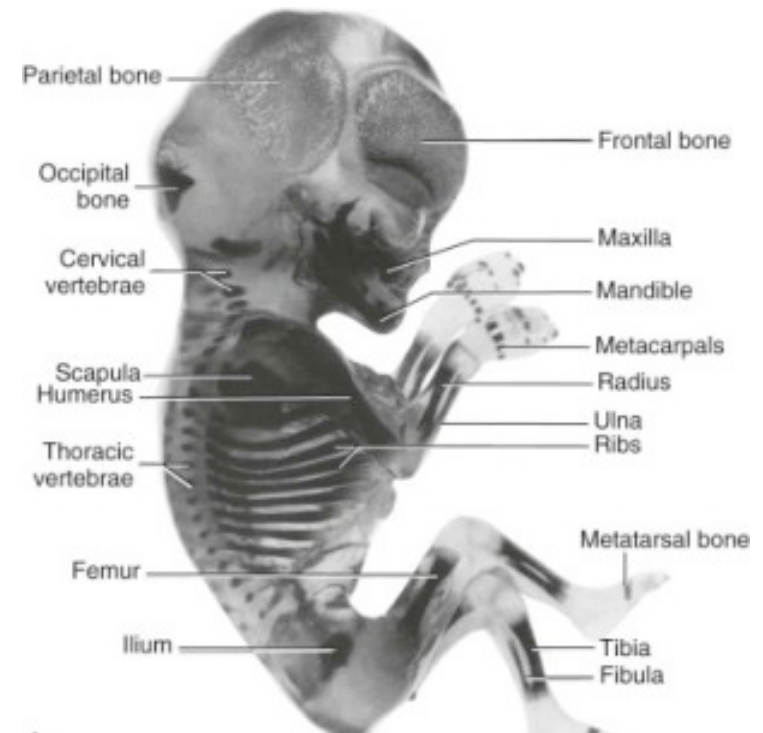


Ossification

By 12 weeks, primary ossification centers have appeared in nearly all bones of the limbs

Secondary ossification centers around the knee joint are the first to appear *in utero*

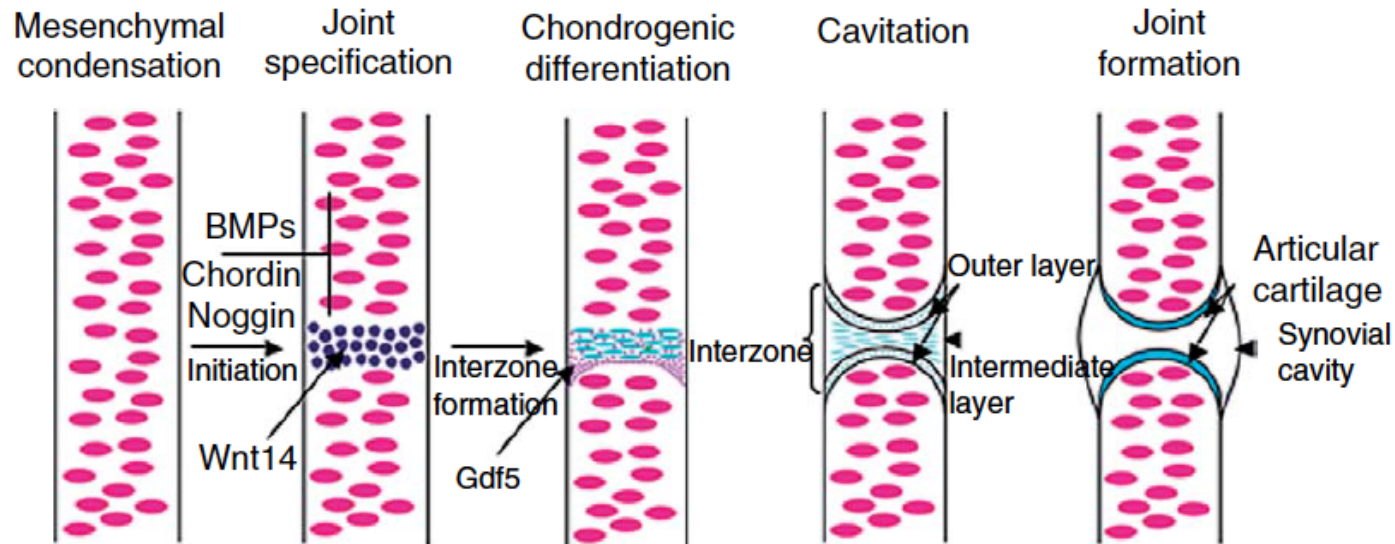
The centers for the distal femur and of proximal tibia usually appear during last month



Knee joint formation

At the sites of joint formation, the resident cells flatten and become nonchondrogenic to form an interzone

Unknown trigger – wnt14 – Gdf5 – cells elongate – joint forms
Chordin and noggin stabilize joint-inducing positional cues

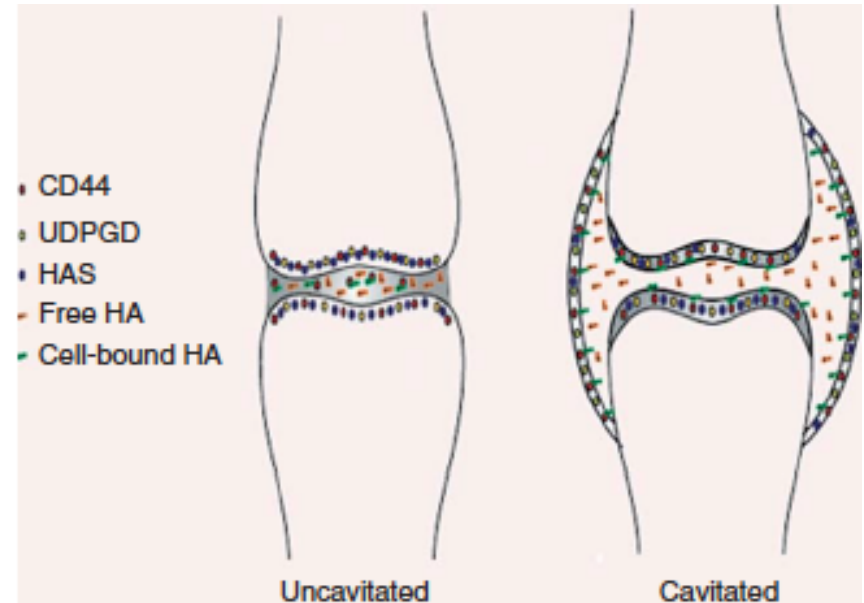


Knee joint formation

Cavitation markers present in the interzone include hyaluronan and hyaluronan synthase

Interzone adopts a 3 cell-layered structure that cavitates following mechanically induced synthesis of hyaluronan

Movement dependent – paralysis of embryo leads to failure of cavitation

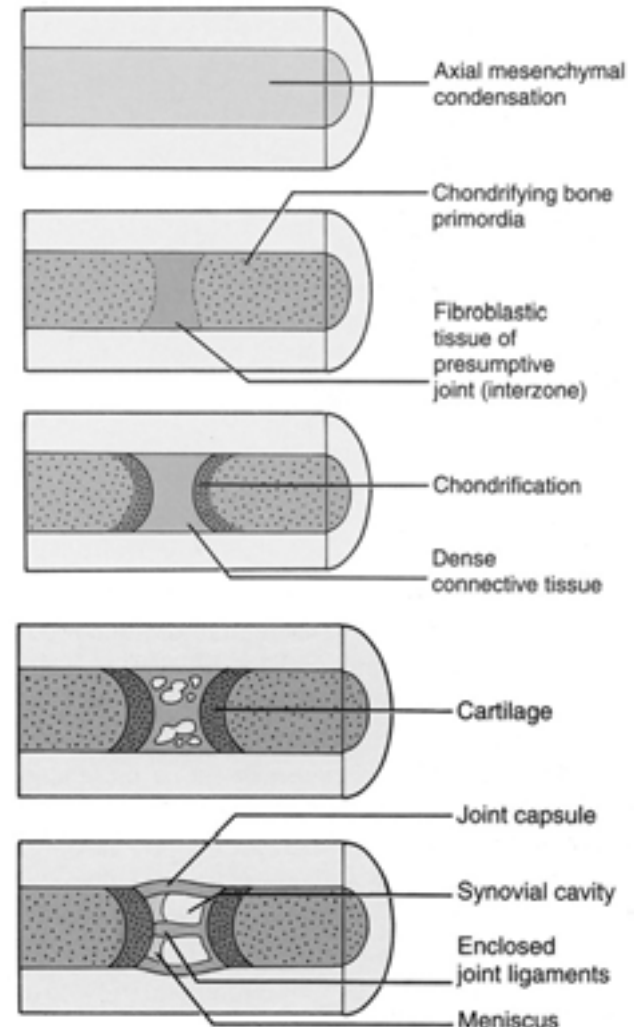


Knee joint formation

3 layers = 2 cartilage layers with dense connective tissue in between

Central region forms menisci and ligament surrounded by capsule

Vacuoles form and coalesce to become synovial cavity



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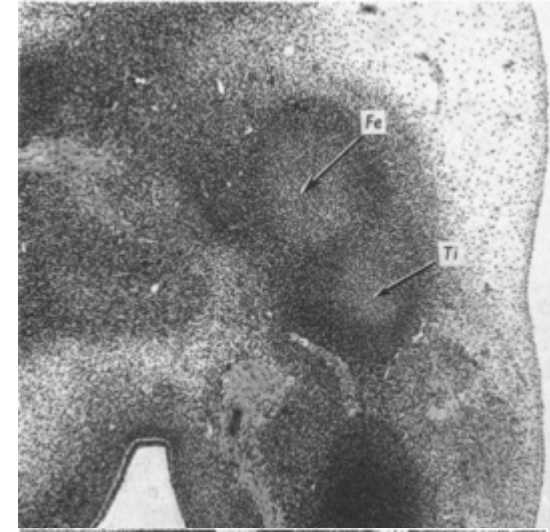
Later embryonic and fetal growth

Embryonic stages

6 weeks

The femur, tibia, and fibula had begun to undergo chondrification

The region of the knee joint represented by a mass of blastemal cells



7 weeks

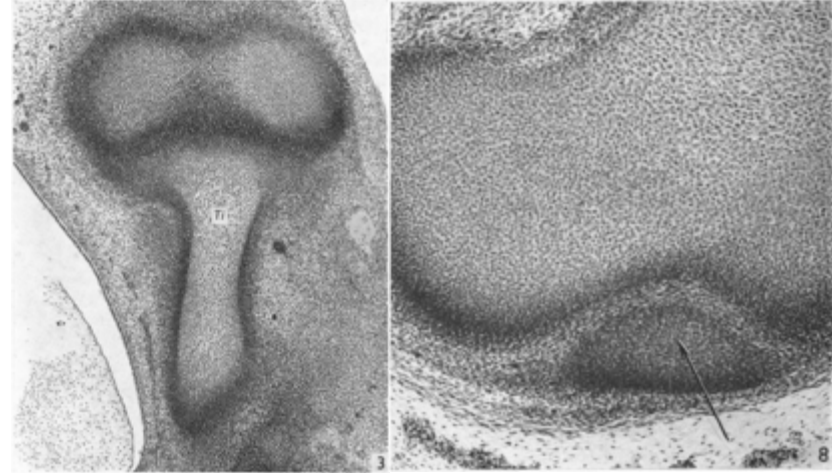
Cellular condensation for patella visible



Embryonic stages

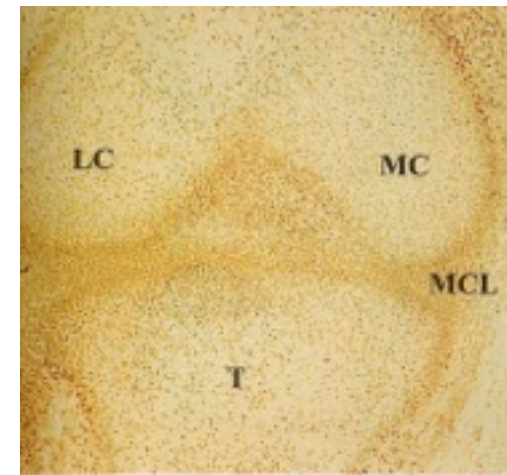
7-7.5 weeks

Intervening homogeneous interzone visible



Condyles and patella evident

Ligaments (MCL and LCL appear)



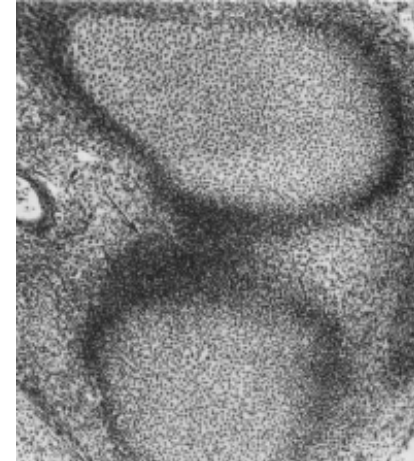
Embryonic stages

7.5-8 weeks

Tibia, fibula, and femur clear-cut, cartilaginous forms

Knee joint resembles that of adult

Menisci and PCL clearly defined

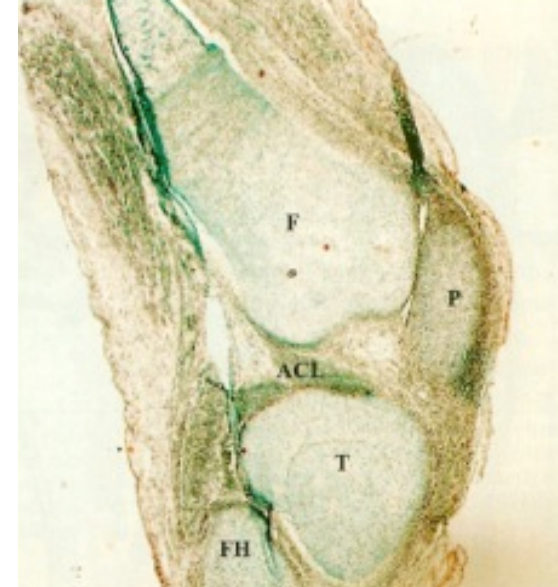


Embryonic stages

10 weeks

Menisci more clearly defined

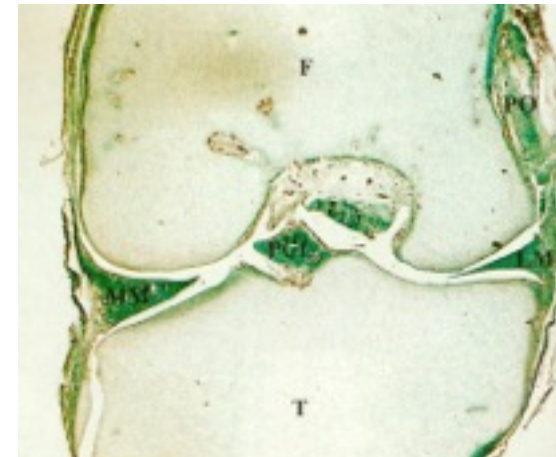
ACL evident



12 weeks

Popliteus

Vascular channels appear



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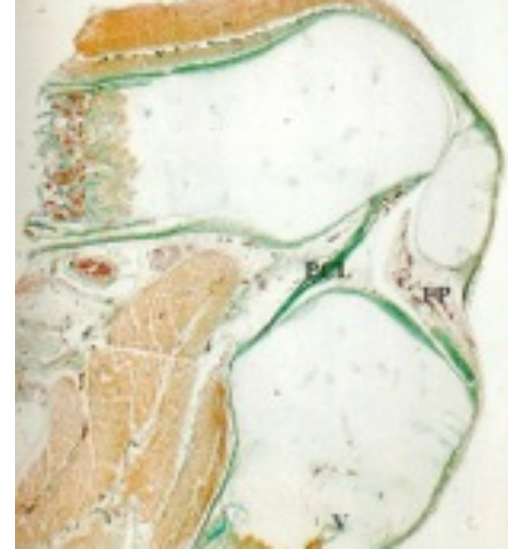
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Embryonic stages

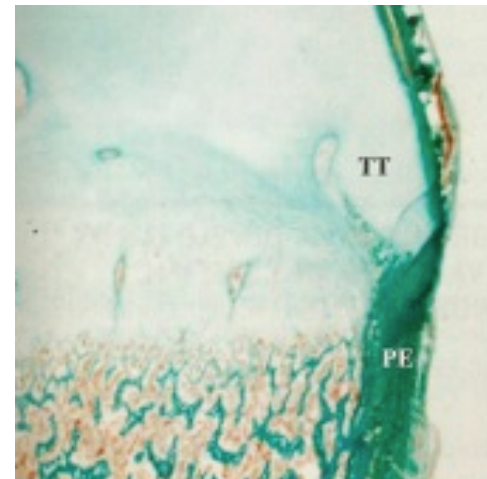
16 weeks

Proceeding ossification



18 weeks

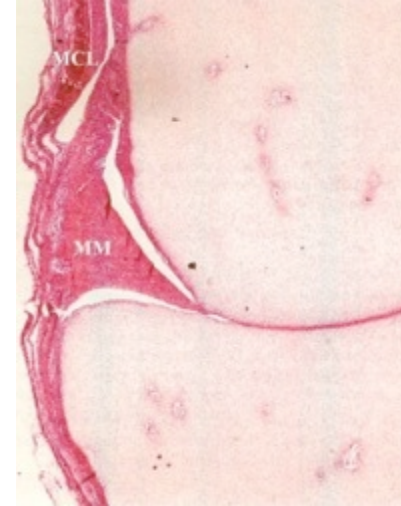
Tibial tuberosity apophysis starts to separate



Embryonic stages

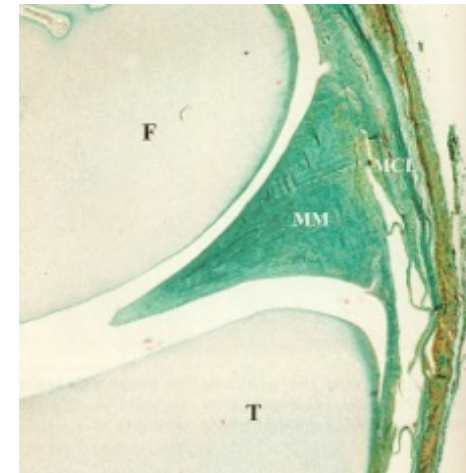
20 weeks

Medial meniscus has no inner vascular structures



40 weeks

Vascularity of entire meniscus



Postnatal development

Knee growth

Distal femoral and proximal tibial physes contribute the most to longitudinal growth of the lower extremities

The distal femoral physis contributes 70% of the total femoral growth and provides an average growth of 1 cm per year

Closure usually occurs at 12–14 years in girls and 14–16 years in boys

The proximal tibial physis contributes 55% of the total tibia growth and grows 0.6 cm per year

The proximal tibial physis closes around the same time as the distal femur

Coronal alignment

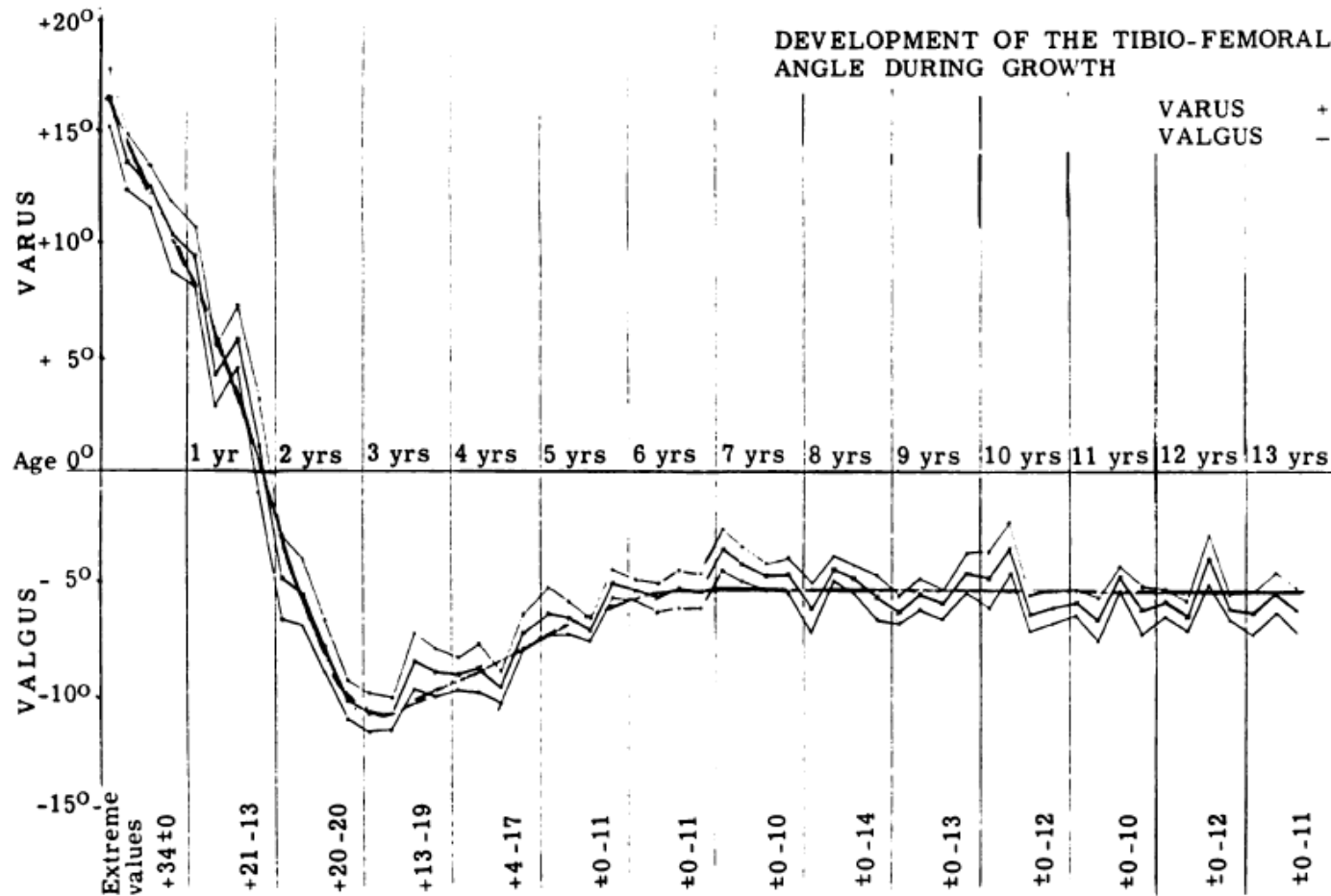


FIG. 1

The development of the tibiofemoral angle in children during growth. The results are based on 1,480 measurements of the tibiofemoral angle of children at different ages. The mean of the measurements is in the middle and on both sides of this is the error of the mean, which was an average of ± 4.4 degrees. The standard deviation was ± 8 degrees.

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Coronal alignment

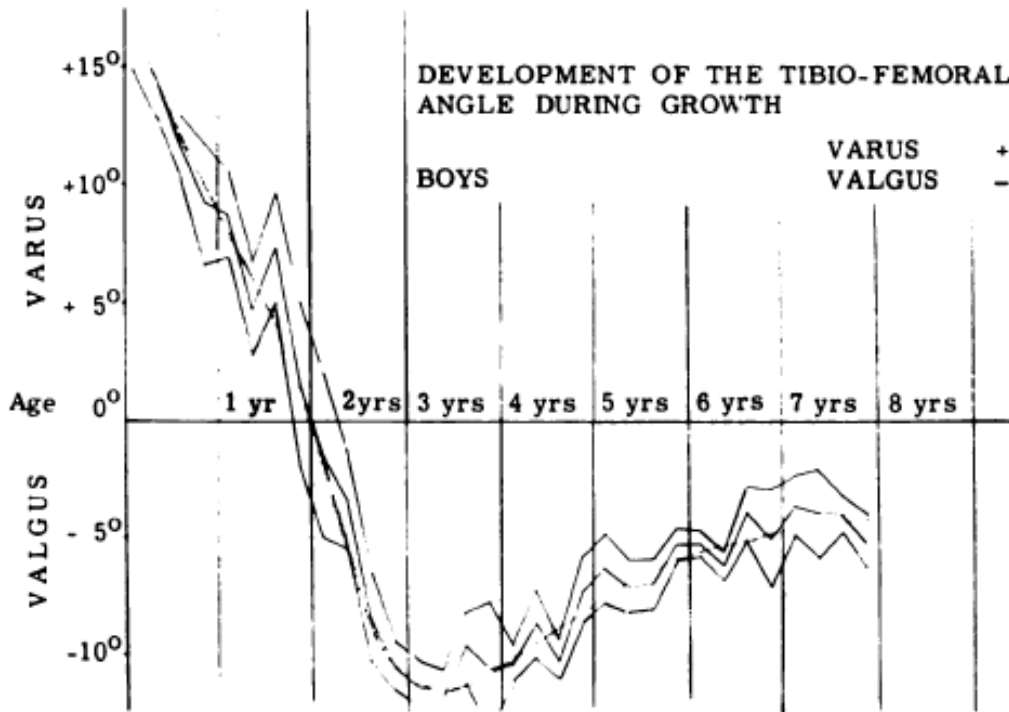


FIG. 2

The development of the tibiofemoral angle in boys.

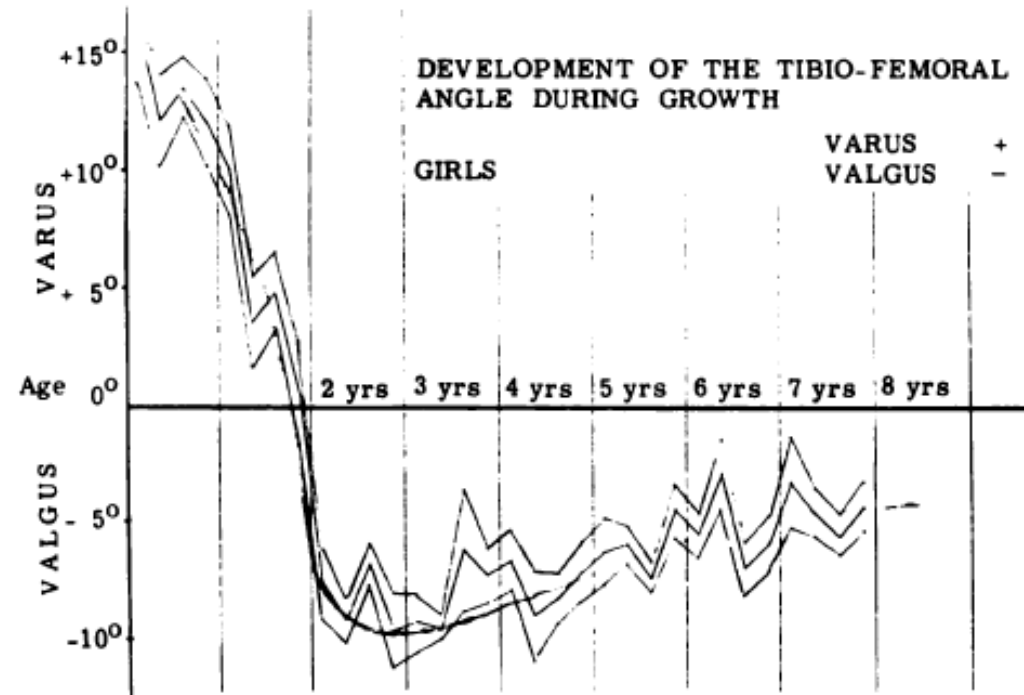


FIG. 3

The development of the tibiofemoral angle in girls.

When to worry

aSymmetrical

Stiff

Swollen

Systemic disorder

Syndromic

Stressed parents!

Summary

Early knee joint formation

Later embryonic and fetal growth

Postnatal development

Thank you!



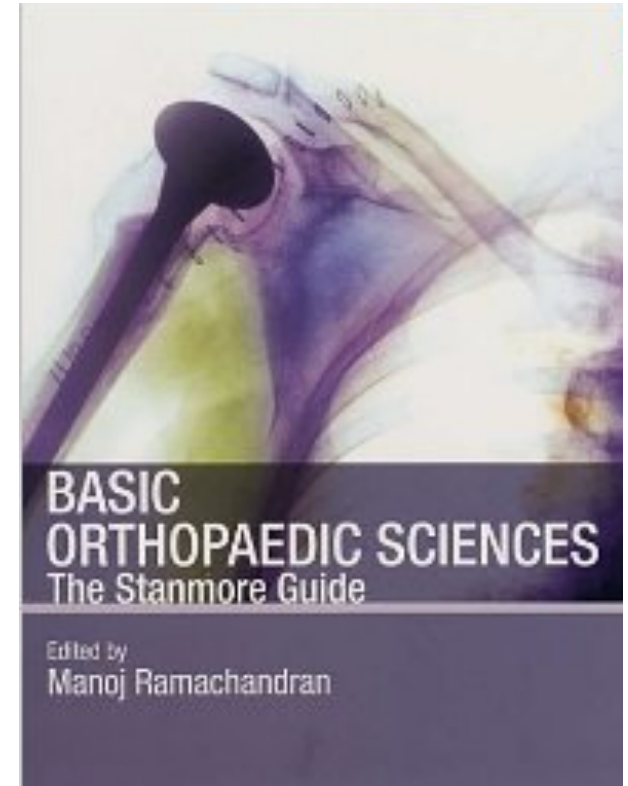
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Resources

The screenshot shows a web browser window with the URL embryology.med.unsw.edu.au/Notes/skimus7.htm. The page is from The University of New South Wales, Sydney, Australia. The main heading is "UNSW Embryology" and the sub-heading is "Musculoskeletal - Limb Development". The author is listed as "© Dr Mark Hill (2010)". The page includes a navigation menu on the left with links for Home Page, Embryo stages, Fetal Dev, Dev Notes 1, Dev Notes 2, System Notes, Acknowledgements, Internal Links, Musculoskeletal, Introduction, Abnormalities, Stage 13/14, Stage 22, Selected stage 22, and Somite. The main content area has an "Introduction" section with text about somites and limb development. It features two small images: one of a developing upper limb bud and another showing changes in external appearance. A "Comments" section on the right shows a user profile and a comment stating: "This page is an overview of Limb development covering a few key issues on pattern formation and mesoderm development with links to additional resources." The page also includes a "Google Embryo" search box and a "New 2010 Site" announcement.



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