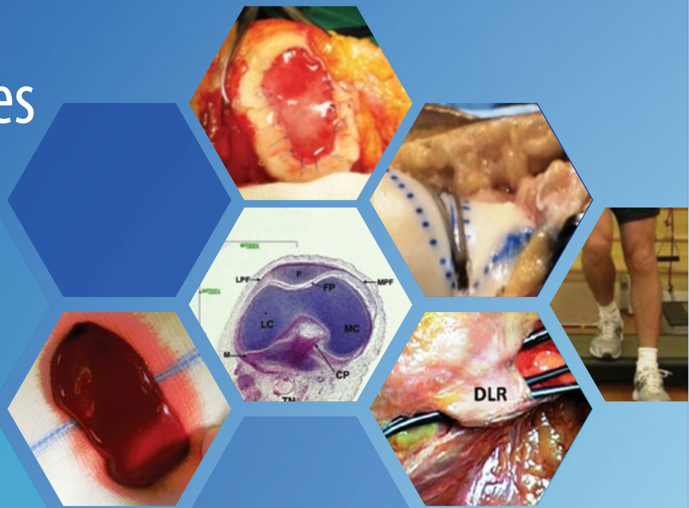
Alberto Gobbi
João Espregueira-Mendes
Norimasa Nakamura
Editors



The Patellofemoral Joint

State of the Art in Evaluation and Management

International Society of Arthroscopy, Knee Surgery & Orthopaedic Sports Medicine • 1995 •

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Editors
Alberto Gobbi
Orthopaedic Arthroscopic Surgery
International (O.A.S.I.) Bioresearch
Foundation, Gobbi N.P.O.
Milan
Italy

Norimasa Nakamura
Department of Orthopaedics
Osaka Health Science University
Osaka
Japan

Department of Rehabilitation Science
Osaka University
Center for Advanced Medical
Engineering and Informatics,
Osaka
Japan

João Espregueira-Mendes
Clínica do Dragão – Espregueira-
Mendes Sports Centre – FIFA
Medical Centre of Excellence
Porto
Portugal

ICVS/3B's Research Group – Biomaterials
Biodegradables and Biomimetics
University of Minho
Headquarters of the European
Institute of Excellence on Tissue
Engineering and Regenerative Medicine
Guimarães
Portugal

Department of Orthopaedics
Minho University
Braga
Portugal

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“Dedicated to my father Augusto and my son Nicolò, who together with my Family, taught me that life is a constant journey. Dedicated to all my Friends, who believed this dream might become true.”

Preface

It is our great pleasure to introduce the new book *The Patellofemoral Joint: State of the Art in Evaluation and Management.*

A medical education, where basic science together with medical innovations and state of the art in surgical techniques are indispensable, is an important challenge. ISAKOS wants to provide an educational umbrella in which all would collaborate and benefit. This is intended to leverage the education skills in arthroscopy, knee surgery and orthopedic sports medicine around the world.

Patellofemoral joint pathologies represent common but difficult-to-treat entities, due to the difficulty in elucidating the etiology of anterior knee pain as well as in restoring back to normal patellar tracking and stability. If untreated, repetitive trauma due to altered joint surface contact pressures can result in significant loss of articular cartilage, progressive degenerative changes of the patellofemoral joint and development of osteoarthritis. Currently, there has been remarkable progress in anatomy, biomechanics and biology related to patellofemoral joint treatment. Improved rehabilitation strategies are now available together with novel conservative or surgical procedures, with the aim to address biological problems utilizing biological solutions.

ISAKOS has given us a special opportunity to invite international orthopedic surgeons and researchers all over the world to provide their specific insights into patellofemoral problems. Originally conceived as a small booklet at the ISAKOS Congress in Toronto in June 2013, this work quickly turned into a major project, involving more than 35 authors worldwide. We invited orthopedic surgeons, physiotherapists, and researchers from all over the world to provide their specific research works related to patellofemoral problems. As a result, we have organized a comprehensive review on a global overview of the physiology, pathology, diagnosis and treatment options. We are confident this special issue will not only cover all the essential issues to be learned by young doctors and researchers, but also will manage to offer the most advanced suggestions specifically in the new treatment options and diagnosis.

Our hope is that this book will be also valuable for all clinicians and researchers interested in the patellofemoral joint and its disorders and will represent an outstanding reference in the future for the treatment of this unique joint structure. Our effort in this book was to give no less.

Milan, Italy — Alberto Gobbi
Porto, Portugal — João Espregueira-Mendes
Osaka, Japan — Norimasa Nakamura

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Introduction

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Alberto Gobbi, João Espregueira-Mendes,
and Norimasa Nakamura

Medical education represents a challenge worldwide. ISAKOS intends to leverage education and plays a role in the field of orthopedic sports medicine around the world, providing equal opportunities among its members. Uneven realities described and emphasized by fellows and residents, arriving from all around the world, along with their extraordinary learning skills and strong motivation, made us realize that ISAKOS had the responsibility to provide an educational umbrella in which all agents could collaborate and profit. This assumed an important role and it is today an admirable ongoing reality. Therefore, in one unparalleled determination and effort supported by many, we can bring you into high-performing educational sets, no matter what zip code you live in. We will join you or you will be joining us in this priceless educational mission. Consequently, this book shows the most advanced techniques with ultimate technologies under the guidance of globally renowned experts.

In this book dedicated to patellofemoral joint, the reader will be able to get acquainted with the state of the art in this subject. This knowledge conveys a comprehensive and friendly resource of education. It is a secure value and an important reflex of authors' commitment to ISAKOS educational mission. The intelligibility, interest, and actuality of the reading you are about to begin consubstantiate a catch-up that, we believe, will contribute to provide the best health care to our patients. Science and skills brought to you by this group of authors arise from an intense willing of helping on behalf of better quality of life. ISAKOS strives to give no less.

A. Gobbi (✉)
Orthopaedic Arthroscopic Surgery International (O.A.S.I.)
Bioresearch Foundation, Gobbi N.P.O., Milan, Italy
e-mail: gobbi@cartilagedoctor.it

J. Espregueira-Mendes
Clínica do Dragão – Espregueira-Mendes Sports
Centre – FIFA Medical Centre of Excellence,
F.C. Porto Stadium, 4350-415 Porto, Portugal

ICVS/3B's Research Group – Biomaterials,
Biodegradables and Biomimetics, University of Minho,
Headquarters of the European Institute of Excellence on
Tissue Engineering and Regenerative Medicine,
Caldas das Taipas, Guimarães, Portugal

Department of Orthopaedics,
Minho University, Braga, Portugal
e-mail: jem@espregueira.com

N. Nakamura
Department of Orthopaedic Surgery,
Osaka University Graduate School of Medicine,
2-2 Yamadaoka, Suita,
Osaka 565-0871, Japan
e-mail: norimasa.nakamura@ohsu.ac.jp

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2 Morphogenesis of the Patellofemoral Joint

Pedro Guillen-Garcia
and José Francisco Rodríguez-Vázquez

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The development of the patella and the femoropatellar joint is intimately related to the development of the tendon of quadriceps and the knee joint which are integrated morphologically and functionally, providing the articular component for the extension mechanism.

After 6 weeks of development, a band of mesenchymal tissue is displayed between the femur and tibia which were in a chondrification process that corresponded to the articular homogeneous interzone [3, 12]. The anlage of the patella appeared as a slight mesenchymal condensation located between the femoral condyles and the anlage of the tendon of the quadriceps muscle [3, 10]. The latter is differentiated from the patellar area forming a continuous condensed mesenchymal band, which is extended from the quadriceps muscle to the anlage of the tibia (Fig. 2.1).

The differentiation of the anlage of the patella is much more evident after 7 weeks of development (Fig. 2.2). It appears dorsally, in contact with the quadriceps tendon and separated from the inferior end of the femur by an area of loose mesenchymal tissue. The chondrification continues at the inferior end of the femur and at the superior end of the tibia, thus resulting in the origination of the femoral condyles and the superior surface of the tibia (Fig. 2.3). The femorotibial interzone is formed by two eccentric bands of mesenchymal tissue which cover the condyles of the femur and the superior surface of the tibia and a medial band that is loose in comparison with the eccentric bands, which corresponded to the three-layered interzone (Figs. 2.2 and 2.3).

P. Guillen-Garcia (✉)
Trauma Unit, Clinica Cemtro, Madrid, Spain

Unidad de Investigation Biomedica, Madrid, Spain

Universidad Catolica San Antonio
de Murcia, Murcia, Spain
e-mail: pedroguillen612@gmail.com

J.F. Rodríguez-Vázquez
Clinica Cemtro, Madrid, Spain

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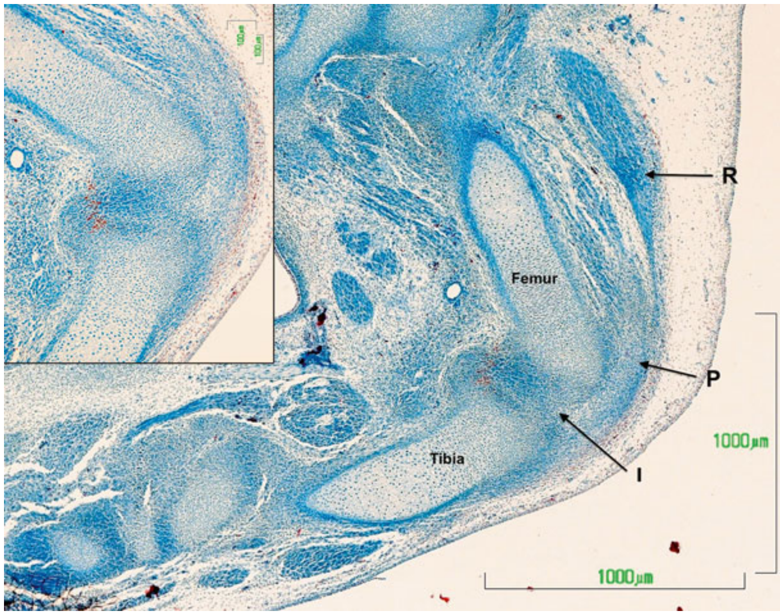

Fig. 2.1 Human fetus at 6 weeks of development (16 mm GL, 18 Carnegie stage). Sagittal section of the left lower limb. Formation of the interzone between the femur and the tibia (*I*) and appearance of the anlage of the patella (*P*). Rectus femoris muscle (*R*)

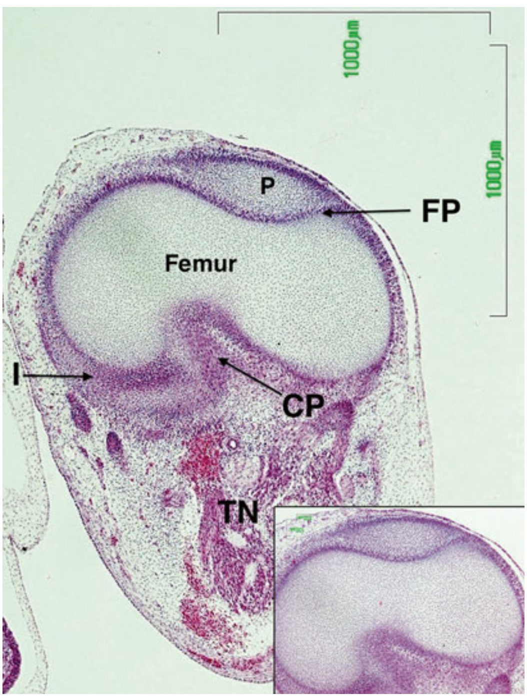

Fig. 2.2 Human fetus at 7 weeks of development (20 mm GL, 20 Carnegie stage). Transverse section of the femoropatellar joint. Differentiation of the patella (*P*) and formation of the interzone of the femoropatellar joint (*FP*). Cruciate posterior ligament (*CP*). Femorotibial interzone (*I*). Tibial nerve (*TN*)

The patellar anlage increases, configuring a harmonious and uniform formation [7]. The more advanced chondrification of both the femur and the anlage of the patella clearly defines them, identifying a fine mesenchymal band which forms the femoropatellar interzone (Fig. 2.2). The mesenchyme condenses cranially and caudally at the patella making both the tendon of quadriceps muscle and the patellar tendon evident (Fig. 2.3). At this stage, the formation of the cruciate ligaments has also begun, the posterior cruciate ligament becoming identifiable earlier than its counterpart [10] (Fig. 2.2).

Two anlagen appear at the end of the 7 weeks: the suprapatellar bursa which was observed as a small cavity, dorsally to the tendon of quadriceps and cranially to the patella, and the first sign of the cavitation of the femoropatellar joint [4, 9, 3]. The fibers of the quadriceps tendon begin to appear visible at its attachment, on the patella base (Fig. 2.4).

After 8 weeks of development, the cavitation of the femoropatellar interzone is evident, while the patella is in a clear phase of chondrogenesis (Fig. 2.5). At the femoral and tibial condyles, a dense band of connective tissue is formed, which marks the first sign of organization of the articular cartilage. The densification to initiate the formation

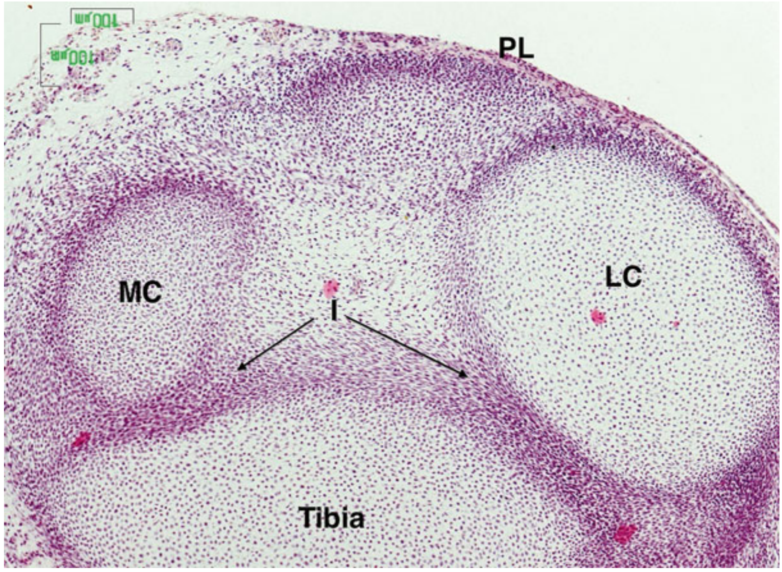

Fig. 2.3 Human fetus at 6 weeks of development (20 mm GL, 20 Carnegie stage). Transverse section of the patellar tendon (*PL*). Femorotibial interzone (*I*). Lateral condyle (*LC*). Medial condyle (*MC*)

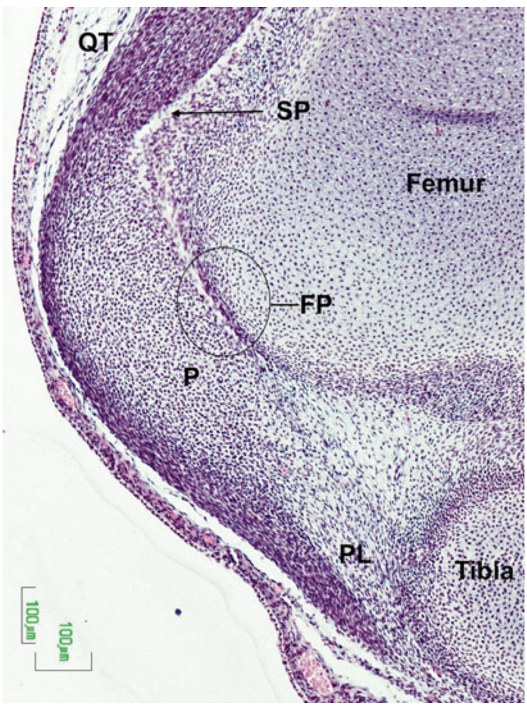

Fig. 2.4 Human fetus at 7 weeks of development (22 mm GL, 21 Carnegie stage). Sagittal section of the femoropatellar joint. Beginning of the cavitation of the femoropatellar interzone (*FP*). Patella (*P*), Patellar tendon (*PL*), Tendon of quadriceps (*QT*), Suprapatellar bursa (*SP*)

of the menisci increases at the lateral parts of the femorotibial interzone [6], with small cavities between the menisci and the condyles of the femur and tibia (Fig. 2.6) appearing laterally and at interlayer level. On the contrary, the interzone of the superior tibiofibular joint is visible without signs of cavitation (Fig. 2.6). The cruciate ligaments are clearly visible at the intercondylar notch (Fig. 2.5), surrounded by a poorly organized mesenchyme which contains many vascular elements.

From the margins of the patella, the articular capsule surrounds the femoral condyles and attaches itself to the external surface of the menisci. The formation of the patellofemoral ligaments has also commenced (Fig. 2.5). The articular cavities of the femoropatellar, femoromeniscal and meniscotibial joints now became apparent.

After 9 weeks of development, the patella faces the femoral trochlea (Fig. 2.7). The topographical arrangement of the fibers which form the quadriceps tendon and its length on the superficial aspect of the patella become apparent, constituting the patellar tendon which reaches up to the developing tibial tuberosity (Fig. 2.7). Below the patella, deeper than the patellar ligament and ventrally to the anterior cruciate ligament, there

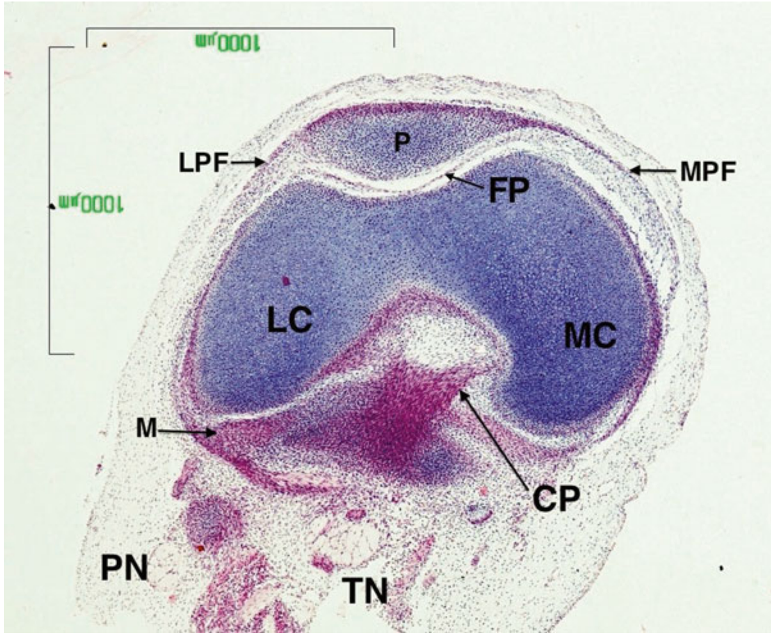

Fig. 2.5 Human fetus at 8 weeks of development (28.5 mm GL, 23 Carnegie stage). Transverse section of the femoropatellar joint. Formation of the cavity in the femoropatellar joint (*FP*). Cruciate posterior ligament (*CP*). Lateral meniscus (*M*), Lateral condyle (*LC*), Medial condyle (*MC*), Lateral patellofemoral ligament (*LPF*), Medial patellofemoral ligament (*MPF*), Patella (*P*), Common peroneal nerve (*PN*), Tibial nerve (*TN*)

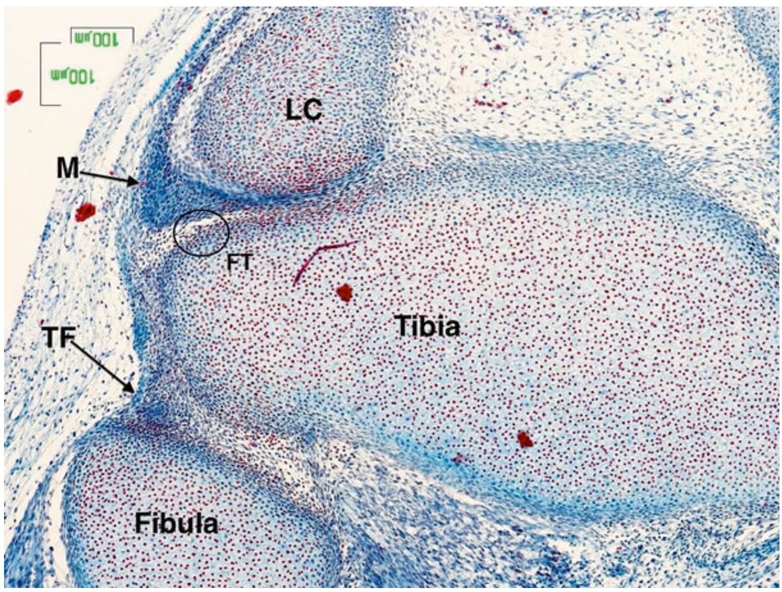

Fig. 2.6 Human fetus at 8 weeks of development (28.5 mm GL, 23 Carnegie stage). Transverse section of the knee and the tibiofibular joint (*TF*). Beginning of the formation of the menisci (*M*) and the cavitation of the femorotibial interzone (*FT*). Lateral meniscus (*M*), Lateral condyle (*LC*)

is a loose mesenchyme mass arranged as a septum forming the medial septum or mediastinum, the anlage of the fat pad ligament (Fig. 2.8).

In weeks 10 and 11, the progressive reduction of the medial wall and its further arrangement consequently forms the fat pad ligament [2, 7] with the presence of collagen fibers as well as the regression of the remaining mesenchymal tissue limited by the space between the posterior aspect and inferior border of the patella together with the prespinal portion of the tibia, both of which determine that the joint will have a similar

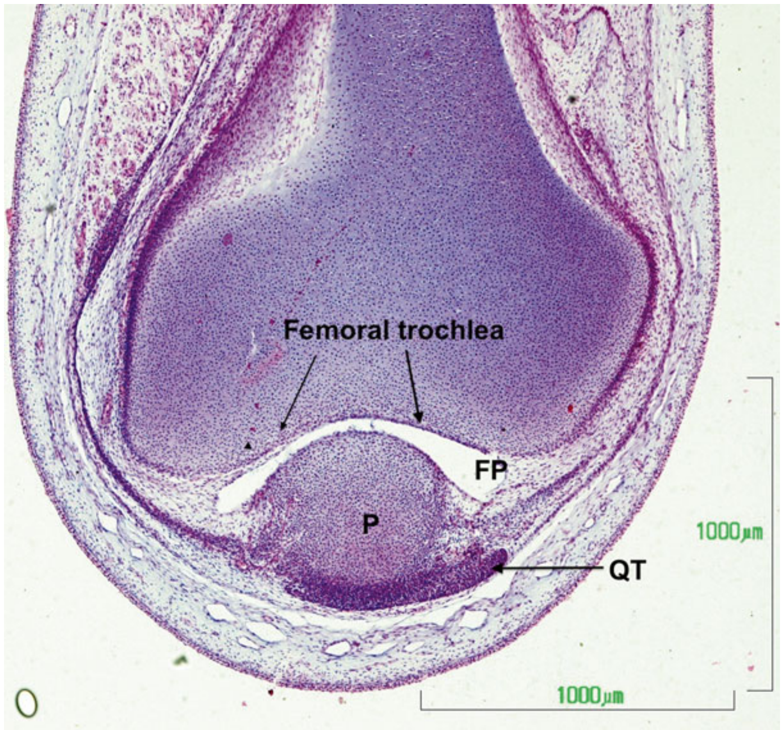

Fig. 2.7 Human fetus at 9 weeks of development (38 mm GL). Frontal section of the femoropatellar joint (*FP*). Patella (*P*), Tendon of quadriceps (*QT*)

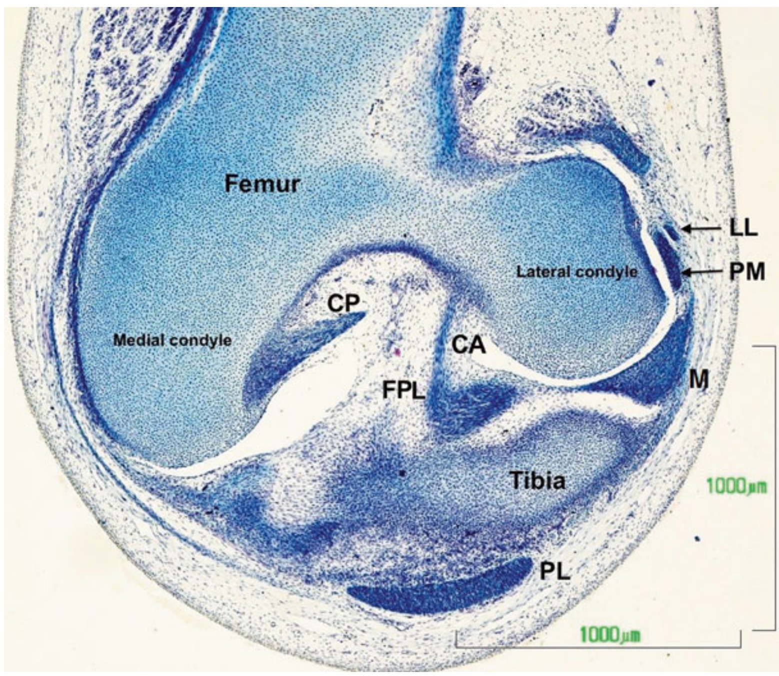

Fig. 2.8 Human fetus at 9 weeks of development (38 mm GL). Frontal section of the knee joint and the patellar tendon (*PL*). Formation of the anlage of the fat pad ligament (*FPL*). Anterior cruciate ligament (*CA*), Posterior cruciate ligament (*CP*), Fibular collateral ligament (*LL*), Popliteus muscle (*PM*), Lateral meniscus (*M*)

morphology to what it will be in adulthood. The posterior cruciate ligament attaches itself to the posterior area of the articular surface of the tibia and extends dorsoventrally trough the internal aspect of the medial condyle of the femur. The anterior cruciate ligament extends from the anterior part of the surface of the tibia to the internal aspect of the lateral condyle of the femur and in

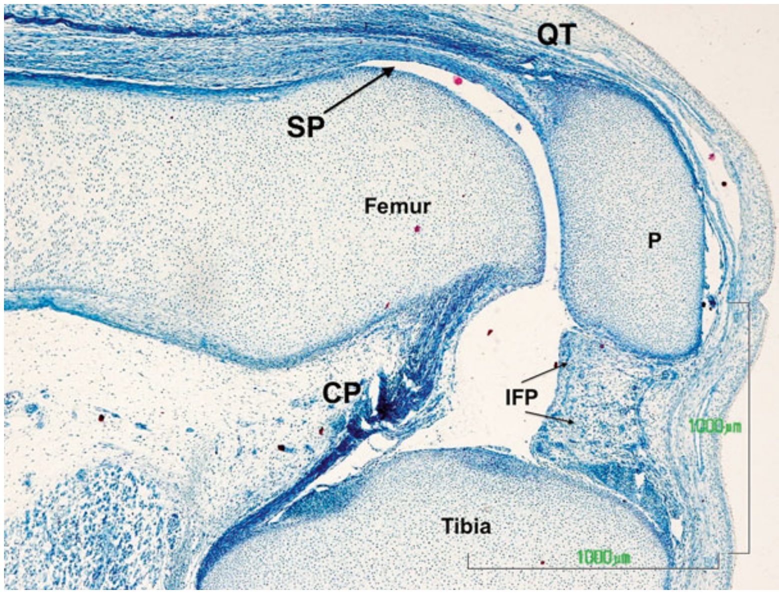

Fig. 2.9 Human fetus at 10 weeks of development (47 mm GL). Sagittal section of the knee and the femoropatellar joint. Topographical arrangement of the suprapatellar bursa (*SP*), intrapatellar fat pad (*IFP*) and the posterior cruciate ligament (*CP*). Patella (*P*), Tendon of quadriceps (*QT*)

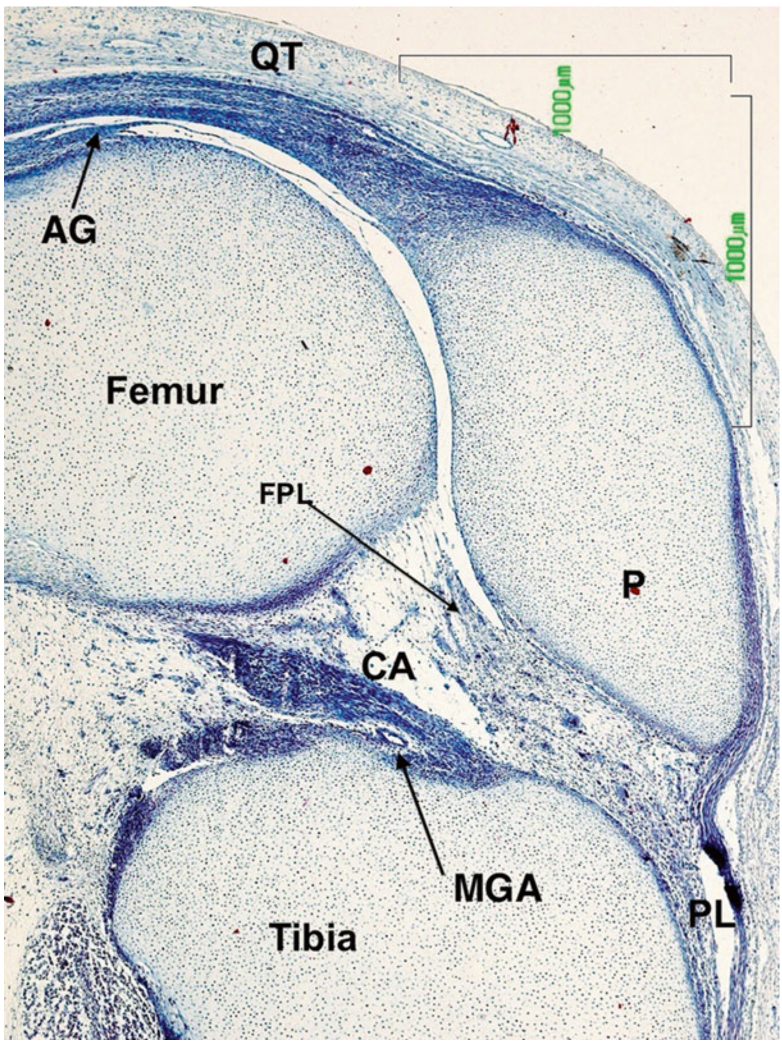

Fig. 2.10 Human fetus at 10 weeks of development (47 mm GL). Sagittal section of the knee and the femoropatellar joint. Topographical arrangement of the anterior cruciate ligament (*CA*) and fat pad ligament (*FPL*). Patella (*P*), Patellar tendon (*PL*), Articularis genus muscle (*AG*), Middle genicular artery (*MGA*), Tendon of quadriceps (*QT*)

relation to the fat pad ligament. Also, the lateral articular surface of the patella clearly starts to be larger than the medial one. The suprapatellar bursa extends to the femoral diaphysis, on which a little contingent of muscular fibers appears, the anlage of the articular muscle of knee or articularis genus muscle. However, the suprapatellar bursa is not totally completed until weeks 14–15 of development [4, 10, 11].

After 12–13 weeks, the articular cavity of the knee has reached its adult appearance since the communicating structure between the lateral meniscotibial cavity and the superior tibiofibular cavity [5], the latter previously formed at 11 weeks, disappears [1] giving way to the fully completed organization of the ligaments of the knee joint.

After 14 weeks, the ossification of the patella commences with cartilage canals penetrating from the anterior and superior surfaces. The patella increases its relative size until the sixth month of fetal life, after which it will follow the same ratio as other bones of the lower limb [8].

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Patellofemoral Anatomy

3

Pedro Guillen-Garcia, Vicente Concejero-Lopez, Jose F. Rodriguez-Vazquez, Isabel Guillen-Vicente, Marta Guillen Vicente, and Tomas F. Fernandez-Jaén

Contents

P. Guillen-Garcia (✉) • V. Concejero-Lopez
J.F. Rodriguez-Vazquez • I. Guillen-Vicente
M.G. Vicente • T.F. Fernandez-Jaén
Trauma Unit, Clinica Cemtro, Madrid, Spain
e-mail: pedroguillen612@gmail.com

3.1 Introduction

The femororotulian joint situated on the anterior side of the knee is made up of the kneecap and the femoral trochlea as joint components. It works as a reflection pulley through the flexo-extension movements of the knee similar to the way a mechanical pulley slides, the kneecap being the footing for the transmission of forces. The femororotulian joint has been the forgotten compartment of the knee for quite a while now. Its anatomy (Fig. 3.1), biomechanics, and function are well known, but there are unfinished business:

1. The origin of pain; the true value of cartilage damage
2. The adequate diagnostic means
3. The reliability of surgical techniques

In this chapter, we will try to explain all the relevant anatomical data that explain the femororotulian biomechanics and pathology.

3.2 Morphology

According to Jiménez Collado, P Guillen Garcia, and Sobrado Perez [1], the kneecap can be studied theoretically through its anterior or superficial side, posterior side, and deep or articular side and also through its upper or base rim, lower vertex or angle, and lateral rims.

On the morphological level, the kneecap is a transverse edged trochlear arthrosis with a degree of freedom of movement. The arrangement of the

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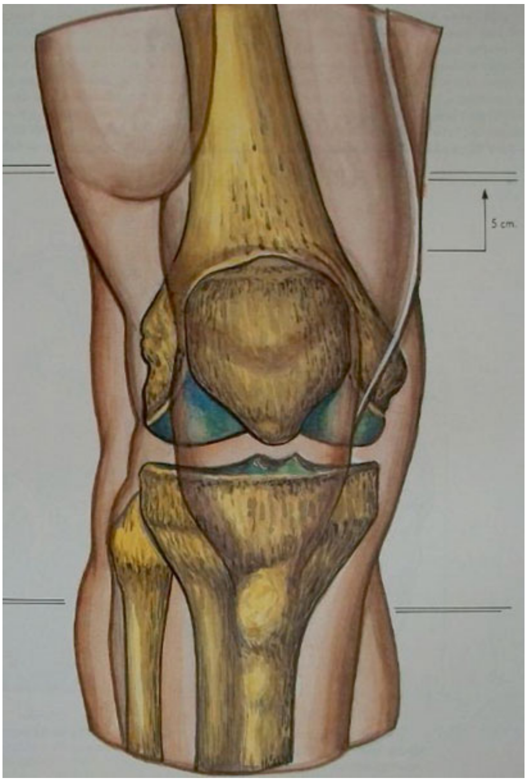

Fig. 3.1 Schematic view of the anterior side of right kneecap and boundaries (Licensed by Jimenez Collado et al. [1])

femoral trochlea and the deep articular side determines the degree of the kneecap lateral instability during the first degrees of bending and the major overload of one of its articular sides on the other. Wiseber classification is prototypical: type I, both articular sides are concave and significantly of the same amplitude; type II, lower internal concave side than the external one; and the most common of all, type III, internal convex side with a small surface borderlining patellar hypoplasia. On the other hand, the normal trochlear angle is 140°; larger angles cause a greater degree of lateral instability; lower angles are more likely to cause cartilage involvement (Fig. 3.2).

When it comes to the femur, the rotulian cartilage footing on the femoro-trochlear cartilage can be established according to the various degrees of bending [1, 3]:

- From 0° to 10°: Only the rotulian cartilage lower part contacts the trochlea – low lateral rotulian stability.
- From 10° to 30°: The rotulian cartilage lower part contacts the upper side of the trochlea – greater rotulian stability.
- From 30° to 60°: The rotulian cartilage lower part contacts the medial side of the trochlea, and a geometrical dynamic fitting of the kneecap and the trochlea occurs – the degree of biomechanical stability is just perfect.
- From 60° to 90°: The kneecap upper side rests on the lower side of the trochlear area.
- Over 90°: The kneecap enters the intercondylar notch and only the marginal parts of its sides – specially the lateral ones – make the femorotibial contact.

The ligament and tendon structures for rotulian support formed by the quadriceps tendon and its insertion in the upper rim of the kneecap; the rotulian tendon inserted in the lower rim, typically called by the anatomist rotulian ligament since it goes through from bone to bone; and the external and internal rotulian retinacula make up what we know as the cruciform elements (Fig. 3.3). We can see this cross-like arrangement of the rotulian ligament and tendon structures in a 30 mm fetus, and if tendons transmit muscle strength to the rotulian retinacula, they act as a joint guide and controllers.

Different pathologies are associated to such cross-like arrangement based on the length between the rotulian tendon and the kneecap which frames the upper or lower patella – the longer the rotulian tendon, the weaker the medial stabilizers. When alterations depend on the angle made up of the quadricipital tendon medial line and the rotulian tendon medial line, the decompensation of the force vectors increases or reduces the lateral rotulian instability. Also the greater or lesser tension variation between retinacula or reduction of one retinaculum with respect to the other can unleash factors of rotulian inclinations at the axial level and a greater or lesser degree of instability [1, 3].

The internal rotulian retinaculum is made up of three layers. The most important of all from the point of view of rotulian semiology is the intermediate layer where we find the medial patellofemoral ligament, MPFL, as the main stabilizer together with the medial patellotibial ligament, MPTL, and