Operative Techniques: Knee Surgery

Second Edition

Mark D. Miller, MD

S. Ward Casscells Professor
Department of Orthopaedics
University of Virginia
Charlottesville, Virginia

James A. Browne, MD

Associate Professor and Division Head of Adult Reconstruction
University of Virginia
Charlottesville, Virginia

Brian J. Cole, MD, MBA

Professor
Department of Orthopaedic Surgery
Rush University Medical Center
Chicago, Illinois

Andrew J. Cosgarea, MD

Professor
Department of Orthopaedic Surgery
Johns Hopkins University
Baltimore, Maryland

Brett D. Owens, MD

Professor of Orthopaedic Surgery
Brown University Alpert Medical School
Providence, Rhode Island

ELSEVIER

ELSEVIER

1600 John F. Kennedy Blvd.
Ste 1800
Philadelphia, PA 19103-2899

OPERATIVE TECHNIQUES: KNEE SURGERY, SECOND EDITION ISBN: 978-0-323-46292-1

Library of Congress Cataloging-in-Publication Data

Names: Miller, Mark D., editor. | Browne, James A., editor. | Cole, Brian J., editor. | Cosgarea, Andrew J., editor. | Owens, Brett D., 1972- editor.
Title: Knee surgery / [edited by] Mark D. Miller, James A. Browne, Brian J. Cole, Andrew J. Cosgarea, Brett D. Owens.
Other titles: Knee surgery (Miller) | Preceded by (work): Sports knee surgery. | Operative techniques.
Description: Second edition. | Philadelphia, PA : Elsevier, [2018] |
Series:
Operative techniques | Preceded by Sports knee surgery / [edited by] Mark D. Miller,... [et al.] ; associate editors, Ammar Anbari, Geoffrey S. Baer. Philadelphia, PA : Saunders/Elsevier, c2008. | Includes bibliographical references and index.
Identifiers: LCCN 2016053067 | ISBN 9780323462921 (hardcover : alk. paper)
Subjects: | MESH: Knee--surgery | Knee Injuries--surgery | Orthopedic Procedures--methods | Atlases
Classification: LCC RD561 | NLM WE 17 | DDC 617.5/82059--dc23 LC record available at https://lccn.loc.gov/2016053067

Content Strategist: Kayla Wolfe
Content Development Specialist: Laura Schmidt
Publishing Services Manager: Catherine Jackson
Senior Project Manager: Rachel E. McMullen
Design Direction: Amy Buxton

Printed in China

Last digit is the print number: 9 8 7 6 5 4 3 2 1

Contributors

Ammar Anbari, MD
Orthopedic Partners
North Franklin, Connecticut

James A. Browne, MD
Associate Professor and Division Head of Adult Reconstruction
University of Virginia
Charlottesville, Virginia

Andrew J. Bryan, MD
Resident
Mayo Clinic
Rochester, Minnesota

M. Tyrrell Burrus, MD
Resident Physician
Orthopaedic Surgery
University of Virginia Health System
Charlottesville, Virginia

Jourdan M. Cancienne, MD
Department of Orthopaedic Surgery
University of Virginia Health System
Charlottesville, Virginia

S. Evan Carstensen, MD
Resident Physician
Department of Orthopaedic Surgery
University of Virginia
Charlottesville, Virginia

Brian J. Cole, MD, MBA
Professor
Department of Orthopaedic Surgery
Rush University Medical Center
Chicago, Illinois

Andrew J. Cosgarea, MD
Professor
Department of Orthopaedic Surgery
Johns Hopkins University
Baltimore, Maryland

Matthew M. Crowe, MD
Southern California Orthopedic Institute
Van Nuys, California

Diane L. Dahm, MD
Professor of Orthopedics
Mayo Clinic
Rochester, Minnesota

Craig J. Della Valle
Professor
Department of Orthopaedic Surgery
Rush University Medical Center
Chicago, Illinois

Ian J. Dempsey, MD
Chief Resident
Department of Orthopaedic Surgery
University of Virginia
Charlottesville, Virginia

David R. Diduch, MS, MD
Alfred R. Shands Professor of Orthopaedic Surgery
Vice Chairman, Department of Orthopaedic Surgery
Head Orthopaedic Team Physician
University of Virginia
Charlottesville, Virginia

Kevin W. Farmer, MD
Associate Professor
Orthopaedic Surgery
University of Florida
Gainesville, Florida

Rachel M. Frank, MD
Department of Orthopaedic Surgery
Rush University Medical Center
Chicago, Illinois

Matthew E. Gitelis, BS
Orthopaedic Research Fellow
Rush University Medical Center
Chicago, Illinois

Justin W. Griffin, MD
Sports and Shoulder Surgery Fellow
Orthopaedic Surgery
Rush University Medical Center
Chicago, Illinois

F. Winston Gwathmey, MD
Assistant Professor
Orthopaedic Surgery
University of Virginia
Charlottesville, Virginia

Peter A. Knoll, MD
Fellow in Adult Reconstruction
University of Virginia
Charlottesville, Virginia

Benjamin Lehrman, BS
Orthopedic Surgery
Rush University Medical Center
Chicago, Illinois

Timothy S. Leroux, MD
Fellow
Department of Orthopaedic Surgery
Rush University Medical Center
Chicago, Illinois

Eric C. Makhni, MD, MBA
Sports Medicine Fellow
Department of Orthopaedic Surgery
Rush University Medical Center
Chicago, Illinois

Mark A. McCarthy, MD
Orthopaedic Sports Medicine Fellow
Rush University Medical Center
Chicago, Illinois

Maximilian A. Meyer, BS
Research Assistant
Department of Orthopaedic Surgery
Rush University Medical Center
Chicago, Illinois

J. Ryan Macdonell, MD
Fellow in Adult Reconstruction
University of Virginia
Charlottesville, Virginia

Mark D. Miller, MD
S. Ward Casscells Professor
Department of Orthopaedics
University of Virginia
Charlottesville, Virginia

O. Brant Nikolaus, MD
Resident
Mayo Clinic
Rochester, Minnesota

Louis Okafor, MD
Resident
Department of Orthopaedic Surgery
Johns Hopkins University
Baltimore, Maryland

Lucy Oliver-Welsh, MBChb
Department of Trauma and Orthopaedics
Tunbridge Wells Hospital
Tunbridge Wells
Kent, England

Brett D. Owens, MD
Professor of Orthopaedic Surgery
Brown University Alpert Medical School
Providence, Rhode Island

Sarah G. Poland, MD
Sports Research Fellow
Department of Orthopaedic Surgery
Rush University Medical Center
Chicago, Illinois

John Pollack, BS
Georgetown University School of Medicine
Washington, D.C.

Jay S. Reidler, MD, MPH
Resident Physician
Department of Orthopaedic Surgery
Johns Hopkins University
Baltimore, Maryland

Dustin L. Richter, MD
Sports Medicine Fellow
Orthopaedic Surgery
University of Virginia
Charlottesville, Virginia

Andrew J. Riff, MD
Sports Medicine Fellow
Department of Orthopedics
Rush University Medical Center
Chicago, Illinois

Bryan M. Saltzman, MD
Resident, Orthopaedic Surgery
Rush University Medical Center
Chicago, Illinois

Miho J. Tanaka, MD
Assistant Professor
Department of Orthopaedic Surgery
Johns Hopkins University
Baltimore, Maryland

Michael J. Taunton, MD
Assistant Professor of Orthopedics
Mayo Clinic
Rochester, Minnesota

Atsushi Urita, MD, PhD
Department of Orthopaedic Surgery
Rush University Medical Center
Chicago, Illinois

Brian R. Waterman, MD
Director of Orthopaedic Research
Department of Orthopaedic Surgery and Rehabilitation
William Beaumont Army Medical Center
El Paso, Texas

Alexander E. Weber, MD
Assistant Professor
Director
Section of Primary Care Sports Medicine and Primary Care Sports Medicine Fellowship Program
Rush University Medical Center
Chicago, Illinois

Lucy Oliver-Welsh, MBChB
Department of Orthopaedic Surgery
Rush University Medical Center
Chicago, Illinois

John H. Wilckens, MD
Associate Professor
Orthopaedic Surgery
Johns Hopkins University School of Medicine
Baltimore, Maryland

Adam B. Yanke, MD
Assistant Professor
Department of Orthopaedic Surgery
Rush University Medical Center
Chicago, Illinois

Preface

It is with sincere pride and gratitude that we present the second edition of ***Operative Techniques: Knee Surgery***. This work is a culmination of several years of planning, writing, editing, and publishing what is perhaps in the top 10% of most modified second editions in all of medical publishing. In fact, one might argue that this publication does not even qualify as a second edition. The first edition was entirely focused on Sports Medicine Knee Surgery. This edition includes an entire section on total knee arthroplasty, and therefore includes all of knee surgery—hence the title change.

In addition to several new chapters and major reworks of old ones, this edition greatly benefited from the contributions of associate editors. These surgeons were carefully selected to bring new life and exciting updates from recently trained specialists, and they have done a superb job! Special thanks also to Rachel McMullen, Katy Meert, Laura Schmidt, and the whole Elsevier "family" in producing this excellent text. It truly has been a labor of love, and, like many projects, we have learned much in writing and editing this book and are sure that you will learn more in reading and studying it. We certainly hope that this edition finds a place not only on your bookshelf but also in your clinic and operating room.

Editors:
Mark D. Miller, MD
James A. Browne, MD
Brian J. Cole, MD, MBA
Andrew J. Cosgarea, MD
Brett D. Owens, MD

Associate Editors:
F. Winston Gwathmey, MD
Miho Jean Tanaka, MD
Michael J. Taunton, MD
Brian R. Waterman, MD
Adam B. Yanke, MD

PROCEDURE 1

Knee Examination and Imaging

Brian R. Waterman and Brett D. Owens

KNEE HISTORY AND PHYSICAL EXAMINATION

History

- Chief complaint
- Patient age
- Duration and progression of symptoms
- Mechanism of injury
  - Contact/noncontact
  - Overuse
  - Twisting or pivoting
  - "Pop"
  - Swelling/effusion: immediate versus delayed onset
- Location and/or type of symptoms
  - Pain
    - Anterior, posterior, medial, and/or lateral
    - Localized or global
  - Instability/"giving way"
  - Catching
  - Locking
  - Swelling
  - Activities that exacerbate symptoms
  - Alleviating factors
- Prior knee injury and/or surgery
- Previous treatment
  - Physical therapy
    - Duration
    - Modalities
    - Response to treatment
  - Injections
    - Type
    - Quantity
    - Response
- Sports participation
- Occupation
  - Worker's compensation
- Medico-legal considerations (e.g., litigation)
- Sources of secondary gain

General Physical Examination

- Height, weight, body mass index
- Observation
  - Soft-tissue swelling/effusion
  - Deformity
- Standing clinical limb alignment with knee extended and feet together (Fig. 1.1)
  - Varus/valgus malalignment
- Pelvic obliquity/leg length
- Foot/ankle
  - Planovalgus
  - Cavovarus

FIG. 1.1

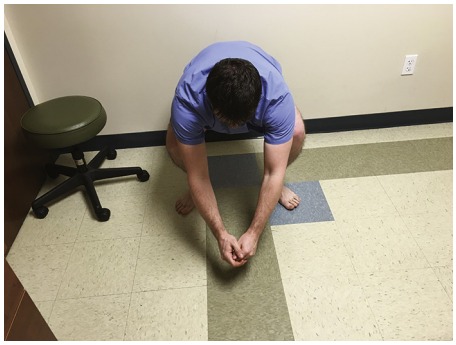


FIG. 1.2

FIG. 1.3

FIG. 1.4

- Squatting maneuver (Fig. 1.2)
  - The patient is asked to squat in a position of deep knee flexion to assess for sites of provocative pain
  - Pain
    - Meniscal
    - Patellofemoral
  - Weakness
- Gait
  - Dynamic varus thrust: posterolateral corner (PLC) injury of insufficiency
  - Bent knee gait: flexion contracture
  - Antalgic gait
  - Quadriceps avoidance gait
- Range of motion
  - Normal: 0° to 135°
    - Contralateral comparison
  - Active extension
  - Extensor mechanism dysfunction
- Effusion
  - Ballottement or palpation of a fluid wave in the suprapatellar pouch (Fig. 1.3)
  - Quantify volume
- Quadriceps atrophy
  - Circumferential thigh measurement at a position 15 cm above the proximal pole of the patella in full extension with comparison to the uninvolved, contralateral extremity (Fig. 1.4)

FIG. 1.5

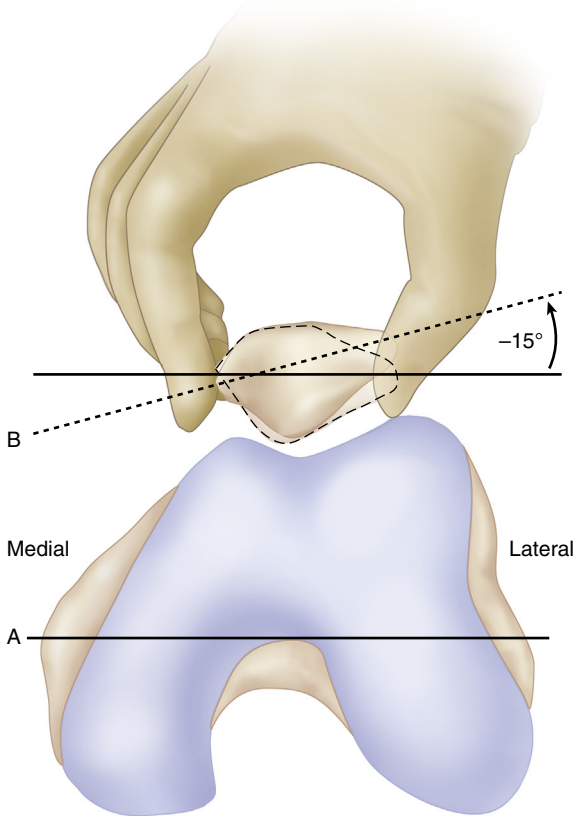


FIG. 1.6

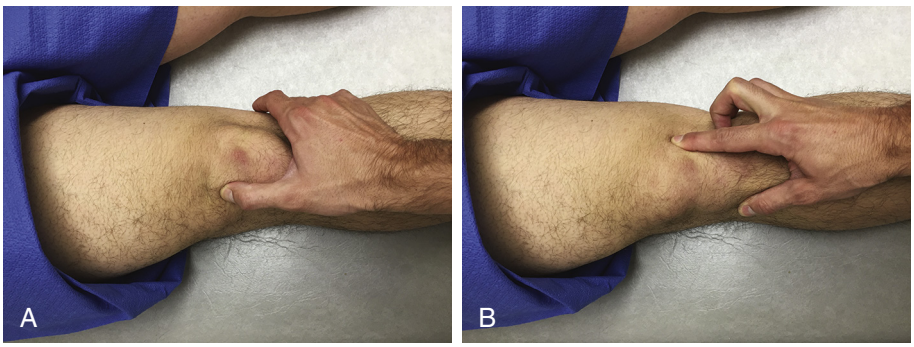


FIG. 1.7

Patellofemoral Examination

- Prepatellar bursitis
- Crepitation with range of motion
  - Pain with resisted patellofemoral grind test (Fig. 1.5)
- Patellar tracking
  - J sign—excessive lateral patella translation during terminal knee extension (Video 1.1)
- Tenderness of the medial and/or lateral facet, superior or inferior pole, medial or lateral retinacula, and tibial tubercle
- Patellar tilt
  - Passive correction to less than 0°: tight lateral retinaculum (Fig. 1.6)
  - Passive correction greater than 15°: lateral retinaculum (e.g., benign hypermobility joint syndrome, prior lateral release)
- Medial and lateral patellar glides
  - Degree of translation quantified in patellar quadrants (normal = 2 quadrants)
  - Lateral patellar glide is assessed by gently moving the patella laterally (Fig. 1.7)
    - One quadrant indicates retinacular tightness

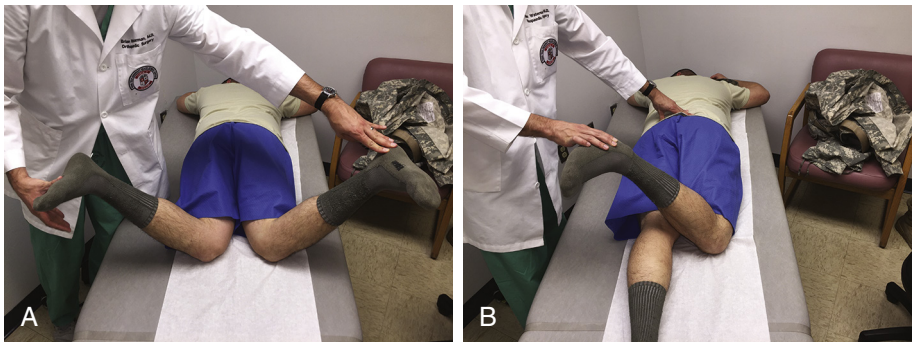


FIG. 1.8

FIG. 1.9

PATELLOFEMORAL EXAMINATION PEARLS

- Iliotibial band and posterior horn medial meniscus provide secondary restraint to anterior translation in anterior drawer test.
- Positive pivot shift test may be very specific for an ACL injury; however, it must be compared with the contralateral side as physiologic laxity does exist.
- In the posterior drawer test
  - Normal: 10 mm of tibial stepoff
  - Grade I: 3 mm to 5 mm of tibial stepoff
  - Grade II: flush with medial femoral condyle
  - Grade III: behind the medial femoral condyle
- Reducing the posterior tibia anteriorly in the posterior drawer test may give a false-positive anterior drawer test!
- If the posterior sag sign increases with external rotation, then consider PLC injury.
- Anterior tibial translation in the quadriceps active test is indicative of posterior cruciate ligament (PCL) injury.
- Opening at 30° during valgus stress testing suggests medial collateral ligament (MCL) injury. Opening at 0° suggests MCL/bicruciate ligament injury.
- Opening at 30° during varus stress testing suggests lateral collateral ligament (LCL) injury. Opening at 0° suggests LCL/bicruciate ligament injury.
- Tibia must be held in a reduced position for the external rotation dial test.
- In the external rotation dial test
  - Increased external rotation at 30° but reduced at 90° suggests PLC injury.
  - Increased external rotation at 90° but reduced at 30° suggests PCL injury.
  - Increased external rotation at both 30° and 90° suggests combined PLC and PCL injury.

  - Three or more quadrants indicates incompetent retinacular restraints
- Compare to contralateral extremity
- Apprehension
  - Subjective instability with medial or lateral patellar glide in extension and varying degrees of flexion
- Quadriceps (Q) angle measurement
  - Subtended by anterior superior iliac spine–patella–tibial tubercle angle
    - Male: 10° to 15°
    - Female: 15° to 18°
    - At 90° angles, should be less than 10°
  - Increased Q angle may lead to abnormal lateral force on patella.
- Rotational profile
  - Prone hip motion (Craig's test): internal (normal 20° to 60°) and external rotation (normal, 30° to 60°) to assess for increased femoral anteversion (Fig. 1.8)
  - Prone thigh–foot angle: normal, 0° to 20°
  - Increased femoral anteversion and increased external tibial torsion (i.e., miserable malalignment syndrome) may predispose to anterior knee pain or lateral maltracking.

Ligament Examination

Anterior Cruciate Ligament

- Lachman test (see Video 1.2)
  - Most sensitive and specific for anterior cruciate ligament (ACL) deficiency
  - Anterior translation of tibia in 20° to 30° of knee flexion with gentle anterior tibial traction while stabilizing femur (Fig. 1.9)

FIG. 1.10

FIG. 1.11

FIG. 1.12

FIG. 1.13

- Grade 1 (1 mm to 5 mm), grade 2 (6 mm to 10 mm), grade 3 (10+ mm)
- Anterior drawer test
  - Anterior translation of tibia in 90° of knee flexion (Fig. 1.10)
- Pivot shift test (see Video 1.3)
  - Difficult to perform in acute setting
  - Knee in full extension with axial load, internal rotation, and valgus: subluxation of tibia anteriorly with reduction during slow flexion at 30° (Fig. 1.11)
  - Jakob classification: grade 1 (slide), grade 2 (clunk), grade 3 (locking)

Posterior Cruciate Ligament

- Posterior drawer test (see Video 1.4)
  - Most sensitive test for PCL injury
  - Reference the anteromedial tibial stepoff to the medial femoral condyle at 90° of flexion with posteriorly directed force (Fig. 1.12).
  - Must reduce tibia anteriorly to normal anterior tibial stepoff before posterior force is applied
  - Grade 1 (anterior to condyle; 1 mm to 5 mm), grade 2 (flush with condyle, 5 mm to 10 mm), grade 3 (posterior to condyle, 10+ mm)
  - With internal rotation, posterior laxity should decrease unless PLC is also injured.
- Posterior sag sign
  - Compare to contralateral leg.
  - Check in both full extension and 90° of flexion (Fig. 1.13).
  - Check in both internal and external rotation.
- Quadriceps active test

- Active quadriceps contraction with the knee at 90° with stabilization of foot
- Anterior tibial translation or reduction indicates PCL laxity.

Posteromedial (i.e., MCL) and Posterolateral Corner (i.e., LCL)

- Valgus stress testing (see Video 1.5)
  - Valgus stress applied at 0° (Fig. 1.14A)
  - Valgus stress applied at 30° to evaluate for MCL injury (Fig. 1.14B)
- Varus stress testing (see Video 1.5)
  - Varus stress applied at 0° (Fig. 1.15A)
  - Varus stress applied at 30° (Fig. 1.15B) to evaluate for LCL injury
- External rotation dial test
  - May be performed in supine or prone position
  - Increased external rotation (>10° to 15°) is tested at both 30° (Fig. 1.16A) and 90° (Fig. 1.16B) and compared to the contralateral side.
  - May also indicate isolated or combined medial knee injury
- Reverse pivot shift test
  - Knee is held in 90° of flexion, external rotation, valgus, and an axial load.
  - Knee is slowly extended, and tibia will reduce as a shift or pivot anteriorly.

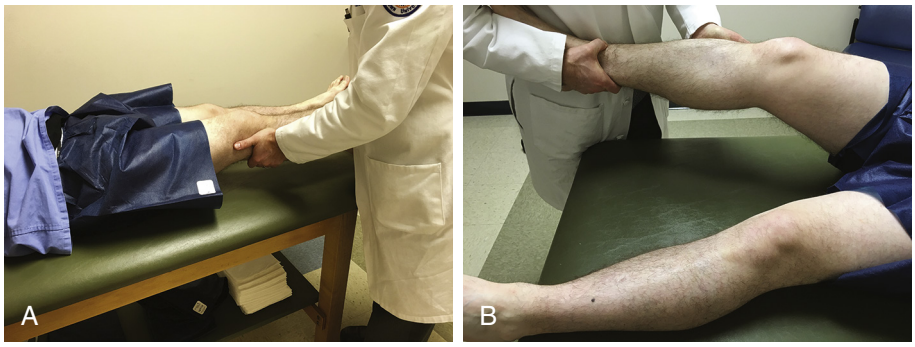


FIG. 1.14

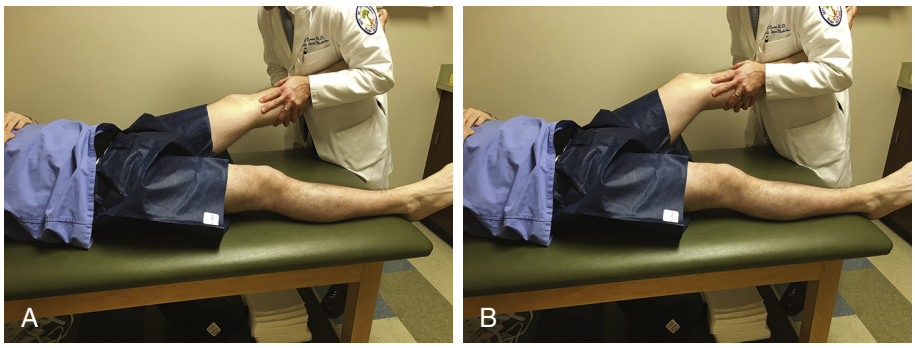


FIG. 1.15

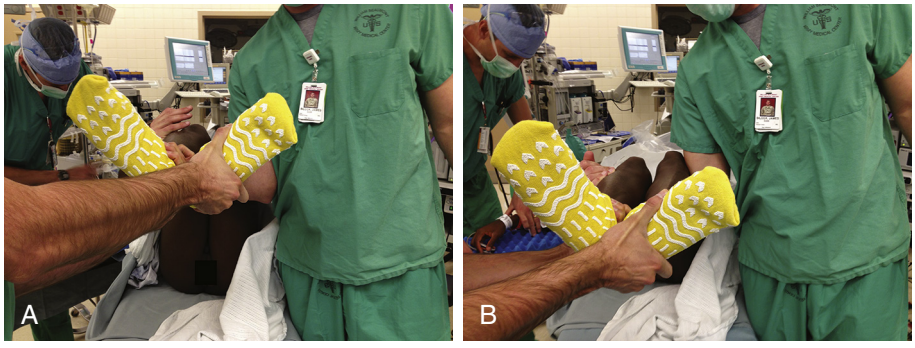


FIG. 1.16

  - Side-to-side comparison to evaluate physiological laxity versus PLC injury
- Instrumented laxity testing
  - KT-1000 or KT-2000 (Medmetric, San Diego, CA, USA) for anteroposterior (AP) laxity
    - Stress testing at 30° to evaluate for objective measure of anterior laxity and translation (Fig. 1.17)
    - Significant laxity with side-to-side differences ≥3 mm
  - SE 2000 TELOS (Telos Medical Devices, Friedberg, Germany)
    - Provides varus/valgus laxity measures with quantified pressure measures

Meniscal Examination

- Joint line tenderness
  - Palpate both medial and lateral joint line for tenderness (Fig. 1.18).
  - Palpate for swelling, effusion, or parameniscal cyst (i.e., Baker's cyst).
    - Interval between medial head of gastrocnemius and semimembranosis
- McMurray's test (see Video 1.6)
  - Pain or palpable click along the joint line in the affected compartment with flexion, axial load, varus/valgus stress, and internal/external rotation of tibia
- Thessaly test
  - Knee rotation in single-limb stance in 20° flexion with joint line pain or catching sensations (Fig. 1.18)

MENISCAL EXAMINATION PEARLS

- A thorough hip examination should be performed in any child or adolescent who presents with a complaint of knee or hip pain.

Additional Examinations

- Hamstring flexibility/popliteal angle
  - In the supine position, the hip is flexed to 90°, the knee is straightened as far as possible, and the angle from vertical is measured.
  - Distance from 180° provides a measure of relative hamstring tightness.
- Ober's test
  - Patient is in lateral position with the affected extremity facing upwards.
  - The hip is abducted and slightly extended, and the knee flexed to 90° and then allowed to fall into adduction.

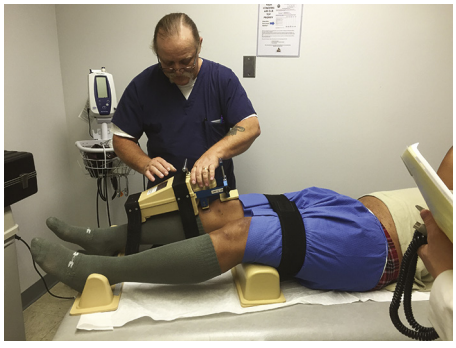


FIG. 1.17

FIG. 1.18

- If the leg cannot fall into adduction, then the iliotibial band is tight, a possible cause of laterally based knee pain.

- Hip examination
  - Hip range of motion—flexion, extension, abduction, and internal and external rotation at 90° flexion
  - Assess for impingement, particularly in combined flexion, adduction, internal rotation.
  - Stinchfield resisted hip flexion test: pain with resisted straight leg raise at 30° flexion indicates potential intra-articular pathology.
  - Thomas test: maximum flexion of the contralateral hip to neutralize lumbar lordosis and assess for presence of hip flexion contracture in affected extremity.
  - Strength testing.
- Lumbar spine
  - Examine for presence of midline or paravertebral back tenderness, sensorimotor disturbances, and provocative straight leg raise that could present as knee pain.

IMAGING

Plain Radiographs—Standard Views

- AP weight-bearing view of bilateral knees
  - Fracture
  - Joint space narrowing
  - Fairbank's changes
  - Segond fracture
    - Avulsion of the proximal lateral tibia
    - ACL injury
  - Pelligrini-Stieda lesion
    - Calcification of femoral insertion of MCL
    - Chronic MCL injury
- 45° flexion weight-bearing view of bilateral knees (Rosenberg view; Fig. 1.19)
  - Evaluates posterior femoral condyles
  - Loose bodies
  - Osteochondritis dissecans: medial aspect of lateral femoral condyle
  - Joint space narrowing
- Lateral view 30° flexed (Fig. 1.20)
  - Tibial spine avulsion
  - Anterior or posterior tibial station relative to distal femur
  - Aberrant sagittal tibial slope
  - Patella height measurements

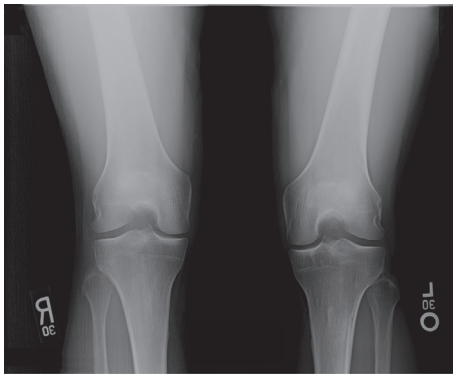


FIG. 1.19

FIG. 1.20

  - Inferior pole of patella should intersect with extension of Blumensaat's line
  - Insall-Salvati index (ratio of patella tendon length to patella length): normal, 1.0; patella alta >1.2; patella baja <0.8
  - Caton Deschamps index (ratio of the length of patellar articular surface to the length from the inferior margin of the patellar articular surface to the proximal aspect of the tibial plateau): normal, 1.0; alta >1.3; baja <0.6
- Merchant axial patella view (Fig. 1.21)
  - Joint space narrowing
  - Patella subluxation or maltracking
  - Patella tilt
  - Osteochondral injuries
  - Sulcus angle
    - Defined by tangential lines from the deepest section of the trochlea to the highest point of the medial and lateral condyles
    - Angles >150° suggest trochlear dysplasia and elevated risk for patella instability
  - Congruence angle
    - Defined by a line from the apex of the sulcus angle through the lowest ridge of the patella and a bisecting line of the sulcus angle
    - Angles greater than +15° are abnormal
  - Lateral patellofemoral angle
    - Defined by a line from the highest point on the medial and lateral trochlea and a line tangential to the lateral surface of the patella
    - Parallel lines or an angle that opens medially suggest increased lateral tilt and a potential risk for lateral patella maltracking or instability.

Plain Radiographs—Special Views

- Oblique AP view with internal and external rotation
  - May help with diagnosis of tibial plateau fractures
- Standing long cassette alignment view to assess for malalignment (Fig. 1.22)
  - Mechanical axis: line from center of the femoral head to center of the ankle
    - Determines location of weight-bearing axis
    - Varus—line falls in medial compartment
    - Valgus—line falls in lateral compartment
  - Degrees of varus or valgus are determined by the angle created by lines drawn for the mechanical axis of the tibia and femur.

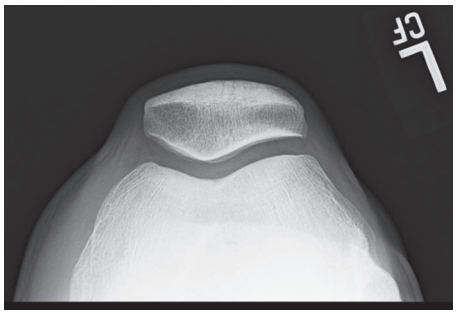


FIG. 1.21

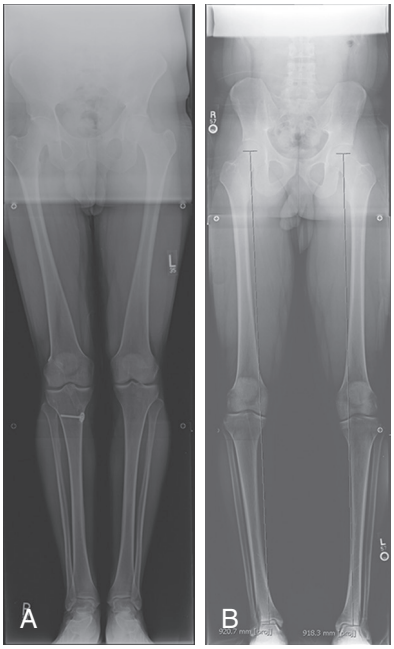


FIG. 1.22

- Stress radiographs
  - Unstable physeal injuries in skeletally immature patients
  - Absolute or relative degrees of anterior or posterior translation
  - Side-to-side differences in degree of varus or valgus opening

Computed Tomography

- Evaluates bony architecture
  - Fractures
  - Osteochondral injuries
  - Axial rotational alignment: selected hip, knee, ankle images
    - Tibial tubercle:trochlear groove (TT:TG) distance

Magnetic Resonance Imaging (MRI)

- Extremely useful for evaluation of soft-tissue injuries
  - Ligament:
    - Fig. 1.23A is a sagittal MRI demonstrating the intact ACL.
  - Meniscus:
    - Fig. 1.23B and C show a sagittal MRI demonstrating the intact anterior and posterior horns of the medial meniscus and lateral meniscus, respectively, as well as intact chondral surfaces.
  - Cartilage:
    - Fig. 1.23D shows an axial image demonstrating the thick articular cartilage of the patellofemoral joint.
  - Tendon
    - Patellar or quadriceps tendon, biceps femoris, popliteus
  - Synovitis or periarticular chondral loose bodies
  - Plica band

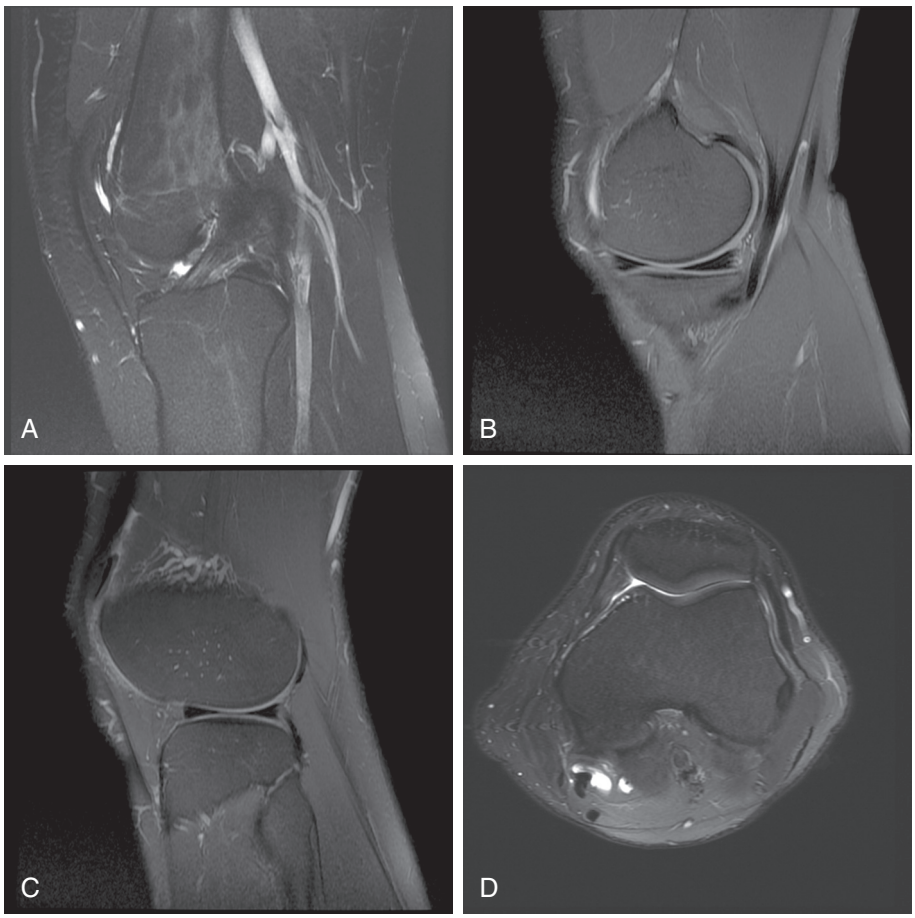


FIG. 1.23

- Also useful with bone injuries
  - Stress-related injuries
  - Occult fractures
  - Avascular necrosis or osteochondral lesions
  - Bone marrow edema

EVIDENCE

Hoppenfeld S: Physical examination of the knee. In Physical Examinations of the Spine and Extremities, Norwalk, CT, 1976, Appleton & Lange.
A complete review of the physical examination of the knee with several illustrations and discussion of findings.

Jung TM, Reinhardt C, Scheffler SU, Weller A: Stress radiography to measure posterior cruciate ligament insufficiency: a comparison of five different techniques, Knee Surg Sports Traumatol Arthrosc 14(11):1116–1121, 2006.
Kneeling stress radiographs serve as a readily available imaging modality that accurately quantifies posterior laxity in PCL insufficiency relative to the previous golden standard using the Telos device.

Lane CG, Warren R, Pearl AD: The pivot shift, JAAOS 16(12):679–688, 2008.
The "pivot shift" test indicates functional ACL laxity with combined rotational and translational movements. Positive testing reflects complex pathologic kinematics that can persist after ligament reconstruction, and the authors explore the determinants of continued instability.

LaPrade RF, Wijdicks CA: The management of injuries to the medial side of the knee, J Orthop Sports Phys Ther 42(3):221–233, 2012.
Despite their frequent incidence, isolated and combined medial ligamentous knee injuries may be under-recognized. MCL and posteromedial corner injuries can be effectively evaluated with thorough careful assessment of coronal plane laxity and rotational stability followed stress radiography and advanced magnetic resonance imaging.

Saggin F, Saggin JI, Dejour D: Imaging in patellofemoral instability: an abnormality-based approach, Sports Med Arthrosc Rev. 20:145–151, 2012.
Appropriate radiographic workup of patellofemoral instability must assess for patellar height, TT:TG distance, trochlear dysplasia, patellar tilt on various imaging modalities in order to individualize treatment strategy.

Singer A, Tresley J, Dalal R, Subhawong T, Clifford P: Of the iceberg: subtle findings on traumatic knee radiographs portend significant injury, Am J Orthop 43(3):E48–E56, 2014.
The authors review nuanced radiographic findings on basic and advanced knee imaging that suggest more complex intra-articular and extra-articular injuries that often warrant time-sensitive orthopedic management.

PROCEDURE 2

Diagnostic Knee Arthroscopy

Brian R. Waterman and Brett D. Owens

INDICATIONS

- Meniscal tears or other meniscal pathology
- Ligamentous injuries
- Chondromalacia or focal chondral lesions
- Symptomatic, intra-articular loose bodies
- Patellar maltracking
- Localized or diffuse synovitis
- Tumor-like conditions (e.g., pigmented villonodular synovitis, lipoma arborescens)
- Peri-articular fractures
- Septic arthritis

EXAMINATION/IMAGING (SEE PROCEDURE 1)

- Comprehensive history and physical examination are critical to evaluate for intra-articular pathology that may be treated in a minimally invasive fashion.
- Standard weight-bearing, 4-view, radiograph knee series (anteroposterior; AP, lateral, Rosenberg, and Merchant views) to correlate with subjective symptoms and clinical examination while helping establish a differential diagnosis
- Special radiographic views or stress imaging may be warranted on a selected basis.
- Magnetic resonance imaging is often sought to more fully evaluate for intra-articular pathology, particularly ligamentous, chondral, and/or meniscal injuries.

SURGICAL ANATOMY

Surface Anatomy

- Relevant surgical anatomy of the anterior (Fig. 2.1A), medial (Fig. 2.1B), lateral (Fig. 2.1C), and posterior (Fig. 2.1D) aspects of the knee.
- The location of the following structures should be able to be identified or localized on the skin prior to placement of incisions (Fig. 2.2):
  - patellar border
  - patella tendon
  - tibial tubercle
  - medial and lateral joint lines
  - Gerdy's tubercle
  - pes anserine tendon insertion
  - medial and lateral femoral condyles
  - medial and lateral epicondyles
  - medial collateral ligament (MCL)
  - lateral collateral ligament (LCL)
  - medial patellofemoral ligament
  - popliteus
  - fibular head and neck
  - biceps femoris tendon
  - iliotibial band
  - common peroneal nerve
  - infrapatellar branch of saphenous nerve
  - popliteal artery

ANATOMY PEARLS

- Utilizing a footrest and lateral post allows more freedom for access to accessory incisions and permits greater knee flexion angles than does use of a leg holder.

ANATOMY PITFALLS

- If utilizing a leg holder, care should be taken not to overtighten the leg holder, as it may act as a tourniquet. This is especially an issue with long surgeries!
- Excessively distal placement of the arthroscopic leg holder, tourniquet, or drapes may also preclude accessory posterior portal placement.

EQUIPMENT

- 5-lb sandbag to 10-lb sandbag, intravenous solution bag, gel pad, or roll may be used for the foot support
- Padded, lateral articulating post
- Padding—egg crate foam, gel pads, cotton cast padding
- Tourniquet
- Rolled hip bump

CONTROVERSIES

- Selective tourniquet use may improve arthroscopic visualization but may not be necessary and may result in a venous tourniquet and/or increased perioperative thigh pain.

FIG. 2.1 Clinical photograph demonstrating superficial soft-tissue and bony landmarks for knee arthroscopy, (right vs. left knee) (A) anterior view, (B) medial view, (C) lateral view, and (D) posterior view.

POSITIONING

- The patient is positioned supine on a standard operating room table.
- All bony prominences are well padded, and the common peroneal nerve and heelpad are padded on the contralateral leg prior to taping in place.
- A padded bump is placed below the ipsilateral buttock to neutralize external hip rotation.
- A well-padded tourniquet is placed as high as possible on the operative extremity (Fig. 2.3A). This may be preferentially used if arthroscopic visualization is impaired during the procedure.
- A lateral post is positioned at least a hand's breadth above the superior pole of the patellar or at the midthigh to support the leg during applied valgus stress (see Fig. 2.3A).
- A footrest is secured to the operative bed and positioned to allow a resting position in approximately 70° to 90° of knee flexion (Fig. 2.3B), but the knee may be allowed to hang off the side of the bed for arthroscopy (Fig. 2.3C) after final preparation (Fig. 2.3D).
- General or neuraxial anesthesia may be considered depending on patient's preferences.
- Alternative approach:
  - The nonoperative leg is padded and placed into a well leg holder in abduction and combined hip and knee flexion (Fig. 2.4A).
  - A lateral post (Fig. 2.4B) or circumferential arthroscopic leg holder (not featured) is applied to the midthigh of the operative extremity, and the leg is allowed to hang free after dropping the foot of the table after final preparation (Fig. 2.4C).

PORTALS/EXPOSURES

Standard Portals

- Standard anteromedial and anterolateral arthroscopic portals are established (Fig. 2.5A).
- Anterolateral portal (viewing portal)
  - The arthroscope is placed in the lateral soft spot approximately 10 mm below the inferior border of the patellar and directly lateral to the border of the patellar tendon.

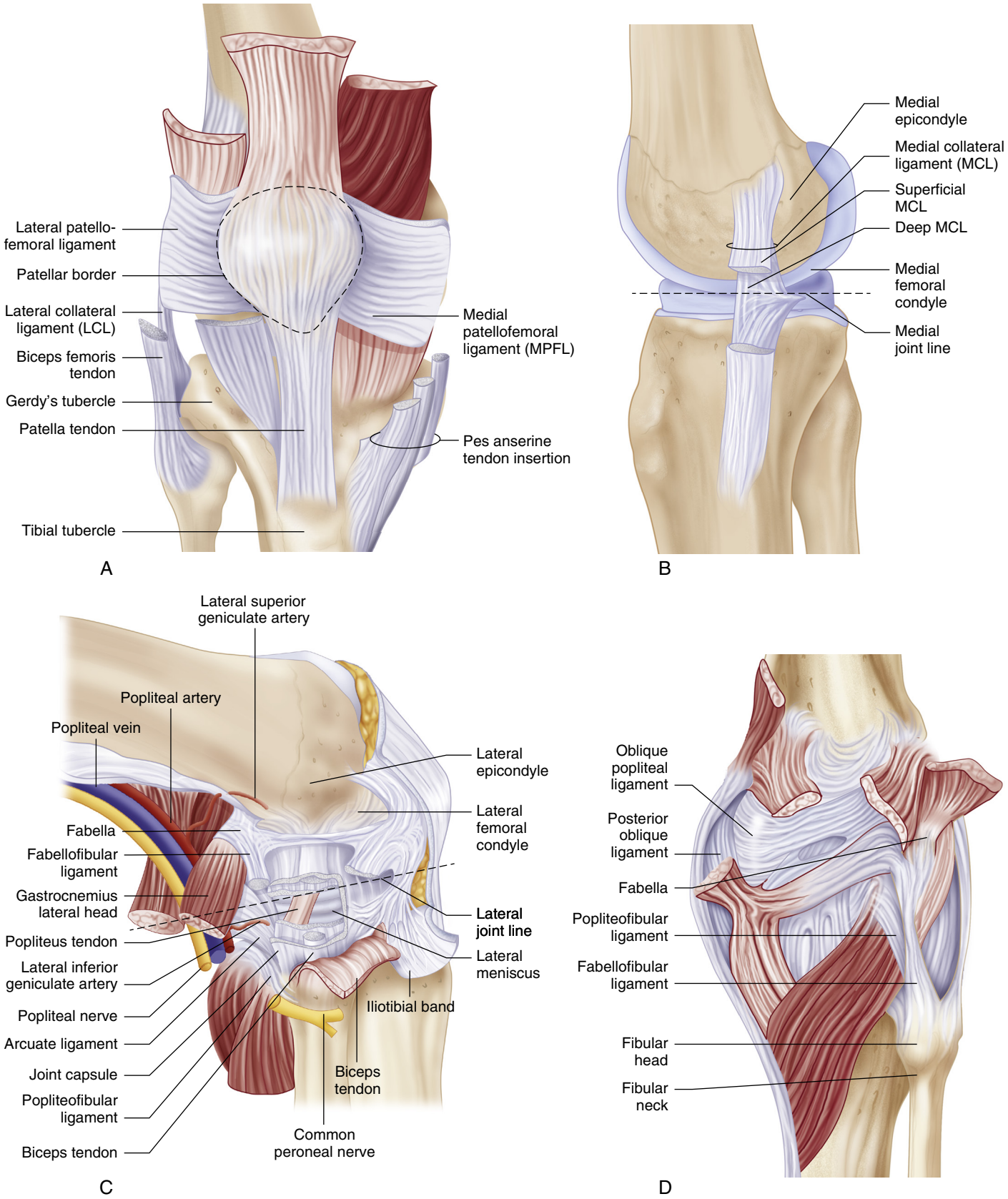


FIG. 2.2 Illustration of selected anatomic landmarks of the (right vs. left) knee.

FIG. 2.3 Preoperative patient positioning with (A) lateral post, tourniquet placement, and (B) footrest position; (C) flexion off the side of the bed; and (D) final positioning after sterile preparation.

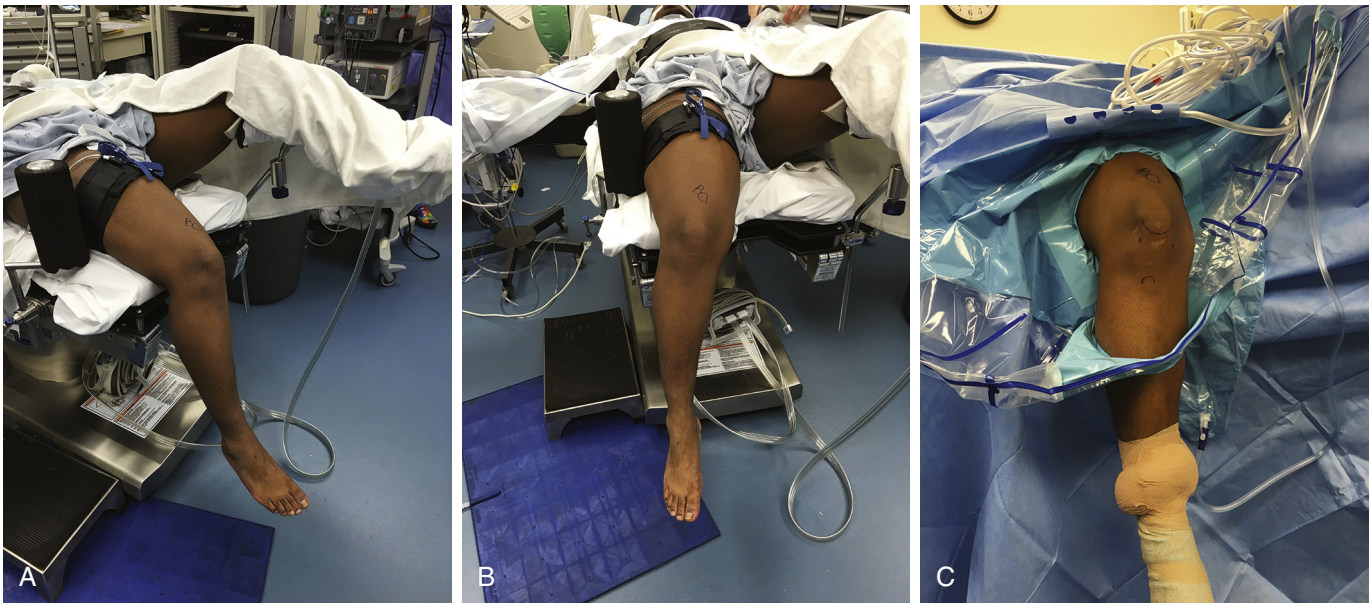


FIG. 2.4 Alternative patient positioning and with (A) well leg holder and (B) lateral post or arthroscopic thigh holder (not featured).

STANDARD PORTAL PEARLS

- Patellar height (e.g., alta) should be accounted for during portal placement.
- Injecting with local anesthetic with epinephrine at portal sites may decrease bleeding and improve arthroscopic visualization.
- Aim instruments toward the intercondylar notch during portal placement to prevent iatrogenic damage.
- The anterior inferomedial portal may be first localized with an 18-gauge spinal needle in order to ensure optimal positioning.

STANDARD PORTAL PITFALLS

- Avoid placing portals in too close proximity or at similar heights to avoid interference or portal convergence.
- The anterior horn of the meniscus may be transected with inferior portal placement or errant sharp dissection.
- The saphenous nerve or vein may be injured with sharp dissection for a posteromedial portal.
- The common peroneal nerve lies immediately posterior to the biceps tendon.

- Anteromedial portal (working portal)
  - An arthroscopic probe or working instrument may be utilized through a portal in a medial soft spot approximately 10 mm above the medial joint line and 5 mm to 10 mm medial to the medial border of the patellar tendon.
  - Ideal trajectory and position are assessed with 18-gauge spinal needle prior to establishing anteromedial portal (Fig. 2.5B and C).

Accessory Portals

- Superomedial or superolateral portal (outflow portal)
  - In full knee extension, the portal is placed approximately two to three finger breadths above the respective border of the superior pole of the patella, deep to the quadriceps tendon, and 30° toward midline of the suprapatellar pouch.
  - Most commonly used as an outflow portal for improved visualization, but may also be utilized to visualize patellar tracking, addressing patella pathology, and for removal of loose bodies.
- Posteromedial portal (Fig. 2.6A)
  - The arthroscope is directed through the intercondylar notch and beneath the posterior cruciate ligament (PCL) into the posterior aspect of the knee while viewing medially.
  - An 18-gauge spinal needle is utilized to localize the portal approximately three finger breadths above the posteromedial joint line and one fingerbreadth behind the MCL origin.

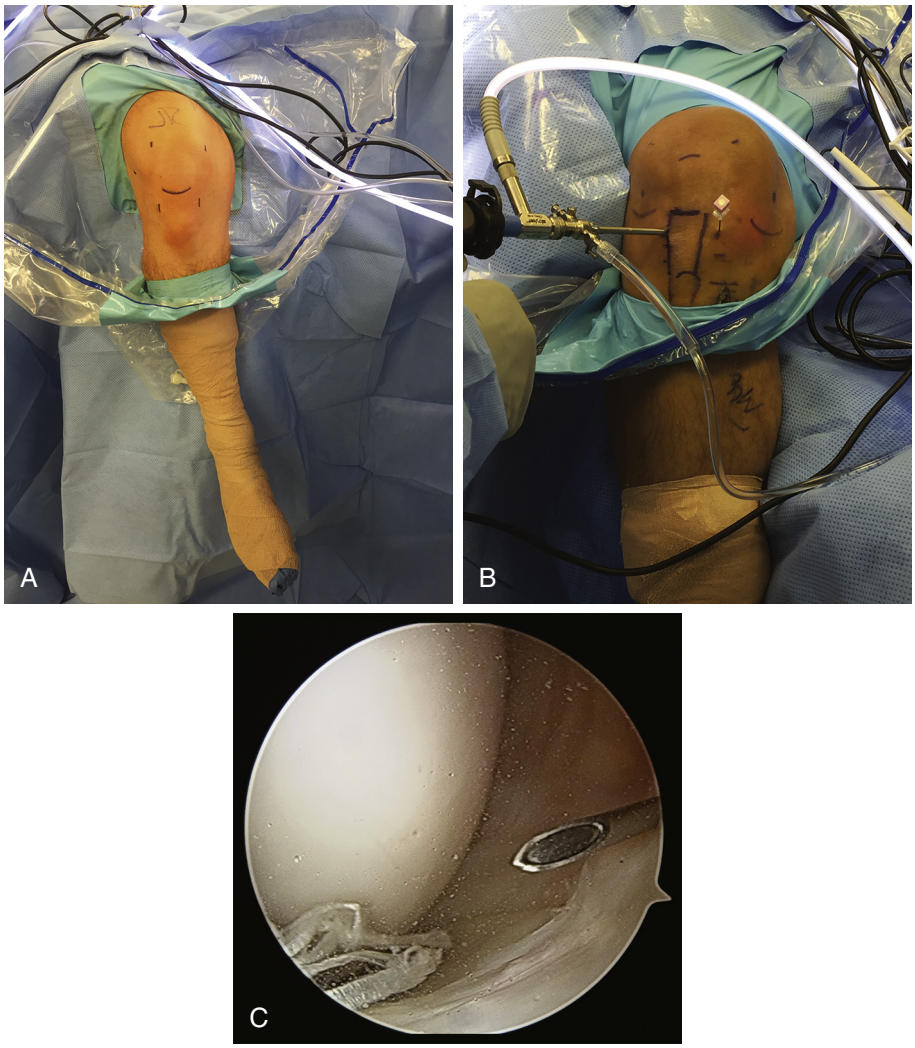


FIG. 2.5 (A) Standard and accessory portals for knee arthroscopy; (B) anterolateral portal viewing while triangulating an anteromedial working portal with a spinal needle; and (C) to ensure the appropriate entry point and trajectory.

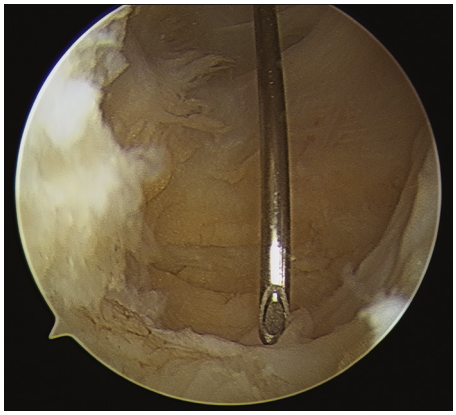


FIG. 2.6 Accessory posteromedial arthroscopic portal.

- Incise the skin with a knife blade and then use a straight hemostat, Wissinger rod, and/or soft-tissue dilators to bluntly open the capsule.
- Useful for posterior knee visualization or loose body removal, localized synovectomy, PCL reconstruction, and posterior horn or root repair of the medial meniscus.

PROCEDURE

Step 1: Examination Under Anesthesia

- Permits knee reassessment without resting muscle tension or apprehension.
  - Passive range of motion, patellofemoral tracking and stability, and cruciate (i.e., Lachman test, anterior and posterior drawer tests, pivot shift test) and collateral (varus/valgus stress, dial test, Slocum test) ligamentous examination are more reliable in the relaxed or sedated patient.
  - Side-to-side comparison with contralateral extremity may serve as a reference.

Step 2: Suprapatellar Pouch

- The arthroscopic scope sheath is inserted using a blunt obturator through the anterolateral portal into the intercondylar notch in 70° to 90° flexion. The leg is then extended and the arthroscope is brought into the suprapatellar pouch (Fig. 2.7). The trocar is exchanged for a 30° arthroscope while maintaining the knee in full extension.
- Examine the pouch in a systematic manner from superior to inferior and medial to lateral.
  - Examine for synovitis, plica band, loose bodies, crystalline deposits, and suprapatellar adhesions.

Step 3: Patellofemoral Compartment

- The arthroscope is brought inferiorly and the lens rotated upward to allow visualization of the patellar articular surface (see Video 2.1), including the central ridge and medial and lateral facets.

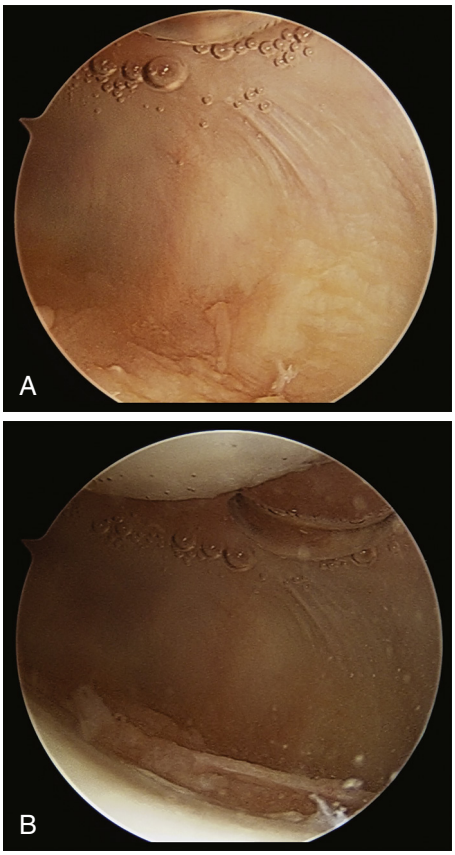


FIG. 2.7 Examination of the (A) suprapatellar pouch and (B) proximomedial gutter.

INSTRUMENTATION

- 18-gauge spinal needle
- #11 blade for skin incision
- Straight hemostat
- Wissinger rod and soft-tissue dilators
- Threaded 5-mm to 7-mm arthroscopic cannula
  - Posterolateral portal (Fig. 2.6B)
- Inherent risk of common peroneal nerve injury with errant portal placement
- Palpate landmarks with the knee in a "figure-4" position
- Localize with an 18-gauge spinal needle placed posterior to the LCL but anterior to the biceps femoris tendon
- Useful for posterolateral loose bodies, localized synovectomy, and repair of posterior horn/root tears of the lateral meniscus

ACCESSORY PORTAL PEARLS

- Examination under anesthesia can help determine the final surgical plan.

STEP 1 PEARLS

- A 30° arthroscope is most commonly used, but a 70° arthroscope may be optimal for viewing in the posteromedial and posterolateral compartments through a modified Gillquist view.
- Examination under anesthesia may reveal unrecognized pathology and alter surgical decision making.

INSTRUMENTATION/IMPLANTATION

- Blunt trocar
- 30° arthroscope
- Arthroscopic probe
- Arthroscopic shaver
- Arthroscopic grasper
- Arthroscopic baskets and punches
- Optional outflow cannulas

STEP 2 PITFALLS

- Cautious arthroscope insertion may prevent iatrogenic damage to articular surfaces.

STEP 2 PEARLS

- Modified Outerbridge/Insall articular cartilage classification system
  - I—Softening, swelling, or indentations of superficial cartilage
  - II—Partial thickness (<50%) fissuring or defect <1.5 cm in diameter
  - III—Fibrillation or full-thickness, articular defect with a diameter >1.5 cm
  - IV—chondral lesions with exposed subchondral bone
- International Cartilage Repair Society Grading System
  - 0—Normal
  - 1—Nearly normal with indentations, superficial fissures, or cracks
  - 2—Abnormal with partial thickness lesions >50% of cartilage depth
  - 3—Severely abnormal with defects >50% cartilage depth (A), down to calcified layer (B), to subchondral bone (C), or blistering (D)
  - 4—Severely abnormal with subchondral bone involvement

  - Visualization of the patellofemoral joint for chondral lesions, tracking, and medial/lateral transition is done from the anterolateral portal (Fig. 2.8A to C), ideally without tourniquet inflation and minimal intra-articular fluid distension.
  - Alternatively, visualization of patellar tracking can be done from the superolateral portal with a 70° arthroscope (Fig. 2.8D).
- Rotating the lens and performing gentle knee flexion allows inspection of the cartilage of the trochlear groove.
- Examine the medial and lateral peripatellar capsular attachments for evidence of pathologic plica or unstable bipartite patella.

Step 4: Lateral Gutter

- With the knee in full extension, the arthroscope is brought from the suprapatellar pouch over the lateral ridge of the trochlea into the lateral gutter.
- After slightly withdrawing the arthroscope to clear the lateral synovial folds, the scope is directed distally to visualize the capsular reflection, peripheral lateral meniscus, popliteus tendon, and margins of the lateral femoral condyle.
- Milking or ballottement of the back of the knee may help dislodge loose bodies or express perimeniscal cyst contents from the popliteal hiatus into the lateral gutter.

Step 5: Medial Gutter

- The arthroscope is brought from the suprapatellar pouch over the edge of the medial ridge of the trochlea and rotated to view down into the gutter (Fig. 2.9).
  - Examine the medial gutter for presence of loose bodies, synovitis, or mediopatellar plica while milking the posteromedial knee and popliteal fossa.
- The arthroscope is then delivered down the medial gutter and anterior to the medial femoral condyle before flexing the knee to allow exposure of the medial compartment.

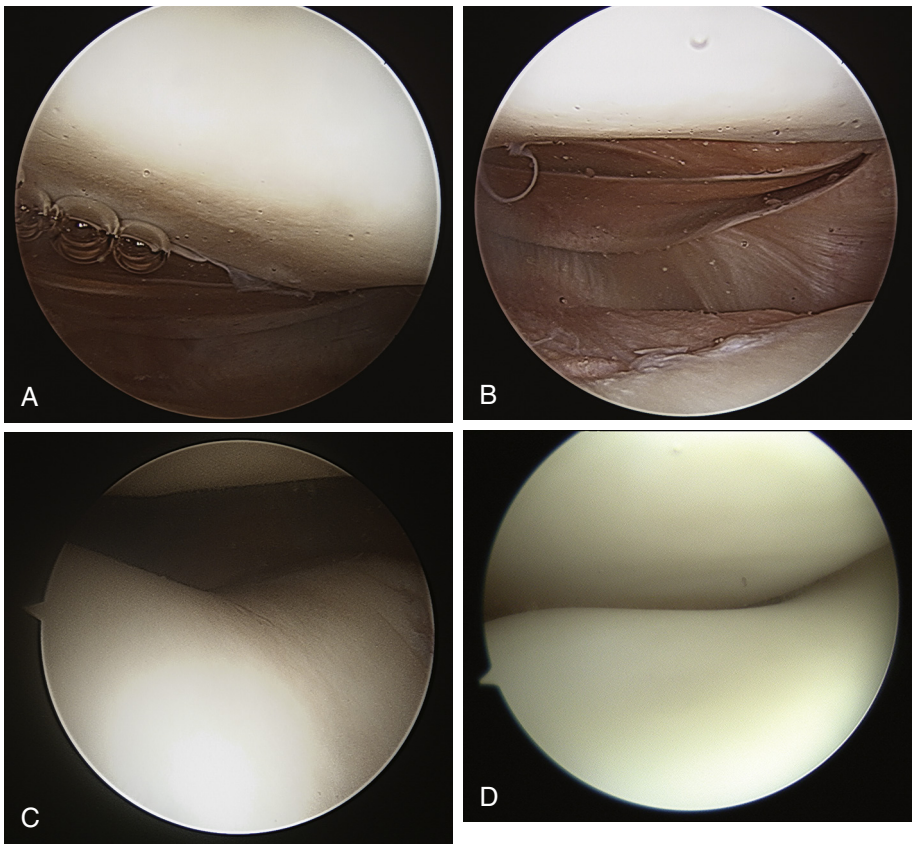


FIG. 2.8 Patellofemoral examination of (A) lateral facet, (B) medial facet and central ridge of the patella; (C) "skyline view" of the patella and trochlea; and (D) superomedial view of the patellofemoral articulation.

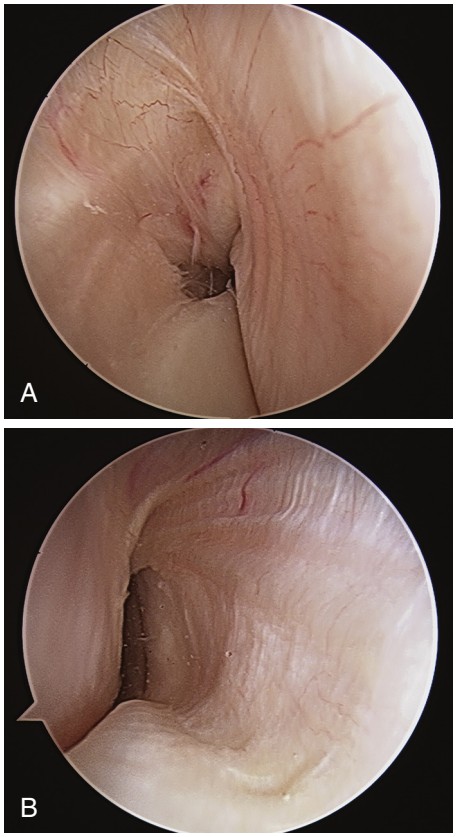


FIG. 2.9 Visualization of the (A) popliteus and capsulomeniscal junction in the lateral gutter and (B) capsulomeniscal junction and articular margin of the medial femoral condyle in the medial gutter and posteromedial corner.

Step 6: Medial Compartment

- Valgus stress and external rotation help open the medial compartment.
  - For a tight medial compartment, titrated release ("pie-crusting") of the MCL with a spinal needle may be performed at the medial joint line or proximal femoral attachment to achieve fractional lengthening and a greater working space medially (Fig. 2.10A).
- Examine the entire meniscus from anterior horn, midbody, posterior horn, and root attachments (Fig. 2.10B).
  - Palpate, elevate, and probe both the superior and inferior surfaces of the undersurface of the meniscus.
  - Determine the location, size, pattern, and stability of any meniscal tear.
- Examine the femoral and tibial articular surfaces.
  - Use the arthroscopic probe to test the articular surface for softening, flaps, or subchondral collapse.

Step 7: Intercondylar Notch

- The arthroscope and probe are brought from the medial compartment into the intercondylar notch (see Video 2.2).
  - A small portion of the fat pad or ligamentum mucosum may need to be resected to permit better visualization, although this should be limited to avoid bleeding, compromised visualization, and postoperative adhesions.
- The intercondylar notch is inspected and probed (Fig. 2.11) for the following:
  - ligamentum mucosum
  - anteromedial and posterolateral bundles of the anterior cruciate ligament (ACL)
  - PCL
  - medial and lateral tibial spines
  - intermeniscal ligament
- Posteromedial compartment
  - Modified Gillquist maneuver: From the anterolateral portal, insert the arthroscopic sheath and blunt trocar with gentle pressure, slight valgus stress, and inferiorly directed force along the medial wall of the intercondylar notch and under the PCL. This will allow visualization of the posterior compartment after exchanging the obturator for the 30°, or preferably 70°, arthroscope (Video 2.3).
  - Examine the posteromedial compartment for PCL injury, loose bodies, medial meniscal root injuries, and so-called "ramp lesions" or meniscal-capsular injuries (Fig. 2.12), common with associated ACL injuries.

STEP 5 PEARLS

- Overinsert the arthroscope into the suprapatellar pouch and lift up on the cannula to deliver it over the superolateral trochlear ridge to avoid scuffing the articular surface.

STEP 6 PEARLS

- Medial plica run from the suprapatellar pouch into the fat pad inferior to the patella.
- Medial plica are present in 40% of knees, though few are pathologic or symptomatic.
- Symptomatic plica may lead to corresponding chondral changes on the medial femoral condyle.

STEP 7 PEARLS

- The trajectory and access of anteromedial portal placement may be first assessed with the use of an 18-gauge spinal needle, particularly for ACL or meniscal surgery.
- Early medial compartment wear is usually posterior on the femoral condyle and is best visualized with deep knee flexion and valgus stress.
- A 70° arthroscope may be very helpful in examining the posteromedial or posterolateral compartments using the modified Gillquist maneuver.
- Scrutinize excessive hypermobility of the posterior horn of the lateral meniscus for possible popliteomeniscal fascicular tears in association with chondral lesions of the lateral femoral condyle.

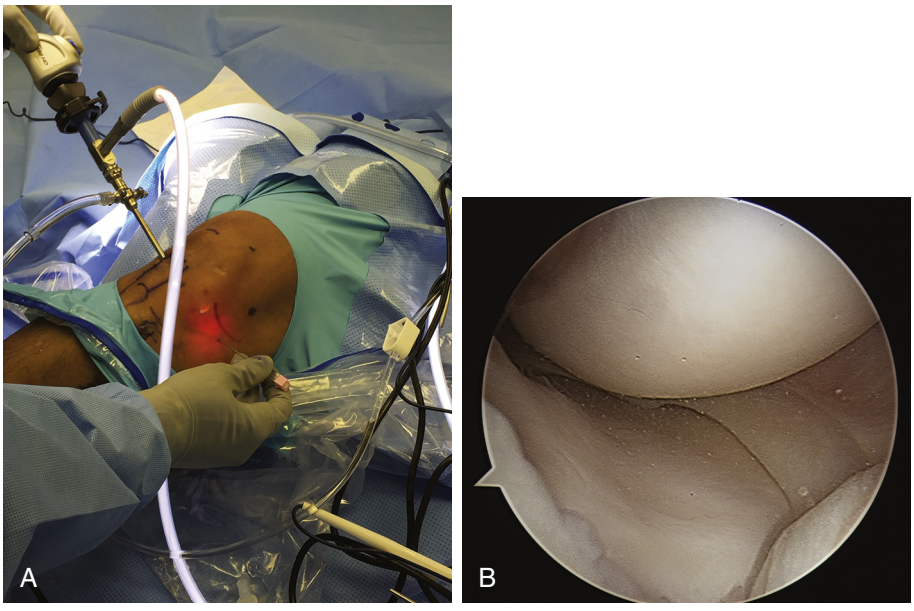


FIG. 2.10 (A) Percutaneous pie-crusting of the medial collateral ligament to allow (B) complete arthroscopic view of the medial compartment.

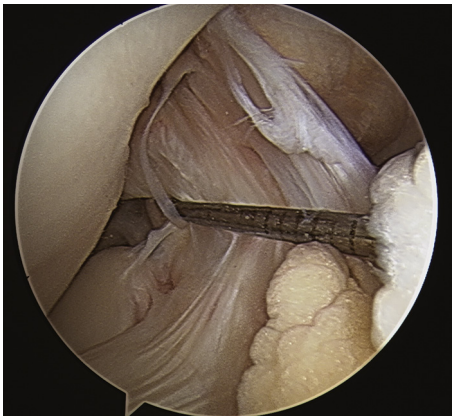


FIG. 2.11 Visualization and palpation of the anterior and posterior cruciate ligament in the intercondylar notch.

STEP 7 PITFALLS

- Forcing the arthroscope into the medial compartment can damage the articular surface.
- Exercise care not to penetrate the posteromedial capsule during the modified Gillquist maneuver, as this may result in fluid extravasation or neurovascular injury.

- Adjunctive posteromedial portal may also be established to address identified pathology, particularly synovitis, PCL injuries, or large loose bodies.
- Posterolateral compartment
  - Similarly, a 70° arthroscope may be introduced into the posterolateral compartment through the anteromedial portal under the ACL along the lateral intercondylar face.
    - Examine for loose bodies, synovitis, lateral meniscal root tears, capsulomeniscal injuries, and popliteomeniscal fascicle tears, the latter of which are often difficult to visualize and can occur in association with far posterior chondral lesions of the lateral femoral condyle.

Step 8: Lateral Compartment

- Varus stress may be applied to the leg while the knee is flexed over the side of the bed, or the knee may be placed into the "figure-four" position to improve visualization of the lateral compartment (Fig. 2.13A).
  - Apply downward pressure on the distal medial thigh or adjust degree of knee flexion to maximize visualization.
- Slide the arthroscope and probe from the intercondylar notch into the lateral compartment to avoid damage to the articular cartilage during knee repositioning (Videos 2.4 and 2.5).
- Probe the entire meniscus from its posterior root insertion around to its anterior horn attachment (Fig. 2.13B).
  - Probe the superior and inferior surface of the lateral meniscus to evaluate for tears and capsular injuries, as well as discoid meniscal variants.
- Evaluate the popliteal hiatus in a knee with a deficient LCL/posterolateral corner with an arthroscopic "drive-through sign," or excessive widening of the lateral joint line with limited varus stress. This may also confirm clinical findings during examination under anesthesia.

STEP 8 PEARLS

- Examine the popliteal hiatus for hidden loose bodies.
- Switching viewing and working portals may help assess meniscal pathology.

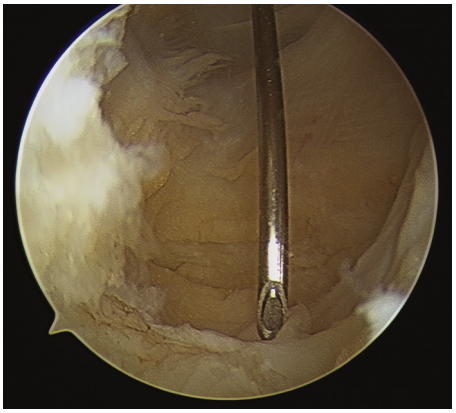
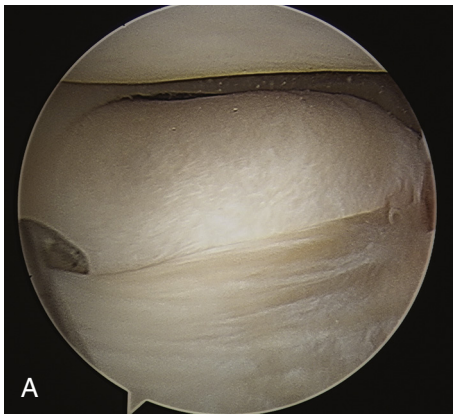
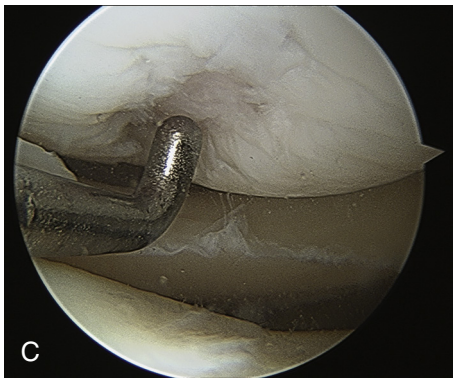


FIG. 2.12 Transcondylar view of the posteromedial compartment.





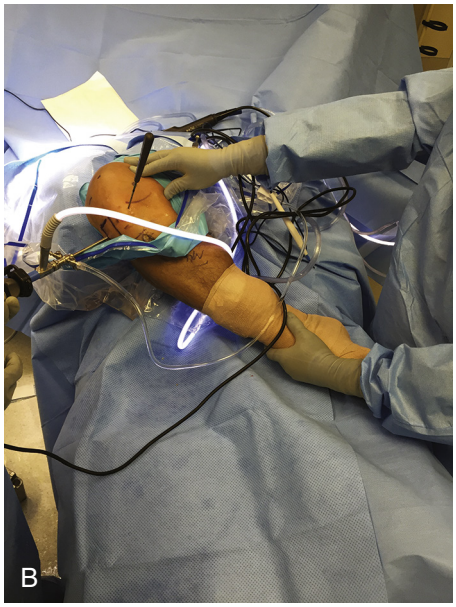


FIG. 2.13 (A) Arthroscopic view of the lateral compartment during (B) "figure-4" positioning, and (C) positive "drive-through sign" in the lateral compartment indicating posterolateral corner laxity in association with a lateral condyle chondral defect.