Total Knee Arthroplasty

A Comprehensive Approach

Edited by

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Preface

This monograph represents an attempt to come to grips with the specific problems which have surfaced after a decade of experience in total knee arthroplasty. The authors who have contributed their expertise for the individual chapters have participated in the development and evaluation of the solutions which this attempt has produced. In the title, *Total Knee Arthroplasty: A Comprehensive Approach*, we have not intended to convey the impression of an encyclopaedic approach. We have called upon each author to present, on the basis of extensive experience, his personal methods, with the reasons for his selections from the number of alternatives available.

This monograph could as well be entitled "One Way to Do and Handle the Problems of Total Knee Arthroplasty." To that extent, it is a systematic coverage of all the multitudinous problems surrounding the replacement of this complex articulation. Other investigators have developed other solutions and no attempt has been made to survey all of the prostheses and technical measures available except to build upon the failures of the past. It is in fact these failures, individual and collective, which have provided the stimulus for our efforts. Undoubtedly, the next decade will prove where these solutions are correct and where further improvement is necessary.

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CONTENTS

CHAPTER 1

History and Evolution of Total Knee Replacement

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William L. Healy III, M.D.

Total knee arthroplasty as practiced in 1983 is a product of 120 years of development of biomechanical concepts, prosthetic materials, and surgical techniques. Although the course of this development is long, the history of successful total knee arthroplasty is relatively short. We are, however, at a point in the evolution of total knee arthroplasty where success can be predicted with a high degree of certainty.

Stability, mobility and freedom from pain are the requirements of a normal knee. Successful knee arthrodesis satisfies two of these requirements—stability and freedom from pain. However a fused knee is by definition immobile, and it is not an acceptable treatment for all patients in this era. Nevertheless, arthrodesis provides consistent and predictable results, and it is essential to compare the results of knee arthroplasty to those that can be achieved with arthrodesis.

To the best of our knowledge resection of contiguous articular surfaces of the knee—resection arthroplasty was the first form of knee arthroplasty. In 1861 Ferguson reported a knee resection following which the patient was said to be functioning in a satisfactory fashion 5 years later (12). Following this procedure the patient's knee may have been mobile, relatively painless, and not completely unstable, but the knee certainly would not be expected to meet the demands of daily living in our modern society.

Interpositional arthroplasty was first investigated in 1863 when Verneuil (45) used flaps of joint capsule to cover resected articular surfaces. Other autogenous tissue transplants interposed between joint surfaces in the knee include: fat and fascia lata (1, 36), fascia lata (38), prepatella bursa tissue (8), and skin (6). Campbell (8) reported success utilizing fascial interposition in ankylosed knees, but this procedure was less successful in the treatment of other types of knee disease. Other materials used in interpositional arthroplasty include: chromicized pig bladder (4), cellophane (41), and nylon (25). However, the results of all methods of interpositional arthroplasty were not sufficiently satisfactory to replace arthrodesis as the initial surgical treatment for the patient with a severely diseased knee.

Hemiarthroplasty of the knee was introduced in 1938, when a metallic mold of the distal femur designed by Dr. Harold Boyd was used by Harold Boyd and Willis Campbell (5, 9). Their work was stimulated by Smith-Peterson's recently reported experiences with mold arthroplasty of the hip (44). Smith-Peterson reported his experience with mold arthroplasty of the distal femur in 1950 (23). A medullary stem was added to Smith-Peterson's initial femoral mold by a group at the Massachusetts General Hospital (MGH) which included Jones, Aufranc, and Kermond, who reported results achieved with this implant in 1967. They noted 41% good results and 37% poor results in 78 patients (23). In 1969 Platt and Pepplar (37) reported encouraging results noted after a 10-year evaluation of patients treated with their metallic distal femoral mold. It was similar to the MGH prosthesis, but it did not have a medullary stem.

Hemiarthroplasty of the tibial plateau was first performed by Kiaer Jansen, who used a proximal tibial prosthesis made of acrylic (28). In the late 1950s McKeever (34) began using a metal tibial plateau replacement, and in 1966 MacIntosh (38) reported his experience with a metal tibial plateau. The early experiences with hemiarthroplasty of the knee were not sufficiently successful to encourage most orthopaedic surgeons to abandon arthrodesis as the surgical treatment for destroyed knees. Components frequently failed due to loosening, and the unaltered joint surfaces continued to be a source of pain. In 1957 Walldius (46) reviewed the results of 896 knee hemiarthroplasties reported in the literature between 1941 and 1953. A successful result was achieved in only 46% of those patients even by the most generous of criteria.

Total knee replacement, or simultaneous replacement of both femoral and tibial articular surfaces, began in the late 1950s with hinged or constrained total knee units. Although Judet, Judet, and Crepin (24) designed an experimental hinged prosthesis made of acrylic in 1947, and Magnoni (27) reported the successful use of a hinged total knee unit in 1949, Walldius was the first to achieve significant clinical success utilizing a hinged knee replacement unit. Walldius inserted his first acrylic hinged prosthesis in 1951, but by 1958 he was using a metal hinged unit, and he has reported success with that unit (47). Modifications of the Walldius hinged total knee were used by Seddon (2), Jackson-Burrows (2), Shires (43), McKee (32), and Young (50). The indications for hinged total knee arthroplasty that evolved during that era included far advanced degenerative joint disease, rheumatoid arthritis, reconstruction following tumor resection, and post traumatic changes. Although more successful in patients with sedentary life styles, and associated with a significant failure rate, hinged total knee arthroplasty offered an alternative to arthrodesis in a few carefully selected patients by 1960.

Constrained total knee units that have evolved during the past 20 years include the Guepar (49), spherocentric (31), Sheehan (42), and Attenborough (3), of which only the Guepar is a true hinge. The Guepar prosthesis was developed by a group of orthopaedic surgeons in Europe and was first used in 1970. Flexion to 130° is permitted as a result of a posterior offset hinge. A polyethylene bumper was provided to absorb shock when the unit locked in extension, although subsequent arthroscopic studies have suggested its effectiveness as a shock absorber was lost after 6 months of use. Another advantage to the Guepar was that it could be inserted with a sacrifice of only 2 cm of bone in the event that salvage arthrodesis became necessary. In our experience with the fixed, hinged total knee units, the Guepar has provided the most satisfactory results in that small group of carefully selected patients in whom a fully constrained unit is indicated. The spherocentric knee was designed by Matthews and Kaufer with a ball and socket joint to allow triaxial motion. Their goal was to provide the stability of a hinged unit and yet to permit greater motion, thus shielding the bone-acrylic interface from rotational forces by dissipating them at the joint surface (31).

The evolution of total knee arthroplasty progressed quickly in the early 1970s with the verification of several principles upon which successful total replacement of the hip depended. These principles were: 1) Prosthetic materials can be fixed to bone with methylmethacrylate which provides a satisfactory interface for long periods of time. 2) The bone-acrylic interface can tolerate reasonable forces associated with activities of daily living. 3) Materials such as stainless steel, chrome-cobalt alloys, and high density polyethylene are acceptable materials from which to fashion total joint units, and they and their breakdown products are well tolerated in the body (10, 33). Acceptance of these principles and dissatisfaction with hinged prostheses led to the development of the nonhinged or unconstrained total knee units.

The first nonhinged total knee was designed and used by Dr. Frank Gunston in 1968 while working with John Charnley in Wrightington, England. Gunston's design included the concept of low friction arthroplasty with a metal femoral component and a high density polyethylene tibial component fixed to bone with polymethylmethacrylate. The unit was minimally constrained, retaining the cruciate and collateral ligaments, and it required minimal bone resection in the event salvage arthrodesis was necessary. A significant design aspect of Gunston's unit was its capacity for polycentric motion similar to that found in the normal human knee. In addition to flexion and extension in the sagittal plane, abduction and adduction in the coronal plane, and internal and external rotation about a transverse axis were permitted. Gunston was the first investigator to apply these biomechanical principles of the normal knee to knee prosthesis design (17). Bryan and Peterson (7) utilized Gunston's polycentric unit at the Mayo Clinic and reported good results with its use in 1973.

Freeman and Swanson developed a nonhinged knee unit at the London Hospital and the Imperial College of London which Freeman has used successfully since 1970 (15, 16). The geometric total knee unit developed by Coventry, Riley, Upshaw, Finerman and Turner was first used in 1971 (11). The geometric knee unit retained the anterior and posterior cruciate ligaments (if present) and the collateral ligaments. It had the capacity to allow for correction of moderate varus, valgus, and flexion deformities at the time of insertion; but did not allow resurfacing of the patellofemoral joint. The geometric unit was widely used in the early 1970s with encouraging results. Other units developed during the early 1970s include the Marmor modular knee (29, 30), the UCI knee (48), the uni-condylar knee (20, 22), and the duo-condylar knee (20, 39).

The total condylar knee unit developed at the Hospital for Special Surgery was the first widely used nonhinged unit to permit resurfacing of the patellofemoral joint and to sacrifice the cruciate ligaments (21). Stability was maintained by deepening the tibial cups and by altering the thickness of the tibial component in order to maintain tension in the collateral ligaments and joint capsule throughout the arc of motion. It has been widely used in the United States and abroad since the mid 1970s.

By 1975 it became apparent that there was a significant advantage to decreasing forces at the bone-acrylic interface and to increasing motion of the knee. In order to achieve these goals and maintain a stable joint, total knee units were designed which used the collateral ligaments, the posterior cruciate ligament and the joint capsule for stabilization (40). These soft tissue biologic restraints permitted an increased arc of flexion and absorbed forces which would otherwise be transmitted to the bone-acrylic interface. In an attempt to further increase flexion and to allow greater rotation, separate right and left femoral components were designed with progressively decreasing radii of rotation as is found in the normal femoral condyles.

The first unit designed in accordance with this principle was the anametric total knee (13, 26). The design features upon which it was based had several advantages, which included increased flexion and increased rotation and gliding motions of the tibiofemoral articulation. The design also decreased posterior stresses during flexion, which permitted ligamentous structures to restrain limits of motion, and therefore reduce forces which would otherwise be transmitted to the bone-acrylic junction. Other units that include these principles are the RMC, Townley, Kinematic and PCA knees (18, 19).

Most nonhinged total knee units available at this time provide metal-backed high density polyethylene tibial units. Many feel that this design feature will provide more diffuse force transfer to the bone-acrylic interface and will be associated with less interface breakdown than would be noted if metal backed units were not utilized.

The importance of accurate and reproducible surgical techniques for total knee arthroplasty has been recently emphasized by Hungerford, Krackow, and Kenna (18, 19). There is no doubt that the quality of results achieved for the patient is to a large extent dependent upon the accuracy of implant insertion. The Universal Instrumentation System developed by Kenna, Hungerford and Krackow assists the surgeon in achieving the goal of accurate and reproducible implant insertion. The importance of proper cementing technique to achieve a stable bone-acrylic interface has been emphasized by Miller (35). Proper cementing technique should decrease the incidence of bone-acrylic interface breakdown and when combined with accurate placement of prosthetic units, it should result in a marked improvement in the quality and longevity of results that can be achieved with nonhinged total knee arthroplasty.

An exciting new development in total knee arthroplasty involves the fixation of the prosthetic components to bone without acrylic-bone cement. Freeman has utilized press-fit fixation techniques and finned polyethylene pegs to eliminate the use of acrylic (14). Kenna and Hungerford have developed the PCA knee which is porous coated to allow bony ingrowth into the interstices of the porous coated metal. Ideally this creates a true bone to prosthesis interlock. Clinical experience is limited, but use of this system to date is encouraging (18, 19).

The current state of the art of total knee arthroplasty suggests that the principles and materials of low friction arthroplasty can be well applied to the knee; that the nonhinged prostheses which are designed to mimic the normal knee and utilize biological, rather than mechanical, restraints to motion will be associated with favorable results; that polymethylmethacrylate can effectively fix the prosthetic components to bone, but porous coated units may make its use unnecessary for many patients in the near future; and that patient selection and surgical technique continue to be important variables for successful results. The indications for total knee arthroplasty have become reasonably simple and straightforward. Contraindications include: sepsis, insuffcent bone stock, fixed deformity which cannot be corrected, and obesity. However, all contraindications are relative and they must be considered in relation to individual patients and specific prostheses. All total knee units will fail if they are submitted to stresses greater than those which they were designed to accommodate.

After 120 years of development, total knee arthroplasty must be considered an acceptable alternative to arthrodesis, and will provide for many patients a stable, painless and moveable knee for many years.

References

1. Albee FH: Original features in arthroplasty of the knee with improved prognosis. *Surg Gynecol Obstet 47*:312, 1928.
2. Apley AG: Citation of arthroplasty of the knee. In *Modern Trends in Orthopaedics*. London, Butterworth, 1972.
3. Attenborough CG: The Attenborough total knee replacement. *J Bone Joint Surg 60B*:320, 1978.
4. Baer WS: Arthroplasty with the aid of animal membrane. *Am J Orthop Surg 16*:171, 1918.
5. Boyd H: Personal communication.
6. Brown JE, McGaw WH, Shaw DT: Use of cutis as an interposing membrane in arthroplasty of the knee. *J Bone Joint Surg 40A*:1003, 1958.
7. Bryan RS, Peterson LFA: Polycentric total knee arthroplasty. *Orthop Clin North Am 4*:575, 1973.
8. Campbell WC: Arthroplasty of the knee: report of cases. *Am J Orthop Surg 19*:430, 1921.
9. Campbell WC: Interposition of vitallium plates in arthroplasties of the knee; preliminary report. *Am J Surg 47*:639, 1940.
10. Charnley J: The long term results of low friction arthroplasty of the hip performed as a primary intervention. *J Bone Joint Surg 54B*:61, 1972.
11. Coventry MB, Finerman GA, Riley LH, et al.: A new geometric knee for total knee arthroplasty. *Clin Orthop 83*:157, 1972.
12. Ferguson M: Excision of the knee joint: recovery with a false joint and a useful limb. *Med Times Gaz 1*:601, 1861.
13. Finerman GAM, Coventry MB, Riley LH, et al.: Anametric total knee arthroplasty. *Clin Orthop 145*:85–90, 1979.
14. Freeman MAR, Blaha JD, Bradley GW, et al.: Cementless fixation of ICLH tibial component. *Orthop Clin North Am 13*:141, 1982.
15. Freeman MAR, Sculco T, Todd RC: Replacement of the severely damaged arthritic knee using the Freeman-Swanson knee prosthesis. *Clin Orthop 94*:153, 1977.
16. Freeman M: Personal communication.
17. Gunston F: Personal communication.
18. Hungerford DS, Kenna RV, Krackow KA: The porous coated anatomic knee. *Orthop Clin North Am 13*:103, 1982.
19. Hungerford D, Kenna RV: Preliminary experience with a total knee prosthesis with porous coating used without cement. *Clin Orthop 176*:95–107, 1983.
20. Insall J, Ranawat C, Aglietti P, et al.: A comparison of four different total knee replacements. *J Bone Joint Surg 56A*:1541, 1974.
21. Insall J, Scott WN, Ranawat CS: The total condylar knee prosthesis: a report of two hundred and twenty cases. *J Bone Joint Surg 61A*:173, 1979.
22. Insall J, Walker P: Uni-condylar knee replacement. *Clin Orthop 120*:83, 1976.
23. Jones WN, Aufranc OE, Kermond WL: Mould arthroplasty of the knee. *J Bone Joint Surg 49A*:1022, 1967.
24. Judet J, Judet R, Crepin GT: Essais de prosthese osteo-articulaire. *Presse Med 52*:302, 1947.
25. Kuhns JG, Porter TA: Nylon arthroplasty of the knee joint in chronic arthritis. *Surg Gynecol Obstet 91*:351, 1950.
26. Ma, Steuen M, Finerman GAM: Anametric total knee arthroplasty. *Orthop Clin North Am 13*:345, 1982.
27. Magnoni d'Intignano JM: Genou en resine acrylique. *Rev Orthop 35*:556, 1949.
28. MacIntosh DL: Arthroplasty of the knee. *J Bone Joint Surg 48B*:179, 1966.
29. Marmor L: The Marmor knee replacement. *Orthop Clin North Am 13*:55, 1982.
30. Marmor L: The modular knee. *Clin Orthop 94*:242, 1972.
31. Matthews LS, Sonstegard DA, Kauffer H: The spherocentric knee. *Clin Orthop 94*:234, 1973.
32. McKee GK: Personal communication.
33. McKee GK, Watson-Farrar J: Replacement of arthritic hips by the McKee-Farrar prosthesis. *J Bone Joint Surg 48B*;245, 1966.
34. McKeever DC: Tibial plateau prosthesis. *Clin Orthop 18*:66, 1960.
35. Miller J, Burke DL, Stachiewicz JW: Pathophysiology of loosening of femoral components in total hip arthroplasty. *Hip Society: Proceedings*. St. Louis, C. V. Mosby, 1978, pp 64–86.
36. Murphy JB: Arthroplasty. *Ann Surg 57*:593, 1913.
37. Platt G, Peppler C: Mould arthroplasty of the knee. *J Bone Joint Surg 51B*:76, 1969.
38. Putti V: Arthroplasty. *Am J Orthop Surg 19*:421, 1921.
39. Ranawat CS, Shine JJ: Duo-condylar total knee arthroplasty. *Clin Orthop 94*:185, 1973.
40. Riley LH: Evolution of total knee arthroplasty. *Clin Orthop 120*:7, 1976.
41. Sampson JE: Arthroplasty of the knee joint. *J Bone Joint Surg 31B*:50, 1949.
42. Sheehan JM: Arthroplasty of the knee. *J Bone Joint Surg 60B*:333, 1978.
43. Shires LGP: Hinge arthroplasty of the knee. *J Bone Joint Surg 47B*:586, 1965.
44. Smith-Peterson MN: Arthroplasty of the hip, a new method. *J Bone Joint Surg 21*:269, 1939.
45. Vernenil A: Resultats obtain for France par l'operation d'esmarch: Examen des causes d'insucces et moyen d'y remedier. *Gas Hebd Med Chir 10*:97, 1863.
46. Walldius B: Arthroplasty of the knee joint using endoprosthesis. *Acta Orthop Scand (Supp) 24*:19, 1957.
47. Walldius B: Arthroplasty of the knee joint using an acrylic prosthesis. *Acta Orthop Scand 23*:121, 1953.
48. Waugh TR, Smith RC, Orofino CF, et al.: Indications, techniques and results of knee arthroplasty using the UCI prosthesis. *J Bone Joint Surg 56A*:1302, 1974.
49. Witvoet J: Guepar total knee prosthesis. *Excerpta Med 298*:28, 1973.
50. Young HH: Use of a hinged vitallium prosthesis for arthroplasty of the knee, preliminary report. *J Bone Joint Surg 45A*:1627, 1963.

CHAPTER 2

Anatomy and Kinematics of the Normal Knee

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INTRODUCTION

This chapter presents aspects of the anatomy and kinematics of the knee as they specifically relate to total knee arthroplasty. It is not intended to be an encyclopedic presentation replacing various anatomy texts or other articles on these topics. In fact, it is suggested that this material be read while simultaneously reviewing a standard anatomy text or atlas (2, 3). The anatomic features are discussed as they relate to surgical exposure, and as they define certain features of rotational alignment. In addition, structures involved in soft tissue balancing when correcting varus or valgus deformity are discussed, and the implications of extraordinary bone cuts on subsequent ligament balance are addressed. Last, the fine details of normal joint contours are presented followed by descriptions of the complex kinematic patterns of the normal bone.

SURGICAL EXPOSURE

The satisfactory vascularity of the skin over the knee provides several options regarding initial incision. Planning must include consideration of prior incisions as well as the extent of exposure necessary for handling any unusual deformity. Since lymphatic drainage of the anterior aspect of the knee has been shown to proceed principally toward the medial aspect (4), more extreme median parapatellar incisions may be expected to interrupt more of the medial lymphatic drainage and, thereby, predispose to flap edema over the patella. In addition, one must note the expected locations of major cutaneous branches from the saphenous nerve as these course from medial to central over the anterior knee. With these points in mind, a straight anterior or gently curving median parapatellar incision is the incision of choice (Fig. 2.1).

The deep capsular incision is also generally made along the median parapatellar plane (Fig. 2.1). Certain anatomic points are, however, important. The incision must extend into the region of the quadriceps tendon for adequate exposure. Careful dissection through the overlying deep fat and identification of the medial and lateral margins of the quadriceps tendon are necessary so that the incision can be accurately placed within this structure, thereby affording strong repair at the time of closure and avoiding inadvertent transection of this major tendon.

An alternate exposure proceeding along the inner medial edge of the vastus medialis has been decribed, which obviates incision into the substance of the quadriceps tendon (6). Although we have not used this exposure ourselves, when one considers the rich vascularity entering the superior medial aspect of the patella from the vastus medialis attachment, this different approach may be quite appropriate in certain cases of severe deformity where extensive lateral release and tibial tubercle osteotomy or transposition are predicted at the outset.

Mobilization of the capsule and exposure of the proximal tibia, in consideration of the level of the transverse tibial cut, necessitate detachment of soft tissue from the tibia for a short distance below the joint line as far medially, posteromedially, and laterally as possible. Detachment of soft tissue from the medial flare of the tibia is limited by the insertion of the superficial medial collateral ligament. As one passes farther posteromedially, close to the joint line, dense fibers of the semimembranosus tendon and posterior oblique ligament are encountered. As the lateral tibial flare is exposed, there is no similar concern for the lateral collateral ligament since it attaches to the fibular head. However, upper fibers of the iliotibial band are commonly encountered and some may need to be freed. Removal of a portion of the infrapatellar

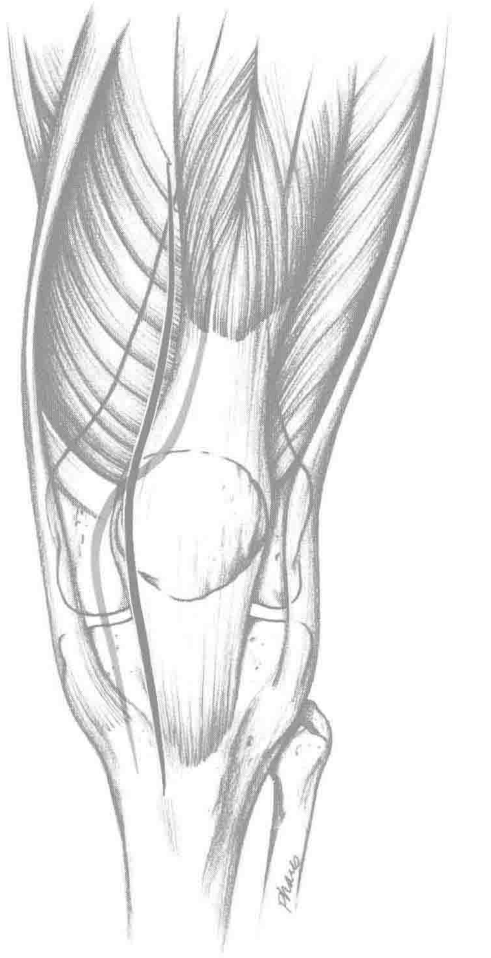

Figure 2.1. The dark line running from medial to the quadriceps tendon, along the medial edge of the patella and down along the medial border of the patellar tendon represents the location of the authors' standard skin incision. The second (red) line running along the junction of the medial and central thirds of the patellar tendon, to the superior medial corner of the patella and distally, medial to the patella and patellar tendon, represents the capsular incision.

fat pad facilitates exposure of the lateral compartment. However, the inferior blood supply to the patella, near the distal pole, should be preserved to the extent possible, particularly if lateral patellar release is anticipated.

Exposure at the lateral flare of the tibia must be done with some caution regarding the perforating anterior tibial artery approximately an inch distal to the usual area of dissection. Careless use of a knife or elevator at this point could produce troublesome bleeding into the anterior compartment.

Eversion of the patella, the next step in exposure, requires adequate proximal incision into the quadriceps tendon, and sometimes reflection of the superior medial corner of the insertion of the patellar tendon on the tibia. Osteophytes on the lateral femoral condyle and lateral patella, and possible contracture of the lateral parapatellar soft tissues may restrict patellar mobilization. More proximal incision into the quadriceps tendon and greater elevation of the patellar tendon from the tibial tuberosity, in order to evert the patella, will not be effective if the surgeon fails to address these problems of patellofemoral osteophytes and synovial and lateral retinacular contracture.

ALIGNMENT

With the patella everted and the knee flexed, several anatomic features relating to alignment can be seen. Upon viewing the distal femur end on, the lateral trochlear facet is seen to be more prominent anteriorly than the medial one. Posteriorly, the femoral condyles appear "level" in the normal knee and actually define neutral rotation of the femur (Fig. 2.2). Even in the diseased knee, preservation of the posterior aspects of the femoral condyles is the rule rather than the exception. They generally survive as reliable indicators for rotation of the femoral component.

Medial-lateral position of the knee may be expressed on the femoral side in relation to the patellar tracking mechanism, and one can define the mid point of the knee by following the patellar groove into the intercondylar notch. The relative prominence of the medial femoral epicondyle and the tissue covering the lateral aspect of the lateral femoral condyle, i.e. fat pad, other peripatellar tissue, etc., can combine to create an optical illusion that the center of the knee is more medial than it is in fact (Fig. 2.3).

From the tibial side, the tuberosity for the patellar tendon lies slightly lateral to the mid line. This is true in flexion and is even more pronounced in extension. In our experience, the medial-lateral position of the tibial tubercle is an unreliable landmark for *definition* of tibial rotation.

While definitive rotational alignment of the tibia may be determined by the relative position of the ankle malleoli (Fig. 2.4), the positions of the posterior margins of the medial and lateral tibial plateaus are helpful in assessing rotation of the tibia. The posterior extent of each tibial plateau is approximately equal on a normal spec-

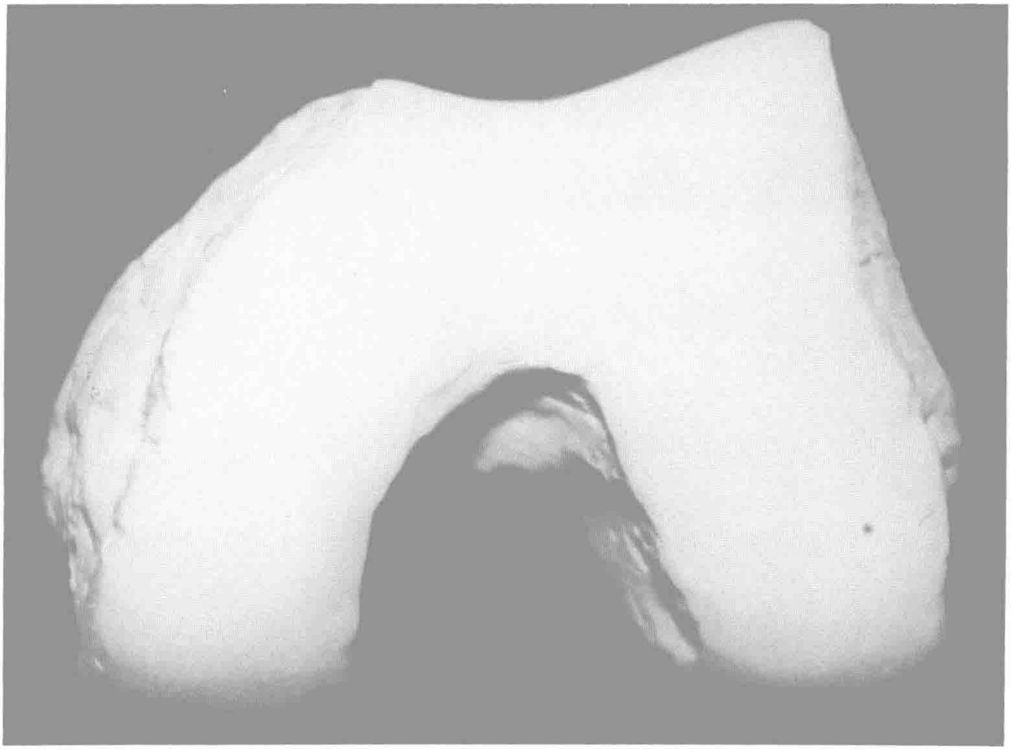

Figure 2.2. View of the distal femur. The posterior aspects of the femoral condyles are "level" and actually define neutral rotation. The lateral trochlear facet is more prominent than the medial one.

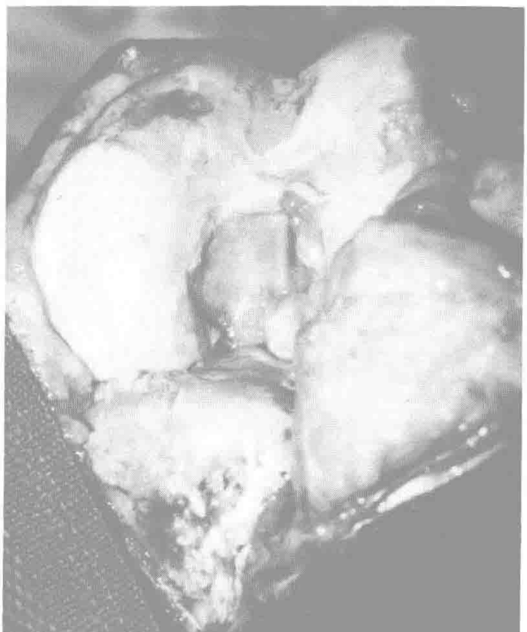

Figure 2.3. Intraoperatively, infrapatellar soft tissue overlying the lateral femoral condyle may give the false impression that the center of the knee is farther medial than it actually is.

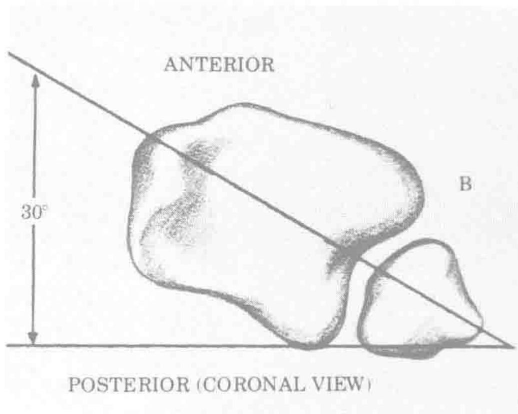

Figure 2.4. View of the ankle from below demonstrating orientation of malleoli in neutral rotation. A line connecting the center of each malleolus forms an angle of approximately 30° with the coronal or frontal plane.

imen; therefore, rotational alignment of a tibial component is facilitated by making use of this fact (Fig. 2.5). The presence of posterior osteophytes possibly remaining after performing the transverse tibial cut, and sometimes the more posterior projection of the medial tibial plateau,

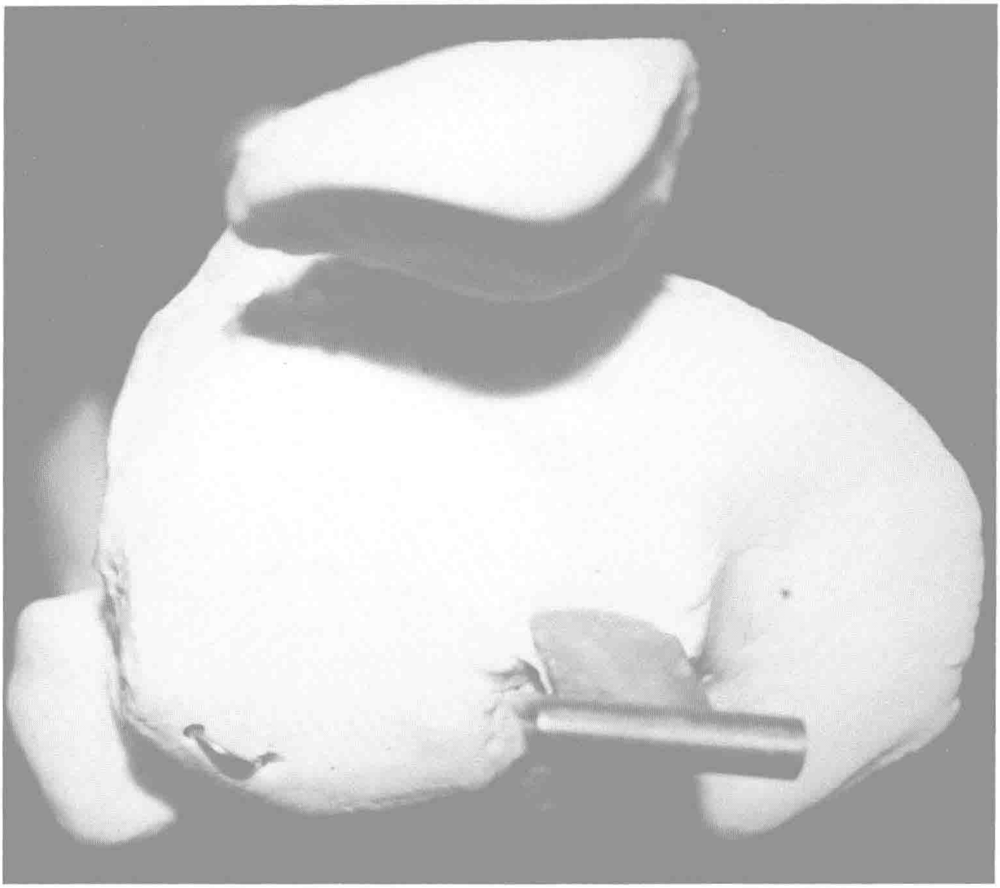

Figure 2.5. View of proximal tibial and fibula from above. This standard instructional skeleton shows the approximately equal posterior extent of both tibial plateaus.

will occasionally alter the reliability of establishing rotational alignment solely on the basis of the posterior margins of the tibial plateaus. Therefore, although the Universal Total Knee Instrumentation System utilizes the posterior margins of the tibial plateaus, it does not depend solely upon these, as will be fully developed in Chapter 3.

LIGAMENT POSITION

Collateral and posterior cruciate ligament positions greatly affect the stability characteristics after total knee arthroplasty and place certain restrictions on the surgeon when bone resection and soft tissue releases are performed.

The medial and collateral ligaments attach to the femur at their respective epicondyles (Figs. 2.6 and 2.7). They are covered by capsule and synovium and are not directly apparent by visual inspection. They are also difficult to identify by palpation with the knee in flexion as the ligaments are relatively relaxed and soft. These femoral attachments limit the level to which the distal femur may be resected. Furthermore, location and orientation of the collaterals make them vulnerable to injury from the saw when making the distal femoral, posterior femoral, and proximal tibial cuts unless they are carefully protected. In addition, the femoral attachment of the posterior cruciate ligament is vulnerable to injury while removing the posterior aspect of the medial femoral condyle.

Since tibial attachment of the posterior cruciate ligament lies just below the normal joint line at the back of the tibia, it is generally possible to make an adequate transverse tibial cut completely across the top of the tibia without damaging this ligament (Fig. 2.8). However, if a relatively deep tibial cut is necessary due to differential wear in one compartment, provision for protection of the posterior cruciate ligament at its tibial attachment will be necessary.

SOFT TISSUE BALANCING

In order to perform lateral soft tissue release comfortably and adequately in situations of mild and moderate valgus deformity, the surgeon must be familiar with the locations of structures on the lateral and posterolateral aspects of the knee (7) (Figs. 2.9 and 2.10). The iliotibial blends proximally, posteriorly with the intermuscular septum and courses superficially to

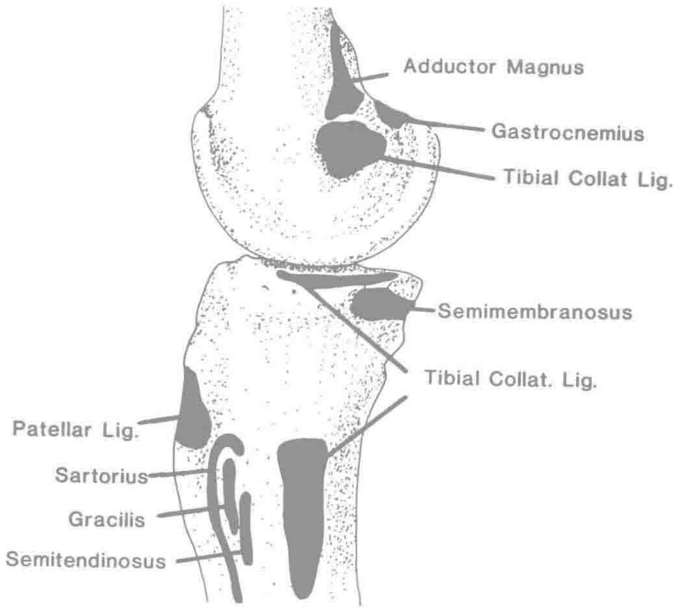

Figure 2.6. Medial view of the femur and tibia. Ligament attachment positions are demarcated. The origin of the medial collateral ligament from the medial femoral epicondyle certainly limits the extent of femoral resection on this side of the joint.

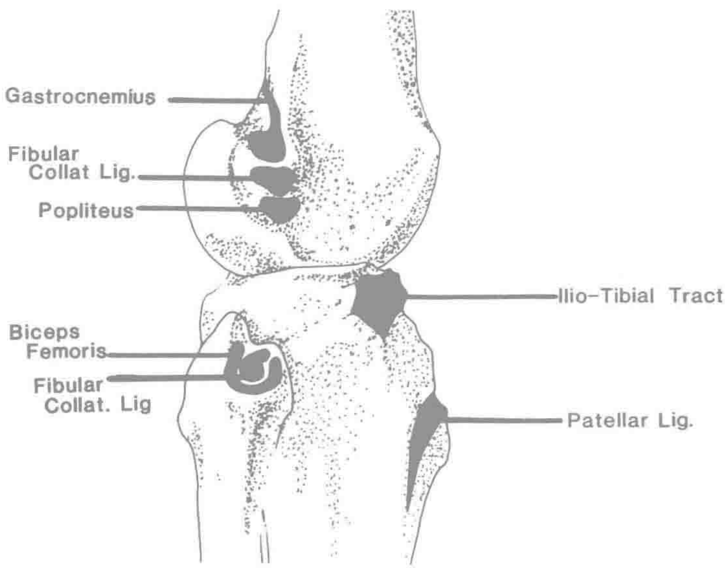

Figure 2.7. Lateral view of the knee. Ligament attachment positions are demarcated. The origin of the lateral collateral ligament from the lateral femoral epicondyle certainly limits the extent of femoral resection on this side of the joint.