Management of Extra-Articular Deformities in Total Knee Arthroplasty
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Summary

Limb alignment, whether “intra-”, or “extra-” articular is the key to success of an arthroplasty. Malalignment of a knee replacement may result in component loosening, prosthetic wear, instability and patellar complications. It is the alignment of the entire limb, from the hip to the ankle referred to as the mechanical axis, that is important, not just the alignment of the knee joint. Component position in the plane of motion of the joint is less important, but correct rotational positioning is essential.

A “neutral mechanical axis” or straight line through the centers of the hip, knee, and ankle results from the angular position of the tibial and femoral components. The joint must then be stabilized with either ligamentous releases or mechanically constrained implants. Extra-articular deformities pose technical challenges.

Bone deformities may be corrected outside or inside the arthroplasty. In the first case, a corrective osteotomy may be performed at the site of the deformity (a fracture malunion or the apex of a rickets deformity) or closer to the joint where it may be performed concurrent with the arthroplasty. If an extra-articular deformity is corrected inside the joint, aggressive and even innovative soft-tissue procedures or a constrained implant will be required to stabilize the knee.

Introduction

Extra-articular deformity is no less important than deformity of the joint itself for surgeons considering knee arthroplasty, but it does pose unique technical challenges [1-6]. Limb alignment is the key to controlling forces across the knee- forces that are usually responsible for failure of the arthroplasty. These deformities may have genetic (tibiae vara), metabolic (rickets), or traumatic origins (fracture malunion or osteotomy) They may be considered “extra-articular” when present in the femur proximal to the epicondyles or distal to the tip of the fibula [1] (beyond the attachments of the collateral ligaments). They must not compromise the arthroplasty; it must be remembered that it is the alignment not of the knee, but of the entire limb that matters.

Lotke and Ecker established the importance of alignment in 1977 [7] and John Insall, instrumental in developing ligament balancing techniques, confirmed this observation with 10-12 years follow-up [8]. The problems of malalignment are manifold. Varus is associated with tibial loosening, breakage, wear, and osteolysis. Valgus exacerbates instability and patellar maltracking. More recent studies reveal how patellar complications (originating in maltracking), knee stiffness, and instability result from rotational malalignment.

Alignment may be restored in the presence of extra-articular deformity through corrective osteotomy at the site of deformity, compensatory osteotomy distant from the deformity, and intra-articular correction through positioning of components. The preferred technique depends on the specifics of the deformity.

Intramedullary instrumentation and rotational landmarks, so useful in routine knee replacement surgery, fail in the presence of extra-articular deformity. Extra-medullary instruments and recent navigation systems enable surgeons to accurately “look beyond” extra-articular deformities and visualize the articulations above and below the knee.

Understanding Alignment: the Anteroposterior Radiograph

The point has been made that if one considers the “six degrees of freedom” in terms of potential component positioning, the potential for error is immense [9]. Extra-articular deformity can confound the positioning of tibial and femoral components in all directions. The word “alignment” is most commonly associated in the minds of surgeons with the varus and valgus angles on an anteroposterior radiograph. This can be expressed as either the “anatomical” or the “mechanical” axis of the knee joint. The former refers to the angle formed by the intersection of the axes of the intramedullary canals of the tibia and the femur. This is a useful and pragmatic frame of reference, as this is precisely what we see on a conventional ra-
diograph, what we expose surgically, and where we place instruments during an arthroplasty. It is only useful, however, because it approximates the more important “mechanical axis”.

The mechanical axis is the angle formed by two lines: one that connects the centers of the hip and the knee and another that connects the centers of the knee and the ankle. This “mechanical axis” is more important, because it is not influenced by deformity between these joints. There is general agreement that the goal of arthroplasty surgery is to re-establish a “neutral mechanical axis”, an angle of 180° or a “straight line” that passes through the center of each joint (Fig. 32-1).

Mechanical alignment can also be expressed, not as the angle of intersection of the mechanical axis of the femur and tibia but as the point where a line from the center of the hip to the center of the ankle intersects the knee joint line or its theoretical extension into space [10]. Deformity would then be expressed as a linear measurement, or deviation from the center of the knee and not as an angle. This is less useful in planning surgery. We must acknowledge, however, that these are all “static” and structural evaluations that neglect potentially formidable dynamic effects [11].

Normal knee alignment (assuming ligamentous integrity), as viewed on an anteroposterior radiograph, is comprised of the respective angles of the articular surfaces of the distal femur and proximal tibia. Similarly, the alignment of an arthroplasty results from the positioning of the respective components. With ligament compromise, the sum of the distal femoral articular surface and tibial articular surface, plus the ligamentous instability, will equal the alignment. Extra-articular deformity, whether from fracture, osteotomy, or unusual anatomy, adds to this equation.

Surgical Alignment

Moreland and colleagues quantified normal lower extremity alignment in a study of UCLA resident physician volunteers [12] (Fig. 32-1). This raises the question as to whether knee arthroplasties should be aligned in “normal alignment” or some mechanically more advantageous alternative, such as a neutral mechanical axis. The idea that patients are somehow restored to normal alignment by knee arthroplasty is suspect. Indeed, many individuals become arthritic because a “normal” tendency to varus (or valgus) has overloaded one compartment, leading to cartilage failure. Accordingly, the releases that confer stability to a re-aligned joint are also non-anatomical, though highly effective at reducing load on the knee joint and enhancing durability. This means that, irrespective of deformity, we must ultimately place the tibial component at right angles to the axis of the tibia and the femoral component at right angles to the “mechanical” axis of the femur, i.e., the line drawn from the center of the femoral head to the center of the knee joint.

Radiographic Assessment of Alignment

How can alignment be assessed most accurately? Small X-ray cassettes and non-weight-bearing films are both inaccurate. Radiographs must show enough of the medullary canal to approximate the anatomical (let alone the mechanical) axis. Similarly, unless the patient is bearing weight we will not appreciate the effects of instability, pseudo laxity, and cartilage loss on alignment. While the full-length radiograph shows the hip, knee, and ankle (i.e., the mechanical axis), vagaries of rotational positioning may compromise these studies as well [13].

Extra-articular deformity requires the full-length radiograph. The tibia is resected at right angles to its long axis and the femoral cut is planned at right angles to the mechanical axis, to the line drawn from the center of the femoral head to the center of the knee. The divergence between the femoral mechanical axis and the intramedullary canal will be the desired amount (of valgus) that is selected on an intramedullary femoral guide. The discrepancy between the angle of the distal femur and the proximal tibia will usually be eliminated by ligament