Knee replacements have evolved from the single-axis fixed-hinge devices of the 1950’s (Walduis, Shiers) [23] to the unlinked fixed-axis devices of the 1960’s (Geomedic, Polycentric) [3, 13], both of which had a limited clinical use because of loosening and wear problems.

In the early 1970’s incongruent contact fixed-bearing prostheses (UCI, Marmor, Townley, Total Condylar) [8, 16, 19, 20] improved the outlook for replacements is by enhancing fixation and improving kinematics to the point where pain relief and kneereasonable function was the usual outcome. However, the price for incongruent contact was higher than allowable contact stresses of the polyethylene, which was subjected to accelerated wear in heavy or active patients.

By the late 1970’s, a »renaissance in total knee development« occurred. A more congruent contact fixed-bearing with an intercondylar posterior-stabilized post (Insall-Burstein) [21] was developed to improve upon the successful Total Condylar device which had limited flexion and dislocation problems. An important advance in the late 1970’s, however, was the introduction of mobile-bearings (Oxford, New Jersey LCS) [5, 10] to improve congruent contact during walking, while eliminating constraint forces. By using metallic components for fixation, these wear resistant implants could be implanted with methyl methacrylate (bone cement) or be used with biological fixation (Porocote) to improve wear properties and minimize loosening.

Another important feature of mobile bearings, aside from ease of bearing exchanging in case of necessity, was their ability to self-adjust the tibia rotation and patella rotation position to optimize knee kinematics, thus allowing the collateral ligaments and extensor mechanism to physiologically balance during flexion-extension and rotary motion of the knee.

The 1980’s brought an increasing number of poorly designed fixed-bearing knee replacement implants (PCA, Ortholoc I, Miller-Galante I, AMK) [9, 11, 26, 27] that overloaded the tibial and patellar polyethylene surfaces and also created »backside wear« from poorly connected modular trays. These fixed-bearing implants were developed to broaden the commercial total knee market while avoiding the overly burdensome requirements of the United States Food and Drug Administration (FDA) by use of the 510 k equivalence process. These devices avoided a formal clinical trial by claiming to be substantially equivalent to knee replacement devices sold prior to 1976, when the FDA Medical Device Act came into existence. Without substantial mechanical or clinical data to support their efficacy, these devices became widely used and developed significant failures, mostly because of premature, accelerated wear. The Anatomic Graduated Component (AGC) total knee [17] was a »bright spot« for fixed bearings of the 1980’s, as it successfully used compression molded polyethylene on the metal tibial component to avoid the wear seen in other fixed bearing designs.

Current total knee designs from the 1990’s and beyond the year 2000 are generally modifications of previous designs, trying to optimize the fixed-bearing surfaces and eliminate metal-backed fixed-bearing patella components. Most of these designs have developed a mobile bearing alternative, to take advantage of the wear reduction potential offered by this concept, especially since the New Jersey LCS mobile-bearing design has shown such outstanding 20 year total knee results in a rotating platform that is still available in its original form [6].
**Mechanical Axis**

Proper limb alignment or mechanical axis alignment in total knee replacement is of paramount importance for long-term successful outcome. Normal mechanical axis alignment is defined as a line that passes and through the center of the femoral head, the center of the knee and the center of the ankle (Fig. 24-1). This normal limb alignment provides even load distribution on the medial and lateral bearing surfaces during walking and other activities of daily living (ADL). Excessive wear is avoided when bearing surfaces are well-designed and well-aligned (see Fig. 24-1).

Deviations from mechanical axis alignment will cause excessive loads on the medial polyethylene bearing surface if varus alignment occurs and excessive loads on the lateral polyethylene bearing surface if valgus alignment occurs (Fig. 24-2). Additionally, in valgus malalignment, the lateral border of the patella bearing may be overloaded (Fig. 24-3), and cause excessive wear leading to failure and the need for revision. Lateral retinacular release may be needed to restore central patellar tracking during flexion and extension.

![Fig. 24-1. Normal mechanical axis alignment is shown along with proper implant alignment](image)

![Fig. 24-2. Deviations from mechanical axis alignment will cause excessive loads on the medial polyethylene bearing surface if varus alignment occurs and excessive loads on the lateral polyethylene bearing surface if valgus alignment occurs](image)

![Fig. 24-3. In valgus malalignment, the lateral border of the patella bearing may be overloaded](image)

**Soft Tissue Balancing**

To gain proper alignment, soft tissue balancing has become the 'art form' of total knee replacement. Strictly making bone cuts to fit the prosthetic parts will not provide stable function if the collateral ligaments are not balanced. Proper ligament balance requires that the flexion-extension arc of knee motion proceeds without impingement and with complete medial-lateral stability in both flexion and extension.

The posterior cruciate ligament (PCL), if retained and properly balanced, should not pull the femur posteriorly beyond the middle one-third of the tibia in the lateral plane during flexion (too tight), nor should it allow forward translation of the femur beyond the middle third of