Chapter 3
The LCS Story

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1 The Early Beginning

As a first year orthopaedic surgery resident at New Jersey Medical School in Newark, New Jersey, I first met Michael J. Pappas, PhD, my biomechanics teacher from New Jersey Institute of Technology, (NJIT) (also in Newark, N.J.). It was early in 1974 when my orthopaedic chairman, Anthony F. DePalma, MD (a feisty, world renowned shoulder surgeon and founder of Clinical Orthopaedics and Related Research) decided that his orthopaedic residents needed to have an understanding of engineering principles as they applied to bone and joint surgery. To that end he enlisted two mechanical engineering volunteers from NJIT, Harry Herman, PhD and his junior associate Michael J. Pappas, PhD.

They gladly came to Martland Hospital in Newark once weekly to give us lectures on Forces, Kinematics and Structural design. The orthopaedic residents were overwhelmed by the mathematics involved and perceived lack of relationship to the field of orthopaedics. I was one of those intimidated residents, but I recall asking questions like: “Dr. Pappas, bridge building is all well and good, but can these principles help us to identify stronger nails and plates used to fix fractures?” Dr. Pappas responded by asking to be shown the various internal fixation appliances so he could mechanically evaluate them for strength and durability. I promptly supplied some old Jewett, Massie, and Holt nails for his review and he promptly used cantilever-bending equations, combined with strength of materials science to give us the answers. To me, it was enlightening to know that our field of orthopaedics could be more fully understood by understanding basic mechanical engineering principles. Time-based senior surgeon knowledge of bone remodeling could be compressed by understanding the nature of bone loading forces and their biomechanical consequences.

In addition, the field of joint replacement, which was quite new in 1974, could be more easily understood with mechanical engineering concepts, and in fact, was not intelligible without them. Concepts such as compressive, tensile and shear loading as well as material property strengths were for the first time integrated into our orthopaedic knowledge base. Kinematic motion studies gave us an improved understanding of normal joint function while suggesting the direction for prosthetic joint function.

2 The First Mobile-Bearing

After an unsuccessful attempt to develop a satisfactory fixed-bearing, cylindrical total ankle replacement, [5] Dr. Pappas and I developed the first mobile-bearing joint replacement in 1974, called the “Floating-Socket” total shoulder (Fig. 1) [2]. This device had two spheres with offset pivot points that extended the range of motion of simple ball-socket systems and had application in constrained knee and hip embodiments, which were never clinically tested. The floating-center prosthetic joint United States patent, [3] which was filed in 1974, issued in 1975 after a successful interference was concluded against the kinematically similar “Spherocentric” shoulder replacement. Our earlier conception, diligence and reduction to practice prevailed in the interference proceeding.

This “Floating-Socket” shoulder device seemed to solve a basic lack of motion problem seen in early ball-socket implants. Clinical and animal (chimpanzee) research with this device [1] gained national attention as the Founder’s Award Paper at the Eastern Orthopaedic Annual Meeting at the Breaker’s Hotel in Palm Beach, Florida in 1976.

3 Commercial Interest in Mobile-Bearings

Several implant companies, most notably DePuy, became interested in the floating-socket shoulder replacement and offered a licensing agreement for the right to
manufacture and sell it. Dr. Pappas and I were interested in the offer, but wished to pursue development of a knee replacement system as part of the deal, and specifically linked our acceptance of the agreement to the acceptance of our knee system once it was developed. This was put into writing in 1977 and marked the initiation of formal development of the New Jersey Integrated Knee Replacement System.

4 Knee Design Challenges of the 1970’s

Dr. Pappas and I had been working on a fixed-bearing knee replacement in 1975 and 1976 to improve upon similar implants of the time. Challenges to be addressed in TKR surgery at that time were lowering contact stresses on the poly in both the patellofemoral articulation as well as tibiofemoral articulation to reduce wear. Additionally, overconstraint was seen to cause loosening, so minimizing or eliminating constraint in knee replacement was an important issue. More uniform bone loading using metal support was also an important concept to be explored to eliminate poly bending of tibial and patella bearing surfaces.

5 The Meniscal Bearing Connection

A key moment in time was February 1977 at the annual AAOS meeting in Las Vegas, when Dr. Pappas and I attended a research society meeting in which Dr. John O’Conner, (a mechanical engineer from Oxford, England) presented a concept of meniscal washers (bearings) to be used with intact cruciate ligaments to allow normal knee kinematics after TKR. This presentation stimulated me tremendously, although Dr. Pappas was less enthused. By allowing congruity with mobility, the artificial knee could reduce contact stress on the bearing surface and eliminate constraint forces – the two major challenges of the time. Of course, there were drawbacks to a completely free-floating meniscal bearing in the knee joint, most notably irreducible dislocation.

We did not collaborate at all with the Oxford Group. The reason that our knee inventions, which were licensed to DePuy in 1977, required a sublicense from the Oxford Group was that our Floating-Center prosthetic joint patent claims, which superceded the Oxford patent, were too narrow to govern the Oxford claims, a mistake of our patent attorney, R. Gale Rhodes, Jr., when he filed in 1974. The additional wording of “a floating-bearing with a curvature of infinite radius” would have covered meniscal bearings! Our loss was Oxford’s gain. The trade-off was acceptable.

6 Developing The LCS Knee

The early days of knee replacement development, after signing the license agreement with DePuy in 1977, led to a methodical program of mobile-bearing design