The Patellar-Tendon-Bearing Prosthesis

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Obviously there is no "ideal" leg substitute short of regenerating or transplanting another normal leg. The surgeon, the prosthetist, and the amputee alike have long accepted major deficiencies in leg prostheses as inescapable concomitants of aid in a situation demanding drastic compromise. Substitution of an artificial leg for a natural one involves not only manual skills and the principles of inanimate mechanisms but is also dependent on anatomy, physiology, and biomechanics. Mutual application of these disciplines toward the advancement of leg prosthetics was slow in coming. As the science of astronomy emerged from the superstitions of astrology, so too there is sound reason to hope that the profession of prosthetics will continue to grow increasingly rapidly beyond the great dependence on "experience in the finger tips" of the ancient skill of limbmaking by adding to its art more general application of the discoveries of science.

Time after time, like recurrent approaches of a comet from its far-reaching orbit, dazzling prospects of improvements in prostheses for below-knee amputees have illuminated the prosthetics scene. The slip socket, the many attempts at end-weight-bearing, the "muley" leg without side joints or corset, the single sidebar, the various polycentric joints, and the several attempts at below-knee suction sockets have been spectacular objects visible for varying periods in Europe, the United States, or alternately in both regions. Unhappily, these phenomena, like comets, have often receded into outer darkness as abruptly as they appeared, leaving the typical amputee with crutches, peg leg, or the centuries-old "conventional" prosthesis.

Pads, straps, locks, and similar devices often reflect either lack of knowledge or incomplete application of such knowledge as there is to control pressure or to overcome instability. Freedom of the human knee joint, distribution of forces in proportion to tolerance of tissues, improved rather than constricted circulation, and better kinesthetic appreciation—all major goals in recent years—demand simplicity of mechanism and reduction of the false joint between the prosthesis and the body by use of an intimate fit.

The patellar-tendon-bearing (PTB) prosthesis developed by the Biomechanics Laboratory of the University of California, to which much of this issue is devoted, combines many long-controversial features—each long used by some, yet rejected by others. PTB is almost a code name integrating a long list of elements which the prosthetist through logical principles and teachable techniques employs to distribute forces comfortably. Because of individual variations, not all so-called "PTB prostheses" contain all the major features. The name implies weight-bearing on the patellar tendon, more properly called the patellar ligament. Because in fact the nearby retinacula also share weight, perhaps the name might well be the "patellar-tendons--bearing" prosthesis! Actually, as later pages of this issue describe, many other areas of the socket (notably the closed distal end) are at least in contact with the stump, and some *(e.g.*, the flares supporting the tibial condyles) share substantial portions of body weight.

Because of its typical use of cuff suspension, with consequent freedom from thigh corset, the PTB prosthesis is often erroneously identified with the "muley" leg, which has stomped the field for as much as a century and yet has so often developed complications during prolonged use. One may speculate that the common complaints of instability of the knee attributed to the "muley" principle were at least partially related to poor alignment between socket and foot, excessive extension or even hyperextension of the socket axis and hence of the human knee, and needlessly low brim levels offering less than maximum stability to the stump. Careful prescription and medical supervision, not available for the earlier "muley," should also characterize use of the PTB and greatly enhance its chances of success.

This writer's personal observations, from visits to the birthplace of PTB and to numerous clinics throughout the United States, have indicated misconceptions of the role of knee flexion in initial alignment of the socket axis. Certainly hyperextension is to be avoided and mild flexion sought. Because the *cast* is taken with the knee in substantial (possibly excessive?) flexion, some newly trained prosthetists initially aligned the socket bore similarly but with a very large angle of flexion. The horizontal components of forces on the condyles were reduced; but the resulting extreme bent-knee gait was tiring, the quadriceps were unduly stressed in their atrophied state immediately after their release from bondage within the thigh corset, and the unique mechanical stability of the extended human knee was transformed into the capability of substantial horizontal rotation of the flexed knee. In the below-knee amputee lacking an actively steerable ankle and foot, an unimpaired but controlled horizontal rotation in the knee joint must be considered of added importance. Thus neither the rigid "screw-home" of final extension nor the gross instability of major flexion will be as suitable as mild flexion with control of unencumbered hamstrings as internal and external rotators.

In many past efforts too little attention has been paid to the popliteal space.

The PTB includes logical principles allowing a higher brim in the popliteal space (and indeed on all aspects) than has been customary in a majority of cases yet freedom for action of the hamstrings and avoiriance of bulging of tissue during sitting. The high brims medially and laterally, reflecting better appreciation of anatomy and of the force patterns dictated by biomechanics. should give greater mediolateral stability than was typically available with a "muley" limb. Eventual use of brims of tapering flexibility, by avoiding sharp pressure points at the very edge, may ultimately allow still better fitting.

No one, especially among its developers, would acclaim the PTB as the ultimate solution. Some of its features represent successive reincarnations over a century, each with a higher survival percentage. Yet the PTB is only an evolutionary step toward greater mechanical freedom under better neuromuscular discipline. Many apparent failures can be salvaged by careful adherence to the principles and techniques enunciated in the UCB manual and its recent revision and in the following papers of this issue of ARTIFICIAL LIMBS.

The conveniences which the PTB leg accords its wearer are so numerous that continued efforts seem assured. Though a single breaker may recede, the tide is surely coming in.