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My First 50 Years of Orthopaedic Surgery

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My career has spanned not only one half century but, more specifically and more importantly, the most spectacular half century in the history of medicine. After World War II, an astonishing confluence of remarkable resources created a unique environment for progress in medicine that had never occurred before. These resources included the flowering of scientific capabilities and personnel in remarkable ways, the influx of massive funding for patient care and research, and a social environment that placed major emphasis on medicine in Western civilization.

The high expectations have not been disappointed. Extraordinary progress has been made in these 5 decades—more, by far, than during the entire history of medicine before that era. More importantly, the platform or base from which medicine will progress from here will dwarf the successes of the past 5 decades.

So, too, has the nature of practice of orthopaedics changed drastically. Early in my career, I did the orthopaedic surgery of the first successful human limb replantation (May 1962) and continued to design techniques and performed all the orthopaedic surgery for the limb replantations at the Massachusetts General Hospital (MGH) for years [1,2]. While this was occurring, I also did tumor surgery, such as hemipelvectomies for chondrosarcoma, and wrote a book on the management of fracture cases [3].

During that same early period, my research work focused on the effects of growth hormone on skeletal tissues and the interaction of calcium and phosphate metabolism on skeletal mass, bone turnover, and osteoporosis [4–11]. It was also in that era that we concentrated our work on the prevention of venous thromboembolic disease.

Think of the width of that experience in musculoskeletal disease. Such a panoply of interests is unheard of today. During that time, I also began to work on new ideas in reconstructive hip surgery, ideas in those days that emphasized ways to improve the surgery of and the results of cup arthroplasty [12–14]. Now, fast forward to the present time, when our major effort is the decade-long project of the development of electron-beam, cross-linked, melted ultra-high molecular weight polyethylene, with its high potential to revolutionize another type of hip reconstruction, total hip arthroplasty (THA) surgery.

The range, depth, scope, and extent of this odyssey is, in major part, a reflection of this remarkable period of time. It is also a reflection of a decision I made from the start of my career to weave research into an academic clinical career. It has been varied and fascinating. Permit me to reflect on what I consider to be the 3 most lasting areas of my activities, those perhaps that are the most influential on the current and future practice of orthopaedics.

Among the most satisfying areas of progress in our work during this half century have been the contributions to the conquest (or near-conquest) of fatal pulmonary embolism after major hip surgery in adults. In 1959, when I was Chief Resident at the MGH, ignorance was massive in all 5 major aspects of venous thromboembolic disease (VTED): the nature of the disease, its true incidence, the ability to diagnose VTED *in vivo*, prevention of VTED, and treatment.

In those days, fatal emboli were considered to be acts of God or *bolts out of the blue*. The incidence of deep venous thrombosis after surgery of the lower extremities in adults was thought to be about 12%, and this diagnosis was based mainly on Homan's sign. There were no widely used diagnostic tools, no preventive measures, and no effective treatment. Along with Ed Salzman and Roman DeSanctis, we did the first study of the use of warfarin (Coumadin) in the prophylaxis against VTED after hip frac-

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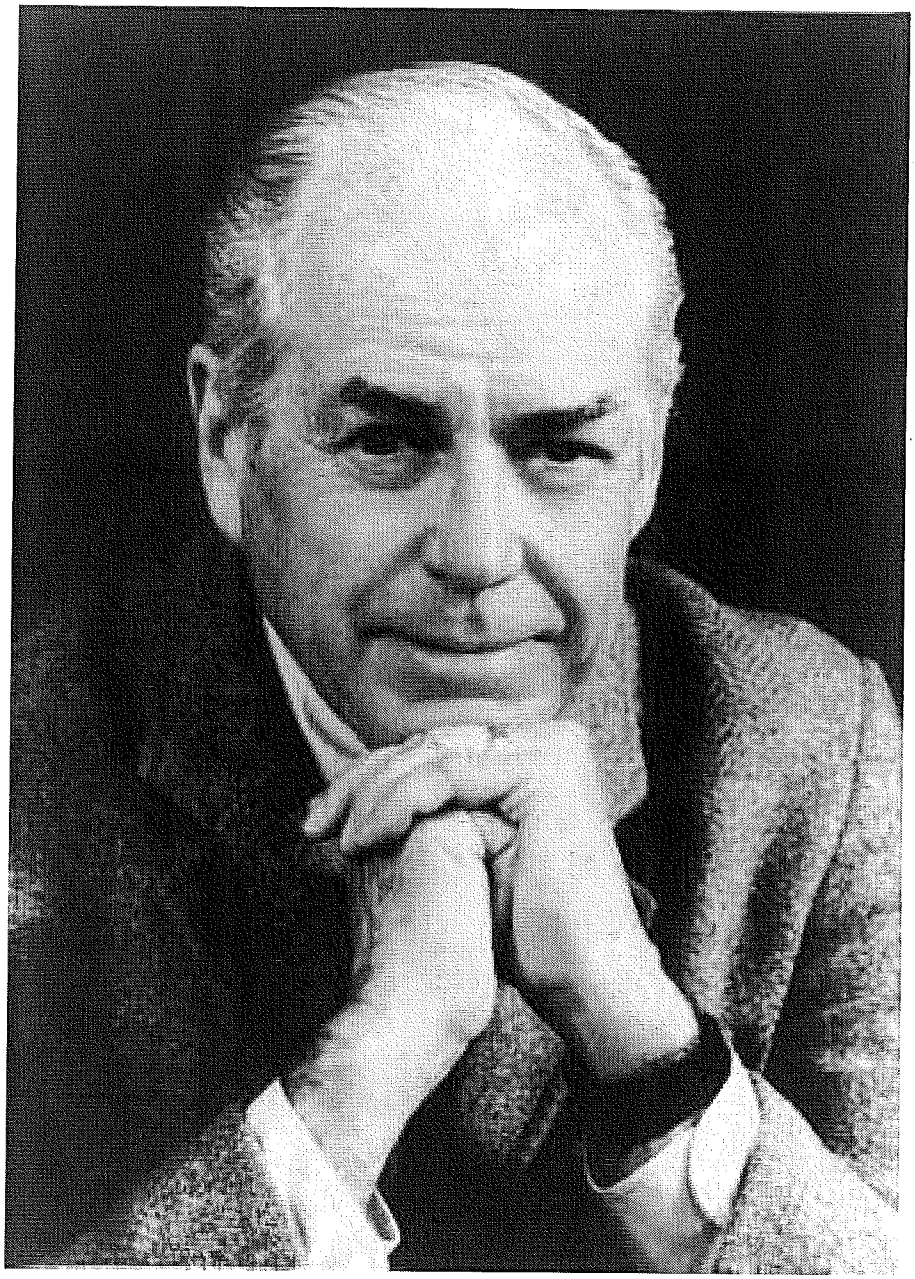

tures [15]. Imagine, voluntarily using an anticoagulant in elderly patients with a fracture and a large hip wound!

When that proved to be effective, we initiated studies of a similar nature for prevention of VTED after elective hip surgery [16–25]. This research was done to refute the accumulated wisdom of our elders that the unilateral massive swelling of the extremity after cup arthroplasty was "the postoperative swelling of hip surgery." The results of this work plus the huge contributions of so many outstanding investigators can be estimated in 3 different forms:

1. The adoption of effective prophylaxis is extremely wide and in some areas nearly universal in high-risk cases.
2. The major discussions about prevention of VTED now are no longer focused on *how*, *if*, or *why*, but rather are focused on making choices over the uses of safer and more effective modalities of prophylaxis.
3. The last fatal pulmonary embolism after hip surgery in a patient of mine was 42 years and 3,000 cases ago.

The second overarching theme of my work has dealt with concepts, designs, techniques, and instruments to further the efficacy of reconstructive surgery of the hip. These efforts ranged from new incisions [26–28] and new approaches regardless of incision [29–32], through many instruments, to many implants and on to innovative concepts [33–39]. We were the first to use a cement gun to deliver bone–cement; use is now worldwide. We designed the first modular acetabular component and the first metal-backed acetabular component. In North America, most acetabular components are modular. We did the first femoral head autograft and first femoral head allograft for acetabular augmentation for THA and designed the first special components for and performed the first THA on a hip that had a congenital total dislocation [40–47]. Later on, we developed the hybrid THA concept, recognized as the state-of-the-art at the last consensus report of the National Institutes of Health [48–52]. Our commitment to quantification of results in hip surgery led to the development of the Harris Hip Score in 1967 [13,53]. It is a validated instrument [54].

Our work was active in the design of cemented and cementless THA, with special emphasis on improved fixation. Perhaps one of the most lasting efforts in this realm is the work with Jorge Galante that culminated in the design of the hemispherical, porous acetabular component transfixed with screws (or press fit) that has changed THA surgery so drastically [46,55–57]. It has played a major role in solving many of the problems of acetabular revision surgery, has improved acetabular reconstruction surgery in young patients greatly, and is now gaining increasing scientific backing as the best acetabular component in primary THA in the older patients as well. This implant is valuable in the *high hip center* concept [58–61] and the *Jumbo* socket concept [62]. These efforts continue apace with major work now aimed at reducing dislocation, increasing range of motion, and augmenting the quality of life by creating more normal and more anatomic THA.

Third, an exciting avenue of research has been the role we played in the identification, definition, and, it is hoped, the cure of a worldwide disease, periprosthetic osteolysis [63–73]. Many excellent investigators have played major roles in this effort. Our particular pathway began with the publication in 1976 of 4 cases of periprosthetic osteolysis [63]. Many others had seen this affliction, including Charnley, McKee, and Willert. Charnley et al [71] had thought it most likely due to infection but could not identify bacteria. McKee and Watson-Farrar [75] thought it was secondary to the motion of loose components. Willert et al [76] advanced the concept of particle migration.

From this small start (the publication of 4 cases) [63], for us the next step was work with Goldring and Schiller [65,66], which was the first demonstration that the periprosthetic membrane which people had been discarding for >20 years as *fibrous tissue* had the capacity to elaborate prostaglandin E_2 and collagenase and to resorb bone. All the work identifying the many cytokines and enzymes involved in the lysis that constitutes periprosthetic osteolysis followed rapidly thereafter.

We also identified the role of this lytic process in acetabular loosening and femoral loosening [67–69]. Because the submicron particulate debris, primarily particulate ultra-high molecular weight polyethylene generated at the metal-to-polyethylene articulation, is the offending agent that initiates periprosthetic lysis, we initiated in 1990 a program to determine if we could decrease such debris by creating a better articulation for artificial joints. Rather than starting our research on materials, however, we began by inventing a new hip simulator, driven by the belief that without such a device that could quantify the efficacy of any proposed new articulation in terms of reduced wear, any proposed new material would long remain a hypothetical possibility.

The effort to design a better hip simulator also drove us to define, for the first time, the actual pathways that individual points on the femoral head must take inside the hip joint during the gait cycle [77]. When the hip simulator was established, in collaboration with Professor Ed Merrill at MIT, our group invented a new material, electron-beam irradiated, melted, highly cross-linked ultra-high molecular weight polyethylene [78,79]. Massive *in vivo* experiments have shown it to be remarkable, not only in wear resistance and oxidation resistance, but also in physical properties as used in an acetabular component. This material has been approved by the Food and Drug Administration for use in hips and knees. Should it prove to be as effective *in vivo* as its behavior is *in vitro*, a new age of THA will be with us. The duration of success, reduction of complications, decrease in revisions, improvements in functional outcomes, decrease in cost, improvements in activities of daily living, and extended indications all would follow. More importantly, should this material show long-term success, it would close the loop in the story of the worldwide disease of periprosthetic osteolysis. Periprosthetic osteolysis is a man-made disease, never seen before in the history of humankind. It is the direct result of the invention of total joint surgery. If the improved polyethylene works over the long-term, this disease may have been fully cycled—introduced, identified, defined, explained, and cured, all in 1 generation. Were that to occur, it would be remarkable.

In everything I have described there have been many powerful and massive contributing forces. These include, but are not limited to, the giants in our field who built the platform that made any such effort possible; the large number of remarkably bright, dedicated, and inventive colleagues and coworkers who were a constant source of solace, inspiration, and renewal throughout the 5 decades; and in particular, the Fellows. As a source of renewal, challenge, excitement, and inspiration, the Fellows are unequaled and, almost without question, they are my most impressive legacy. To all these people, I owe an incalculable debt. Many thanks.

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