

# HISTORY OF SELF-EXPERIMENTATION IN ORTHOPAEDICS

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During his medical training at the University of Berlin in the 1920's, Werner Forssman encountered a sketch in a physiology textbook of physicians passing a tube through the jugular vein of a horse and into the horse's heart in order to record changes in pressure in the heart. He became convinced that the procedure would work on a human. He cajoled a nurse into being his subject, but once he strapped her to the operating table, he opted to perform the procedure on himself while the nurse acted as his captive witness. He explained his choice by saying, "I was convinced that when the problems in an experiment are not very clear, you should do it on yourself and not on another person."<sup>1</sup> He published his results in 1927, and the procedure revolutionized our understanding of cardiac anatomy and physiology, ultimately earning a Nobel Prize in Medicine in 1956.

Although Forssman's experiment was perhaps one of the most dramatic and well known, he was neither first nor the last physician to engage in self-experimentation. Physicians may choose to be their own subjects for a variety of reasons. There may not be other subjects available, or, as in Forssman's case, the risks of the experiment may be unknown. In some cases, the use of surrogates such as animals is not desirable because the researcher wishes to document the human experience. As discussed below, in cases such as Dr. Scott F. Dye's interest in knee pain, the physician may desire firsthand experience of the treatment or procedure. For these and other reasons, physicians have subjected themselves to sudden changes in atmospheric pressure and extreme temperatures, exposure to infectious agents, and even surgical procedures. Orthopaedic surgeons are no exception, and some orthopaedic self-experiments have resulted in important advances in medical knowledge.

Some of the earliest self-experimentation in orthopaedics occurred in the investigation of osteomyelitis. In the late 1800's, understanding of disease transmission remained very rudimentary. Osteomyelitis was a com-

mon and sometimes deadly problem. A Scottish surgeon named Alexander Ogston had isolated staphylococcus and used the bacteria to infect animal subjects, but the role of staphylococcus in human disease remained unclear. Dr. Carl Garre, a surgeon and bacteriologist in Basel, Switzerland became interested in bacterial transmission of disease after he cultured staphylococcus from both bone and skin infections. Though cultures from both sources appeared to be staphylococcus under the microscope, he was uncertain whether the same staph species could cause relatively harmless skin infection as well as severe osteomyelitis. To determine if the same species could cause this spectrum of infections, he used a wire inoculated with bacteria from a patient's bone infection to scratch his nailbed. That produced a very mild superficial infection, but he wanted to be more certain. In 1883, he scratched his forearm with wire and smeared staphylococcus cultures over the wound. He used his other arm as a control, placing sterile culture medium on that wound. By the end of the first day, he noted that the staph-inoculated wound had already become red and painful. On day 2 of his experiment, he noted that, "the whole thing began to be unpleasant,"<sup>2</sup> and he ultimately developed an abscess, lymphadenopathy, and fevers. Garre concluded that staphylococcus were responsible for both bone and skin infections. Other scientists confirmed Garre's results, prompting further investigations into the role of staphylococcus in human disease.

Although inadvertent, osteomyelitis also played a role in the self-experiments of another famous orthopaedic surgeon. During his training, Sir John Charnley became interested in the role of periosteum in bone grafts. Against the advice of his superiors, he convinced a colleague to remove a piece of bone from his tibia and reimplant one portion beneath the periosteum and one portion superficial to the periosteum. The exact results he sought are unclear, as the wound became infected within a few days, and Charnley required surgery to eradicate the infection.<sup>3</sup>

Undaunted, several years later, Charnley performed a second self-experiment that revolutionized hip arthroplasty. In the 1950's, Charnley devoted himself to the creation of a low friction hip arthroplasty. He began performing hip replacements that used polytetrafluoroethylene (PTFE, aka Teflon) as a bearing surface, and published his early results in *Lancet* in 1961. In his article

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entitled "Arthroplasty of the hip: A new operation," he described how, "most patients can execute "a straight-leg raise" and have no pain or spasm on passive movement."<sup>4</sup> Unfortunately, such promising results were not long lasting. After only a few years, patients returned with failed prostheses and extensive bone loss. Although PTFE had performed well as a bearing surface in the lab and was chemically inert, Charnley suspected that PTFE wear particles were to blame for the osteolysis. To prove this, Charnley placed small particles of PTFE under the skin in one thigh, and particles of his new proposed bearing surface, high molecular weight polyethylene (HMWP)\* under the skin in his other thigh. As he suspected, the PTFE elicited an inflammatory response. Fortunately, the HMWP did not.

Meanwhile, the remainder of the orthopaedic community quickly embraced arthroplasty with PTFE. Charnley, devastated by the rapid failure of the PTFE implants, attended the British Orthopaedic meeting intending to warn others of the dramatic failures due to osteolysis. Unfortunately, the chair of the meeting concluded discussion before Charnley could speak.<sup>5</sup> In an effort to stop the use of PTFE and its unintended consequences, Charnley wrote a letter to *Lancet*, published in 1963 that began, "Sir- Surgeons, and especially orthopaedic surgeons, should be warned that tissue reactions are likely to follow the implantation of polytetrafluorethylene . . . if this material is subjected to abrasion, and that these reactions may not be manifest for two years"<sup>6</sup> (Figure 1). In this letter, he goes on to describe his self-experiment, stating

I have had introduced subcutaneously into my thigh, . . . two specimens of P.T.F.E. and one specimen of "high-density" polyethylene, prepared in finely divided form. After nine months in situ the two P.T.F.E. specimens are clearly palpable as nodules . . . almost twice the volume of the original implant. The "high-density" polyethylene can not with certainty be detected by palpation, which I take to indicate that no tissue reaction has been produced by this material in finely divided form.<sup>7</sup>

\*How Charnley happened upon HMWP as a bearing surface is an interesting story in itself. After the failure of PTFE became evident, Charnley and his engineering lab supervisor Harry Craven began searching for an alternative bearing surface. They tried a number of different materials in the lab, but none were superior to PTFE. With patients piling up in his clinics, and no good treatments available, Charnley and Craven were struggling to find a solution. A young man approached the hospital supplies officer in an effort to sell him plastic gears made for weaving machines. He supplied Craven with a piece of the plastic used in manufacturing the gears. At the time, few people were aware of this material, known as high molecular weight polyethylene, but this serendipitous stop by the plastic gear salesman resulted in handing Craven and Charnley the key to hip arthroplasty. (Waugh, W. *John Charnley: The man and the hip*. London: Springer-Verlag, 1988. p.123-124.)

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LETTERS TO

#### TISSUE REACTIONS TO POLYTETRAFLUORETHYLENE

SIR,—Surgeons, and especially orthopaedic surgeons, should be warned that tissue reactions are likely to follow the implantation of polytetrafluorethylene (P.T.F.E., 'Teflon', 'Fluon') if this material is subjected to abrasion, and that these reactions may not be manifest for two years.

In biological tests insufficient attention seems to have been paid to P.T.F.E. in finely divided form. After pioneering its use in arthroplasty I abandoned it over two and a half years ago, and I write this because I have been told that a firm which distributes this material is still having frequent requests to supply P.T.F.E. to orthopaedic surgeons in sheet form for insertion between the femur and the tibia as an arthroplasty of the knee. This simple, and therefore attractive, operation was announced at the

Figure 1. Charnley's 1963 Letter to the Editor of *Lancet* reporting the failures of hip arthroplasty and PTFE and his self-experiment comparing tissue reaction to PTFE and HMWP.

Reassured that the HMWP wear particles were less inflammatory than those of PTFE, Charnley moved forward with low friction hip arthroplasty, and his designs remain the basis for total hip arthroplasty performed today.

Although self-experimentation may seem a thing of the past, using oneself as a subject remains the only way to truly understand the human experience firsthand. As JBS Haldane explained, "For rough experiments one uses an animal, and it is really only when accurate observations are needed that a human being is preferable . . . it is difficult to be sure how a rabbit feels at any time. Indeed, many rabbits make no serious attempt to cooperate with one."<sup>8</sup> Some questions simply require personal involvement to solve.

Dr. Scott F. Dye encountered one such question. After seeing numerous patients with persistent anterior knee pain, he became interested in the source of patellofemoral pain. He noted that many patients who had arthroscopic surgery for other reasons had fibrillated cartilage in their patellofemoral joint, but did not have patellofemoral pain. Meanwhile, patients with presumed patellofemoral pain might have pristine cartilage in their knee at the time of arthroscopy. This led him to ask the question, "What anatomic structures in the knee can really feel pain?" Previous studies examining sensory output from the knee had focused on histologic evidence of neural structures, or nerve transmission from the knee in anesthetized patients. As Dr. Dye stated, "Documentation of sensory evoked potentials with electrical stimulation of intraarticular structures of anesthetized patients at surgery does not address the question of

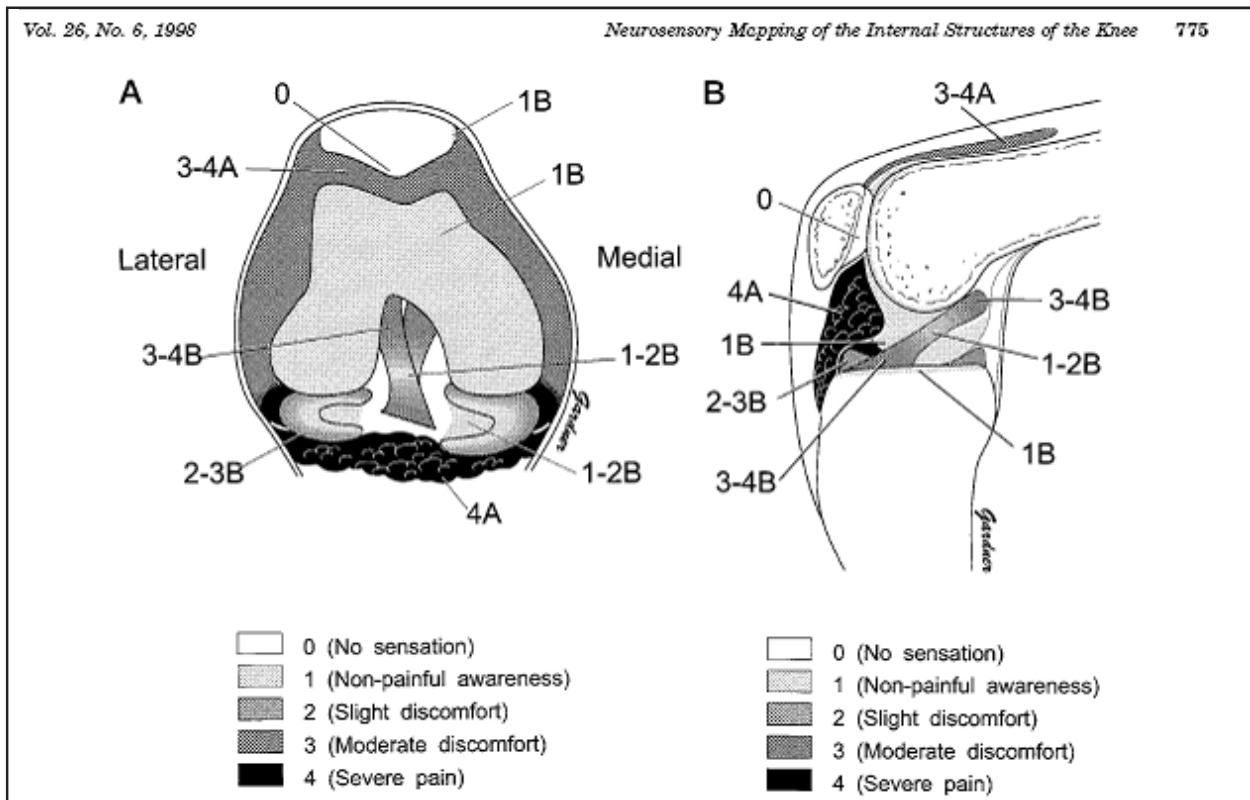


Figure 2. Dye's neurosensory map of the knee. A, accurate spatial localization. B, poorly localized sensation. (Reprinted with permission, SAGE Publication, through Rightslink)

whether and to what extent a person would consciously experience palpation of those structures.”<sup>9</sup>

To answer the question, Dye asked a colleague to perform knee arthroscopy on his knee without anesthetic. During the arthroscopy, the surgeon would probe different anatomic structures, and Dye would report what he felt. He described both the intensity of the sensation and whether he could localize the sensation (Figure 2). As a result, he discovered that he had almost no pain with palpation of the patellofemoral joint, while probing of the anterior fat pad and anterior joint capsule was exquisitely painful. Correctly identifying the anatomic structures that lead to knee pain should help provide direction for treatments in the future.

Although self-experimentation may seem an odd or arcane research method, results of such experiments remain relevant today. Without physicians using themselves as subjects, we might not have effective treatment for cardiac disease, infection, and myriad other diseases. In orthopaedics alone, self-experimentation has yielded important advances in the treatment of osteomyelitis and hip arthroplasty, and may offer more knowledge in the future.

## REFERENCES

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