

Surgical innovation in the cold war era: Gavriil Ilizarov and his apparatus as a device for external fixation and limb lengthening

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Abstract

Gavriil Abramovich Ilizarov [1921-1992] was a researcher and innovator of orthopedic surgery. In the setting of the Second World War, he was forcibly evacuated from Crimea where he studied medicine. He finished his studies in Kazakhstan before working in rural Siberia. Being positioned behind the Iron Curtain complicated the dissemination of the surgeon's apparatus to North America. From rudimentary materials in rural Siberia, Ilizarov pioneered an external fixator used to lengthen limbs and treat comminuted fractures.

Ilizarov's early years and education

Gavriil Ilizarov was born in Białowieża, Poland (present day Belarus) in 1921. In childhood, he sustained a bout of food poisoning and, upon his recovery, developed a deep and persistent interest in human illness.

Ilizarov's father died when Gavriil was very young, resulting in tremendous economic hardship for his family. There was little support for Ilizarov to attend school and, consequently, his formal education was delayed until age 11. By age 16, Ilizarov had completed the equivalent of ten years of education in five consecutive years. In the setting of the Second World War, Ilizarov was forcibly evacuated from Simferopol, Crimea where he studied at the Simferopol Medical Institute. Finally, he would finish his studies in Kzyl-Orda, Kazakhstan and, at the age of 22, was awarded his medical degree in 1943.

In 1944, Ilizarov returned to a rural setting when he was assigned to practice general medicine in Dolgovka, Siberia, a remote region that had previously been used for the exile of Tsars and their families.¹ Ilizarov came across a shaft-bow harness connecting a horse to its carriage through shafts. This served as inspiration and he attempted to incorporate this mechanism into a prototype to repair fractures. Before ever testing on a living subject, Ilizarov first created an apparatus based on the shaft-bow harness to "treat" broken broomsticks. He made several rudimentary versions of the device, trying each time to further reduce mobility of the broken broomstick. Ilizarov would eventually seek help from a local metal-worker to fashion ring-shaped wires that would be suitable for use on human limbs.

The Ilizarov apparatus became a system of external fixators consisting of stainless steel rods, rings, and kirschner wires. The method was distinct from conventional external fixators in that the apparatus encased the limb and formed an external cylinder around it. The circular construction afforded early weight bearing for patients since it provided greater support than monolateral fixators. A key biophysical element was that the superior rings of the apparatus allowed force to be transferred from the bone distal to the fracture site, through the external frame (bypassing the fracture site), directly to the bone proximal to the fracture. Although its initial application was to effectively stabilize severe fractures for healing, Ilizarov realized that the apparatus could also be used to lengthen a limb. The Ilizarov

external fixator apparatus' use for this purpose relied on the principle of distraction osteogenesis; when two ends of a bone are distracted but the periosteum remains intact, new bone is laid down to fill the space. This regeneration of bone was applied to correct limb length discrepancies.²

Ilizarov's studies proved that the ideal setting for new bone formation consisted of a low-energy osteotomy followed by one week of latency and a distraction of the bone at a rate of one mm/day in four divided increments.³

New beginnings: Ilizarov moves to Kurgan and creates the apparatus

In 1950, Ilizarov moved to Kurgan, Siberia. Practicing in this larger center allowed Ilizarov to develop his apparatus and broaden its scope.

Though formally trained in general medicine, Ilizarov was promoted to Director of the Kurgan Research Institute for Experimental Orthopaedics and Traumatology because of his experience with his innovative apparatus. He chose former Russian soldiers in the Second World War as his initial patients. Ilizarov was disheartened by the time required for severe fractures to heal and wished to use his technique in an effort to repay veterans for their service.

In 1964, Soviet high jumper and Olympic champion Valery Brumel found his career cut short after a severe automobile accident. Brumel sustained comminuted fractures resulting in the near complete loss of the use of both legs. In desperation, Brumel sought help from Ilizarov and was successfully treated in 1967.

Knowledge transfer: The Ilizarov Apparatus comes to the western world

At the time, University of Toronto orthopedic surgery resident, Dror Paley, was motivated to learn of this new technique and bring its benefits to North America. But tensions in the Cold War era Soviet Union made it extremely difficult for people from the Western World to gain access to this "closed" Soviet city. In 1986, Ilizarov and other Soviet-based surgeons hosted an International Conference on Transosseous Osteosynthesis, giving Paley the perfect justification to enter Kurgan.

Ilizarov felt it was important to disseminate his method to an American audience but was simultaneously wary of not receiving

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credit from American scientists and clinicians, especially given the air of secrecy between the two nations. Paley helped to assuage these tensions by being able to communicate with Ilizarov in Russian. Since Ilizarov was more willing to share the confidential details on the use of his apparatus in the absence of an intermediary translator, Paley enjoyed greater access to the intricate details of mastering the technique. As well, being from Canada, as opposed to the United States, made him less threatening. For Paley, learning Russian provided an opportunity to make sense of many of Ilizarov's original documents.⁴

The Ilizarov procedure of Transosseous Osteosynthesis was alive and well by the late 1980's.³ When Ilizarov eventually went to Rome in 1982 to lecture on his innovation, the Ilizarov apparatus had already begun to acquire global fame. Italian surgeons dubbed Ilizarov "The Michelangelo of Orthopedics."

Ilizarov Apparatus in the 21st Century

Ilizarov was a rigorous and thorough researcher and surgeon. As outlined by Baker and Offut,⁵ hundreds of hours are required before a surgeon is considered adept at employing Ilizarov's external ring fixator technique. Preassembling specific external frame designs proves especially time-consuming.⁵ Today, the Ilizarov external fixator is primarily used to correct leg length discrepancies. Infection of the pins is a common complication of the apparatus, limiting its use in stabilizing comminuted fractures. Sometimes, patients must maintain the apparatus for several months and the months of required rehabilitation necessitates a motivated patient.² Dror Paley, one of Ilizarov's earliest trainees, is now the medical director at Florida's Paley Institute. Here, the Ilizarov apparatus is employed to correct limb length discrepancies due to skeletal dysplasia, congenital short stature, as well as achondroplasia and other forms of dwarfism. In adults, the apparatus is most often used to manage post-traumatic limb length discrepancies.³

Hero of Socialist Labor

Constantly absorbed in his work, Ilizarov had been known to regularly work sixteen-hour days, from ten in the morning until two o'clock the following morning. Ilizarov had been bestowed the rare honor of Hero of Socialist Labor in 1981 and was named a member of the Russian Academy of Sciences ten years later. He was awarded the Lenin Prize in 1979. This prestigious award was given to an individual for significant contribution to any of the fields of science, literature, arts, medicine, architecture, or technology. In 1992, the decorated surgeon, researcher, and pioneer, died of heart failure at the age of 71 in his hometown of Kurgan. The Ilizarov Centre for Orthopedic Surgery in Kurgan has been repurposed to focus on the surgical correction of congenital limb abnormalities. A scientific journal in honour of Ilizarov was created shortly after his death entitled "Genii Orthopedii" (Orthopaedic Genius).⁴

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