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☭AN IRON CURTAIN ORTHOPAEDIC REVOLUTION☭

Allied victory in WWII may not have been possible without strong Soviet efforts. Despite their ally status, a 1945 telegram from Winston Churchill to President Truman stated that "An iron curtain is drawn down upon their front. We do not know what is going on behind." (Churchill, 1962) The growing void between the USSR and the western world resulted in two independently advancing 20th century powers. The race to the moon showcased a battle of ideology and a taunting of military potential. Technologies unknown to one another, however, were not limited to space exploration and military proliferation. While both powers were in lock-step with many advances, an exception was in orthopaedics where the Soviets had an innovative genius obtaining unimaginable outcomes deep in the heart of Siberia.

Gavril Abromovich Ilizarov outpaced his western contemporaries by decades and founded a new field of orthopaedics. He is the undoubted father of external fixation and limb lengthening. Ilizarov was not the first physician to describe external fixation techniques but with his patented circular fixator he and

Figure 1: Dr. Ilizarov at his desk in Kurgan.

his colleagues in Kurgan Russia pioneered the field. He performed successful lengthening procedures and healed non-union fractures 20-30 years before similar results could be obtained by Western Contemporaries.

Born in 1921 to uneducated Jewish parents in the Belarusian region of the USSR Ilizarov had no formal education until the age of 11. Believed by many of his later pupils to be genius, he excelled through school and enrolled at the Crimean Medical institute in 1939. Soviet involvement in WWII displaced his medical education to Kazakhstan where he graduated in 1944. He was sent to a Siberian outpost where he worked as a general practitioner in a log cabin hospital with wood stove heat. He was the only physician serving an area close to the size of Belgium. He found himself treating many lower leg war injuries and was frustrated by poor results from casting. As soon as two years into practice he was tinkering with early circular external fixators that would later make him famous. In 1952 Ilizarov patented his external fixator device. (Beadling, 2009)

THE ILIZAROV METHOD:

The product of Ilizarov's meticulous study and research was a device now known as the Ilizarov External Fixator (IEF). An IEF is a series of stainless steel rings anchored to bone segments with extremely strong wires called

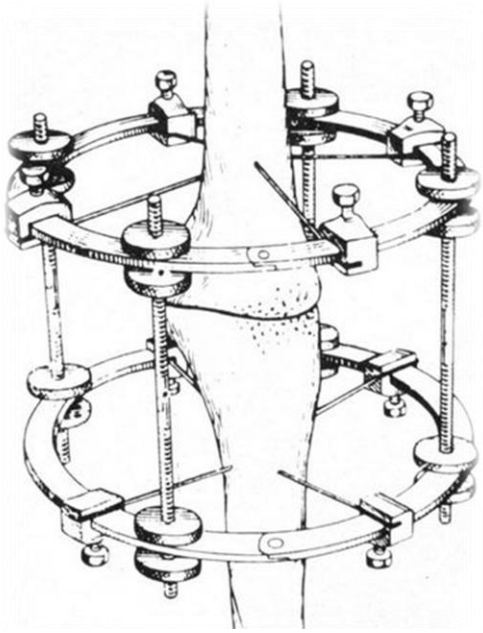

Figure 2: A sketch depicting the basics of the Ilizarov External Fixator.

Kirschner Wires. The rings are connected with threaded rods and adjustable nuts which allow serial distraction. Tensioning the wires across the rings allows the load on the bone to be born by the wires and longitudinal components of the device rather than the healing portion of the bone. Modern application of the device sometimes uses placement of half-pins rather than wires in some locations for increased rigidity.

Use of an IEF requires one operation for placement of the wires and application of the device, and at least one more operation for removal. After placement, the bone begins to grow together. Subsequent serial adjustment of the device pushes the rings further from one another.

Figure 3: An IEF in place on the right tibia

Lengthening procedures require an osteotomy, where the bone is cut, leaving the periosteum intact. Western Physicians scrambled to use his device with limited success. He would scoff at failed attempts to duplicate his outcomes stating "that is my apparatus but not my method" (Paley). Ilizarov emphasized several main tenets of his method including: "maximum preservation of extraosseous and medullary blood supply; stable external fixation; a delay prior to distraction; a distraction rate of 1mm per day in frequent small steps [generally .25mm every 6 hours]; a period of stable neutral fixation after lengthening; and physiologic use of the elongating limb" (Ilizarov,

1990). Physiologic usage and physical therapy were keys in his treatments and patients were strongly encouraged to bear weight as soon as the second post-operative day.

It is important to note that Ilizarov's success was based on extremely sound scientific research and animal modeling. His daughter Svetlana Ilizarov, MD, commented on his methodical approach stating that

> "It was not a device which made the difference, but years of experimental and clinical work discovering the potentials of bone tissue and its growth, as well as the new biological laws and the tension-stress theory on regeneration of all tissues. It was learning from nature, as my father often said" (Beadling, 2009)

His research on the tension-stress theory showed that "controlled, mechanically applied tension produced reliable and reproducible generation of bone and soft tissue" (Beadling, 2009). Italian physician Victor H Frankel MD, PhD said "He didn't blindly do things. He thought about it and he tried different experiments to find out what was the proper lengthening amount, the speed and the duration of treatment". (Beadling, 2009) This diligence was also applied to expanding the use of his device to more orthopaedic pathologies.

The driving force for Ilizarov's development of the device was the treatment of war injuries. Indication for use of IEF's was therefore initially limited to complicated non-union fractures and bone infections. Ilizarov and his team successfully expanded use of the device into many other complex fractures and deformities. Today the device is used primarily for the following:

- Non-unions and mal-unions
- Complex or open fractures
- Increasing long bone length in dwarfism
- Addressing leg length inequalities
- Bone infections
- Sequelae of poliomyelitis
- Congenital and acquired limb defects.

Figure 4: A child wearing IEF devices to help correct a congenital malformation.

A recent retrospective case-control study published in the November 2010 *Journal of Pediatric Orthopaedics B* compared the IEF to its most similar alternative. The study concluded that the "Ilizarov method appears to be superior to the Taylor Spatial Frame struts and should still be considered the gold standard" for limb lengthening and deformity correction in children. (Lobst, 2010) Expanded usage of the IEF devices for reshaping malformed bones has given countless individuals with congenital abnormalities levels of functionality that could not previously be imagined.

IEF treatments, like any invasive procedure, are not without complications. In fact, most treatment courses encounter some adversity. It is the mitigation of these complications that is the focus of current research in the field. Pin tract infection is not uncommon and avoidance requires diligent cleansing regimens. An expansion rate which is too quick can cause nerve palsy as well as need for surgical tendon lengthening. A rate too slow can cause premature consolidation which can require re-osteotomy to continue therapy.

One major difficulty with IEF treatment is the time that must be spent in the fixator. In the near future Ilizarov's methods may see increased success and decreased healing times due to biological products which could aid in bone growth. Morphogenic proteins, growth factors, hormones, bisphosphonates and stem cells could play roles in catalyzing more rapid bone regeneration. Ultrasound and hyperbaric oxygen therapy also show promise as adjunctive therapeutic modalities.

DISSEMINATION OF THE ILIZAROV METHOD:

Much of the intrigue of the Ilizarov story comes from the exceedingly long period of time between his achievement of favorable outcomes and the implementation of the technique outside of his institution. A 1952 Kurgan newspaper reported treatment of a 12.3 cm leg length inequality with Ilizarov's new device. The article claimed his inspiration for the circular frame came from the wheels on a horse cart as well as from the shaft bow style horse harness. Likening the axle to the fractured bone and the rim to his device he carried out testing by passing wires, like spokes, through broken sticks and fixing them to his device. (Kristiansen, 2009) Despite this article much of his successful work remained below the radar of not only Western Powers, but also the Soviet authorities of orthopaedics in Moscow. The attention he did receive from Moscow was that of skepticism, causing him to be less inclined toward publication of his developments. Ilizarov systematically studied bone growth and worked toward perfecting his methods in relative anonymity until 1967.

Ilizarov was quietly changing hundreds of lives in Siberia. One of these lives was that of Valery Brumel. He won the 1964 Olympic gold medal in the high jump and broke 6 world records for the USSR. Brumel fractured his leg in a motor vehicle accident after the games. An unsuccessful course of treatment at a famed Soviet hospital, including twenty operations, led to a non-union fracture with leg shortening of several inches. After much frustration with these poor results Brumel was secretly recommended to Dr. Ilizarov by staff doctor Vladimir Golyachovsky. Brumel was successfully treated by Ilizarov and his device in 1967, allowing Brumel to clear a height of over two meters the following year (Paley). This event began Ilizarov's rise to national fame. The Russian Ilizarov Scientific Center for Restorative Traumatology and Orthopaedics was founded in Kurgan in 1971 to support Ilizarov's work. Under his leadership it became the largest orthopaedic center in the world and remains a leader in orthopaedic care today. While Ilizarov's methods were becoming more well-known within the Soviet sphere, they remained undiscovered by Western Physicians.

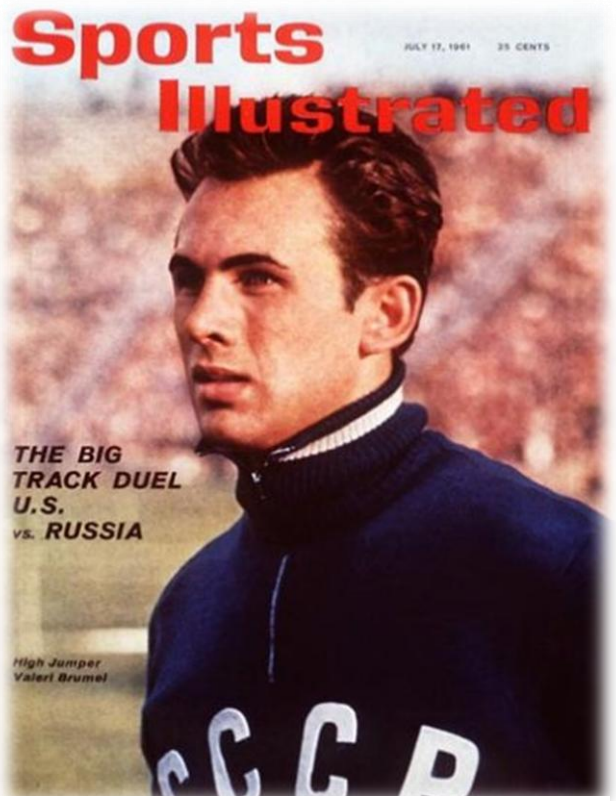

Figure 5: A 1961 Sports Illustrated cover showing Valery Brumel, the Soviet track and field icon.

Discovery of Ilizarov's techniques in the West is credited fully to physicians from Italy who delicately built a relationship with Ilizarov after learning of his treatment of Italian alpinist Carlo Mauri. Mauri suffered from an 18-year-old infected non-union fracture with equino-varus deformity and tibial shortening before being successfully treated by the "miracle doctor in Russia" in 1980. (Paley) When Italian Physicians saw Ilizarov's work manifested in the newly healed Mauri, they immediately began a correspondence. This eventually led to Ilizarov traveling to Italy, leaving Russia for the first time, in 1981 to lecture to the Italian Physicians. Mauri and the press dubbed him the "Michelangelo of Orthopaedics". Some of the physicians who heard him speak founded ASAMI (Association on the Study and Application of the Method of Ilizarov). ASAMI built a trusting relationship which resulted in licensure for his devices to be manufactured and sold legally by the Western manufacturer Medico-Plastic. This single event is felt by most to be the key step in breaking down the Iron Curtain that separated Ilizarov's methods from the West.

Figure 6: Carlo Mauri (left) and Dr. Ilizarov (right) photographed together after Mauri's successful treatment.

Later in life Ilizarov's success and legendary status among Russian lay people began to wear him down and may have ultimately contributed to the heart attack which took his life at the age of 71 in 1992. His daughter recalls that "He saw so many patients,

he literally had to run away from them. He would stay at his office until 2 or 3 o'clock in the morning and the patients would still be there. They had traveled to there from all areas of the country to see him and be healed". He was known to care deeply for his patients and attributed his determination to a desire to help them. As he aged he became overwhelmed by the volume and pressure to continue delivering outstanding results.

Dr. Gavril Ilizarov revolutionized an entire field of orthopaedics and has amassed a body of work as substantive as that of any orthopedist in history. His work becomes all the more extraordinary in lieu of his training, lack of resources and relative isolation. His work has and continues to transform the lives of innumerable patients throughout the world. His methods have allowed otherwise crippled to walk and otherwise debilitating injuries to be healed. A methodical genius in his own right, working with determination and fortitude to successfully obtain results not dreamed of by Western Physicians of his era. The story of Gavril Ilizarov and his method is truly that of a revolution of orthopaedics behind the Iron Curtain.

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