

History of Bone Fracture: Treatment and Immobilization

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REVIEW

SUMMARY

Bone fracture, loss of stability, limb pain, stress and dysfunction of the extremities, as stress conditions have emerged in the first days of the human existence. Severity of injury, in conjunction with the pathophysiological disorder, often led to the loss of limbs. The humans have recognized, long time ago that animals with the injured and soothed- fractured limb tended to reduce the limb movement to a minimum, did not move it up and down bl, in order to prevent the further injury. Following these observations the humans started to utilize a primitive splint (i.e. a piece of bark or wood), in order to prevent the movement of the injured limb(s). It is important to note that these primitive procedures were known to all people of the ancient cultures. With the increasing development of the human mind and the development of different technologies, the process of development and sophistication of the bone immobilization (e.g. by utilizing metal splints and various plaster osteosynthetic means) reached the highest level ever.

Key words: bone fracture, imobilisation, hystory of imobilisation.

1. INTRODUCTION

The oldest proof of immobilization treatment was given by researcher Mr. Edwin Smith. Remains of the immobilized limbs were discovered in Egypt in 1903 (1). Discovered limbs were showing the immobilization of two damaged vertebrae and there was also found an immobilized femur, along with the sticks, which were tied together by bandages. It is important to note that the additional remains with antebrachi fractures were also found. In this context, we must mention that the mummification skills had a large impact on the entire immobilization experience.

Scientific discovery proved that some patients did recover—by the virtue of the bone callus and bone reparation process.

Wooden splints were used by Greeks, by the physician Hipocrat and afterwards they were used by Romans and in the medieval Europe (2).

2. ARTISTS THROUGH THE HISTORY

Heidelberg Picture collection owned by Codex Manesse in 1315 is showing the crus immobilisation made by a wooden splint (2). Doctors from Islamic and Arab medicine had gained the important experience in the aspects of the fracture treatment and immobilization (1, 2, 3).

They were preparing different mixtures, which were used to fixate the primitive splints, after they were stiffened. One of the most famous surgeons from Middle Arabic period is Abu al Kasim az-Zahrawi from Al Zahra, Cordoba (936 – 1013) (1, 2) who had written about 30 books within the field of surgery.

He described the fracture treatment by using the bandages in multiple layers and these bandages were placed centripetal in relation to fracture's location. This scientist spotted the edema as a problem of fracture and he was replacing definitive splint, when the edema had subsided. He used reed and palm branches in his treatments. Splint was fixed with bandages and rope by the virtue of applying the

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Figure 1. The oldest archeological finding of immobilization

controlled pressure. EL Zahrawi also used the milled powder as a mixture (i.e. the flour was mixed with the albumen), but in the same way he mixed the rubber with a droppings and albumen. Experiences with the above mentioned method were also successfully used later, by the English scientist, Dr. William Cheseldon (1688 – 1752) (1, 2).

In the year 1715, Dr. Hans Gersdorf was giving the instructions for the placement and the application of a splint during fracture (2). Dr. Gersdorf described the splints, which were fixed by a wire. In addition, he innovated the traction device, which was used to make the reposition. Similar devices were described by physicians; Hipocrat, Galen and Pavao from Aegine.

In the year 1676, the surgeon, Dr. Benjamin Eocch (1708 – 1776) managed to improve Gersdurf traction device in England (2).

A book, titled, "A practical Traticese of wound and other Chirurgical Subjects", gave an overview of the latest developments in the anatomy and surgery by giving an accent to the detailed description of immobilization (i.e. by utilization of a wooden splint).

Wooden splint immobilization devices were considered to be fairly functional and they were leading in fracture treatment until the discovery and the application of the improved immobilization treatment in the 19th century.

In the year 1967, the so called, Sarmiento method was introduced, which, in essence was the method of functional gypsum immobilization (2). The actual treatment was conducted and presented on the so called, „crus fracture“, and it is important to note that this treatment was not the standard application above a knee gypsum boot; to the contrary, physician Sarmieto was using the so called „moment device“, (i.e. the pattellar – tendon – Bearing cast). The Gypsum was applied below the knee and it was stretching up to the curve of pattelas fossae and was located and placed higher in front in relation to pattelae.

Chinese had been gaining the immobilization experience for a long time and their knowledge was later improved by Sri Lanka's surgeons (e.g. by combining the synthesis of traditional Chinese medicine and modern immobilization). Their success was published in 1964. When they gained fracture consolidation in 98% cases, it is important to say that many accretions were followed by mutilation and the reposition was not total.

The end of the 19th century was marked by the usage of gypsum, which became a leading medium for the immobilization (2). We need to mention that the Arabs were also familiar with a certain types of gypsum immobilisation methods, which were used in the Islamic countries. Similar knowledge was used centuries earlier in Europe and in 1798 the English diplomat Mr. Eaton had delivered some elements of that particular knowledge to Europe. In France that knowledge was used by Paris based scientist Prasre (i.e. dehydrated Potassium sulfate). After dehydrated Potassium sulfate was put in water it became very stiff, in order to be used in the fracture reposition treatment.

Gypsum became very popular during the 19th century and was primarily used during conservative fracture treatments (2).

One of the best descriptions of the Gypsum treatment

was given by Dr. Joseph – Francois Malgaigne (1806 – 1865). German physician, Herr. Keyl, based in the hospital Chante – in the city of Berlin, Germany, also made some method improvements. Dr. Dieffenbach, another very famous surgeon was also working with Dr. Keyl.

For a long period of time the immobilization treatment was plagued by some types of deficiencies (e.g. muscle atrophy, joint contracture, etc.). Physician Sutch Antonius Mathijesn discovered a special method of gypsum bandage that developed gypsum with the , so called, "window". He made an opening above the wound of the open fracture, and later he transferred his experience to the American surgeons. In 1976, M. C. Gorii – 1976 invited him to the City of Phyladelphia, State of Pennsylvania, USA where he presented his observations and achievements (2).

Sintetical gypsum was developed in a few last decades and was in essence composed of a woven fiberglass that was reinforced by the polyurethane resin. It was much lighter than classical gypsum and it was more comfortable and more pleasant for the patient.

3. TRACTION

Traction is described as the method that helps in the process of reposition and it prevents the healing of the fracture with fragment dislocation and shortening of extremities by the influence of the muscle fiber force.

Scientist Galen (130 – 200 A.D.) was a pioneer of the extension and fraction – blossoming treatment (1, 3).

In addition to the surgeons listed above, the French surgeon, Mr. Quven (14th century) (1300 – 1307) was using the traction treatment method and he gave a good description of it in his book titled, "Chirurgic Magna".

Traction treatment was especially developed by German surgeons. Surgeon Herr. Albot Hoffa (1859- 1907) used the traction for the reposition of humerus and femur bones. Surgeons like Josh Crosby used the traction, in addition to: the adhesive tapes, bandages and set of weights for traction making and traction maintaining. It is important to note that the traction can be replaced by a gypsum immobilization as a permanent solution, just following the relative fracture consolidation.

Mr. Christian Billoth was the first surgeon who was using trenches treatment and he gave some descriptions of it, followed by physicians, Mr. George Perlines (London, United Kingdom) and R.H. Russell. Modern traumatology uses the process of the traction intra operation by using the tables with the special construction). In that scenario, after the reposition the osteo synthesis can be achieved (1, 2, 3).

Hand surgery is special in the sense, in which it uses the cross skin extensions, something like a glove.

4. OPEN FRACTURE

In many unfortunate scenarios, an open fracture ended with the limb amputation or even death. Main characteristic of the open fractures is that the skin integrity is disrupted and infections can develop.

In 1497, Mr. Hieronymus Brunschwig was writing about the issues with the open fractures and this work was performed in the professional manner (2). "Cauterization" was used until the time of the antiseptic procedures and Lister,

in treatments of the open bone fractures, but, unfortunately, due to the incidences of infections the patients mostly ended up with the amputation or death.

Support treatment was later used to stop bleeding and to make a blood vessel ligature. First time it was used by a famous French surgeon, Mr. A Pare (1510 – 1590) (1, 2, 4). He had a huge war experience, especially in the area of the amputation surgery and he had also suffered from an open fracture of cross by falling from the horse. In his words, while with immobilization and bandage changing he used a lot of prayers and the epilogue was happy. Mr. Percival Pott, the famous English surgeon had also survived the similar faith, as his colleague above in 1756 (1, 2, 4).

Mr. Christian Billoth was interested in surgery and treatment of open fractures and he performed the statistic analysis for 93 patients, where, unfortunately, the death outcome had occurred in 46 patients. In this context, it is important to mention that the mortality rate, after injuries and amputation was very high (i.e. the French–Prussian war 77%, the American civil war 54%, etc.).

According to the sources from the British military, in the

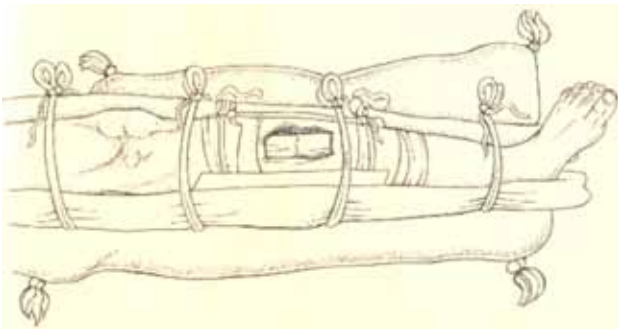


Figure 2. The fracture that suffered Ambroise Paré and the first successful open fracture healed without amputation

course of the First World War (WW1) the death outcome with the incidences of open fractures was 80%. Gaining experience from these difficult and complex treatments these percents were significantly reduced during the last year of the war (i.e. 1918). During Second World War (WWII), the Indochina, Korean and Vietnam War, the primary wound suture of amputation wound and at the locations of open fractures was forbidden due to the high risk of infection. Secondary suture and delayed wound healing was preferred mode of treatment, in conjunction with the antiseptic conditions and antibiotics. Success of primary suture was noticed in sporadic cases in Cambodia War theatre (foreign surgeons). In his book "War amputations" Bosnia and Hercegovina, Zenica Cantonal Hospital based orthopedic surgeon, Dr. S.N.Muminagic, displayed a rich experience with the applications of the primary suture, which ended in healing per prim am in 64 percent of cases, at upper extremities and 48-49 percent at lower extremities. The above results represent a 4 year average and the results were better in fourth year in comparison with the first three years (e.g. gaining experience, praxis)(5).

5. OSTEOSYNTHESIS CERCLAGE

First attempt of osteosynthesis-cerclage was performed in 1770 by Dr. Malgaigne, in the City of Toulouse, France.

The next historical experimentations by the physicians, Mr. Lapoujde and Sicre, who researched the humerus fractures in 1827, followed by the New York State, U.S.A., doctor, Mr. Keany Rodgers who utilized the "Humerus Pseudoarthrosis", in 1838, the silver wire thread by the Surgeon, Mr. Achilles' Cleophas Flaubert (Gustav Flaubert's father) in conjunction with the open fracture of humerus – wire thread (2).

The first literature appearance of the above mentioned treatments occurred in 1870, in the book, titled, "Trate de L'Immobilisation Directe, des Fragments Osseux Dans Les Fractures". These articles were based on the open tibia fracture research performed by Dr. Long Lerclage, in the Hospital Dioj, City of Toulon, France (2).

In conclusion, Dr. Feraud also mentioned that the similar operations were made by the Arab surgeons.

6. SCREWS

In 1850, Dr. Correlirigaud performed two cases of screw fixation (sternum fracture), in the treatment scenario, where the reposition and traction were made by the screw and the second patient suffered from an ulna colcannon fracture. (2).

First use of the wire loop, which was the scientific precursor of the so called, "zuggurtung", similar technique, was also successfully used in the patellae treatment.

Physicians Mr. Albin and Mr. Lambotte were using screws, which were placed between fragments, and these procedures were written in the authors' earlier book.

7. TILES

First published information on tiles treatment was published by, City of Hamburg, Germany-based, Dr. Hansmann, in 1886.

Dr. Hansmann used a tile with a special form, which was easy to remove after an accretion, the screw with the head that was placed just above an open operation wound.

Osteosynthesis, as the technique and a name was inaugurated in surgery by Dr. Albin Lambotte (1866 – 1955), from Belgium, who was a chief of surgery department from 1900 and who introduced a series of innovations to a bone fracture treatment (2).

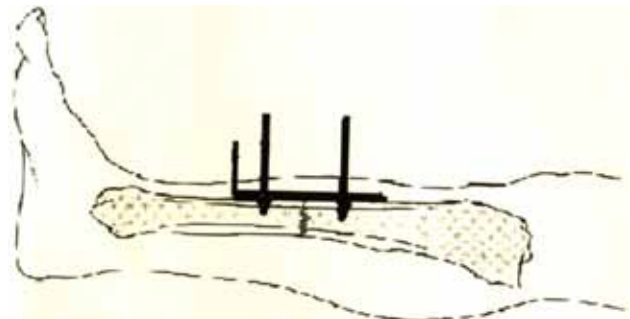


Figure 3. Hansmann publication scheme from 1886th in the internal fixation plate. It is the first publication of the fracture fixation plate and screws

Tiles, screws and fixates were also constructed to be used in the Osteosynthesis. In 1913, Dr. Lambotte published a book about the bone fractures.

There were also some other pioneers of Osteosynthesis,

such as the English Dr. Arbuthnot Lane (1856 – 1943) was a first physician who used a wire and cerclage.

After 1893, Dr. Lane was using the screws and tiles in his treatments. His colleagues named him as the pioneer of Osteosynthesis. He was supporter of Lister and because of that he used carbolic acid.

Dr. Lane was considered to be the pioneer of a "Non touch" technique in the orthopedic surgery. He was the first scientist in this area of medicine who described the process of the accretion, without the presence of an outside callus; and this technique will be described later by Dr. Ao Gruba.

The above mentioned surgeons innovated on the new types of screws. They were making stiff and safe osteosynthesis and did not allow support before an accretion.

They have been visionaries and precursors of the modern orthopedic surgical science.

8. EXTERNAL FIXATION

The first External Fixation device was made in 1843 by Dr. Mulgaigne Par (2). Following this beginning surgeon Mr. Griffé Metalu devised the construction, which allowed distraction and he used it to treat the patella fractures.



Figure 4. Griffé métallique, external fixator. Malgaigne 1843, Chassin fixator for clavicle 1852.

Distracter on both of its ends has spikes, which are used to go into the bone. This Device was slightly changed by Dr. Chassin in 1852. He applied it at the clavicle fracture and, modified as such, was allowing the dislocation corrections. Surgeons noticed that a fracture was better fixated by nails, which extend through the entire thickness of the bone.

Dr. Kondon Keetly's fixate was the precursor of the new fixations, where the pins were placed and nod wire was connected and coated with the ionized gauze.

Wars in 19th and 20th century unfortunately created many patients with the open bone fractures.

Today's fixator precursor was Dr. Clayton Parkhill's innovation. In 1897, in the City of Denver, State of Colorado, U.S.A. he invented the new type of pins, which were strengthened with an external tile (2).

In 1902, Dr. Lambotte noticed, and then advised that each fragment should be fixed with multiple pins, in an action that was providing for better stabilization. Further innovations were related to Swiss based surgeons, Dr. Raoul Hoffmann,

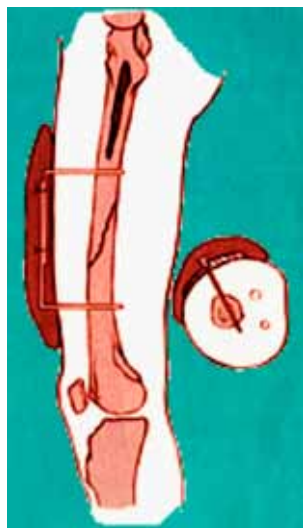


Figure 5. Fixator external, Ketley 1893

Bourgois and Vidal who published their experiences in 1938. The External fixator has a long history of usage in surgery and traumatology and it is used in the treatment of the internal fractures. Some decades after this method discovered, another method of choice for external fracture was adopted, because the pins were placed outside the fracture and their construction enabled the bandaging and taking care of the wound(s).

The above mentioned methods became widely used with multifragmental fractures and pseudoarthrosis. In their construction they have distraction and compressing components (6).

In further innovations, scientists, Mr. Bus, Kurgan and Lizarov were emphasizing themselves the usage of a tied axes rims' (e.g. that were outside of the extremities), where the bone was stitched with a Kirshner needles, needles that were later improved with pins. This device was frequently used for the extremity elongation. Ao school was making further improvements of the external fixator. The External fixator was experiencing numerous variations and its construction was similar to the treatment results and the treatment success. In conclusion, in a war surgery, it was noticed that the external fixation was a method of choice (e.g. Vietnam War (1961-1975), Bosnia and Hercegovina War (1992-1995)) (7).

9. INTRAMEDULLARY FIXATION

First records of the so called, „Intramedullary fixation“, were discovered in the ancient Egypt and the so called deceased-human-„Mummy“ from Egypt was displayed at the Rosecrucian museum, in the City of San Jose, State of California, USA (2).

This „Mummy“ was interesting, through the fact that the intramedullary bar extended through the femur and tibia. It was discovered by X- rays of the knee joint and it looked like it was resected. Additional research showed that this orthopedic procedure was done after death, during the embalming process.

In 1858, Dr. Langebeck made the first intramedullary fixation on fracture of the femur collum. Dr. Olius Nicolaysen made that same procedure during the same year in Norway (2). Finally, in 1886, there were also some recorded attempts of intramedullary fixation by utilizing the ivory by Dr. Bircher (2).

In the first decade of the 20th century, Dr. Högglund performed multiple surgeries where he used the implantants made from the human and beef bones. City of Bristol, England- based, Dr. Ernest Heygroves made the intramedullary fixation and later he used this fixation type for humerus,

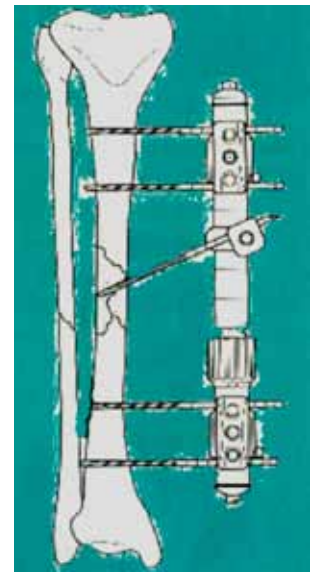


Figure 6. Fixator external in situ, Fixation of multifragment fracture of tibia and fibula

ulnar and femur fracture. During the performance of these surgeries the surgeon met with the complications, such as the: infection, corrosive changes and metallosis and the patients' outcome was very bad. Dr. Heygroves was ironically and mockingly called the "Septical Erny", by his colleagues. Intramedullar osteosynthesis with metal implants was not accepted in that period. Later on, Dr. Marius Nygaard Smith – Petersen (1886– 1953) from Norway, inaugurated his three -bladed wedge for fixation of the femur collum fracture. This was an very important innovation in the orthopedic surgery. This kind of the operative treatment was followed by many surgeons and this procedure was modified in order to better accommodate and enable RTG control (i.e. devices in the Operative rooms).

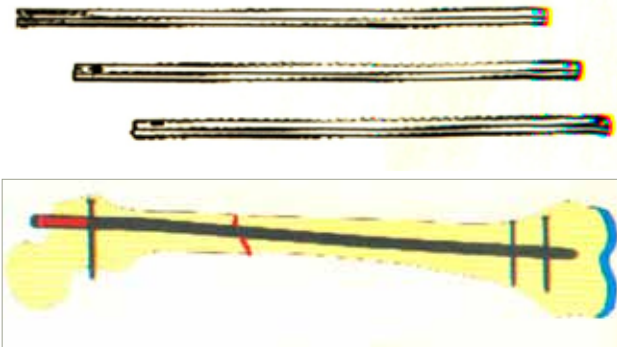


Figure 7. Presentation of nails for intramedullary fixation of femur

Swede Dr. Sven Johnsen and English, Dr. Reginald Watson Jones, were stand out world renowned surgeons. After Dr. Petersen, Dr. Reginald Watson Jones will become one of the leading world orthopedics and he will later write great orthopedic textbooks.

Additional surgeons who used the nails in their treatments were, English, Dr. Lamberton and brothers Ruch in the USA who used slim nails. Ruch's technique and nails are still in use in some hospitals.

German Gerhard Kucher (1900-1972) made the revolution in the application of the intramedullar nails (5). Kucher was working with Fischer and Ernesto Pol, an engineer who was helping him to construct the nail(s). After the WW2 war had ended in 1945, he published his experience in his book. He was very popular with surgeons from the AO school and they started to assimilate and improve on his work. Intramedullar nails became the method of choice in the treatment of long bones. Lack of rotation instability was solved by using the special type of nails, which were introduced percutaneously, through the openings of distal and proximal opening of the nail (it is performed with the help of rtg device). AO School innovated the special nails for humerus, proximal part of femur (gamma nail) and tibia (6).

10. AO SCHOOL

Robert Danis (1880-1962) was one of the pioneers of the modern orthopedic science, which he emphasized, during his fracture treatment (e.g. he was the general surgeon who

first tried to perform the general and vascular surgery).

In 1949, Dr. Danis, published his experiences in his book titled, "Theorie et Pratique de l' Osteosynthese" (6).

Danis was supporter of the exact, anatomical reposition and rigid osteosynthesis. He indicated and persisted on the creation of an endosteal callus, in combination with the creation of periosteal callus without accretion. This allowed an early immobilization, which made prophylaxis of the muscle atrophy and joint contractions easier. He was the most frequently using the tile and screw treatment.

Swiss citizen, Mr. Maurice Muller was developing the idea of bone fixation based on R Danis's work. Together with his colleagues, Martin Ailgower (Basel), Hans Willeneger (Liestal), Robert Schneider (Biel) they made the foundation of the school, which will be called AO school (Arbeitsgemeinschaft Fur Osteosynthesefragen) (6). They conducted the experiments on animals and after that they had introduced the so called osteosynthesis -compression - (i.e. where the scientists put the fragment under pressure). Their goal was achieved by using the special implantant widgets. The above mentioned scientist developed the Scientific Research center in Davos, Switzerland, with the purpose of improving the bone fracture' treatment and education.

These researchers created the data basis; – H. Willinger in 1974. He was reporting about 20, 000 documentation papers containing the discussion of treated patients by utilization of the above mentioned method. They published a book, "AO principles of Fracture Management". These physicians were using the video, CD-ROM and DVD educational sources, while organizing courses all around the world and in each country they were representing their principles, which were at the same time the AO school's principles.

M Ailgower became a chief of his Clinic – Switzerland, he was also working with Thomas R Roedy as his teacher, while the Experimental Center was led by scientist Perren (6).

AO school today is a leader in a modern treatment of the bone fracture (6).

11. DISTRACTION OSTEOGENESIS

Distraction Osteogenesis was discussed and researched on by the scientist, Mr. Sibir Kurgan in 1950s.

Gavril Avramovic Ilizarov had discovered a new way of bone fracture treatment, infection, bone pseudoarthrosis and long bone elongation (2). He was using the principle, which was showing that the bone tissue under the influence of the withdrawn forces started to grow.

There is a story, which was in essence telling that he came on this idea by looking at one patient who was pulling his bar and vice versa, because he did not know the proper way, as a result of this process he experienced the distraction and not a desired compression. Good RTG results and fracture accretion gave an idea to Ilizarov. He started to work with animals, and after he experienced some success he inaugurated this method to humans. His principles were based on the premise that the distraction should be done

after bone corticotomy and he ensured this claim by using the device, which was constructed by him.

Bone defect condition (known as pseudoarthrosis) was solved by the creation of the new bone. Hoffmann and other authors had improved this device by using their own implants. Kirschner needles, which were used in the first way, were replaced by pins, which were providing the stronger stabilization support, (e.g. Osteolysis can be developed around the Kirschner needles).

All improvements and implant innovations were pointed to a better patient treatment, pain prophylaxis, joint contracture, fast immobilization and rehabilitation. The final result of these activities was to rehabilitate the resocialized patients, without losing the functioning of the extremities.

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