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, immobilisation, history of immobilisation.

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 mumification 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

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 Gersdorf 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 1867, 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 Sarmiento was using the so-called “moment device”, (i.e. the patellar – tendon – Bearing cast). The Gypsum was applied below the knee and it was stretching up to the curve of patellae fossae and was located and placed higher in front in relation to patellae.

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 immobilization 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. Diefenbach, 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. muscule 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 Bilroth 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 Bilroth 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 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 the hospital Dioj, City of Toulon, France (2). In conclusion, Dr. Feraud also mentioned that the similar operations were made by the Arab surgeons.

5. OSTEOSYNTHESIS CERCLAGE

First attempt of osteosynthesis-cerclage was performed in 1770 by Dr. Malgainge, in the City of Toulouse, France. The next historical experimentations by the physicians, Mr. Lapoujide and Sicre, who researched the humorous 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/Clephas 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 articulated were based on the open tibia fracture research performed by Dr. Long Lerclage, in the Hospital Dioj, City of Toulon, France (2).

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. Lambote 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).
such as the English Dr. Arbuthnor 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. Griffe Metalu devised the construction, which allowed distraction and he used it to treat the patella fractures.

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, Bourgeois 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 where 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 axises rims’ (e.g. that were outside of the extremites), where the bone was stiched 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. INTRAMEDULAR FIXATION

First records of the so called, „Intramedular 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 intramedular 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 intramedullar 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 intramedullar fixation by utilizing the ivory by Dr. Bircher (2).

In the first decade of the 20th century, Dr. Hoglund 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 intramedullar fixation and later he used this fixation type for humerus,
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 metallic 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 colhum fracture. This was an 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).

Swede Dr. Sven Johnnsen and English, Dr. Reginald Watson Jonnes, were stand out world renown surgeons. After Dr. Petersen, Dr. Reginald Watson Jonnes 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. Lambrinot and brothers Ruch in the USA who used slim nails. Ruch’s technique and nails are still in use in some hospitals.

German Gerhard Kuncher (1900-1972) made the revolution in the application of the intramedullar nails (5). Kuncher 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 experiences in his book titled, “Theory et Practique de l’Osteosynthesis” (6). These researchers created the data basis; – H. Willenger 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 Allgower became a chief of hur 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. DISTRACITION OSTEONEGESIS

Distraction Osteogenesis was discussed and researched 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 pseudoarthroisis) 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 Kurchner 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.

REFERENCES

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