SCOPING REVIEW

A Brief Overview of the Evolution of Splints and Casts in Medical History, Specifically Persian Medicine

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Abstract

Objectives: Fixing a broken limb has been a concern of humans for thousands of years. They have used different methods, devices, and combinations to do this. This study deals with the two hypotheses of the ancient use of the delayed splint method and the use of Plaster of Paris material in Persian Medicine.

Methods: This narrative-analytical review is based on the documentation of authentic books of Persian Medicine, such as Liber Continents and the Canon of Medicine, data from databases such as PubMed and Scopus, and search engines such as Google Scholar, to find information from other civilizations as well as Persian Medicine.

Results: The documentation reveals a global exchange of medical knowledge, with the fixation of broken limbs starting in Egypt and spreading to India, China, and Greece. In the 7th century AD, this knowledge reached Iran, where medical scholars, in their keen observation, extracted techniques from this wealth of knowledge. The renowned delayed splint technique, credited to Rhazes (865-925 AD), and the use of Plaster of Paris, as evidenced in the writings of Hakim Abu Mansour Movafagh Heravi (10th century AD), are just a few examples of the innovative methods developed in this medical school.

Conclusion: A careful study of ancient books will sometimes reveal traces of the use of today's techniques in the past. Although their report is focused on contemporary centuries and a new method has been introduced, their use has been recorded in past centuries. For instance, the delayed splint technique, named after George Keynes (1892-1979), and the application of Plaster of Paris, named after Antonius Mathijsen in 1852, was introduced in orthopedic science. This makes it necessary to search and analyze past medical books in various branches of modern medical knowledge to correctly teach the older ones and preserve the identity of medical schools.

Level of evidence: IV

Keywords: Albucasis, Avicenna, Movafagh Heravi, Persian Medicine, Plaster of Paris, Rhazes

Introduction

People have always faced bone fractures since the first days of human creation. The first evidence of damage to Neanderthal skeletons dates back to 130,000 BC. The development of early civilizations led many ancient physicians to pioneer interventions that managed orthopedic injuries. The history of orthopedic surgery in ancient Egypt, Greece, and Iran is well documented. The first evidence of neurosurgery is related to skulls pierced with a drill in the Neolithic period (8000 BC) in the Burnt City of Iran.[1–3] Additionally, the first use of an intramedullary device similar to a nail is documented in ancient Egypt. The famous Usermontu mummy discovered in Tutankhamun's tomb had a corkscrew pin inserted between the femur and tibia to fix his broken knee bone. More detailed archaeological studies indicated that the bones of this person were well reconstructed and that he could resume walking despite the effects on his mobility [Figure 1].[4,5]

In addition to surgery, humans were inspired by animals that kept their arms and legs still and did not move in cases of broken bones. Accordingly, during this era, the primary treatment for most orthopedic fractures centered around nonoperative management, including splinting, casting, traction, and bracing. Fracture immobilization was done

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with whatever tools and materials were available at the time. Early examples of non-surgical fracture management can be attributed to the ancient Egyptians. Archaeological evidence has also been documented in this regard. The earliest documentary evidence of splinting and stabilizing damaged bones using wooden splints and palm bandages was found in mummies. Fractured femurs, bound together with bandages and fixed with sticks, were evident in this mummy. This method of bone fixation is also documented in the Edwin Smith Papyrus [Figure 2].[6]

Figure 1. Radiograph of the right knee of the ancient Egyptian mummy Usermontu (11th-16th century BC), Rosicrucian Museum, San Jose, California[4]

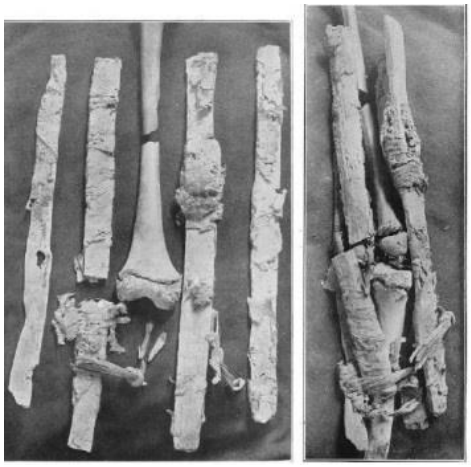

Figure 2. An ancient splint of an Egyptian mummy with a fractured femur from the ancient Egyptian civilization is documented in the Edwin Smith Papyrus[9]

Apart from archaeological documentation, the advent of writing allowed the evolution of fracture treatments to be roughly traced among medical writings. The Edwin Smith Papyrus (1500-1550 BC) is the most valuable text on medicine from this period of the ancient world. Other medical papyri exist, such as the Ebers Papyrus and the London Medical Papyrus, but they are primarily rooted in magic. Edwin Smith's papyrus mentions metaphysical spells only twice and is almost entirely analytical. In this papyrus, arranged reports of 48 cases of bone trauma are mentioned; the instructions for teaching begin with the head and include only injuries of the upper body. These forty- eight bone injuries are summarized below:

- 27 cases of hitting the head (cases 1 to 27)
- 6 cases of throat and neck injuries (cases 28 to 33)
- 2 cases of damage to the clavicle (cases 34 to 35)
- 3 cases of injury to the arm (cases 36 to 38)
- 8 cases of damage to the sternum and ribs (cases 39 to 46)
- 1 case of shoulder injury (case 47)
- 1 case of injury to the spine (case 48)

The study of these reports shows the origin and the early history of medical triage. For example, in the case of a clavicle fracture in case 35, placing the splinter in position is recommended, using a linen splint, and finally, drug therapy with honey. In this papyrus, forty-eight wounds and fractures are mentioned, and in cases 36, 37, 38, and 47, splints, bandages, and resin are noted for arm fractures [Figure 3]. In ancient Egypt, splints were made of bark, clay, straw, plant fibers, animal hair, and cloth.[2, 6–10]

Figure 3. A fragment of the Edwin Smith papyrus describing a broken clavicle[7]

In ancient Indian medicine, Sushrat (800 BC) took a step forward in innovative principles and used traction, pressure, compression, and bamboo splints and bandages, mainly used for the spine.[11–13]

After Sushrat, in ancient Greece, Hippocrates (460-377 B.C.) improved splints and bandages with honey, grease, and lint for humerus fractures, developed by Smith's Derpapyrus, as well as discussions of traction and compression in Indian medicine and splints. He also introduced a copper splint. His traction and compression methods were also used in spine disorders [Figure 4].[3,14–16]

In the school of Chinese medicine, archaeological excavations of the Wulanyingge Cemetery dating back to

375 BC also show signs of trauma to a skeleton, as well as the splinting of its right leg. However, some believe that traditional orthopedics in China originated from the Hippocratic tradition and was later integrated with Indigenous herbal medicine.[17,18] In this civilization, the Yao-tsu (lumbar column) consisted of four wooden splints connected by threads and tied at the waist [Figure 5A], and Ton-mu (porous wood), which was a wooden board with straps to immobilize spinal injuries [Figure 5B].[1]

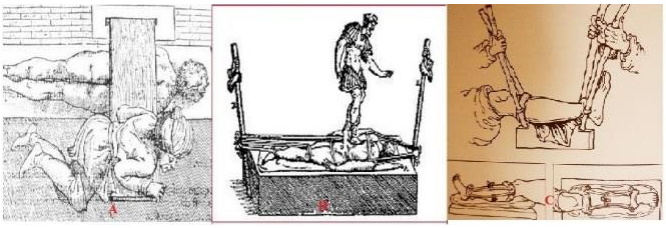

Figure 4. Some techniques for removing disorders and stabilizing the injured bone by the Hippocratic method are A: Pressure, B: Stretching, and C: Splinting[15,21]

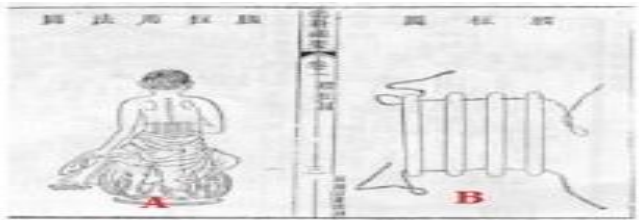

Figure 5. Two tools for stabilization in spinal disorders in ancient China A: Yao-tsu B: Ton-mu[1]

After this period, for many years, the method of fixing the body ended with the same information, sometimes changing slightly. So, Aulus Cornelius Celsus (25 BC-50 AD) used starch to stiffen bandages during bandaging and splinting in the first century AD.[7,19,20] After him, in the second century AD, in addition to corn bandages, Galen invented the glossocomium, which was used to treat and temporarily fix broken limbs. This device was based on tension with ropes that could be adjusted and rotated with a handle. Ambroise Paré depicted it in 1564 [Figure 6].[6,19]

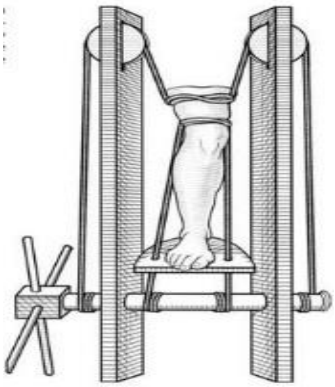

Figure 6. Galen described a device called the glossocomium and illustrated it in the writings of Ambroise Paré (1564)[6]

After Galen, no new method was added to fix broken limbs, and the same techniques were improved. Oribasius (325-403 AD) changed the wooden bench of the previous sages in the treatment of spinal disorders and fractures to simultaneously treat areas with trauma and spinal disorders and added a rod in the middle [Figure 7].[21]

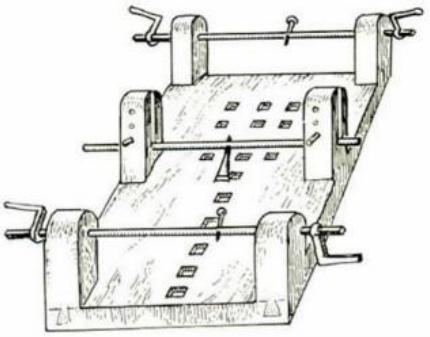

Figure 7. The improved board made by Oribasius is effective in the treatment of trauma and spinal deformities[21]

After this period, although Paulus of Aegina (635-690 AD) developed muscle fracture surgery, there were no changes in available treatments.[22,23] In these centuries (7th century AD), medical knowledge, especially in Greek medicine, became stable and did not progress much. Ponseti writes: "After Galen, nothing was important in orthopedic literature until the 11th century."[24] Additionally, in the book "Hand and Upper Extremity Splinting: Principles & Methods," the history section ends with only sentences related to orthopedics and splinting in ancient Egypt and the actions of the sage Hippocrates. In addition, Movafagh Heravi - (Abu Mansour *Movafagh* Ibn-e *Heravi*-10th Century AD), a Persian sage who is the author of the book "Al-Abniyyah an Al-Ahqaiq al-Adawieh" (Al-Abniyyah), ignored the series of events and efforts made in the field of orthopedics from the 10th to the 15th centuries. He then points to an explosion of orthopedic knowledge production worth pondering from the 15th century onwards. In fact, for 2000 years, orthopedic knowledge remained in an aura of ambiguity. However, it is worth mentioning that this outstanding growth in the 15th century was not without impact from the 10th to the 15th centuries AD and gradually formed during these centuries. Its result was manifested in this century, which is entirely attributed to the scientists of the 15th century AD. It is true that in the 7th century, medical science in the West stagnated. Still, at this time, civilizations with elites in the science of translation and access to the books of Greek, Indian, Roman, and Egyptian schools, etc., also developed medicine based on their knowledge. This case item is sometimes neglected. In addition to changes in the splinting principles, new materials, and tools were introduced to stabilize the broken limb. Rhazes suggested a delay in splinting, introduced a plaster-like composition (calcium oxide) to immobilize the fractured bone, and then Albucasis (Abu Qasim Khalaf Ibn Abbas Al Zahrawi) (936-1013 AD) slightly changed its composition. Finally, Movafagh Heravi published the use of plaster in the modern sense (calcium sulfate). Despite their importance,

some cases have not been addressed, and the report on the evolution of orthopedic knowledge has disturbed their correct tracking. These innovations have been attributed to scientists of contemporary times. The present study aims to examine the details of the cases mentioned by these scholars and present the way of reporting these techniques and their tools in modern orthopedics. [25–30]

Materials and Methods

In the current review, studies related to the stabilization of injured bones were searched through a broad search with keywords such as a splint, cast, Plaster of Paris, Albucasis, Islamic civilization, Persian Medicine, Unani medicine, traditional medicine in reliable databases, resulting in the collection of 382 articles. The articles were published in the last ten years; previous years were also explored to see if the desired information still needed to be obtained. Data collection was done in August and September 2024. After the saturation of information, the works of eminent sages of the Persian school of medicine, such as Liber Continens, *The Canon of Medicine, Al-Tasrif li-man ajaza'an al-ta'lif (Al-Tasrif),* and *Al-Abniyeh*, were explored with the aim of a more detailed analysis. After collecting related materials and analyzing them in reliable databases, each one was placed in the corresponding position in the article, and finally, the final summary and research were presented.

Results & Discussion

Today, Professor George Keynes from Great Britain knows the delayed splint technique. In this technique, he forbids the quick use of splints due to inflammation and swelling and postpones their use until a few days after the injury [Figure 8].[31–33]

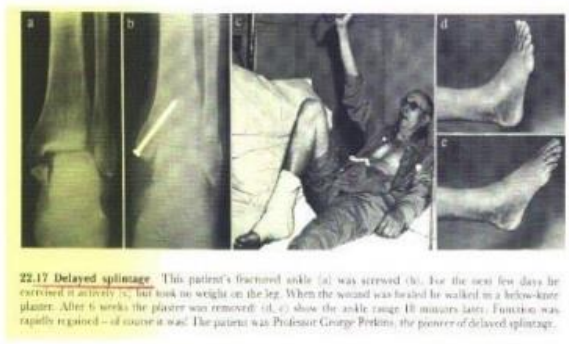

Figure 8. The topic of the delayed splint in the book Apley's System of Orthopedic and Fractures calls Professor George Keynes as its pioneer[32]

For years, George Keynes was introduced as the first person to use and recommend this technique in numerous medical books, including surgical and orthopedic texts. On the other hand, in a handful of articles, Avicenna (980-1037 AD), in the book The Canon of Medicine, and Albucasis in Al-Tasrif are mentioned as pioneers in this science without any details.[8,34–37] This issue will surely arouse the curiosity of every medical history researcher in identifying the advanced individual. Investigations indicate this technique is very close to the content from volume 13 of the book *Liber Continens*, authored by Rhazes. In this book, he faithfully mentioned the advice of sages before him by citing their names or referencing their works. Surely, he did not only present the experiences of his predecessors, but in some cases, he criticized their knowledge with an analytical approach; sometimes, he offered his pure and innovative views, which are based on his clinical observations in continuation of the discussions of the sages of the past. In his book, he expresses his opinions with the phrase "my view".[27,38]

In the same chapter, in the section on hand orthopedics, while expressing the opinions of sages such as Hippocrates and Galen, he states in a sentence that reflects his point of view:

"My point of view: Today's fracture repairers (in Rhazes's time) immediately place the orthopedic wood on the fracture without checking the initially damaged area. This is appropriate if the body is free from abscesses and tears, but in most cases, they base their treatment on incorrect assumptions, which will result in fever, blisters, and other serious injuries. When you want to perform orthopedic treatment, the area should not have any irritation, pain, or complications from the onset of the disease. If not, several days of fracture treatment should be postponed until the irritation is resolved. Relax the limb with a soft bandage and pain-relieving ointments, and when you are sure there is no swelling of the limb, you should turn to the use of fracture sticks."[27]

As evident in this sentence, he refers to the delay in using the splint to reduce swelling and inflammation, according to his findings. Surely, this theory is directed at more than just his book. A little after him, Albucasis, in volume 30 of *Al-Tasrif*, mentions this issue in the section on the necessary information before doing orthopedics and writes:

"And know that every fracture should not be closed with splints from the first day. Even if it is a large limb, it is not appropriate to put a splint on it five or seven days or more after the day of the fracture. This is a period that is required for safety from swelling" [Figure 9].[25,39]

Figure 9. Pages from Al-Tasrif's book where Albucasis mentions the delayed use of splints[25]

Another Persian sage, Avicenna, mentions this issue in his book, The Canon of Medicine: "When it is appropriate to apply a splint, five days or more have passed since the first fracture. When you are completely sure of the damage caused by swelling, itching, and blistering and know these possible events will not occur, you should use a splint. Many times, they have been hasty in placing the splint, and they have placed the splint before the appropriate time, and the mentioned injuries have occurred. If the broken part of the bone is larger, the splint should be applied later" [Figure 10].[26,40]

Figure 10. A page from the Law book showing the delayed use of splints in fractures[26]

Cast from Iran to Holland

Plaster of Paris has been used for centuries as a stiffening agent to treat fractures and other musculoskeletal conditions requiring rest, immobilization, or deformity correction. Plaster was made 9,000 years ago [Figure 11].[41]

Figure 11. The use of plaster forms in the Egyptian pyramids by the pharaohs[41]

Plaster is derived from the Greek word Plássein' (πλάσσειν), which means to daub on. The Greeks realized the health and antiseptic value of plaster due to the presence of lime and used it to prevent diseases and vermin. The use of gypsum (calcium sulfate), according to the review of old medical books and credible articles by the sage Movafagh Heravi in the book Al-Abniyeh in the 10th century AD, was also used in bone disorders and organ stabilization. Some orthopedic articles and books have dealt with it in short sentences without detail or citations.[41–43] Calcium oxide was used for the first time by Rhazes in organ fixation. Rhazes writes in *Liber Continens* under "My views": "Burn the oyster until it becomes lime, then roast it with moisture, and put it on the fracture, which is a wonderful medicine. If you want to add light and egg white on it, it will have a more amazing answer that is much better and more efficient because it will make it like a stone, and there will be no need to remove it and bandage it".[27] About a few decades after Rhazes, Albucasis also proposed this combination to make a cast-like composition that he used alongside bandages, which was both soft and had healing properties. This composition consisted of pulse, gum mastic, acacia, elder, might, sukk, myrrh, aloe vera, clay, and water with egg white.

After him, Hakim Movafagh Heravi directly benefits from the form of calcium sulfate (gypsum) in stabilization. In his book, under "Gol Jas" and "Tain Jabsin," which share the same concept as casting in Persian Medicine, he writes:

"Plaster flower is cold and dry because it is applied to the head with vinegar; it is useful for nosebleeds, and it is beneficial to cover broken and irritated bones." He also writes: "Gol Jabsin joins" [Figure 12].[28,41]

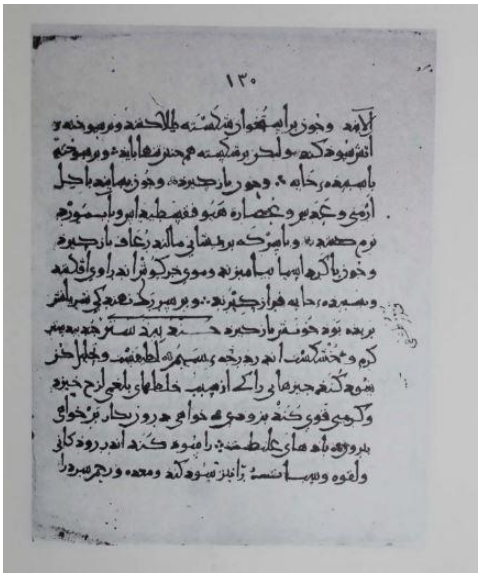

Figure 12. Right: A variety of manuscripts of al- Abniyeh containing materials related to plaster; Left: manuscript, suitable: lead copy[41]

Movafagh Heravi also writes in the book Al-Abniyeh: "When the box is ready, smear its inner surface with oil or ointment to prevent the plaster from sticking to it, and then grease the leg for the same purpose. Then, the foot is placed in the box so that it does not come into contact with the walls and its extension. Then, liquid plaster is gradually and carefully poured into it so that the box is evenly and accurately filled and almost reaches the anterior surface of the limb. It should not be completely covered. so that a part

of the front surface remains uncovered. Then, as soon as the plaster hardens enough, open the box and take it out. At the end of the course, it is helpful to cut with a hammer and chisel in the upper part of the plaster bandage" [Figure 13].[41]

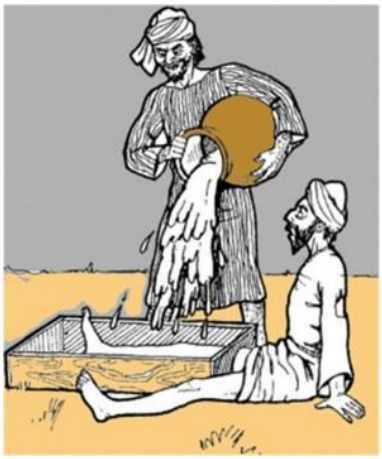

Figure 13. An imaginary image of the act of leg plastering by the sages of Islamic civilization[41]

This knowledge was used with slight variations for centuries by different sages and civilizations until William Eton, the former British consul in Basra, told a Petersburg doctor in 1798 about such treatment of an Arab soldier who had broken his leg. He wrote in his letter:

"In the eastern part of the empire, I observed a method of fixing the bone, which I think deserves the attention of surgeons in Europe. In this method, the bone is placed in a plaster box that is exactly the shape of the limb without pressure, and within a few minutes, a solid mass of plaster is formed on the affected limb with an open end. This material can be easily cut and removed with a knife. Once the swelling subsides, if the cavity is too large for the limb, or if a hole remains, liquid plaster can be poured back into the void". The Eton letter was published in some European journals, and subsequently, Professor Mathijsen used it in Holland and developed it over time.[41]

Conclusion

The treatment of fractures has progressed over the centuries, transitioning from rest and immobilization to advanced internal fixation and surgical techniques.

Modern technologies, including anesthesia, antibiotics, and metal implants, have significantly enhanced this evolution. Valuable practices such as traction techniques, delayed splinting, and the use of materials like plaster splints have been preserved and adapted over time. Consequently, the current medical landscape reflects a synthesis of past successes. Understanding the efforts of our ancestors not only helps maintain continuity between contemporary treatments and those of ancient ancestors but, by extrapolation, may help us gain glimpses of what might happen in the future. Even after thousands of years, there are similarities between these old techniques and modern techniques. The history of medical science shows that many developments, innovations, and creations have been rooted in the opinions of various sages and doctors centuries ago. Almost a thousand years before George Perkins, the sage Razi, by stating the delay in the use of splints (Jabireh), and Movafagh Heravi in the use of plaster, laid the groundwork for enlightenment and reference in this matter in the writings of later sages such as Albucasis and then Avicenna. These sages have played a role in the growth and evolution of this view with small theories. In addition to Rhazes's knowledge, Avicenna also states that the larger the broken limb, the later the splint should be used. Sometimes, a more detailed examination of the techniques and theories used in modern medicine in the context of history shows the initial use and discovery by individuals or medical schools in the distant years. This underscores the necessity for further investigation into the history of medical science and the evolution of various disciplines and theories.

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