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Review Article

Lower Limb Fractures by Ibn Sīnā (Avicenna) in Context of Al Qanūn Fī Al-Tibb (Canon of Medicine): A Comprehensive Review

Dr. Asma Mehmood[1*], Dr. Abdul Malik[2], Dr. Mohd. Abu Bakar Quadri[3], Dr. Md Imran Khan[4], Dr. Nafasat Ali Ansari[5], Dr. Ahtasham Khatoon[1]

[1]PG Scholar, Department of Anatomy, State Takmil-ut-Tib College and Hospital, Lucknow, U.P. India
[2]Associate Professor, Department of Anatomy, State Takmil-ut-Tib College and Hospital, Lucknow, U.P. India
[3]Associate Professor and Head, Department of Anatomy, State Takmil-ut-Tib College and Hospital, Lucknow, U.P. India
[4]Assistant Professor, Department of Anatomy, State Takmil-ut-Tib College and Hospital, Lucknow, U.P. India
[5]Retd. Professor, Department of Anatomy, State Takmil-ut-Tib College and Hospital, Lucknow, U.P. India

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Abstract: *Ibn Sīnā* emphasizes the importance of proper splinting techniques and meticulous wound care in the management of fractures, providing specific and detailed instructions for effectively managing particularly complicated cases, such as comminuted fractures, as well as those involving major bones and joints like the hip, femur, patella, and foot. His extensive work reveals not only a profound understanding of human anatomy and the complex mechanisms of treatment methods but also underscores practices that resonate with modern medical approaches, thereby highlighting the enduring historical significance of his contributions to the field of orthopedics and their relevance to contemporary medicine. This paper provides a comprehensive overview of *Ibn Sīnā*'s significant insights into the complex topic of fractures, meticulously encompassing various types of fractures that may occur, including comminuted fractures, longitudinal fractures, and transverse fractures, along with a detailed discussion of the associated symptoms that are essential for effective diagnosis, such as pain, swelling, and deformity. Furthermore, the text delves deeper into the critical aspects of healing times that are necessary to understand for different types of fracture and elaborates on various factors that may hinder the recovery process, thus affecting patient outcomes, particularly in what is now known as the Theory of Delayed Splintage.

Keywords: *Ibn Sīnā* (Avicenna), Fracture (*Kasar*), *Al Qanūn fī al-Tibb* (Canon of Medicine), Splint, Callus.

INTRODUCTION

Abū ʾAlī al-Ḥusayn Ibn ʿAbd Allāh Ibn Sīnā, commonly known as Avicenna, was a prominent scholar in the fields of Islamic philosophy and medicine, whose life spanned from 980 to 1037 A.D., producing 276 works, predominantly in Arabic. Celebrated posthumously, his contributions have been honored globally, with UNESCO recognizing his significance in 1978. His extensive writings spanned various disciplines, although many have been lost. Regarded as a leading medieval physician and philosopher, his legacy continues to influence both fields today.

Ibn Sīnā's Al Qanūn fī al-Tibb (Canon of Medicine) is a significant work that integrates medical theories from Hippocrates and Galen with Aristotle's biological principles. It is comprised of five essential volumes, each containing various treatises structured into chapters and sections [1]. Gerard of Cremona, a renowned scholar, translated this significant work into Latin from 1114 to 1187, marking a substantial milestone in the spread of medical knowledge in the Western world. Following this translation, further editions in other languages, notably Hebrew and Arabic, were published in the years 1491 and 1593, respectively, thereby broadening its reach and influence across different cultures and regions [2]. Canon of Medicine is a foundational authority in medicine, and critical examination of its content is often seen as blasphemy [3]. Its influence and significance in medical literature cannot be overstated.

***Corresponding Author:** Dr. Asma Mehmood
PG Scholar, Department of Anatomy, State Takmil-ut-Tib College and Hospital, Lucknow, U.P. India

Particularly notable is the fourth volume, which delves into fractures through two detailed treatises, "Fractures of Every Bone Separately" and "Fractures as a Whole." These works meticulously classify fractures, analyze their causes, outline treatment options, and recognize potential complications, mirroring the structure of modern medical texts. *Ibn Sīnā's* pioneering approach and systematic methodology in examining fractures have profoundly influenced medical understanding and practice, establishing a lasting legacy that continues to resonate within the field. His contributions highlight not only his expertise but also his significant role in advancing medical science and literature.

Furthermore, he dedicates considerable attention to elaborating on the specific ways that each individual bone within the human body can sustain a fracture, thereby providing invaluable information that contributed to its status as the most widely utilized medical textbook in both Islamic and European contexts for many centuries, continuing to influence medical thought and practice until the 17th century.

METHODOLOGY

This research focuses the analysis and synthesis of information extracted from the pivotal medical text, *Al Qanūn fī al-Tibb* (Volume IV), authored by *Ibn Sīnā* and translated by G.H. Kantoori, while also incorporating perspectives from current academic literature, including peer-reviewed journals, research papers, and contemporary publications.

Objective

The objective of this research paper is to bridge the understandings gained from *Al Qanūn fī al-Tibb (Vol-IV)* with current scientific discourse, thereby improving the understanding of fractures, particularly those affecting the lower limbs. By integrating this significant historical text, the study intends to provide a comprehensive analysis of lower limb bone fractures, highlighting the importance of historical knowledge in the context of contemporary medical science and its practical applications.

LITERATURE REVIEW

Al Qanūn fī al-Tibb, written by *Ibn Sīnā*, is considered the most well-known medical textbook ever produced by William Osler. It contains medical information acquired from numerous civilizations up until Ibn Sīnā's time, making it a unique reference or document [4].

Ibn Sīnā's Al Qanūn fī al-Tibb, widely used in Islamic and European nations, provided comprehensive explanations of disease classification, causation, epidemiology, symptoms, signs, therapy, and prognosis. However, by the 12th century, the compilations became too large for quick reference, leading to the creation of epitomes and commentaries to facilitate quick accessibility. The Concise Book in Medicine by *Ibn al-Nafīs* is a well-known and extensively read example of al-Qanūn, a corpus of medical literature that had a big impact on how people understood and practiced medicine.

Al Qanūn fī al-Tibb (Canon of Medicine), a series of five volumes, includes the fourth volume, which focuses on bone fractures and dislocations [5]. The chapter titled *Al-Jabr*, having three parts referring to orthopedics, provides a comprehensive overview of bone dislocation. In its first part, describing *Al-Khala* (Dislocation), Avicenna's introduction to this topic is followed by a detailed exploration of diagnostic techniques and treatment approaches for dislocations affecting fifteen bones in both upper and lower limbs [6]. The chapter is structured into three sections, ensuring a comprehensive understanding of the complex issue of bone fractures and dislocations.

The second part is about *Fil Kasr Kalam-e Kollī fil Kasr* (Fracture as a Whole), he identifies various manipulation techniques for fracture reduction and categorizes different types of fractures [6]. He differentiated between open and closed fractures and explores management strategies for each type. *Ibn Sīnā* emphasized the importance of using specific instruments, such as drills and saws, to effectively treat bone fractures. This practical approach highlights the importance of appropriate equipment in achieving successful outcomes in fracture treatment. In the third part *Fī Kasr Ozv Ozv* (Fracture of specific bone), he provided a detailed account of nineteen distinct types of bone fractures, highlighting the diversity of fractures and the specific treatment protocols required for each type [6]. *Ibn Sīnā*'s dedication to advancing medical knowledge and improving patient care in orthopedics is evident in his work on bone fractures.

His early medical knowledge on bone fractures, particularly the use of tight bandaging, is significant. He argued that this obstructs blood supply to the extremity, leading to severe pain and eventual amputation. This early explanation of compartment syndrome, which involves increased pressure in confined anatomical spaces and adversely affects blood circulation, is eight centuries before Richard von Volkmann's 1881 explanation [6-8]. Avicenna's approach to managing fractures is considered an early example of current medical knowledge.

The First Treatise: General Fracture [9]

Ibn Sīnā, in his work *Al Qanūn fī al-Tibb*, characterizes a fracture as an interruption in the continuity of bone structure. He categorizes various types of fractures, such as comminuted, longitudinal, and transverse. In his examination of the symptoms associated with fractures, he emphasizes that pain, swelling, and deformity of the affected limb are essential

for accurate diagnosis. Furthermore, *Ibn Sīnā* differentiates fractures that reach the joint line, noting that if a fracture occurs at this location and subsequently heals, the joint may experience restricted movement due to the prolonged rigidity of the callus.

Contemporary understanding supports *Ibn Sīnā*'s observations, indicating that fractures involving the joint line can lead to stiffness in that joint post-healing, unless appropriate physiotherapy is administered. This highlights the importance of rehabilitation in restoring function and mobility to the affected limb, reinforcing the relevance of *Ibn Sīnā'*s insights in modern medical practice.

Bone Healing

Ibn Sīnā suggested that children's fractures exhibit a faster healing rate compared to those of adults. He meticulously calculated the duration required for various bones to heal. His findings indicated that a fractured nasal bone typically requires around 10 days for recovery, while a rib takes approximately 20 days. In contrast, a forearm fracture may take between 30 to 40 days, and a femur fracture can take anywhere from 50 to 120 days. Notably, these timeframes align closely with the information presented in modern medical literature.

Ibn Sīnā identified various elements that hinder the recovery of bones. He emphasized that the absence of a splint at the fracture site, excessive movement of the injured limb, blood loss leading to anemia, and the presence of pre-existing medical conditions are significant contributors to delayed recovery. These factors, as identified by *Ibn Sīnā*, continue to be recognized in contemporary medicine as critical elements affecting the healing timeline.

The insights provided by Ibn Sīnā not only reflect an advanced understanding of bone healing for his time but also resonate with current medical practices. He described the different methods for healing of the fractures as well as its proper care and management. This historical perspective enriches our comprehension of orthopedic medicine and highlights the enduring relevance of *Ibn Sīnā*'s contributions to the field.

Bone Splinting

Ibn Sīnā elaborates on the procedure for splinting a fractured bone. He warns medical practitioners about the potential risk of gangrene that may arise from excessively tightening the splint on the injured limb. *Ibn Sīnā* underscores the importance of prioritizing wound care over the fracture itself, particularly in cases now classified as open fractures. He advises that if a hematoma exacerbates the fracture, the bone setter should make an incision in the swollen area to facilitate the drainage of blood.

Additionally, *Ibn Sīnā* delves into the management of comminuted fractures, highlighting their complexity. He stated that when a fracture occurs together with pain and is related to a sequestrum, it is imperative to restore the fracture to its original position. Should this realignment prove impossible, he recommended the removal of the sequestrum through the creation of multiple holes at its base or by employing a fine saw. In either case, he emphasized the necessity for the physician to proceed with utmost caution to prevent harm to surrounding vital structures.

Although the sequestrum may not always be visible externally, its occurrence can often be deduced from the discharge that arises from the wound. It is removed through an enlargement of the incision, ensuring clear visualization and safe removal of necrotic tissue or foreign material for optimal patient healing. *Ibn Sīnā*'s insights reflected a comprehensive understanding of fracture management, emphasizing both the technical aspects of treatment and the critical need for careful observation and intervention.

Bone Setting

*Ibn Sī*nā recommended that any doctor diligently and thoroughly inspect as well as analyze any fracture before proceeding with treatment. He emphasized the necessity of splinting the affected area immediately since delaying treatment could result in more complex issues, making the reduction of the fracture significantly more challenging and potentially leading to undesirable complications. It is noteworthy that *Ibn Sīnā* also highlighted the importance of a strategic delay in splinting the fracture. Specifically, he suggested that medical practitioners should refrain from applying a splint for at least five days or until the swelling has subsided. This recommendation was pioneering for its time and aimed at optimizing the healing process. In modern times, Professor George Perkins has gained recognition as the founder of what is now widely referred to as the Theory of Delayed Splintage, which draws upon *Ibn Sīnā'*s foundational ideas and further develops the understanding of fracture management [10].

Wound-Related Fractures

These are fractures connected to a wound. *Ibn Sīnā* discussed how to manage wound-related fractures in this chapter. He emphasized the need of avoiding putting a splint on the wound; instead, ointment should be applied first, followed by a particular dressing that would allow the doctor for the application of medication so that the wound may be discharged.

With the exception of using sterile techniques while treating open fractures, the approach outlined by *Ibn Sīnā* is comparable to modern methods in many ways.

Fractures Leading Malunion

According to *Ibn Sīnā*, malunion fracture causes deformity of the limb as it is dealt with

inappropriately. He recommended appropriately splinting the bone at the location of the previous fracture in order to treat this instance. Avoid using this procedure if the callus is firm, as it may cause a fracture elsewhere. *Ibn Sīnā* advised that a bone setter must utilize a substance to soften the callus, thereby facilitating proper splinting of the limb. In modern medical practice, surgical procedures are used to rectify various forms of malunion.

The Second Treatise: Regional Fracture

The fourth volume of the treatise delves into the intricate nature of fractures, focusing on separate fractures of specific bones. It offers a comprehensive understanding of the complexities of healing and management of these injuries, common in clinical practice and athletic settings.

Hip Fractures

Hip fractures occur frequently, especially in elderly people, especially women, who are more prone to osteoporosis. They are also frequently associated with low-energy falls, which emphasizes how serious these injuries are [11]. *Ibn Sīnā*, a renowned medical expert, highlighted the rare cases of central hip fractured dislocation and sacral fractures, also known as broad bone fractures. He emphasized that these fractures are similar to those of an arm or shoulder, causing severe pain and anesthesia. To effectively reduce broad bone fractures, he advised that doctors should position the patient in a prone position, employ bandages and splints, and have two strong individuals tract the patient's thighs [12].

Femoral Fracture [13]

According to *Ibn Sīnā*, "Torsion should be upward to be more effective if the femur fracture requires severe traction to reduce it to the normal position, which is convex in its lateral side and concave in its medial side" [13]. Additionally he stated that since the femur is wider on that side, the distal pieces move outside and anteriorly when this fracture happens. A bandage should be placed above the fracture and another below it if the fracture is in the center of the femur once the reduction has been accomplished by providing intense traction. Fractures of the femur heal in approximately 50 days.

Patellar Fracture [14]

Ibn Sīnā highlighted the importance of the patella in preventing fractures and sprains. Crepitation, a diagnostic tool, can help identify fractures. Furthermore, he advised to extend the leg and reposition the patella for its treatment. In cases of comminuted fractures, gathering fragments before reduction ensures thorough treatment and addresses the complexities associated with multiple fracture pieces.

Tibial and Fibular Fracture [14]

Ibn Sīnā expressed a preference for fibula fractures in comparison to tibia fractures, noting that movement remains feasible in the upper tibia when the deformity is located laterally and anteriorly and in the lower tibia when the deformity is positioned laterally and posteriorly. The condition becomes critical when both bones are fractured, and the resulting deformity may manifest in various directions. He recommended that the physician employ the same method used for treating forearm fractures, specifically traction, to alleviate the fracture.

Talus Fractures [14]

Ibn Sīnā noted that the Talus bone is safeguarded from fractures due to its robust structure and protective characteristics. He suggested that there could be instances where this bone has shifted. Additionally, he stated that Talus bone may be dislocated from its anatomical position. In modern medical practice, fractures of the Talus are uncommon, and accurately diagnosing them without X-ray imaging presents significant challenges.

Calcaneus Fractures [14]

Ibn Sīnā described that fractures of the calcaneus posed significant risks due to their challenging nature in terms of treatment. Such injuries typically occur when an individual falls from a considerable height. Patients may experience severe symptoms, including fever, confusion, tremors, and muscle spasms. Once a calcaneus fracture has healed, individuals often find walking to be a considerable challenge [10]. This type of fracture is commonly referred to as the "parachutist's fracture" in modern medical science.

A major complication associated with calcaneus fractures is the resultant difficulty in ambulation, which can arise from the onset of osteoarthritis in the talocalcaneal joint following the healing process. This condition underscores the long-term implications of such fractures, highlighting the importance of effective management and rehabilitation strategies to mitigate the adverse effects on mobility.

Toe Fractures [15]

Ibn Sīnā distinguished that the methods employed to treat fractures in the toes are remarkably similar to those utilized for fractures of the fingers. This insight allows for a better understanding of the principles of treatment across different parts of the human body, thereby emphasizing the shared characteristics of how various fractures can be effectively managed.

CONCLUSION

Al Qanūn fī al-Tibb, written by *Ibn Sīnā*, is a significant medical work that focuses on traumatology and fractures. It is a comprehensive reference that reflects the medical insights from various civilizations. This influential work not only encompasses disease classification and therapy but also provides detailed insights into the management of fractures, illustrating a clear understanding of bone healing, diagnostic methods,

and treatment approaches analogous to modern medicine. His discussions on the types of fractures, factors affecting healing, and practical recommendations for physicians reflect profound clinical acumen. *Ibn Sīnā* emphasized the importance of rapid assessment and treatment of fractures while also advocating for methods to minimize complications such as mal-union and gangrene, aligning closely with contemporary medical practices. Thus, his detailed exploration of fractures and their management not only reflects advanced medical insights of his time but also laid foundational principles that continue to inform modern medical practices.

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