Araştırma Makalesi – Original Article

Avicenna's Dental Anatomy: Bridging Ancient Insights with Modern Knowledge*

İbn-i Sina'nın Diş Anatomisi: Kadim Görüşleri Modern Bilgiyle Birleştirmek

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ABSTRACT

Objective: This study examines Avicenna's knowledge of dental anatomy and compares it with modern dental anatomy. The aim is to identify similarities and differences between ancient and contemporary understandings of dental structure.

Materials and Methods: The original Arabic text of *Canon of Medicine* (القانون في الطب) and its English translation (1973, AMS Press) were used. Additionally, the Turkish translation of *Tahbiz al-Mathun*, a commentary on *Canon* by Tokadī Mustafa Efendi, was referenced. The dental anatomy sections from the first book and the basic anatomy of the mouth and tongue from the third book were analyzed, translated, and compared across the Arabic, English, and Turkish versions.

Results: Despite some differences, Avicenna's dental and oral anatomy descriptions largely align with modern knowledge. The sutures and structures of the jaw bones are similar, and Avicenna notes that teeth can sense temperature, a concept consistent with the contemporary understanding of dental nerves. However, his descriptions of the nerves and their functions do not fully match current anatomical knowledge. The arteries and veins of the mouth, as described by Avicenna, generally align with today's anatomical understanding.

Conclusion: The study reveals both agreement and discrepancies between Avicenna's dental anatomy and modern knowledge. While his insights into specific structures and functions are accurate, his explanations of nerve pathways and muscle anatomy require further clarification. This work emphasizes the importance of integrating ancient medical knowledge with modern scientific understanding, providing a foundation for future research in the history of medicine.

Keywords: Avicenna, Anatomy, Canon of Medicine

ÖZ

Amaç: Bu çalışma, İbn-i Sina'nın diş anatomisi hakkındaki bilgisini incelemeyi ve bunu modern diş anatomisi ile karşılaştırmayı amaçlamaktadır. Amaç, eski ve çağdaş diş yapısı anlayışları arasındaki benzerlikleri ve farkları belirlemektir.

Gereç ve Yöntem: Bu çalışmada, Tıp Kanunu'nun (القانون في الطب) orijinal Arapça metni ile 1973'te AMS Press tarafından yayınlanan İngilizce çevirisi kullanılmıştır. Ayrıca, Tokadī Mustafa Efendi tarafından yazılmış olan ve Kanun üzerine bir açıklama olan Tahbiz al-Mathun'un Türkçe çevirisi de referans alınmıştır. Birinci kitaptaki diş anatomisi bölümleri ve üçüncü kitaptaki ağız ve dilin temel anatomisi analiz edilmiş, çevrilmiş ve Arapça, İngilizce ve Türkçe versiyonlar arasında karşılaştırılmıştır.

Bulgular: Bazı farklara rağmen, İbn-i Sina'nın diş ve ağız anatomisi tanımlamaları genel olarak modern bilgilerle uyumludur. Çene kemiklerinin suturları ve yapıları benzer şekilde tanımlanmıştır ve İbn-i Sina, dişlerin sıcaklık hissedebileceğini belirtmiş, bu da modern diş sinirleri anlayışıyla tutarlıdır. Ancak, İbn-i Sina'nın sinirler ve işlevleri hakkındaki açıklamaları, mevcut anatomik bilgiyle tam olarak örtüşmemektedir. İbn-i Sina'nın ağızda tarif ettiği arterler ve damarlar, günümüz anatomik anlayışıyla genelde uyumludur.

Sonuç: Çalışma, İbn-i Sina'nın diş anatomisi ile modern bilgi arasında hem benzerlikler hem de tutarsızlıklar ortaya koymaktadır. İbn-i Sina'nın bazı yapılar ve işlevlerle ilgili tespitleri doğru olsa da, sinir yolları ve kas anatomisi açıklamaları daha fazla açıklamaya ihtiyaç duymaktadır. Bu çalışma, eski tıbbi bilgilerin modern bilimsel anlayışla entegrasyonunun önemini vurgulayarak, tıp tarihindeki gelecekteki araştırmalar için bir temel sunmaktadır.

Anahtar Kelimeler: İbn-i Sina, Anatomi, El-Kânûn Fit-Tıbb

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Introduction

Abu Ali al-Hussein Ibn Abdullah Ibn Sina, known as Avicenna, was born around 980 in Efşene near Bukhara. His father, Abdullah, was from Balkh and was a Turk. He married a Turkish woman named Yıldız in the town of Afshan in Bukhara, inhabited by Turks like his hometown. Avicenna, who started his education at five, progressed quickly. He knew many fields, such as philosophy, arithmetic, theology, and medicine. After deepening his expertise in philosophy, he started to read medical literature. It is stated in historical sources that he treated patients at the age of seventeen and was appointed as a palace physician at the age of eighteen. Avicenna left Bukhara at the age of twenty-one due to the political disturbances and his father's death. Then, he traveled to various regions and interacted with the scholars of the period he encountered. During his stay in Urgench, he had the opportunity to author many books and teach his students the Canon of Medicine, which was finished in the early 1020s. From 1024 to death in 1037, he resided in Isfahan and continued to compose his works. [1-3] Canon consists of five books. Dental anatomy is mentioned in the first book and explained briefly in the third book, before mouth diseases. In the anatomy of bones, the borders of the maxilla are explained with sutures. Teeth are also counted as bones; their ability to sense is one of the most significant differences. The muscle anatomy of cheeks, lips, jaws, and tongue is also explained in depth. The nerves that innerve the area and the arteries and veins mentioned differ from today's anatomy.

Tokadī Mustafa Efendi was born in Tokat, a city in Anatolia, and died in 1782 in Istanbul. 4 He was an influential scholar and state official of the Ottoman Empire. After the request of Sultan Mustafa III, Tokadī Mustafa Efendi started translating Canon to Ottoman Turkish while adding commentaries of Canon by many esteemed scholars and himself. He completed his work, Tahbiz al-Mathun, in 1766-67 and presented it to Sultan Mustafa III.[5] Tahbiz al-Mathun is the first translation of a text in Islamic literature by comparing the printed copy with the manuscripts. In his endeavor to obtain the correct copy, Tokadī compared many Canon copies, which are spread over a large geographical area and have many copies, including the Roman printed copy printed in the 16th century. He uses reference texts to construct a solid text. His first reference here is the commentaries on Canon. The main commentary he focuses on is Qutb al-Din al-Shirazi's al-Tuhfah al-Sa'diyya. In addition, he also evaluated the commentaries of scholars such as Ibn Jumay, Fakhr al-Din al-Razi, Muhammad ibn Yusuf al-Īlāqī, and Masīhī. With all these aspects, this work is a foundational text for Turkish translation history and edition-critical studies.[5]

We aim to examine the knowledge acquired about dental anatomy by Avicenna and compare it to modern dental anatomy. Therefore, we will determine the similarities and differences between the ancient dental anatomy and the anatomy we learn today.

Material and Methods

We used the original Arabic text of Canon (القانون في الطب) and the English translation (the Canon of Medicine) published in 1973 by AMS Press in the United States was used to compare. We mainly used the Turkish translation of Tahbiz al-Mathun, a Canon commentary by Tokadī Mustafa Efendi. For dental anatomy, the first book's anatomy section was used. Firstly, sections about dental anatomy were selected and analyzed. Then, it was translated and summarised in modern Turkish. The same procedure was applied to the basic anatomy of the mouth and tongue, taken from the third book. Names of the terms and section titles were confirmed with Arabic and English versions. In addition, the leading book used as a source for modern anatomy comparisons is Gray's Anatomy: The Anatomical Basis of Clinical Practice (41st edition).

Results

Dental anatomy

According to the dental anatomy described in the Canon of Medicine, there are thirty-two teeth. Some individuals may not have wisdom teeth at the maxilla and mandible far left and right ends. Therefore, they would have only twenty-eight teeth. The medial incisors (ثنايا تان) are the four front teeth; two are in the maxilla, and two are in the mandible, side by side. Next to the medial incisors are the lateral incisors (رباعيتان), making a total of four incisors. These eight teeth are used for cutting food, similar to a knife. Next to the lateral incisors are the canines (ناب), four in total, which assist in cutting. The molar teeth (أضراس) are located in the maxilla and mandible, usually numbering sixteen (in most people, there are five on each side, making a total of twenty). These molars are responsible for grinding food. Wisdom teeth (النواجذ) are located at the end of the molars and erupt during the growth period, typically between puberty and the prime of life (ages 30-45) .[5]

Teeth have roots that are thin and sharp. They are embedded in sockets in the jawbones, and powerful ligaments surround each socket. Some molars have a single root, while molars in the mandible typically have at least two, often three. Wisdom teeth may have even more roots. Molars in the maxilla have at least three roots, and generally four. Molars have more roots than other teeth because they are larger and have a more demanding function.

Additionally, teeth in the maxilla resist gravity and require additional protection, hence the need for more roots. Teeth in the mandible do not require as much protection. Unlike other bones, teeth can sense stimuli. Galen stated that teeth were designed to sense stimuli, such as differentiate between hot and cold.[5] It was also observed that the terminology used in various languages could differ and was tabulated (***Table 1***).

Table 1. Translations of Certain Terms from The Canon of Medicine in Various Languages

Arabic	English	Latin	Turkish
ثنيتان	Incisor tooth I (medial incisors)	Dens incisivus I	Üst Orta Kesici Diş (Santral Diş)
رباعيتان	Incisor tooth II (lateral incisors)	Dens incisivus II	Üst Yan Kesici Diş (Lateral Diş)
ناب	Canine tooth	Dens caninus	Köpek dişi
أضراس	Molar tooth	Dens molaris	Azı dişi
النواجذ	Third molar tooth; wisdom tooth	Dens molaris tertius; dens serotinus	3. Azı dişi, Akıl dişi, Yirmi yaş dişi
السباتي لشريان	Common carotid artery	Arteria carotis communis	Karotid arteri, Şah damarı
الوداج الظاهر	External jugular vein	Vena jugularis externa	Dış jugular ven
الوداج الغائر	Internal jugular vein	Vena jugularis interna	İç jugular ven

Anatomy of bone structures

The section on dental anatomy begins by describing the sutures of the maxilla in the Canon of Medicine. The upper jaw, or maxilla, connects with a suture between the jaw and the frontal bone on the upper side of the head. This suture is located between the eyelids and extends to the temporal sides. On the outer side, a suture starts from the ear and passes through the jaw and sphenoid bone. Behind the molars, this suture curves. After curving, it ends at the median palatine suture. The final suture separates the maxilla from the palatine bone. These sutures define the maxilla's borders, further subdivided by additional sutures. The first of these is the previously mentioned median palatine suture. The second starts from the midpoint between the two eyebrows and ends near the maxillary central incisors. The third begins in the

exact location as the second, curves downward, and ends between the lateral incisors and the canine teeth. Together, these sutures, along with the joint suture between the maxilla and sphenoid bone, define the boundary of the ears.[5]

Two triangle-shaped bones are located at the incisors' roots and canines. However, the bases of these triangle-shaped bones do not align with the roots; instead, they terminate near the nostrils. Therefore, there are two additional bones, one on each side, located near the bases of these triangle-shaped bones. These bones surround the bases of the triangular bones, the roots of the anterior teeth, and the sutures on each side of the maxilla. These bones form a right angle with the middle suture of those above three primary sutures, an acute angle with the canine level, and an obtuse angle with the nostrils. From the maxillary sutures, one from the joint region extends to the orbit and divides into three branches without entering the orbit. The first branch passes under the suture that connects the forehead and maxilla above the orbit and joins the eyebrows. The second branch passes under the first but does not involve the orbit. The third branch enters the orbit, passes beneath the eyebrows, and joins the facial muscles. The lower jaw comprises two bones united at the center by an immobile joint. One bone has a protrusion with two smaller protrusions.[5]

As the Canon states, the nose is formed by two triangular-shaped bones. On the upper side, the two corners face each other, and their base connects at a corner. As they come together, they separate into two corners. These bones contribute to the sutures of the maxilla. Beneath these bones is soft cartilage with two formations, and in the middle of these, a third cartilage extends to the middle suture of the maxilla. This cartilage is longer and more robust than the other two.[5]

Muscle anatomy

In terms of muscle anatomy, the cheek has two types of movement. One movement is linked to the mandible's motion, while the other is related to the cheek movement of the lips. The difference between these movements lies in the fact that the first depends on the movement of the mandible itself, which causes the cheek to move as well. The second movement involves a muscle between the cheek and lips, which moves the cheek and lips together on either side of the face. This muscle is called the cheek muscle and consists of four parts, with fibers originating from four different points.

- The first fiber originates from the clavicle and merges with the cheek below the lips, causing the mouth to move downward and sideways.
- The second fiber arises from the ribs and clavicle, and its fibers run obliquely. The fiber originating from the left rib and clavicle ends at the right side of the lower lip, while the fiber from the right side does the opposite. When these fibers contract, they cause the mouth to pucker and the lips to protrude, resembling a pouch.
- The third fiber originates from the coracoid process and moves the lips to the sides.
- The fourth fiber originates from the spinous process and runs along the process to join the cheek at the level of the ears. This fiber moves both the cheek and lips outward. In some individuals, this fiber reaches the ears and causes movement there.[5]

In addition to the mutual muscle with the cheek, the lips are controlled by four muscles. Two of these muscles originate above the cheeks and end at the lips, while the other two arise from below. These four muscles are sufficient for the movement of the lips. When one muscle contracts alone, the lips follow its direction. When two muscles contract simultaneously, the lips spread to both sides, allowing four different

movements. These four movements are made possible by the collaboration of the mutual muscle and the four lip muscles, enabling the lips to sense. Small but strong muscles located near the nostrils, although not part of the lip and cheek muscles, help to strengthen the nose, which is weak due to the absence of bones. These muscles also help widen the nostrils.[5]

Regarding the movement of the jaws, the mandible is unique in its mobility. This mobility offers several advantages: the movement of the maxilla may affect other organs on the upper side of the head, such as the eyes, and diminish its connection with the rest of the head. The mandible can have three types of movement: the first is opening the mouth, the second is closing the mouth, and the third is chewing. The opening movement involves the jaw moving downward, while the closing movement involves the jaw moving upward.[5]

According to the muscle anatomy of the tongue described in the Canon, nine muscles are involved in tongue movement. Two of these are broad muscles that originate from the hyoid bone (سهم بة زوائد) and extend to both sides of the tongue. Two other long muscles are located in the middle of the tongue. Two muscles originate from the underside of the hyoid bone and move the tongue laterally. The remaining two muscles pull the tongue backward and are positioned beneath the other muscles. The final muscle is located between the tongue and the hyoid bone, allowing the tongue to move in and out.[5,6]

Cranial nerves

In the Canon part that discusses nerves, there are seven cranial nerves. Only the ones associated with dental anatomy are mentioned in this. The third cranial nerve originates from the middle of the brain's base and the union point of the frontal and hindbrain. It merges with the fourth cranial nerve and then splits again. The third cranial nerve is divided into four branches. The first branch goes down the neckline and arrives at the diaphragm. The second branch merges with the fifth cranial nerve branch. The third branch comes off from orbit and splits up into three parts. The first one innerves temporal sides, jaws, eyebrows, forehead, and eyelids—the second part goes deep in the nose. The third part is not small like the first two; it is significant. It goes out of the tiny space of the maxilla and splits into two little branches. The first one innerves teeth and gums (the nerves that go to teeth are so thin that they are not visible.). The second branch spreads to the cheek, nose, and upper lip. The fourth part goes from the maxillary foramen to the tongue and spreads to the outer layer of the tongue; it gives the sense of taste. Other branches go to the gums, papilla, and lower lip. This is thinner than the nerve that goes to the eye. The fourth cranial nerve comes from the third cranial nerve behind and goes to the palate. It is smaller than the third cranial nerve but more robust. The sixth cranial nerve originates from the hindbrain and splits into three branches. The first branch goes to the pharynx and tongue. (The second branch goes to the shoulders, and the third branch goes to the internal organs) The seventh branch originates from the edge of the brain and medulla spinalis. It goes to the tongue as a motor nerve, making it move. It also goes to the muscles between the hyoid bone and the thyroid.[5]

Spinal nerves

There are eight spinal nerves mentioned in the Canon. Only the ones associated with dental anatomy will be mentioned. The fifth spinal nerve originates between the fourth and fifth vertebrae. The first branch innerves the cheeks, and the second innerves the muscles that move the head.[5]

Blood supply pattern

Blood vessels that supply the mouth are described in detail. When the common carotid artery (ل شريان الـ سباتي) reaches the neck, the common carotid artery splits into two branches. The first branch also

splits into two. One branch goes deep and reaches the tongue and the muscle inside the lower jaw. The superficial one goes to the ears and temporal muscles. The external jugular vein (الوداج ظاهر ال) is formed of two parts—one part spreads to the upper and lower jaw, around the tongue, and near. The second part goes to the head and ears. The internal jugular vein (الوداج غائر ال) reaches the trachea and oesophagus and lasts at the hyoid bone region.[5,6]

Relationships with other structures

The general anatomy of the mouth and tongue in Canon is described in the third volume. The mouth is a necessary organ that is used for the transportation of nutrition to the below. It also cooperates with the nose when transporting air down. It is also used for throwing up waste when it cannot be cast away from below. It also provides speech for humans and sounds for animals. The tongue is an organ that mixes chewed food and helps to make sounds and taste. After comes the esophagus, which joins with the soft palate at the level of the sagittal suture and is connected to the stomach. The tip of the tongue is thin and called أسَلَة. The thinner the sole is, the more precise the sound and better the speaking. If the tongue is too big or too little, or shrank, those people cannot have the ability to speak. The matter of the tongue is soft and white meat, surrounded by capillary. Thus, the tongue appears red. The tongue also consists of veins and arteries. Although small, the veins, arteries, and nerves it houses are more than expected. There are two openings under the tongue, which a needle can penetrate. Saliva flows from those openings. Those are called sublingual ducts. Saliva keeps the tongue moist.[7]

Discussion

Galen says that teeth were created to distinguish between cold and heat. The definition in this direction coincides with current information. Because there is at least one nerve fiber in each tooth root, and in addition to these, the teeth also have proprioceptive sense. In addition, Avicenna describes the tooth as "a bone that senses through soft nerves." Current science confirms that the structure of a tooth consists primarily of highly mineralized structures, which is consistent with Ibn Sina's statement about bone. These mineralized tissues surround the dental pulp, a specialized, nerve-rich connective tissue corresponding to his statement of "soft nerves." Remarkably, Ibn Sina's description of the tooth's structure is entirely accurate, even without the aid of modern scientific instruments.[8]

The descriptions of the sutures made by the maxilla and other bone structures in its neighborhood coincide with today's knowledge of general structure.[9,10] The information about the external nose and the general structure of the teeth is compatible with today's modern anatomy definitions. Another finding is that the teeth in the maxilla resist gravity and, therefore, have more roots than the mandible. This is a logical philosophical explanation based on the laws of physics. In addition, one of the most important differences between the mandible and the maxilla is that the maxilla has spongiosis, while the mandible has compact bone. This situation also supports the explanation above.

The mention of the cheek muscle and the four muscle fibers that make up this muscle in the Canon of Medicine does not reflect reality. This situation can be explained in two ways: Either the dissection of this region was performed on an animal that fits the description, not on a human, or the muscles that extend from the facial area to the neck or from the neck to the facial region, such as the platysma, were evaluated as a single muscle. It is mentioned that there are four muscles around the lips. These muscles indicate the muscles that cause elevation and depression according to their descriptions. However, in addition to these, there is also the orbicularis oris muscle, which forms the main skeleton of the lip. The muscle specified as the mutual muscle is likely the risorius muscle. On the other hand, lips are not limited to only four movements but have more movement patterns. The information about the muscles that expand the

nostrils is consistent with today's anatomy consensus. This muscle is the alar part of the nasalis muscle. Three mandible movements are mentioned: opening, closing, and chewing. These movements are correct, but additional information that can be given to detail the definition is that the mandible also makes protrusion and retrusion movements.

Some sources mention eight and some nine tongue muscles. These muscles are generally examined as extrinsic and intrinsic. Although the information is usually correct, the two tongue muscles mentioned are attached to the hyoid bone: the genioglossus and hyoglossus muscles.

The third and fourth cranial nerves are the motor and sensory branches of the trigeminal nerve. Although the courses of the nerves are given accurately in general, some details could be improved compared to modern anatomy. For example, the branch is shown as the first branch and is stated to reach the diaphragm; it fits the phrenic nerve in terms of its course and definition. However, this nerve originates from the cervical plexus, not the trigeminal nerve.[10]

Although the information about the cervical nerves is given correctly, the information provided for C5 differs from today. C5 participates in the brachial plexus structure, activating some shoulder area muscles. It also engages in the phrenic nerve. Avicenna presented detailed insights on peripheral nerves and proposed an anatomical theory for the cerebellum and caudate nucleus that closely aligns with modern understanding. Additionally, he offered thorough descriptions of the vertebrae and their components.[11]

Dentistry was a significant branch of medical science in the 11th century. Ibn Sina's extensive observations across various fields of medicine guided physicians for six centuries. Some of his insights remain relevant today and continue to be applicable in modern medicine.[12] The literature contains information about the carotid artery and jugular vein. The language used is compatible with the current consensus regarding its main lines and macrostructure. The English copy we used of Canon does not develop into details in the anatomy section, and it is omitted, arguing that the anatomy knowledge of those times was inadequate.[13] Some scientific studies have discussed Avicenna's toothache and its influencing factors. However, this topic is not included in our study.[14]

Conclusion

This study reveals remarkable alignments and discrepancies between Avicenna's descriptions of dental anatomy and modern anatomical knowledge. While many aspects, such as the general structure of teeth, their function, and the description of maxillary sutures, align with contemporary understandings, specific details—especially regarding muscle anatomy and nerve pathways—show discrepancies. Avicenna's observations on the relationship between teeth and sensory functions, like distinguishing temperature, are consistent with modern concepts of proprioception. However, his interpretation of facial and oral musculature and nerve distributions warrants further clarification. This highlights the strengths of Avicenna's contributions, particularly in the context of his time, while also pointing out areas where additional research is needed to fully reconcile ancient and modern medical knowledge. Ultimately, this study underscores the value of exploring historical medical texts to enrich our understanding of the evolution of anatomical science and its continued relevance today.

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Author Contributions

Burak Karıp: Concept, design, supervision, data collection, analyses and interpretation, literature search, writing-review, editing.

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