

Research article – History of anatomy and embryology

Ocular anatomy in medieval arabic medicine. A review

Konstantinos Laios^{1,*}, Marilita M. Moschos², Androutsos George¹¹ Department of History of Medicine, Medical School, University of Athens² 1st Ophthalmological Clinic, Medical School, University of Athens

Abstract

In medieval Arabic medicine Ophthalmology had a central role. Ocular anatomy was described in many ophthalmological treatises of the physicians of the time. These physicians followed the doctrines of Galen according ocular anatomy, nevertheless their contribution to the history of ocular anatomy was the presentation of ocular anatomical sketches in their manuscripts for the first time in medical history.

Key words

Medieval Arabic Medicine, Ocular Anatomy, Galen, Ophthalmology, Anatomical Design

Introduction

Medieval Arabic medicine has a prominent place in the world history of medicine (Pormann and Savage-Smith, 2007). It is the link which bridges ancient Greek, Indian, Persian and traditional medicine of Anatolia with European medicine (Campbell, 1926). Even if ancient Greek medicine and particularly Hippocratic Corpus (4th-3rd century BC) and Galen (129 - ca. 200/ca. 216 AD) influenced greatly medieval Arabic medicine (Pioreschi, 2001), this period in the history of medicine is rich in discoveries and innovations (Rashed, 2009). The knowledge of anatomy had a fundamental role in medieval Arabic medicine, therefore it was basic teaching in medical schools of that era, while the most important medical books of that period had special chapters devoted to the anatomy of each part of the body (Pioreschi, 2006). Ophthalmology was a medical specialty where medieval Arabic medicine gave a significant contribution, even if it was not learned at the medical schools of the time and someone had to study it next to an experienced physician (Schoretsanitis, 2011).

Ocular anatomy in medieval Arabic medical texts

The philosopher Ibn al-Haytham (Abū^c Alī al- Ḥasan ibn al- Ḥasan ibn al-Haytham) (about 965 - about 1040), known as Alhazen, made the revolutionary discovery in optics that vision derives from light rays coming into the eye from every point of an object, which is a perfection of Aristotle's intromission theory of vision. He thus overturned the established perception of ancient Greek physicians, which was introduction by Euclid (about 350-250 BC) and Ptolemy (about 90-168 AD), that vision is

* Corresponding author. E-mail: konstlaios@gmail.com

an outcome of a visual spirit emanating from the eyes. Notwithstanding the majority of Arab physician followed unquestioning Galen's conception about eye's anatomy (Smith, 2015).

Galen described ocular anatomy in two different works, *De usu partium* (Helmreich, 1968) and *De anatomicis administrationibus libri ix* (Kühn, 1964). His dissection methods and conclusions were accepted and welcome by medieval Arab physicians (Temkin, 1973) probably because they too performed dissections only in animals (Rust, 1982) due to religious prohibitions (Savage-Smith, 1995). Therefore medieval Arab physicians found in Galen's detailed ocular anatomical description a suitable work for their medical education, which did not need further analysis. In addition it is probable that Galen's book about ocular diseases (Savage-Smith, 2002), now lost, influenced Arab physicians to trust this physician and his views about eye.

Galen recognized the following parts of the eye (from outside to inside, concentrically), which were accepted by medieval Arab physicians: conjunctiva (Greek; ἐπιπεφυκώς, Arab; multahim), sclera (Greek; σκληρός, Arab; şalba), cornea (Greek; κερατοειδής, Arab; qarñja), uvea (Greek; ὀραγοειδής, Arab; 'inabija), chorioidea (Greek; χοριοειδής, Arab; mašimja), retina (Greek; ἀμφιβληστορειδής, Arab; šabakja), albuminoid (Greek; ὠοειδής, Arab; baiđja), lens crystalline (Greek; κρυσταλλοειδής, Arab; ğalidja), vitreous (Greek; ὑαλοειδής, Arab; zuġāġja) (Hirschberg, 1899-1918).

Medieval Arab physicians adopting Galen's ocular anatomy recognized three humours: crystalline in the middle of the eye, vitreous behind crystalline and albuminoid in front of it; and seven tunics: retina, chorioidea, sclera which surrounded crystalline humour, conjunctiva and cornea in front of albuminoid humour, crystalline tunic in front of crystalline humour and uvea around pupil (Hirschberg, 1899-1918).

In their anatomical descriptions of the eye these physicians did not forget to underline the role of the optic nerve as an encephalic projection and the existence of the eye muscles for the movement of the eye ball. Nevertheless, they did not avoid many anatomical errors which reveal their lack of dissection experience on humans. They believed that the optic nerve had a canal, it was impossible for them to distinguish exactly the borders of the tunics, they thought that the eye ball had a somehow oval form and the intraorbital portion of the optic nerve contained also an ocular muscle. In addition, due to the fact they did not know eye's physiology, they could not detect where the optic image representation was formed, in order to approach the real anatomy of the eye. Hirschberg first underlined the significant role of ophthalmology in medieval Arabic medicine pointing to the great number of eminent Arab oculists and their massive production of treatises on ocular diseases and anatomy (Hirschberg, 1899-1918).

Among the greatest medieval Arab physicians we can distinguish the ocular anatomical descriptions of Muhammad ibn Zakariyā Rāzī (854-925) known as Rhazes (Modanlou, 2008), 'Alī ibn al-'Abbas al-Majusi (died 982-994) known as Haly Abbas (Ullmann, 1970) and Abū 'Alī al-Ḥusayn ibn 'Abd Allāh ibn Al-Hasan ibn Ali ibn Sīnā (980-1037) known as Avicenna (Khan, 2006). Rhazes in his treatise *Al-Mansūrī* (on Medicine), Haly Abbas in his *Kitab al-Maliki* (Royal Book) and Avicenna in his *The Canon of Medicine* give us elaborate anatomical descriptions, which point out the important role of the optic nerve as a link between cerebrum and eye ball and represent the persuasion of those authors about the existence of three humours and seven tunics,

even if they disagree about their borders. The other anatomical descriptions were not appreciably different from the above mentioned treatises (Hirschberg, 1899-1918).

Nevertheless, the fact which distinguishes medieval Arabic eye's anatomical texts is that for the first time in some of these manuscripts there are anatomical drawings.

Manuscripts presenting ocular anatomy according to ancient Greek physicians lacked anatomical designs. According to our point of view, in ancient times there must have been anatomical drawings even if they have not survived, because ancient Greek artists were capable of producing them and ancient Greek physicians presented many anatomical details in their texts, which made almost necessary the existence of anatomical atlases (Laios et al., 2013). In additions, many terracotta figurines found in Smyrna and representing human figures with the signs of various diseases have been considered as models for medical education in the famous medical school of that town (Laios, 2009). Therefore we can place also the question of the existence not only of anatomical sketches but also of plastic models of body parts, which were very easy to be constructed either of terracotta or of other cheap materials such as wax.

The earliest design of eye anatomy is found in a 12th century manuscript which is a copy of the physician's 'Abū Zayd Ḥunayn ibn 'Ishāq al-'Ibādī, known as Iohannitius (809-877; De Lacy, 1949), work, *The Book of the Ten Treatises of the Eye* (Meyerhof, 1928). Studying this drawing, even if it is not the original of Iohannitius, we notice that the designer chose to give a face view of the eye, probably reproducing the image as it can be seen by a physician in his every day work. Although in this medical text there is a detailed presentation of the seven ocular tunics, these are not presented in the image, but with a thick round black line is designed the orbit, which is framed by the ocular muscles in very abstract form. Very interesting is the unpainted round area in the middle of the black painted iris, in order to leave the impression of the lens, which in the text is described as white and transparent.

The same face view is presented in another anatomical sketch in a manuscript dated ca. 1200 about eye's anatomy, kept now at Cairo National Library and written by the physician al-Mutadibih (Istanbuli, 1981), who acted ca. 1170-1199. In this drawing only the eye ball is presented (Fig. 1). There are no ocular muscles, but with the use of concentric cycles and colours the author tried to represent simultaneously the seven tunics and the three humours. In the middle of the eye the small circle filled with dark grey colour stands for the crystalline humour, while the thin red cycle around him represent the crystalline tunic. The light grey colour in the form of semicircle, now mostly lost, over the small cycle represents vitreous humour and the dark grey colour in analogous form before it represents the albuminoid humour. This central complex is surrounded by a thick semicircle, two thick circles and an outer very thin one. The outer thin red circle stands for conjunctiva and its expansion out of the eye ball points to its route from cerebrum. The inner thick red semicircle stands for the retina, while the other two thick circles, an inner red one and an exterior black one, represent in their upper semicircle chorioidea and sclera and in their lower one cornea and uvea respectively. The black crescent is a profile representation of cornea, while the small white circle in its lower part represents the pupil through which the visual spirit passes. This design is a detailed and accurate presentation of Galen's theories about ocular anatomy, which were followed faithfully by the writer of the manuscript.

Two other anatomical designs shift from eye ball's anatomy to optic chiasma and vision perception. The first one is found in an Arabic manuscript of the book *Kitab*



Figure 1 – Anatomical drawing of the eye in al-Mutadibih's manuscript dated ca. 1200. See text for explanation. On line at: https://en.wikipedia.org/wiki/File:Cheshm_manuscript.jpg. This work is in the public domain in its country of origin and other countries and areas where the copyright term is the author's life plus 70 years or less and in those where the copyright term is extended to 100 years after author's death. Indeed the author's death dates back at least 600 years.

Tanqih al-Manazir li-dhawi al-absar wa-'l-basa'ir (The revision of Optics), of the mathematician Kamal al-Din al-Farisi (1267-1319) in which he reproduced the designs of the optic nerves made by Ibn al-Haytham's (Daneshfard et al., 2014) in his book, *Kitab al-manazir* (Book of Optics). This manuscript is now in: Tanqih al-Manazir, Istanbul, Topkapi Palace Museum Library, Ahmed III, MS 3340, folio 16a (Rashed, 2009).

In this drawing the main theme is the optic chiasma, therefore there is an effort to present the connection of the eye ball with the cerebrum which is the background of the scene. The true representation of the optic chiasma overpasses the detailed anatomy of the eye ball. Here there is not a full representation of ocular humours and tunics as seen before. The eye ball has an oval shape, where only pupil, iris and albuminoid humour are presented. Nevertheless, there are a lot of legends pointing to the areas of the other anatomical structures in the eye ball including ocular muscles. The emphasis on the iris and the pupil probably is due to the interest about the route of vision and their significant role in relation to the optic nerve. On the other hand, the optic nerve is designed as a tube, where the visual spirit passes through.

The second design is found in a manuscript of 1407 now in U.S. National Library of Medicine: MS A67, fol. 167b (Savage-Smith, 1996). This manuscript contains a commentary called *A commentary on the Mujiz (Concise Book) of Ibn al-Nafis* and was written by the physician al-Aqsara'i, who died in 1370. In this text there is a drawing in a panoramic view of a schematic representation of visual system. Here the interest is focused on the route of vision, therefore five concentric circles and an semicircle in the upper part represent in abstract form the tunics and the humours of the eye ball, while a small circle in the lower part represents the pupil. Legends help the reader to have an idea about the places of these anatomical structures. Both eyes are designed in order to emphasize the optic chiasma, which is pointed by two thick crossing lines which show the route of the visual spirit.

Conclusion

Medieval Arab physicians demonstrated a special interest in the study of Ophthalmology. Although they were based on the ophthalmological doctrines of ancient Greek medicine, they recorded special achievements in this medical field, their most notable discovery being the right explication of intromission theory of vision by Ibn al-Haytham (Tbakhi and Amr, 2007). Many medieval Arab physicians became famous oculists performing many ocular operations, especially for cataract. They developed the already known instruments for ocular surgery and invented new ones to ameliorate their work (Arrington and Mart-Ibanez, 1959). The most famous medieval Arab oculist is considered to be 'Alī ibn 'Isā al-Kahhal, known as Jesu Oculist (fl. 1010). 'Al-Kahhal' is his surname, meaning 'oculist'. His book *Tashkiratul-Kahhalin* (Notebook of the Oculists) received a wide reputation, and was used for many centuries by European physicians. In this book he registered more than a hundred ocular diseases according to their anatomical appearance (Hirschberg, 1899-1918). Furthermore, medieval Arab physicians presented a remarkable massive production of ocular treatises, unseen before. In spite of the fact that anatomy played a fundamental role in medieval Arabic medicine, the physicians of the time did not dispute Galen's views on ocular anatomy, therefore they constantly repeated his ideas. Nevertheless,

their manuscripts are the first in anatomical history which present ocular anatomical sketches. The surviving material indicates that these images were not drawn by artists but by physicians themselves. Their common characteristic is the representation of the eye in face view, which let us believe that they reproduce the view of the physician when examining a patient. The profile view of the eye was known in European medicine, therefore Latin translations of Arabic ocular treatises have profile ocular drawings as seen in the Latin translation of Ibn al-Haytham's *Kitâb al-Manâzir* (Book of Optics), *Opticae thesaurus: Alhazeni Arabis libri septem, nuncprimum editi; Eiusdem liber De Crepusculis et nubium ascensionibus* edited by Friedrich Risner in 1572. Finally, it should be noted that this great interest of medieval Arab physicians in Ophthalmology is not clearly explained. We can only make the hypothesis that this interest derived from the fact that they lived in a territory (from India and Anatolia to northern Africa and Spain) where there is sunlight in the most of the year, therefore these physicians had a lot of patients experiencing ocular disorders due to the detrimental effect of solar rays for the eyes.

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References

- Arrington G.E. Jr., Mart-Ibanez F. (1959) A History of Ophthalmology. MD Publications, New York.
- Campbell D. (1926) Arabian medicine and its influence on the middle ages. K. Paul, Trench, Trubner & Co., London.
- Daneshfard B., Dalfardi B., Nezhad G.S. (2014) Ibn al-Haytham (965-1039 AD), the original portrayal of the modern theory of vision. J. Med. Biogr. Apr 15. Ahead of print.
- Helmreich G.(1968) Galeni de usu partium libri xvii. Hakkert, Amsterdam.
- Hirschberg J. (1899-1918) Geschichte der Augenheilkunde. Band II. Engelmann, Leipzig.
- Istanbuli M.N. (1981) The history of Arabic medicine based on the work of Ibn Abi Usaybe' Ah. Diss. Loughborough University of Technology.
- Khan A. (2006) Avicenna (Ibn Sina): Muslim physician and philosopher of the eleventh century. Rosen Pub. Group, New York.
- Kühn C.G. (1964) Claudii Galeni opera omnia, vol. 2. Olms, Hildesheim.
- Laios K. (2009). Diseases and their iconography during the antiquity. Diss. University of Athens.
- Laios K., Tsoucalas G., Karamanou M., Androutsos G. (2013) Anatomy and art. Ital. J. Anat. Embryol. 118: 263-266.
- Meyerhof M. (1928) The book of the ten treatises on the eye, ascribed to Hunain ibn Is-Hâq (809-877 A.D.) The earliest existing systematic text-book of ophthalmology. Government Press, Cairo.
- Modanlou H.D. (2008) A tribute to Zakariya Razi (865 - 925 AD), an Iranian pioneer scholar. Arch. Iran. Med. 11: 673-677.

- De Lacy O.E. (1949) *How Greek science passed to the Arabs*. Routledge and K. Paul, London.
- Pormann P.E., Savage-Smith E. (2007) *Medieval Islamic Medicine*. Georgetown University Press, Washington, D.C.
- Prioreschi P. (2001) *Byzantine and Islamic Medicine*. Horatius Press, Omaha.
- Prioreschi P. (2006) Anatomy in medieval Islam. *J. Int. Soc. History Islamic Med.* 5: 2-6.
- Rashed R. (2009) *Encyclopedia of the History of Arabic Science, Vol.2*. Routledge, London/New York.
- Rust J.H. (1982) Animal models for human diseases. *Perspect. Biol. Med.* 25: 662-672.
- Savage-Smith E. (1995). Attitudes toward dissection in medieval Islam. *J. Hist. Med. Allied Sci.* 50: 67-110.
- Savage-Smith E. (1996). A shelflist of Islamic medical manuscripts at the National Library of Medicine. National Library of Medicine, History of Medicine Division, Bethesda, MD.
- Savage-Smith E. (2002). Galen's lost ophthalmology and the *Summaria Alexandrinorum*. In Nutton V. *The Unknown Galen*. Institute of Classical Studies, School of Advanced Study, University of London, London. Pp. 121-138.
- Schoresanitis G. (2011) *History of Islamic Medicine*. Beta, Athens. (in Greek).
- Smith A.M. (2015) *From sight to light: the passage from ancient to modern optics*. University of Chicago Press, Chicago/London.
- Tbakhi A., Amr S.S. (2007) Ibn Al-Haytham: father of modern optics. *Ann Saudi Med.* 27: 464-467.
- Temkin O. (1973) *Galenism: Rise and Decline of a Medical Philosophy*. Cornell University Press, Ithaca.
- Ullmann M. (1970) *Die Medizin im Islam. Handbuch der Orientalistik. I. 1*. Brill, Leiden.