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SORANUS' TEXT "*ON SIGNS OF FRACTURES*"

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Abstract

Soranus, a famous physician of Ephesus, practiced medicine in Rome at the time of the emperors Trajan (98-117 AD) and Hadrian (117-138 AD) and wrote approximately twenty books. Of all these surviving books in ancient Greek, Gynaikeia/Peri gynaikeiōn pathōn, his treatise on women's diseases, obstetrics and pediatrics, is considered the most important one. Soranus' text On Signs of Fractures (Peri sēmeiōn katagmatōn) is generally accepted as an excerpt from a large work, On Surgery (Kheirourgoumena). This text comprises twenty four brief chapters in which the signs of fractures are organized from the head to the foot. The chapters 1-9 are related to the types of cranial fractures while the chapter 10 deals with the types of fractures in other parts of the body and the remaining chapters are on the fractures from the nose to the ankle bone. In this study, we aim first to give a brief introduction on Soranus' life, then to present Soranus' chapters related to the signs of fractures which to the best of our knowledge, have no English translation and to evaluate his classification of cranial and general fractures in the chapters 1-10 within the context of ancient medicine, and finally to

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mention the probable influence of his classification on the medical writers of the Golden Age of Islam through Paulus Aegineta.

Keywords: *Soranos, fractures, signs of fractures, cranial fractures, differences of fractures.*

Öz

Efesli Soranus'un Kırık Belirtileri Başlıklı Eseri

Efesli Soranus, Roma İmparatorları Traianus (İS 98-117) ve Hadrianus (İS 117-138) dönemlerinde Roma'da yaşamış ve yaklaşık yirmi eser yazmış ünlü bir hekimdir. Tıp alanındaki en önemli eseri kadın hastalıkları üzerine yazdığı Peri gynaikeiōn pathōn'dur. Kırık Belirtileri (Peri sēmeiōn katagmatōn) başlıklı bölümün ise daha geniş bir kitap olan Cerrahi (Kheirourgoumena) adlı eserin bir parçası olduğu düşünülmektedir. Kırık Belirtileri klasik olarak kafadan başlayarak sırayla ayağa kadar kırık belirtilerinin ele alındığı toplam yirmi dört kısa bölümden oluşmaktadır. Soranus, ilk dokuz bölümde kafatasında yer alan kırık tiplerine, onuncu bölümde ise genel olarak kırıkların sınıflandırılmasına yer vermiştir. On birinci bölümden itibaren sırasıyla burundan ayağa kadar oluşan kırık belirtilerini ele almıştır. Yirmi dört bölümün tamamında yanlızca belirtiler aktarılmakta, tedavi yöntemlerine hiç değinilmemektedir. Bu çalışmada ilk olarak, Soranus hakkında kısa bir girişin ardından Kırık Belirtileri ile ilgili bilgiler sunulmuştur. İkinci olarak bildiğimiz kadarıyla İngilizce çevirisi olmayan ilgili bölüm çalışma içinde sunulmuştur. Son olarak Soranus'un kafatasındaki ve genel kırık tiplerine ilişkin yapmış olduğu sınıflandırmanın yer aldığı ilk on bölüm, Hippokrates, Celsus, Heliodorus, Galenus ve Aeginalı Paulus gibi antik dönemin ünlü hekimlerinin konuyla ilgili yazdıklarıyla karşılaştırılıp, Paulus'un aracılığıyla İslam tıbbına etkisine kısaca değinilmiştir.

Anahtar Sözcükler: *Soranos, Kafatası Kırıkları, Kırıklar, Kırık Tipleri, Kırık Belirtileri*

Introduction

Soranus of Ephesus is generally accepted by ancient sources as the principal representative of the Methodist sect (*Methodicorum princeps*)[1] and

[1] Tertullianus, *De anima* 6.6.; Cael.Aur. *De morbis chronicis*, I.50. See also: Touwaide, Alain (Madrid), "Methodists", in: *Brill's New Pauly*, edited by Hubert Cancik and, Helmuth Schneider, English Edition by: Christine F. Salazar, Classical Tradition volumes edited by:

recognized in the 20th century as one of the most significant physicians and the greatest gynecologist of antiquity.[2] Two articles under the title "Soranus" in Suda,[3] the 10th century Byzantine encyclopedic lexicon, are our main source for his life. One of them (Σ 851) mentions that a physician of Ephesus, son of Menandros of Phoebe, spent time in Alexandria, practiced medicine in Rome under the emperors Trajan and Hadrian and wrote a large number of very fine books. The other (Σ 852) is said to be another physician of Ephesus who wrote 'Gynaikeia in 4 volumes; Lives of physicians and their sects and treatises in 10 volumes, and various other things.' This information that Suda recorded under the identity of two different people, is generally evaluated as complementary and therefore combined into a single life.[4] On account of this aforementioned evaluation, today it is agreed by the most modern authors that Soranus, a physician born in Ephesus, studied medicine during the period which he spent in Alexandria, then came to Rome and practiced medicine at the time of the emperors Trajan and Hadrian (98-138 AD). There also some self-references in Soranus' works which support his presence both in Alexandria and Rome.[5]

He wrote approximately twenty books. They ranged in subject matter from philosophy (*On the soul*), literary and philology (*Etymologies of the body of man*, *Lives of the physicians*: *sects and treatises*, *Commentaries to Hippocrates and to some of his treatises*), to medical writings. His medical treatises also cover a wide variety of topics including gynecology, surgery, internal medicine, hygiene, ophthalmology, embryology, pharmacy etc.[6]

Manfred Landfester, and English Edition by: Francis G. Gentry. Accessed November 29, 2018. doi:http://dx.doi.org/10.1163/1574-9347_bnp_e802450.

2 Sarton G., *Introduction to the History of Science vol.1: From Homer to Omer Khayyam*, Carnegie Institution of Washington. 1927: 282; Reus, Werner A. "Soranus", in: *Brill's New Pauly*, edited by Hubert Cancik and, Helmuth Schneider, English Edition by: Christine F. Salazar, Classical Tradition volumes edited by: Manfred Landfester, and English Edition by: Francis G. Gentry. Accessed November 29, 2018. doi:http://dx.doi.org/10.1163/1574-9347_bnp_e1117440.

3 Suda Σ 851, 852 Adler: "Sôranos." Suda On Line.. Tr. David Whitehead. 23 September 2002 <http://www.stoa.org/sol-entries/sigma/851>; " Sôranos." Suda On Line. Tr. David Whitehead. 27 September 2010 <http://www.stoa.org/sol-entries/sigma/852>.

4 Hanson, A.E. and Green, M. H., "Soranus of Ephesus: Methodicorum Princeps." *Aufstieg Und Niedergang Der Römischen Welt, Teil II: Principat* 37 (1994): p.981.

5 Sor. *Gyn.* I.10; II.44 and III.2-3: Cael.Aur. *De morbis acutis,* II. 130-131.

6 Kind, E., "Soranos", In *Pauly's Real-Encyclopädie Der Classischen Alterthumswissenschaft:* 2nd ser. 5 Halbband*,* Metzler, Stuttgart*,* 1927: 1115-1130; Hanson and Green, *Soranus of Ephesus*: 1005-1042. For the list of Soranus' works, manuscripts, early and modern editions, modern translations see also: Fischer, Klaus-Dietrich, "Soranus of Ephesus", in: *Brill's New Pauly Supplements I - Volume 2 : Dictionary of Greek and Latin Authors and Texts*, edited by Manfred Landfester, in collaboration with Brigitte Egger, Tina Jerke, Volker Dallman, Hubert Cancik,

Unfortunately, most of them are now lost. Of all those surviving in ancient Greek, *Gynaikeia/ Peri sēmeiōn katagmatōn*, his treatise on women's diseases, obstetrics and pediatrics, is the most important one and represented gynecological and obstetrical practice at its height.[7] Not only does it contain Soranus' descriptions of many diseases and therapeutic advice, but also his admirable description of the womb, the use of a speculum and of the obstetric chair and of an instrument to make injections into the womb[8]. The book, *On Acute and Chronic Diseases*, another important work of his, is known through Caelius Aurelianus' (lived in the 5th or 6th century AD) paraphrase in Latin, *De morbis acutis et chronicis* in 8 books, which is considered almost a translation of Soranus' original work[9].

Soranus and His Treatise *On Signs of Fractures* (*Peri sēmeiōn katagmatōn)*

Soranus' another book is *On Surgery* (*Kheirourgoumena*). There is a self-reference in *Gynaikeia*[10] where he points out that he has shown the drainage of the parturient's suppurated breasts in his books on *Surgery*. Caelius Aurelianus is also said to have mentioned this book in different places of *Acute and Chronic Diseases*.[11] Soranus has two short treatises preserved in ancient Greek, namely: *On Bandages* (*Peri epidesmōn)* and *On signs of fractures* (*Peri sēmeiōn katagmatōn*). The text *On signs of fractures* is preserved in the 10th century Codex of Nicetas (Codex Laurentianus 74,7) in Biblioteca Medicea Laurenziana. In 1754, Antonio Cocchi, in his *Graecorum Chirurgici Libri*,[12] edited Soranus' text (45-51), together with Oribasius' two treatises *On fractures* and *On dislocations* in ancient Greek-Latin. In 1841, J.L. Ideler, in his *Physici medici Graeci minores*[13] (248-260), once again published Soranus' *On Signs of Fractures* in ancient Greek with other

Manfred Landfester, and Helmuth Schneider. Accessed: December 25, 2017. doi:http://dx.doi.org/10.1163/2214-8647_bnps2_COM_0205.

7 Temkin, O., *Soranus' Gynecology*, translated with an introduction by Owsei Temkin, Johns Hopkins University Press, Baltimore, 1991: xxv.

8 Sarton, *Introduction to the History of Science vol.1*:283.

9 Sarton, *Introduction to the History of Science vol.1*:283; Temkin, *Soranus' Gynecology*: xxiv.

10 Temkin, *Soranus' Gynecology*: 77.

11 Kind, E., "Soranos", s.1129:; Hanson and Green, *Soranus of Ephesus*: 1041.

12 Cocchi A., *Graecorum Chirurgici Libri: Sorani Unus De Fracturarum Libris, Oribasiii Duo De Fractis et Luxatis e Collectione Nicetae ab Antiquissimo et Optimo Codice Florentino*, Florentiae, 1754.

13 Ideler, J.L., *Physici et Medici Graeci Minores, Vol.I.*, Typis et Impensis G. Reimeri, Berolini, 1841.

fragments. In 1927, Johannes Ilberg edited Soranus' *On Signs of Fractures* with *Gynaikeia*, *Bandages*, and *Life of Hippocrates,* in the 4th volume of *Corpus Medicorum Graecorum*.[14] In the preface of this edition, Ilberg also points out that *Signs of Fractures* is probably an excerpt from a large work *On Surgery*[15]

Soranus' *On signs of fractures* comprises twenty four brief chapters in which fractures are organized from the cranium to the foot. Chapters 1-9 are related to types of cranial fractures, while chapter 10 deals with the types of fractures in other parts of the body. The remaining chapters are on fractures of the nose, jaw, collarbone, scapula, spine, breastbone, rib, coxa, arm and thighbone, forearm and leg, knee-pan, carpus-metacarpus and finger bones, and the last talus (ankle bone) in seriatim. The treatise ends with the affection of the bone fractures with wound and fragmentation. In this study, we aim to present Soranus' chapters related to the signs of fractures, which to the best of our knowledge, have no English translation, and to evaluate his writings in chapters 1-10 within the context of ancient medicine. To achieve our aim, we used the Greek-Latin edition of Antonio Cocchi, and created an English text. Additionally, relevant literature of ancient authors was reviewed.

Text

I. *A fracture*[16] *is a division of the bone. The cranial fractures are named according to their nature, as fissure*[17]*, incision*[18]*, arched fracture*[19]*, overlapped fracture*[20]*, depressed fracture*[21]*, chipped fracture*[22]*, and, as some have said, contrecoup*[23] *and contusion*.[24]

II. *A fissure is a division of bone as seen on the small vitreous vessels. Some of them are very thin and capillary, others are a bit thicker and differ in respect of their length. Some of them*

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[14] Ilberg, J.,(ed.) *Sorani Gynaeciorum libri IV, De signis fracturarum, De fasciis, Vita Hippocratis secundum Soranum*, CMG IV, Leipzig et Berlin 1927.
[15] *Ibid*.: *praef*. XI,-XII. ; Fischer, Klaus-Dietrich, "Soranus of Ephesus".
[16] Lat. *fractura*, Gr. *τό κάταγμα*.
[17] Lat. *fissio,* Gr. *ἡ ῥωγμή*.
[18] Lat. *incisio*, Gr. *ἡ* ἐγκοπή.
[19] Lat. *cameratio*, Gr. *ἡ κἄμάρωσις*.
[20] Lat. *subgrundatio*, Gr. *τὸ ἐγγείσωμα*.
[21] Lat. *impactio,* Gr. *τὸ ἐμπίεσμα*.
[22] Lat. *dedolatio*, Gr. *ὁ ἀποσκεπαρνισμός*.
[23] Lat. *resonantia*, Gr. *τὸ ἀπήχημα*.
[24] Lat. *inversio* (Sor. *Fract*. 1) ve *impressio* (Sor. *Fract*.9), Gr. *τὸ ἔλιγμα* (Sor.*Fract*. 1): *τὸ θλάσμα*, (*Fract*. 9.)

extend to most parts of the cranium, while the others are limited to within the boundaries of the suture. They also differ in respect of their depth for the reason that a fracture is sometimes only superficial and sometimes extends to the spongy core[25] *or to the brain membranes*.[26] *The fissure can be recognized visually if the subjacent parts of the wound are opened out first, and by using a probe if the wound is narrow. This is because, when a thin probe is inserted into the wound, a roughness is felt. A fissure can be distinguished from a suture by the fact that it is more straight than a suture. Sometimes it pricks and makes the things that laid upon it rough, whereas a suture is more spiral and never roughens. A fissure extending to the brain membranes should generally be recognized from concomitant symptoms such as pricking to the dura mater, inflammation or suppuration. Therefore, when none of these symptoms occur, it is not useful to look for a fissure in detail, but whenever one of these mentioned symptoms occur, then treatment is necessary.*

III*. An incision is a transverse fracture of the bone due to the impact of a sharp edged material. In respect of depth, its difference is nearly equal to the fissure. The incision can be diagnosed visually and a pulsation of the dura mater also can be seen.*

IV. *An arched fracture is a flexure of two bones reciprocally pressing upon each other, At the same time, a part of the bone, which is pointed and shaped like a wedge, is torn out due to pressure. One can identify this visually. A protuberance with roughness will be the indication for diagnosis. Even if the spongy core was not damaged, it occurs whenever the edges are reciprocally shattered. The tip of the probe, which is sent down along the fracture, moves into the gap.*

V. *An overlapped*[27] *fracture is a downward sinking of the fractured bone under the opposite one, applying pressure upon the membranes enclosing the brain. Sometimes, the continuity of the broken bone is entirely perished, other times, partially remained.*

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[25] Lat. *meditullium*, Gr. *ἡ διπλόη.*

[26] Lat. *ad membranas*, Gr. *μέχρι μηνίγγων.*

[27] Liddle H.G. and Scott R., *Greek-English Lexicon with a Revised Supplement,* Clarendon Press, Oxford, 1996, p.467, sv. "*ἐγγείσωμα*"= fracture of the skull, such that one piece slips under the bone like a cornice.

VI. *A depressed fracture is a breaking of the bone consisting of many parts, with a sinking piece so far as to make pressure. Both of them*[28] *are recognized visually and by using a probe. This is because, hollow with a roughness occurs around each of them and the broken bone completely collapses.*

VII. *A chipped fracture is an oblique cutting of a bone quite completely, just the same as the wood being cut off with an axe. This is because the blow also takes away the flesh from the bone.*

VIII. *According to some, a contre-coup is a fissure without a wound, occurring on the parts of the cranium opposite of those which have received the blow.*

IX. *According to some, a contusion is a hollow on the bone of children resembling nearly the hollow without fracture on the oil-flasks which is made of leather or lead.*

X. *Fractures also occur in the other parts of the body. Some of them are splinterlike*[29] *so far as they are divided longitudinally, some of them are stalklike*[30] *or radishlike*[31] *or cucumberlike*[32] *and some of them are clawlike*[33] *or reedlike*[34], *which reciprocally has an obliqueness at its extremities so as its sharp-edged curve resembles the shape of a claw. Some of the fractures are comminuted*[35] *so that the bone preserves its continuity despite being crushed from every side. Others are flourlike*[36] *or nutlike*[37], *so far as they are broken into small pieces in collision and consist of many parts.*

XI. The Nose:[38] *The indication of a broken nose is its obliquity. Sometimes a part of the nose has a comminuted fracture and it is possible to divert it by the fingers. We seize the fracture by a*

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[28] Overlapped fracture and depressed fracture.
[29] Lat. *assulose*, Gr. *σχιδακηδόν*.
[30] Lat. *cauli modo*, Gr. *καυληδόν*.
[31] Lat. *raphani modo* Gr. *ῥαφανηδόν*.
[32] Lat. *cucumeris modo*, Gr. *σῖκῦηδόν*.
[33] Lat. *in unguem*, Gr. *εἰς ὄνυχα*.
[34] Lat. *calami modo*, Gr. *κᾰλᾰμηδόν*.
[35] Lat. *comminutim*, Gr. *κατὰ ἀπόθραυσιν*.
[36] Lat. *in farinam*, Gr. *ἀλφῖτηδόν*.
[37] Lat. *nucium modo*, Gr. *κᾰρῦηδόν*.
[38] Lat. *nasus*, Gr. *ἡ ῥίς*.

probe if it has no distortion or by the fingers if the parts laid on it prick on the surface.

***XII*. *The Jaw*:**[39] *The jaw is generally broken radishlike but it also has a splinterlike fracture sometimes. The fracture is comminuted when it remains undistorted or remains distorted by inclining to a point or by deviating upwards or downwards, or by diverting inside or outside. Signs of this fracture should be a process, concavity and distortion of one of the above-mentioned parts, like teeth not corresponding with each other. A crepitus and pricking sensation also occur when it is moved by the fingers. In the case of inclination to a point, we find a prominence in the oral cavity. Since a mass or concavity occurs also in dislocations, it should be distinguished from the radishlike fracture occurring near the condyles, through motion during the coaptation in setting this fracture by the fingers, whereas the dislocation is motionless up to the junction.*

***XIII*. *The Collarbone*:**[40] *When the collarbone is broken splinterlike, we see the position of the bone more broadly. When pressure is applied with the fingers, a longitudinal hollow is formed on the skin and it also pricks. But, in radishlike fractures, while applying pressure on it with fingers, the bone collapses underneath and during the coaptation in setting this fracture, it crepitates throughout the contact. However if the bone turns inside, the chest appears narrower, meanwhile distortion, mass, and concavity are observed. In a clawlike fracture, the apex of the fracture is more solid and pricks the flesh like a needle. In flourlike fractures, an anomaly often happens through the pressure of the fingers.*

***XIV. The Scapula*:**[41] *The Scapula is a trapezium-shaped*[42] *bone, although rarely seen, a fissure and depressed fracture occur.*

***XV*. *The Spine*:**[43] *The Spine is also broken into pieces. It is recognized visually if a wound occurs. If not, the simple fracture can be understood through the anomaly with topical pain after applying pressure on it with the fingers. The depressed fracture*

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[39] Lat. *maxilla*, Gr. *ἡ γένυς*.
[40] Lat. *iugulum*, Gr. *ἡ κλείς*.
[41] Lat. *scapula*, Gr. *ἡ ὠμοπλάτη*.
[42] In Latin text, The adjective *latus* has been used for *τρἄπεζώδης* in Greek.
[43] Lat. *spina*, Gr. *ἡ ῥάχις*.

(empiesma) is also diagnosed through hollowness, pricking pains, numbness and weakness of the adjacent arm and crepitus.

***XVI. The Breastbone*:**[44] *The middle of the breastbone is divided and depressed*.[45] *The extremity of the bone is also broken off*.[46] *In that case, the signs of a fracture should be anomalies and crepitus when a pressure is applied to it with the fingers. The signs of the depressed fracture*[47] *are concavity and giving way, difficulty in breathing, a cough, pricking and sometimes expectoration with blood.*

***XVII. The Rib*:**[48] *If the rib is broken, an anomaly, crepitus and distortion occur, while applying pressure with fingers on it. For the most part, bending inward, pricking pain accompanying to cough, difficulty in breathing and sometimes expectoration with blood happen.*

***XVIII. The Coxa bones*:**[49] *They are shattered in the extremities, longitudinally broken in the middle and depressed by producing pricking pains and numbness in the adjacent legs. One should add to this the signs which we have mentioned about the scapula, in like manner as the bones of pubes*.[50]

***XIX. The Arm and the thigh bone*:**[51] *If an arm or thigh bone is broken, a distortion occurs in one of the four parts. In the majority of instances in the thigh-bone, it occurs towards the foreside <and towards the outside>, since it was naturally bent in these directions. The concomitant symptoms are a mass, which is distorted towards it, a concavity which is diverted from it, a motion during the coaptation in setting a fracture with the hands, and also crepitus and a reduction in the length [of a fractured limb].*

***XX. The Forearm and the leg*:**[52] *If one of the bones of the forearm and leg is broken into pieces, the fractures are similar*

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[44] Lat. *pectus,* Gr. τό *στέρνον.*
[45] Soranus used here *ἐμπιεζεῖται* in the text which is the verb form of ἐμπίεσμα.
[46] Soranus used here *ἀποθραύεται* in the text which is the verb form of *κατὰ θραῦσιν*.
[47] Lat. *impulsio*, Gr. *ἐμπίεσμα.*
[48] Lat. *costa,* Gr. *ἡ πλευρά.*
[49] Lat. *ossa coxarum,* Gr. *τὰ τῶν ἰσχίων ὀστᾶ.*
[50] Lat. *ossa pectinis*, Gr. *τὰ* τῆς ἤβης *ὀστᾶ.*
[51] Lat. *humerus et femur,* Gr. *ὁ βρᾰχίων καὶ ὁ μηρός.*
[52] Lat. *brachium et crus,* Gr. *ὁ πῆχυς καὶ ἡ κνήμη.*

to those of the arm and thigh bone. Since the twisting of one of these bones is less, it deviates towards two directions, forwards and backwards. If the ulna[53] *is affected, it deviates inward, if the radius*[54]*, outward and if the tibia*[55] *is affected, it deviates backward, if the fibula*[56]*, then forward.*

XXI**. **The Knee-pan:[57] *In case of a fracture of the knee-pan, a motion occurs throughout its parts, and also concavity and crepitus.*

XXII**. **The Wrist, the palm of the hand and its finger bones, the flat of the foot and its fingers:[58] *If the bones of the wrist, the palm of the hand, the flat of the foot and all fingers are broken into pieces, motion and crepitus occur. The cubical bone*[59] *is also broken similarly.*

XXIII**. **The Anklebone:[60] *The anklebone is not broken thanks to being surrounded by fibula and cubical bone. For the same reason, neither the bone of the ear nor the vertebra of the neck is broken. Since they are covered with a cavity.*

***XXIV**. In all fractures, wheresoever the affection of bone fractures occurs with a wound and a compound fracture, one should jointly note the risk of them. Since the affected parts will prick the surface followed by a sympathetic affection, a blackening of flesh, speechlessness and becoming cold. Besides, one must understand that the fractures taking place by the side of the joints are more difficult than those taking place in the middle of the limbs. For they will not adequately carry the bandaging. These are sufficient on fractures.*

Chapters 1-9 of *On Signs of Fractures* present a classification of cranial fractures and the signs of these fracture types. In the first chapter, Soranus lists eight varieties of fractures: *rhōgmē*, *enkopē*, *kamarōsis*,

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53 In Latin text, the word cubitus *latus* has been used for *πῆχυς* in Greek.
54 Lat. *radius*, Gr. *ἡ κερκίς*.
55 Lat. *tibia*, Gr. *ἡ κνήμη.*
56 Lat. *fibula*, Gr. *ἡ περόνη.*
57 Lat. *patella,* Gr. *ἡ ἐπιγονατίς.*
58 Lat. *prima et altera palmae pars et digitorum ossa et planta ac digiti,* Gr. *ὁ καρπός καὶ τό μετακάρπιον καὶ σκυταλίδες καὶ ὁ ταρσός καὶ οἱ δάκτυλοι.*
59 Lat. *os cubo simile*, Gr. *κυβοειδής.*
60 Lat. *talus,* Gr. *ὁ ἀστράγαλος.*

engeisōma, *empiesma*, *aposkeparnismos*, *apēkhēma,* and *heligma*, whereas he designates the latter *thlasma* in chapter 9. In chapters 2-9, he handles seriatim types of fractures by explaining briefly the general characteristics and indications for diagnosis, but he does not touch upon the treatment. Therefore, the evaluations in this study will be based on Soranus' classification of cranial fractures, and treatment methods of these will not be mentioned.

Soranus' classification of cranial fractures and the terms which he used to define them, appear to be slightly different from those of Hippocrates. In *De Vulneribus Capitis*[61]*,* Hippocrates classifies cranial fractures as *rhōgmē*, *phlasis* (=*thlasis*), *esphlasis* (=*eisthlasis*) *hedra* and contre-coup[62] which he just explained without using any technical term. He also uses the term *diakopē*[63], which corresponds to *enkopē* in Soranus' classification, but he indicates that *diakopē* of any size is a *hedra* as long as the rest of the bone around the *diakopē* keeps its natural place, but, if the bone is crushed in, it is called *esphlasis*.

In *De medicina*, Aulus Cornelius Celsus, who lived during the reign of Emperor Tiberius (14-37 AD), has a lengthy account on head traumas but did not make a direct list for the classification of cranial fractures. However, he mentions fissure, contre-coup and depressed fracture. He also states that one margin of the broken bone may override the other (engeisōma?).[64] Soranus never mentioned the symptomps which Celsus enumerated[65] for cranial fractures, such as bilious vomiting, obscurity of vision, speechlessness, bleeding from the nose or ears and for a lacerated brain membrane such as stupor, paralysis, and spasms. In cases where these symptoms are not seen, one of Celsus' diagnosis methods of the fissures is by exploring the roughness with a probe and the inflammation originating from the pressure of the fractured bone upon the brain membrane. These are also found in Soranus' text.

Oribasius of Pergamum (320-400 AD), the personal physician of the emperor Julian, wrote *Collectiones Medicae* in seventy books, a compilation of excerpts from earlier medical writers including also the fragments of

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61 Hipp.*VC.* 4-8.

62 Hipp.*VC.*8: *Ὀστέον τιτρώσκεται ἄλλῃ τῆς κεφαλῆς, ἢ ᾗ τὸ ἕλκος ἔχει ὤνθρωπος, καὶ τὸ ὀστέον ἐψιλώθη τῆς σαρκός· πέμπτος οὗτος τρόπος.* "The skull is wounded in a part of the head other than that in which the patient has the lesion and the bone is denuded flesh. This is a fifth mode." (Translation is from: *Hippocrates Vol.III*, (tr.) E.T.Withington, Loeb Classical Library, William Heinemann Ltd., London, 1959, p.19).

63 Hipp.*VC.*7.

64 *Celsus, De medicina,* 8.4.3 (*rima- fissio*); 8.4.6 (contre-coup); 8.4.13-17 (fissio and depressed fracture).

65 *Celsus, De medicina,* 8.4.1.

Heliodorus and Galen on cranial fractures.[66] Heliodorus was a surgeon, lived during the time of Roman poet Iuvenalis (60-140 AD) and was Soranus' contemporary. Soranus' classification of cranial fractures and the terms he used are nearly the same compared to those of Heliodorus, who classifies them as fissure (*rhōgmē*), incision (*enkopē*)**,** arched fracture **(***kamarōsis*), depressed fracture (*empiesma*), overlapped fracture (*engeisōma*) and contusion (*thlasma*). In the classification of Heliodorus, unlike Soranus, the chipped fracture (*aposkeparnismos*) is not mentioned.

Galen of Pergamum (2nd century AD) in *Methodus Medendi*, classifies cranial fractures as fractures that are extended to the diploe, those that extended to the internal surface of bones, simple fractures (*rhōgmē*), contusion (*thlasis*) and *hedra*.[67] Although he describes the types of fractures and their treatment, which young physicians called overlapped fracture (*engeisōma*) and arched fracture (*kamarōsis*), he does not include them in his classification. Besides, in the fragments handed down to us through Oribasius, he states that the type of cranial fracture which young physicians called *aposkeparnismos*, belongs to the genus of *hedra*, while *engeisōma* and *kamarōsis* belong to another. He also describes the contre-coup fracture by using the term *apokopēma* and says that it is a fissure (*rhōgmē*). He also mentions the depressed fracture by using the term *eisthlasis*. Therefore, it would not probably be wrong to say that Galen, criticized the young physicians' classification of cranial fractures and some of the terms, which is also found in the works of Heliodorus and Soranus.

Paulus Aegineta (625-690 AD), Byzantine physician and surgeon, also gives a detailed account on cranial fractures in his *Epitomae Medicae Libri Septem.* In his classification of cranial fractures[68] and in the technical terms he used, the influence of Soranus and Heliodorus is evident. He classifies the cranial fractures, either superficial or deep, as fissure (rhōgmē), incision (*enkopē*), depressed fracture (*empiesma*), overlapped fracture (*engeisōma*), arched fracture (*kamarōsis*), which he describes with a quotation from Galen, and contusion (*thlasis*) which has two different kinds. Paulus, unlike Soranus, while explaining the incision, said that in the case of affected bone being broken off, some use the term *aposkeparnismos*. Therefore, he seems to evaluate this type of fracture as a genus of incision. He also mentions the capillary fracture and classifies it as a narrow fissure as Soranus did. On the other hand, Paulus says that a contre-coup fracture (*apokhēma*), which is

[66] Oribasius, *Collectiones Medicae*, 46.10-20 (Heliodorus); 46.10.21 (Galen).
[67] Galenus, *Methodus medendi*, 6.6.
[68] Paulus, *Epitomae* 6.90.

considered as a separate type of fracture in Soranus, is not possible. Although his classification is similar to Soranus, Paulus gives much more detailed information about the diagnosis and treatment of cranial fractures.

Haly Abbas (10th century AD), one of the eminent physicians of Islamic medicine, classifies the cranial fractures by providing their Greek names in Arabic forms in his *Royal Book* (Chapter 84th of 19th discourse).[69] He mentions all types of fractures which are also found in the classification of Heliodorus, Soranus and Paulus Aegineta. The classification of Ibn Sina (Avicenna) who describes the cranial fractures as linear, comminuted and depressed, resembles the contemporary classification, which were different from that of Hippocrates and Paulus Aegineta[70], and therefore from that of Soranus as well. But in the case of the treatment methods of cranial fractures, the influence of Galen and Paulus Aegineta on Ibn Sina is obvious.[71]

In chapter 10, after saying that the fractures also occur in other parts of the body, Soranus makes another classification related to the differences of general fractures according to their shape. These are splinterlike (*skhidakēdon*), stalklike (*kaulēdon*) or radishlike (*rhaphanēdon*), cucumberlike (*sikyēdon*), clawlike (*eis onykha*) or reedlike (*kalamēdon*), comminuted (*kata apothrausin*), flourlike (*alphitēdon*) or nutlike (*karyēdon*).

In *De medicina*[72]*,* Cornelius Celsus also describes the differences of general fractures according to their shape without using technical terms. His description is different from that of Soranus. Celsus states that every bone is fractured longitudinally or transversely and, sometimes, obliquely. He adds that in oblique fractures, the end of the fractured bones are sometimes blunted, sometimes pointed. The latter is the worst according to him because it is hard to bring these together, they lacerate the flesh and sometimes they also lacerate nerves or muscles. There may also be several fragments.

Galen also discusses the differences of general fractures in his *Methodus Medendi*.[73] He tells that the term *kaulēdon,* which physicians were accustomed to using for fractures with a complete separation of broken parts,

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[69] Acıduman A., Arda B., Kahya E., Belen D., "The Royal Book by Haly Abbas From the 10th Century: One of the Earliest Illustrations of the Surgical Approach to Skull Fractures" *Neurosurgery* 67:1466–1475, 2010. p.1468.

[70] Acıduman A., Arda B., Özaktürk F.G., Telatar Ü.F., "What does Al-Qanun Fi Al-Tibb (The Canon of Medicine) say on head injuries?" *Neurosurgery Review* 32: 255-263, 2009.pp. 261.

[71] Acıduman et al. "What does Al-Qanun Fi Al-Tibb (The Canon of Medicine) say on head injuries?" p.262.

[72] *Celsus, De medicina,* 8.7. cf. Adams F., *The Medical Works of Paulus Aegineta translated from the Greek with a commentary*, Vol II., C. And J. Adlard, London, 1846, p. 428.

[73] Galenus, *Methodus medendi*, 6.5.

is actually a transverse division of the bone and also the term *skhidakēdon,* which they used for the fractures without a complete separation of the affected bones, is a longitudinal division. He also adds that some of the younger physicians are seeking to extend this classification by using specific terms such as *rhaphanēdon* and *alphitēdon* for all the differences of fractures, being not satisfied the term which signifies the bone being shattered in many forms. On the other hand, Galen states that Hippocrates does not like this sort of classification, although he uses traditional terms as much as possible to discuss and explain the differences of fractures. Therefore, Galen criticizes the detailed classification of younger physicians which also appeared in Soranus' text and he thinks that they refined it too much.[74]

The technical terms used by Paulus on the differences between fractures (6.89) are exactly the same as those of Soranus. He states that *rhaphanēdon* is a transverse fracture, and unlike Soranus, he presents an explanation of why they are also called *sikyēdon* or *kaulēdon:* because broken stalks and cucumbers look like this. Like Soranus, Paulus says that *skhidakēdon* is a longitudinal fracture while *eis onykha* or *kalamēdon* is a fracture lunated at its extremities. After describing the *alphitēdon* or *karyēdon* in almost the same way as Soranus, he defines *apothrausis* as a fracture with a part of a bone taken away by tearing of the skin.[75] This definition is different from that of Soranus. Considering the classification on the differences between fractures, with the exception of *apothrausis*, Paulus describes the differences between fractures with similar words as those of Soranus.

Ibn Sina classifies these differences very similar to those of Paulus and Soranus in the 4.5.2. of his *al-Qānūn fī al-Ṭibb* (*The Canon of Medicine*).[76] In this chapter, after saying that every type of fracture is named according to their properties, he enumerates *fujlī*, *qithawī,* and *qaḍībī*, which correspond respectively to *rhaphanēdon*, *sikyēdon, and kaulēdon*, and describes them as transverse and profound fractures. For longitudinal fractures he mentions the term *mushaṭṭab*, which correspond to *skhidakēdon*. The terms*, hilālī* and *qaḍībī,*(for the second time), which he defines them as longitudinal with transverse fractures, correspond respectively to *eis onykha* and *kalamēdon.* For the fractures which consist of very small pieces, he uses the terms, *suwayqī, jarishī* and *jawzī.* These correspond respectively to *alphitēdon,*

[74] Adams F., *The Medical Works of Paulus Aegineta, p. 428.*
[75] Adams F., *The Medical Works of Paulus Aegineta, p. 428.*
[76] Abū ʿAlī Ibn Sīnā, *Kitāb al-Qānūn fī al-Ṭibb*, Romae: In Typographia Medicea; 1593, 4.5.2., p. 108.

apothrausin, and *karyēdon* found in Soranus and Paulus. Adams asserted that Haly Abbas and Albucasis also adopted the terms used by Paulus.[77]

To sum up, Soranus' classification of the cranial fractures and of the differences between fractures are very similar to those of Heliodorus and Paulus Aegineta with minor differences. Considering the fact that Heliodorus' fragment has reached us indirectly, that is to say through Oribasius, it can be said that the classification provided by Soranus is the primary ancient source which is handed down to us directly. However, there are significant differences between their classification and those of Hippocrates, Celsus, and Galen. The criticisms of Galen, which are directed towards their technical terms in reference to younger physicians, can be seen as the expression of these differences. The technical terms used by Heliodorus and Soranus to classify the cranial fractures and the differences between the fractures, are also seen in the works of Haly Abbas and Ibn Sina through Paulus Aegineta.

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1. Soranus's Classification of Cranial Fractures

Greek	**Latin**	**English**
ῥωγμή (rhōgmē)	fissio	fissure
ἐγκοπή (enkopē)	incisio	incision
κᾰμάρωσις (kamarōsis)	cameratio	arched fracture
ἐγγείσωμα (engeisōma)	subgrundatio	overlapped fracture
ἐμπίεσμα (empiesma)	impactio	depressed fracture
ἀποσκεπαρνισμός (aposkeparnismos)	dedolatio	chipped fracture
ἀπήχημα (apēkhēma)	resonantia	contre-coup fracture
τὸ ἕλιγμα (heligma) θλάσμα, (thlasma)	inversio impressio	depression without fracture/contusion

[77] Adams, *The Medical Works of Paulus Aegineta*, p.429.

2. Soranus' Classification of the Differences of Fractures

Greek	Latin	English
Σχιδακηδόν (skhidakēdon)	assulose	splinterlike fracture
καυληδὸν (kaulēdon) ῥαφανηδὸν (rhaphanēdon) σῖκῠηδόν (sikyēdon)	cauli modo raphani modo cucumeris modo	stalklike fracture radishlike fracture cucumberlike fracture
εἰς ὄνυχα (eis onykha) κᾰλᾰμηδόν (kalamēdon)	in unguem calami modo	clawlike fracture reedlike fracture
κατὰ ἀπόθραυσιν (kata apothrausin)	comminutim	comminuted fracture
ἀλφῖτηδόν (alphitēdon) κᾰρῠηδόν (karyēdon)	in farinam nucium modo	flourlike fracture nutlike fracture (consisting of many small pieces)

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