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Manuscript title: Surgery in Early Middle Ages: evidence of cauterization from Pisa

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Dear Editor,

This brief article describes a case of surgical practice from 8th-10th century Italy: in archaeological excavations carried out in the famous Miracle Square of Pisa the skull of a woman with evidence of cauterisation was brought to light. The use of cautery is attested by written sources, but rarely observed in ancient human remains. So this evidence is very interesting, in our opinion, from the paleopathological and historical point of view, documenting surgical practices in the Dark Ages following the decline of the Roman Empire.
Therefore we would ask you to consider this paper for eventual publication in Surgery.

The material has not been previously published or submitted elsewhere for publication and will not be sent to another journal until a decision is made concerning publication by SURGERY.
All authors declare no conflict of interest.
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Yours sincerely,

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SURGERY IN THE EARLY MIDDLE AGES:

EVIDENCE OF CAUTERISATION FROM PISA

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Archeological excavations carried out in the famous Cathedral Square of Pisa brought to light a multiple ground grave dated back to the early Middle Ages (8-10th centuries AD)[1]. The well preserved skull of an adult female aged about 30 years showed evidence of surgical practice.

In the central part of the frontal bone, 4 cm from the bregma, an elliptical lesion of 20 x 17 mm, limited by a shallow 1-mm thick groove, is well visible (fig.1a); the surface of the lesion appears to be finely cribrose with minute bone crests radially disposed around a more marked central crest (fig.1b). The endocranial surface is intact. The lesion is the result of an inflammatory process of the soft tissues and the periostium that involved the underlying skull vault.

The central position on the sagittal axis, the size and regular shape of the lesion make it possible to rule out disease, suggesting that the lesion is an artifact, in particular the result of cauterization, a surgical practice attested ever since the times of Hippocrates. The last sentence of his Aphorisms, which had a large circulation in the Antiquity and in the Middle Ages, reads: "What drugs will not cure, the knife will; what the knife will not cure, the cautery will; what the cautery will not cure must be considered incurable".[2]

The Roman iron cautery, *ferrum candens*, was heated and extensively employed in Roman medicine and surgery for various purposes: mainly as a counterirritant, to produce irritation in one part of the body in order to relieve pain or inflammation in another, or as a haemostat, to treat bleeding vessels in order to stop haemorrhage; cautery was also used as a bloodless knife, to destroy tumours and to treat a variety of infections, diseases, lesions and traumas.[3] Despite poor archaeological evidence, because iron deteriorates easily,[4] Roman literary sources often cite cauteries, but with only few descriptions; the instruments must have varied in size and design so as to perform their specific medical and surgical functions.

The iron cautery continued to be used throughout the Medieval period to treat trauma, epilepsy, ulcers, cancers and became the standard method to produce haemostasis. After the 12th century this surgical practice spread considerably in the West, thanks to the influence of Arabic medicine, that

largely promoted cauterization; in particular, Albucasis prescribes the use of cautery in many chapters of his treatise *al-Tasrif* and dedicates a long section to the subject.[5]

The Pisa skull dates back to the early Middle Ages, considered a time of widespread diffuse ignorance during which most of the ancient knowledge became lost. Medicine and surgery were no exception and, after Galen, little was produced with the exception of mere compilations, mainly in the form of herbals or domestic recipe books. The handbook available in the Latin West between the 6th and the 11th centuries included only simple surgery, essentially represented by phlebotomy and cautery. Basically, Greek surgery remains inaccessible to direct knowledge until the 15th century, with the exception of some Hippocratic treatises that were the main source for the compilations on surgery written by Aulus Cornelius Celsus (1st century AD) and Paul of Aegina (7th century).[6]

Celsus, one of the best sources concerning medical knowledge in the Roman world, reserved two chapters (VII-VIII) of his *De medicina* to surgery, describing several procedures that included the use of cautery. In particular, when dealing with the eye disease caused by a flux of humours, Celsus affirms: "… Physicians have been found in Greece who… also applied the actual cautery to the turgid veins on the temples and between the forehead and top of the head. …on the temples [cauterize] rather cautiously; lest the subjacent muscles be injured, which maintain the jaws; but between the front and vertex so effectually that a scale may be detached from the bone". [7]

In the Imperial age the work of Celsus had scarce fortune, whereas in the late Antiquity and the early Middle Ages it acquired great prestige and was included in official medicine;[8] three manuscripts of *De medicina* were copied in the monasteries of northern Italy in the 9th and 10th centuries.[9] Therefore, the work of Celsus is likely to have been accessible to physicians and surgeons active in this period in Tuscany.

In his *Iatrika*, Paul of Aegina, the most prominent figure in Byzantine medicine, highlights the importance of deep cauterization to desiccate humors. In particular, his words are highly evocative in relation to the case presented: "In ophthalmia, occasioned by a defluxion from above, and in

dyspnoea, produced by a redundance of a recrementitious humour which is sent from the head down to the chest, and by longing there proves injurious to the parts contained in it, they burn the middle of the head in this manner. Having first shaven the parts about the vertex, they apply cauteries shaped like olive-kernels and burn the skin down to the bone, scraping the bone after the falling off of the eschar. Some by burning even the bone itself make a small scale exfoliate from it, in order to allow the humours of the head to perspire and be evacuated the more readily; and for this purpose they keep the ulcer open for some time and then allow it to cicatrize". [10]

In the early Middle Ages the compilation by Paul of Aegina was one of the most prominent medical texts, with circulation in the monasteries or in the rare schools of that time. The surgical tradition was concentrated in religious and urban centers, where the schools and laboratories could offer some source of knowledge. Pisa in the 8-10th centuries did not decline in the same way as other cities in Italy but, favoured by its river system, it started to emerge as relevant port of the Upper Tyrrhenian Sea; here the Graeco-roman tradition probably merged with the German and popular medical practice, before the impact and diffusion of Arabic medicine in the western world.

The localization of the lesion in the examined skull is exactly the one described by both Celsus and Paul of Aegina: it is in the center of the frontal bone, between the forehead and the top of the head, along the sagittal axis. The cautery was applied vigorously as prescribed in the texts and the skin was burnt reaching the bone, where the instrument left its precise mark. The size and regular form of the lesion correspond to the morphology of cauteries with olive-shaped head; the typology of these cauteries has been documented since Roman times (fig.2) and has become the preferred form for haemostasis after Albucasis.[11]

The case presented reflects the exact use of cautery as described by the reference authors for surgery in the early Middle Ages. The similarities between the description of the literary sources and the observed lesion leads to hypothesize the pathology for which the cautery was applied to the woman, namely an eye disease.

Direct documentation of cauterization in ancient human remains is very rare, because this practice mainly involved the soft tissues and was only occasionally applied to regions in which the underlying bone could be reached easily and safely. In Medieval Oslo, 24 skulls dug during the archaeological excavations at St. Clemens' church, showed rounded or oval grooves, about 2 cm in diameter and 2-4 mm in depth in the bony surface. However, the finds date back to the 12-16th centuries[12]. The Pisa skull is of particular interest not only because it contributes to the knowledge of an obscure period in the history of medicine, but also because it represents the direct documentation of surgical practices well attested and described by the written sources of the period.

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Fig.1 a) Skull with lesion in the centre of the frontal bone; b) detail of the lesion

Fig.2 Roman cauterizing probe with olive-shaped head (Wellcome Library, London)

Figure 1

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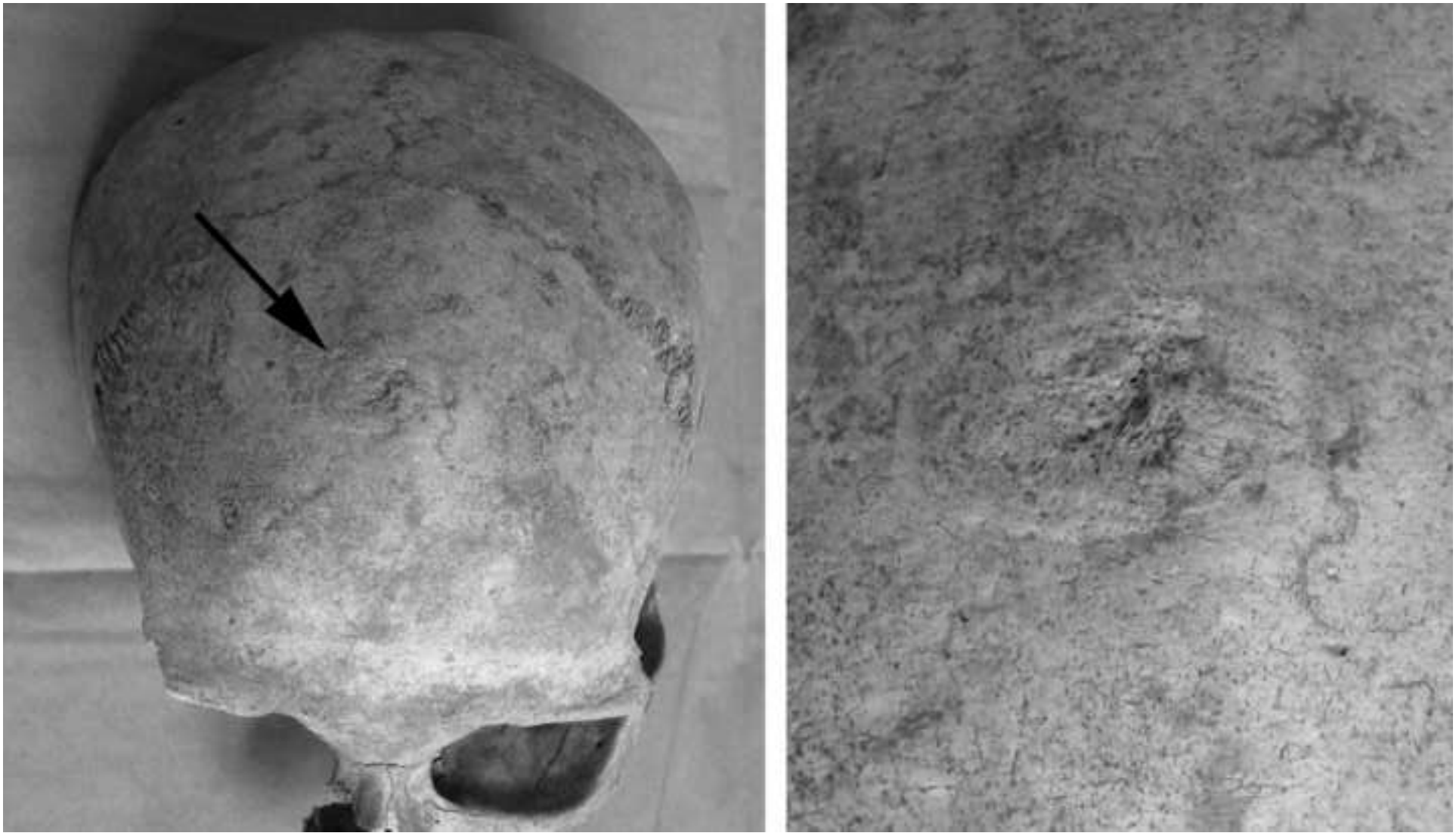

Figure 2

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