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Brief tour through the history of spine surgery: From Egyptian mythology to minimally invasive surgery

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Abstract

Knowledge of the contributions to spine surgery made over time provides us with the context of understanding current surgical techniques and the success that this area has had over the years. In this work the author carried out a search for the historical milestones that marked the course of spinal surgery, which represented an arduous work by great figures of medicine, starting from Egyptian mythology, passing through the Greek, Arabian, the Renaissance, until the Modern Age and the development of minimally invasive surgery.

Keywords: *History, spine surgery, vertebral instrumentation, fusion.*

Introduction

Most advances in spine surgery were made in the 19th and 20th centuries. However, to reach this point it is worth commenting on the foundations that forged the guidelines we know today, namely the anatomical and biomechanical descriptions established in the Greco-Roman period and the Renaissance, which meant the use of conservative management such as bed rest and spinal traction[1]. Once the guidelines of the antiseptic technique and the advances in anesthesiology were established, it was possible to generate fundamental techniques in spine surgery such as vertebral decompression and surgical stabilization.

In this paper, we review the history of spine surgery, from the first mention by the Egyptians to minimally invasive surgery.

Materials and Methods

An exhaustive search was conducted in several databases such as MEDLINE (PubMed), Scopus, and Google Scholar, using search terms to relate the history of spine surgery. The most relevant manuscripts were selected for the realization of this work based on their relevance to their time. They were categorized depending on the period in which they were described: Ancient Egypt, the Greco-Roman Period, the Middle and Dark Ages, the Renaissance, the Modern Age (19th and 20th centuries), and the technological era (late 20th and 21st centuries).

Ancient

The oldest allusion to a spinal procedure is documented in Egyptian mythology in the "Book of Death"35, which tells the story of the god Osiris, who is resurrected by Thoth by reassembling his spine. This is represented by the Djed pillar with two vertical and four transversal bars, denoting his spine and ribs. It is one of the most reproduced symbols in ancient mythology, often found on sarcophagi.

It is known that physicians of the ancient period treated spinal ailments based on historical documents. One of the most relevant is the Edwin Smith Papyrus (2600-2200 BCE), which contains the oldest descriptions of the signs and symptoms of spinal injuries. The document contains 48 cases in total of various pathologies, six of them related to spinal injuries in various settings. These descriptions were based on the knowledge of Egyptian physicians and included prognostic factors that could be considered in making treatment decisions[2].

The Greco-Roman Period: The Age of Hippocrates

Hippocrates (460-375 BCE) is considered the father of spinal surgery[1]. He was the first to describe the anatomy of the spine, from its segments, normal curvatures, the structure of a vertebra, the tendons attached to them, the blood supply, and even its anatomical relationships with the surrounding vessels. In his treatise On Joints[3], he divides spinal ailments into five groups: Kyphosis, scoliosis, concussion, vertebral dislocation, and fractures of the spinous processes. He established different managements to treat these injuries from the invention of devices such as the Hippocratic ladder (correction of spinal deformities) and Hippocratic board (reduction of spinal curvatures), which were the main treatments until the 20th century, upon the advent of surgery.

Celsus (25-50 BCE), advisor to emperors and compiler of the medical knowledge of the time, knew that cervical fractures could produce alterations in the respiratory pattern and differentiated them from low lesions associated with paralysis of the lower limbs and urinary retention. Given the complexity of these injuries, he did not recommend their treatment[4].

Galen (130-200 CE), was the official surgeon of the gladiators in the Roman amphitheaters and described the course of the spinal nerves after their exit from the spinal canal through the intervertebral foramina. Since dissections in humans were forbidden, he used his observations on injured gladiators and described the neurological consequences of cervical spinal trauma, considering them more serious for the lower levels, and the implications of transection of the spinal cord at different levels[5].

The Middle and Dark Ages

During the Byzantine period, Paul of Aegina (625-690 CE) developed a seven-volume encyclopedia called Epitome of Medicine, which brought together the medical knowledge described by his predecessors6. It describes the technique of laminectomy, performed on a patient with vertebral fracture and spinal cord compression. For this reason, he is credited with being the first to perform it.

This was followed by the Dark Ages (500-1000 CE), which meant a stagnation of 500 years in medical progress in general. It was not until the emergence of Avicenna (980-1037 CE), with his masterpiece "The Canon of Medicine"[7], which consists of a compilation of Hippocratic, Galenic, and Byzantine period knowledge. He dedicated 8 chapters

to vertebral lesions, in which he laid the foundations of biomechanics by comparing the spine to a chain. He used herbal medicines with anti-inflammatory properties to treat spinal trauma and nerve compression. In addition, like Hippocrates, he used vertebral traction for vertebral dislocation and respected the doctrine of Paul of Aegina, in which it was stated that surgical decompression should be performed in case the vertebral fracture compresses and destroys the spinal nerves or the spinal cord[8].

Serefeddin Sabuncuoglu (1385-1468 CE) was a Turkish surgeon, who described the treatment of vertebral dislocations employing an interesting technique of axial traction[9], warning that it could only be performed on posterolateral dislocations, given that if the anterior and lateral dislocations were performed, it could lead to death.

The Renaissance: Vesalius and Da Vinci

Leonardo Da Vinci (1452-1519 CE) is the epitome of the Renaissance. He studied the perspective, geometry, and anatomy of the spine[10], with great attention to detail showing the correct curvatures, articulations, and number of vertebrae. He also suggested that the stability of the spine is given by the cervical musculature. His work was not oriented to dissection but to the observation and analysis of the physiology of movement, which led to the establishment of biomechanics, the principles of which are still valid today.

Andreas Vesalius (1514-1564), the so-called Father of Anatomy, with his book De Humani Corporis Fabrica occupies a place in the history of spinal surgery for his largely accurate descriptions of the anatomy of the spine, correcting Galen's inaccurate observations[11].

Giovanni Alfonso Borelli (1608-1679) is considered the father of biomechanics. He established that the intervertebral discs function by cushioning the vertebrae against each other, acting as a suspension. He also made calculations describing the force exerted on each vertebra individually and the weight shared in each segment of the spinal load, thus explaining human locomotion in mechanical terms[12].

Fabricus Hildanus (1560 - 1634) was a prominent German surgeon, who proposed a method of spinal reduction extremely advanced to his time, similar to the concept of cervical traction used today. This consisted of placing a needle between the interspinous ligament with forceps attached to it, generating traction on the cervical spine while awaiting fracture reduction[13].

The Modern Age: 19th and 20th centuries

It was not until this era that surgeons dared to practice spinal surgery widely, due to advances in antiseptic technique by Joseph Lister[14], anesthesiology by William T. G. Morton[15], the generation of surgical instruments, and the understanding of biomechanics.

Malgaigne (1806-1865) took up the surgical practice of Paul of Aegina, by removing bone fragments in fractures with spinal cord compression[16]. However, it was not until 1828 that A. G. Smith performed the first successful laminectomy[17]. He performed a multilevel laminectomy on a patient who suffered a fall from a horse, causing paraplegia. He performed a midline approach removing the depressed laminae and spinous processes.

The first description of the resection of a spinal tumor was made by Victor Horsley (1857-1916), the leading neurosurgeon of his era, since he was able to perform brain and spine surgery with an acceptable level of morbidity and mortality[18]. In 1887 he performed such a procedure on a patient with paraplegia, finding an intradural lesion (characterized as fibromyxoma), presenting considerable postoperative improvement. Before his observations, cervical spinal surgery was avoided. However, he reported seven cases of patients with cervical fractures and quadriplegia, operated by laminectomy, three of them with motor recovery[19].

The first internal fusion was described by Hadra in 1891. It was used to stabilize cervical fractures caused by Pott's disease. He fixed a silver wire to the spinous process in the shape of an 8, with successful results[20].

Albee and Hibbs[21] were the pioneers in posterolateral fusion, who independently published their technique in 1911. Hibbs' technique was the predominant one and used autologous bone from the spinous process folded downward and overlapped to contact the affected caudal process. In 1923 an autopsy was performed on 9 persons who underwent this procedure revealing solid fusions in all cases[22].

In 1933 B. H. Burns treated a patient with lumbosacral listhesis using a bony septum taken from his tibia to perform an anterior L5-S1 fusion and correct the displacement[23]. The patient had an adequate evolution with absolute bed rest and was able to walk without pain after two months.

Tourney, in 1943, described a novel technique using facet screws for the first time, favoring fusion and accelerating the recovery process[24].

One of the most important advances in spinal fusion came from Harrington in the late 1950s[25], who created a system using steel rods and hooks in patients with scoliosis to correct the deformity by compression and distraction. He later used the system in trauma and other etiologies.

The first transpedicular screw placement is attributed to King, but in 1959 Boucher[26] perfected the technique and obtained a considerable success rate by placing the screws through the lamina and pedicle and inserting them into the vertebral body. Since then multiple surgeons have developed fixation techniques using the pedicle as the major fixation component.

The technological era: Late 20th and 21st centuries.

After the invention of computed tomography in 1972 by Hounsfield and Magnetic Resonance Imaging two years later[27], advances in spine surgery were not long in coming. Its diagnostic and evaluation use in spinal pathologies led to the adoption of imaging techniques for transoperative use. Yasargil in 1977 reported the use of microsurgery to successfully perform discectomy[28]. In 1981, Spetzler, Selman, and Brown performed a series of surgeries to remove the odontoid processes with fluoroscopic guidance[29], an instrument widely used today and indispensable for most spinal surgeries.

Many attempts have been made to try to reduce the complications associated with spine surgery, using increasingly smaller approaches, leading to the emergence of minimally invasive surgery. One of the first to use this approach was Ascher and Hepner in 1984[30] who performed a percutaneous discectomy to reduce nerve root compression. However, this procedure failed for the treatment of migrated or sequestered disc fragments, so minimally invasive management with direct visualization by endoscopy and tubular system was chosen in 2002, becoming very popular in recent years for the performance of discectomies, laminectomies, and foraminotomies[31].

Where are we headed? Future Directions

Pseudoatrosis continues to be a major problem to this day, due in part to the lack of osteoinduction, osteoconduction, and osteogenicity of the materials used for bone fusion. Bone morphogenic protein type 2 and osteogenic protein type 1 (rhBMP-2 and OP-1) have been used to promote bone fusion. However, they can cause ectopic bone formation and possible cancer risk[32]. New technologies based on stem cells, gene therapy, and tissue engineering used to promote bone fusion have shown encouraging results in animals, which should be demonstrated in future studies in humans[33].

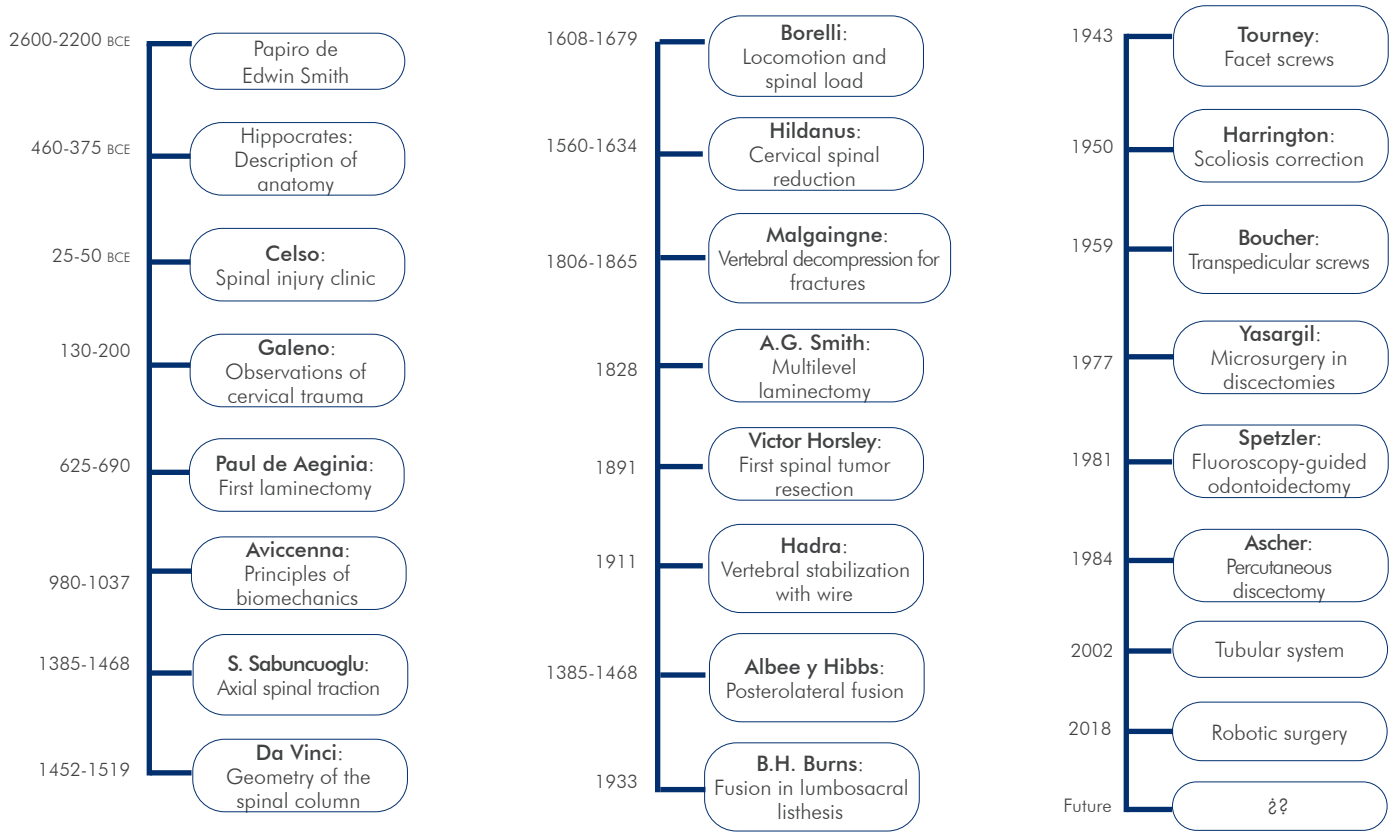
The inadequate placement of transpedicular screws due to screw malposition has led to technological innovation through the use of robotic surgery, which provides trajectory guidance during instrumentation material placement. Despite this, doubts have arisen regarding the standardization of its use, due to the cost-benefit ratio, given that it increases the cost of surgery considerably[34].

Conclusion

In this brief paper, we have mentioned the most relevant antecedents in the history of medicine that have contributed to the development of advances and techniques to make spine procedures safer and more effective. Figure 1 presents these historical milestones in the form of a timeline.

The Egyptian period helped us to understand the anatomy and the Greek and Byzantine period the signs and symptoms of spinal disorders. It was in the Arabian/Islamic period that new surgical instruments and techniques emerged. During the Renaissance, the concepts of biomechanics were established, as well as the writing of masterpieces in medical literature. However, it was in the modern age that there was a major evolution following the establishment of anesthetic techniques and antisepsis, with a considerable upturn in the development of spine surgery in the last 100 years. Advances in this field continue to grow day by day due to the use of new technologies, the development of new techniques, and the improvement in the prognosis of patients, the product of centuries of work and research, which we mention in this manuscript.

Figure 1. Timeline showing the most important historical milestones in spinal surgery, from its first mention in ancient documents to robotic surgery.



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