The Impact of Da Vinci’s Anatomical Drawings and Calculations on Orthopaedics

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Abstract: He who loves practice without theory is like a seafarer who boards a ship without a wheel or compass and knows not whither he travels, a famous quote by Leonardo da Vinci (Da Vinci). Da Vinci is known to be one of the greatest painters of all time and his astounding skills to illustrate the human body enabled surgeons to gain a much better understanding of the human body. The world of Orthopaedics has advanced significantly since the early 1900s where the experience of wartime injuries forced surgeons to develop ways of repairing the musculoskeletal system on the battlefield. Without the theoretical knowledge of the human anatomy however, no such procedures would have been possible, so in this article, we tried appreciate and understand the influence of Da Vinci on Orthopaedics on the limbs. We explored some of his limb drawings and his complementary biomechanical findings to understand its significance in the world of Orthopaedics.

Key words: Leonardo Da Vinci • Nicholas Andry De Boisregard • Surgery • Surgical Instruments • Orthopaedic • Anatomy

INTRODUCTION

From his days as an artist’s apprentice under Antonio Del Verrocchio, Da Vinci was an enthused student of human anatomy and form. His interest within the field only matured during his lifetime and he produced extensive, detailed diagrams of the musculoskeletal system; a combination of both his artistic ability and in his own words: dissection of more than ten human bodies [1].

As Da Vinci professed, observation and acquaintance with the normality of the body’s structure and function are imperative to the understanding of dysfunction and disease, as well as the production of strategies to correct the deviation from this sense of biological normality. In lieu of this, Da Vinci was a pioneer of medicine, notwithstanding his proficiency in a multitude of other scientific disciplines. From his progression of the boundaries of human knowledge, future medical practitioners had a substantial foothold from which to advance and define a completely new region of medicine and develop treatments, inspired by or directly designed by Da Vinci, many of which are still in use to this day. These medical practitioners included Nicholas Andry de Boisregard (De Boisregard), who is widely regarded as the father of orthopaedics [2], a man from whom many of Da Vinci’s medical writings were recorded and implemented.

Aims and Objectives: The aim of this publication was to comprehensively collate and evaluate Da Vinci’s contributions to Orthopaedics in particular. There is current literature pertaining to Da Vinci’s significance to the period of enlightenment, but not so specific to his instrumentalism regarding the birth and progression of this field of modern medicine in particular.

MATERIALS AND METHODS

This article is the culmination of information from a variety of research materials, including journals, books and manuscripts. After understanding the relationship between de Boisregard and Da Vinci from The Genesis of Modern Orthopaedics: Portraits of Three Illustrious Pioneers [3], we used the an English translation of de Boisregard’s book: L’orthopédie ou l’art de prévenir et de corriger dans les enfants les difformités du corps [4] in which he makes reference to the importance of Da Vinci’s work. With particular mention to Da Vinci’s written Codices: Atlanticus [5], Leicester [6], Arundel [7] and
Madrid [8]: The Codex Atlanticus being the main source of the collection of Da Vinci’s anatomical drawings by the sculptor Pompeo Leoni, at the end of Da Vinci’s life. The translation of The Codex Atlanticus was obtained from Anatomical Drawings from the Royal Collection, Windsor Castle [9].

The Genesis of Modern Orthopaedics then makes mention of de Boisregard’s successors, Jean Andre’ Venel and John Ball Brown as well as their achievements that traced back to Da Vinci. From the aforementioned sources, the results were collated and discussed in the proceeding section, in specific relation to orthopaedic medicine.

RESULTS AND DISCUSSION

Hereunder are the manuscripts, courtesy of the Royal Collection, which regard the orthopaedic anatomical drawings of Da Vinci, the translation of the text and the field of orthopaedics, for which it provided the basis.

The Lower Limb: From the text in The Codex Atlanticus, Da Vinci writes, “When the muscles tensor fasciae latae and sartorius pull on the leg, it is raised forward; and the glutaeus medius are relaxed and glutaeus maximus is elongated. Describe this rule in the operation of all muscles and you will be able to make out, without seeing the living, almost every action without exception.” His drawing and description of each muscle of the lower limb (Fig. 1), allowed de Boisregard to define different types of abnormal gait due to various causes and prescribe conservative management to theoretically improve the function of his patients, in addition to correcting posture [10]. Da Vinci then goes on to state “The tendon that takes hold of the heel c [tendo calcaneus or tendo Achillis] raises a man on the ball of his foot a, the weight of the man being at the fulcrum b [the internal malleolus of the ankle]. And because the lever b-c enters twice into the counter lever b-a, 400 pounds of force at c produces a power of 200 pounds [the weight of a man in Florentine pounds] at a with a man standing on one foot.” This is good biomechanics. In the kneeling figure at the centre of the lower row the muscle cords a-b and n-m produce rotation of the lower leg at the knee when it is bent, in contrast to their action when the knee is straight, as shown in the central figure of the upper row.” The understanding of the biomechanics and moments of the lower limb, allowed Da Vinci to invent the most efficient prosthetic limb available at the time and enabled his orthopaedic successors to continue to produce artificial limbs for the dismembered, all the way until the transition between the mechanical and electronic age, some 500 years after his death [11].

The Upper Limb: Also in relation to the biomechanics of the musculoskeletal system, Da Vinci’s description of the upper limb is equally, if not superlatively detailed. He says, “The palm is turned toward the ground, the pronator teres muscle. The biceps rotates the hand as well as bending the elbow.” The nomenclature of numerous orthopaedic terminologies can trace its origin to the Greco-Latin coinage by Da Vinci, as is this example of the description of pronator teres, in addition to the names of pectoralis major, teres major and minor, levator scapulae, supraspinatus, infraspinatus, latissimus dorsi and the rhomboid muscles. For all of these muscles, Da Vinci also drew the lines of action of the force they exert, again initiating the study of biomechanical function (Fig. 2). The isolated functionalisation of each muscle in the upper limb, as well as its tendon insertion and related neurovasculature, were subjects that were conveyed and used to describe tendinopathies some 200 years post Da Vinci’s death.

Furthermore, Da Vinci details the paths of the venous drainage of the upper arm, describing the cephalic and basilic veins.

During the dissection of the upper limb, Da Vinci details the nature and functioning of joints (Fig. 3), weak points of potential fracture and the possibility for joint replacement, for the first time. This was the primary proposal for artificial joints, understanding the means by which joints work as well as areas of special attention for fractures. His appreciation of the importance of function related structure is articulated on this section: “Make the book on the elements and practice of mechanics precede the demonstration of the movement and force of man”.

The Spinal Column and Nerves: Da Vinci famously writes in his codex, “The spinal cord is the source of the nerves that give voluntary movement to the limbs.” The groundbreaking statement that allowed the likes of Venel and Bell to understand segmental innervation of the limbs to produce the concept of the dermatome and isolate the function of individual nerves. Regarding the latter, Da Vinci had started to describe the formation and function of the brachial plexus (Fig. 4): “Here each nerve of the arm is joined to all; and four nerves that issue from the spinal cord.” and in the drawing each nerve is traced to the muscle group, which it innervates. The later dated manuscript then describes the five roots of the brachial
Fig. 1: Muscle Attachments and Movements of the Lower Limb

Fig. 2: Muscle Attachments of the Upper Limb

Fig. 3: Movements and Function of the Joints of the Upper Limb
plexus along with the test: "Any one of the five branches saved from a sword-cut is enough for sensation of the arm. " describing his clinical experience of upper limb nerve palsy.

Another significant leap in the understanding of the nervous control of the limbs, is Da Vinci’s description of the Tree of Nerves, (Fig. 5) where he writes: "All the nerves manifestly arise from the spinal cord remote from the heart and the spinal cord consists of the same substance as the brain from which it is derived." Notwithstanding, the implications this statement had on the origin of neurology, this discovery and the associated diagrammatic information allowed de Boisregard, Venel and Bell to understand and treat some causes of spinal nerve compression, such as conservative management of scoliosis and improve sensation and mobility in patients [12].

CONCLUSIONS

Da Vinci was able to describe the human anatomy in such astonishingly amazing details considering he used only ten corpses for dissection. His drawings were so accurate in fact, that it allowed Boisregard to define abnormal gaits and allowed his patients to improve their posture. His biomechanical descriptions allowed for the
production of artificial limbs hundreds of years after his passing. The terminology of the various muscles in the body also was originated from Da Vinci. The details of the upper limb, of which many students and trainees struggle to visualise even now, have been wholly described by Da Vinci, including tendon insertion, neurovasculature and isolated functions. Da Vinci was not only able to draw and describe the brachial plexus, but he also described how just one branch of the plexus is enough to maintain sensation to the arm.

Da Vinci’s meticulous research and observations undoubtedly served as a catalyst in the world of surgery, not only in terms of the intricate details of the human anatomy, but also the complex human biomechanics. The discoveries made by Da Vinci and taken further by de Boisregard, allowed basic surgical procedures to be undertaken which still take place today in order to improve the lives of countless patients. Not only did Da Vinci stop at complex anatomical drawings, but he went further to illustrate the forces enabling prosthetics to be made.

His comprehensive drawings are of significant help to anatomists and surgeons, highlighting the location of important structures in the human body, whilst also allowing prosthesis to be made due to the detailed biomechanical information. Medical students often struggle to visualise the complexities of the anatomy of the human body however, the drawings of Da Vinci have allowed for the understanding of the human anatomy on an impeccable level. The fundamentals of the human body described by Da Vinci have allowed for significant advances in surgery to develop new prosthesis, to the extent where athletes can now run in the Olympics without significant impediment. With the advancements made already by the successors of Da Vinci, we can only use their work to build upon the foundations and make even better prosthesis and products to aid our patients.

This research also highlighted the importance of the preservation of the works of previous scientists in the progression of a field of medicine. The example of Da Vinci’s Latinised works with the French physicians, is that with the Romance physicians and anatomists with the Middle Eastern scientists and the Middle Eastern polymaths with the ancient Greeks. Each successfully preserved the work of the generation previous to allow for the development of our current knowledge of medicine [13].

With this article, we are able to better appreciate the impact that Da Vinci had on the world of Orthopaedics and his role in allowing surgeons and anatomists to better understand the theory behind the practice. As Da Vinci says, "He who loves practice without theory is like a seafarer who boards a ship without a wheel or compass and knows not whither he travels."

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REFERENCES