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Mini Review

Guinea Pig's Spine as a Biomechanical Model in Neurology and Orthopedic

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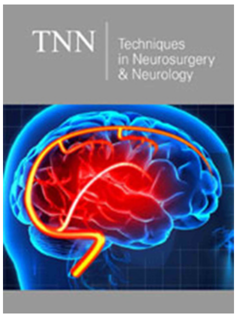

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Abstract

Animal models play an important role in the investigation of spine biomechanics. Guinea pigs are used in some neurological and orthopedic biomedical research, but the biomechanics of their spinal column is little discussed in the available literature. Therefore, the goal of this study was to point out the similarities and differences in the spinal column of humans and these animals, which can be significant when planning experiments.

Keywords: Biomechanics; Guinea pig; Spine

Introduction

Guinea pigs (*Cavia porcellus*) are a herbivorous species of rodents from the family *Caviidae* which due to their low body weight, short reproductive cycle, calm temperament, as well as anatomical and physiological characteristics, are increasingly used as models in various studies [1]. In neurology and orthopedics, guinea pigs have been used to examine ischemic lesions in the spinal cord [2] and for the study of spontaneous and induced osteoarthritis [3]. It should be borne in mind that there are significant differences in the morphologic of the spinal columns of bipedal and quadruped organisms (Figure 1), and therefore in biomechanics, which can significantly impair the quality and applicability of the results obtained.

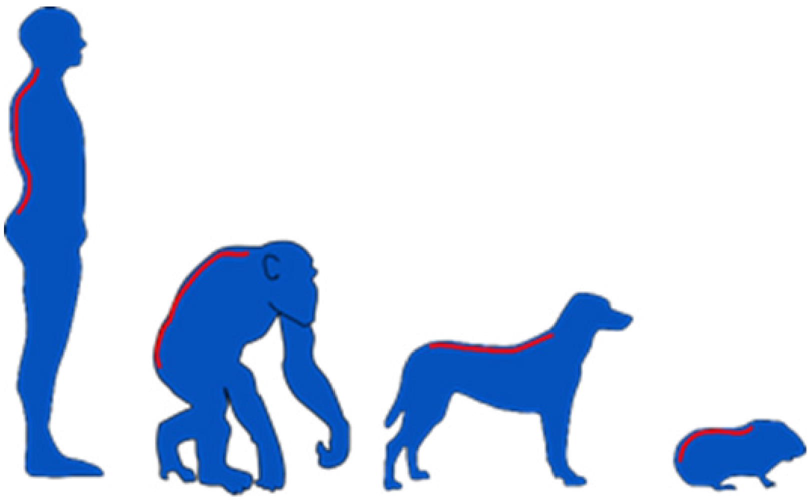

Figure 1: Presentation of the morphology of the spinal column in bipedal and quadruped organisms.

In the available literature, there are various findings of different morphometric and/or biomechanics examinations of the spinal column performed on rabbits [4], dogs [5], pigs [6], sheep [7] and cattle [8,9]; however, the search for an optimal animal model is still ongoing. When using an animal model in tests on the spine, one should know the basic anatomical characteristics of the spinal column of a given animal, such as anatomical characteristics of the spinal column (number and morphology of vertebrae), as well as the direction of forces through the spine column.

Characteristics of the spine of guinea pigs

The spinal column of rodents has a total of 26 presacral vertebrae, composed of 7 cervical and 19 thoracolumbar vertebrae [10]. The cervical spine region of mammals is characterized by the smallest variations in the number of vertebrae, which is usually attributed to the pleiotropic function of Hox genes. In addition, variations in the number of cervical vertebrae are associated with an increased risk of prenatal mortality and neonatal cancer [10,11]. On the other side, the thoracolumbar region of the spine of guinea pigs shows greater variability, and in most individuals, it is composed of 13 thoracic and 6 lumbar vertebrae (Figure 2) [12].

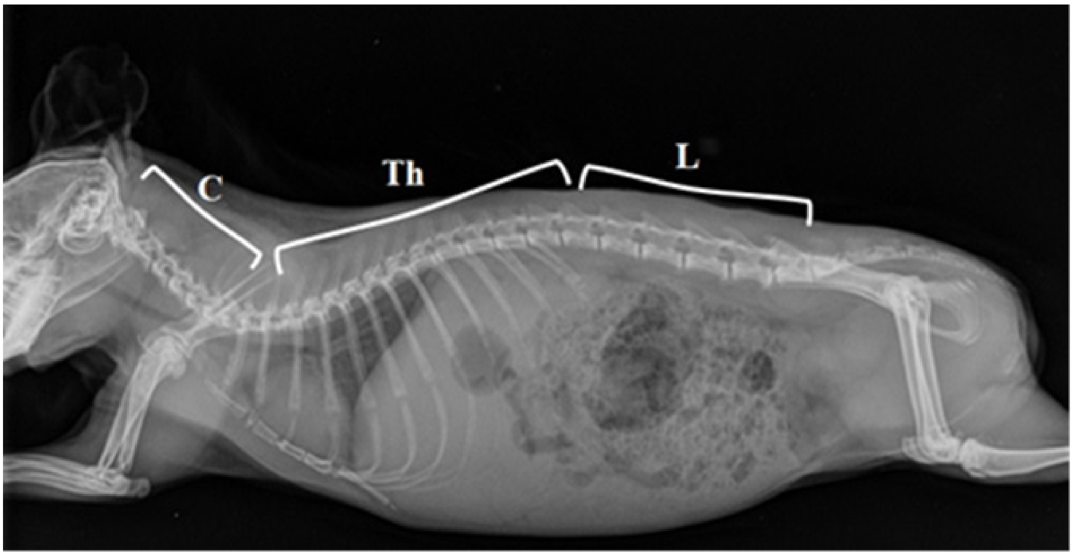

Figure 2: X-ray image of a guinea pig in the later-lateral projection: Cervical (C), Thoracal (Th) and Lumbar Vertebrae (L).

Is axial loading of the vertebral column present only in bipedal organisms?

A common misconception is that quadrupedal spines are not subjected to axial load like the upright, bipedal human spine is. In reality, however, it has been demonstrated that quadruped spines not only experience axial loads but also that they may in fact be higher than in humans. Indeed, high muscle and ligament forces act on the quadrupedal spine to constrain its movement in the frontal and sagittal planes [13]. It is important to note that the trabeculae of the vertebral bodies of both bipeds and quadrupeds are oriented from endplate to endplate, implying that they undergo axial loading [14].

Differences in the morphology of the vertebral bodies in human and guinea pig

It is known that bones adapt to the action of mechanical forces by changing their morphology [15], so the size of the thoracic vertebrae in humans increases from the first to the last [16] and this trend continues distally so that the last lumbar vertebra has the greatest length, height and width [17]. On the other hand, guinea pig's lumbar vertebrae have an irregular trapezoid geometry and the body lengths of L4 and L5 are the largest [18]. The diameter of the spinal canal is not uniform along its entire length and in humans its width increases from the first to the last lumbar vertebra [19]. Thus, in humans, there is a correlation between the diameter of the spinal canal and the place of greatest load on the spine, which can be considered a remarkable protective mechanism that aims to prevent pressure on the spinal cord that could occur when a higher mechanical force is applied. On the other hand, in guinea pigs, the greatest depth of the spinal canal was measured at the level of L4 [18].

Conclusion

Although some authors indicate that the spinal column of quadrupedal organisms (merino sheep) suffers a strong axial load [13], the results of morphometric studies of the spinal column of guinea pigs do not agree with the previous statement [18]. Namely, in guinea pigs L4 behaves atypically in relation to the other lumbar vertebrae and indicate that this level of the spinal column could be the highest load in these animals.

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