JIVS JOURNAL OF ISTANBUL VETERINARY SCIENCES

Silicone plastination of spinal cord of cat: as an alternative specimen for neuroanatomy education

Okan Ekim[1], Hasen Awel Yunus[1, 2,*], Caner Bakıcı[1], Barış Batur[1]

1. Department of Anatomy, Faculty of Veterinary Medicine, Ankara University, Ankara, Turkey. **2.** Mizan-Tepi University, MizanTeferi, Ethiopia.

EKİM O. ORCID: 0000-0002-3322-4161; Yunus H. A. ORCID: 0000-0001-9927-9483; BAKICI C. ORCID: 0000-0003-2413-3142, BATUR B. ORCID:0000-0001-9669-9917

Research Article

Volume: 6, Issue: 2
August 2022
Pages: 65-69

Article History

Received: 01.04.2022
Accepted: 14.06.2022
Available online: 08.08.2022

ABSTRACT

Plastination is a technique that aims to preserve biological materials for education, training, and research. Plastinated models increase knowledge and skill, make students easily understand the complex anatomical parts of the central nervous system, meanwhile can reduce the use of animals in research and education. The study aimed to produce a silicone plastinated model of the spinal cord of a cat for practical teaching of neuroanatomy. The spinal cord of a stray cat that died of natural causes was plastinated using silicone plastination method. The cervical spinal nerves (1-8) and brachial plexus were demonstrated. The thoracic region of the spinal cord was also well preserved, but the demonstration of thoracic spinal nerves became very difficult because of too much thinness of the nerves. The lumbosacral plexus was preserved well. In this region cranial iliohypogastric nerve, caudal iliohypogastric nerve, ilioinguinal nerve, femoral nerve, gluteal nerve, ischiadic nerve, obturator nerve, pudendal nerve and cauda equina were visible. The spinal cord of cats prepared by silicone plastination methods can be used as an alternative sample to formalin preserved specimens.

Keywords: cat, neuroanatomy, silicone plastination, spinal cord

DOI: https://doi.org/10.30704/http-www-jivs-net.1096113
To cite this article: Ekim, O., Yunus, H. A., Bakıcı, C., & Batur, B. (2022). Silicone plastination of spinal cord in cat. ***Journal of Istanbul Veterinary Sciences, 6*(2),** 65-69. **Abbreviated Title*: J. İstanbul vet. sci.***

Introduction

Plastination, invented by Gunther von Hagens in 1977, has produced ideal training models for education, research, and display (von Hagens and Tiedeman, 1987). Plastination is a technique that aims to preserve biological materials for education, training, and research. It is one of the most recent and efficient preservation methods used in departments of anatomy for preserving bodies, body parts, and organs in various forms (Pashaei 2010). This technique offers a unique way of preserving body parts or the entire body of animals and humans (Lahunta et al. 2008, Schoefert 2019).

The spinal cord is a tubular structure composed of nervous tissue that extends from the brainstem and continuing through vertebral canal and anchored caudally by the filum terminale, a fibrous extension of the pia mater anchoring the spinal cord to the coccyx (Bican, 2013; König and Liebich, 2020). It has certain regional variations in form and diameter: at two locations, where nerves to the limbs arise, the relative diameter of the spinal cord is increased. The cervical enlargement or intumescence (intumescentia cervicalis) involves the caudal part of the cervical spine and the initial part of the thoracic spine and gives rise to the spinal nerves that form the brachial plexus that innervates the thoracic limb. The lumbar enlargement (intumescentia lumbalis) gives rise to the spinal nerves, which innervate the pelvic cavity and the pelvic limb (Bican, 2013; Toossi et al., 2021, König and Liebich, 2020).

Plastinated models increase knowledge and skill, make students easily understand the complex anatomical parts of the central nervous system, meanwhile reduce the use of animals in research and

*Corresponding Author: Hasen A. Yunus
E-mail: hasewole@gmail.com

education. Detailed knowledge of the neuroanatomy of the spinal cord is critical for veterinary students to understand its pathologies, for diagnoses and finding possible treatment for the common disorder of a nervous system (Lahunta et al. 2008, Schoefert 2019, Toossi et al., 2021). The most common disease that brings about spinal cord problems in cats is neoplasia of the vertebral column (Marioni-Henry et al. 2004), most commonly spinal lymphosarcoma (LSA) (Vail and Macewen 2000, Forterre et al. 2007, Marioni-Henry et al. 2008), feline infectious peritonitis (FIP) (Baroni et al. 1995, Legendre et al. 1995), and intervertebral disc disease (Knipe et al. 2001, Munana et al. 2001, Lu et al. 2002).

Teaching tools like the plastinated model have paramount importance for the anatomical diagnosis of neurologic disorders. The use of plastinated tissues in the neurosciences greatly facilitates teaching neuroanatomy (Holladay and Hudson, 1989). The is no documented previous study that focused on plastination of the spinal cord of cat. Therefore, the study aimed to produce a silicone plastinated model of cat spinal cord for practical teaching of neuroanatomy.

Materials and Methods

A stray cat that died of natural causes was taken from department of veterinary pathology, Faculty of Veterinary Medicine, Ankara University and used for the study. This study was approved by the Ethical Committee of Ankara University (2021-9-56). The specimen was fixed in a 10% formalin solution for 4 weeks before dissection. Dissection and demonstration of the spinal cord were performed by dorsal laminectomy (Figure 1).

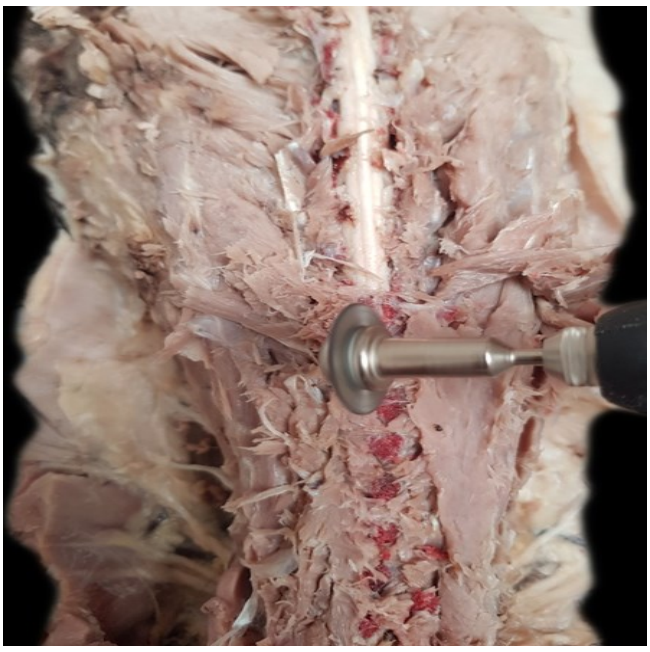

Figure 1. Dissection and laminectomy step

After removing skin and muscles gently, dorsal osseous parts of the vertebral column were removed with an oscillating saw to obtain a clean area and undamaged spinal cord. The dorsal part of the spine was removed starting from the atlas to the end of the sacral region. Then dissection of the spinal nerves was performed. Even though the objective of the study was plastination of spinal cord, from the relative importance point of view, the authors focused on spinal nerves raised from the cervical, lumbar sacral regions, and plexus formation. Following dissection, the cadaver is subjected to fixation. Fixation converts proteins of the body to a longer-lasting substance by forming cross-linkages between adjacent protein molecules. After the fixation, the dehydration step continued. For dehydration three consecutive acetone changes were made at -20 °C. The mass ratio of the acetone to the organs was 10:1. The acetone concentration of the last bath was 99%. Dehydration process take three weeks. After the complete dehydration step, Specimens are removed from the acetone, excess fluid was shake off, and the specimens are submerged in the impregnation mixture. Vacuum pump is applied and bubbles formation was totally ceased at 20 days of forced impregnation. Forced impregnation was carried out in a vacuum tank at -20 °C using S10B silicone polymer and S3 catalyzer. Completion of impregnation was monitored by observing the acetone bubbles on the surface of the silicone-filled vacuum tank. Finally, the gas curing was done with S6 in air-tight bags to harden the specimens (Henry et al., 1997; Henry et al., 2007; Henry et al., 2019). Nomina Anatomica Veterinaria was used for anatomical nomenclature (NAV, 2017).

Results

The vertebral column of the cat was opened and dissected, and then it was plastinated by the silicon plastination method (Figure 2). The cervical nerves were well demonstrated. Due to the chosen dissection technique and the objectives of the study, the evaluation of the existence and course dorsal branch of spinal nerve were not demonstrated. Cervical spinal nerves (1-8) and right and left brachial plexus were demonstrated (Figure 3, Figure 4, Figure 5). They are somewhat flexible and easy to handle. In the thoracic region, the spinal cord was also preserved well but, the demonstration of course of thoracic spinal nerves became very difficult because of too much thinness of spinal nerves. The lumbar, sacral region, and lumbosacral plexus (both left and right) were demonstrated in a way that enables students to a better understanding of the origins and formation of plexuses in the lumbosacral. In this region cranial

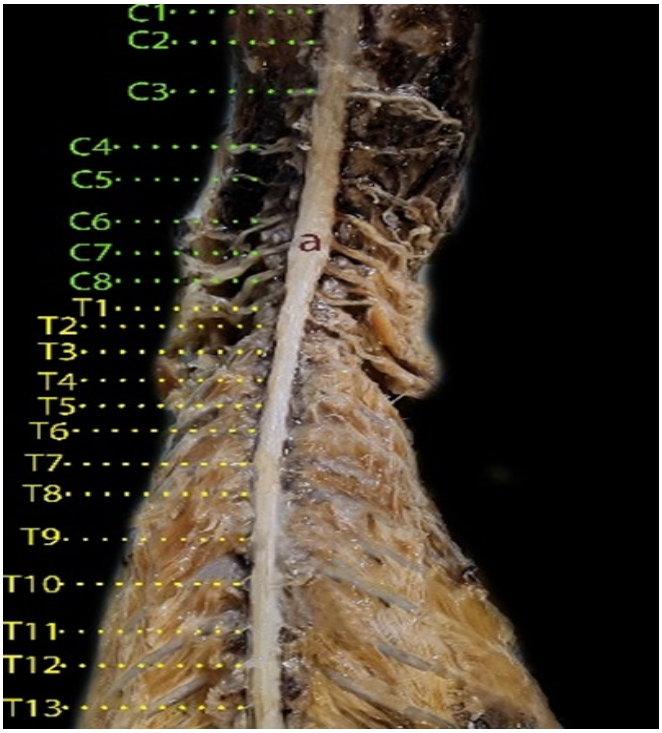

Figure 2. Plastinated anatomical specimen of cervical and thoracic regions of the spinal cord. C1, 1st cervical spinal nerve, C2, 2nd cervical spinal nerve, C3, 3rd cervical spinal nerve, C4, 4th cervical spinal nerve, C5, 5th cervical spinal nerve, (a), cervical intumescence, C6, 6th cervical spinal nerve, C7, 7th cervical spinal nerve, C8, 8th cervical spinal nerve, T1, 1st thoracic spinal nerve, T2, 2nd thoracic spinal nerve, T3, 3rd thoracic spinal nerve, T4, 4th thoracic spinal nerve, T5, 5th thoracic spinal nerve, T6, 6th thoracic spinal nerve, T7, 7th thoracic spinal nerve, T8, 8th thoracic spinal nerve, T9, 9th thoracic spinal nerve, T10, 10th thoracic spinal nerve, T11, 11th thoracic spinal nerve, T12, 12th thoracic spinal nerve, T13, 13th thoracic spinal nerve.

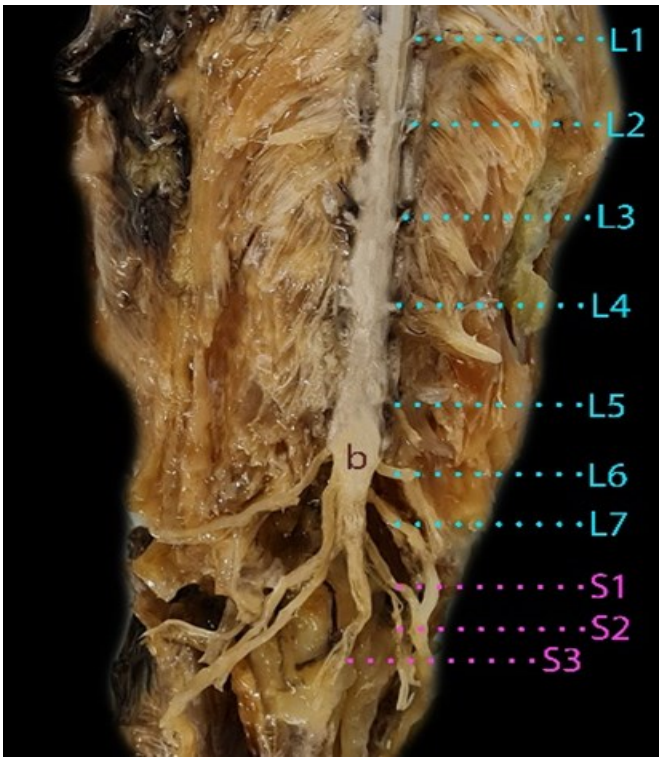

Figure 3. Plastinated anatomical specimen of cervical and thoracic regions of the spinal cord. L1, 1st lumbar spinal nerve (cranial iliohypogastric nerve), L2, 2nd lumbar spinal nerve (caudal cranial iliohypogastric nerve), L3, 3rd lumbar spinal nerve (ilioinguinal nerve), L4, 4th lumbar spinal nerve (genitofemoral nerve), L5, 5th lumbar spinal nerve, (b), lumbosacral intumescence, L6, 6th lumbar spinal nerve, L7, 7th lumbar spinal nerve, S1, 1st sacral spinal nerve, S2, 2nd sacral spinal nerve, S3, 3rd sacral spinal nerve.

iliohypogastric nerve, caudal iliohypogastric nerve, ilioinguinal nerve, femoral nerve, gluteal nerve, ischiadic nerve, obturator nerve, pudendal nerve and cauda equina were visible (Figure 1, Figure 6). The present investigation showed an excellent specimen for display in practical anatomical sessions.

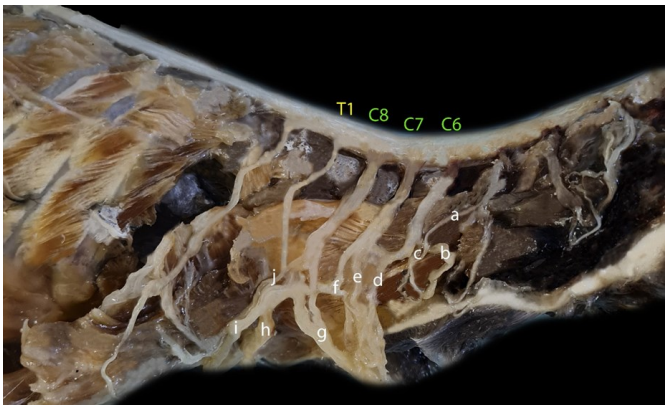

Figure 4. Formation of plexus brachialis and their branches. C6, 6th cervical spinal nerve. C7, 7th cervical spinal nerve, C8, 8th cervical spinal nerve, T1, 1st thoracic spinal nerve. Phrenic nerve (a), dorsal scapular nerve (b), suprascapular nerve (c), subscapular nerve (d), musculocutaneous nerve (e), Abxillary nerve (f), Radial nerve (g), median nerve (h), ulnar nerve (i), lateral thoracic nerve (j).

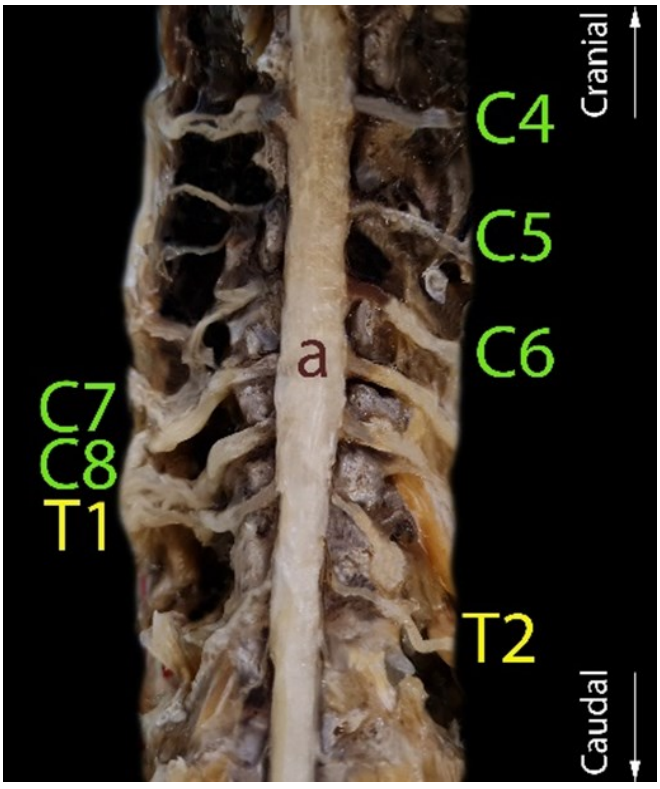

Figure 5. Formation of plexus brachialis. C4, 4th cervical spinal nerve, C5, 5th cervical spinal nerve, C6, 6th cervical spinal nerve, C7, 7th cervical spinal nerve, C8, 8th cervical spinal nerve, T1, 1st thoracic spinal nerve, T2, 2nd thoracic spinal nerve, a, cervical intumescence.

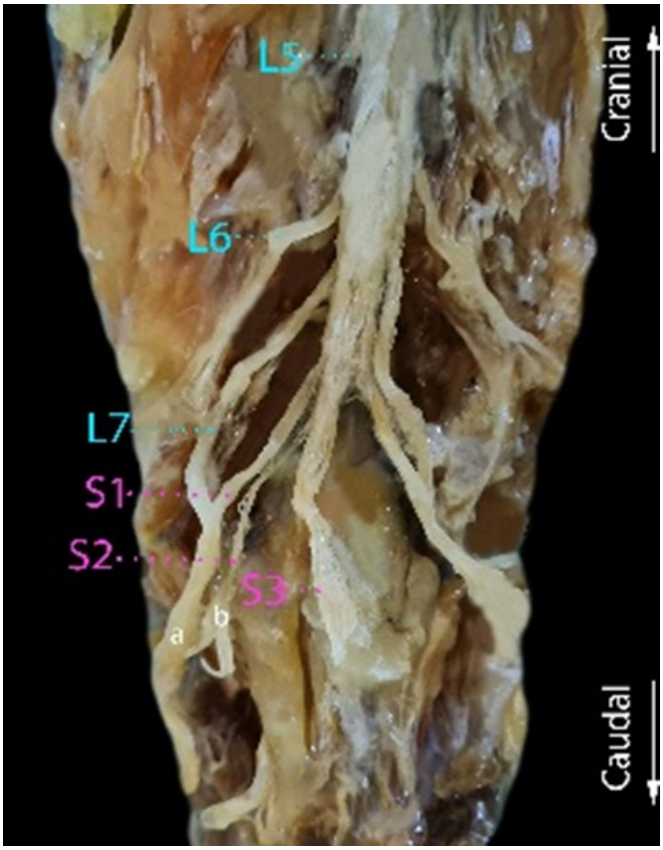

Figure 6. Formation of plexus lumbosacralis. L5, 5th lumbal spinal nerve, b, lumbosacral intumescence, L6, 6th lumbal spinal nerve, L7, 7th lumbal spinal nerve, S1, 1st sacral spinal nerve, S2, 2nd sacral spinal nerve, S3, 3rd sacral spinal nerve, (a) ischiadic nerve, (b) pudendal nerve.

Discussion

Disturbance in the gait of animals is a common neurological problem in veterinary medicine (Garosi 2004). Besides, results of neurological related studies in cats indicate that lymphosarcoma is most common in affecting the spinal cord of cats (Vail and Macewen, 2000, Forterre et al. 2007, Marioni-Henry et al. 2008). For the appropriate treatment of neurological problems, understanding their anatomy is crucial. Therefore, the plastinated specimen in our research will probably provide an efficient preliminary information not only for the clinicians but also for the pathologists. The present investigation showed spinal nerves in the cervical and lumbar region with their ventral roots. In the cervical region, the ventral root spinal nerves (1-5) were visible and the formation of plexus cervical was also demonstrated. The ventral roots of the last three cervical spinal nerves (6-8) and the first thoracic spinal nerve (T1) were well demonstrated and how they formed plexuses brachialis was visible. Ventral branches of plexuses brachialis were also well preserved. Suprascapular nerve, subscapular nerve, musculocutaneous nerve, axillary nerve, radial nerve, median nerve, ulnar nerve, and lateral thoracic nerve were among well-preserved plexuses brachialis. Produced specimens were dry, non -sticky, odorless, with detectable morphological structure, and almost retain their natural form. Central nervous system preserved in formalin solution has been using for practical teaching of neuroanatomy. Long term storage of Central nervous system in formalin solution has strikingly noticeable influence on its lipids content. Central nervous system preserved in formalin can be easily tear or break down while students use it (Jain et al., 2014; Tomalty, 2019, Heslnga and. Delerkauf, 1962).

Our study showed an excellent specimen to display samples in practical anatomical sessions which enable students to better understand the origins and formation of brachial plexus. In the lumbar and sacral region, the spinal cord with its roots (ventral rami) and cauda equina was well demonstrated. In the lumbar region the first three ventral rami (cranial iliohypogastric nerve, caudal iliohypogastric nerve, ilioinguinal nerve) after leaving the vertebral column, didn't form any plexus in both sides (left and right). The last four ramus ventralis of the spinal cord in the lumbar region was attached and forms the lumbar plexus. Lumbar plexus further attached to the sacral plexus and forms lumbosacral plexus. The sacral plexus was formed by joining of the ramus ventral rami of the spinal cord in the sacral region. In comparison to the formalin preserved specimen of the spinal cord and its roots, the specimen preserved with plastination technique was visible, unbroken but they were much firmer. The same finding was also reported by Basset et al. (2014). The skill and knowledge of regional anatomy in the nerve system had an important part in general surgical practice. Having good knowledge and skill of spinal cord regional anatomy could be useful in studying and determining an area for epidural anesthesia during surgical practices.

Conclusion

Spinal cord in cat prepared by silicone plastination method can be used as the best alternative to formalin preserved specimens in the teaching of neuroanatomy, but it needs very careful dissection and specimen preparation for plastination.

References

Baroni, M., & Heinold, Y. (1995). A review of the clinical diagnosis of feline infectious peritonitis viral meningo encephalomyelitis. *Progress in veterinary neurology, 3*, 88 –94.

Basset, A. A. E., Seleem, A. A., & Mohamed, S.K. (2014). Silicon plastination of brachial and lumbosacral plexuses and cauda equina in goat; educational Neuroanatomical Studies. Basrah journal of veterinary research, 1(2):193-212.

Bican, O., Minagar, A., & Pruitt, A. A. (2013). The spinal cord: a review of functional neuroanatomy. *Neurologic Clinics, 31*, 1-18.

Forterre, F., Tomek, A., Konar, M., Vandevelde, M., Howard, J., & Jaggy, A. (2007). Multiple meningiomas: clinical, radiological, surgical, and pathological findings with outcome in four cats. *Journal of Feline Medicine and Surgery, 9*, 36–43.

Garosi, L. (2004). *The neurological examination*. In: Platt S, Olby N, eds. BSAVA manual of canine and feline neurology. 3rd ed. Gloucester: BSAVA, Pp1–23.

Henry, R. W., & Latorre R. (2007). Polyester plastination of biological tissue: P40 technique for brain slices. *Journal of Plastination, 22,* 59-68.

Henry, R. W., Larry, J., & Carol, H. (1997). Specimen Preparation for Silicone Plastination. Journal of International Society for Plastination, 12, 13-17.

Henry, R. W., Van Hagens, G., & Seamans, G. (2019). Cold temperature/Biodur® /S10/von Hagens' Silicone plastination technique. Anatomia Histologia Embryologia, 48, 532–538.

Heslnga, F. J. M., & Delerkauf, F. A. (1992). Action of formaldehyde solution on human brain lipids. https://journals.sagepub.com/doi/pdf/10.1177/10.6.704https://journals.sagepub.com/doi/pdf/10.1177/10.6.704.

Holladay, S. D., & Hudson L. C. (1989). Use of plastinated brains in teaching neuroanatomy at the North Carolina state university, college of veterinary medicine. Department of Anatomy, Physiological Sciences, and Radiology. *Journal of International Society for Plastination, 3*(1), 15-17.

Jain, M., Kasetty, S., & Sudheendra, U. S. (2017). Plastination: An intricate and real display of oral hard and soft tissues specimens. *Journal of Dental Research, 1,* 1-6. DOI: 10.5171/2014.639870.

König H. E. & Liebich, H. G. (2020). Veterinary anatomy of domestic mammals*. Textbook and Colour Atlas. 7th* ed. New York, US: Thieme.

Knipe, M. F., Vernau K, M., Hornof, W. J., & Lecouteur, R. (2001). Intervertebral disc extrusion in six cats. *Journal of Feline Medicine and Surgery, 3*, 161–168.

Lahunta, A. D., Glass, E., & Kent, M. (2008). *Veterinary Neuroanatomy and Clinical Neurology. 3rd Edition*, Sounders US. Pp15-40 ISBN: 9780721667065.

Legendre, A. M., & Whitenack, D. L. (1995). Feline infectious peritonitis with spinal cord involvement in two cats. *Journal of the American Veterinary Medical Association, 167*, 931–932.

Lu, D., Lamb, C. R., Wesselingh, K., & Targett, M. P. (2002). Acute intervertebral disc extrusion in a cat and MRI findings. *Journal of Feline Medicine and Surgery, 4*, 65–68.

Marioni-Henry, K., Charles, H. V., Alisa, L. N., & Thomas, J. V. W. (2004). Prevalence of Diseases of the Spinal Cord of Cats. *Journal of Veterinary Internal Medicine, 18*, 851–858.

Marioni-Henry, K., Van Winkle, T. J., Smith, S. H., & Vite C. H. (2008). Tumors affecting the spinal cord of cats: 85 cases (1980–2005). *Journal of the American Veterinary Medical Association, 232*, 237–243.

Munana, K. R., Olby, N. J., Sharp, N. J. H, & Skeen, T. M. (2001). Intervertebral disc disease in 10 cats. *Journal of the American Animal Hospital Association, 37,* 384-389.

NAV, (Nomina Anatomica Veterinaria) (2017). International Committee on Veterinary Gross Anatomical Nomenclature (ICVGAN). Published by the Editorial Committee.

Pashaei, S. (2010). A brief review on the history, methods and applications of plastination. *Journal of Morphology, 28*, 1075-1079.

Robert, W. H., Larry, J., & Carol, H. (1997). Specimen Preparation for Silicone Plastination. *Journal of International Society for Plastination, 12,* 13-17.

Robert, W. H., Van Hagens, G., & Seamans, G. (2019). Cold temperature/Biodur® /S10/von Hagens' Silicone plastination technique. *Anatomia Histologia Embryologia, 48*, 532–538.

Schoefert, A. K. (2019). Comparative Neuropathology (1962): Attending to Neuropathologies across multiple species. *Journal of the History of Medicine and Allied Sciences, 74* (2), 192–215.

Sivrev, D. P., Hamza, S. R., Dimitrov, N. D., & Georgieva, A. I. (2013). Using of P40 technique for brain sheet plastination. Faculty of Medicine, University of Thrace, St.Zagora,Bulgaria.UDC57611.http://journals.nubip.edu.ua/index.php/Veterenarna/article/view/4202.

Tomalty, D., Pang, S. C., & Ellis, R. E. (2019). Preservation of neural tissue with a formaldehyde-free phenol-based embalming protocol. *Clinical Anatomy, 32*, 224-230.

Toossi, A., Bergin, B., Marefatallah, M., Parhizi, B., Tyreman, N., Dirk., Everaert, G., Rezaei, S., Peter, S, ChristopherGatenby, J., Steve, I. P., & Mushahwar, K. V. (2021). Comparative neuroanatomy of the lumbosacral spinal cord of the rat, cat, pig, monkey, and human. *Scientific Reports, 11*, 1955-1919.

Vail, D. M., & Macewen, E. G. (2000). Spontaneously occurring tumors of companion animals as models for human cancer. *Cancer Investigation. 18*(8), 781-792.

Von Hagens, G., Tiedemann, K., & Kriz, W. (1987). The current potential of plastination. *Anatomy and Embryology,175*, 411-421.